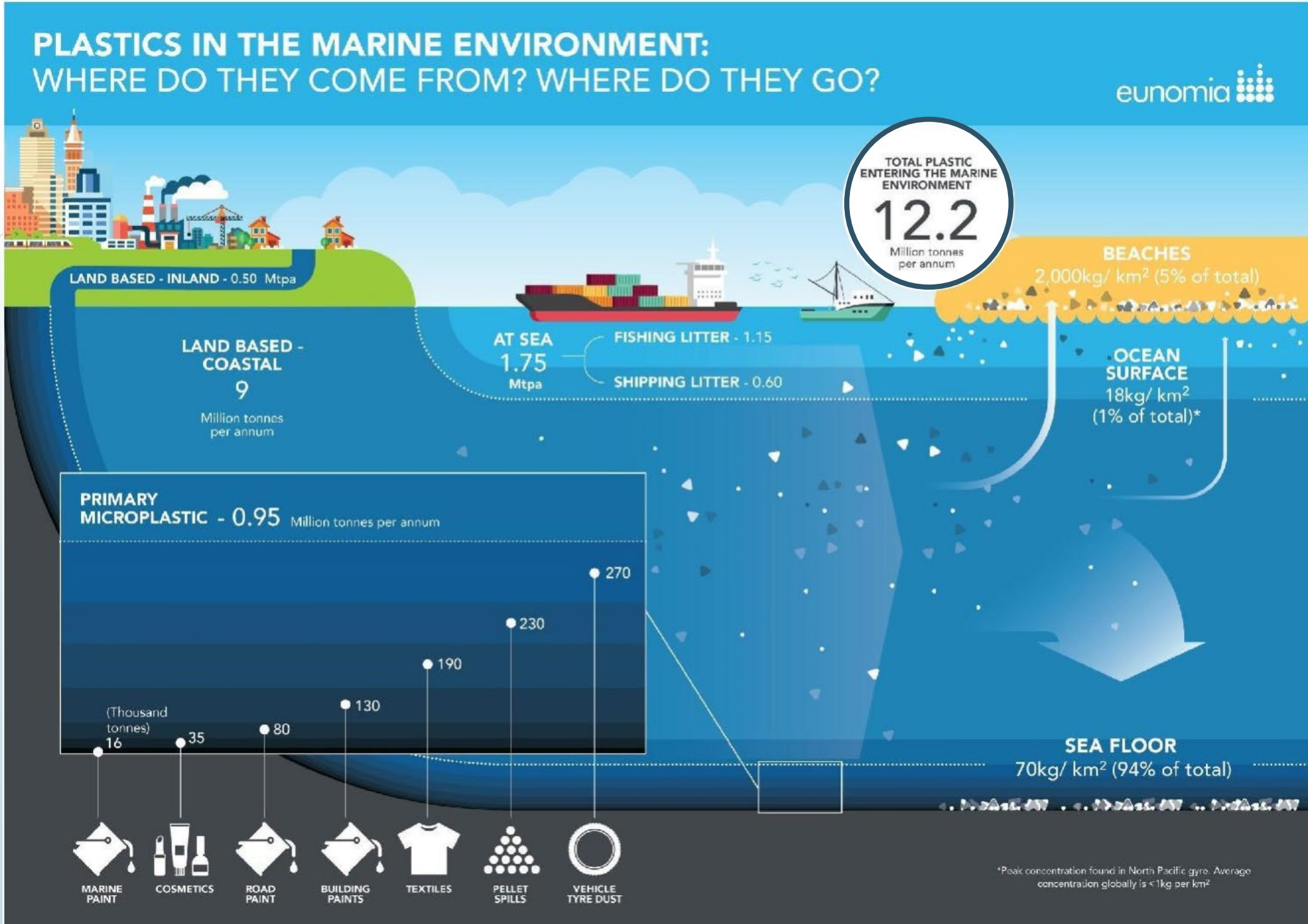
Microplastics in NELHA Waters

Romilly Benedict
George Mason University

Mentor: Pamela Madden

Organization: NELHA


PLASTICS IN THE MARINE ENVIRONMENT:
WHERE DO THEY COME FROM? WHERE DO THEY GO?
eunomia
TOTAL PLASTIC ENTERING THE MARINE ENVIRONMENT
12.2
Million tonnes per annum
LAND BASED - INLAND - 0.50 Mtpa
LAND BASED - COASTAL
9
Million tonnes per annum
AT SEA
1.75
Mtpa
FISHING LITTER - 1.15
SHIPPING LITTER - 0.60
BEACHES
2,000kg/ km² (5% of total)
OCEAN SURFACE
18kg/ km²
(1% of total)*
PRIMARY MICROPLASTIC - 0.95 Million tonnes per annum
(Thousand tonnes)
16
35
80
130
190
230
270
MARINE PAINT
COSMETICS
ROAD PAINT
BUILDING PAINTS
TEXTILES
PELLET SPILLS
VEHICLE TYRE DUST
SEA FLOOR
70kg/ km² (94% of total)
*Peak concentration found in North Pacific gyre. Average concentration globally is <1kg per km²

