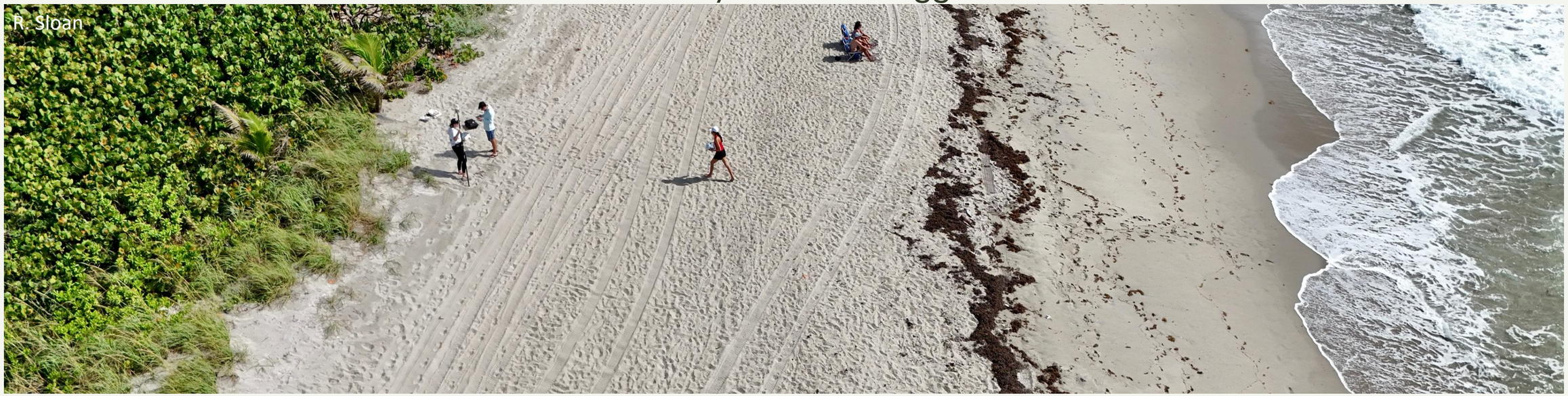
Microplastics in Coastal Sediments

Halaina Hahn
Ph.D. Geoscience Student at Florida Atlantic University
Dr. Tiffany Roberts Briggs



October 2025

Background-Microplastics

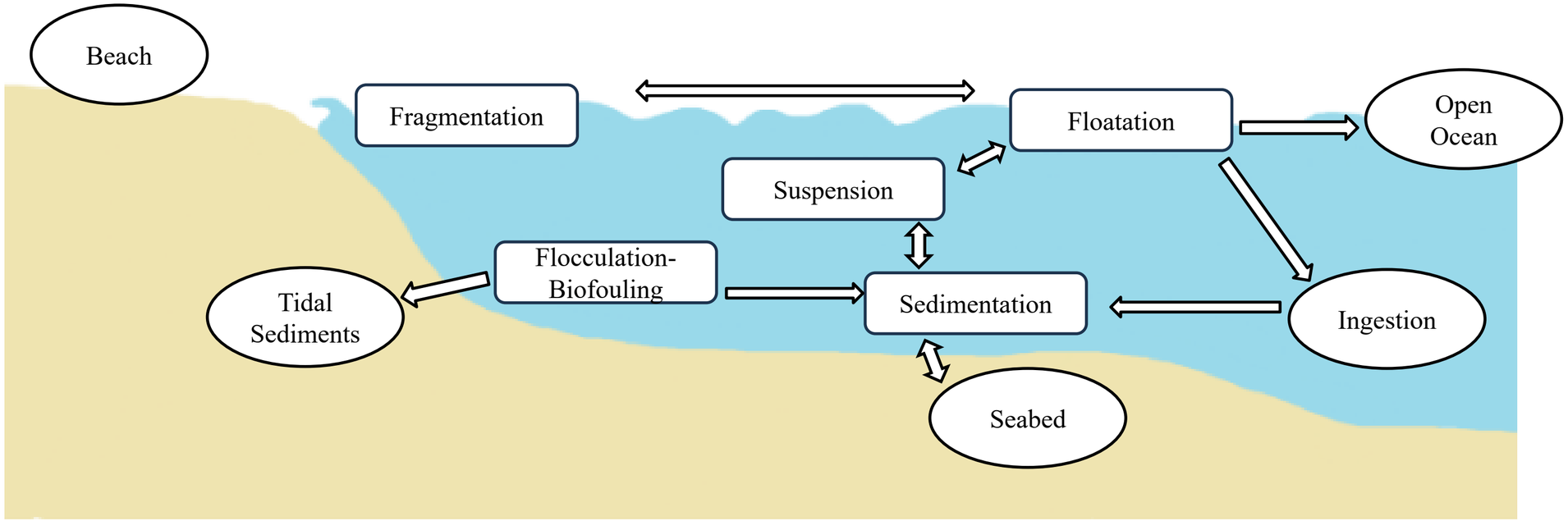
- Pieces 5mm or less
- Classification:

- Primary:
  - purposefully microscopic plastics
  - used in cosmetics and personal care products
- Secondary:
  - breakdown of larger plastic debris

- Shape:
  - fibers, fragments, films, foams, and microbeads

Microplastic Transport

- Accumulation of microplastics in marine sediments can depend on density
- Plastics that are more dense than seawater will sink and settle (Woodall et al., 2015), whereas low-density MPs will float on the surface of water (Suari and Aliani., 2014)



(Schematic of microplastic sources, sinks, and pathways. Modified from Zhang., 2017)

Microplastic Impacts

- Sea turtles:
  - The most affected organism by microplastic pollution
  - number of individual sea turtles contaminated and the mean number of microplastic particles found in the organism (Ugwu et al., 2021)

- Humans
  - exposure in human health via ingestion, inhalation, and dermal exposure (Prata et al., 2019)

  - The increased consumption of microplastics in humans can lead to pulmonary, cardiovascular and infectious diseases (Osman et al., 2022)

Photograph by Jordi Chias sourced from National Geographic

Photograph by Liz Allen from Forbes

Goals

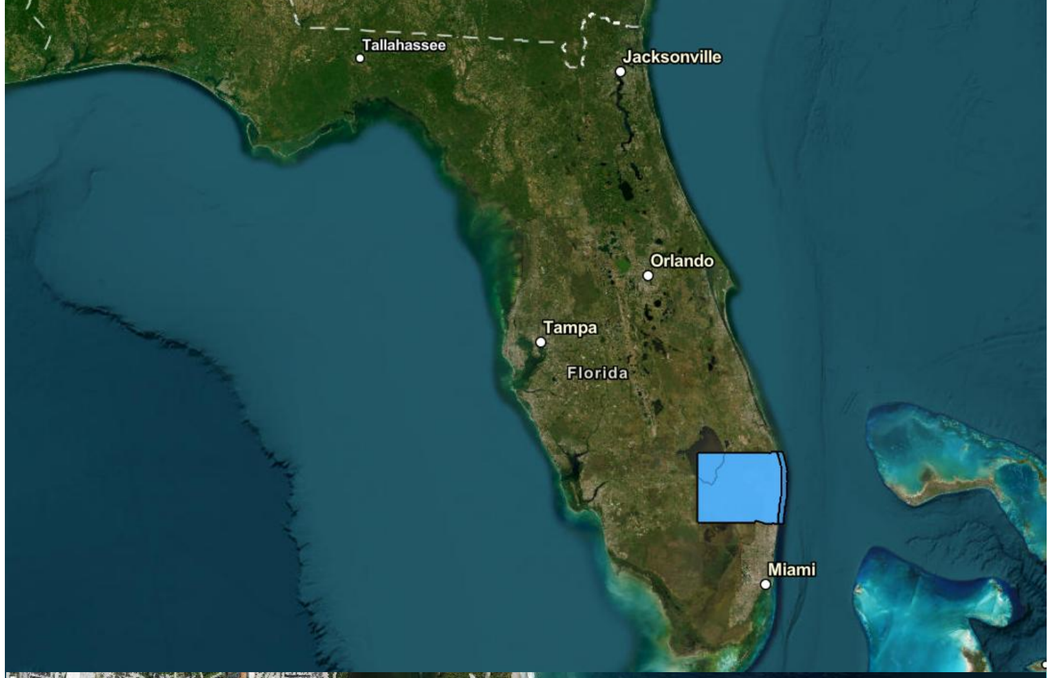
- ***This study aimed to quantify microplastic abundance and variation cross-sectionally on the beach and compare with beach use type and local wave energy in Southeast Florida.***

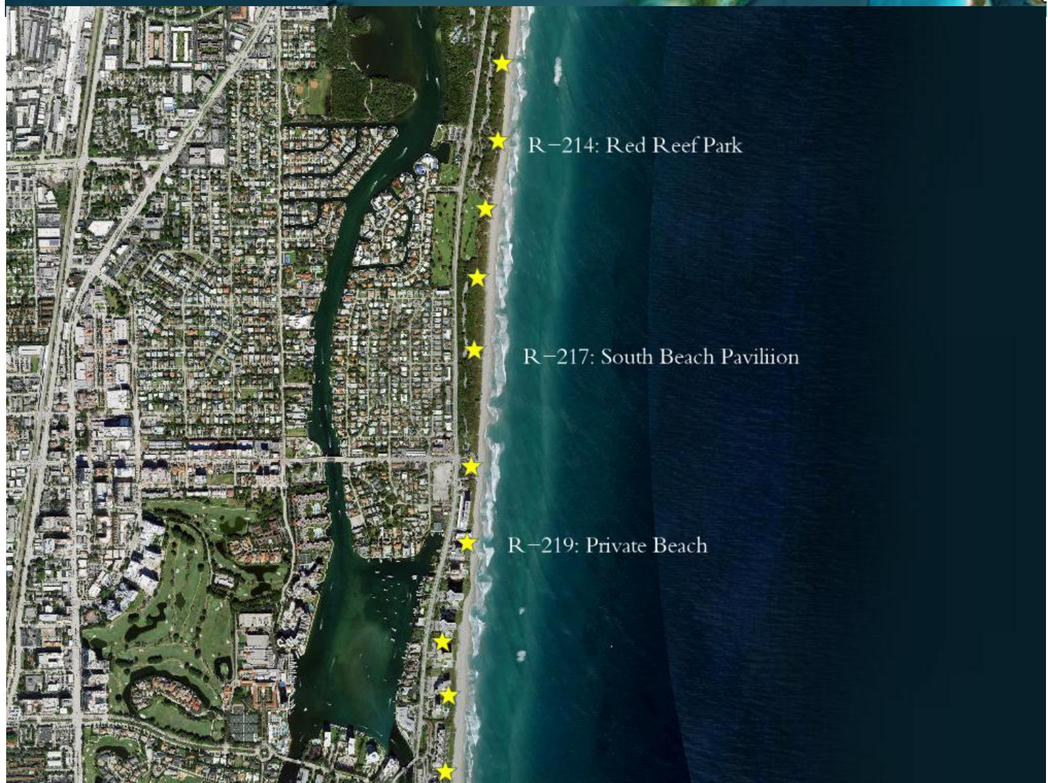
Research Questions:

1. What is the cross-shore abundance of microplastics?
2. Is there a relationship between microplastic variance and geomorphology of the beach?
3. Is there a difference in microplastic abundance and variation by aeolian or wave transport?
4. Is there a relationship between microplastic abundance and beach use/accessibility type?

