Ecosystem Services of Farmed Seaweed

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Aquaculture In Shared Waters

16 December 2021

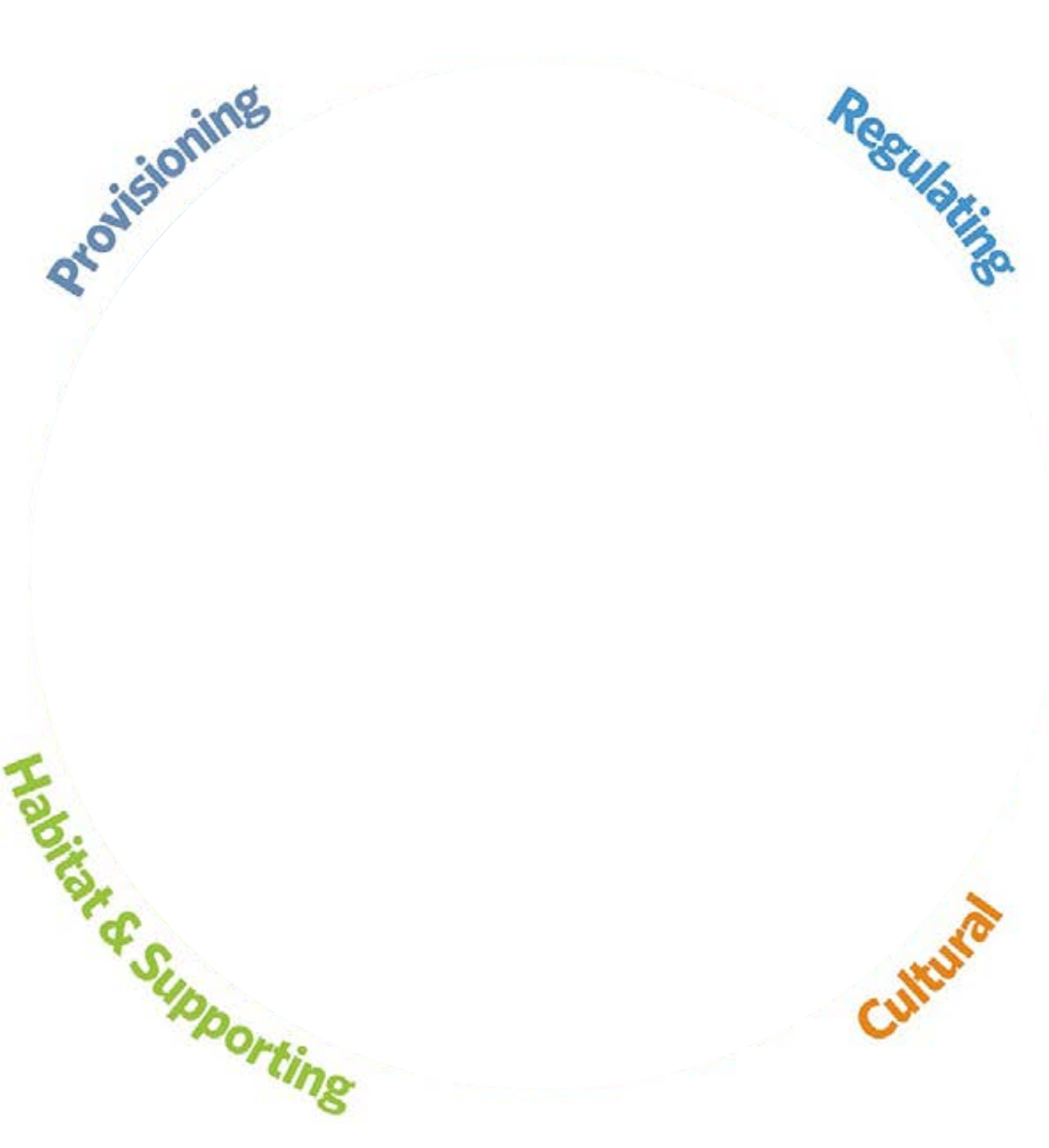
Ecosystem Services

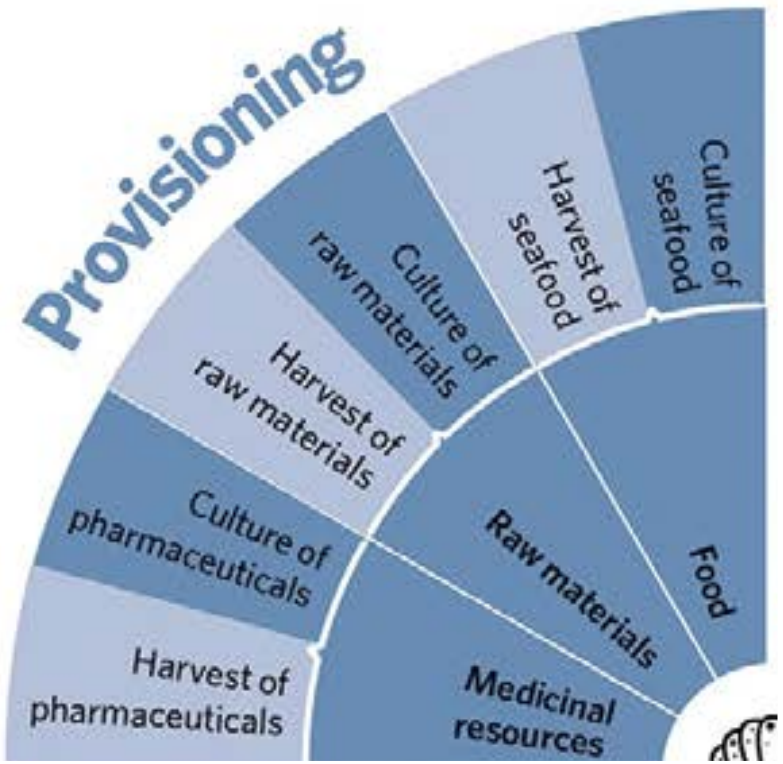
- Benefits to humans provided by an ecosystem.

Ecosystem

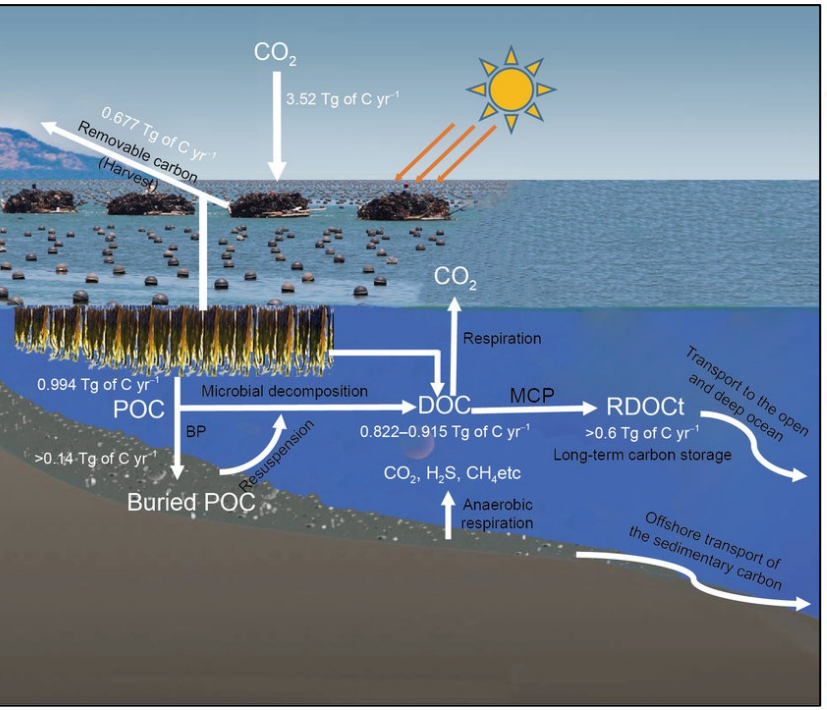
- Biological community of interacting organisms and their physical environment.

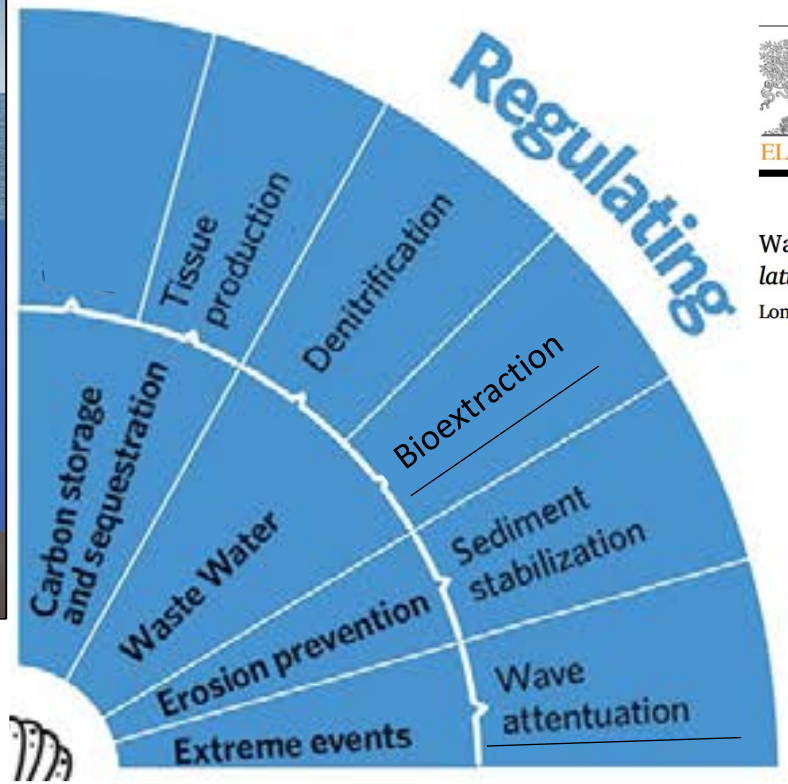
What Ecosystem Services does your seaweed farm provide?


