The role of environmental factors on retention of microplastic in streams

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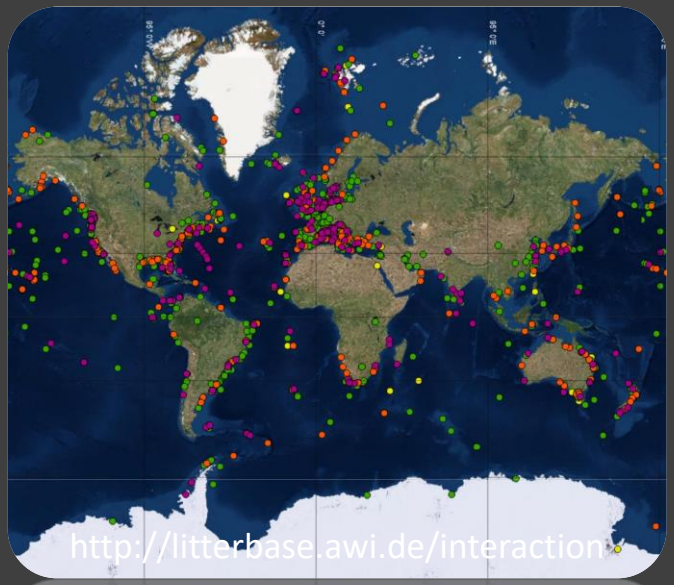
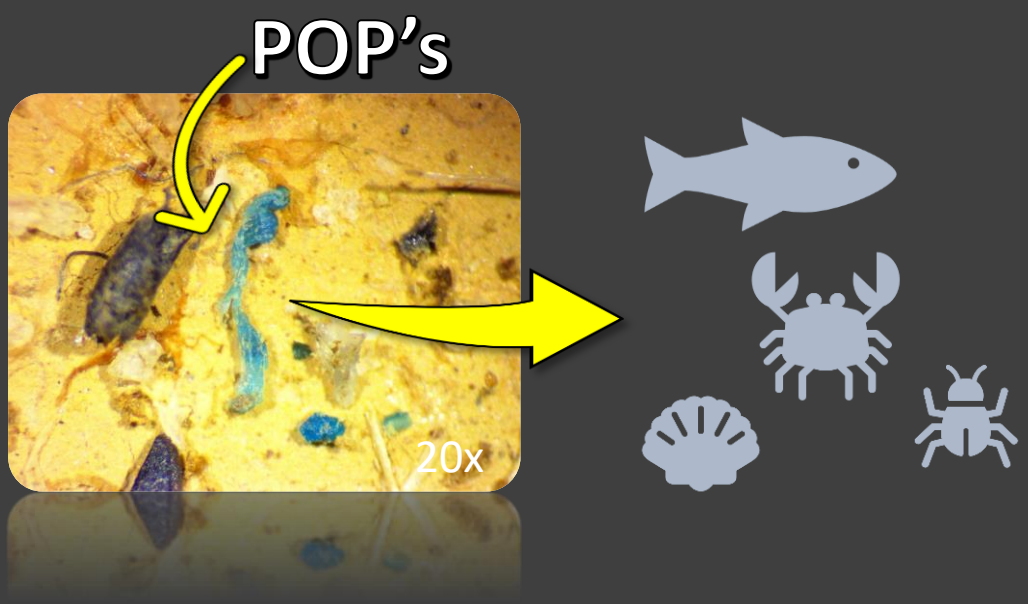
Microplastics are…

- Plastic pieces < 5 mm
- A global emerging pollutant of concern
- Adsorbing harmful chemicals
- Entering food webs
- Persistent in the environment





Microplastic sources

- Breakdown from larger litter
- Terrestrial runoff
- Domestic waste water
  - Fibers from clothing
  - Personal care products
  - Not fully removed by treatment
- Rivers to downstream ecosystems?


archipelago.gr


Consumerreports.org


Huffington Post

Objective: understand the **transport and fate of plastics** in streams to provide clues on **how best to remove microplastics** and **minimize their input** into the environment

Experimental Study @ ND-LEEF

Notre Dame Linked Experimental Ecosystem Facility

Morrison Family Pavilion

Mesocosm Pad

Supply Reservoir

Current Watersheds (1-2)

Terrestrial Research Area

Stream

Pond

Wetland

Laboratory

ND-LEEF

Field

Research Questions

How does retention of microplastics change under different environmental conditions?

And

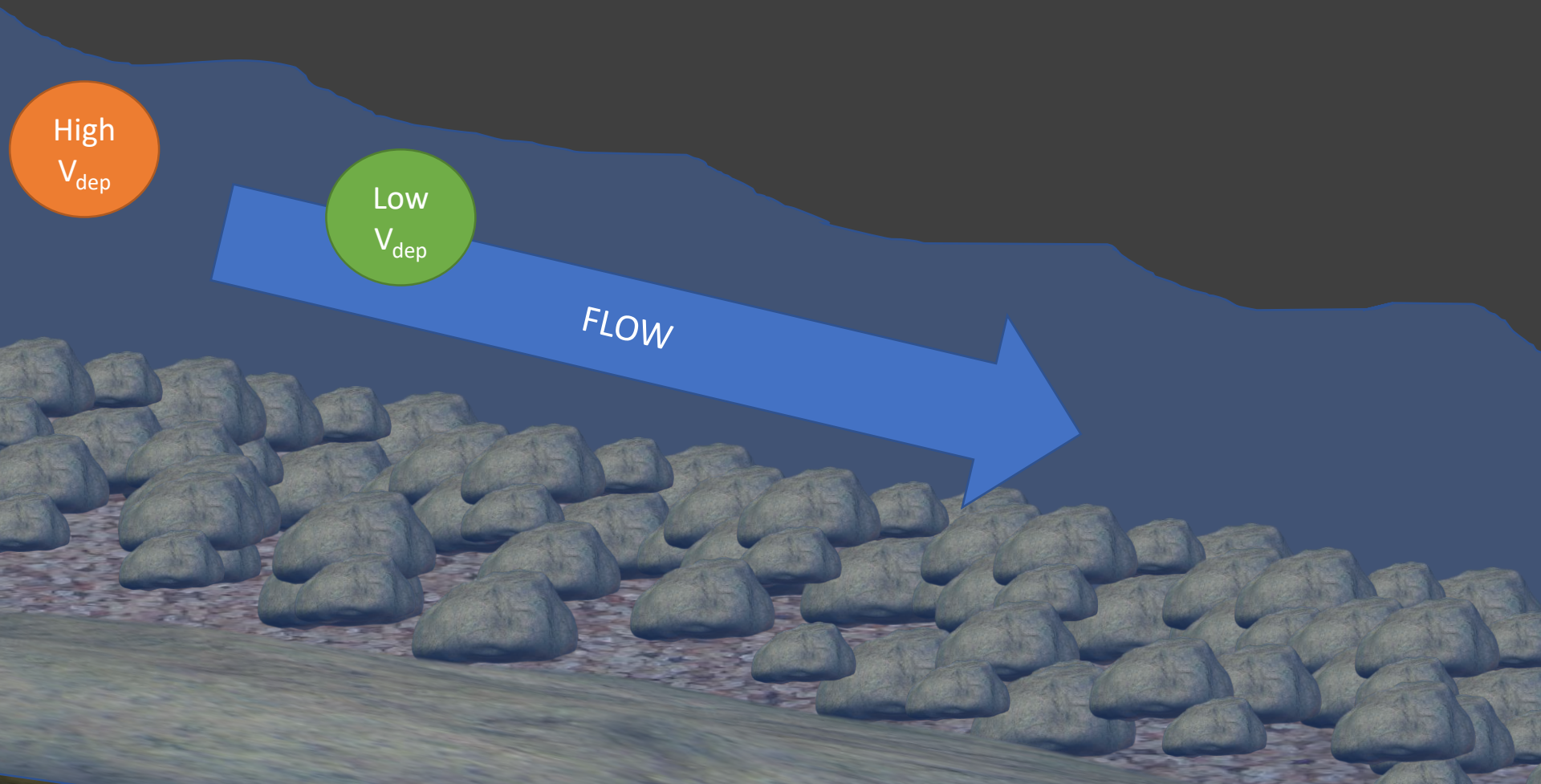
What is the depositional velocity of microplastics?

