Impacts of Environmentally-Relevant Concentrations of Polypropylene Microplastic fibers on Pacific Mole Crab *(Emerita analoga)* Development and Lifespan

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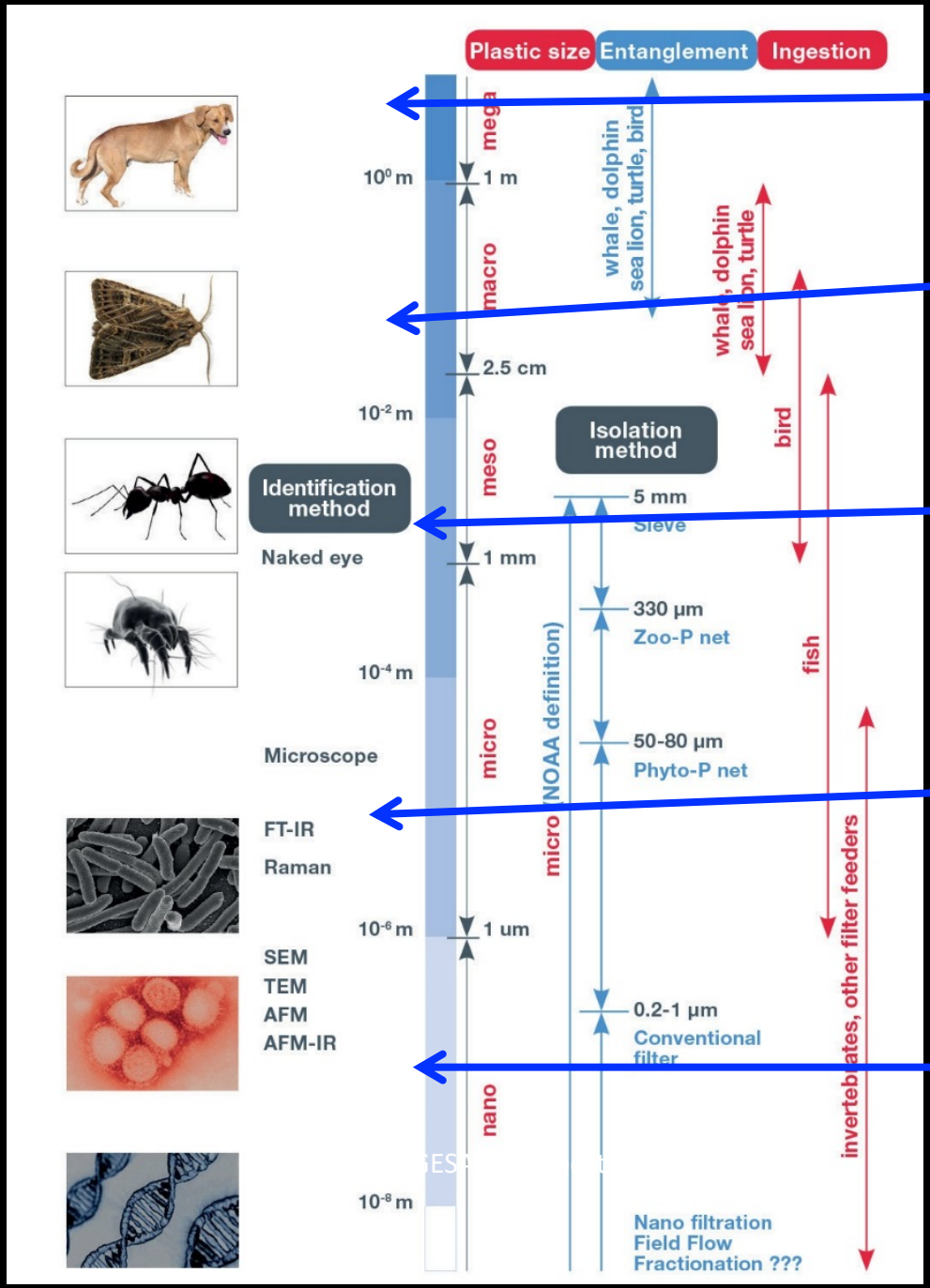
NSF

GRFP NSF GRADUATE RESEARCH FELLOWSHIP PROGRAM

PICES



- **Mega** plastics are those > 100mm
- **Macro** plastics are those 20 - 100mm
- **Meso** plastics are those 5 - 20mm
- **Micro**plastics are those < 5 mm
- **Nano**-plastics are those < 1um

Microplastic types

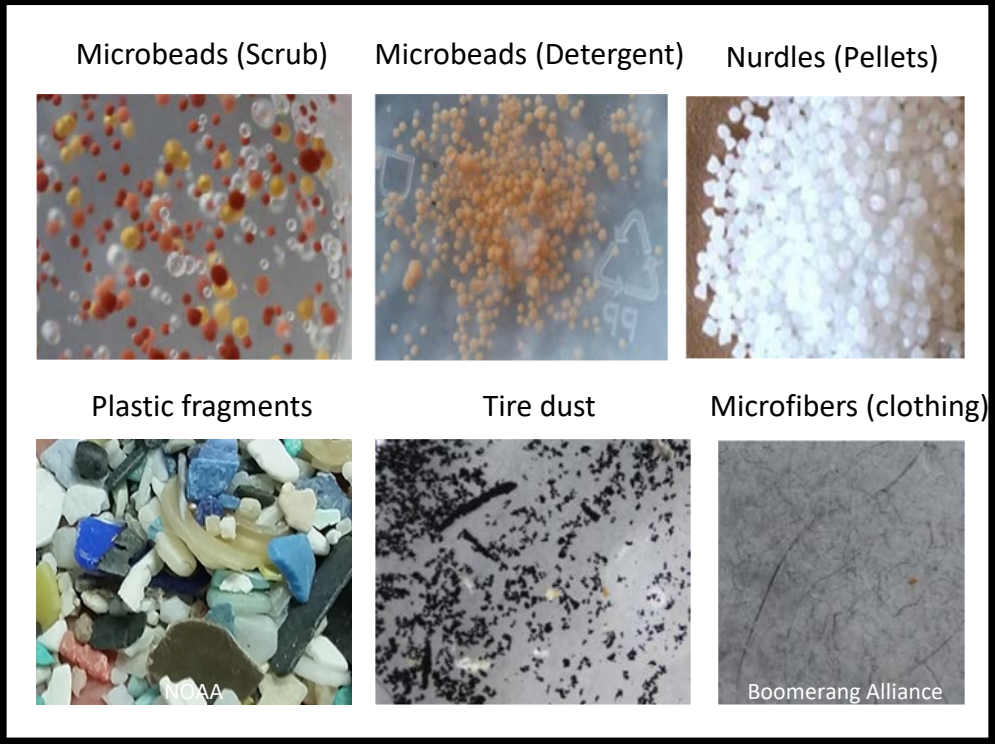
Plastic particles and fibers less than ***5 mm – 0.001 mm***