Provisioning
Regulating
Habitat & Supporting
Cultural



Products obtained from ecosystems





Coastal Engineering 168 (2021) 103947

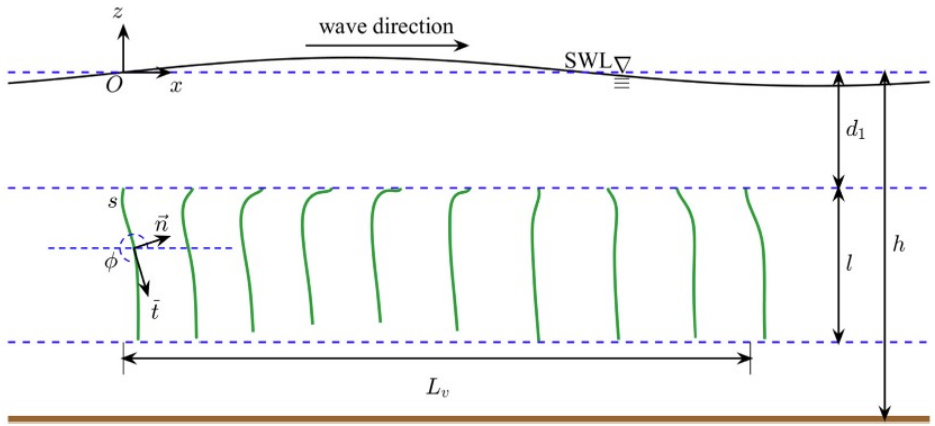
Contents lists available at ScienceDirect

Coastal Engineering

journal homepage: www.elsevier.com/locate/coastaleng

Wave attenuation by suspended canopies with cultivated kelp (*Saccharina latissima*)

Longhuan Zhu [a,*], Jiarui Lei [b], Kimberly Huguenard [a], David W. Fredriksson [c]



Journal of Applied Phycology
https://doi.org/10.1007/s10811-021-02367-6

The nitrogen bioextraction potential of nearshore *Saccharina latissima* cultivation and harvest in the Western Gulf of Maine

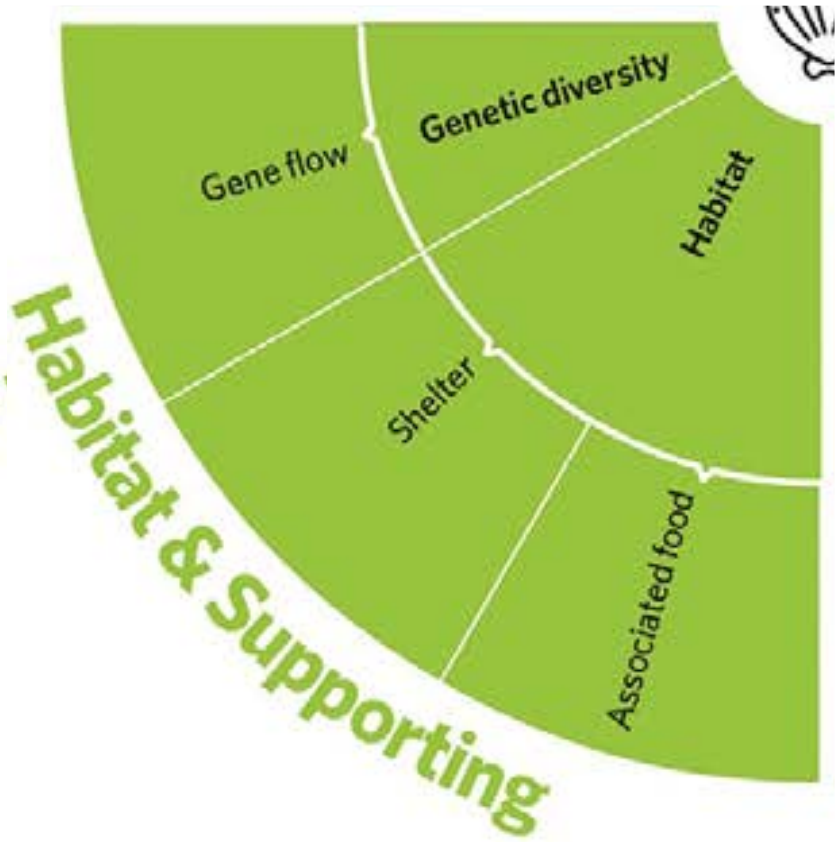
G. S. Grebe [1,2] · C. J. Byron [2] · D. C. Brady [1] · A. H. Geisser [2] · K. D. Brennan [2]

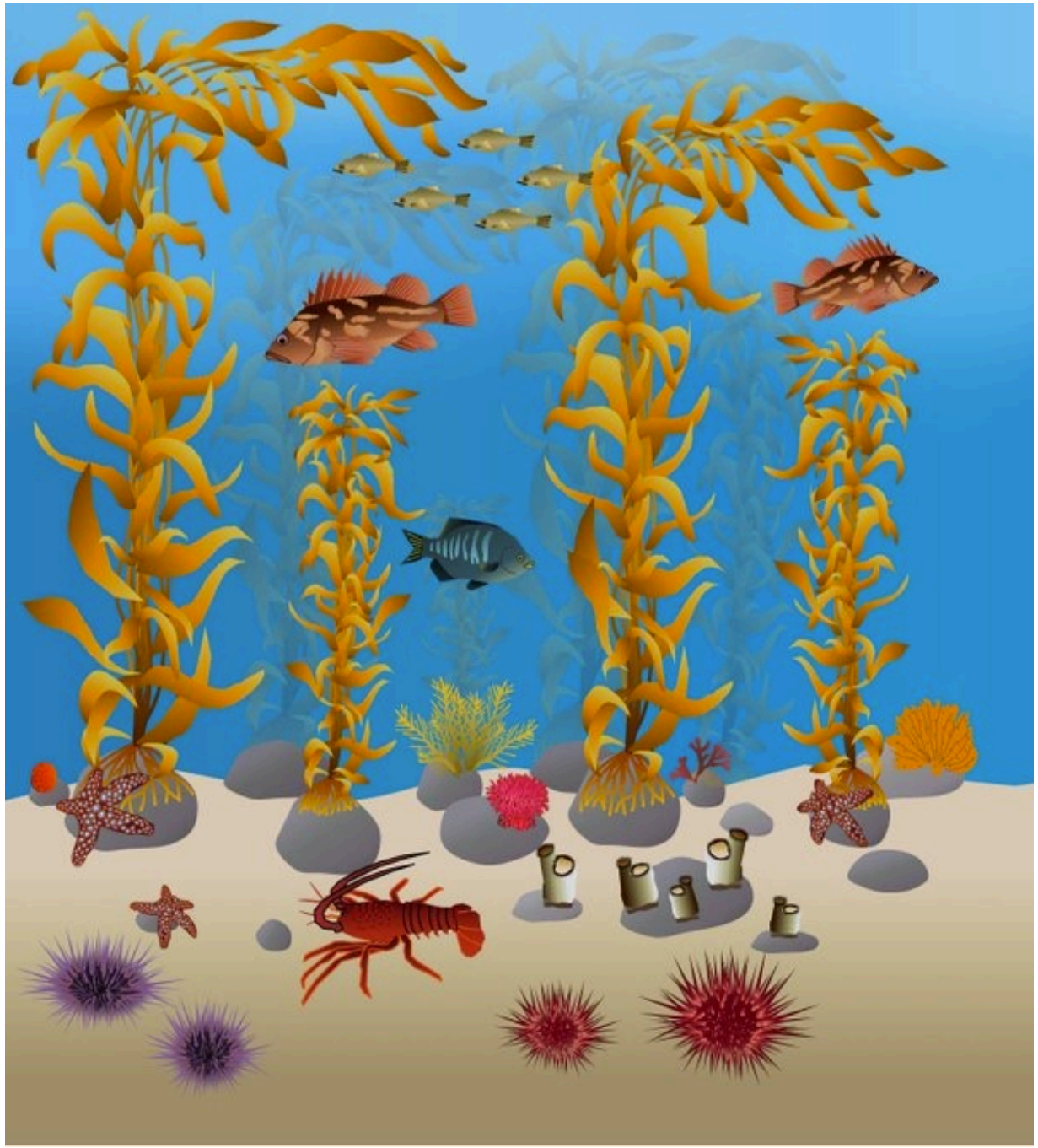
Received: 11 January 2020 / Revised and accepted: 3 January 2021

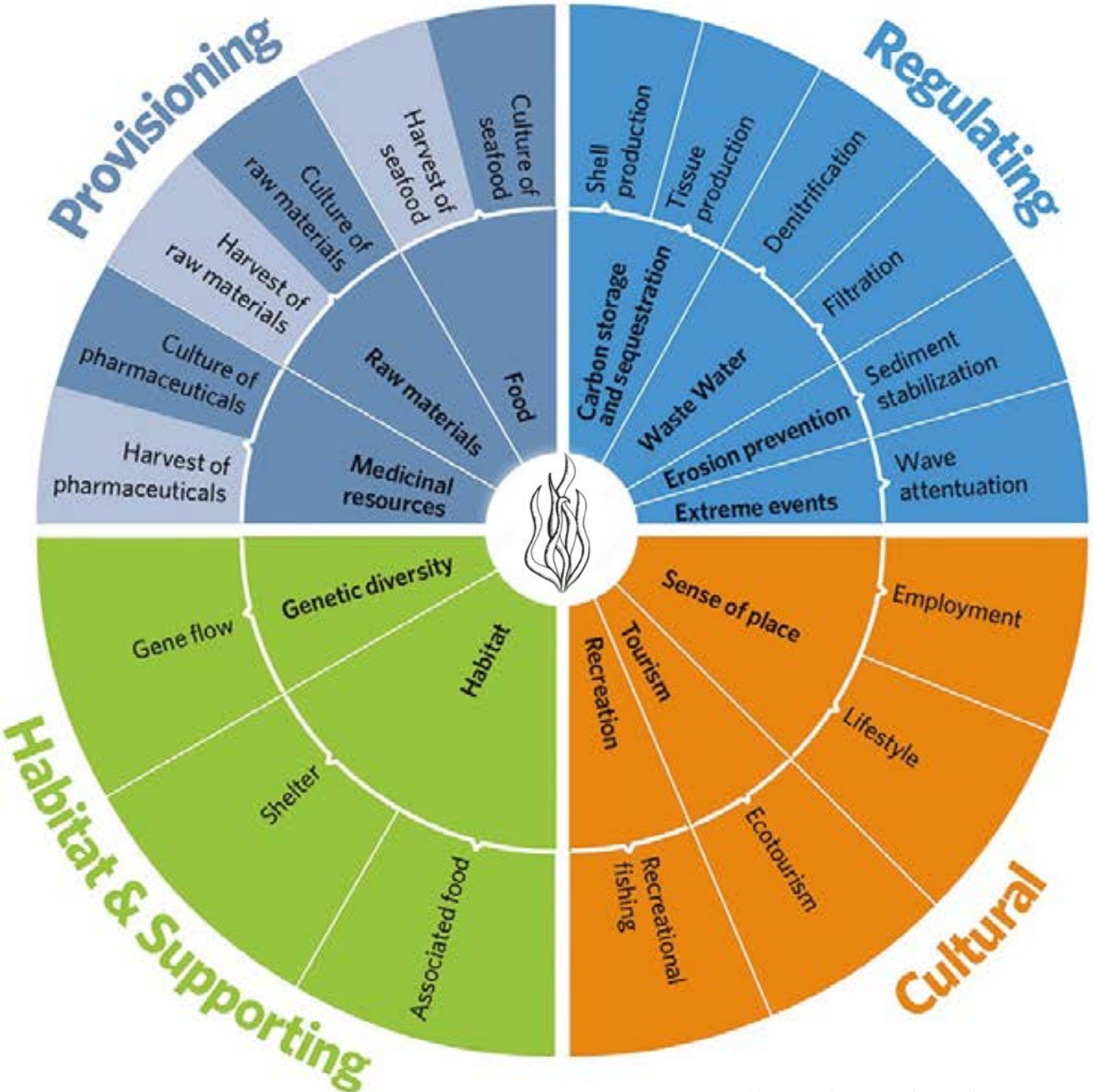
Benefits obtained from the
regulation of ecosystem processes