Depositional Velocity

the speed at which a particle is being deposited in a stream (length/time)

Low V_{dep} = low retention

High V_{dep} = high retention



Foundational Stream Ecology

- Allochthonous (i.e. things from outside the stream) materials travel and are retained in streams at different rates.
- We used spiraling metrics designed for measuring organic matter retention and transport.

Table 8 Summary of the transport and breakdown of organic particles in a typical second-order Coweeta stream. This hypothetical stream reach is located 1000 m below the headwaters. It has a discharge of 20 L s^{-1}, an average depth of 10 cm and a velocity of 40 cm s^{-1} (Webster *et al.*, 1994; Wallace *et al.*, 1995a)

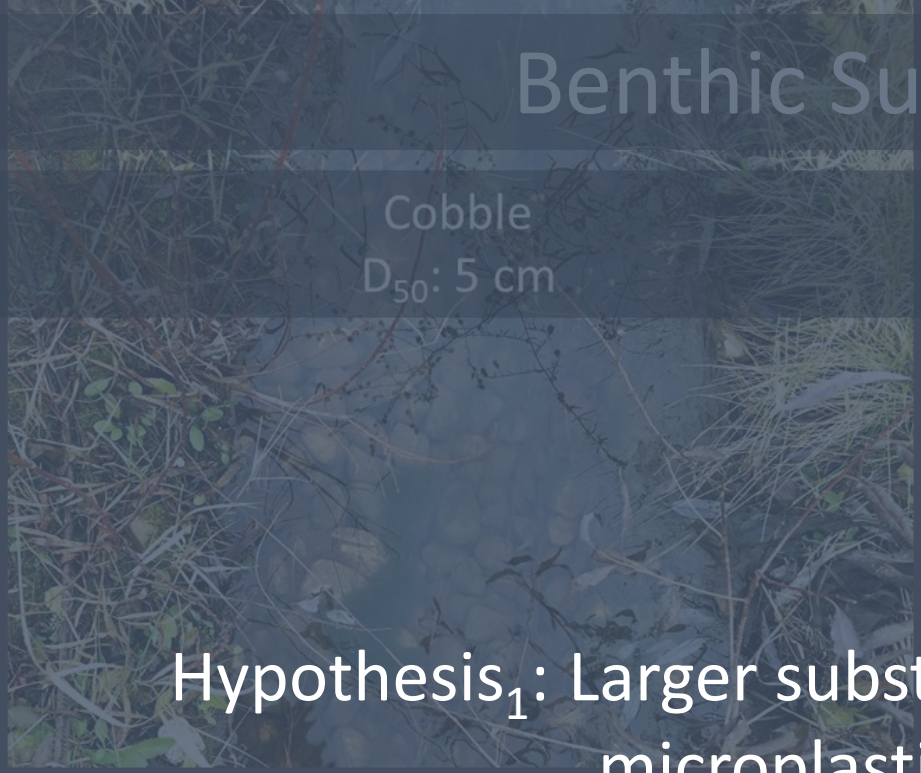
Factor	Sticks	Leaves	FPOM
Breakdown rate (k, day^{-1})	0.00050	0.0098	0.00104
Biological turnover time ($T_b = 1/k$, years)	5.5	0.28	2.6
Transport distance (S_w, m)	1.30[a]	1.56[a]	34.5[b]
Deposition velocity (V_{dep}, cm s^{-1})	3.08	2.56	0.116
Water column concentration (mg L^{-1})	–	0.07[c]	2.0[d]
Deposition flux (mg m^{-1} s^{-1})	0.20	1.79	2.32
Benthic standing crop (C_b, g m^{-2})[e]	306.0	228.5	156.5
Transport turnover time (T_t, h)	422	35.6	18.7
Transport rate (k', day^{-1})	0.057	0.674	1.28
Downstream velocity (V_p, m day^{-1})	0.074[f]	1.06	44.1
Particle turnover length (S_p, m)	148	108	42400

