WRACK AND RUIN:

Characterizing Plastic and Microplastic Occurrences on Southeastern Lake Michigan Beaches

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Goal

Characterize beach litter (> 1 mm) and microplastic (< 1 mm) occurrences in southeastern Lake Michigan

1. First step to identifying sources
2. Plastic litter has been shown to vary along shorelines of Lakes Huron, Erie, and Ontario (Zbyszewski et al., 2014)
3. May help assess multiple hypothesized sources of microplastic

Sampling protocol

For plastic litter, followed Zbyszewski et al., 2014

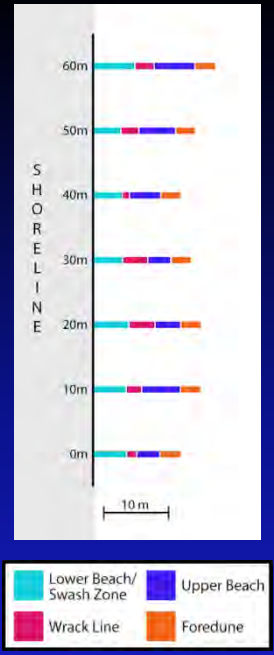
- 7 transect lines perpendicular to beach
- 1 m wide, 10 m spacing

For microplastics, used metal trowel to gather ≈ top 5 cm

- Collected ≈ 0.5 liter samples in glass jars

Besley et al. (2016) report location on a marine beach had little effect on microplastic measurements

- Litter, however, is visibly concentrated in wrack zone
- Sampled swash zone, lower beach, wrack, upper beach, and foredunes as available



Processing sediment for microplastics

Elutriation tower (after Claessens, 2013)

- water and air flow upward from bottom of column
- sand sinks through flow
- plastic recovered in sieve at top
- lower size limit = 63 µm

Processing litter

Identification as fragments, identifiable fragments, pellets, and foam after Zbyszewski et al., 2014 (very few fibers or films noted)