Non-material benefits from ecosystems

Services necessary for the production of all other ecosystem services.







natural ecosystems

sea farm ecosystems

BioScience, Volume 69, Issue 1, January 2019, Pages 59–68, https://doi.org/10.1093/biosci/biy137

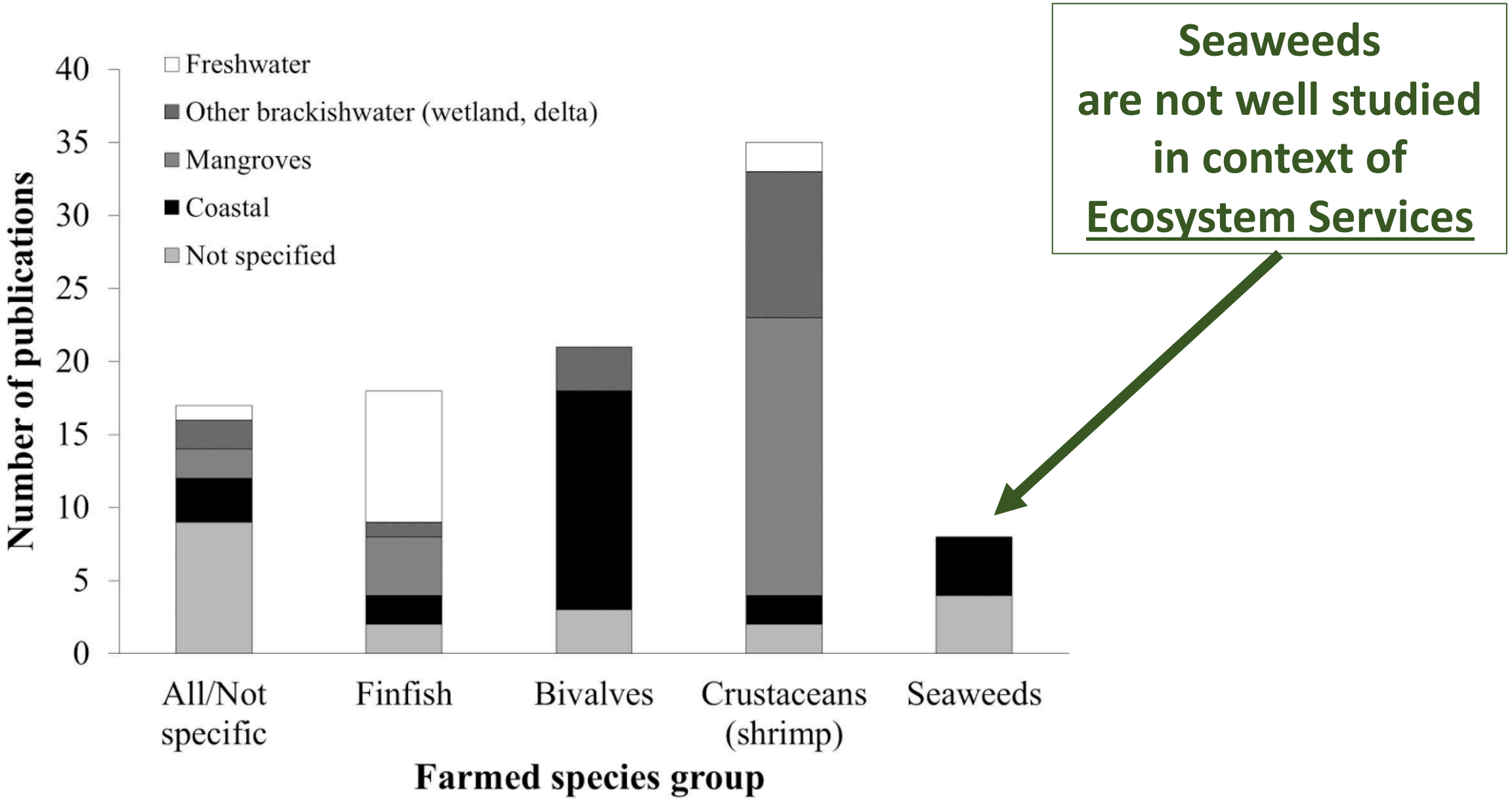
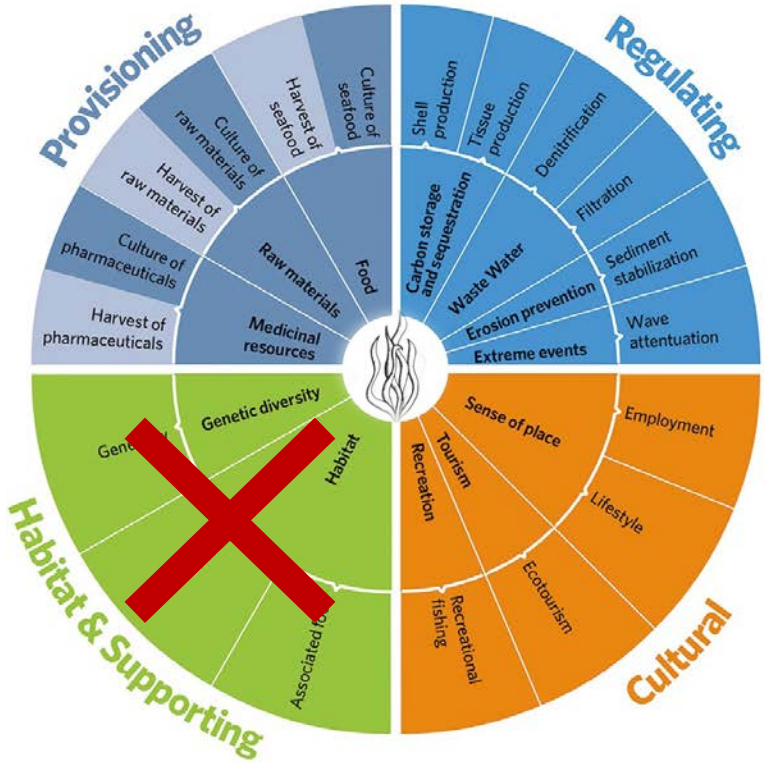


Fig. 4. Types of aquaculture studied in relation to ecosystem services, by farmed species group and habitat type (*N* = 98). *More than 94 papers since some articles referenced more than one group. (Weitzman 2019)

Ecosystem services for seaweed
are not well examined,
and when they are examined,
not all 4 services are considered.



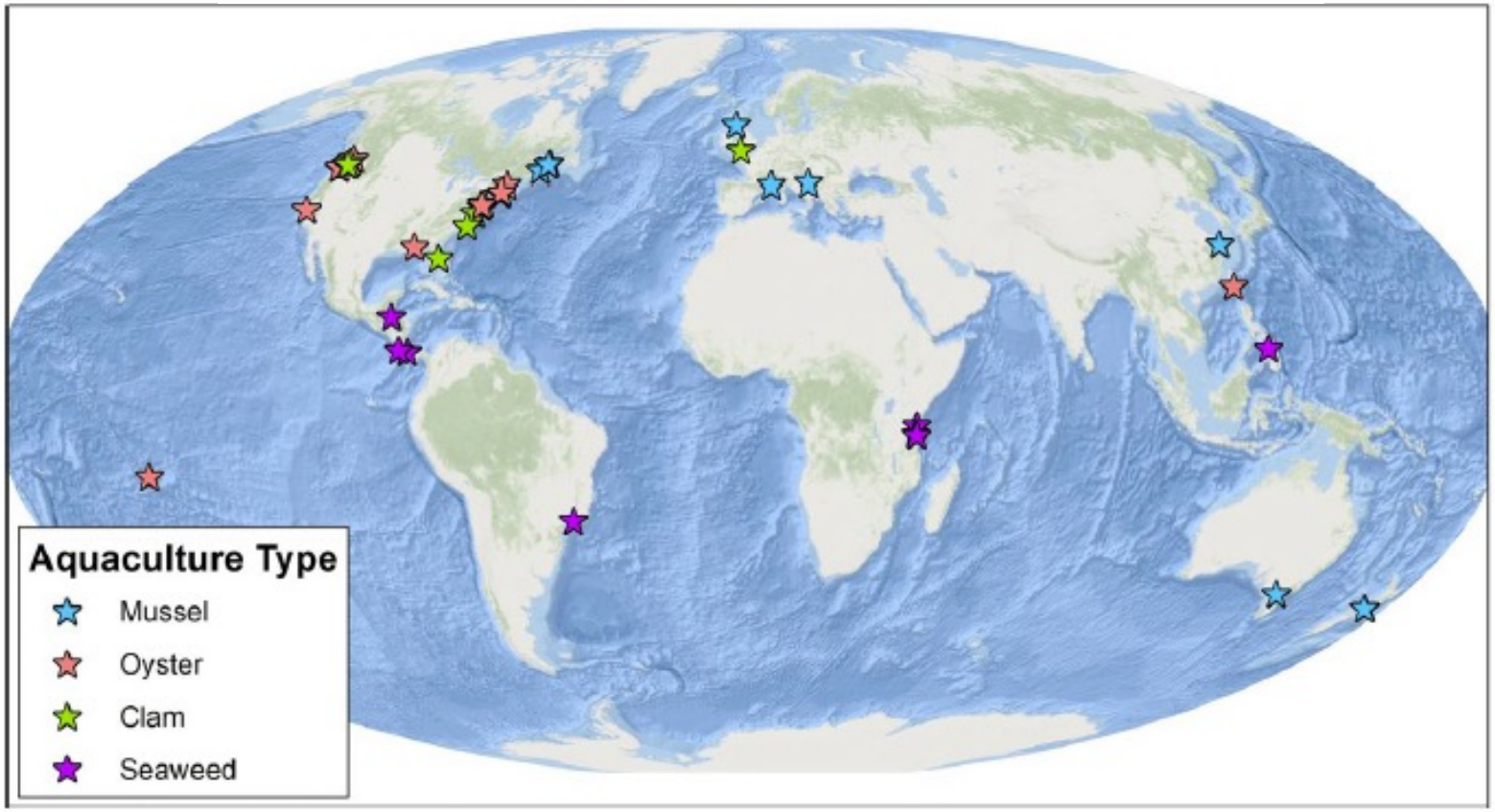
Received: 11 December 2020 | Revised: 7 April 2021 | Accepted: 10 May 2021
DOI: 10.1111/raq.12584

REVIEW

REVIEWS IN Aquaculture

Habitat value of bivalve shellfish and seaweed aquaculture for fish and invertebrates: Pathways, synthesis and next steps

Seth J. Theuerkauf[1] | Luke T. Barrett[2] | Heidi K. Alleway[3] | Barry A. Costa-Pierce[4] | Adam St. Gelais[4] | Robert C. Jones[1]



Tropical seaweeds

FIGURE 6 Map indicating the 46 unique locations worldwide associated with studies that examined fish and mobile macroinvertebrate populations at farm and reference sites that were identified within this study's systematic literature review

Ecosystem Services of Seaweed Farming for Fish through Habitat Creation

- Food for fish
- Protection for fish
- Attraction of fish
- Spawning support

Saccharina latissima in the North Sea

Table 5
The potential impact pathways of seaweed farming on fish community size. (+), (−) and (±) indicates respectively positive, negative and an undetermined effects on fish community size. The LPY indicators developed in this study relies on the pathway shown in italic characters.