Microplastics

- Plastic particles between 0.3 mm – 5mm
- Microplastic particles are ubiquitous in ocean waters

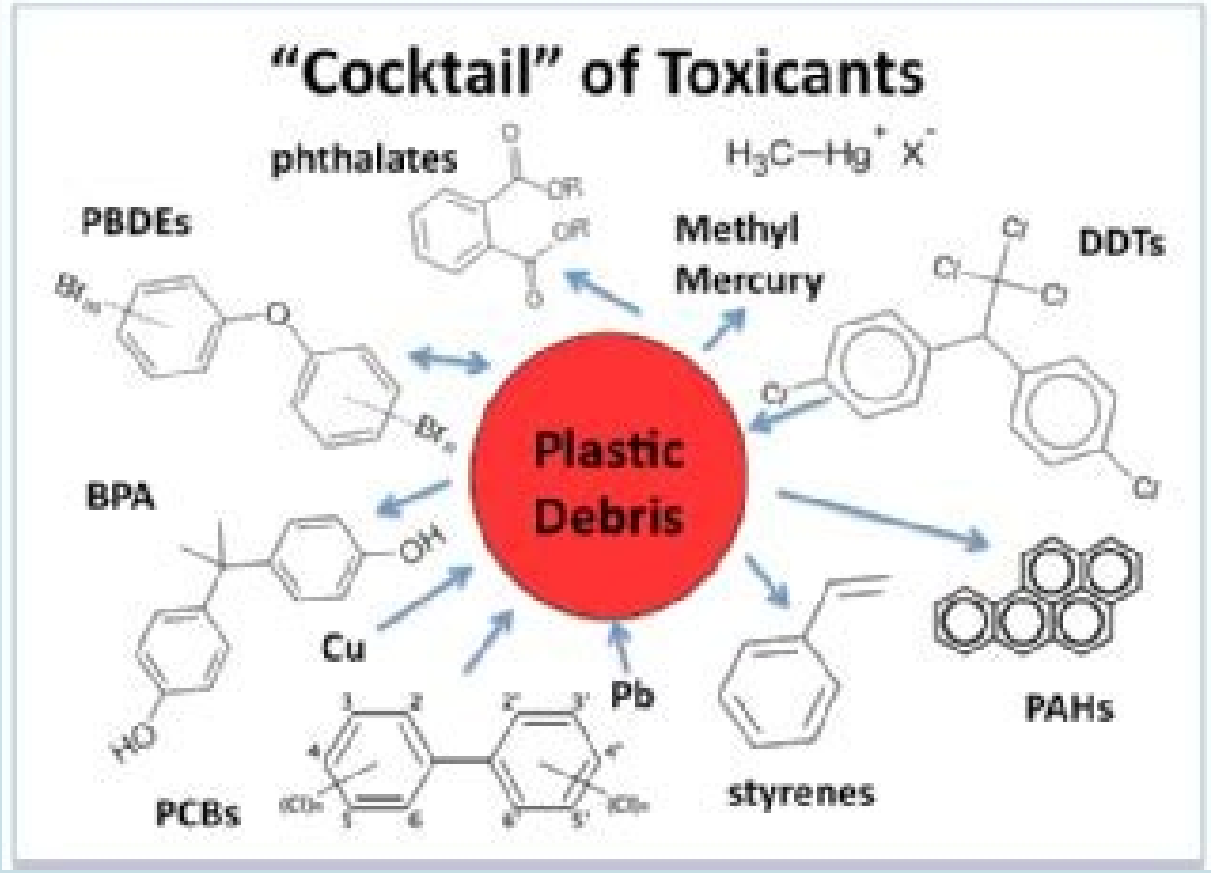
https://plasticchange.org/media/1154/plaststykker i haand.jpg