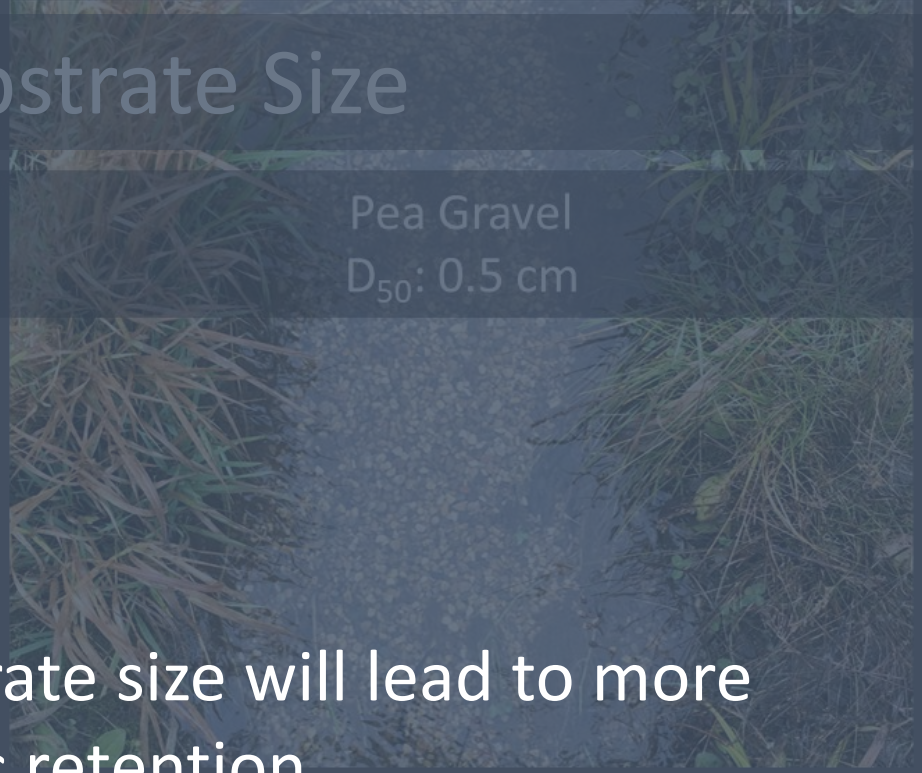
Webster et al. 1999

How do changes in **benthic substrate size, discharge, and benthic biofilm colonization** affect **retention** of microplastics?

Goal: understand factors that drive retention of microplastics in streams, facilitating models that can be scaled-up to larger spatial areas

