



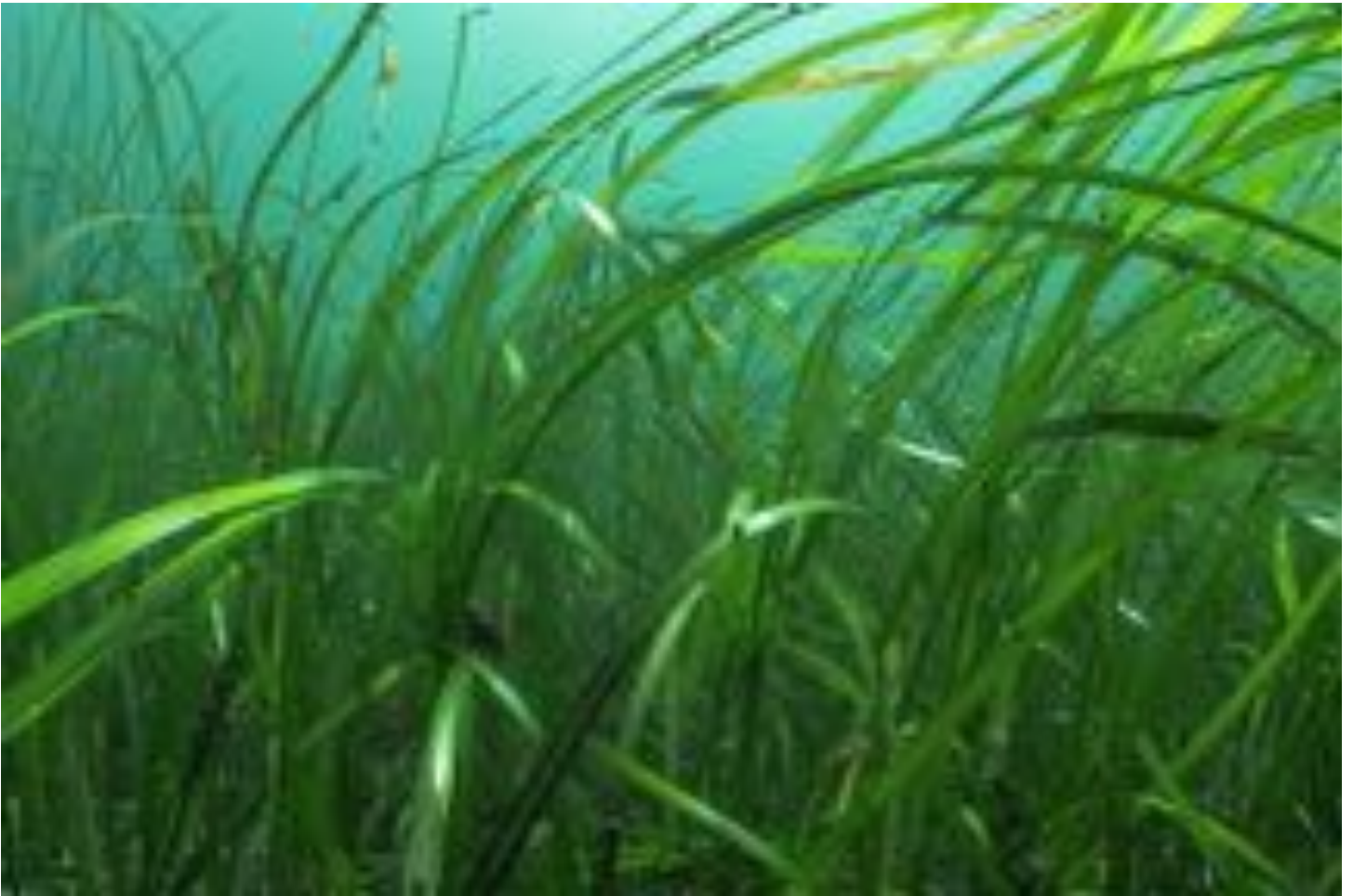
## Swimming with Seagrasses



# Swimming with Seagrasses

A journey through the Casco Bay bioregion. A tale of nested communities.

**Fatema Alkhalifa, Phoebe Brown, Kate Mason, and Belkis Montas**  
**April 7, 2023**



## Prologue...

Imagine...You are sitting in a lush forest. Left and right, plants tower over your head. Bright sun rays sweep across your face and the sky sparkles gently above you, a watercolor painting in hues of blue. You feel a sense of calm as you sway slightly with the strange greenery around you.



Bubbles drift along the leaves like butterflies and bees and a gaggle of minnows dart in and out of the shade. You are underwater. And this beautiful place you find yourself in is a seagrass meadow.



Now...Settle into this leafy land as we tell you a tale—of seagrass, food systems, and environmental stewardship...Let us now set sail!



**Where is this seagrass meadow?**

Let's zoom out a bit!



**More!**



**A Little More!**



**And We're Here In the**

**Casco Bay, Maine Bioregion!**





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Casco Bay, Maine

Team Zostera was formed with the intention of employing citizen science in an effort to map and monitor the health of eelgrass meadows in Casco Bay, Maine, the overarching goal being to increase local stewardship of these vastly important, yet fragile, ecosystems.

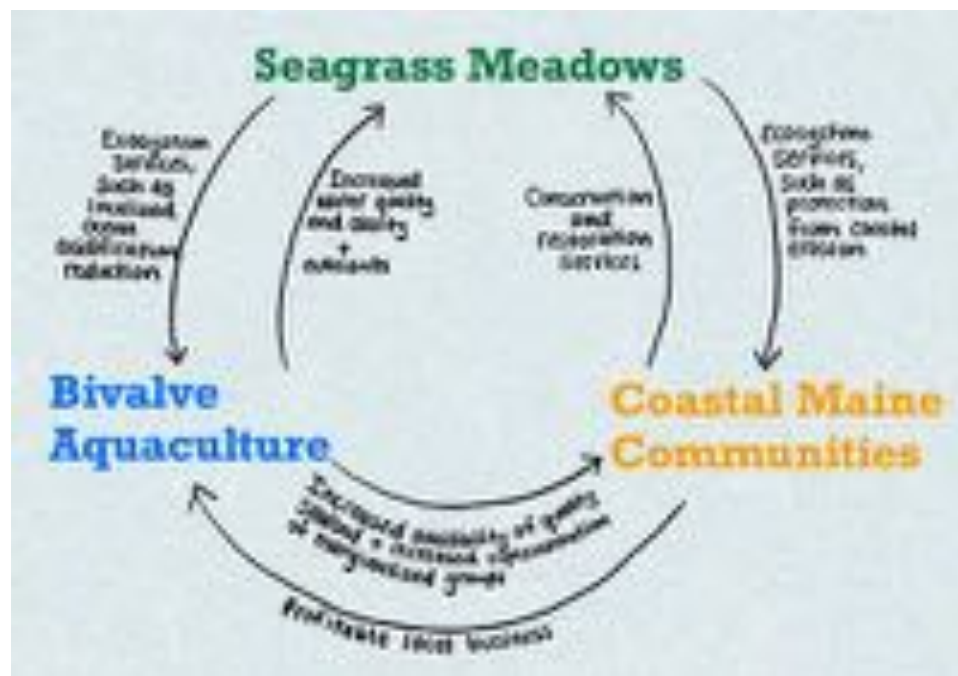
**[Click Here to Find Out More!](#)**

## What is a Bioregion?

If nature could make borders like people do, where would it place them? While it's human nature to categorize things, the natural world does not follow rigid boundaries. A bioregion encompasses a network of nested ecological systems and human communities,

spanning across land, freshwater and ocean systems—the one thing that connects them is a constant dynamic exchange. It is a region that is not only shaped by its physical environment, but also by the cultural, social, and economic characteristics of the people who live within it.