Study Area

- Palm Beach County, FL
- Semi-diurnal, microtidal beaches
- Intermediate beach with bar and trough morphology
- Three beaches selected within 2 km:
  - Park: Red Reef Beach Park (R214)
  - Public: South Beach Park Pavilion (R217)
  - Private: South of public beach (R219)





Sample Locations

- Cross-shore variability
- Sediment was sampled at the dune, berm, berm crest and high tide line
- Seasonal variability

- Overall methodology follows O’Brien (2023) which standardized sampling and extraction methods (modified from Besley et al. 2017)

Lab Methodology

Laboratory Analysis

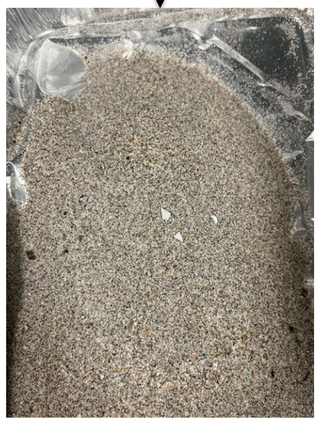
Identification

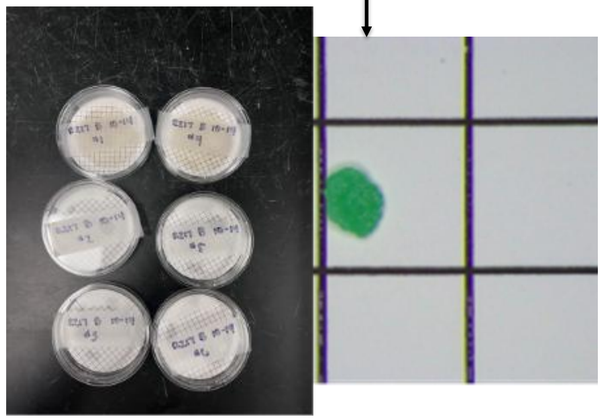
Microplastic Filtration

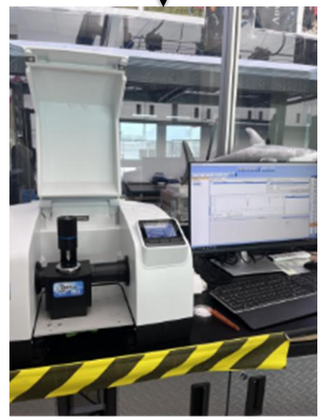
Sediment Characteristics

Microscope

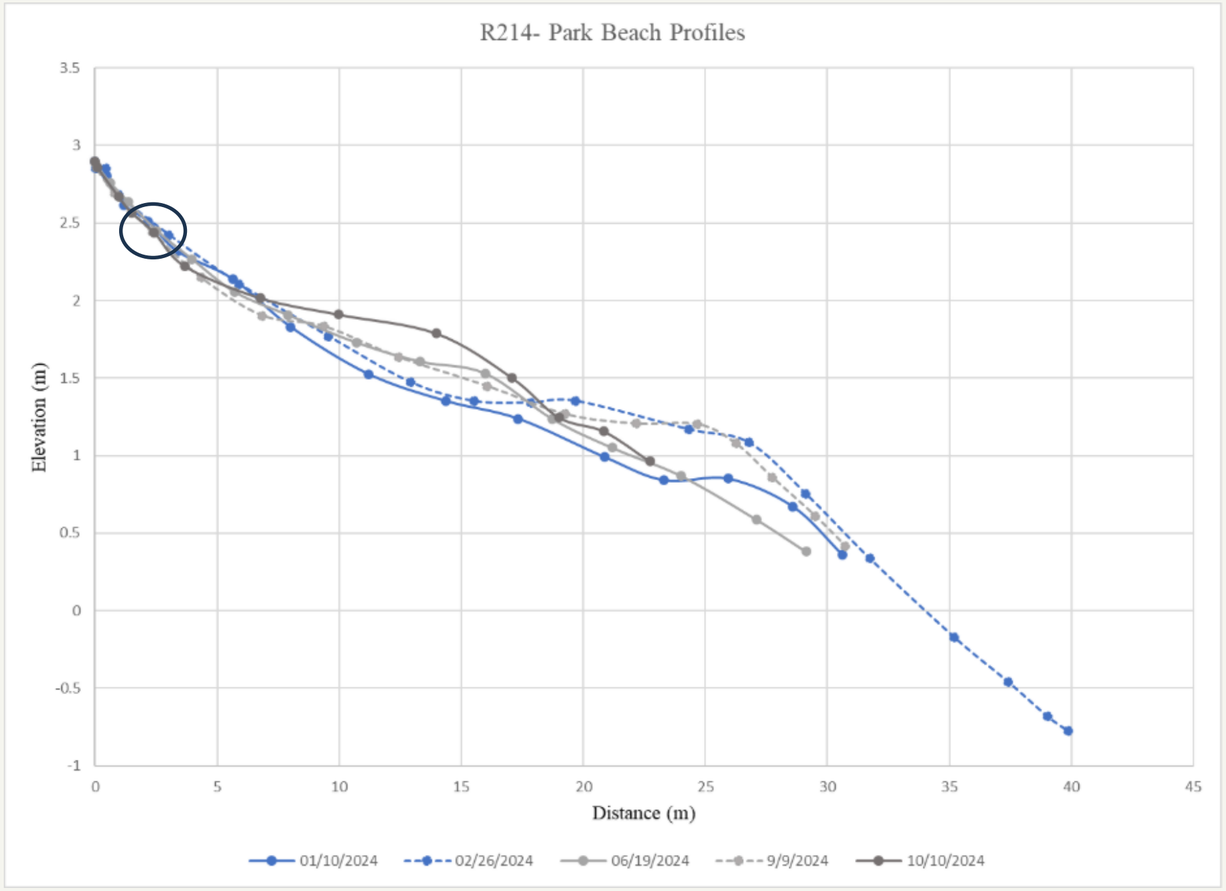
Fourier Transform Infrared (FTIR) Spectroscopy