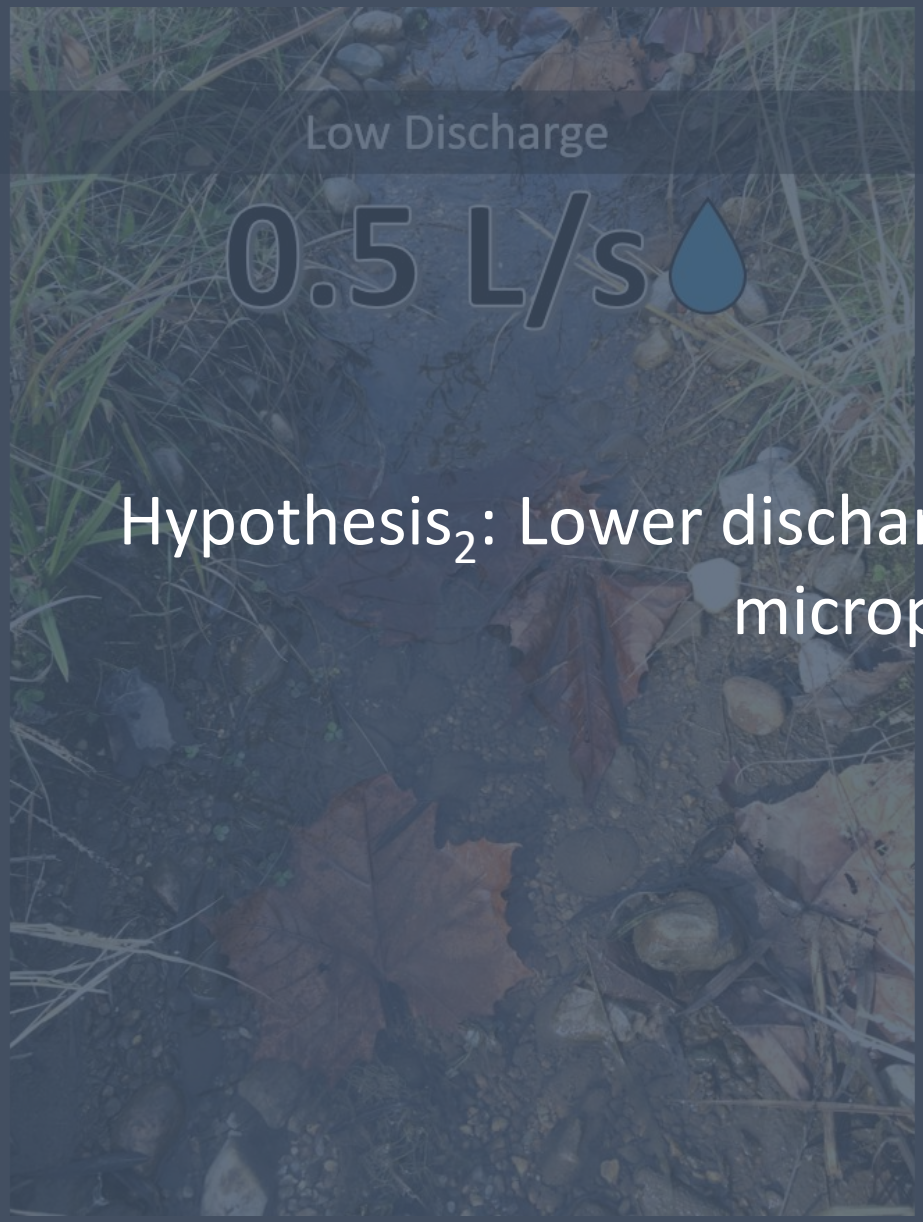
Benthic Substrate Size

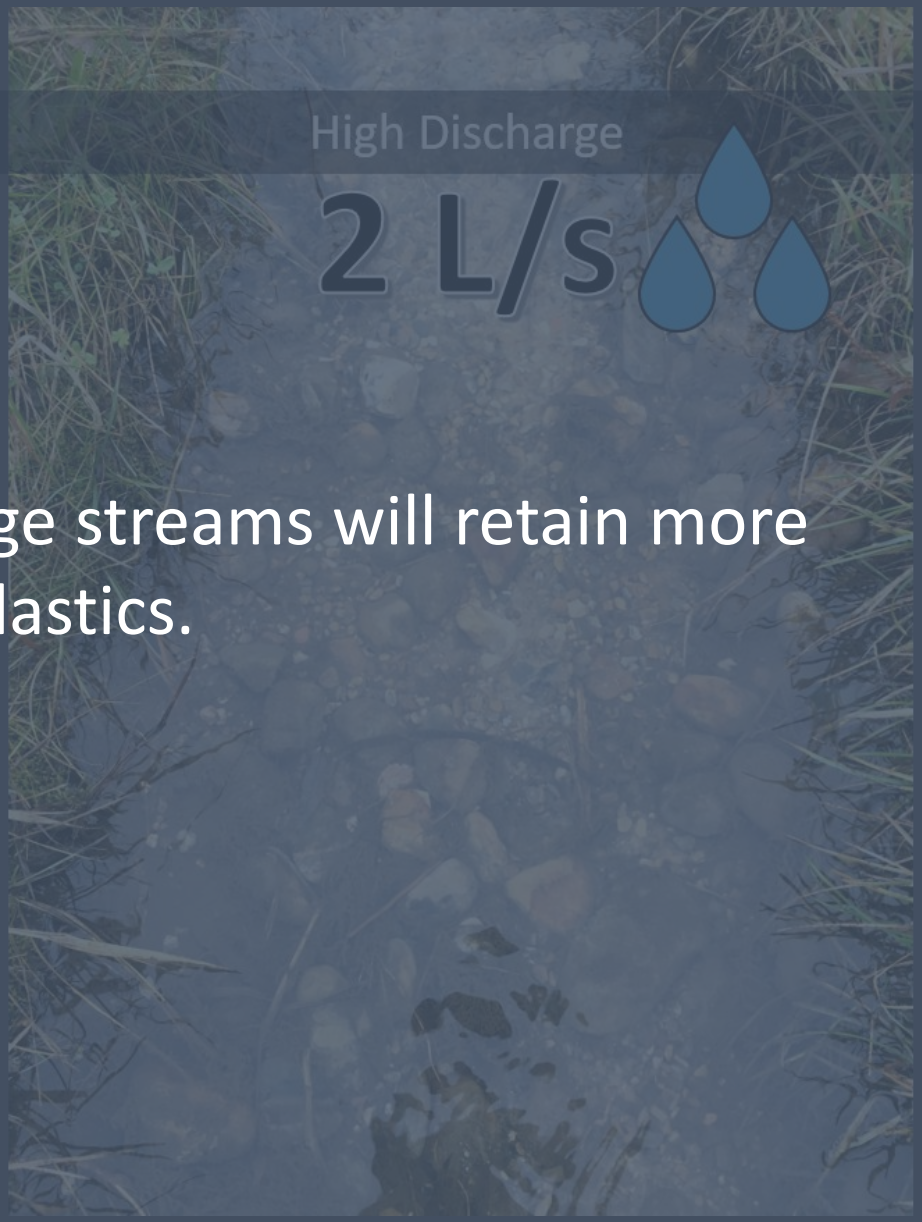




Hypothesis$_1$: Larger substrate size will lead to more microplastic retention.