The meadow we are in is situated within a bioregion, interacting with creatures from and sea, far beyond political boundaries. In fact, because seagrasses interact with such a diversity of actors in innumerable ways, they play an essential role in determining the health of any given bioregion.



A circular story of interconnections within the Casco Bay Bioregion...

**Here are some of the ways it does this...**



## Seagrass Services

What Are Seagrasses and What Do They Do For You?



## What are Seagrasses?

Despite their common name, seagrasses are flowering plants with a genetic lineage that runs closer to that of lilies and orchids. It grows mainly in shallow marine and brackish waters throughout the world, occupying tropical, temperate and even Arctic areas.



## Nursery Habitats

Seagrass meadows serve as crucial nurseries for fish and other marine organisms, providing their young with both food and protection from predators. In supporting these nursery grounds, seagrass meadows support fisheries across the globe. In fact, around 20% of the world's biggest fisheries are supported by seagrass meadows!



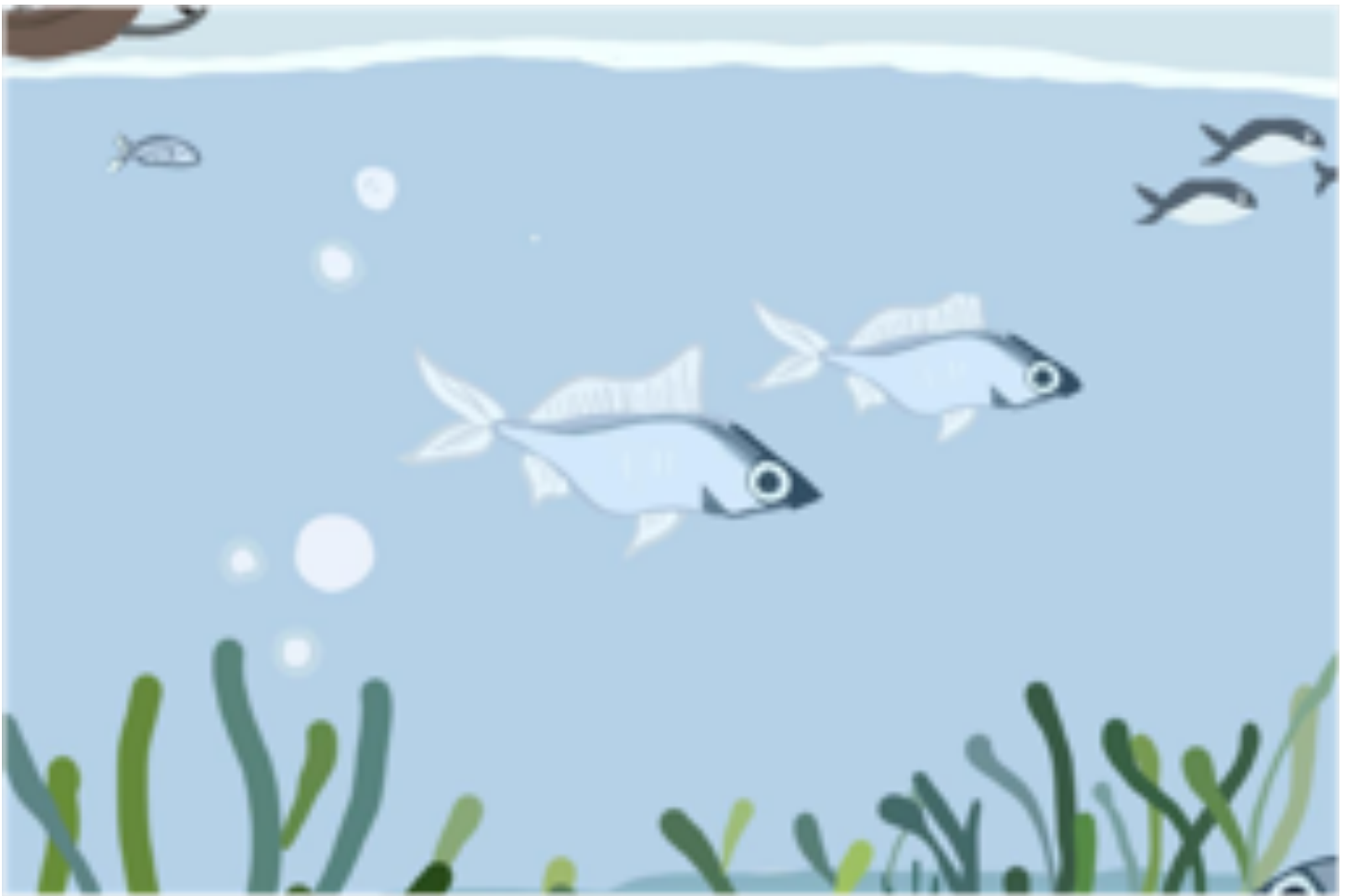
### **Protection from Coastal Erosion**

Seagrass meadows also help absorb wave energy and stabilize coastal sediments, protecting coastal communities and ecosystems, alike!



## Natural Water Filters

Seagrass meadows serve as a filter within the water column too, contributing to improved sanitation and water quality through the local removal of bacteria and viruses.