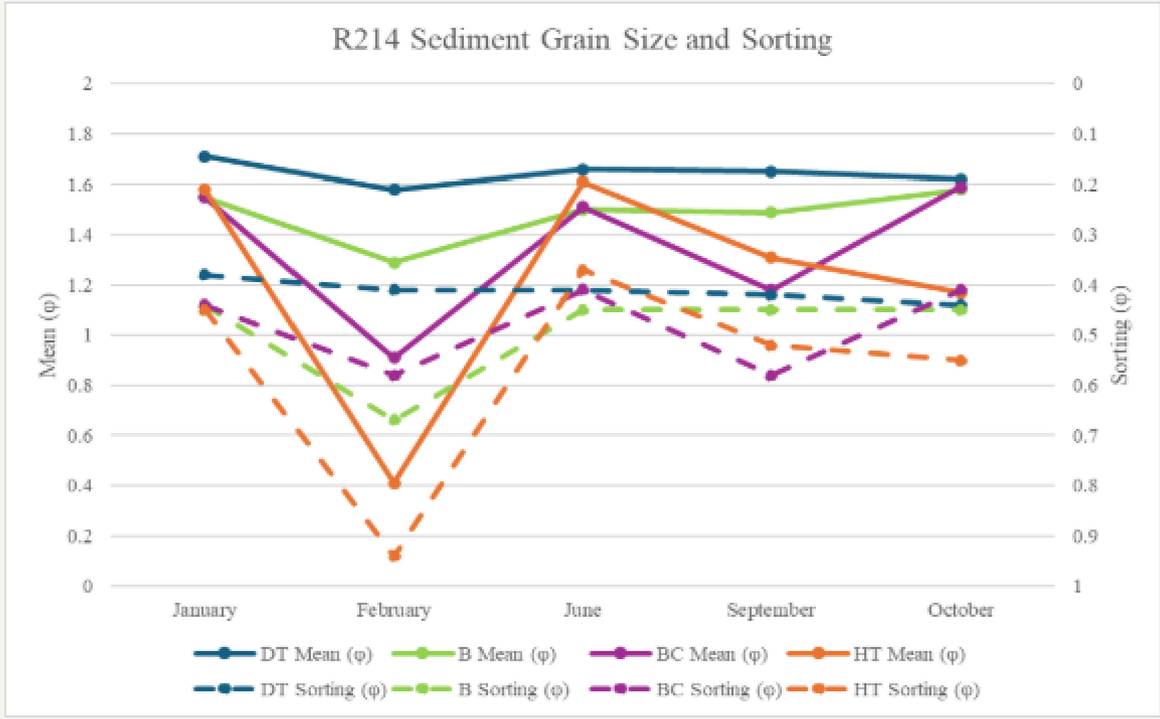




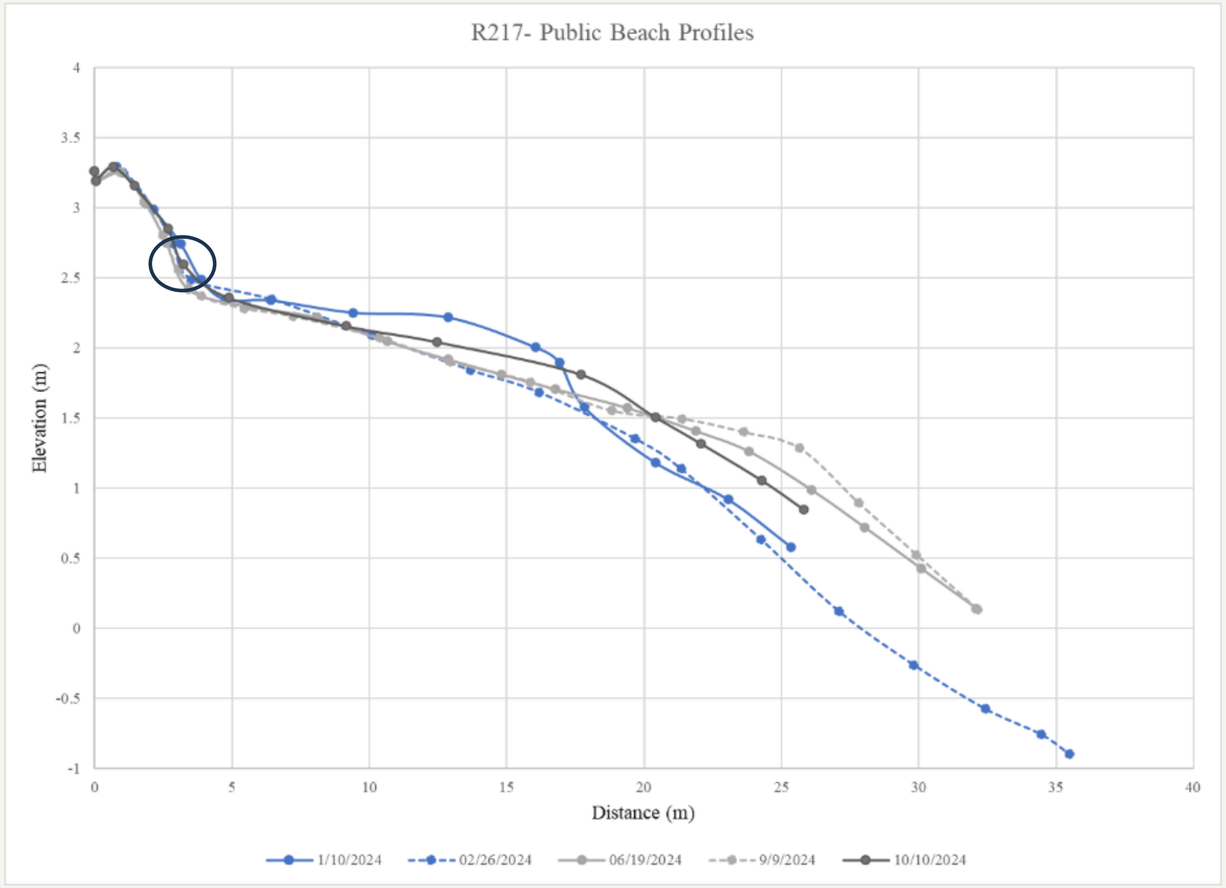


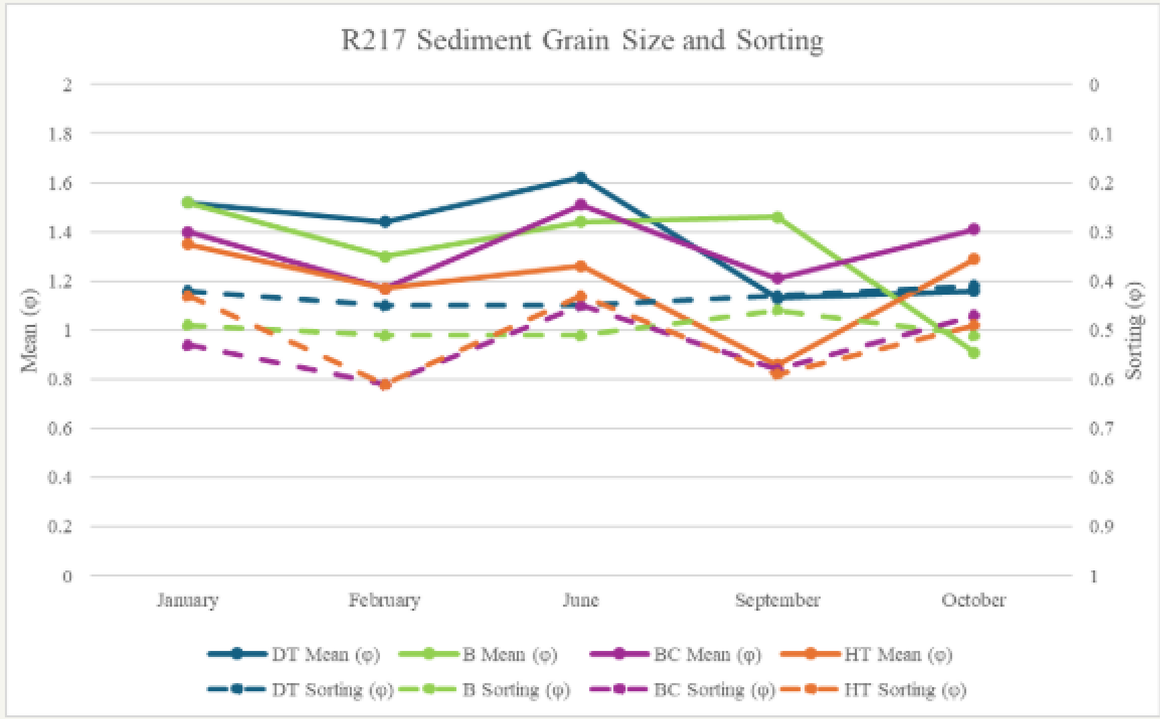
Results — Morphology and Sediment (Park)