Harmful Effects to Organisms

- Microplastics can be ingested by organisms.
- Ingestion of microplastic can cause a variety of negative effects:
  - Intestinal damage
  - Liver damage
  - Impaired reproduction
  - Reduced immune function
  - Oxidative stress
  - Other negative health effects that result in increased mortality

Chemicals within Plastic

- Plastics have chemical additives.
- Microplastics absorb hydrophobic and toxic chemicals from the water and concentrate them.
- Chemicals leach to organisms when particles are ingested



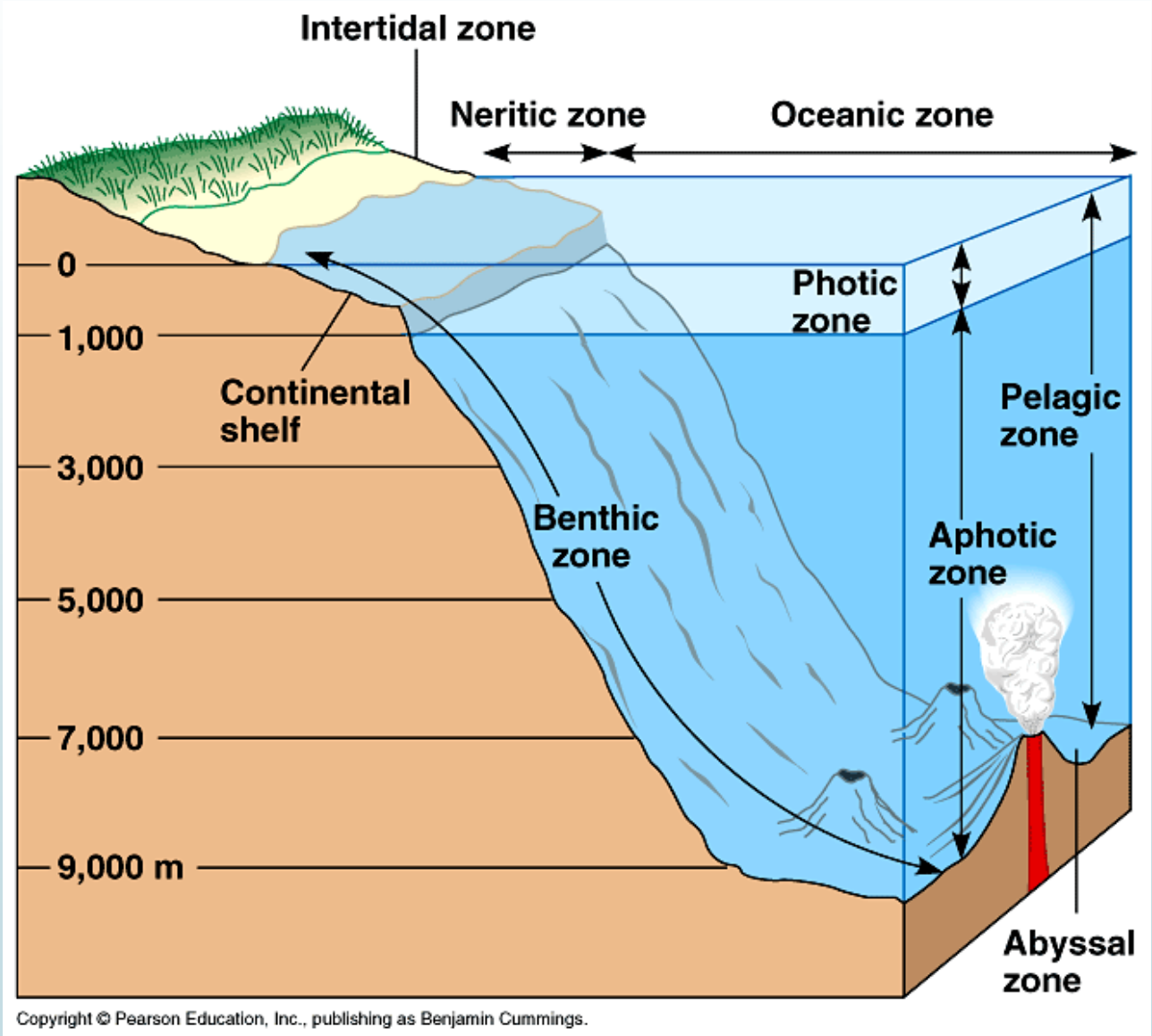
NELHA

- NELHA is a supplier of deep and surface ocean water.
- Some of their clients bottle desalinated drinking water from the deepsea
- Sampling the deepsea and surface pipelines.
- Also sampling coastal surface waters.
- **Goal: determine microplastic concentrations in the pipelines and surface waters.**

https://www.beveragedaily.com/Article/2016/02/16/Kona-Deep-brings-desalinated-deep-ocean-water-to-the-US-market