- Density checked by flotation

Examined 4 locations chosen for

- public vs private/degree of use
- groomed versus ungroomed

Lake Macatawa

Holland

Kalamazoo River

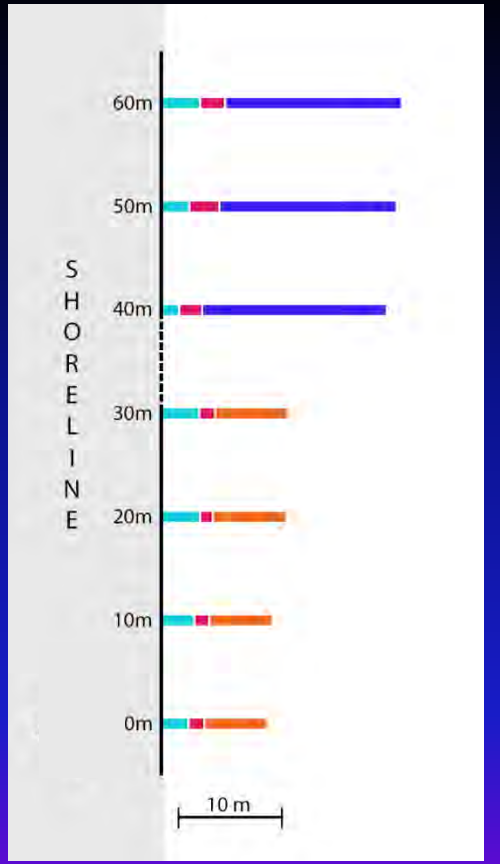
Saugatuck

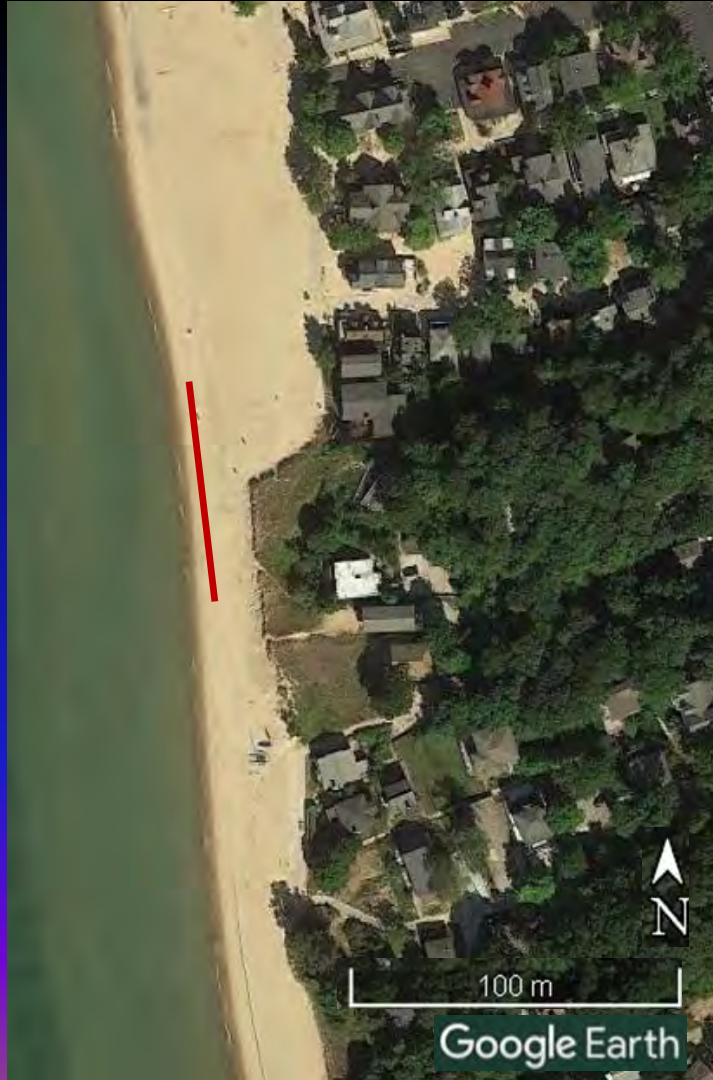
N

9 km

Macatawa Park
June 14, 2019

- Private beach
- Low visitation
- Groomed
- Narrow/wide beach
- Narrow wrack line