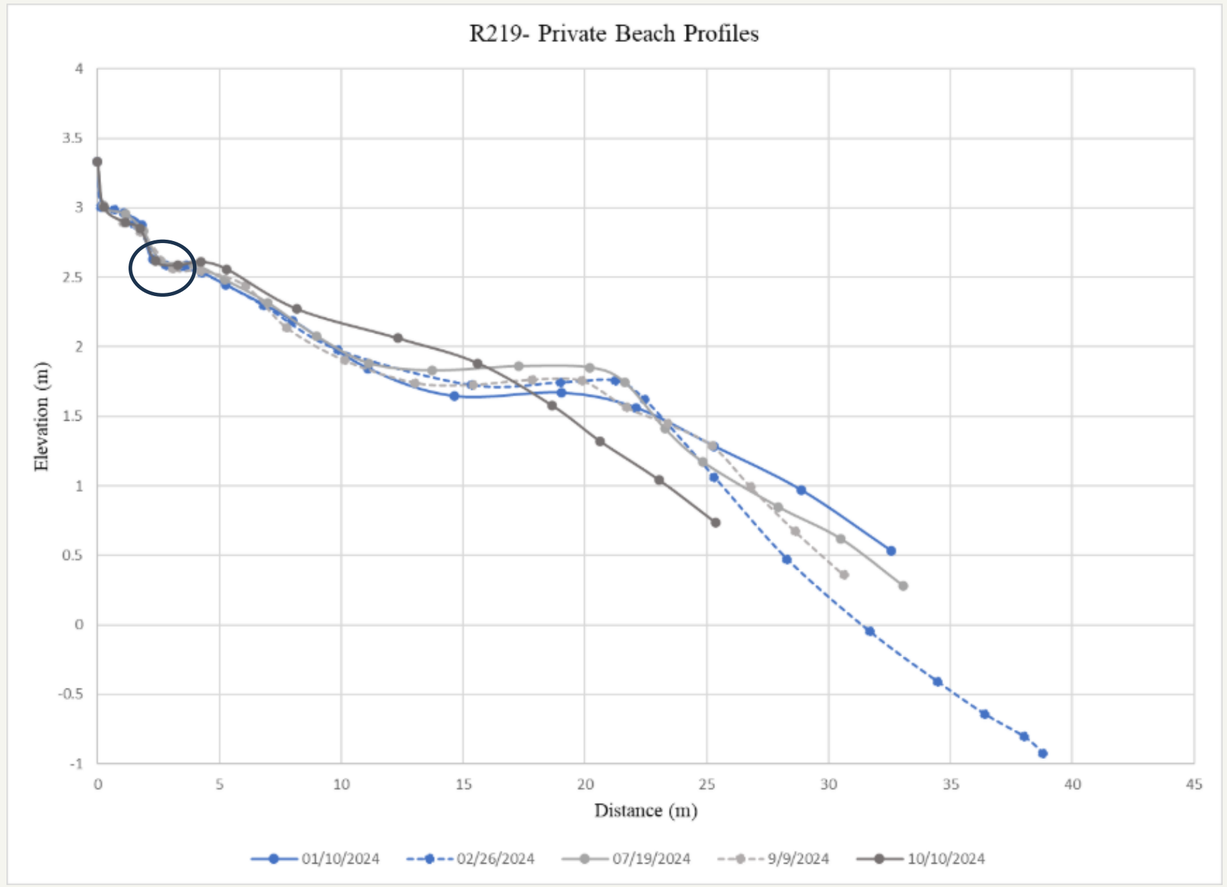


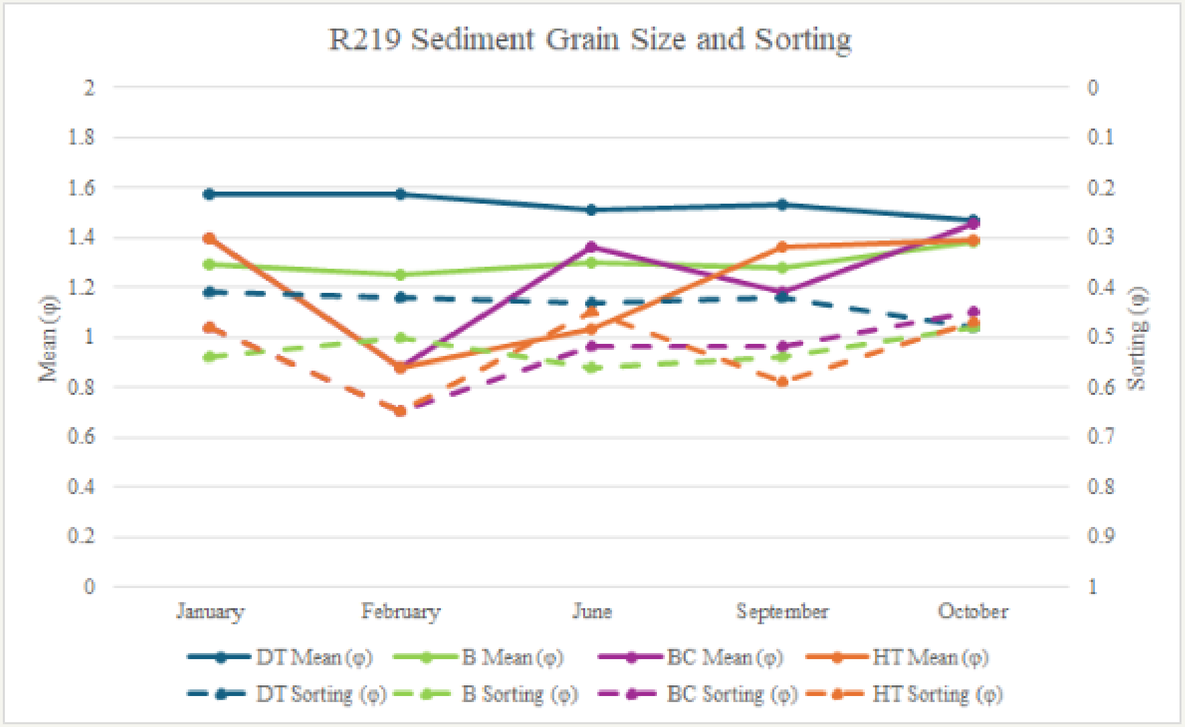
Results — Morphology and Sediment (Public)





Results — Morphology and Sediment (Private)



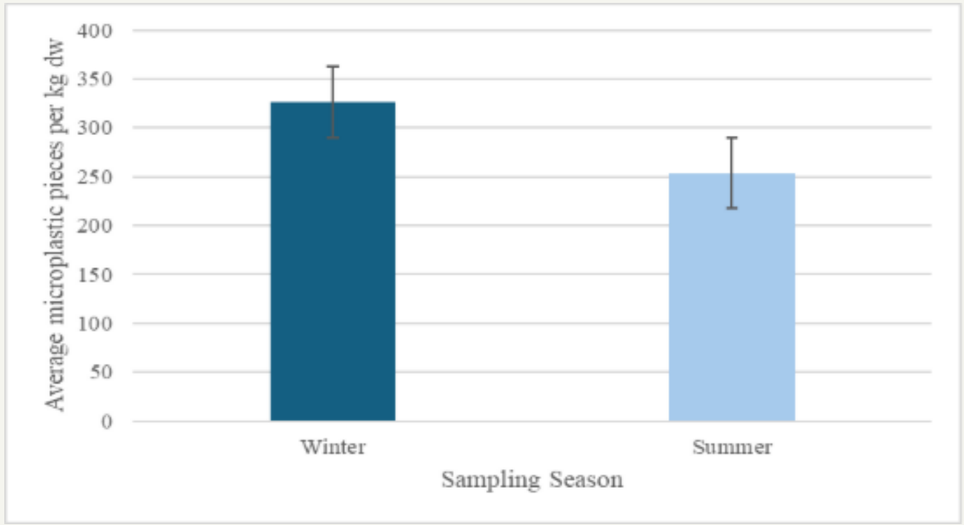


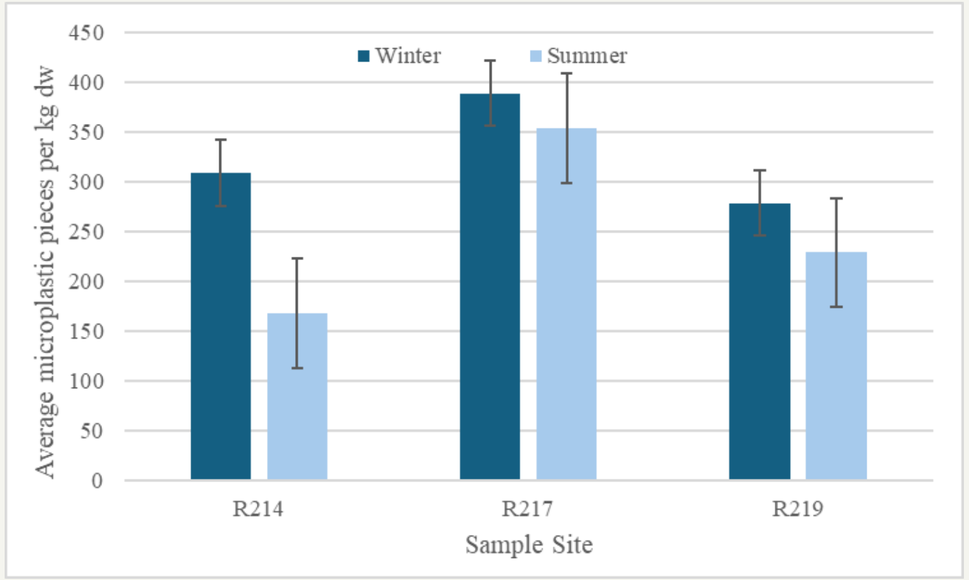
Results — Microplastic Abundance

Overall average was 259 microplastic pieces per kg dw and ranged between 60 and 690 pieces per kg dw per sample.

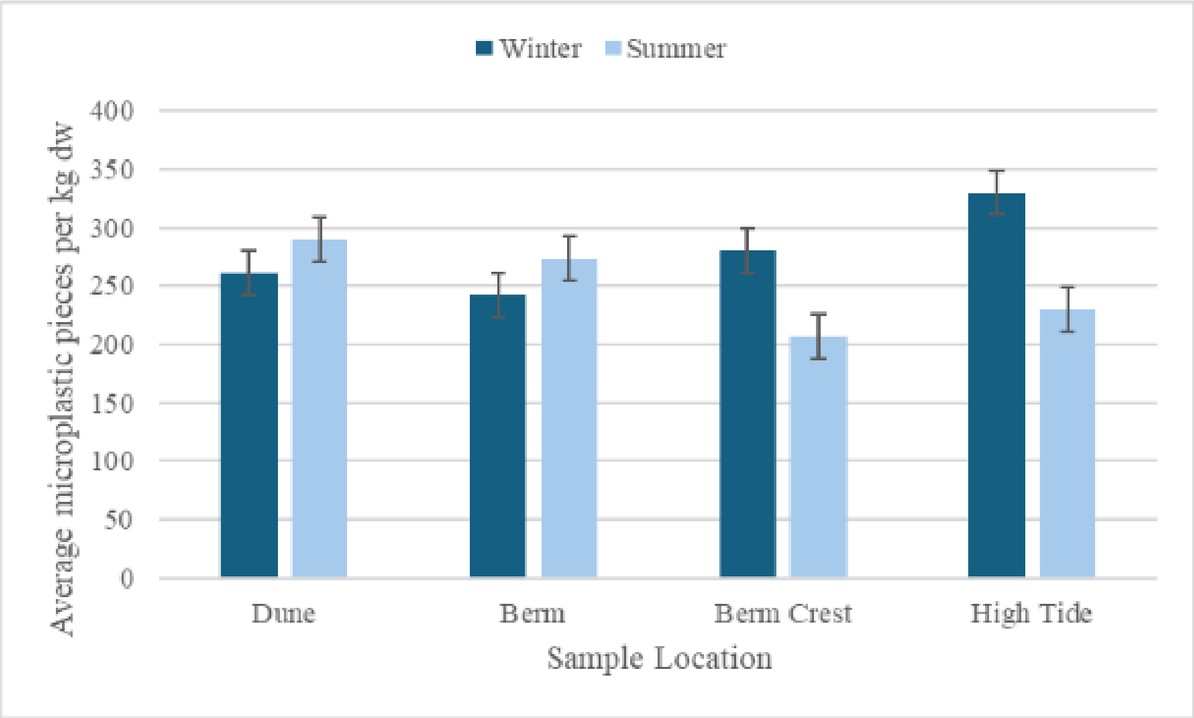
Differences between winter and summer significant