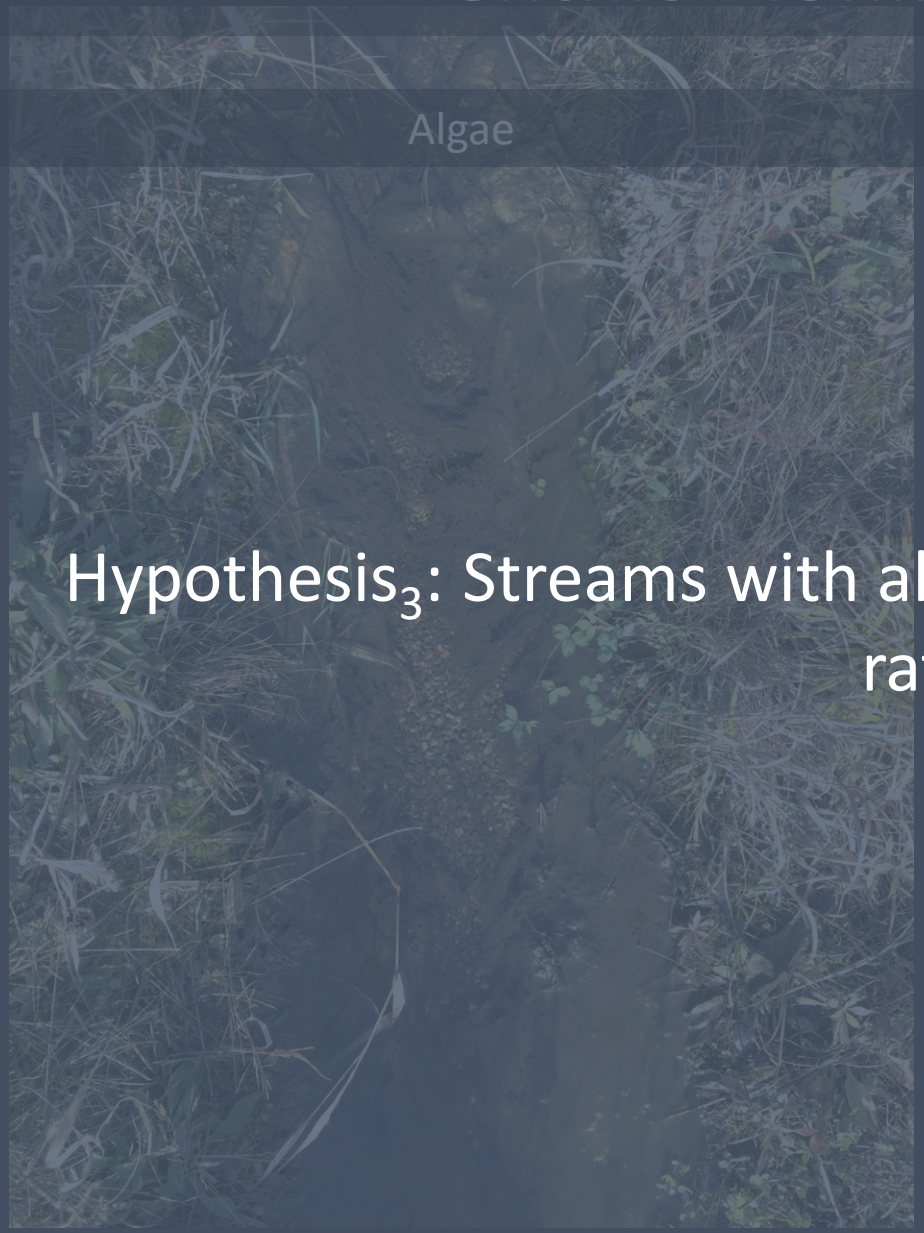
Discharge

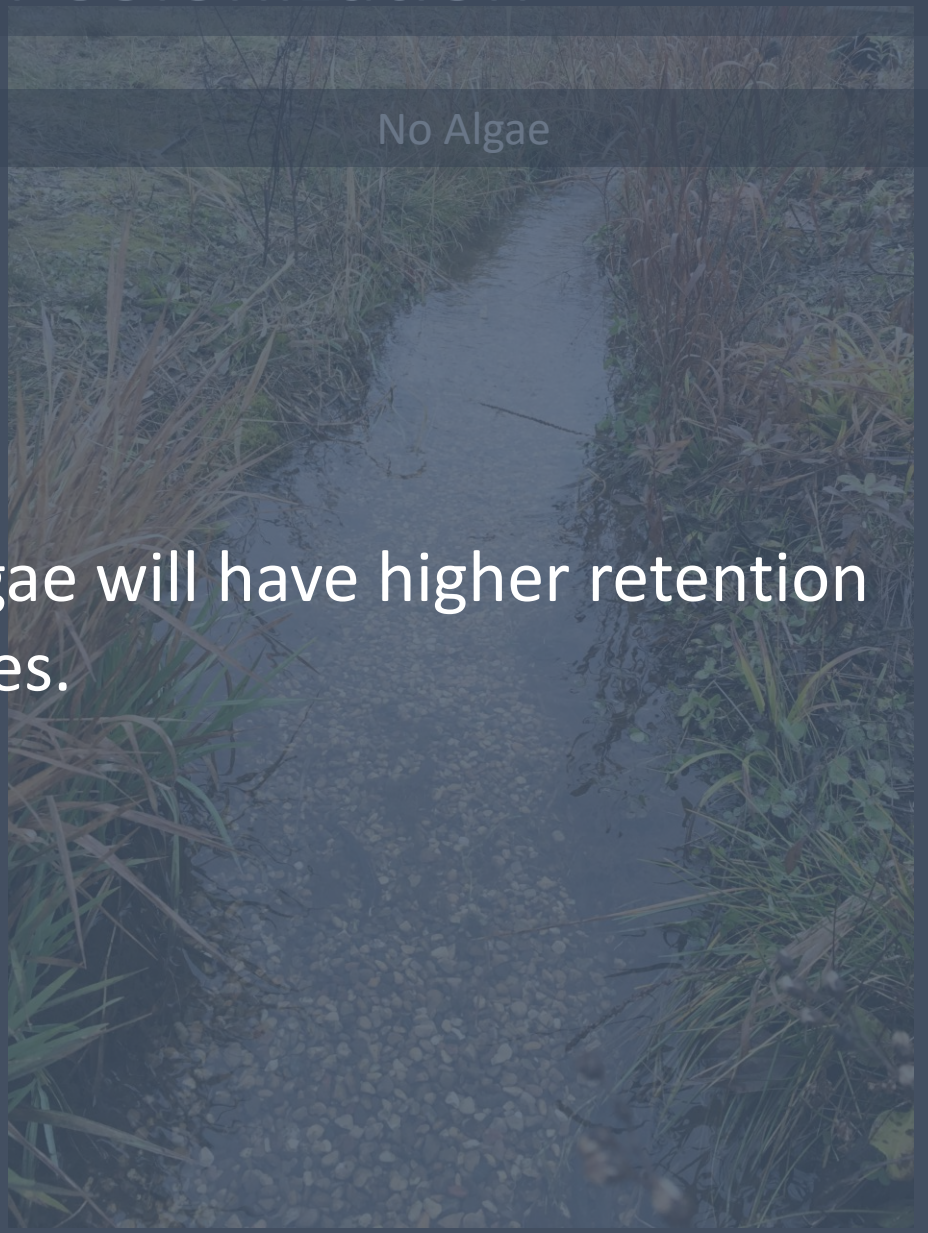




Hypothesis$_2$: Lower discharge streams will retain more microplastics.