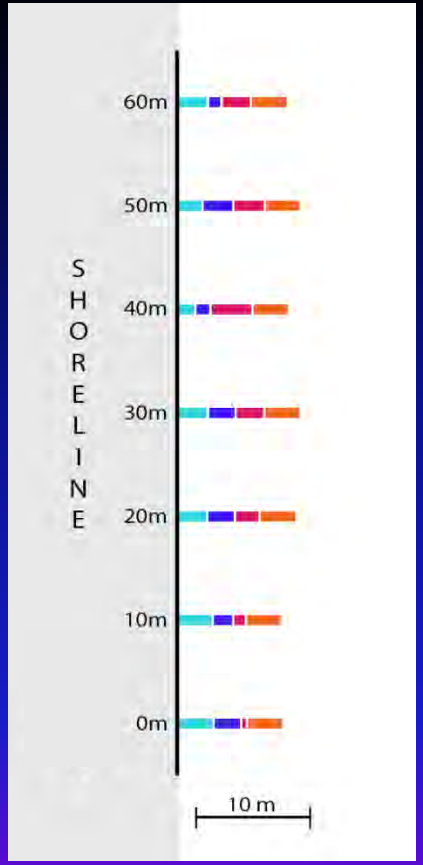


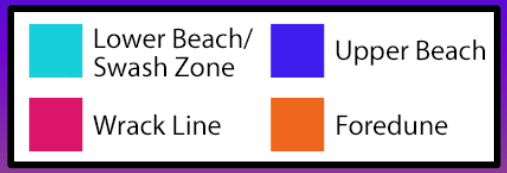

Macatawa Park
Foredunes
Upper beach
Wrack line
Lower beach

Castle Park Preserve

July 11, 2019

- Nature preserve
- Low visitation
- Not groomed
- Narrow beach
- Much wrack



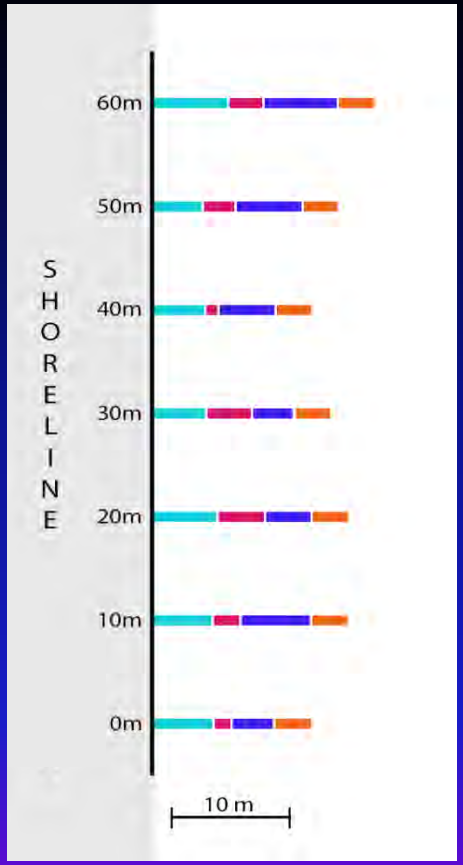


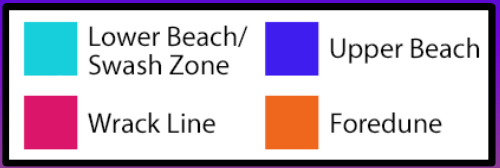

Castle Park
Foredunes
Wrack zone
Upper beach
Lower beach/ swash zone

Saugatuck Harbor Natural Area

May 21, 2019

- Nature preserve
- Low visitation
- Not groomed
- Narrow beach
- Much wrack



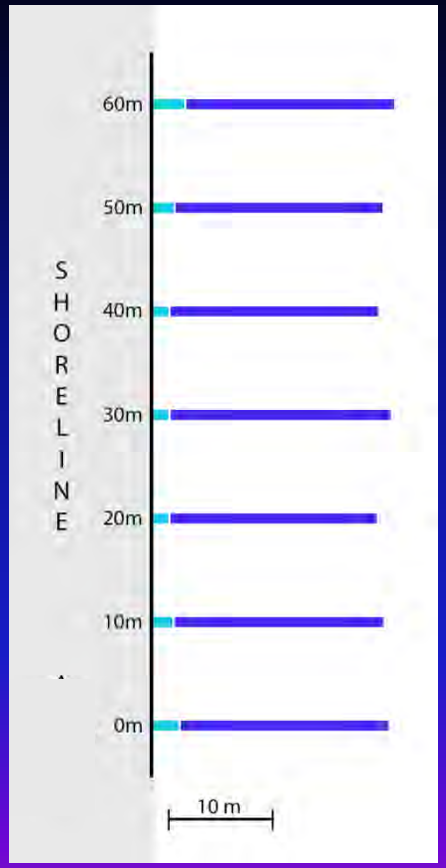


Saugatuck Harbor Natural Area

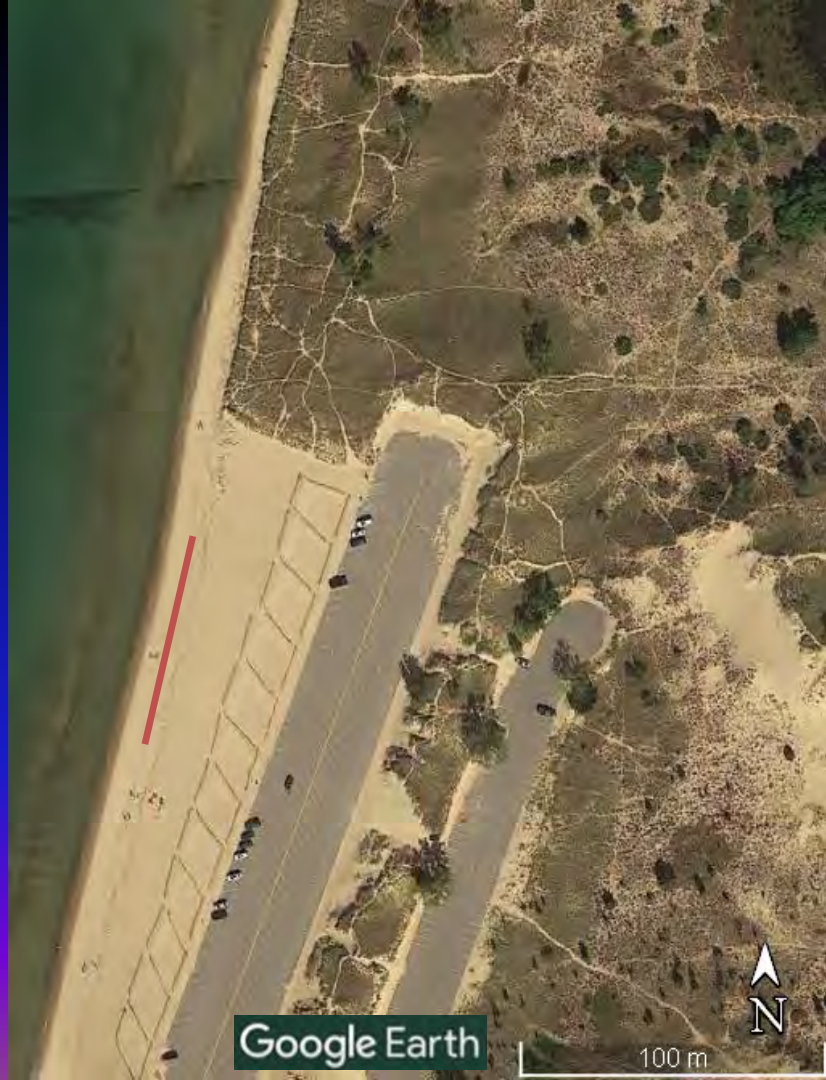
Oval Beach