Intervention	Changes in ecosystem patterns	Causalities	Effects on community size
Seaweed farming	Artificial reef creation	Food concentration	+
		Protection	+
		Attraction	+
		Spawning support	+
		Trophic structure changes	±
	Nutrients levels reduction	*Phytoplankton productivity*	−
		Toxic algae blooms mitigation	+

Preat et al. 2018

Concepts in Conservation:
Foundation of the Sea

What Are Foundation Species?

Foundation species are plants and animals that create and maintain habitats in which other species live. Like the foundation of a building, they provide structure and support to their ecosystems. Anything that threatens their well-being is likely to harm many other species as well.

What Makes a Foundation Species?

Beavers

By building natural dams on rivers and creating wetlands, beavers provide habitats for other wildlife, including many species of fish. The wetlands they create play a vital role in naturally removing pollutants from the water and absorbing carbon from the air.

Kelp

Kelp are large brown seaweeds that form dense underwater forests in rocky areas along the west coast of North America. These habitats provide food and shelter to a wide range of fish and other marine life.

Smithsonian Gardens

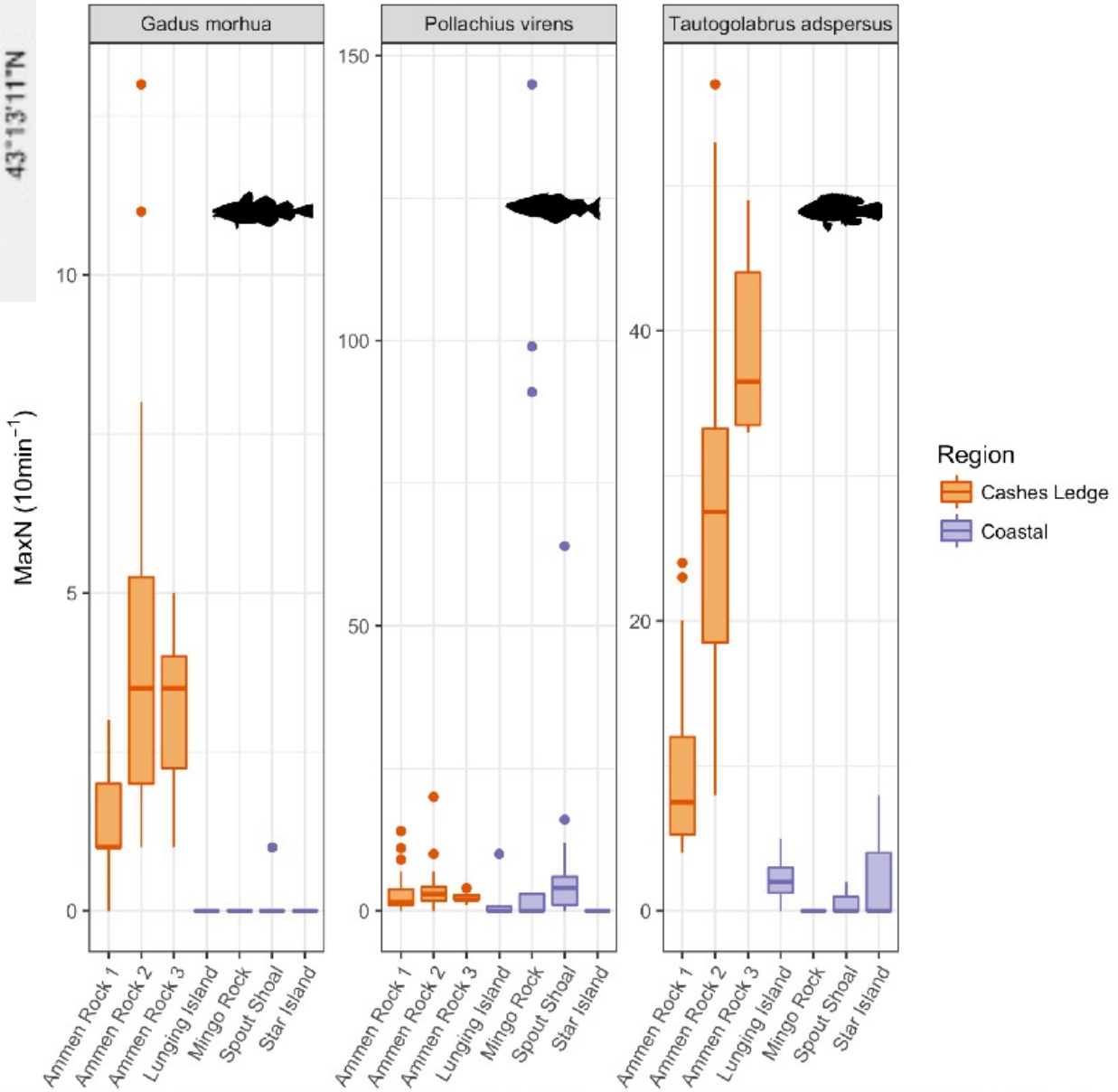
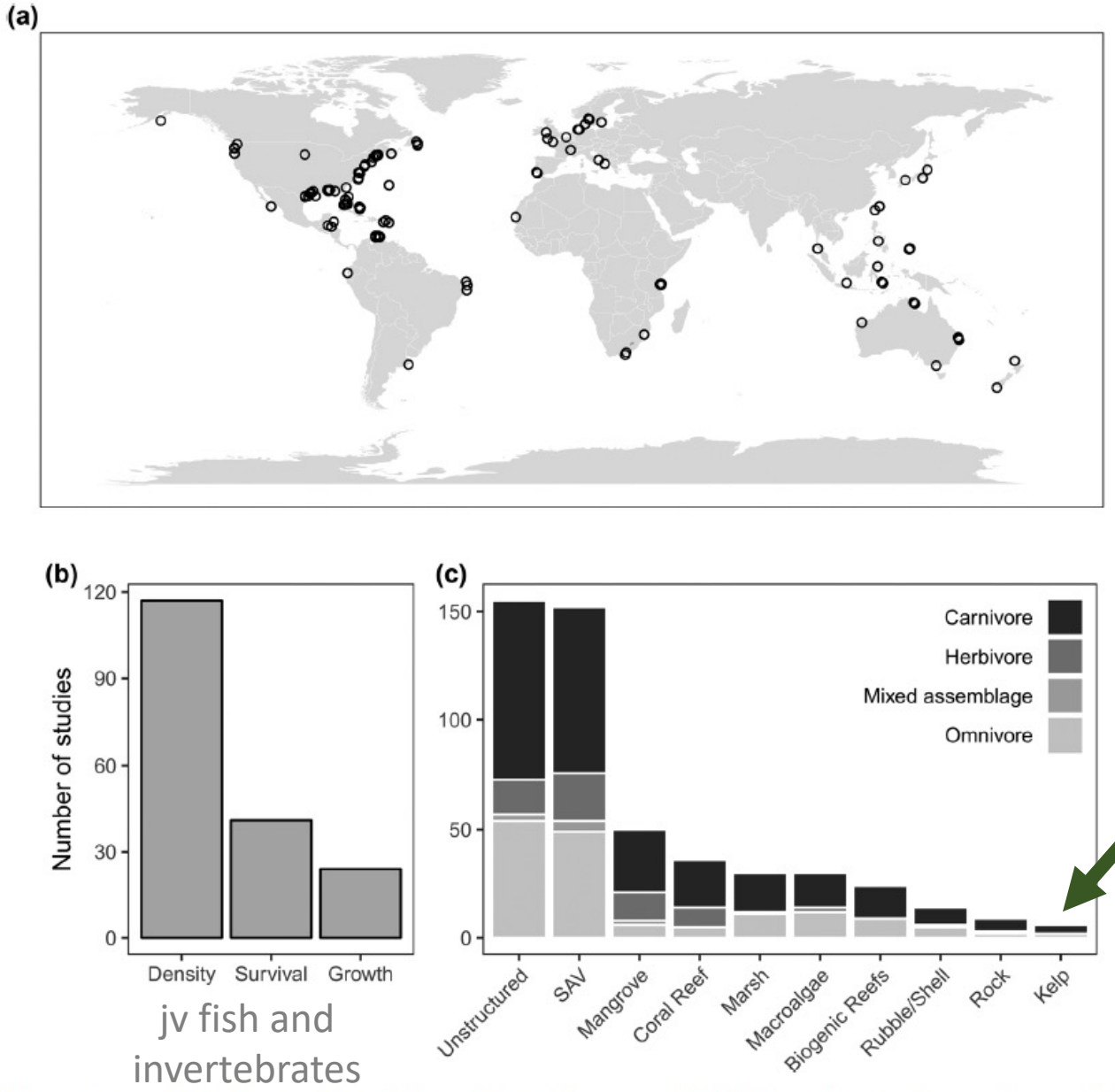


Fig 9. Abundance (maximum number of individuals observed in a single frame–MaxN–during a 10-minute segment) of the three fish species observed in stationary video deployments. Data are compiled for all years (2014–2016) to facilitate coastal to Cashes Ledge comparisons. Boxplots as in Fig 3. Note different scales on y-axes.

https://doi.org/10.1371/journal.pone.0189388.g009

Whitman & Lamb 2018



jv fish and invertebrates

Seaweeds are not well studied in context of fish habitat

FIGURE 1 (a) Geographic distribution of 160 studies used in the final meta-analysis. (b) The number of studies reporting on each of the three juvenile attributes (density, growth, and survival). (c) The number of studies reporting on different habitats, and the trophic composition within each habitat