## Climate Change Mitigation

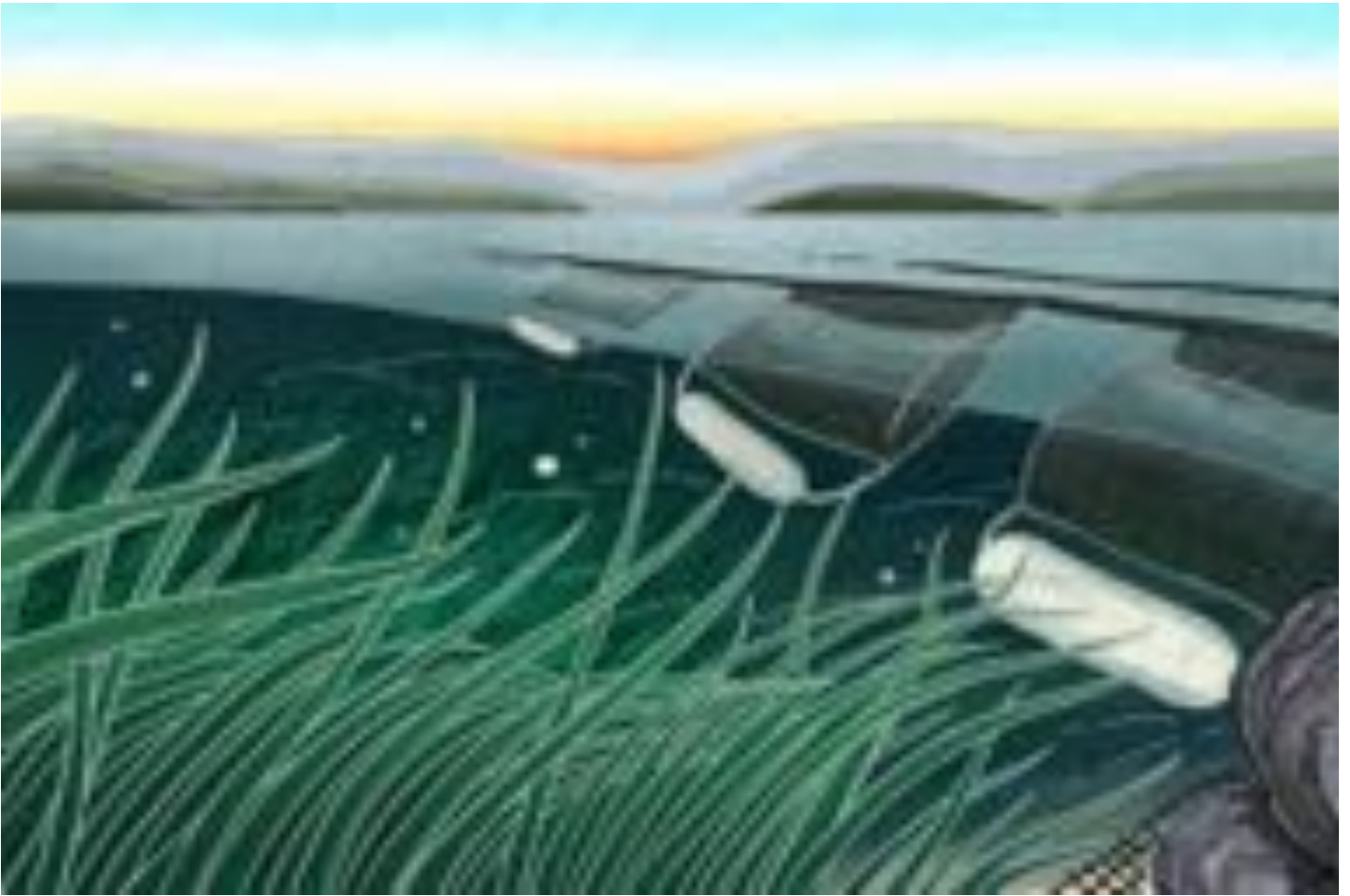
Seagrass meadows can even help combat global climate change! These leafy ecosystems can act as carbon sinks, removing carbon dioxide from the atmosphere as their sediments rapidly accumulate, bury, and store carbon over hundreds to thousands of years. In fact, thanks to their effective ability to trap and bury organic matter, seagrasses can concentrate and store greater volumes of carbon faster than terrestrial forests! But that's not all...



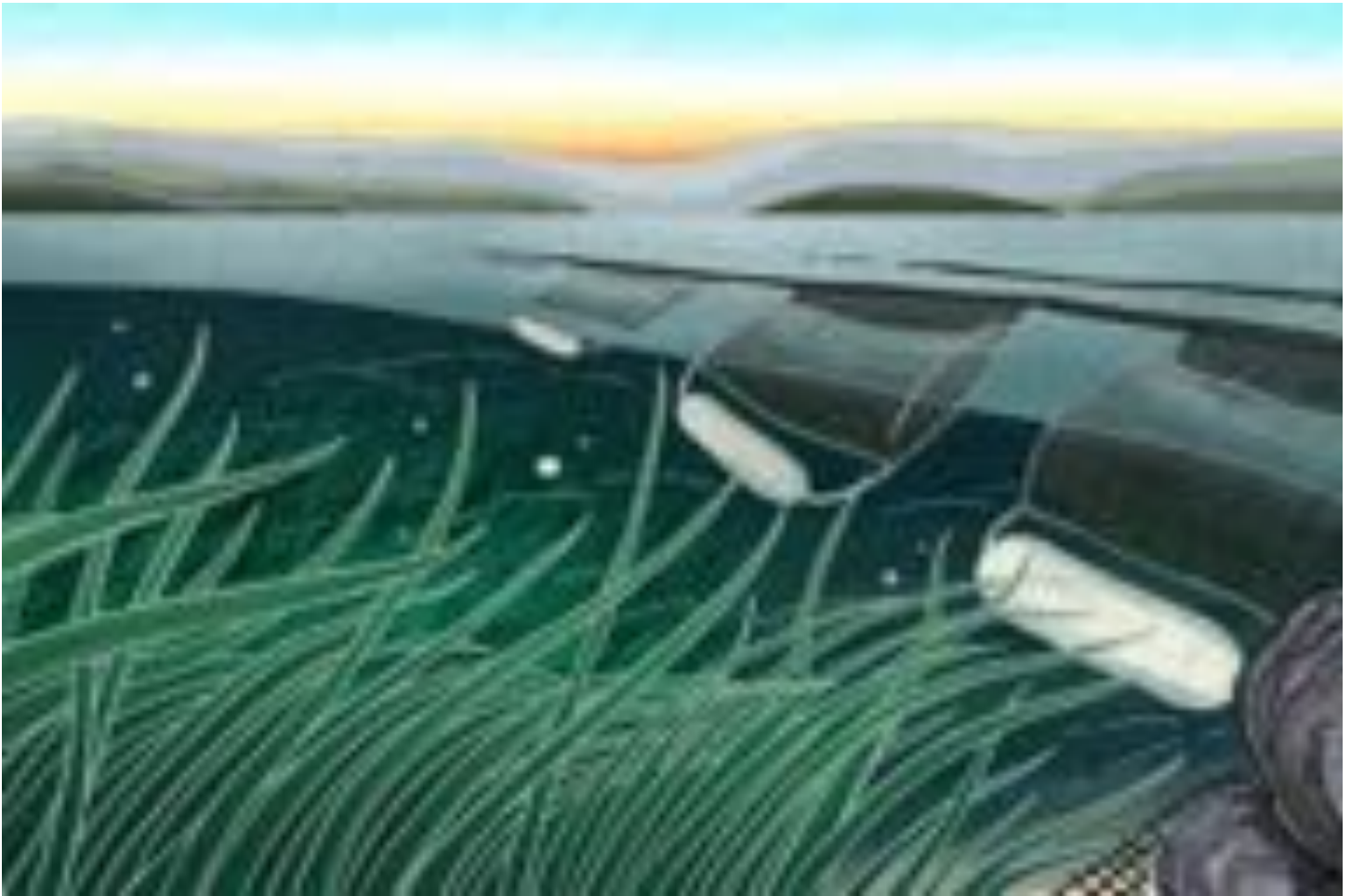


## Ocean Acidification

With their powerful carbon sequestration abilities, seagrasses have been found to reduce the local impacts of ocean acidification caused by climate change! This amazing service helps calcifying organisms, such as mussels, scallops, and oysters, to better survive, as the more acidic oceans become, the harder it is for them to build and maintain their shells.