Locations for Sampling

- Sea surface
- 80 feet
- 2000 feet
- 3000 feet



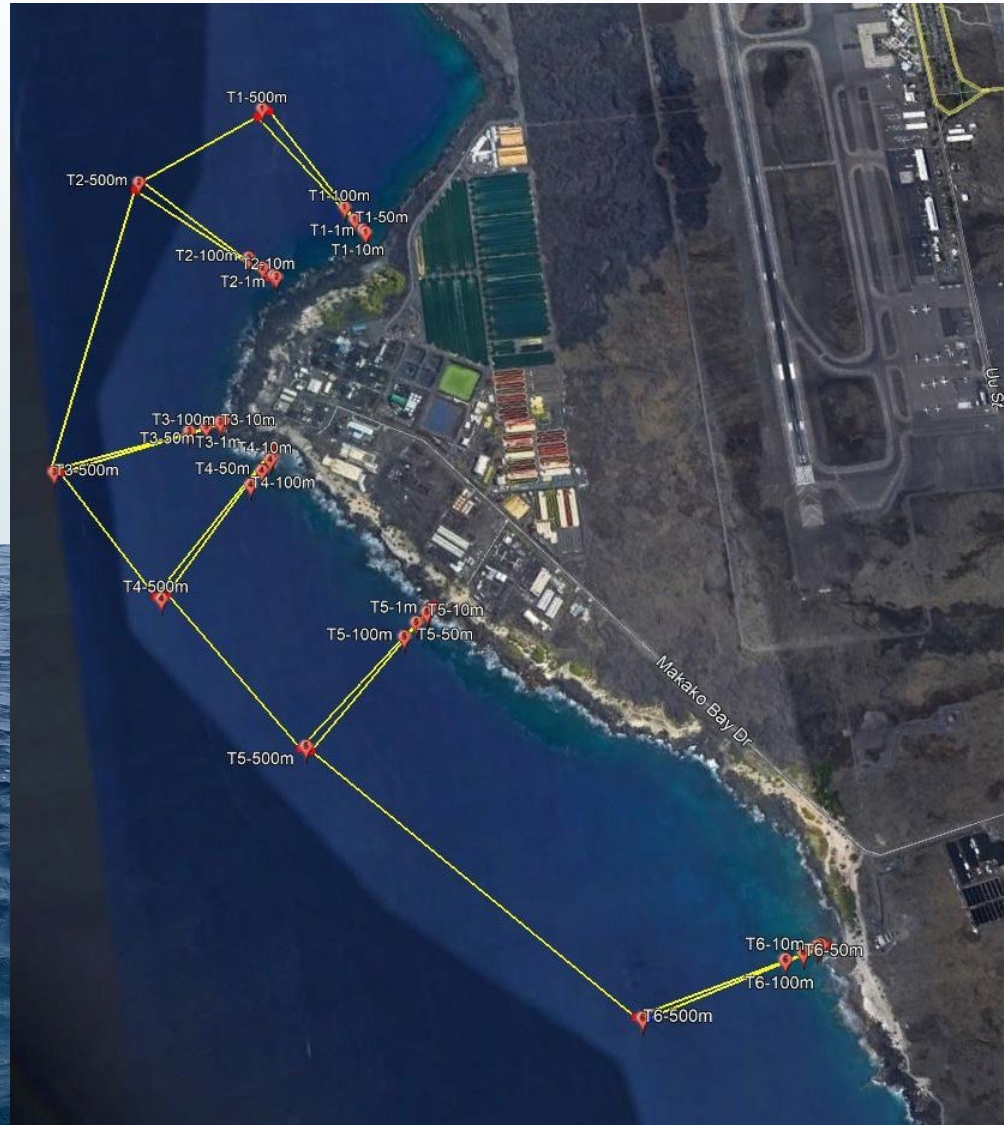
NELHA Facility

Sample Collection - Pipelines

- Designed and constructed a water filtration system
- Installed flowmeters to calculated water volume
- Ran water through 0.333 mm nets

Sample Collection - Ocean

- Used manta trawl net with flowmeter
  - Floats on sea surface
- Went along six transects branching out from the main facility