Primary microplastics

Manufactured microbeads, nurdles

Secondary microplastics

Fragments of larger items



Microfibers

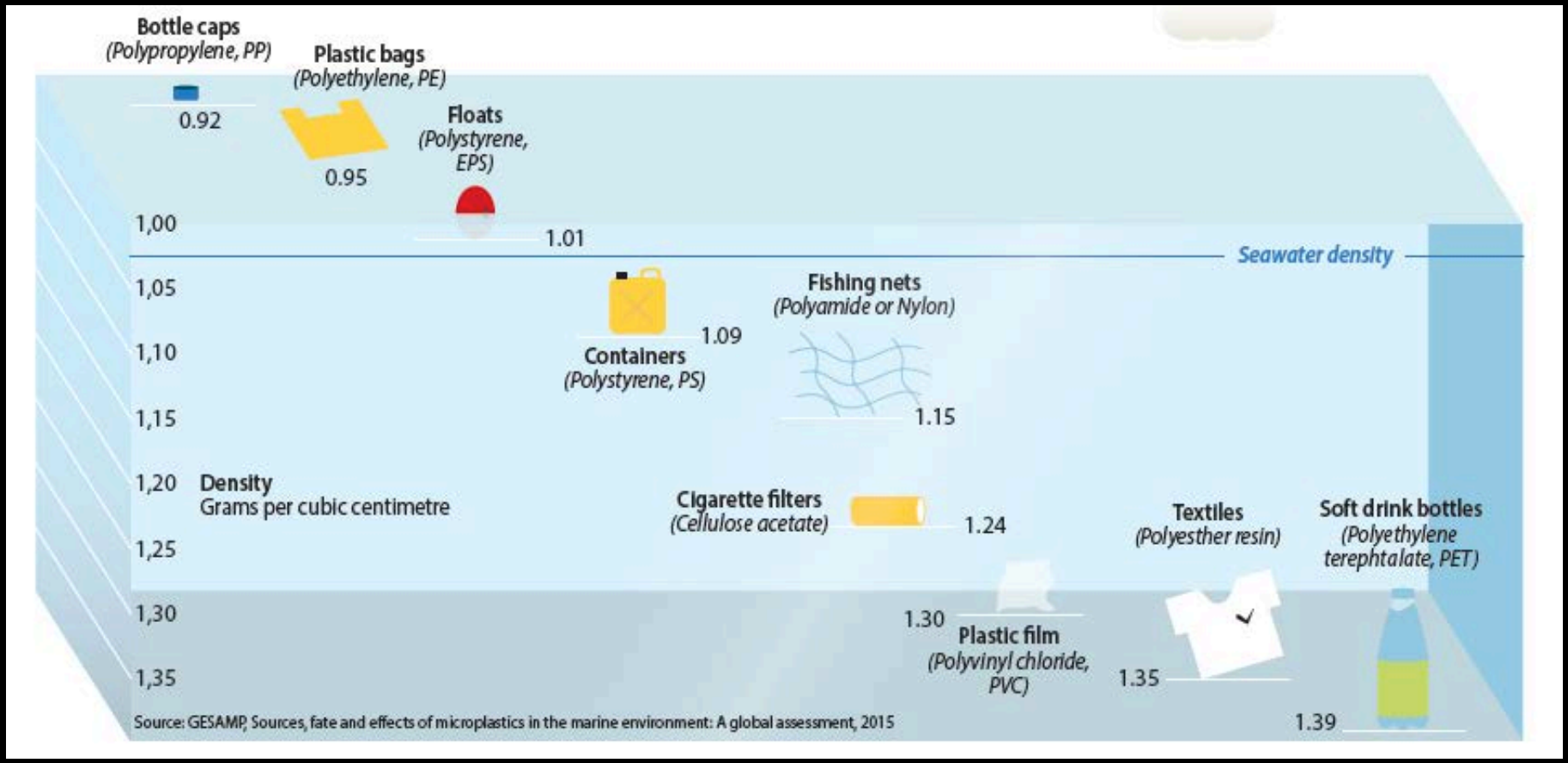
https://www.earth.com/news/microfibers-clothing-polluting-oceans/

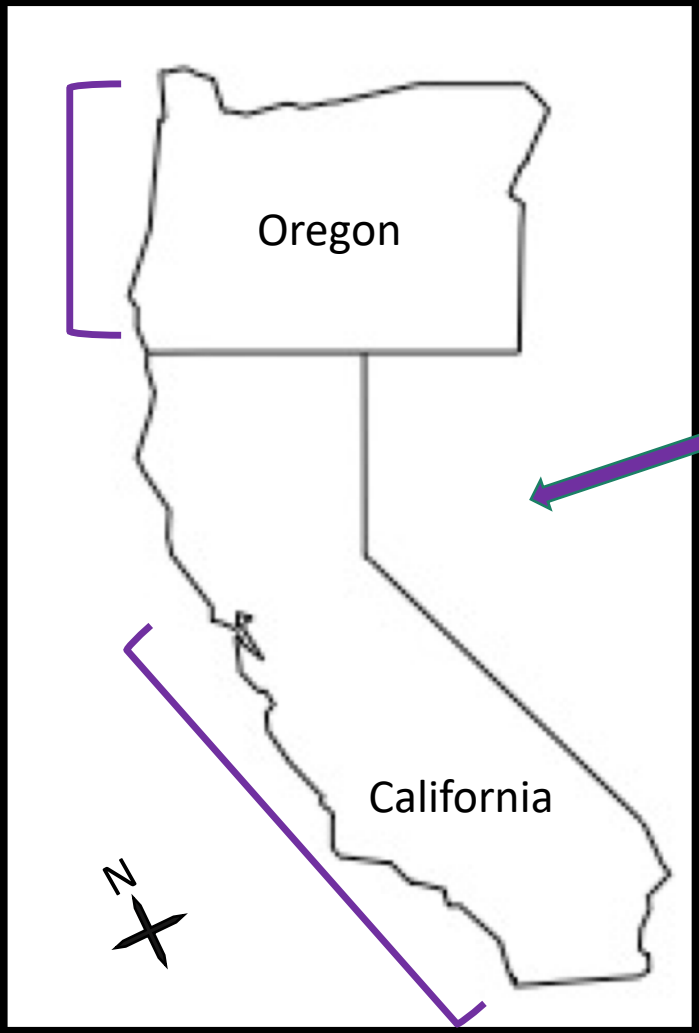
1 fleece jacket ~250,000 fibers released per load

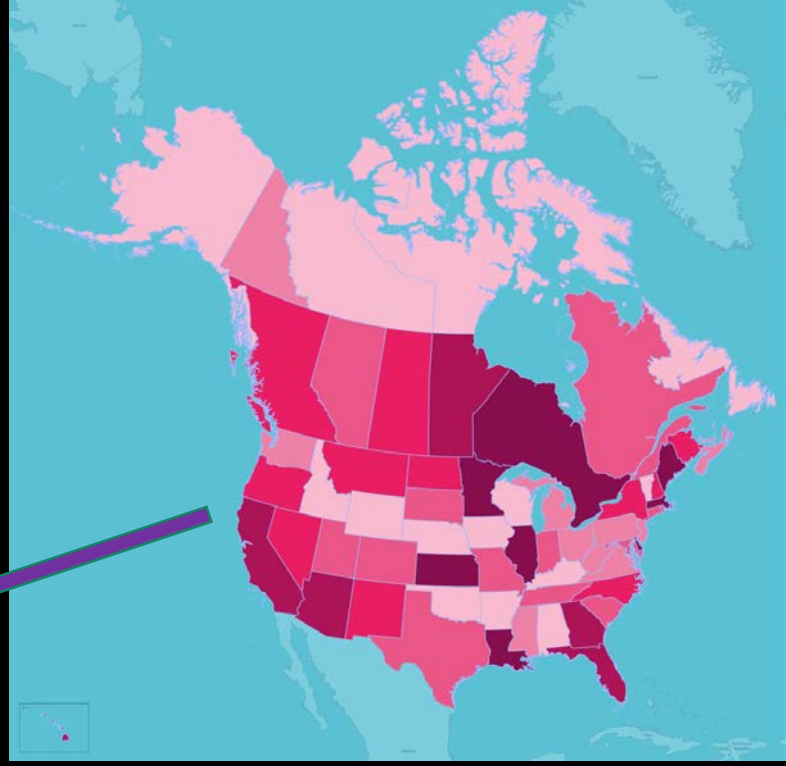
WASH, C. (2015). Featured products

2018 Kosuth et al, PLOS One

Where does the plastic go?