As you run your hands through the soft leaves of the seagrass around you, your gaze is suddenly drawn upwards. There is movement at the water's surface. The bottom of a boat pulls into view and a black, cage-like structure is placed into the water, bobbing up and down before floating just at the surface.



This structure, you realize, is part of an aquaculture farm—a vast network of floating cages where oysters will soon be bountiful. This seagrass meadow will now be sharing its waters with a growing industry.

## Shifting Tides: The Growing Aquaculture Industry

Aquaculture represents a growing industry in Maine and across the world. Between 1988 and 2018 marine aquaculture production increased globally from 6.95 to 33.95 million tons of aquacultural products harvested each year, and since 2016 “aquaculture has supplied the majority of seafood produced for human consumption worldwide.” The ongoing growth of this industry can be primarily attributed to declines in wild-caught fisheries, more affordable product pricing, expanding global trade networks, rising incomes, increased urbanization, and, underlying all of these elements, a significant increase in seafood demand worldwide.

Given this increasing demand and positive industry outlook, many nations are now attempting to expand their aquaculture industries. On the global stage, the U.S. aquaculture industry continues to lag behind those of many other nations, “ranking 17th in worldwide aquaculture production,” however the state of Maine, with its notable maritime heritage and enduring working waterfront infrastructure, is one of the “epicenters for aquaculture in the country,” their total annual harvest valuing between \$85-\$110 million each year and expected to increase to a net value of \$230–\$800 million by 2025. Aquaculture is thus expanding its presence within local food systems across Maine, including the Casco Bay area. In fact, within Maine currently, the “aquaculture industry overall represents nearly 200 farms and more than 700 farmers who produce premium seafood—fin fish, shellfish, and sea vegetables—in Maine’s cold, clean waters”.



Aquaculture production

## A Social-Ecological Approach

Given the bioregional nature of aquaculture development itself—an industry that fosters interactions between a variety of human stakeholders, in addition to actors within the natural world, such as seagrass ecosystems—it is important to view this sector of the Maine food system as a “classic coupled social-ecological [system],” which can be understood by “integrating biophysical, social, and engineering sciences with stakeholder knowledge.” Virtually every system you can think of can and should be considered as coupled in nature, where every actor and stakeholder must work together in order for everyone to benefit.

In looking at how aquaculture influences the social components of the Casco Bay bioregion, it must first be noted that within established fishery industries closely related to those of aquaculture, many ingrained inequalities and injustices exist concerning the participation of women, minority and indigenous peoples. The perspectives and experiences of the members of these groups are perpetually unheard, undervalued, and underrepresented. In Maine today, the seafood “sector is largely dominated by males and there is limited representation of minority populations,” as well as Indigenous peoples. For these marginalized groups, this lack of representation often results in the silencing of their voices, making it harder for them to persist, little less benefit, from the current state of Maine’s seafood sector.

However, aquaculture might offer an intriguing shift in this existing system. In fact, there is hope that the expansion of the aquaculture industry in Maine might create a more inclusive, equitable environment for members of marginalized communities, allowing them to add their voices to Maine’s seafood sector. For instance, sustainable aquaculture has been found to be four times more accessible to women in Maine than the prized lobster fishery! Moreover, women have been able to obtain significantly more representation in the aquaculture industry than in the lobster fishery, such that “All aquaculture associations [include] leadership that [is] at least 30% female, while no lobster association [includes] more than 30% female leadership.” Supporting the diverse array of

people who work in the growing aquaculture industry not only increases the visibility of societally marginalized groups but also helps to create a just and equal environment where the well-being of communities and the ecosystems around them can be supported.



Another floating cage splashes into the water above you and the seagrass meadow...



As you peer up, you notice the farmer who is setting up this aquaculture operation...



## Women in Aquaculture

Let's take a look at some of the incredible organizations who are elevating the voices of marginalized groups in the aquaculture sector and encouraging their participation in this growing part of Maine's seafood industry!





## **Lady Shuckers**

Lady Shuckers is a mobile oyster raw-bar and event catering company based in Portland, Maine. They source their oysters directly from women-owned aquaculture farms throughout Maine and aim to provide an exceptional raw-bar experience while making more visible underrepresented groups who operate on Maine's working waterfront.



## Wolfe Neck Oyster Company

Based in Casco Bay, Maine, Wolfe Neck Oyster Company is a woman-run oyster farm that provides sustainably cultured products for individual sale, restaurant, and wholesale. Their oysters are grown in a cove located between Cousins Island and Little John Island, of which they have actually observed a resurgence of seagrass in over the years!