June 7, 2019

- Public beach
- High visitation
- Groomed by machine twice weekly
- No wrack line



Lower Beach/ Swash Zone Upper Beach

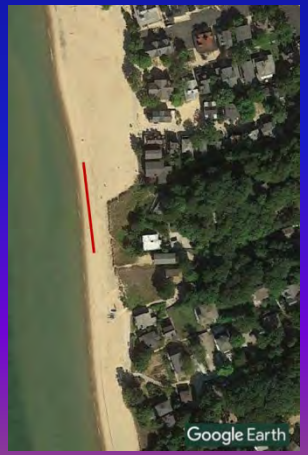


Oval Beach

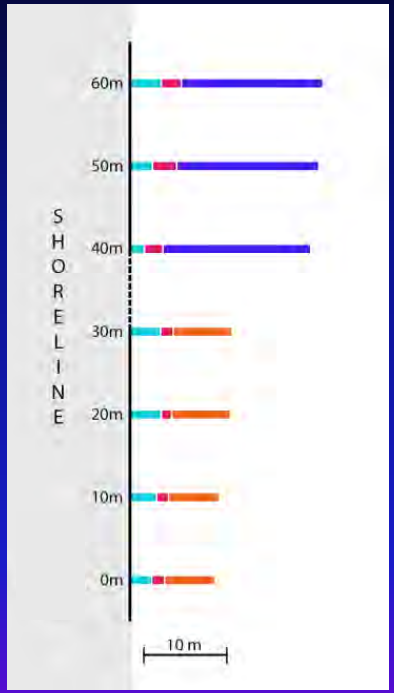
Macatawa Park

Litter (pieces/m^2)

LOCATION	LOWER BEACH (SWASH ZONE)	WRACK LINE	UPPER BEACH	FOREDUNE
60m	0.0	36.8	1.5	-
50m	0.0	34.5	0.9	-
40m	1.3	36.7	2.9	-
30m	8.3	175.3	-	1.3
20m	2.6	115.0	-	0.4
10m	0.3	20.7	-	0.3
0m	0.0	29.3	-	0.0
Average	1.8	64.0	1.7	0.5



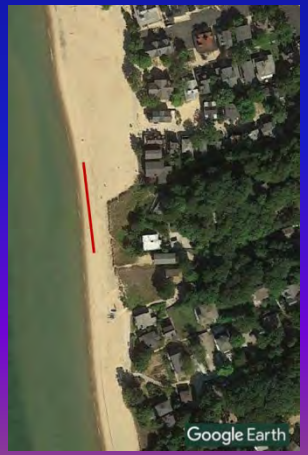
Macatawa Park
litter
30 m wrack line

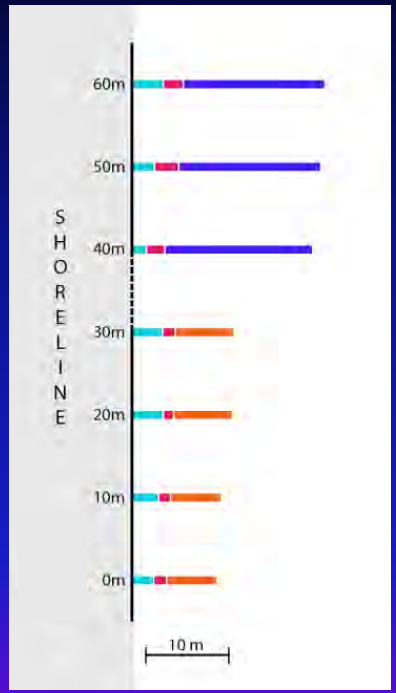


Macatawa Park

Microplastic (pieces/kg dry sand)