Benthic Biofilm Colonization



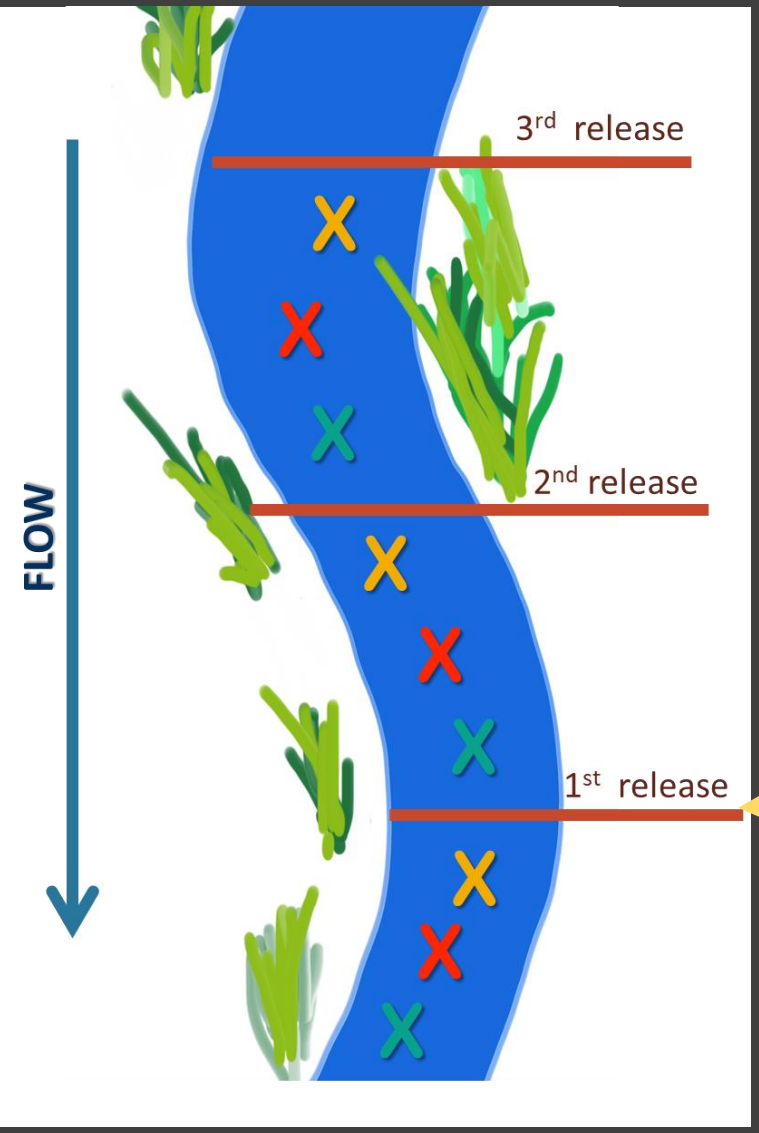


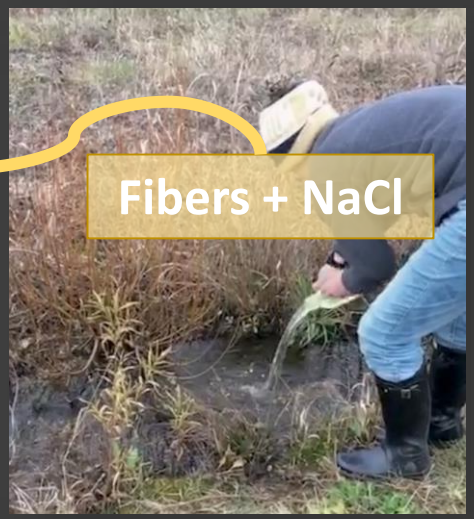
Hypothesis$_3$: Streams with algae will have higher retention rates.

How do changes in **benthic substrate size, discharge, and benthic biofilm colonization** affect **retention** of microplastics?