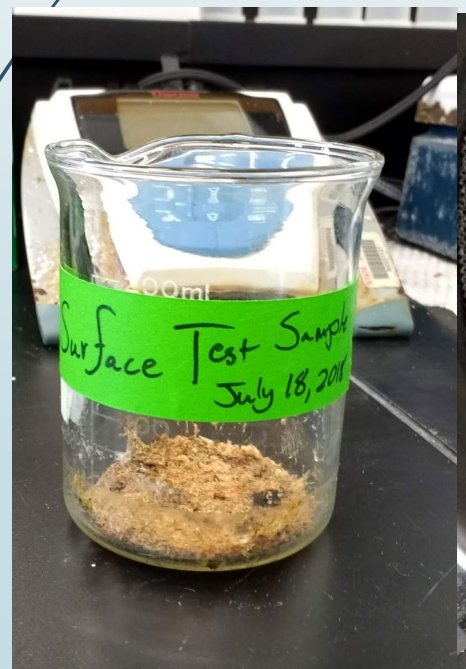


Lab Procedure

- Lab procedure from NOAA (National Oceanic and Atmospheric Administration).
- Recently released as an intended standard for microplastic concentration analysis to create comparable data.

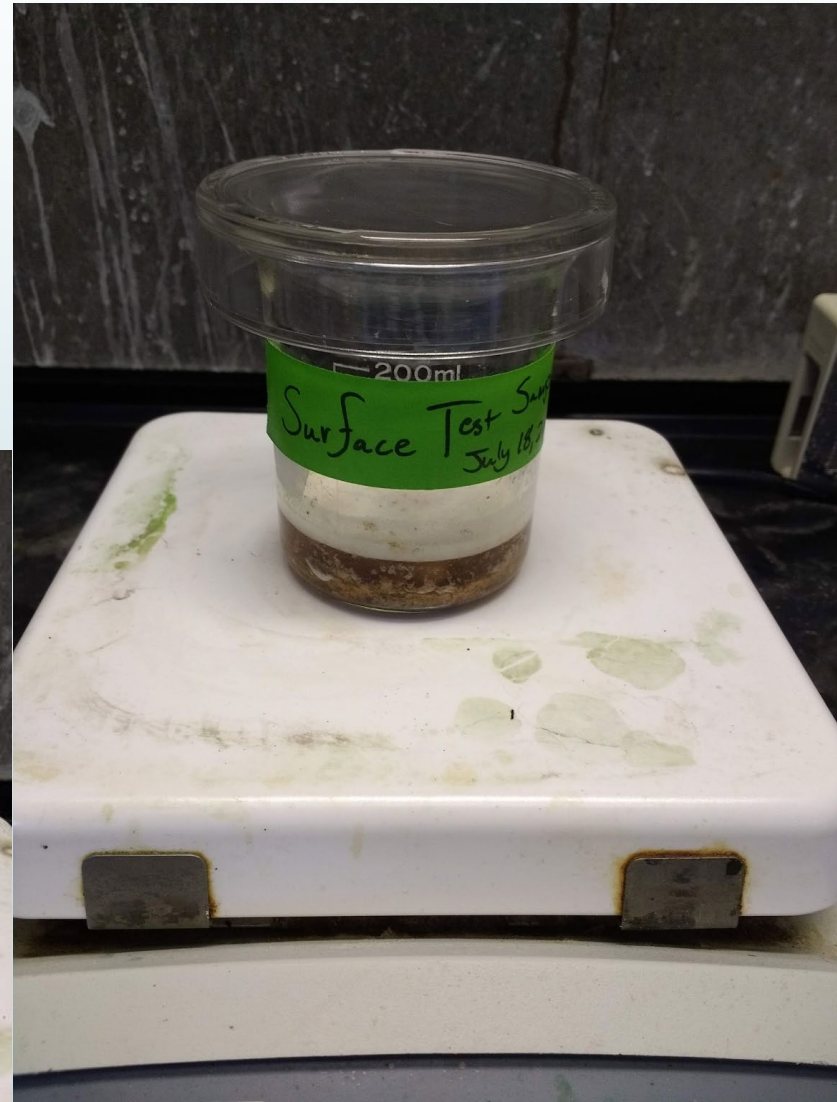
Sieving and Drying

- Samples were sieved using 5mm and 0.333 mm sieves
- Dried at 90° C in a drying oven
- Mass of total solids taken



Wet Peroxide Oxidation (WPO)