## **Nauti Sisters Sea Farm**

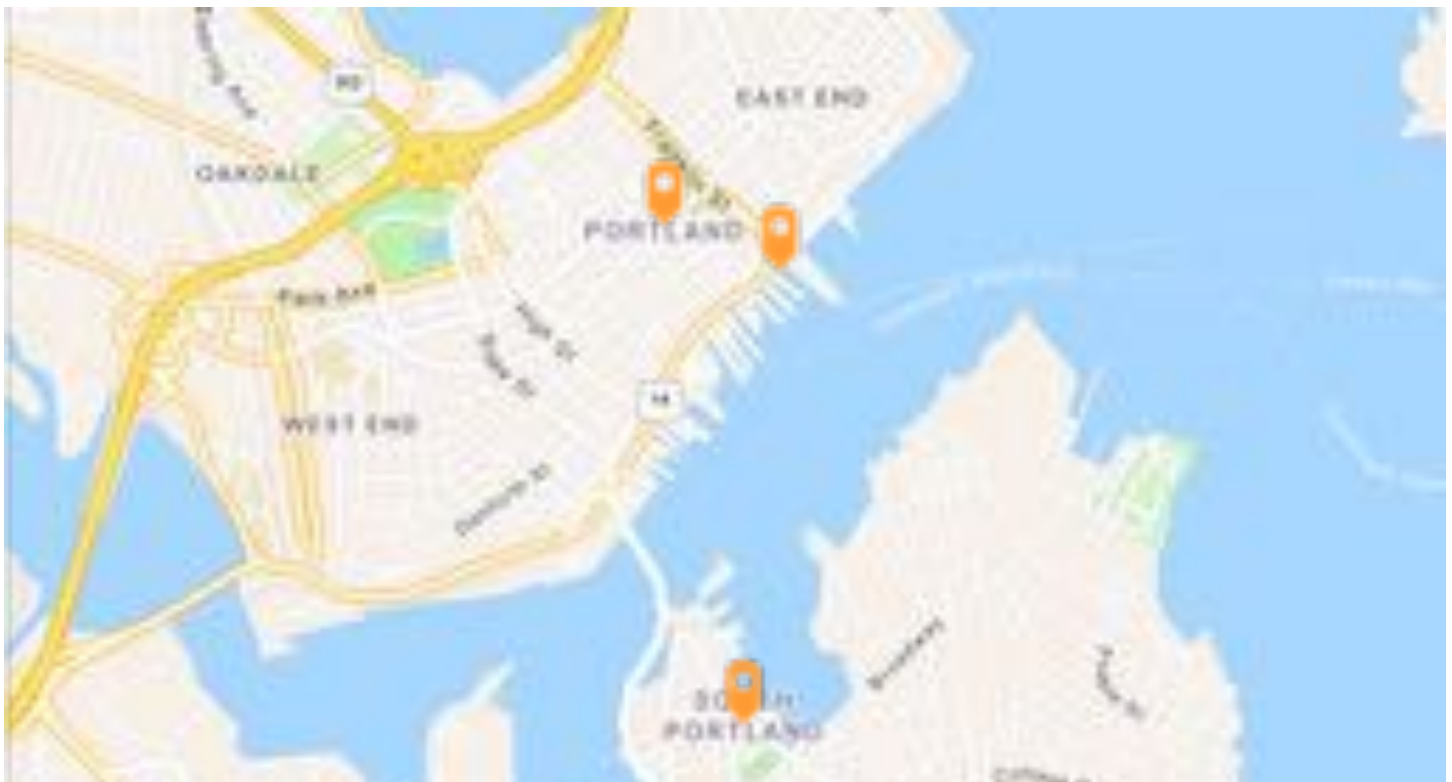
Based in Yarmouth, Maine, [Nauti Sisters Sea Farm](#) is small-scale, woman-run aquaculture operation that produces oysters and scallops, as well as a variety of related products, such as sea-themed decor and shucking kits.



## Minorities in Aquaculture

Minorities in Aquaculture is a nonprofit organization that aims to teach minority women about the environmental benefits provided by local and global aquaculture operations in order to promote a more diverse, inclusive aquaculture industry. They serve all women and gender non-conforming people that are interested in pursuing a career in aquaculture, providing services such as live and virtual workshops, training and certification assistance, academic and professional mentoring, networking, access to job postings, and mini-grants for women of color beginning careers in one of the multidisciplinary fields of aquaculture (finfish, shellfish, seagrass, microalgae, etc).

### **Find These Organizations in Maine!**



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## Meet the Neighbors: Seagrass and Aquaculture

At the other end of this social-ecological framework, let's look at how aquaculture impacts the environment—more specifically, our seagrass meadows! The impacts of bivalve aquaculture (i.e. the farming of oysters, scallops, mussels, etc.) on seagrasses tend to range, depending on the type of farming practices employed. To find out more about these complex interactions, we interviewed Dr. Katie DuBois, the Doherty Marine Biology Postdoctoral Scholar at Bowdoin College's Schiller Coastal Studies Center.

In our interview with Dr. DuBois, she spoke with us about her research regarding the relationships between eelgrass (the most common species of seagrass in Casco Bay) and oyster and blue mussel aquaculture. She revealed to us that one of the positive interactions that takes place between bivalve aquaculture and seagrasses includes how bivalves increase local water quality and clarity via their filter feeding, allowing for more light to penetrate

through the water column, encouraging seagrasses flourish as they are highly dependent upon the availability of light for their survival.

“

*“When you talk to oyster farmers in Casco Bay, a lot of them say that oysters clean up the water clarity. So that could be due to high rates of filtration.”*

In addition, as they grow, bivalves increase the nitrogen, phosphorus, and carbon dioxide concentrations of the water around them, which are nutrients that seagrasses need to grow and photosynthesize.

“

*“We can think about oysters, especially oyster farms, as basically little nutrient slow-release packets raining down nitrogen onto the seagrass meadow.”*

She also talked with us about the trade-offs between these positive interactions and negative ones, such as the shading of seagrasses by aquaculture set-ups, which limits the amount of light they are able to receive and thus limits their growth. However, she acknowledged that the weight of these positives and negatives can be quite variable.

“

*“Shading of individual racks might be completely countered by this filtration. And respiration could*

*increase CO<sub>2</sub> in the water which would fertilize eelgrass growth.”*

When asked about how she believed these relationships could be leveraged to best support seagrass and aquaculture growth, Dr. DuBois believed a mobile aquaculture operation could be used in a manner similar to crop rotations on agricultural lands.

“

*“So for marine spatial planning, think about a patchwork of oyster aquaculture, eelgrass restoration areas, and places where they are co-cultured as well. And maybe there's a way you can shift oysters around over mudflat when you need to... We don't want to lose the benefit when conditions are ambient [because the] presence of oysters can actually enhance the growth of eelgrass and enhance the production of oysters. So if we do a patchwork, then some eelgrass patches will get that boost from oysters under current conditions.”*