North American Study Sites

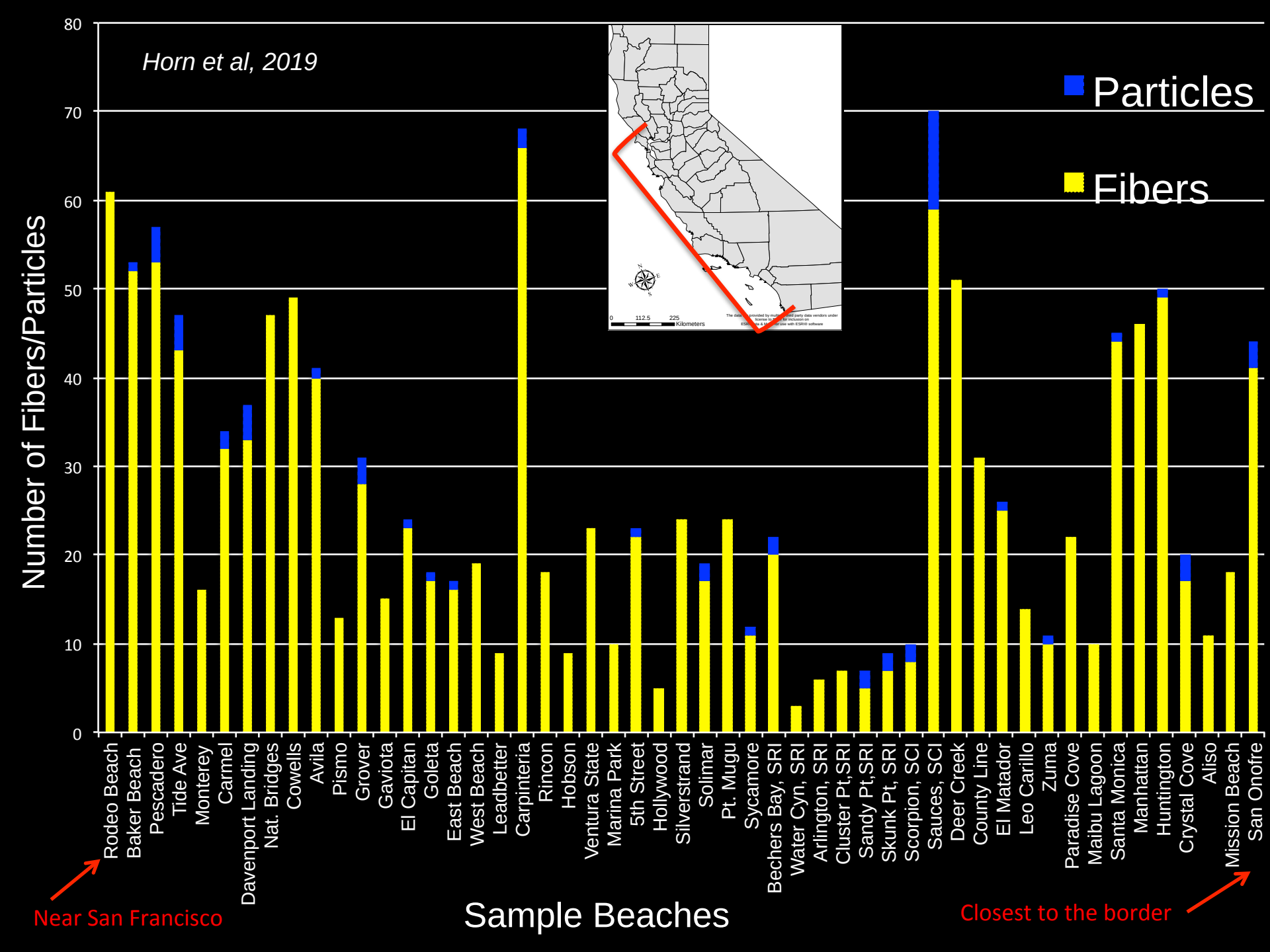
Oregon and California, US

Collected Sand:
Marin County to San Diego - California

Microplastics in sand

(n = 51 beaches):

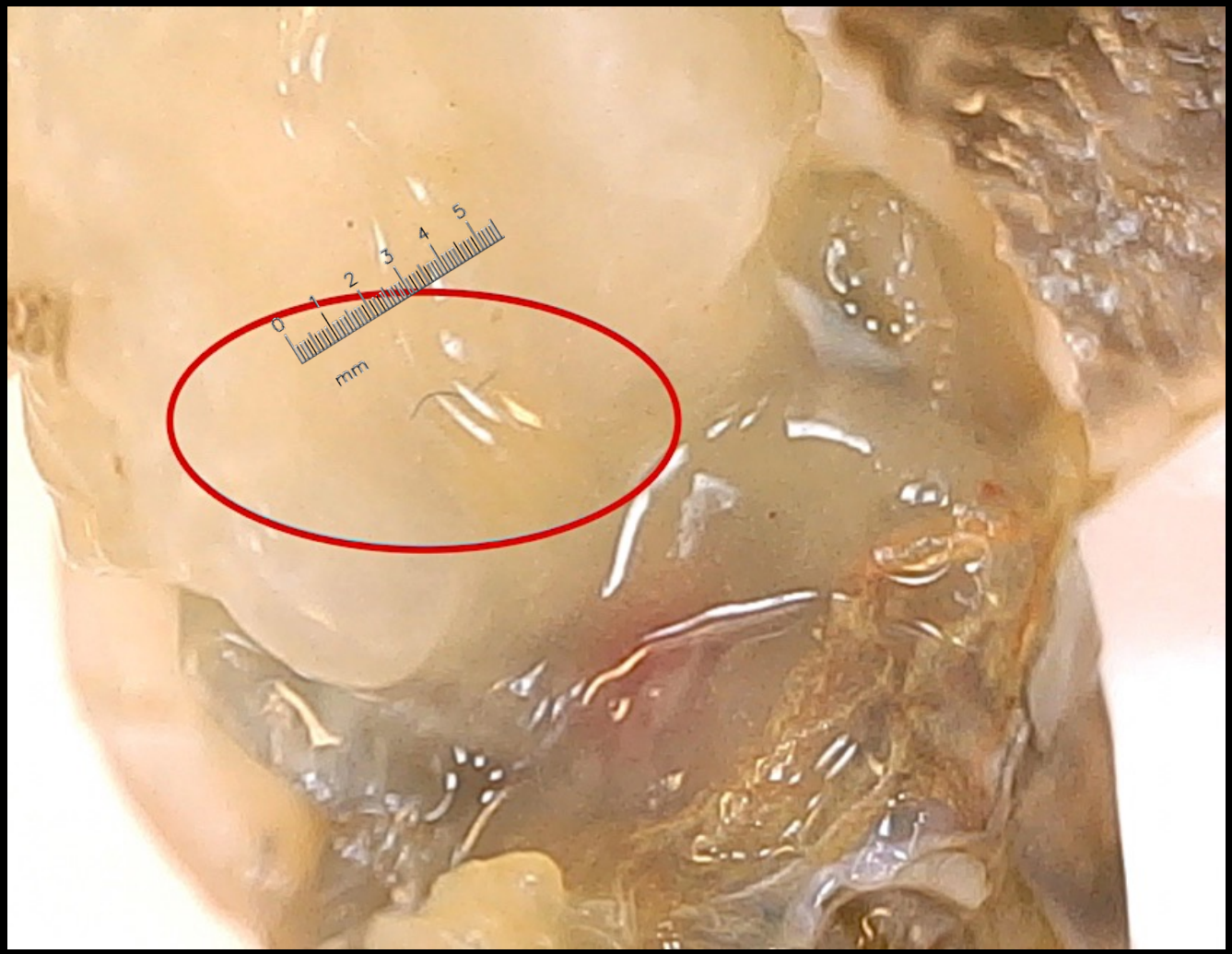
- 200ml of sand was collected from each beach & dried
- supernatant filtered through 1.6 µm glass fiber filters
- categorized visually by color & type – then tested using FTIR