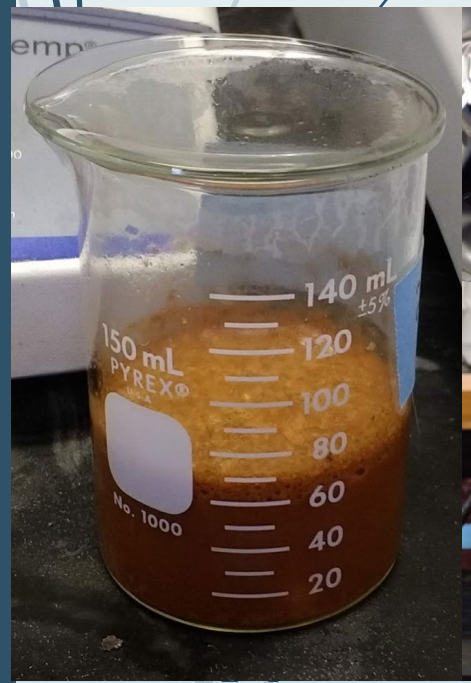
- Natural organic matter oxidized
- Used 30% hydrogen peroxide
- $FeSO_4$ as a catalyst
- Heated to 75° C

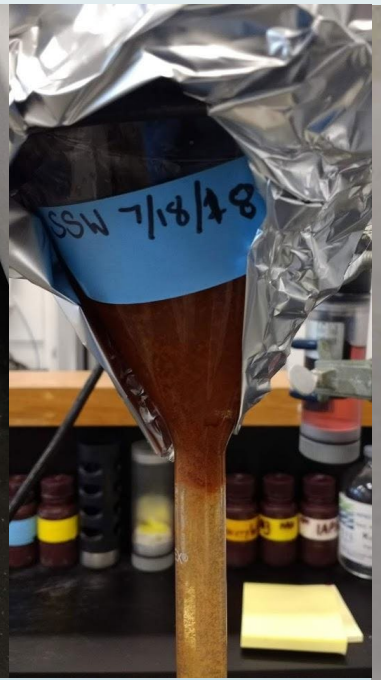


WPO - Success

WPO - Red Precipitate

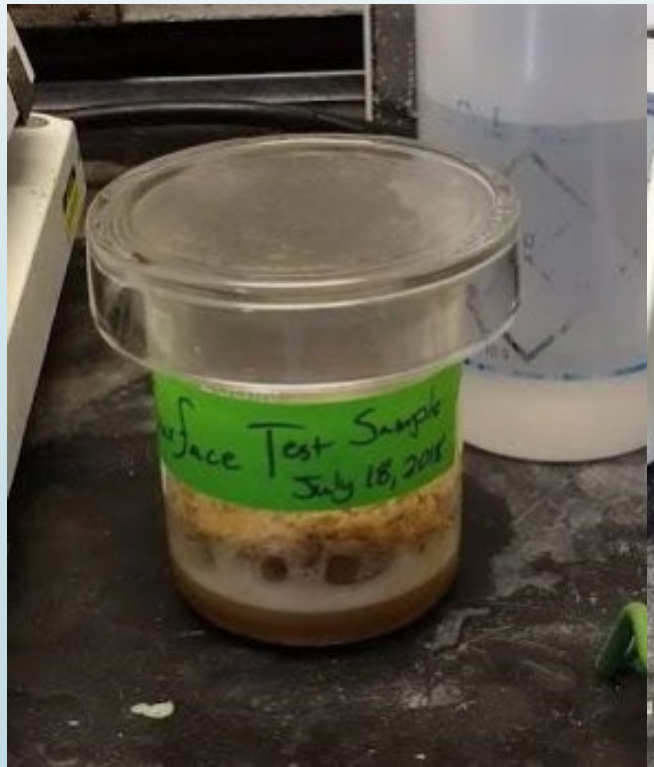
- Two samples produced red precipitates
- Natural organic matter remained
- Process was repeated