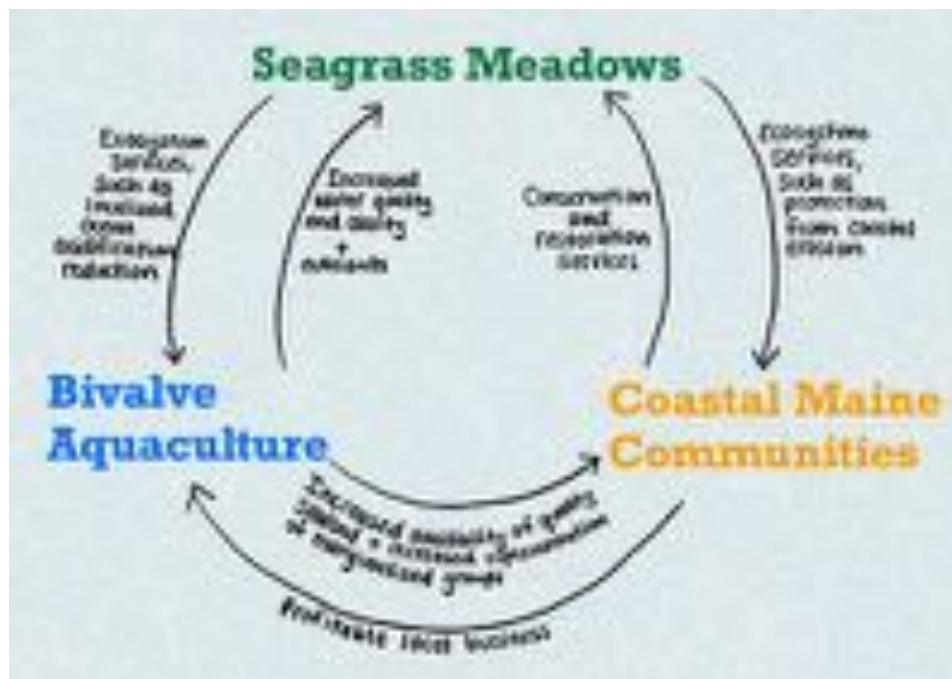
Katie DuBois conducting field research

**Check her out!**

## **Bringing the Bioregion Together: Seagrass and Stewardship**

And thus, we bring our story full circle. Notice the role that seagrass plays throughout the various levels of this bioregional system. These marine meadows protect coastal communities and foster healthy ecosystems that promote the well-being of fisheries and aquaculture operations. In supporting these maritime enterprises, specifically the expanding aquaculture sector, seagrass meadows indirectly contribute to increased representation of minority groups within Maine's seafood industry, contributing to further equity within this part of the food system. In addition, the successful, just expansion of local aquaculture operations could promote the accessibility of high-quality seafood to more Mainers and Casco Bay residents. To complete this web of interconnections, the growth of seagrass meadows can be aided by properly implemented aquaculture practices.





...Coming full circle

Embedded within this system of interactions, seagrasses serve as a key indicator of bioregional health. Therefore, the more you help seagrasses, the more they can help you! Unfortunately, over the past four years, seagrass meadows have been struggling to survive in Casco Bay. A recent survey revealed that Casco Bay has lost 54.5% of its seagrass meadows – the lowest total seagrass coverage on record!

Now is the time for action. As Ivy Frignoca, a Casco Baykeeper with Friends of Casco Bay organization, states: “we were aware of the decline in [seagrass], but we thought we had some time to think about this...The time to act was yesterday.” It is important that seagrass meadows be seen as actors within this bioregion, as so often they are overlooked – quite literally driven over by boats – and hidden in the depths of the sea. As we have discussed, these ecosystems are important stakeholders, in and of themselves, in the local food system. Furthermore, they are supporters of coastal community well-being. Only by hearing all the voices in the bioregion can meaningful changes be made so as to ensure that everyone within it benefits.



## **...Epilogue**

You lean back, sinking into the lush meadow around you. Soft leaves caress your face and envelop your body in a green blanket. You feel the tide coming in, subtle currents in the water gently pushing you back towards the shore. The seagrass around you waves kindly as you sit up and head back towards land, inspired.

## **Acknowledgements**

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# Traditional Ecological Knowledge & Wisdom and Seagrass

Incorporating Traditional Ecological Knowledge & Wisdom (TEKW) in Seagrass Restoration in Casco Bay, Maine

Created by Nihiwok (meaning "Team of Three"): Catherine Hayden, Christina Lau, Arielle Lee  
Draft

Welcome to a journey that explores the intersection of science and culture in the restoration of seagrass ecosystems in Casco Bay, Maine. Together, we'll investigate the realm of Traditional Ecological Knowledge and Wisdom and how it can be incorporated alongside western science to develop creative approaches to environmental issues. Prepare to be inspired by

the stories of those who are integrating science and Indigenous culture to protect one of Maine's most valuable coastal resources, and keep an eye out for meaningful quotes from our wonderful conversation with **Dwayne Tomah**, a Language Keeper and member of the Passamaquoddy tribe, which are interspersed throughout this StoryMap!

*"The western world is about economics, power, control, and domination. Now, talking about a traditional sense: we're talking about sharing. Caring. Stewardship. Communication. What's wrong with those concepts?"*

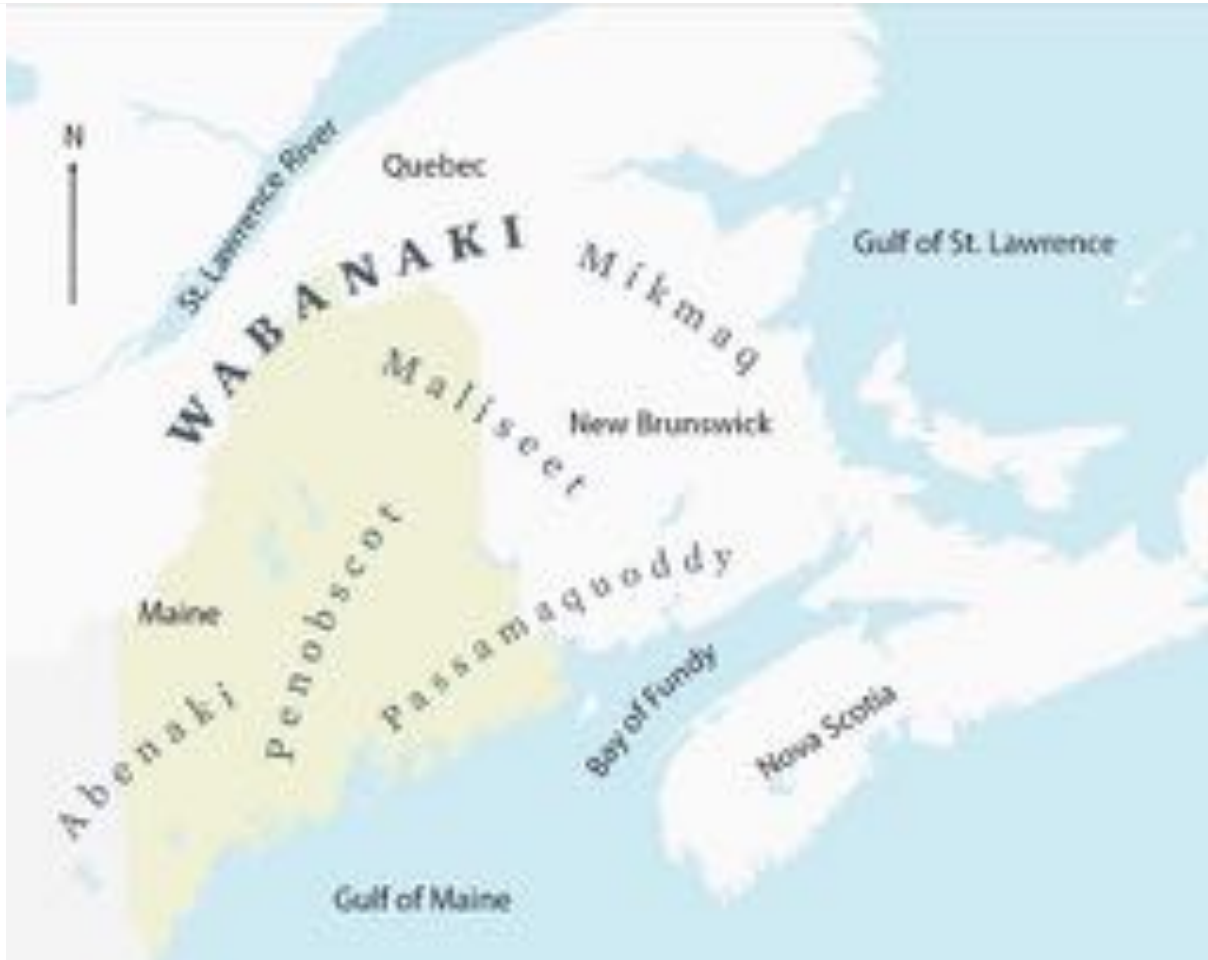
- Dwayne Tomah, Passamaquoddy Language Keeper