Differences between beaches significant





Results – Microplastic Abundance



Berm crest samples had the highest average

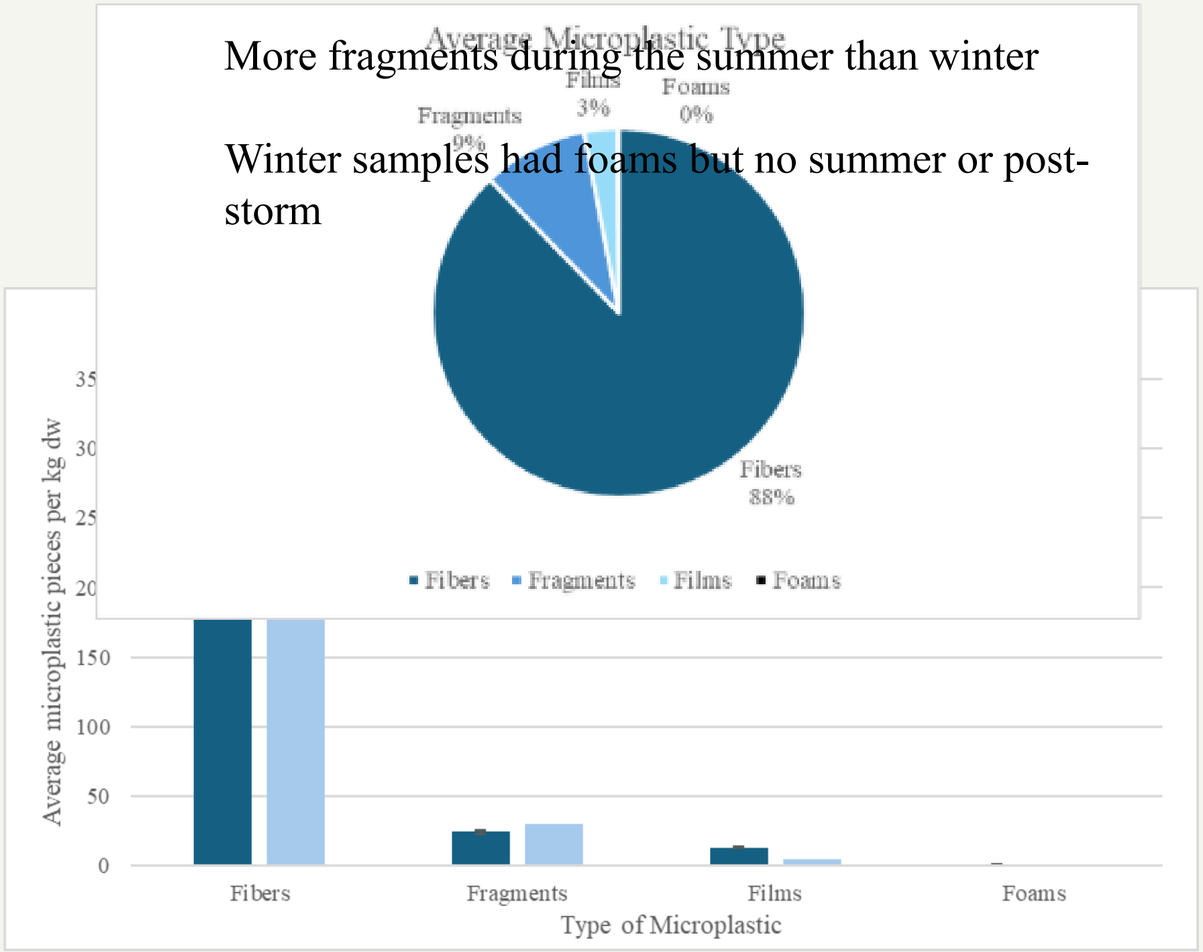
During the winter the high tide had the highest average

During the summer the dune toe had the highest average

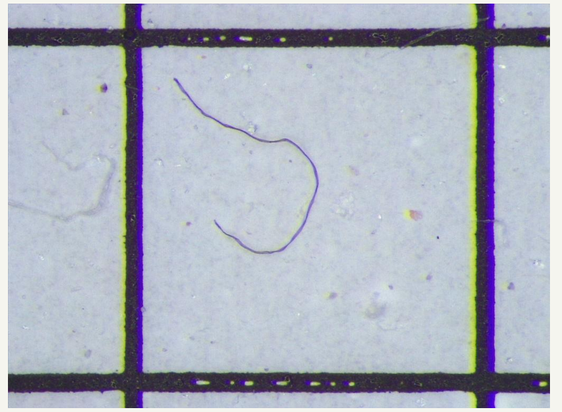
Results – Microplastic Types

More fragments during the summer than winter

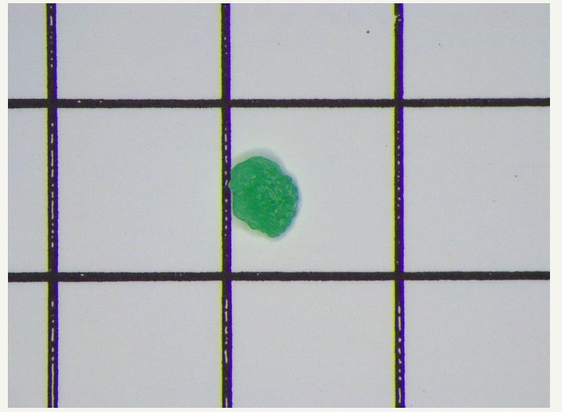
Winter samples had foams but no summer or post-storm



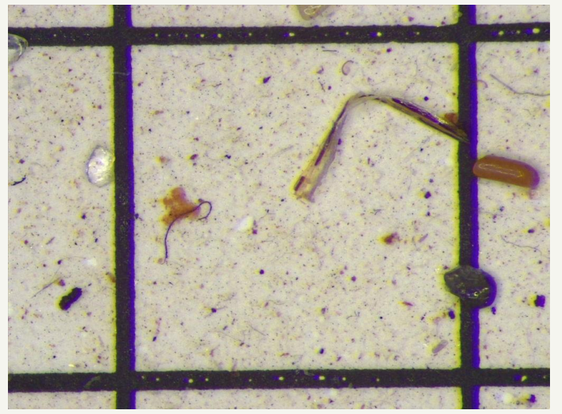
Fiber



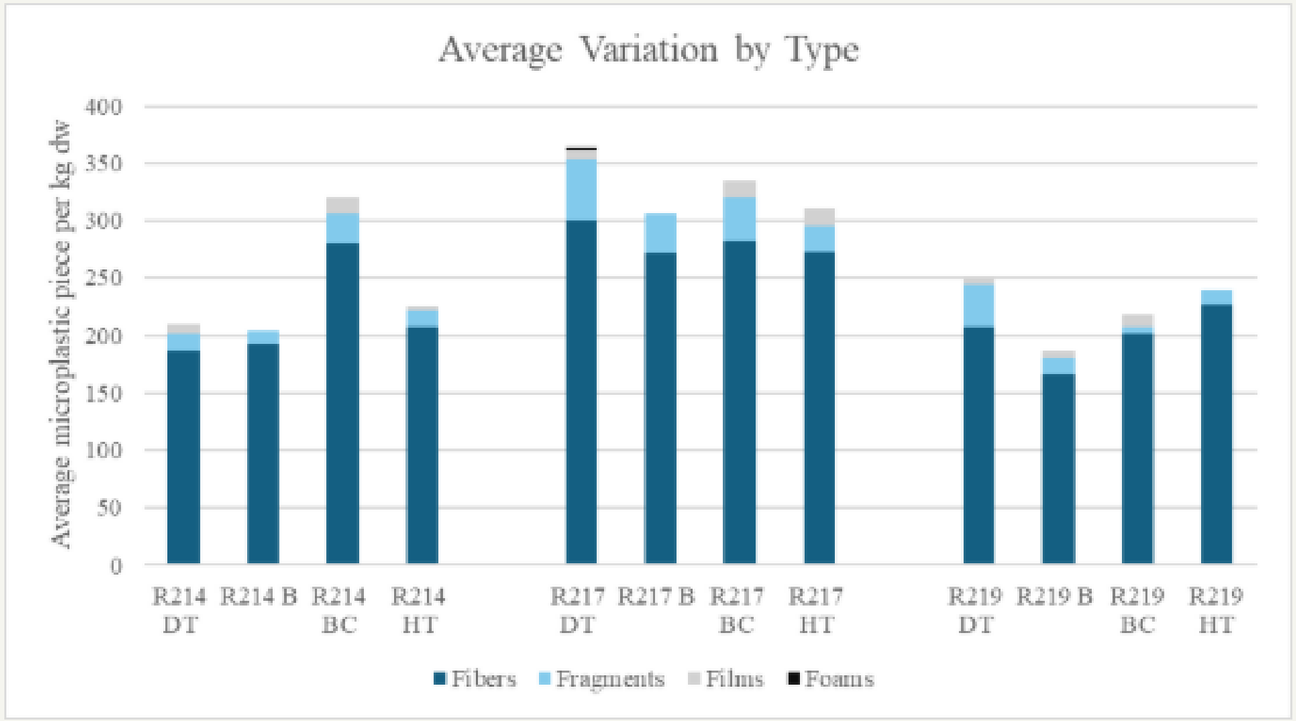
Fragment



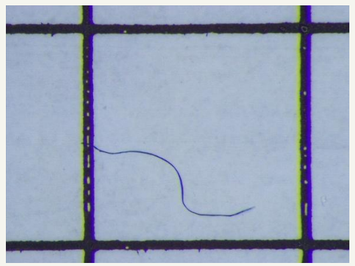
Film

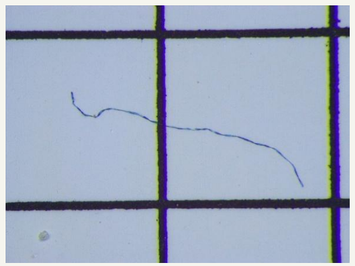


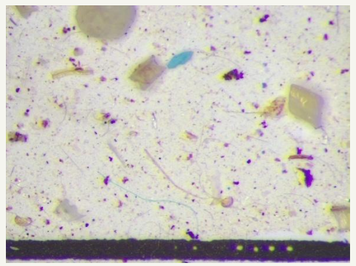
Results — Microplastic Types

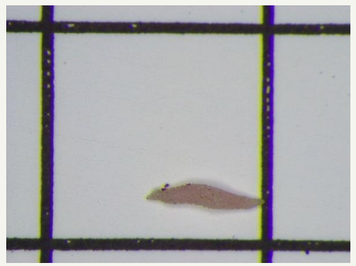


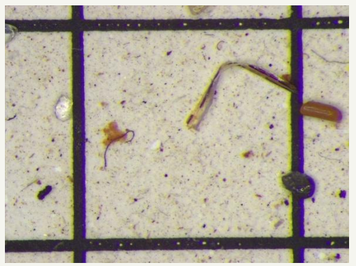
- Park - R214: berm crest samples contained the highest amount of fibers and fragments across all seasons
- Public - R217: dune toe samples had higher amounts of fibers and fragments
- Private - R219: high tide samples had the most fibers and the dune toe had the most fragments