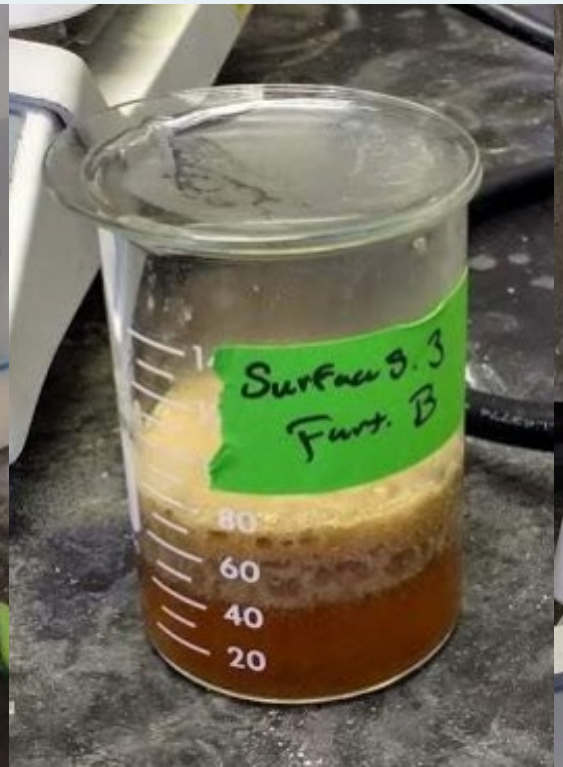


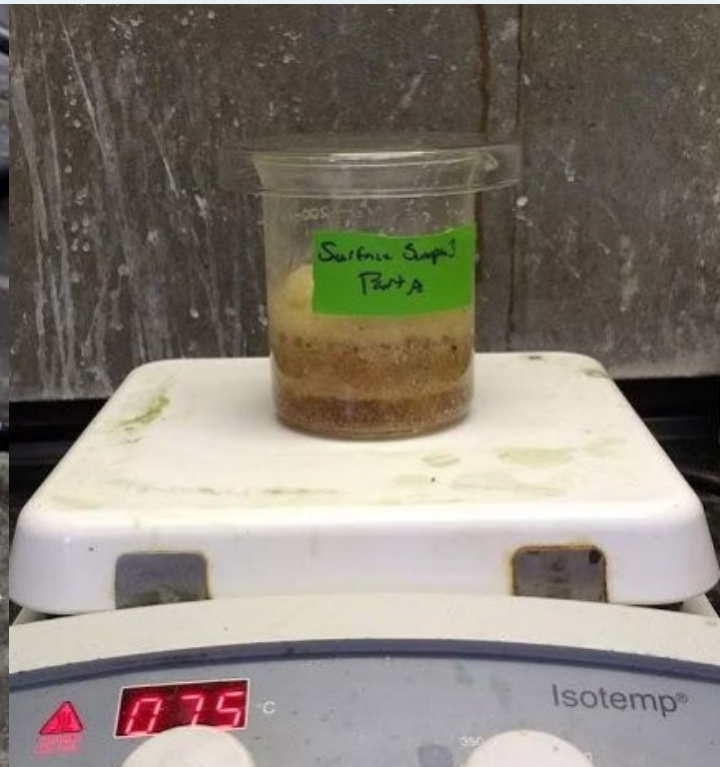


Wet Peroxide Oxidation - Foaming

- Larger amount of organics
- Thick foam lifts solids out of mixture
- Return beaker to stir/hot plate







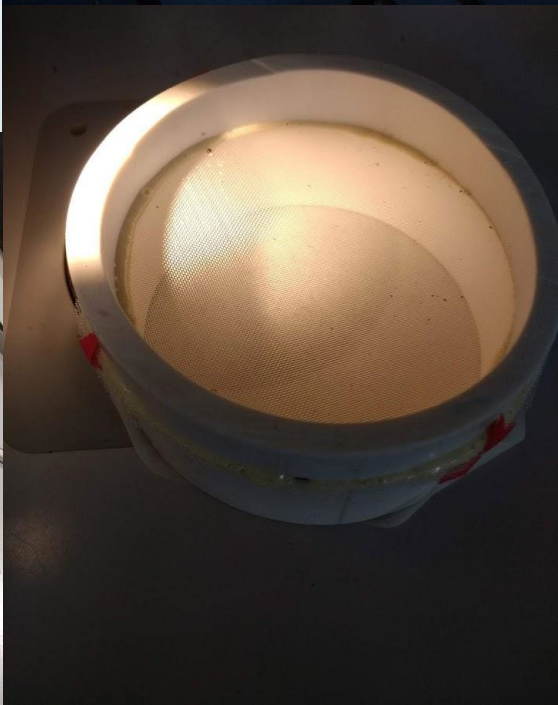
Density Separation

- NaCl solution, density 1.2 g/mL
- Most plastics density less than 1.2 g/mL

Density range of most common polymers of environmental relevance: Density (g/cm3)	
Distilled water	1
Sea water	1.025
Polyethylene (PE)	0.93-0.98
Polypropylene (PP)	0.89-0.91
Polystyrene (PS)	1.04-1.11
Polyvinylchloride (PVC)	1.20-1.45
Polyamide (PA)	1.13-1.5
Polyethylene terephthalate (PET)	1.38-1.39
Polyvinyl Alcohol (PVA)	1.19-1.35