Horn et al, 2019
Particles
Fibers
Number of Fibers/Particles
0
10
20
30
40
50
60
70
80
Rodeo Beach
Baker Beach
Pescadero
Tide Ave
Monterey
Carmel
Davenport Landing
Nat. Bridges
Cowells
Avila
Pismo
Grover
Gaviota
El Capitan
Goleta
East Beach
West Beach
Leadbetter
Carpinteria
Rincon
Hobson
Ventura State
Marina Park
5th Street
Hollywood
Silverstrand
Solimar
Pt. Mugu
Sycamore
Bechers Bay, SRI
Water Cyn, SRI
Arlington, SRI
Cluster Pt,SRI
Sandy Pt,SRI
Skunk Pt, SRI
Scorpion, SCI
Sauces, SCI
Deer Creek
County Line
El Matador
Leo Carillo
Zuma
Paradise Cove
Maibu Lagoon
Santa Monica
Manhattan
Huntington
Crystal Cove
Aliso
Mission Beach
San Onofre
Sample Beaches
Near San Francisco
Closest to the border
0
112.5
225
Kilometers

Microfiber in sand

- Highly abundant sandy beach invertebrate
- Filter feeders

Microfiber in Pacific mole crab:



Ingest microplastics (*Horn et al, 2019 Marine Pol. Bul)*

Pacific mole crab (*Emerita analoga*)

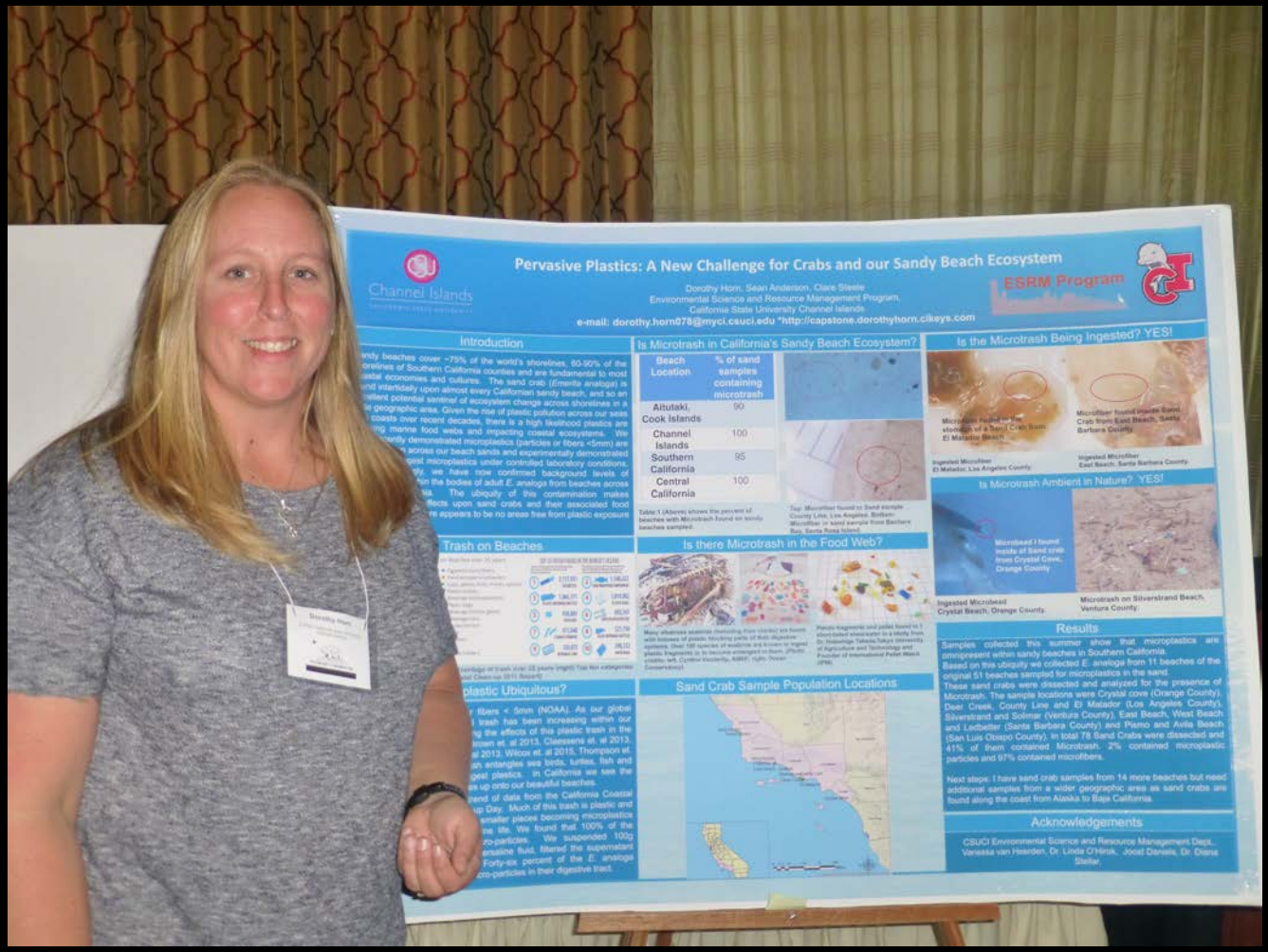

Surf Perch (crabs = 90% of diet)