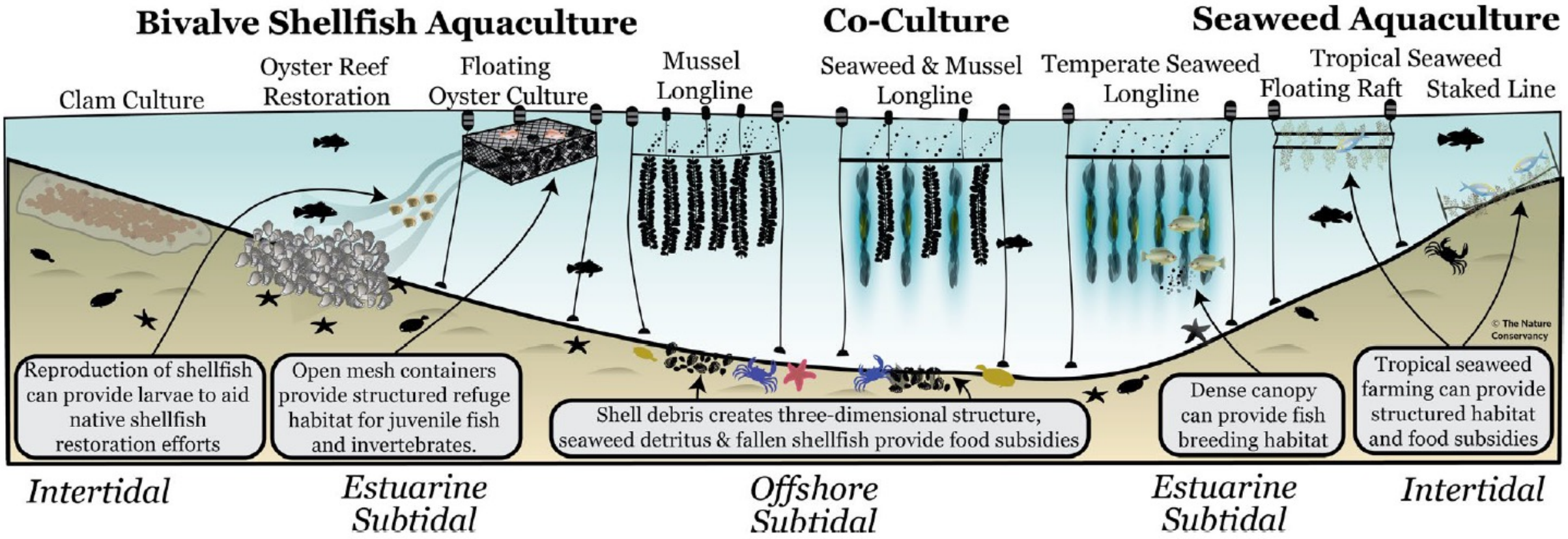


FIGURE 2 Bivalve and seaweed aquaculture production methods and mechanisms and pathways associated with habitat value

The Nature Conservancy

The Nature Conservancy

UNE UNIVERSITY OF NEW ENGLAND

INNOVATION FOR A HEALTHIER PLANET

THE UNIVERSITY OF AUCKLAND

Te Whare Wananga o Tāmaki Makaurau

NEW ZEALAND

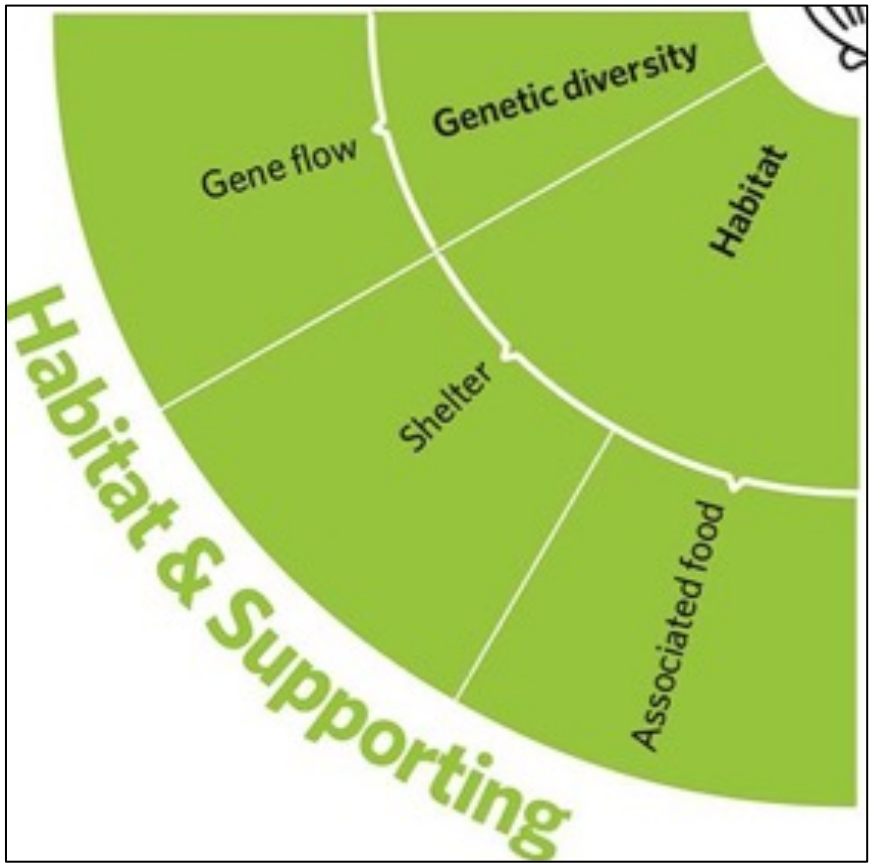
Objective

- Assess habitat creation as a supporting service to see how organisms may be interacting with the kelp biomass and its associated structure.