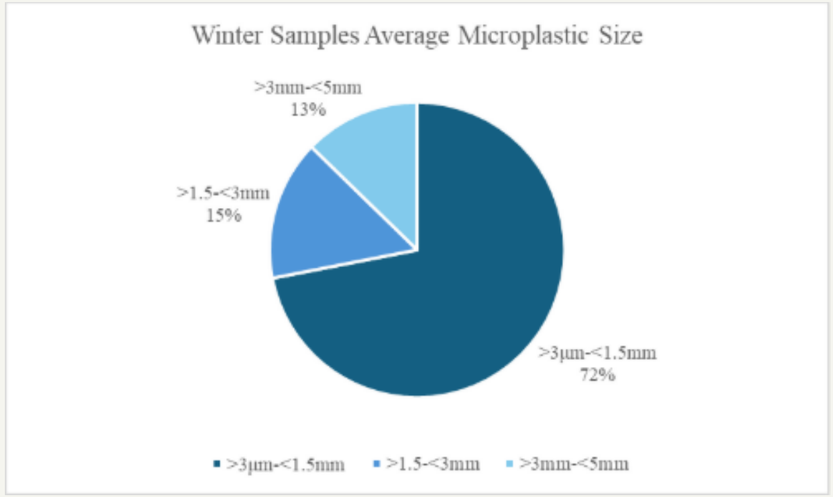


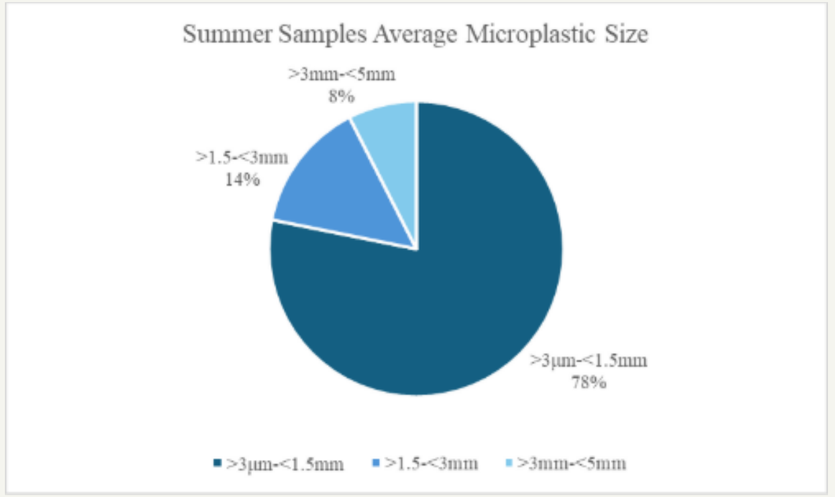


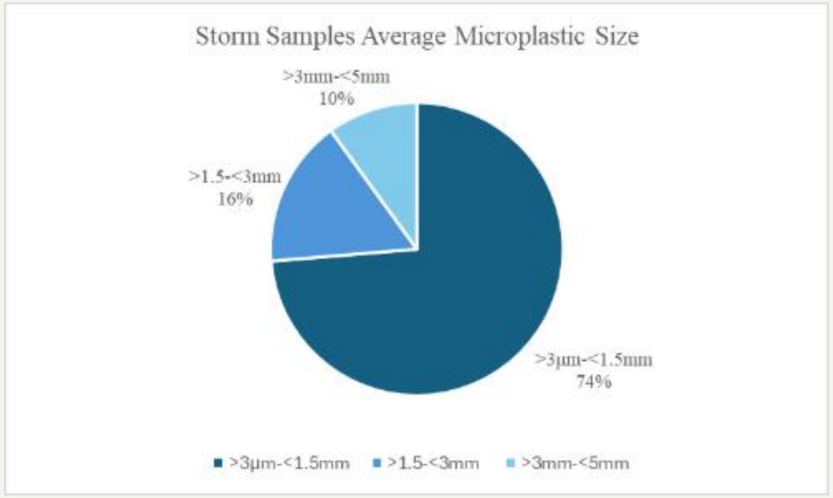




Results – Microplastics Sizes

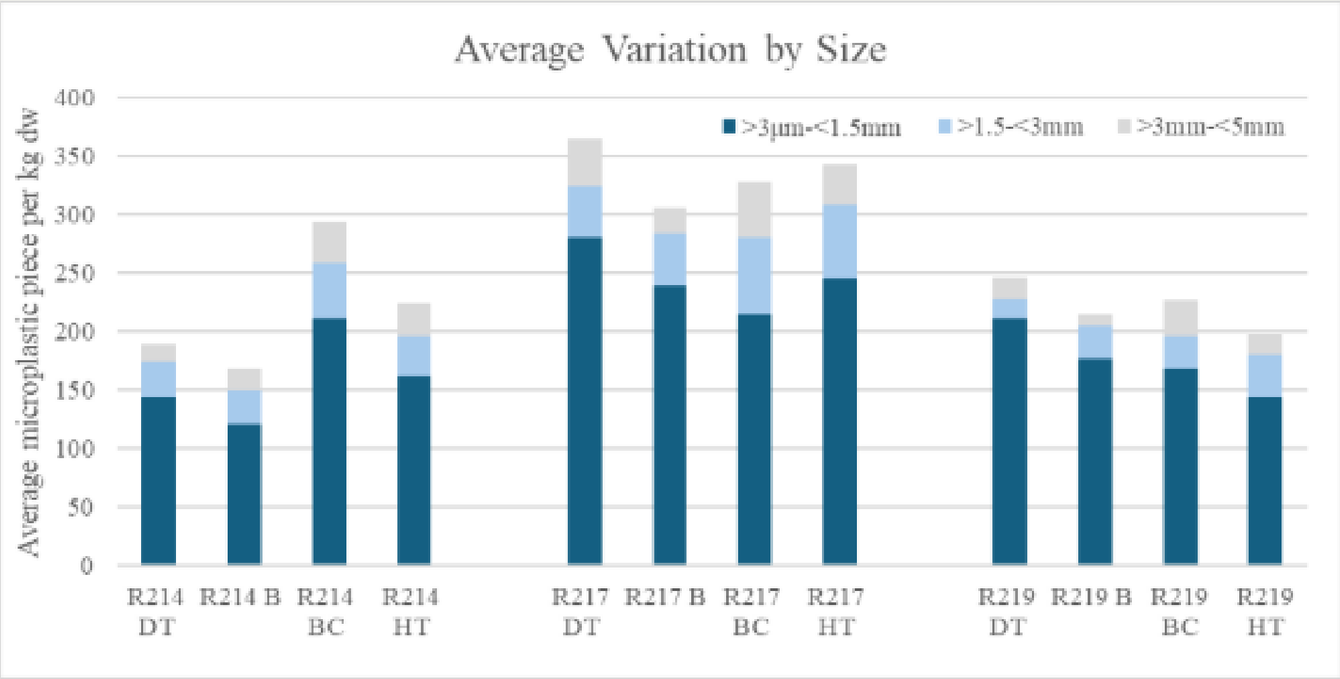






- Across all seasons microplastics fell within the small size category
- The summer and post-storm samples had smaller microplastics

Results – Microplastics Sizes

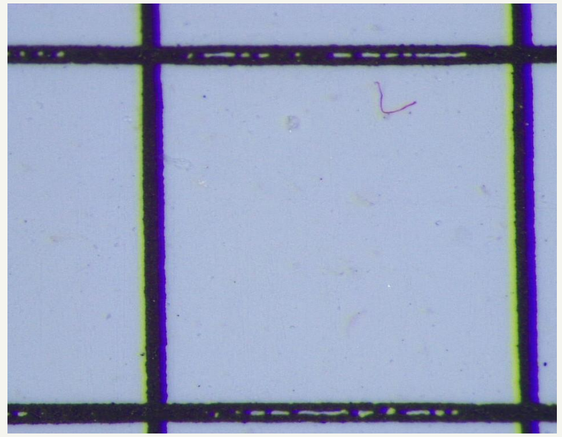


Park - R214: the berm crest samples had the highest amount of small microplastics

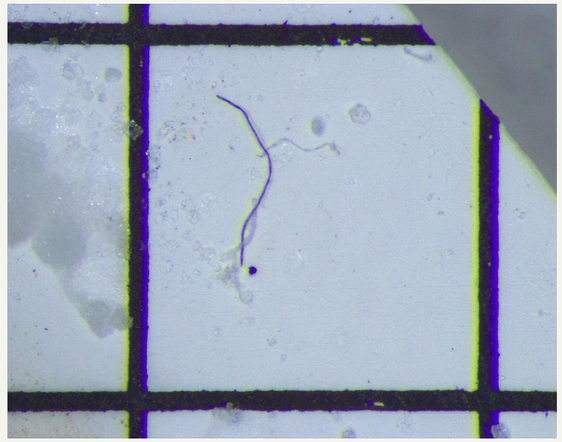
Public - R217: dune toe samples had the highest amount of small microplastics