Shore Birds


~ 2 million sand crabs used for bait per year


Mammalian predator: Sea Otter

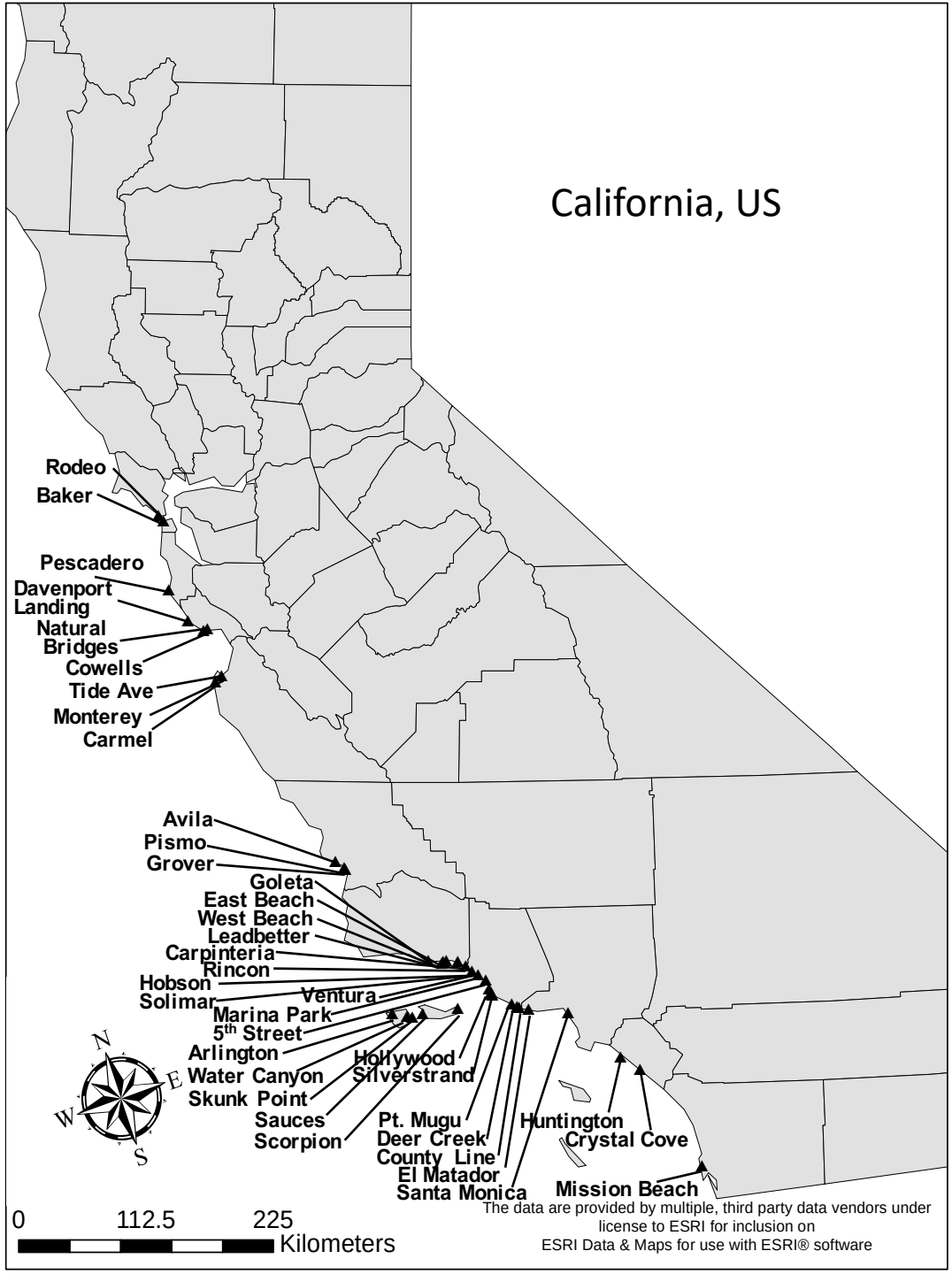
Give Dorothy Crabs

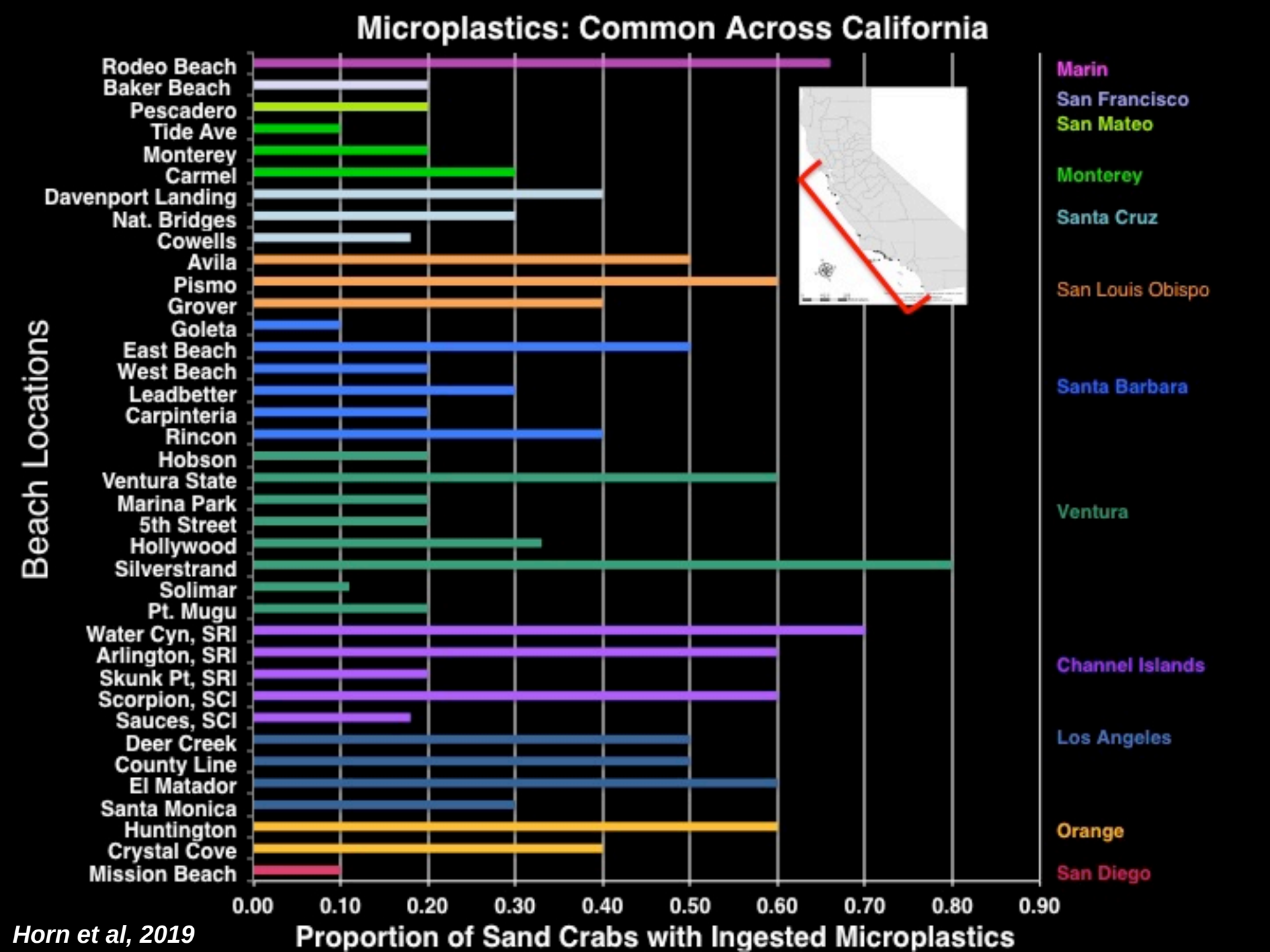


California

Sand Crab Collection Sites

Horn et al 2019

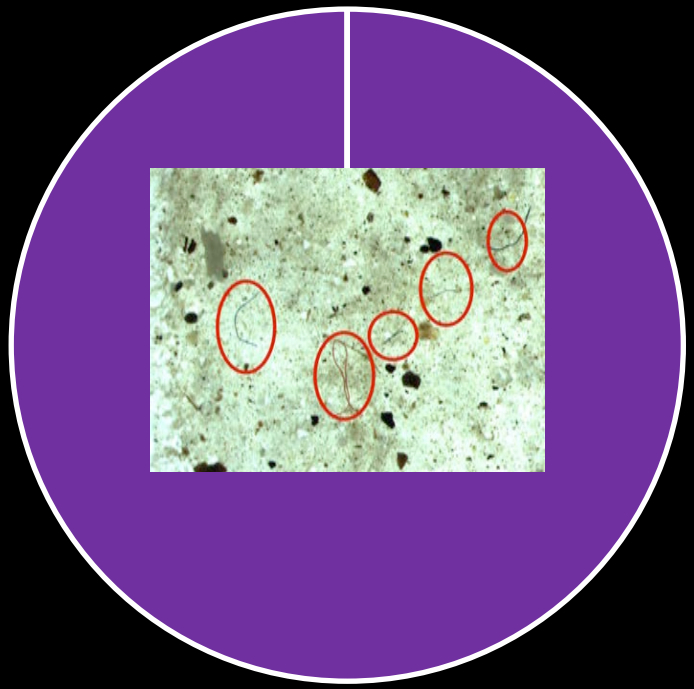



Microplastics: Common Across California
Beach Locations
Rodeo Beach
Baker Beach
Pescadero
Tide Ave
Monterey
Carmel
Davenport Landing
Nat. Bridges
Cowells
Avila
Pismo
Grover
Goleta
East Beach
West Beach
Leadbetter
Carpinteria
Rincon
Hobson
Ventura State
Marina Park
5th Street
Hollywood
Silverstrand
Solimar
Pt. Mugu
Water Cyn, SRI
Arlington, SRI
Skunk Pt, SRI
Scorpion, SCI
Sauces, SCI
Deer Creek
County Line
El Matador
Santa Monica
Huntington
Crystal Cove
Mission Beach
Marin
San Francisco
San Mateo
Monterey
Santa Cruz
San Louis Obispo