The Nature Conservancy

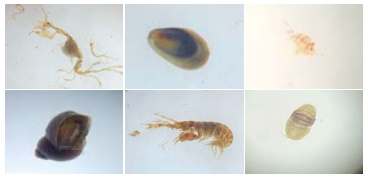
Emilly Schutt, TNC Fellow, UNE MS'2022

Methods: Overview

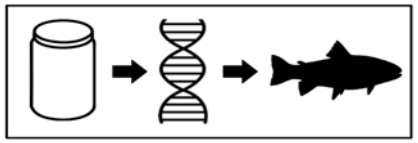


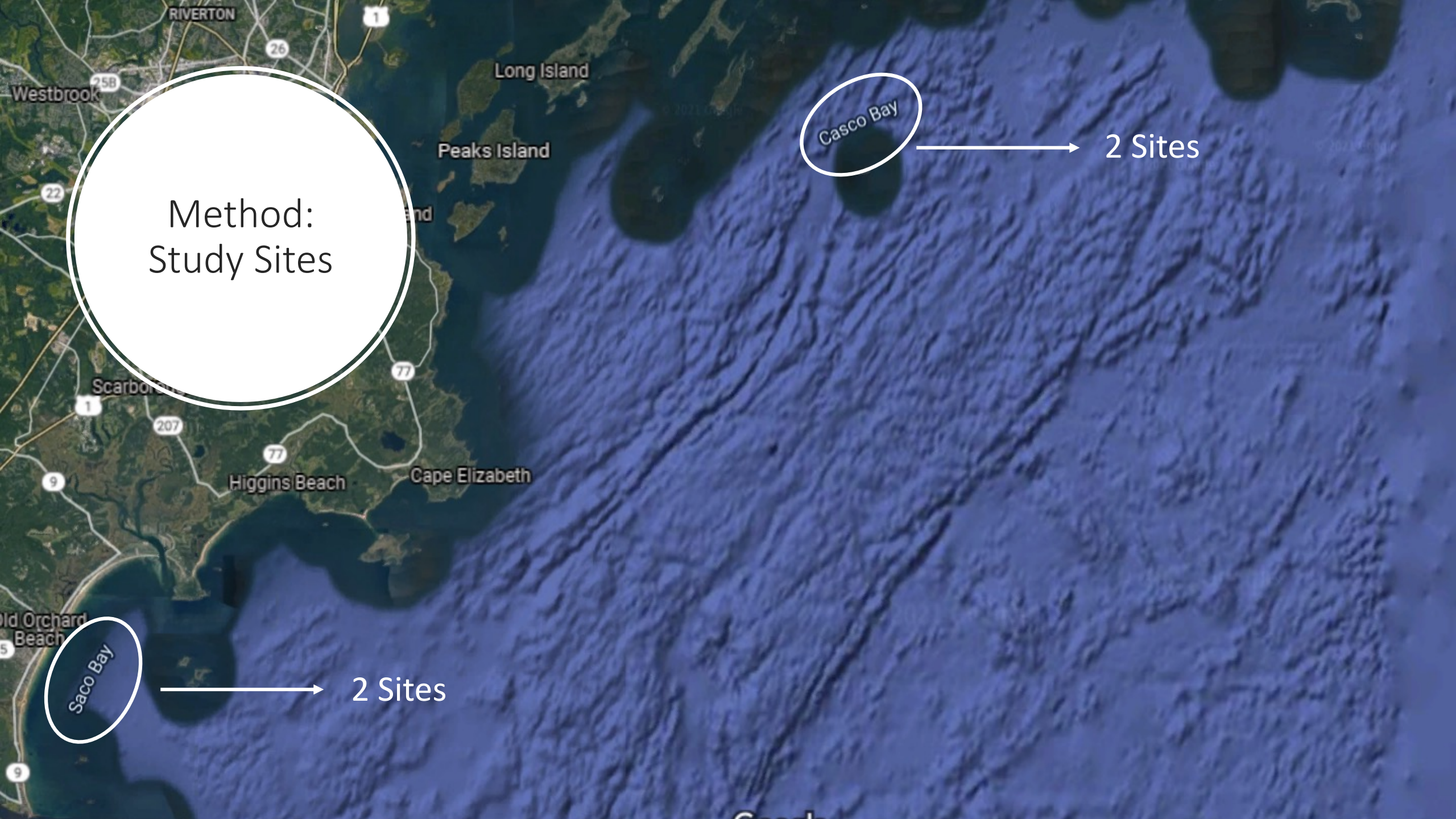
- GoPro camera Visual Survey's

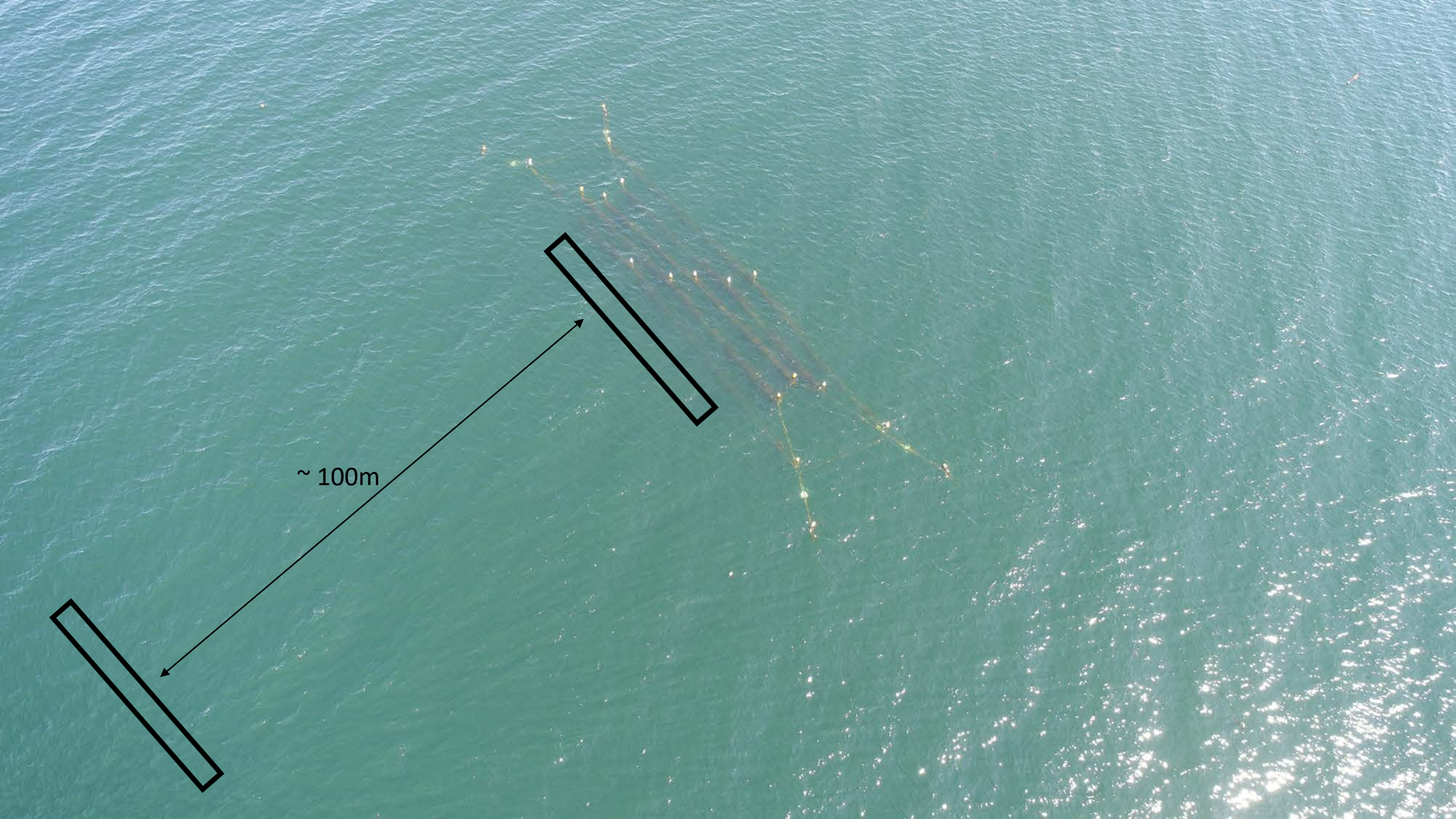
- Small Invertebrate Collections



- Environmental DNA (eDNA)

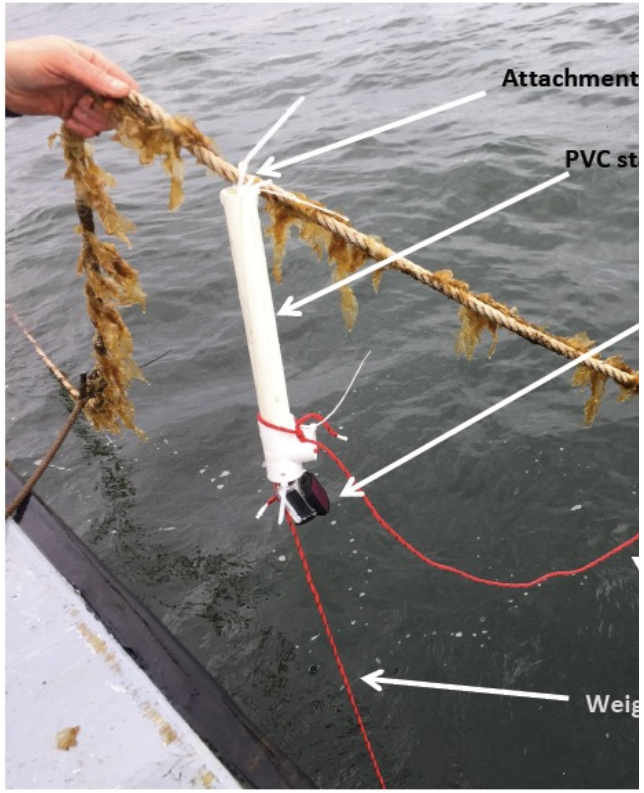


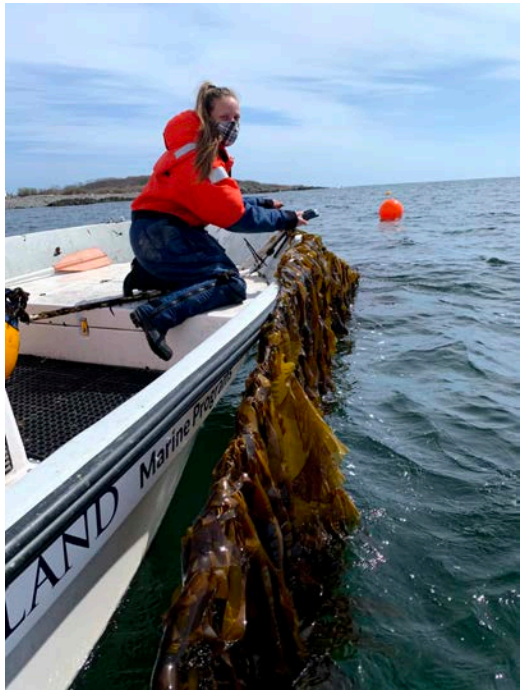

Method:
Study Sites
Casco Bay
2 Sites
Saco Bay
2 Sites
RIVERTON
Westbrook
Long Island
Peaks Island
Higgins Beach
Cape Elizabeth
Old Orchard Beach


~ 100m

Method: GoPro Visual Survey's

'Surface' Camera

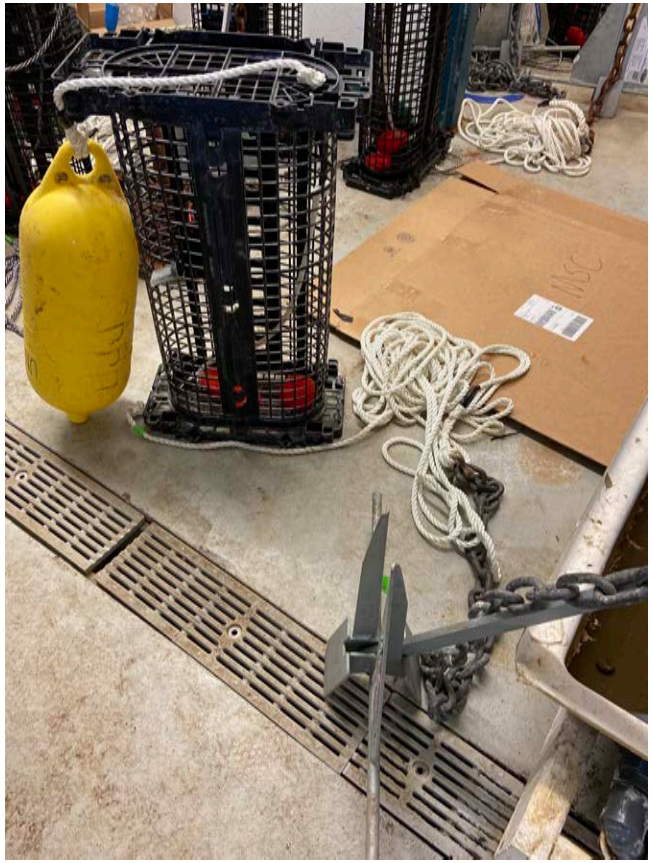


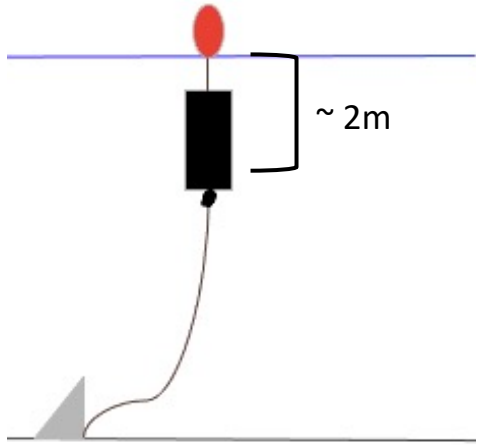


Benthic Camera

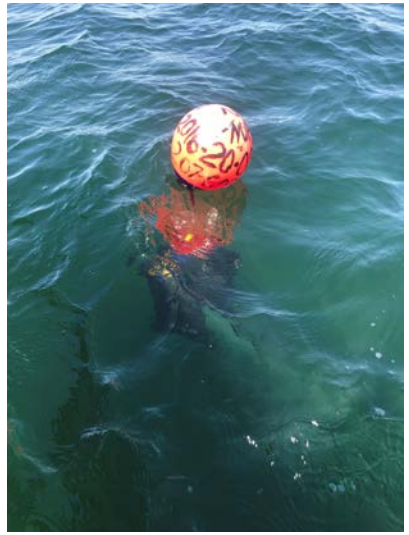
- Designed by: Simona Augyte and Jessica Couture

Method: Small Invertebrate Collections





Method: Small Invertebrate Collections



Growing Season:

- Peak Productivity
- Peak Biomass

Non-Growing Season:

- Early Summer
- Late Summer

Method: Environmental DNA: Background

- DNA extracted from the environment
- Soil and water samples
- Shed skin cells, urine, feces, and mucus