Final Steps

- Sieved
- Air dried
- Microscope Examination
- Gravimetric Analysis



Microplastics in the Pipelines

Sample Data				
Location and Sample #	Mass Total Solids (mg)	Mass Microplastic (mg)	Water Volume (m^3)	Concentration (mg/m^3)
200o ft Deep Point (1)	277.3	2.5	541.844	**0.0046**
2000 ft Deep Point (2)	307.7	0.2	702.648	**0.0003**
80 ft Deep Point (1)	974.2	1.1	599.761	**0.0018**
80 ft Deep Point (2)	386.3	0.5	719.039	**0.0007**
3000 ft Deep (1)	93.9	2.2	722.862	**0.0030**
3000 ft Deep (2)	254.5	1.1	351.324	**0.0031**
80 ft Deep (1)	424.4	1.4	920.877	**0.0015**
80 ft Deep (2)	--	1.3	279.o98	**0.0047**
Surface Trawl (1)	30511.9	1206.9	3,010	**0.4010**
Surface Trawl (2)	11202.5	2056.2	2,660	**0.773**

A World Comparison (Water Column)

NELHA		Water Column (SINTEF Project No. 302003604)		
Pipeline	Concentration (mg m $^{-3}$)	Concentration (mg m^{-3})	Concentration (particles m^{-3})	Location
2000 ft Point	0.0046		0.017	North Pacific central gyre, sampling at 100 m
2000 ft Point	0.0003	0.01-0.02	0.2 to 0.4	Santa Monica Bay, California (offshore); range represents before and after storm conditions
80 ft Point	0.0018	0.01-0.13	1 to 11	Santa Monica Bay, California (nearshore); before and after storm conditions
80 ft Point	0.0007	0.12-0.25	1.56	Santa Monica Bay, California (offshore); before and after storm conditions (Epibenthic)
3000 ft	0.0030		8 to 9180	Northeastern Pacific/coastal British Columbia.
3000 ft	0.0031		1.69	North Atlantic subtropical gyre to a depth of 5 m
80 ft	0.0015		2.46	North Atlantic, Celtic Sea to a depth of 3 m
80 ft	0.0047			

A World Comparison (Surface)

NELHA		Surface (SINTEF Project No. 302003604)		
Surface Trawls	Concentration (mg/ m^3)	Concentration (mg m^{-3})	Concentration (particles m^{-3})	Location
One	0.4010	0.02-0.04	0.2-1.0	Santa Monica Bay, California (offshore); before/after storm conditions
Two	0.773	0.002-2.4	0.5-18.5	Santa Monica Bay, California (nearshore); before/after storm conditions

Conclusion

- Designed and constructed a filtration system to test the pipeline water
- Tested and refined the NOAA lab procedure for NELHA
- Successfully determined microplastic concentrations for the pipelines and the surface waters
  - The pipelines have a very low concentration
  - The surface waters have a much higher concentration

Future Steps and Recommendations

- Determine a mass solids/ hydrogen peroxide solution ratio
- Use a different catalyst such as activated carbon
- Use a different density separation solution to capture heavier microplastics
- Use several solutions of different density to characterize plastic types

- Do a longer term study to determine concentration trends over time

Acknowledgements

- Pamela Madden, NELHA
- Jan War, NELHA
- Dean Towle, NELHA
- Keith Olson, NELHA
- Alex Leonard, NELHA
- James Morioka, NOAA Marine Debris Program
- Natural Energy Laboratory of Hawaii Authority
- Akamai Internship Program
  - Institute for Science and Engineer Educators at UCSC
  - University of Hawaii Institute of Astronomy
- Funding:
  - Thirty Meter Telescope International Observatory
  - Air Force Office of Scientific Research (FA9550-15-1-0427)
  - Hawaii Community Foundation
  - Monty Richards Awards/ The Bank of Hawaii Foundation
  - Daniel K. Inouye Solar Telescope
  - Housing for interns on Hawaii Island was provided by University of Hawai‘i at Hilo, Canada-France-Hawaii Telescope, and W. M. Keck Observatory