### **Statement of Positionality:**

*As non-Indigenous people, we acknowledge that although our work aims to further the incorporation of Traditional Ecological Knowledge and Wisdom (TEWK), we will never fully understand the Indigenous perspective or their lived experiences. We will work to address and unlearn our inherent biases and any misinformation we come into this project with. Simultaneously, we aim to prioritize collaboration with Indigenous peoples and leaders as to not assign additional emotional burden and labor in navigating this subject and project. Lastly, we welcome all constructive criticism on this front and are fully open to changing our project accordingly.*

**Team Zostera** aims to connect the Casco Bay bioregion with the ecologically important seagrass beds on the Maine shore. This StoryMap and other resources aim to advise Team Zostera on the inclusion of Wabanaki TEKW in their future work.

## Who are the Wabanaki People?



Indigenous peoples have resided in the state we now call Maine for thousands of years. The state is home to four tribes: the **Mi'kmaq Nation**, the **Houlton Band of Maliseet Indians**, the **Passamaquoddy Tribe**, and the **Penobscot Nation**. Collectively, they formed the Wabanaki Alliance in June of 2020 to educate the people of Maine and raise awareness about the need for Indigenous sovereignty.

**Dwayne Tomah:** *We already have sovereignty—we just need to exercise it. I tell this to tribal leaders all the time: “The only way you can be sovereign is to **be sovereign.**”*



(Pictured: Map of the Wabanaki Confederacy)



Like many other Indigenous communities, the Wabanaki way of life is deeply intertwined with the environment around them. Agriculture, hunting and gathering, fishing, recreation, and tourism are just a few ways in which their livelihoods, traditions, health, and well-being depend on ecosystem services ([Ranco, 2017](#), [Mi'kmaq Nation, n.d.](#)). However, environmental degradation and encroachment on Indigenous land have violently disrupted these traditions—and in turn, Indigenous physical, mental, and spiritual well-being.

*“For millennia the Passamaquoddy way-of-life was to hunt, fish, trap and gather food and medicine and to employ the natural resources of the environment to sustain our communities” - Penobscot Nation*

(Pictured: The Passamaquoddy People at Pleasant Point, ME)



Click here to listen to Dwayne Tomah telling the Wabanaki creation story of **Gluskabe**, who created the people from the ash tree by shooting arrows into the trees.

00:00 / 00:27 

(Pictured: Artwork of the people of ash dancing about from graphic novel DAWN LAND by Joseph Bruchac and will Davis.)

## **An Intro to TEKW- Traditional Ecological Knowledge and Wisdom**

Indigenous peoples across the world have been caretakers of the environment for thousands of years. Their cultural, historical, and spiritual relationships and identities are shaped by and intertwined with the environment around them. Guided by deep-seated values of reciprocity and stewardship, Indigenous communities hold the local resources, land, and life around them close. The Indigenous way of knowing related to the environment is commonly referred to as TEKW.



Suzanne Greenlaw, a Wolastoqiyik/Maliseet and doctoral candidate at the University of Maine, counts sweetgrass stems in Acadia National Park for a study about sweetgrass harvesting and sustainability of Wabanaki practices. (University of Maine, 2021)

### What is TEKW?

**TEKW is the ecological expertise of Indigenous communities as a result of generations of intertwined living with the local environment.**

TEKW differs from the western science in that its understanding comes from **experience** rather than **experimental data collection** and is a more holistic, area-specific, long-term approach to science (Berkes, 1993).

Characteristics	Western science	TEK
Goals	Seeking universals and testing theories through experiments, the analysis of data, and models	Usually offering data and pattern analysis specific to or bounded by a culturally defined space and time
Participants	Largely done by academically trained professionals and technicians, some of them non-Indigenous	Largely done by "grass professional" non-Indigenous foragers, hunters, farmers, fishermen, and shamans
Communication	Primarily transmitted through written works, graphs, and formal oral presentations	Primarily transmitted orally in an Indigenous language and also through song, story, music, and art
Context	Done by individuals, small teams, or organizations for universal benefits	Done in multigenerational communities primarily for the community
Worldview	Written works, wary of spiritual dimensions and ambivalent on the ethical-moral content	Typically linked to spiritual dimensions and ethical-moral considerations
Methodological content	Makes an separation of object-subject	Link object-subject dichotomy
Location/Scale	Increasingly done irrespective of place or focused on model systems	Embedded in culture-environment specific to place

(Wilder et al., 2016)

## A Legacy of Colonialism

Indigenous ways of knowing have long been dismissed by the western world. Colonialism, an ideology based in white supremacy, has erased centuries of Indigenous history. As Indigenous ways of knowing were muffled, western science rose to international influence. Members of the early scientific community typically considered non-western sciences legitimate “only when they were based on mathematical or empirical methods of demonstration, ignoring all those disciplines that did not fit within this model” (Elshakry, 2010). This persists in modern day science, which is generally equated with western science (Iaccarino, 2003; Mazzocchi, 2006; Elshakry, 2010).

## Benefits of incorporating TEKW

Adoption of TEKW can combat **parachute science**, in which western scientists “parachute” into an area with which they are not familiar, collecting data, and leaving without much, if any, engagement with the local people. Parachute science usage slows rates of scientific discoveries and limits the impacts of findings, given that the conclusions and gained knowledge are removed from those who interact with it most (Woodall et al., 2021). Incorporation of TEWK can combat these issues while uplifting Indigenous voices in science.



(Albuquerque et al., 2021)

While TEKW and western science have developed distinctive strategies for generating and communicating information over time, it would be counterproductive to consider one the antithesis of the other. By acknowledging the **unique and complementary benefits** of both Western and Indigenous

knowledge systems, research and science may challenge what is believed to be "true" and expand our horizons. This leads us to the concept of Two-Eyed Seeing.

## **Making TEKW integration a true collaboration through Two-Eyed Seeing**

**Two-Eyed Seeing** is a learning approach to view science through the lens of an Indigenous perspective and knowledge with one eye, while also seeing it through that of Western perspective and knowledge with the other (Proulx et al., 2021). Without the use of Two-Eyed Seeing, science will be limited to the western perspective and will fail to be as impactful as possible.

TEKW can be gathered and incorporated into western science through interviews with knowledge holders, best identified through discussions with community members (Valdés-Pizzini and García-Quijano, 2009). Elders have been found to hold more local knowledge than younger generations (Okui et al., 2021) and thus are likely the best resources.