LOCATION	LOWER BEACH (SWASH ZONE)	RANDOM WRACK LINE	UPPER BEACH	FOREDUNE
60m	0.0	18.5	0.0	-
50m		0.8	3.2	-
40m			1.2	-
30m	0.0	19.0	-	2.8
20m	0.0	13.4	-	0.0
10m	0.0	2.8	-	5.4
0m	1.0	6.6	-	2.0
Average	0.2	6.0	1.5	2.5

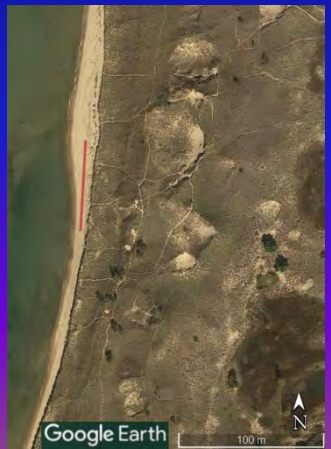


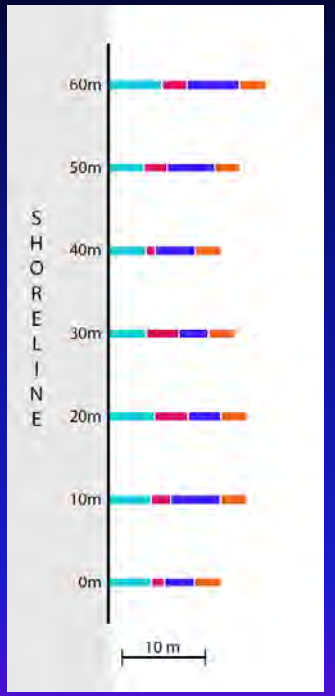


Saugatuck Harbor Natural Area

Litter (pieces/m^2)

LOCATION	LOWER BEACH	WRACK LINE	UPPER BEACH	FOREDUNE
60m	2.1	73.3	1.1	1.3
50m	5.1	80.3	2.6	1.0
40m	1.6	325.5	1.6	1.0
30m	0.0	87.7	1.1	0.3
20m	0.4	98.3	6.4	0.0
10m	1.6	123.8	8.8	1.3
0m	2.6	112.4	1.1	3.0
AVERAGE	1.9	128.7	3.3	1.1



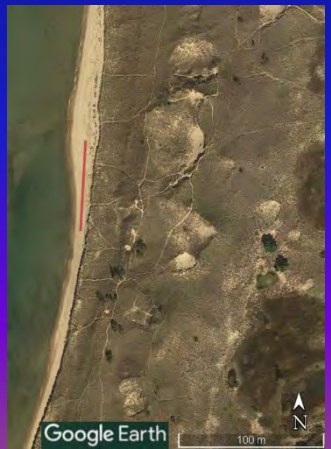


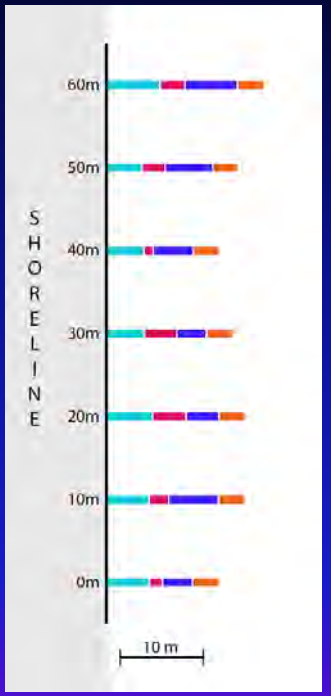
Lower Beach/ Swash Zone
Upper Beach
Wrack Line
Foredune

Saugatuck Harbor Natural Area

Microplastic (pieces/kg dry sand)

LOCATION	LOWER BEACH	WRACK LINE		UPPER BEACH	FOREDUNE
		RANDOM	SELECTED		
60m	1.3				
50m	2.3		55.8		
40m			94.6	4.7	
30m	4.1	76.9	351.9	1.8	14.4
20m	0.0	9.3	71.8	4.9	0.0
10m	1.3	9.6	85.5	12.2	
0m	2.4		87.1	2.1	
AVERAGE	1.9	31.9	124.4	5.1	7.2





Lower Beach/ Swash Zone
Upper Beach
Wrack Line
Foredune

Average litter and microplastic abundance across depositional settings

Litter (pieces/m^2)