Private - R219: dune toe samples had the highest amount of small microplastics

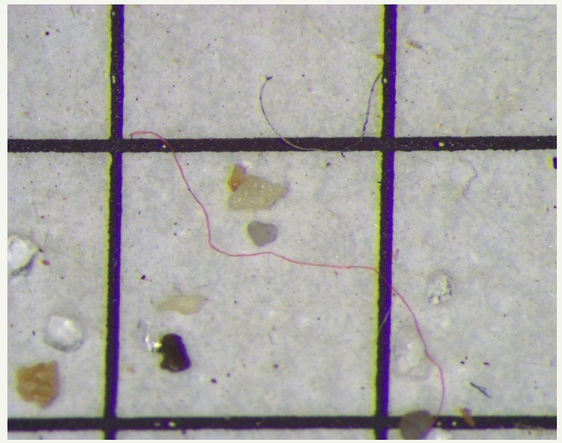
Small



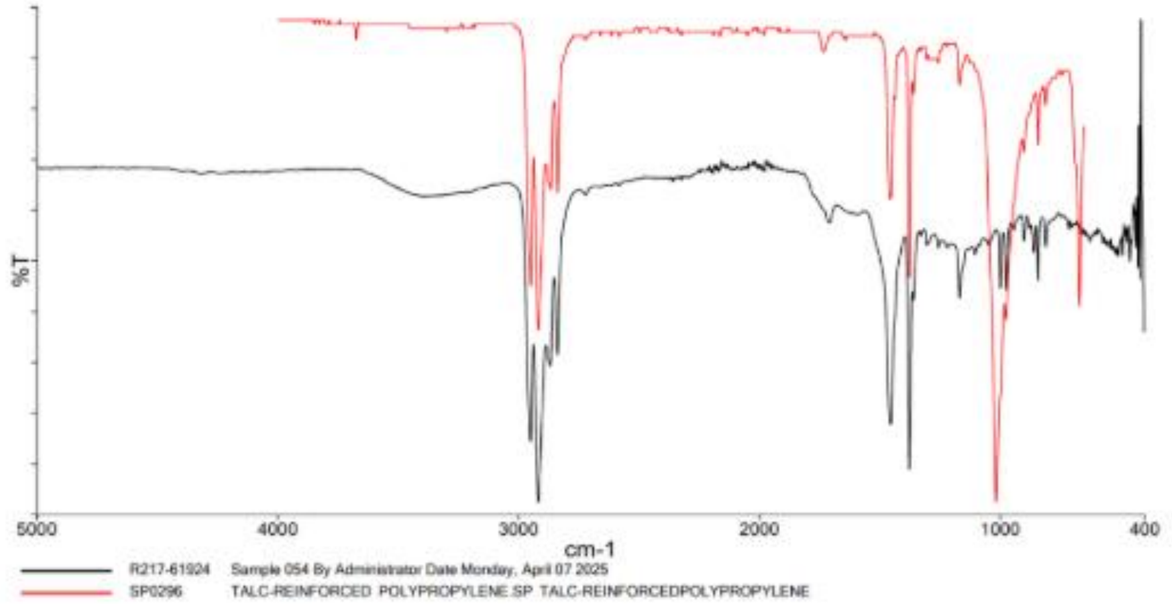
Medium

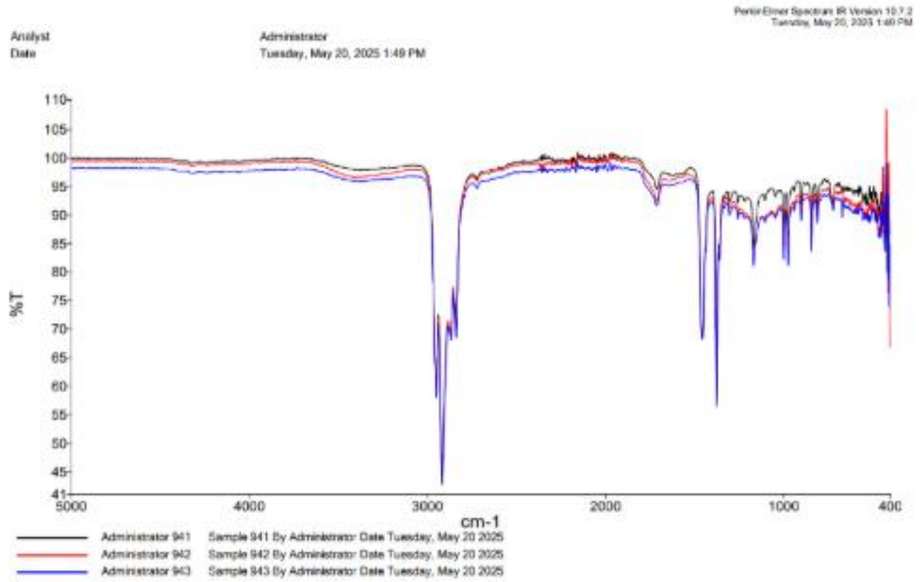


Large



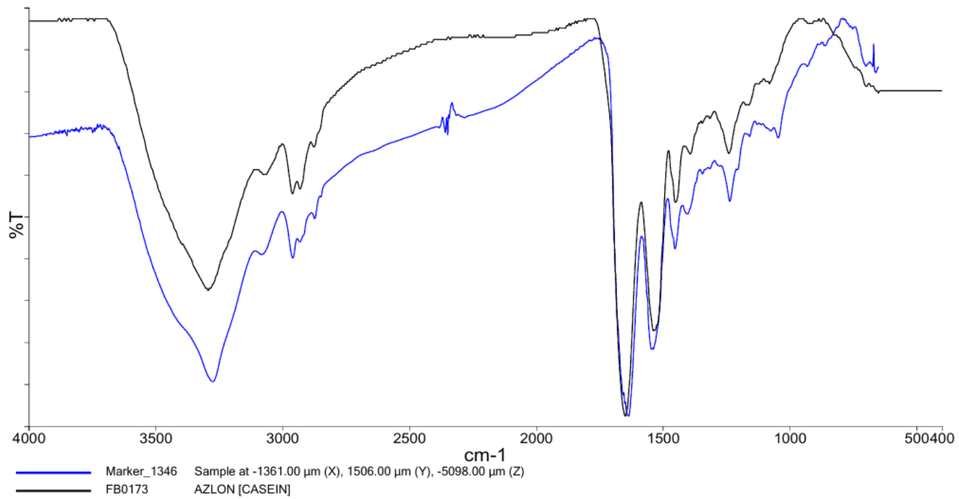
Results — FTIR- ATR

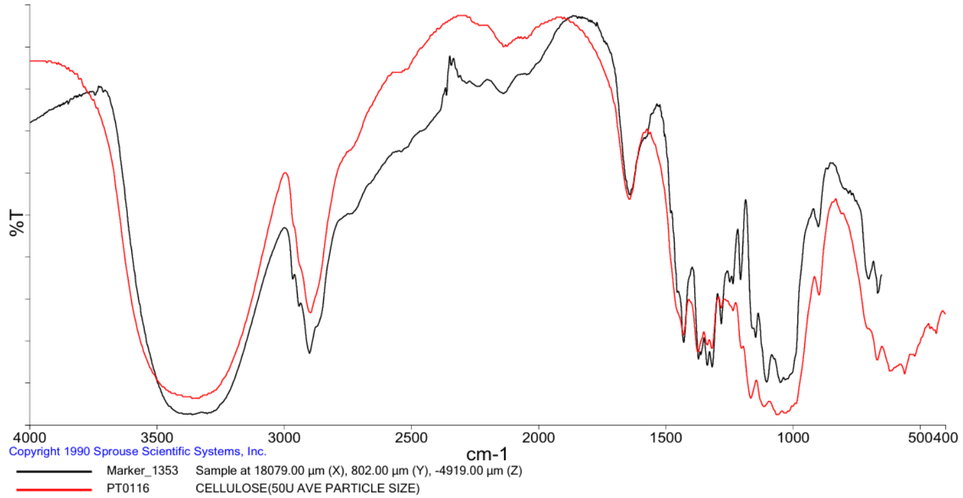




- All three beach sites were found to contain at least one particle of polypropylene
- R219 had 2 PP microplastics, R214 and R217 had one each
- Polypropylene is the second most produced polymer with 68 million tons annually and takes hundreds of years to decompose (Yuan et al., 2022)

Results – µFTIR





- Azlon is considered a textile fiber synthesized from natural protein sources.
- Cellulose is derived from plant material largely the cell walls of plants

Discussion

- Abundance across beach zones does not significantly differ

  - Other studies noted that there was no clear distributional pattern among zones (Luan et al., 2024; Mathalon and Hill., 2014)

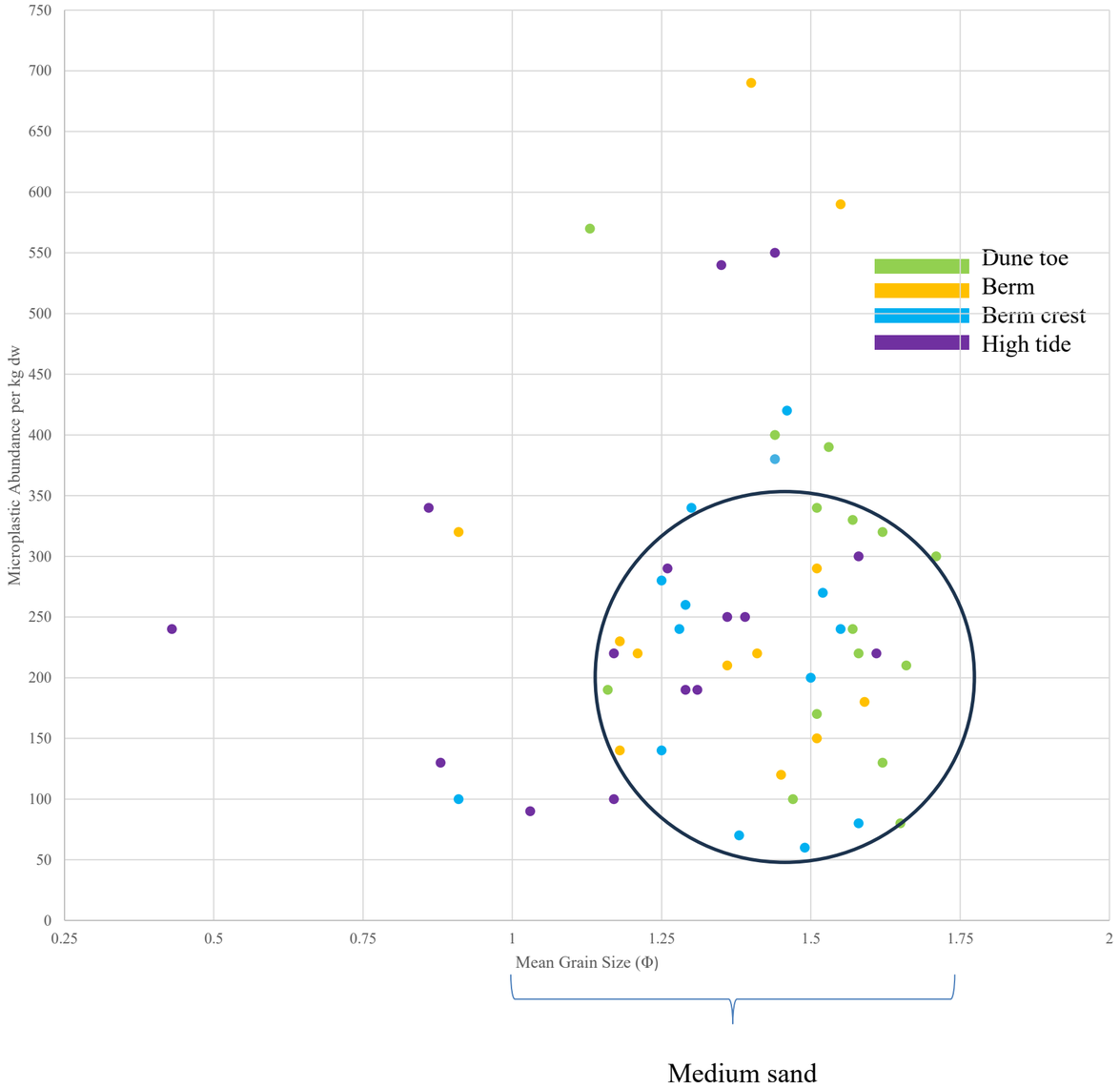
Literature Review:

Study Location	Microplastic Abundance	Source
Nova Scotia, Canada*	2000-8000	(Mathalon and Hill., 2014)
Qingdao, China*	452 (Spring) - 748.5 (Autumn)	(Luan, et al., 2023)
Lesser Antilles	261	(Bosker et al., 2018)
Bangladesh	232	(Banik et al., 2022)
North Palm Beach County, FL	183	(O'Brien., 2023)

- Fibers were the most common type to be found in this study and that aligns with other studies (Abelouah et al., 2022, Bosker et al., 2018, Lots et al., 2017, Turner et al., 2025)

Discussion

- As mean grain size Φ increases and microplastic pieces per kg dw increases.
- Sediment sorting was not a statistically significant factor
- More microplastics were found within finer sediment supported by multiple studies (Rodrigues et al., 2024, Masud et al., 2023, Vermeiren et al., 2021)
- low energy depositional environments more microplastics were found (Tsukada et al., 2021)
- Transportation processes of microplastics is still unknown
  - Studies including densities of microplastics to understand settling velocities to compare to sediment (Nguyen et al., 2022)



Discussion

- The public beach, R217, had the highest average microplastic abundance

- Public beach:
  - Free and hourly parking is located nearby
- Park beach:
  - Public access but with a higher entrance/parking fee ($35 per day on weekdays and $50 on weekends and holidays)
- Private beach:
  - No access to the public

- At each beach, different sampling locations found higher amounts of fibers
  - Public beach: at the dune toe
- Indicating a higher population density that may expand closer to the dune

Discussion

Efficacy of Fourier Transform Infrared Spectroscopy

- Largely, FTIR analysis is time consuming and costly
  - μ-FTIR is used for smaller microplastic particles and requires specific set up precautions, such as specific filters and limit background interference
  - ATR may damage fragile microplastics however this method was the easiest and most efficient
    - Only for larger microplastics
- No standardization in FTIR analysis and reporting
- Polypropylene is approximately produced up to 68 million tons per year
- But this study raises the concern that only utilizing visual identification may contribute to overreporting

Limitations

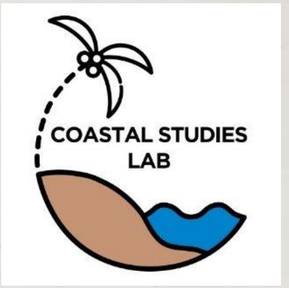
- There is limited research that has been done to examine cross shore abundance and variation of microplastic pollution
- Futures studies should include exact distance of sample locations to understand upper limit
- Study sites selected for this project all contained medium to coarse sand, future work should include ranges of sediment sizes to fully understand the relationship between mean grain size and microplastic abundance
- Including FTIR to ensure accurate reporting of microplastic abundances

Future Work

- Gearing this research towards beach management practices
- Understanding abundances in dredge or borrow material
- Accumulation of microplastics during transport to placement

Questions?

Presenter: Halaina Hahn
Email: hhahn2020@fau.edu
Charles E. Schmidt College of Science, Florida Atlantic University, Boca Raton, FL, USA
Advisor: Dr. Tiffany Roberts Briggs



References

Abelouah, M. R., Ben-Haddad, M., Rangel-Buitrago, N., Hajji, S., El Alem, N., & Ait Alla, A. (2022). Microplastics pollution along the central Atlantic coastline of Morocco. Marine Pollution Bulletin, 174, 113190.

Alberghini, L., Truant, A., Santonicola, S., Colavita, G., & Giaccone, V. (2022). Microplastics in fish and fishery products and risks for human health: A Review. International Journal of Environmental Research and Public Health, 20(1), 789.

Banik, P., Hossain, M. B., Nur, A.-A. U., Choudhury, T. R., Liba, S. I., Yu, J., Noman, Md. A., & Sun, J. (2022). Microplastics in sediment of Kuakata Beach, Bangladesh: Occurrence, spatial distribution, and risk assessment. Frontiers in Marine Science, 9.

Besley, A., Vijver, M. G., Behrens, P., & Bosker, T. (2017). A standardized method for sampling and extraction methods for quantifying microplastics in beach sand. Marine Pollution Bulletin, 114(1), 77–83.

Bosker, T., Guaita, L., & Behrens, P. (2018). Microplastic pollution on Caribbean beaches in the lesser antilles. Marine Pollution Bulletin, 133, 442–447.

Cole, M., Lindeque, P., Halsband, C., & Galloway, T. S. (2011). Microplastics as contaminants in the marine environment: A Review. Marine Pollution Bulletin, 62(12), 2588–2597.

Fadare, O., Wan, B., Guo, L., Zhao, L. (2020). Microplastics from consumer plastic food containers: are we consuming it? Chemosphere 253:126787.

Hall, N. M., Berry, K. L., Rintoul, L., & Hoogenboom, M. O. (2015). Microplastic ingestion by Scleractinian corals. Marine Biology, 162(3), 725–732.

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015). Plastic waste inputs from land into the Ocean. Science, 347(6223), 768–771.

Lindwall, C., (2020) Single-Use Plastics 101 [WWW Document]. Natural Resources Defense Council.

Lots, F. A. E., Behrens, P., Vijver, M. G., Horton, A. A., & Bosker, T. (2017). A large-scale investigation of microplastic contamination: Abundance and characteristics of microplastics in European beach sediment. Marine Pollution Bulletin, 123(1–2), 219–226.

Luan, J., & Wang, Y.-H. (2024). Abundance, morphology, spatial-temporal distribution and sources of microplastics in Shilaoren Beach, Qingdao, China. Regional Studies in Marine Science, 71, 103422.

Mathalon, A., & Hill, P. (2014). Microplastic fibers in the intertidal ecosystem surrounding Halifax Harbor, nova scotia. Marine Pollution Bulletin, 81(1), 69–79.

MERI Marine and Environment Research Institute. (2020). Guide to Microplastics Identification. Blue Hill (ME): Center for Environmental Studies.

Nguyen, N. T., Nhon, N. T., Hai, H. T., Chi, N. D., & Hien, T. T. (2022). Characteristics of microplastics and their affiliated pahs in surface water in Ho Chi Minh City, Vietnam. Polymers, 14(12), 2450.

O'Brien, K. (2023) Microplastics in Mangrove and Beach Sediments on Southeast Florida Barrier Islands.

Osman, A. I., Elgarahy, A. M., Mehta, N., Al-Muhtaseb, A. H., Al-Fatesh, A. S., & Rooney, D. W. (2022). Facile synthesis and life cycle assessment of highly active magnetic sorbent composite derived from mixed plastic and biomass waste for water remediation. ACS Sustainable Chemistry & Engineering, 10(37), 12433–12447.

Prata, J. C., da Costa, J. P., Lopes, I., Duarte, A. C., & Rocha-Santos, T. (2020). Environmental exposure to microplastics: An overview on possible human health effects. Science of The Total Environment, 702, 134455.

Praveena, S. M., Ahmad Pakharuddin, N. A., Nafisyah, A. L., Karuppannan, S., & Sundaramanickam, A. (2025). Baseline assessment of microplastics pollution in beach sediments along tropical coastline (Kuala Langat, Malaysia). Marine Pollution Bulletin, 216, 117938.

Rodrigues, C., Rodríguez, Y., Frias, J., Carriço, R., Sobral, P., Antunes, J., Duncan, E. M., & Pham, C. K. (2024). Microplastics in beach sediments of the Azores Archipelago, Ne Atlantic. Marine Pollution Bulletin, 201, 116243.

Suaria, G., & Aliani, S. (2014). Floating debris in the Mediterranean Sea. Marine Pollution Bulletin, 86(1–2), 494–504.

Tsukada, E., Fernandes, E., Vidal, C., & Salla, R. F. (2021). Beach morphodynamics and its relationship with the deposition of plastic particles: A preliminary study in southeastern Brazil. Marine Pollution Bulletin, 172, 112809.

Turner, A., Fenn, O., & Walklett, E. (2025) 'Relationships between sediment size distribution and microplastic abundance and characteristics along the strandline of a sandy embayment (Whitsand, Southwest England)', Marine Pollution Bulletin, 213.

Ugwu, K., Herrera, A., & Gómez, M. (2021). Microplastics in marine biota: A Review. Marine Pollution Bulletin, 169, 112540.

Vermeiren, P., Lercari, D., Muñoz, C. C., Ikejima, K., Celentano, E., Jorge-Romero, G., & Defeo, O. (2021). Sediment grain size determines microplastic exposure landscapes for Sandy Beach Macroinfauna. Environmental Pollution, 286, 117308.

Woodall, L., Gwinnett, C., Packer, M., Thompson, R., Robinson, L., Paterson, G. (2015). Using a forensic science approach to minimize environmental contamination and to identify microfibers in marine sediments. Marine Pollution Bulletin,

Zahari, N. Z., Vincent, S. D., Cleophas, F. N., Budin, K., & Sabullah, M. K. (2023). Abundance, distribution, and characterization of microplastics on two recreational beaches in Kota Kinabalu, Sabah, Malaysia. Water, 15(15), 2681.