Image: FishBio, 2015

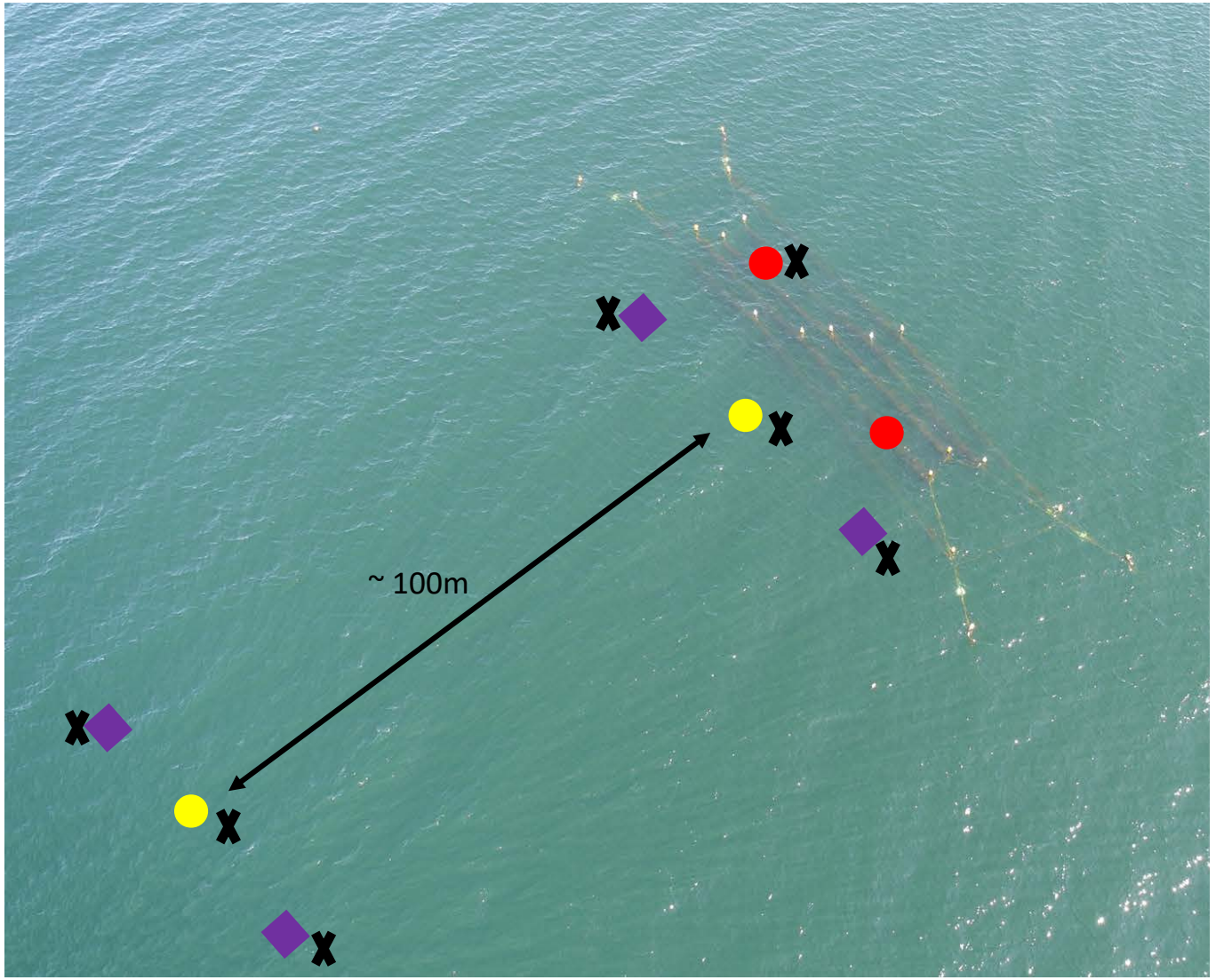
Traces left behind - FISHBIO Fisheries Research, Monitoring, and Conservation

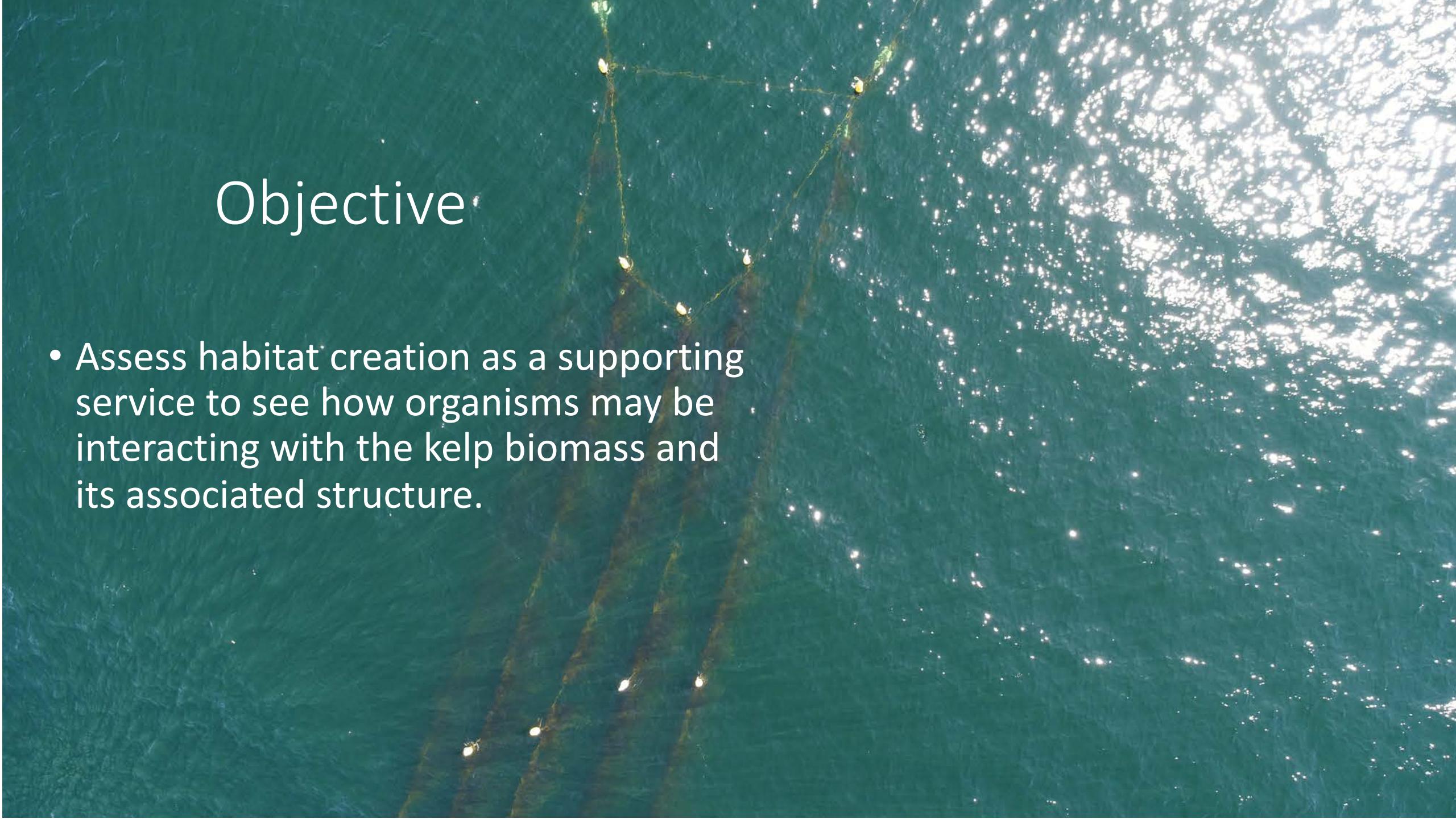
Method: Environmental DNA

(with GoPro visual surveys and small invertebrate collections)

Key

- Surface camera deployed
- Benthic camera deployed
- Invertebrate collector deployed
- eDNA sample collected





Objective

- Assess habitat creation as a supporting service to see how organisms may be interacting with the kelp biomass and its associated structure.

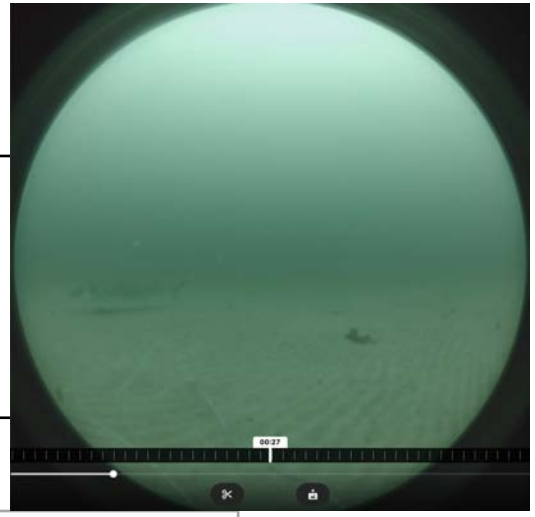
Results: GoPro Visual Survey's

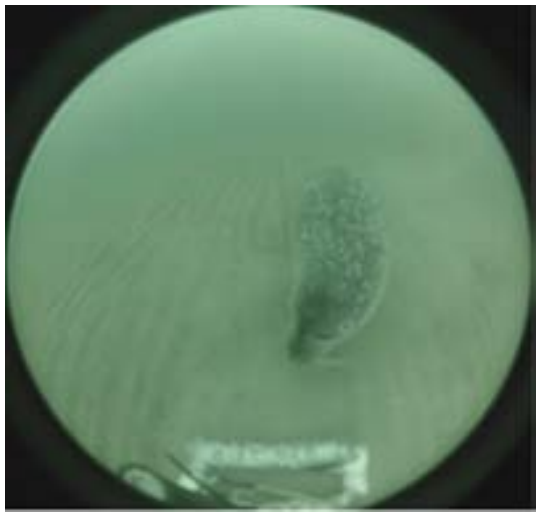
Data Organization:

- Total number of organisms (Abundance) sighted per camera.

Camera Drop Duration: 1.5 to 3.0 hours.

- Variation due to:
  - Weather
  - Equipment malfunction





Results: GoPro Visual Survey's

Question:

- Is there a relationship between Abundance and Drop Duration

Simple Linear Regression

- Response Variable: Abundance
- Explanatory Variable: Drop Duration

- No. Regardless of how long the cameras were deployed (1-3 hours), there was no difference in the number of fish/crabs/lobsters observed.

Results: GoPro Visual Survey's

Questions:

- Are there differences in Abundance between Areas?
- Are there differences in Abundance between Bays?

Multi-way ANOVA

- Response Variable: Abundance
- Explanatory Variables: Area and Bay

- No. There was no difference in the abundance of fish/crabs/lobsters observed in the farm or in analogous non-farm sites. There was no difference observed between Saco and Casco bays.

Results: GoPro Visual Survey's

Question:

- Are there differences in Abundance when gear is absent vs. when gear is present.

One-way ANOVA

- Response Variable: Abundance
- Explanatory Variable: Gear

- Yes. There was a difference in abundance of fish/crabs/lobsters observed at farm sites when farm gear was deployed vs. when there was no gear in the water (i.e. summer).

Results: GoPro Visual Survey's

Question:

- Is there a difference in Abundance when seaweed biomass amounts are different? (None, Seeded, Biomass)

One-way ANOVA

- Response Variable: Abundance
- Explanatory Variable: Biomass Amounts

- Yes. There was a difference in abundance of fish/crabs/lobsters observed at farm sites when there was abundant seaweed (Feb-Apr) vs when there was no seaweed or gear in the water (summer).

Results: GoPro Visual Survey's

Question:

- Are there differences in Abundance as water temperature changes?

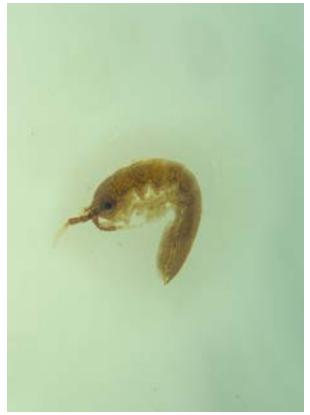
Simple Linear Regression

- Response Variable: Abundance
- Explanatory Variable: Temperature (F)

- Seasonal temperature change is likely the strongest explanation for why we see differences in abundance of fish/crabs/lobsters at farm sites.