Methods

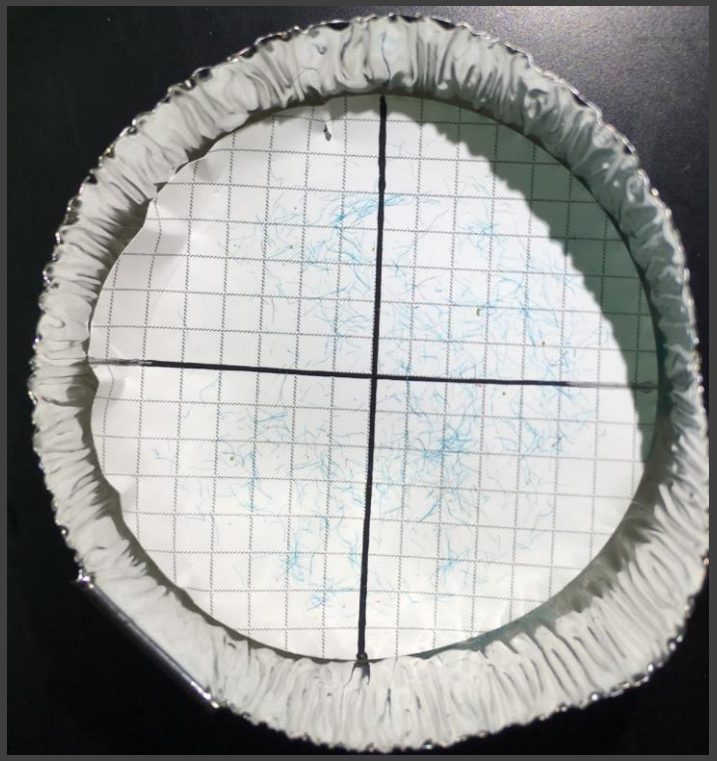
Methods



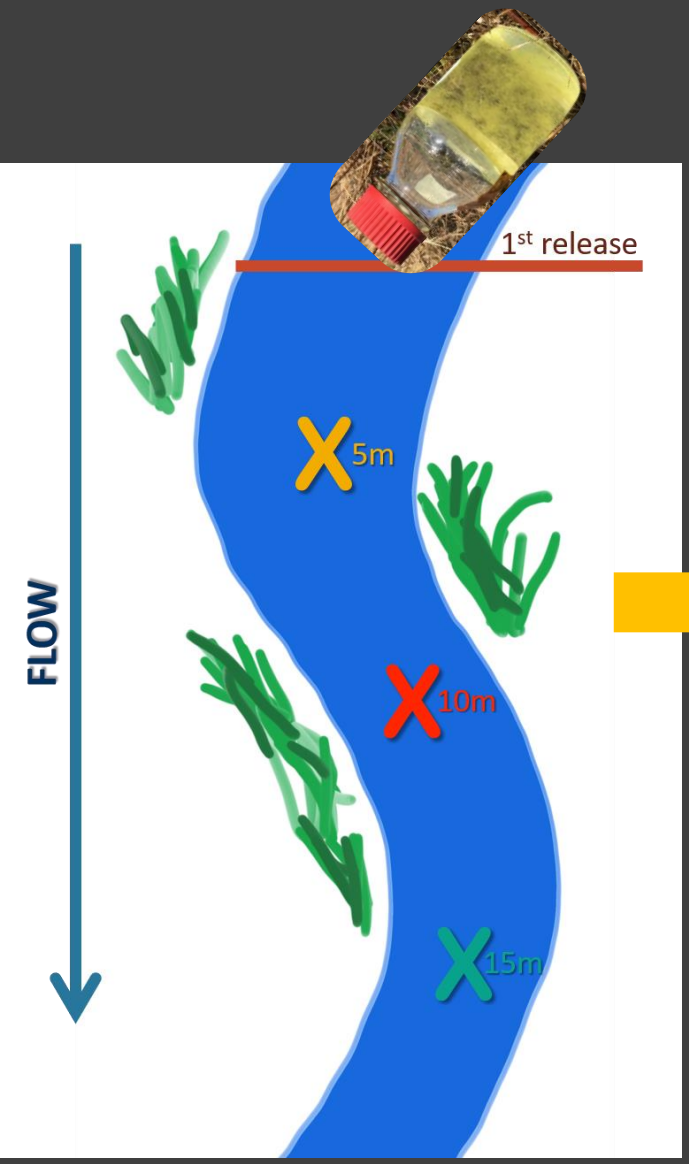


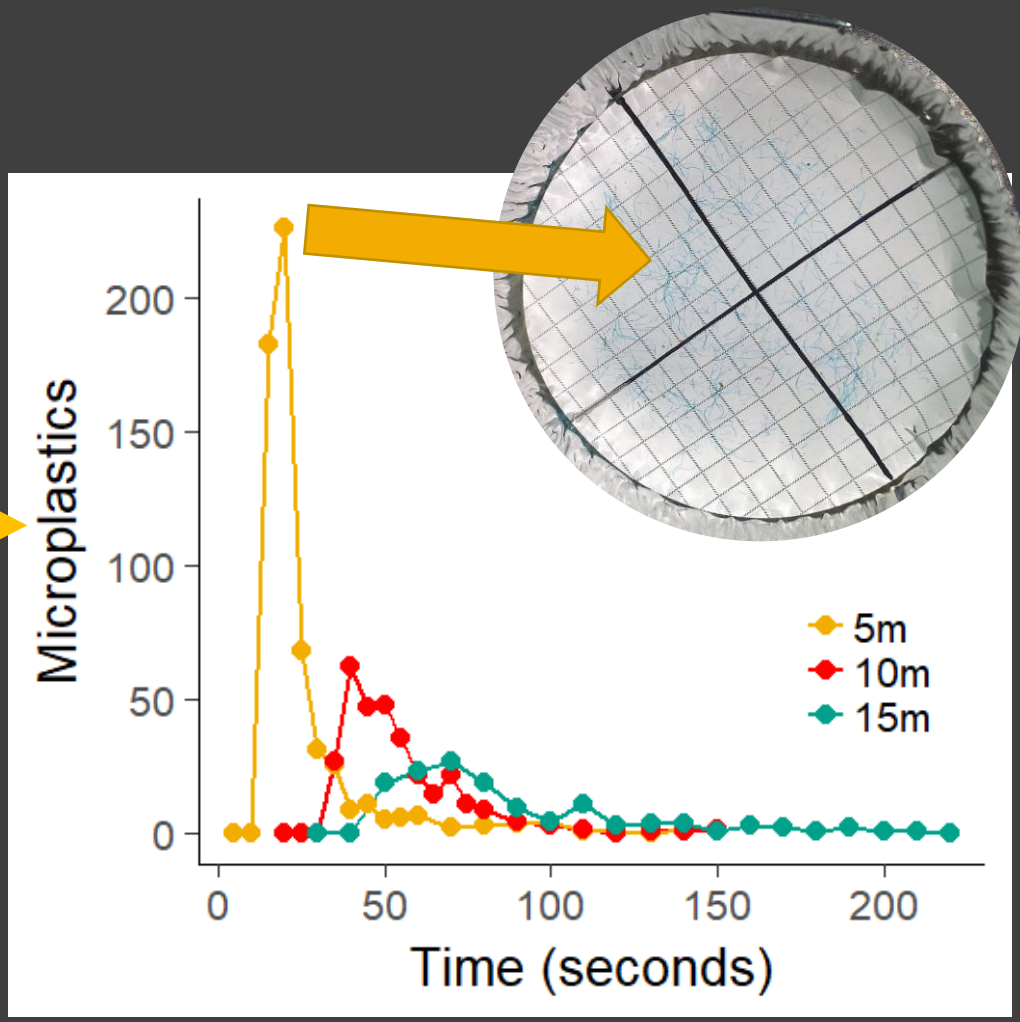
- Released at 3 sites per stream
- Collected at 3 locations per release site
- Timed collection intervals
- 20 sample cups per collection location (X's)

Over 2100 sample containers!!



Calculations





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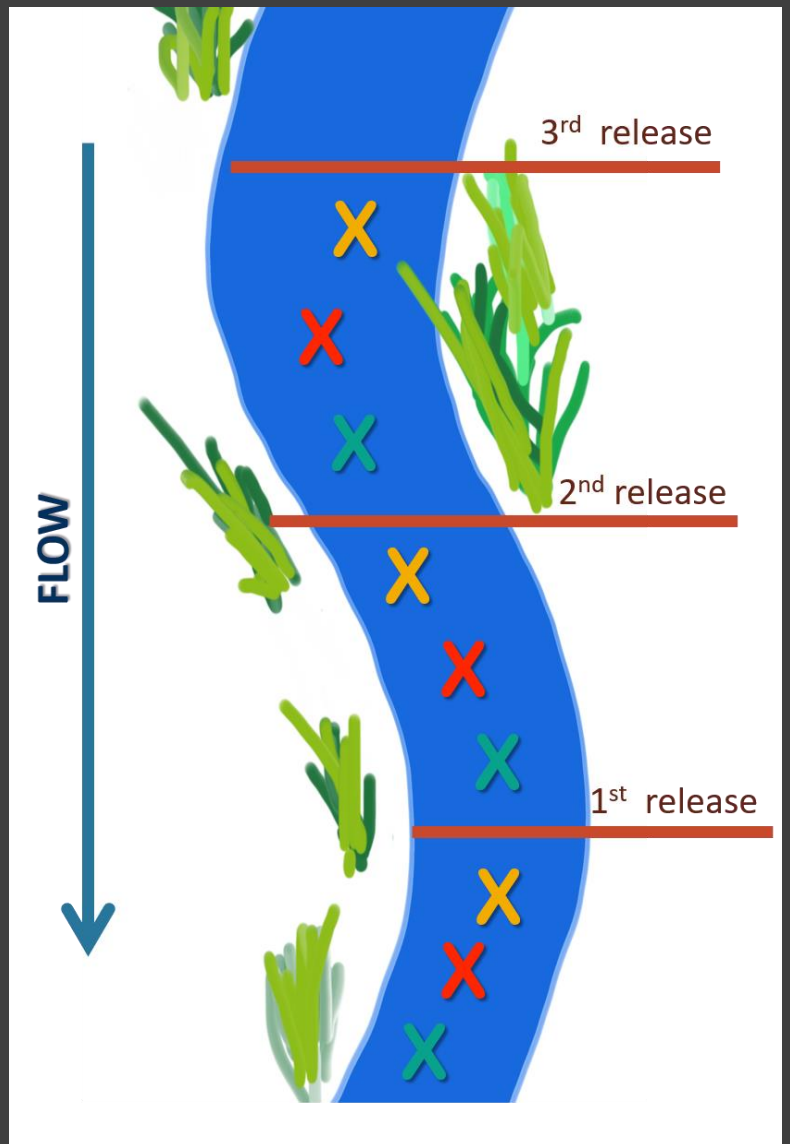
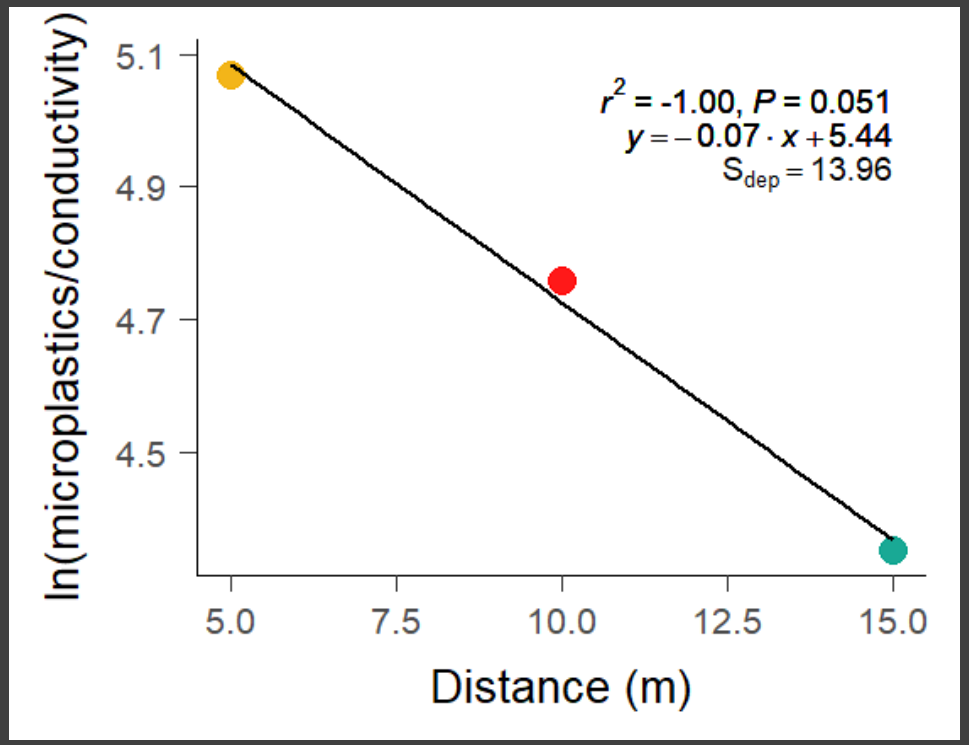