	SWASH ZONE/LOWER BEACH		WRACK LINE	UPPER BEACH	FOREDUNE
MACATAWA PARK	1.8		64.0	1.7	0.5
CASTLE PARK	0	1.6	79.8	-	21.7
SAUGATUCK HARBOR	0	1.9	128.7	3.3	1.1
OVAL BEACH	0.05	0	-	3.9	-

Microplastic (pieces/kg sand)

	SWASH ZONE/LOWER BEACH		WRACK LINE		UPPER BEACH	FOREDUNE
			RANDOM	SELECTED		
MACATAWA PARK	0.2		6.0	-	1.5	2.5
SAUGATUCK HARBOR	1.9		31.9	124.4	5.1	7.2
OVAL BEACH	0.2	10.0	-	-		1.6

Wrack may be an **indicator**

- marks depositional areas along shoreline

Wrack may be a **facilitator**

- baffling may allow microplastic to accumulate, and then accumulate sand to bury it

Relative abundance of litter components

		STYROFOAM	PELLETS	FRAGMENTS	IDENTIFIABLE FRAGMENTS	TOTAL
MACATAWA PARK	Count	89	88	717	29	923
	%	9.6%	9.5%	77.7%	3.1%	
CASTLE PARK	Count	424	42	42	13	521
	%	81.4%	8.1%	8.1%	2.5%	
SAUGATUCK HARBOR	Count	1182	952	1813	305	4252
	%	27.8%	22.4%	42.6%	7.2%	
OVAL BEACH	Count	180	139	197	39	555
	%	32.4%	25.0%	35.5%	7.0%	

Dominant type of litter varies between sites

Relative abundance of microplastic components

		STYROFOAM	PELLETS	FRAGMENTS	TOTAL
MACATAWA PARK	Count	144	24	488	656
	%	22.0%	3.7%	74.7%	
SAUGATUCK HARBOR	Count	516	183	107	806
	%	64.0%	22.7%	13.3%	
OVAL BEACH	Count	5	1	10	16
	%	31.3%	6.3%	62.5%	

Dominant type of microplastic also varies between sites

Comparison of litter (blue) and microplastic (orange) abundance

		STYROFOAM	PELLETS	FRAGMENTS
MACATAWA PARK	Count	89	88	717
	%	9.6%	9.5%	77.7%
MACATAWA PARK	Count	144	24	488
	%	22.0%	3.7%	74.7%
SAUGATUCK HARBOR	Count	1182	952	1813
	%	27.8%	22.4%	42.6%
SAUGATUCK HARBOR	Count	516	183	107
	%	64.0%	22.7%	13.3%
OVAL BEACH	Count	180	139	197
	%	32.4%	25.0%	35.5%
OVAL BEACH	Count	5	1	10
	%	31.3%	6.3%	62.5%

Microplastic abundance doesn't always track litter abundance

Litter specific gravity

	Total litter	Density >1	% with density >1
Macatawa Park	923	4	0.4%
Oval Beach	555	15	2.7%

Vast majority of both litter and microplastic pieces float in water

Conclusions

Goal : Characterize beach litter and microplastic in SE Lake Michigan

1. The great majority of both litter and microplastic accumulates at the wrack line
2. Microplastic does not always mirror most abundant litter type at a site
3. Groomed beaches have less litter and microplastic than the sampled natural beaches

Additional observations

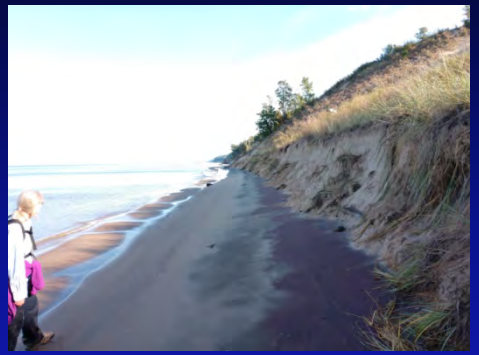
1. Floating is most likely mechanism for transport to beach since >95% of pieces have a density less than 1
2. Coordinated collecting of multiple sites or long term monitoring of a single site may be needed to properly compare sites and understand site variability
3. Haven’t yet linked specific litter to specific microplastics

4. We are trying to apply a standardized collection method to sites that aren't standard

E.g., no wrack zone in this erosional area

Magnetite and garnet sand indicate 7 episodes of varying conditions of sediment transport

Variability of the shoreline, not variability of our particular results, is the big story.
We need to learn how to compare sites in changeable settings.




Acknowledgments

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Literature cited

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