Santa Barbara
Ventura
Channel Islands
Los Angeles
Orange
San Diego
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Proportion of Sand Crabs with Ingested Microplastics
Horn et al, 2019

California Results

35% of Sand Crabs Ingested Plastics

100% Sand Samples had Microplastics



Horn et al, 2019

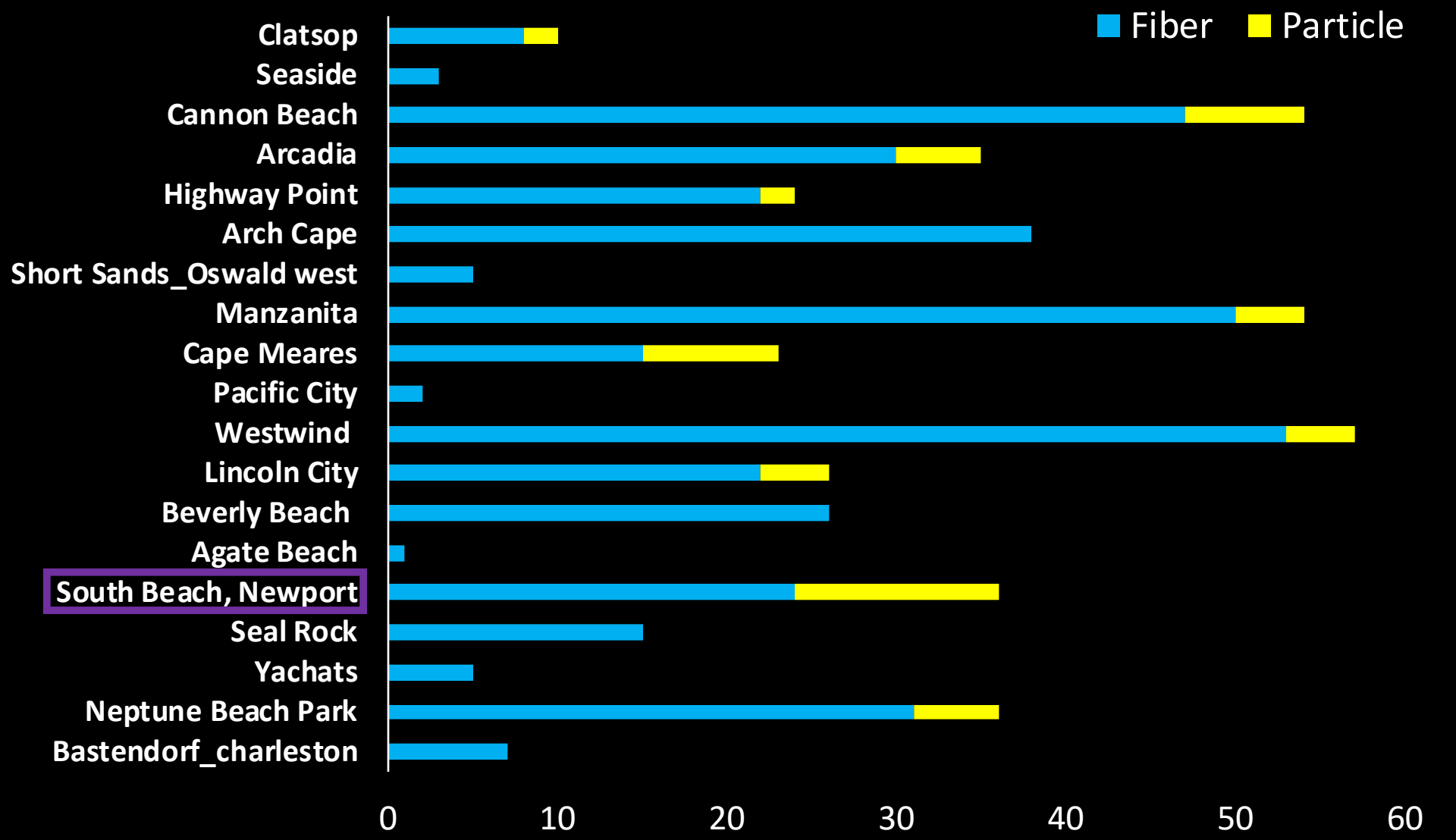
Oregon, US Collection Sites

(n = 19 beaches):

- 100ml of sand was collected from each beach & dried
- supernatant filtered through 1.6 µm glass fiber filters
- Plastic Identification by Nile Red fluorescence (Hidalgo-Ruz et al. 2012, Shim et al. 2016, Wiggin & Holland 2019)

Horn et al, in review (Limnology and Oceanography Letters)

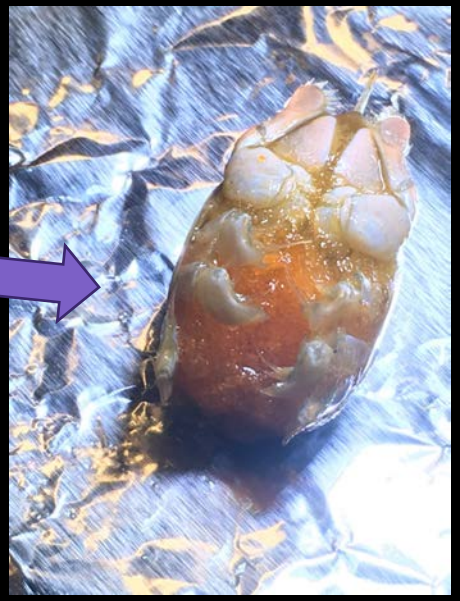
Fibers and Particles in Oregon Sand



Horn et al, in review (Limnology and Oceanography Letters)