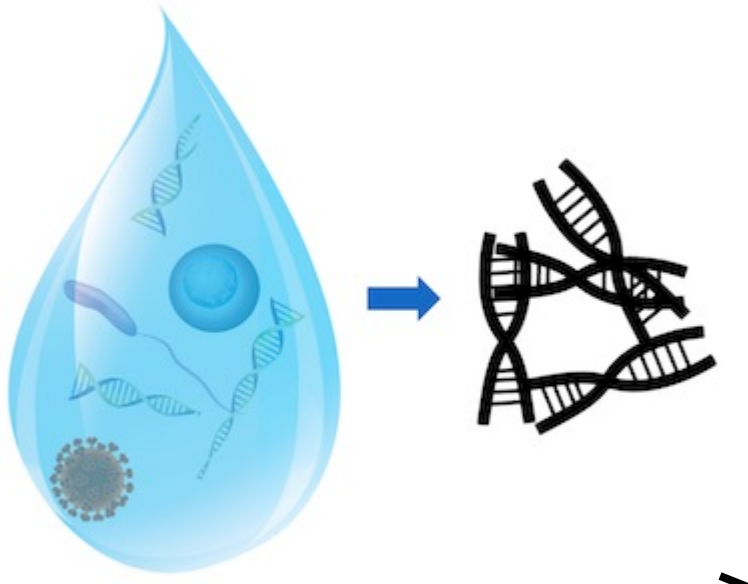
Method: Small Invertebrate Collections





Method: Environmental DNA



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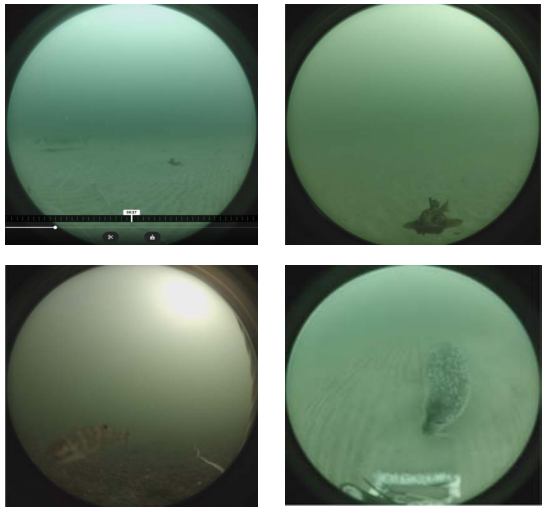

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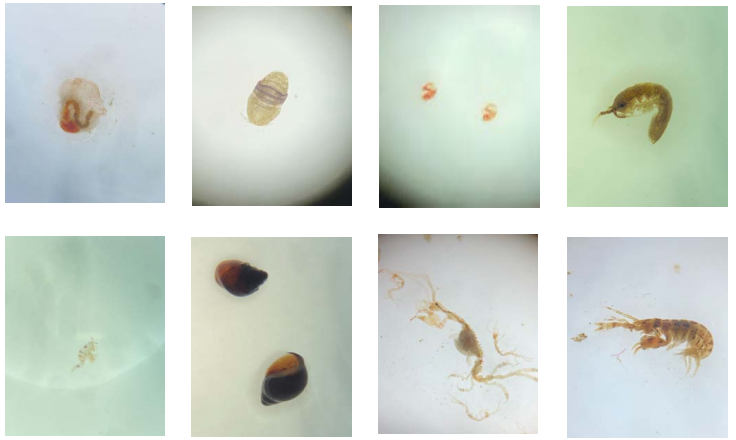
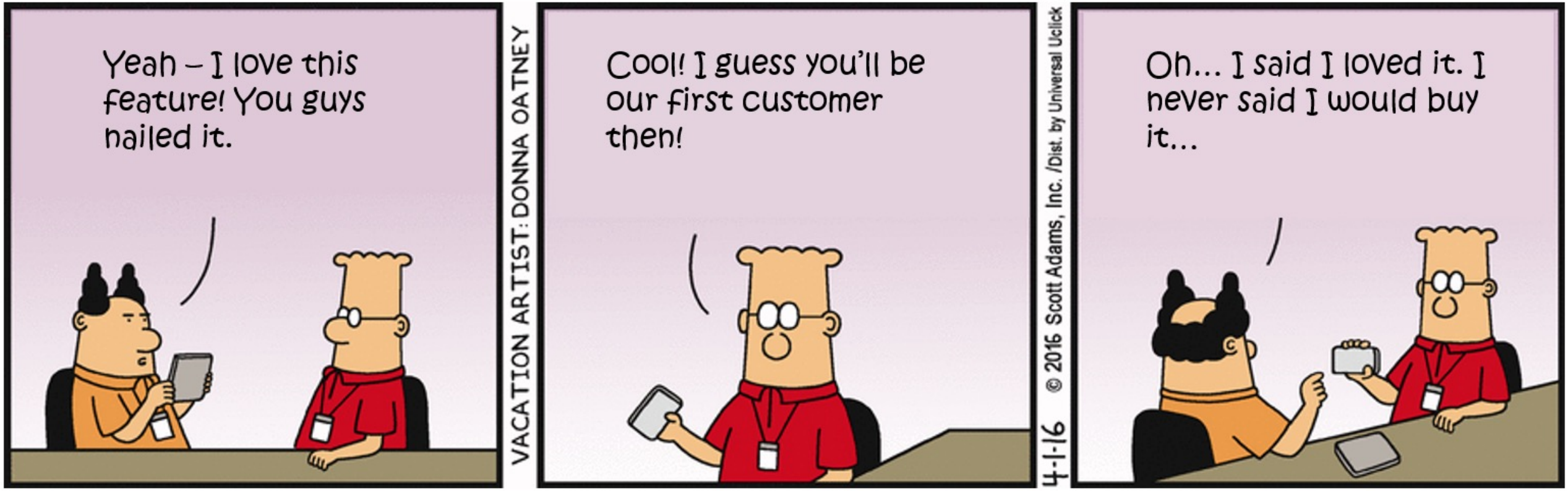


So what?

SOCIAL LICENSE

So what?



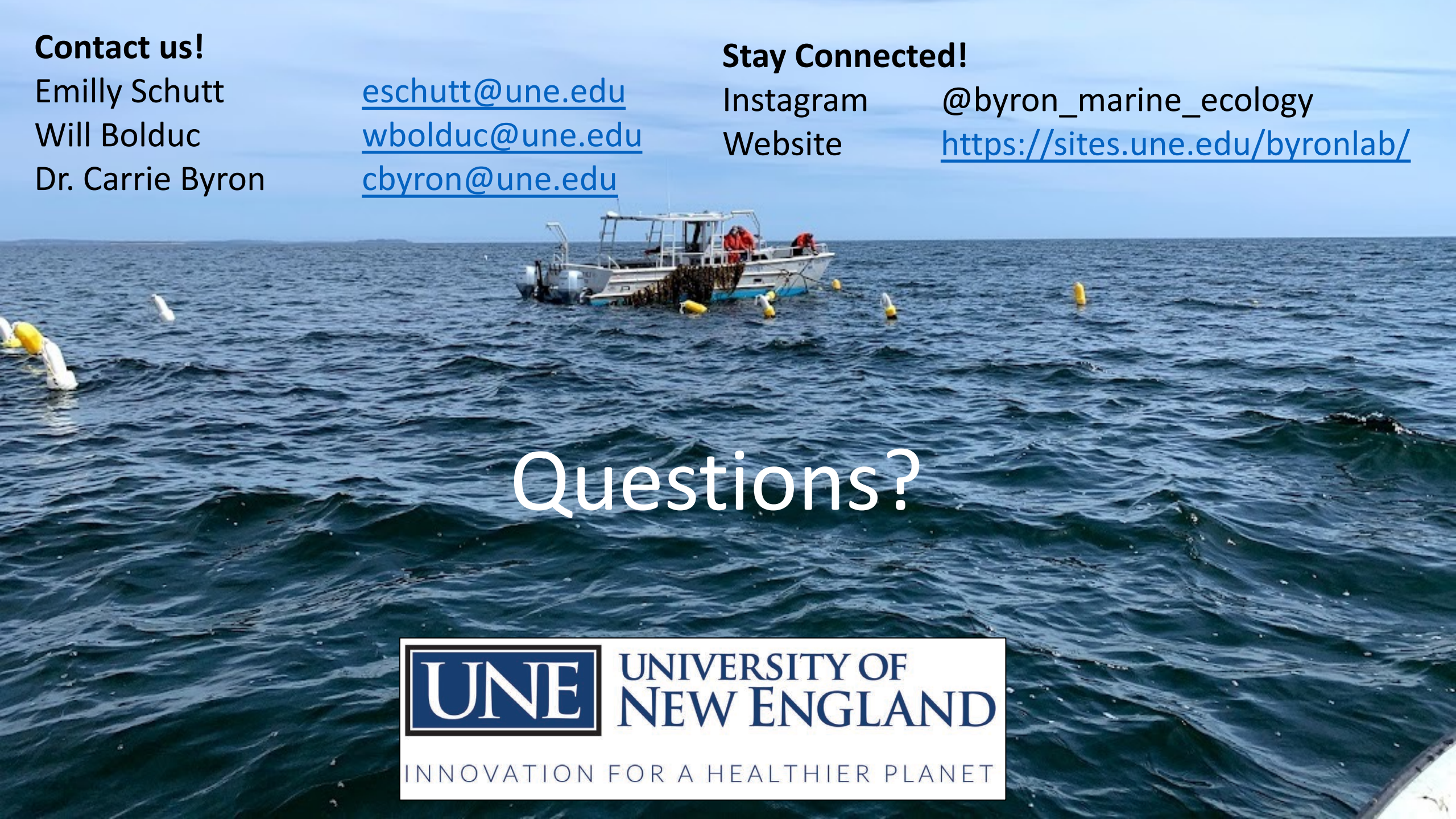
Willingness to Pay

Recent Literature on Willingness to Pay

The Nature Conservancy

Will Bolduc, TNC Fellow, UNE MS'2022

- "...to increase organic food consumption efforts should be made, to communicate health, as well as environmental and social benefits related to the production and consumption of such food, focusing on younger consumers as key stakeholders in the transition towards more sustainable food systems." (Azzurra et al. 2019)
- "The results indicate a positive and significant marginal societal willingness to pay for the ecosystem services associated with kelp forest restoration." (Hynes et al. 2020)
- "The experiment demonstrates that the Irish public has a willingness to pay a price premium for sustainability in salmon farming and for locally produced salmon." (Osch et al. 2017)



Contact us!

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Website https://sites.une.edu/byronlab/

Questions?

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