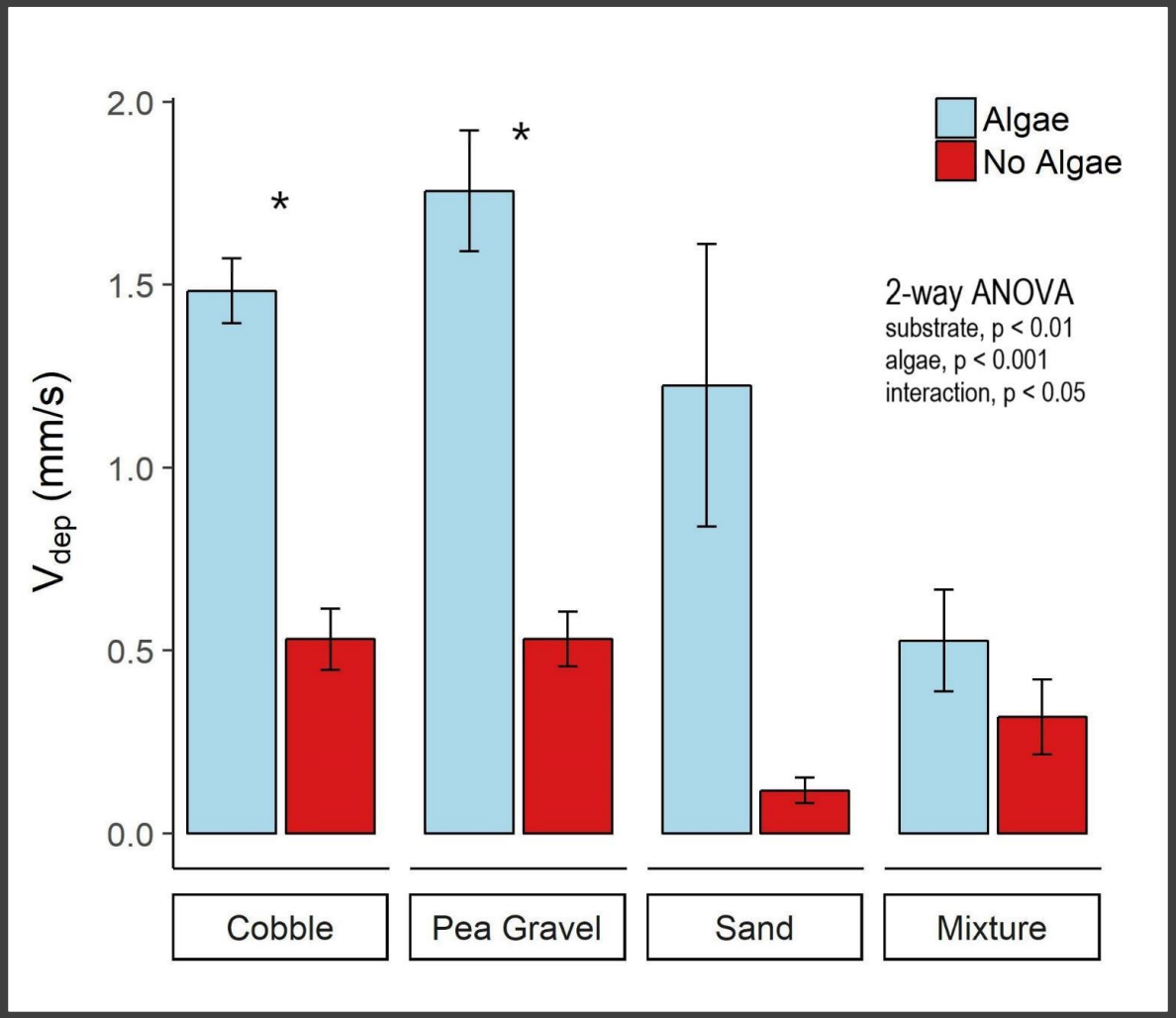
Formula

$$S_{dep} = -\left({}^{1}/_{k}\right)$$

$$z \times V_W \Big/ S_{dep} = V_{dep}$$

z = stream depth
V_W = stream velocity

Preliminary Results



- V_{dep} was ~3 fold greater in cobble and pea gravel streams with extensive benthic algal colonization.
- Substrate size does not effect V_{dep}.

Impacts

- Results from these studies will aid in
  - Producing an accurate global microplastic budget
  - Revealing microplastic accumulation sites
  - Determining when microplastic is transported and when it is retained.

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Questions?