Methods

- 74 Days = 2 reproductive cycles (Boolootian et al 1959)
- 32 Control
- 32 Treatment
- 64 Jars w/1 Female gravid crab



Horn et al, in review (Limnology and Oceanography Letters)

Methods

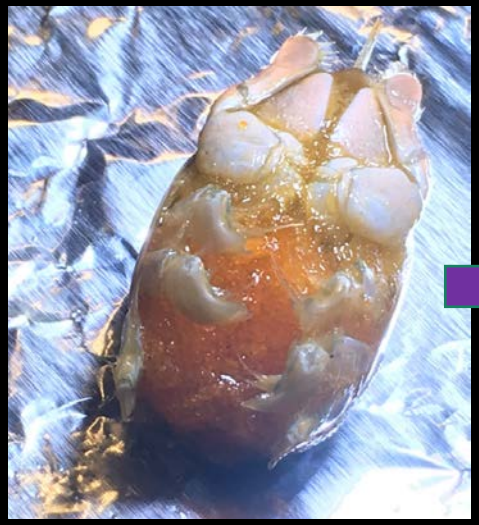
Treatment Dose: 3x1mm pieces
Polypropylene rope every 4 days

All crabs: food and fresh water daily

Horn et al, in review (Limnology and Oceanography Letters)

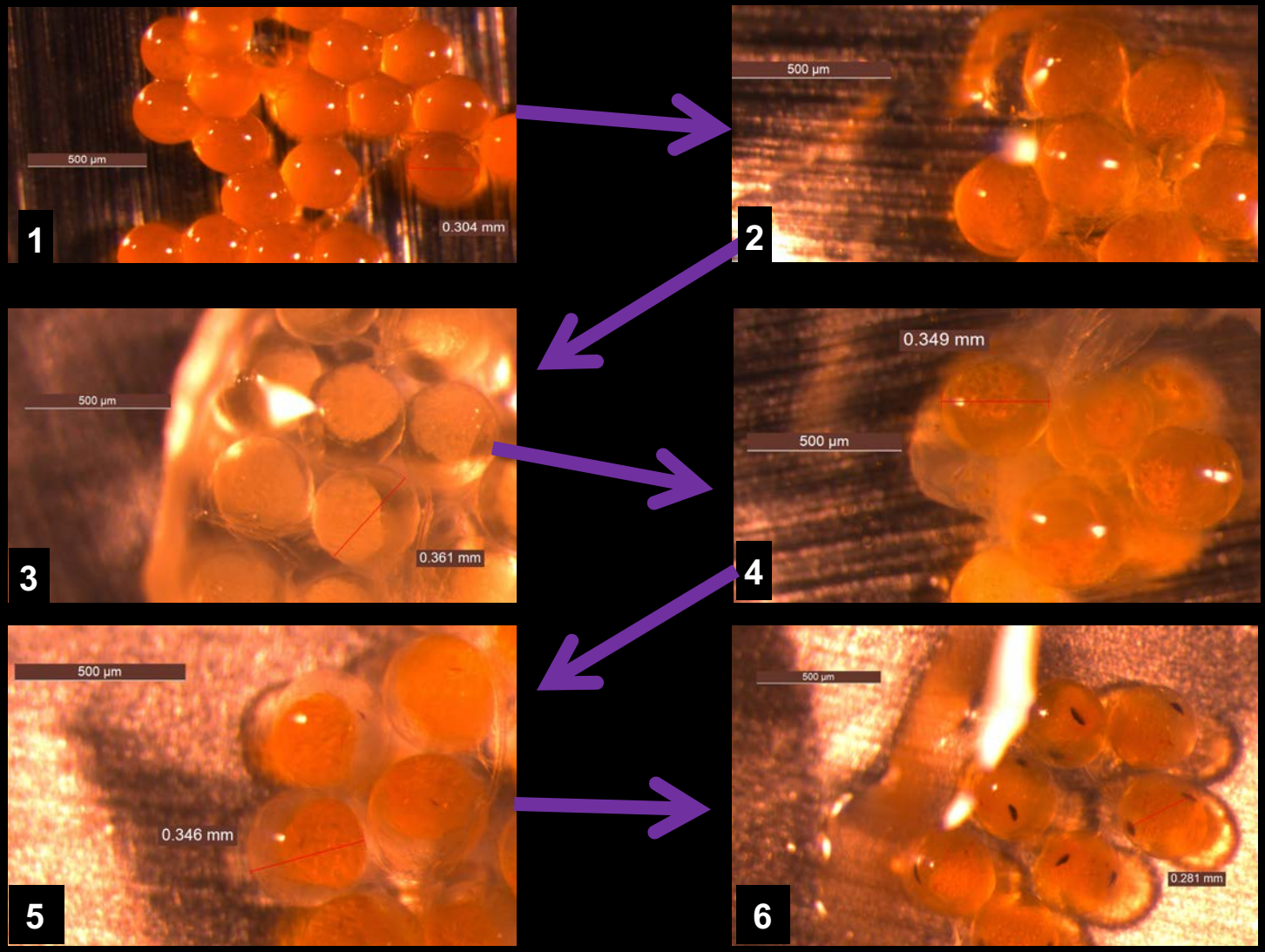
Methods

Sub-sample of eggs collected every 4 days



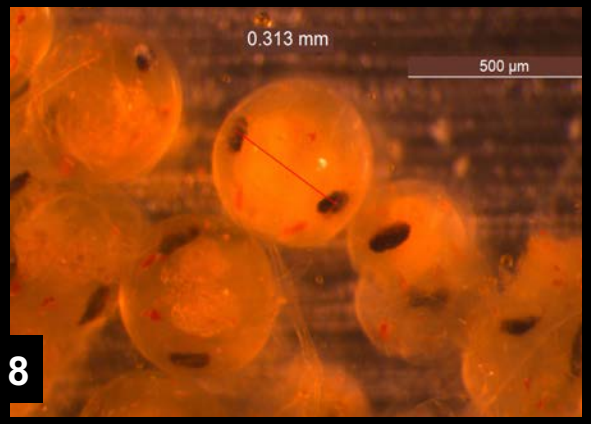
Horn et al, in review (Limnology and Oceanography Letters)

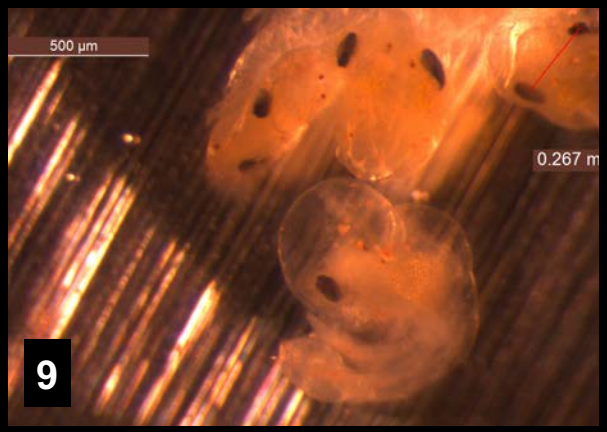
Pacific Mole Crab Egg Development Stages

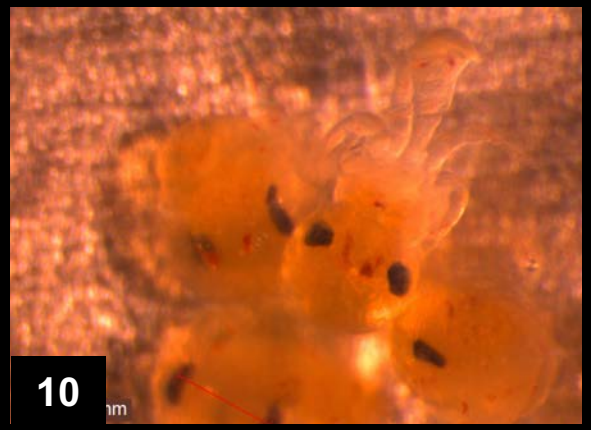


Boolootian et al 1959

Pacific Mole Crab Egg Development Stages







Larval Stages

Boolootian et al 1959

Linear Mixed Effects Model

Does the water bottle in the backpack effect hiking speed?

mdl1

mdl2

mdl1 = hiking speed ~ gallon of water + flashlight
mdl2 = hiking speed ~ flashlight
Using lme4 in R Studio

Likelihood Ratio Test to compare the likelihood of the two models to each other (Winter 2013).

Output from ratio test → Chi sq ($\mathcal{X}^2$) = 9.55, df = 4, p = 0.04

Linear Mixed Effects Model

Random Effects

- Number of microplastic fibers internalized by the adult crab
- Adult crab size
- Molting event
- Number of parasites
- Starting stage of egg clutch

Fixed Effects

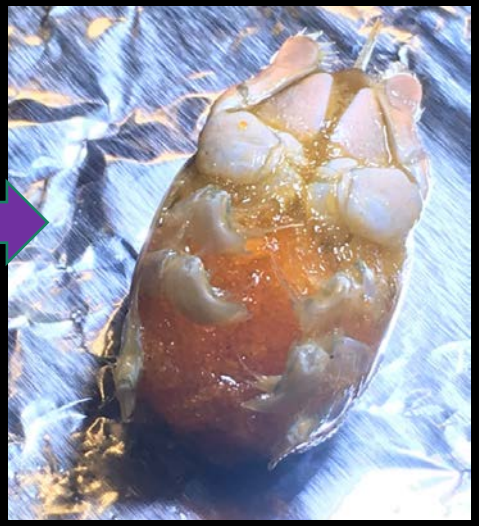
- Exposed to polypropylene microfibers

Response Variables

- Adult mortality
- Number of days adult crabs held live/viable eggs
- Number of development stages egg clutches went thru

Likelihood Ratio Test to compare the likelihood of the two models to each other (Winter 2013).

What did we find?



Adult Crabs exposed to plastic had higher mortality rates

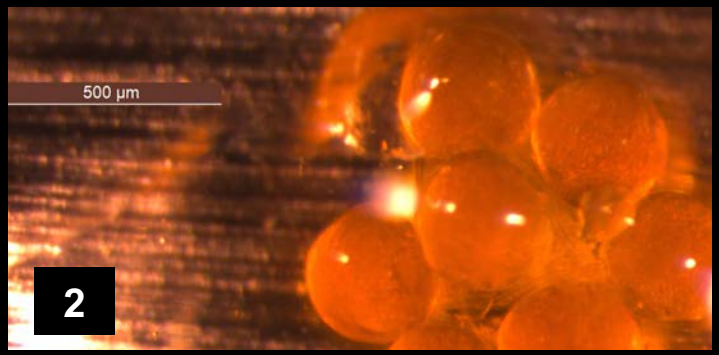
Chi sq (χ^2) = 45.83, df = 30, p = 0.03

Horn et al, in review (Limnology and Oceanography Letters)

What did we find?

adult crab

stage two of
egg development



microplastic
exposure

- The number of days an adult crab held live/viable eggs in her clutch was negatively affected by microplastic exposure when those eggs were at stage two of egg development at the study start (Chi sq ($\mathcal{X}^2$) = 9.55, df = 4, p = 0.04).

Horn et al, in review (Limnology and Oceanography Letters)

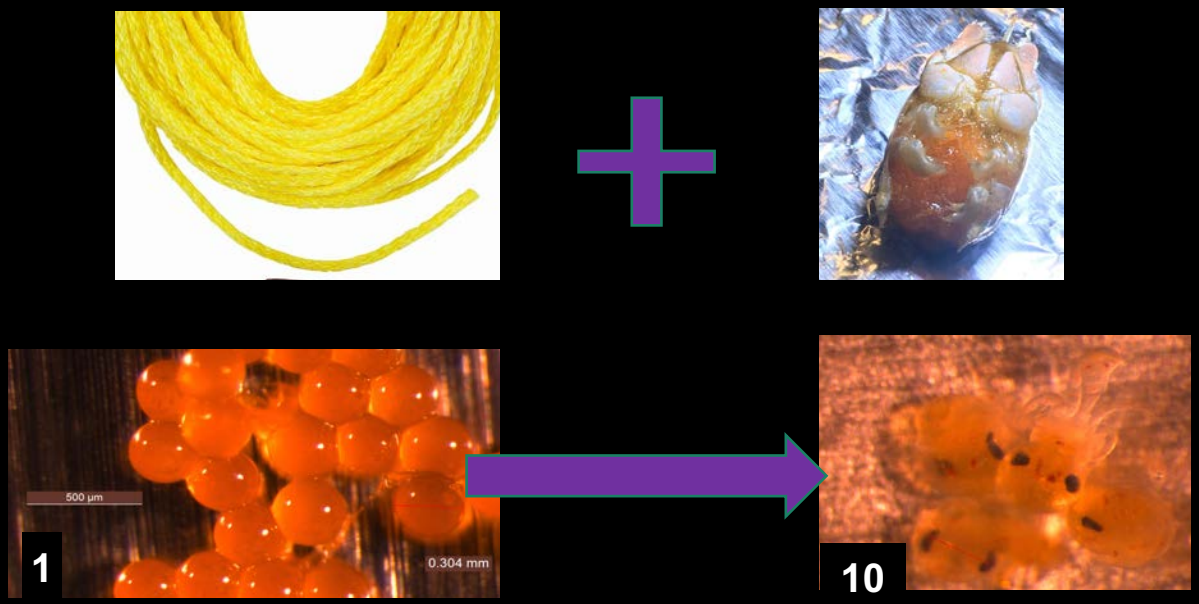
What did we find?

The number of polypropylene microplastic fibers internalized decreased the number of days that an adult sand crab held live/viable eggs.

(Likelihood Ratio test($\mathcal{X}^2(1) = 27.54$, $p<0.001$), by 4.46 days ±0.75 SE)

Horn et al, in review (Limnology and Oceanography Letters)

What did we find?



- Microplastic fibers internalized by the adult crab ***increased*** the number of egg stages by 1.04 stages ±0.5 SE
  ($\mathcal{X}^2$ (1) = 11.53, p = 0.04)

Additives & POPs in the food web

Additives:
Plasticizers, antioxidants, anti-static agents and flame retardants

Adsorbed chemicals:
PCBs, DDT, brominated flame-retardants

Concentration of POPs in plastic pellets a million times higher than in the surrounding seawater (Mato *et al.* 2001)




Take Home

- Microplastics in sand of every beach sampled across the California and Oregon coast.

- Polypropylene microfibers negatively affected sand crab mortality and reproductive output

Take Home

- Pathway of ingestion into coastal food webs.

- Microplastics known to accumulate and transfer harmful chemicals into tissue (Browne *et. al* 2013

What can you do?

Fishy Filaments

It’s Worth the Effort

- Consistent monitoring of debris is important

- 15,000 tons of Debris is removed each year on coastal clean up


AREA CLOSED

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