Adapted from Bartlett and Marshall (2010)

### **An important note:**

It is crucial that the onus of TEKW integration does not fall on Indigenous peoples. Organizations seeking to integrate TEKW **must** remain cognizant of the context that has historically shaped how Indigenous knowledge is currently viewed in the predominantly western narrative of science.

## Zooming Out: Seagrasses and Indigenous Communities Around the World

Indigenous communities around the world have a rich history of interactions with seagrasses. These success stories show us the value of TEKW in seagrass restoration projects and give us ideas for how their strategies could be adapted for use in Casco Bay.



CONANP, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA

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1

**Sonora, Mexico**



The Comcaac are the only Indigenous people to consume eelgrass seeds, but in the last 70 years, beans, rice, and wheat flour have been replacing eelgrass flour in their diets. The Comcaac protect 96% of the eelgrass that grow in their waters.

2

## **Shark Bay - Gathaadu**



The University of Western Australia partnered with the Yadgalah Aboriginal Corporation, who represent the Malgana people indigenous to the land, for Shark Bay seagrass restoration after a marine heatwave that resulted in the decline of species of cultural significance.

**3**

### **British Columbia**





Simon Fraser University collaborated with the Heiltsuk Nation to examine the sustainability of commercially harvesting feather boa kelp. Their studies found that the traditional Heiltsuk practices of only harvesting part of each individual kelp at a time resulted in increases in ecological resilience.

4

#### **Chwaka Village, Zanzibar**



Off the east coast of Zanzibar, the lives of Chwaka Village's locals are closely intertwined with seagrasses. Seagrass-associated fisheries, seagrass-associated fish, and seagrass traditional medicine and fertilizers are all examples of the social-ecological connections between the residents and seagrasses.

5

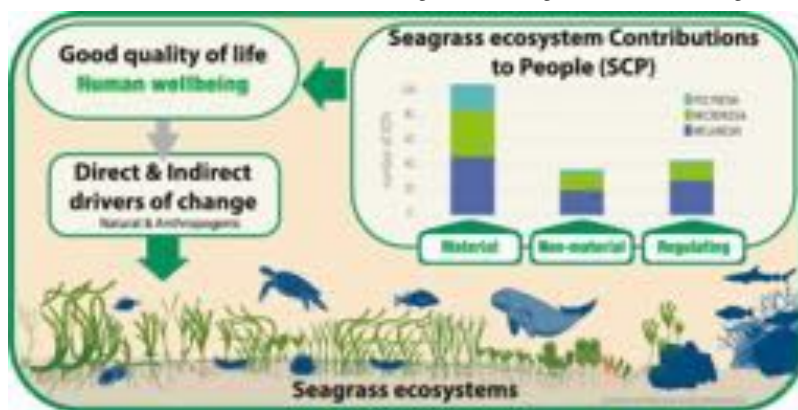
## Casco Bay, ME



Given the significance of seagrass conservation, Team Zostera provides a unique and valuable opportunity to highlight the potential of engaging in cross-cultural resource governance.

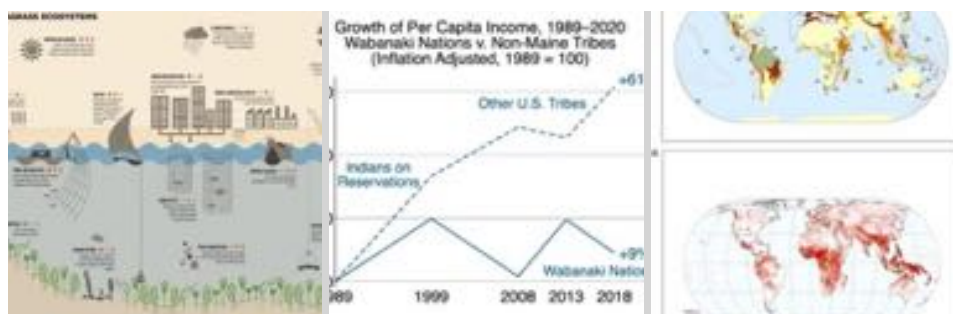
### **Zooming Back Into Casco Bay:**

In order to connect seagrasses and the Wabanaki People, we have to dive in deeper and focus on the ecosystem in Casco Bay.



<https://doi.org/10.1016/j.marpolbul.2021.112307>

Unfortunately, seagrasses and Indigenous communities face similar threats.



*Biologists estimate annual loss of species at 1,000 times or more greater than historic rates, and linguists predict that 50-90% of the world's languages will disappear by the end of this century*

*(Gorenflo et. al, 2012).*

**So, What Can We Do?**

# How Can We Combat this Loss of Biodiversity, Land, Language, and Culture?

## 1: Raising Awareness

### Introducing the Passamaquoddy-English Seagrass Glossary!

Using this glossary,

**Passamaquoddy-Maliseet  
Seagrass Glossary**

**A note for our successors:**  
Thank you for continuing the work we started on this glossary! This is a living, breathing document that will hopefully be expanded as this project progresses.

We are endlessly thankful to Dwayne Tomah for his translations, definitions, and pronunciations. Please feel free to add important terms and/or translations to this document in collaboration with Passamaquoddy

Translations, insight, and wisdom provided by Dwayne Tomah, Passamaquoddy Language Keeper and teacher of the Passamaquoddy language and culture.



## Seagrass: "Supequwi Pskihq"

00:00 / 00:02 

[Click to hear Dwayne's pronunciation!](#)



## **Pollutants: "Nehpahtuwik"**

Translates literally to "Things that could kill you"

00:00 / 00:01 

[Click to hear Dwayne's pronunciation!](#)



**Stewardship: "-ulankeyutom-"**

(full transcription unavailable)

Translates literally to "we take care of our Mother"

00:00 / 00:01 

[Click to hear Dwayne's pronunciation!](#)



## Roots: "Wecopahkiyik"

00:00 / 00:01 

[Click to hear Dwayne's pronunciation!](#)

## 2: Teach TEK

Wabanaki studies are being incorporated into elementary school curricula in the Portland public school district.

## The Wabanaki Youth and Sciences (WaYS) Program

*WaYS' priority is working with and for Wabanaki communities to provide experiential learning opportunities for indigenous youth. This is accomplished with the inclusion of Cultural Knowledge Sharers, western science professionals, and educators in various settings and forms. We work with youth in elementary*

*school through college-age. To accomplish our priorities, WaYS opportunities include:*

### **3: Look Forward Through the Lens of Two-Eyed Seeing!**

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<https://doi.org/10.1098/rsbl.2020.0699>

**Catherine Hayden, Arielle Lee,  
Christina Lau**

# Putting Team Zostera on the Map

A community science effort dedicated to mapping and documenting the health of eelgrass meadows in Casco Bay.

Authors: Alina Moreno, Lauren Smith, Mia Hedengren

April 13, 2023

## Who is Team Zostera?

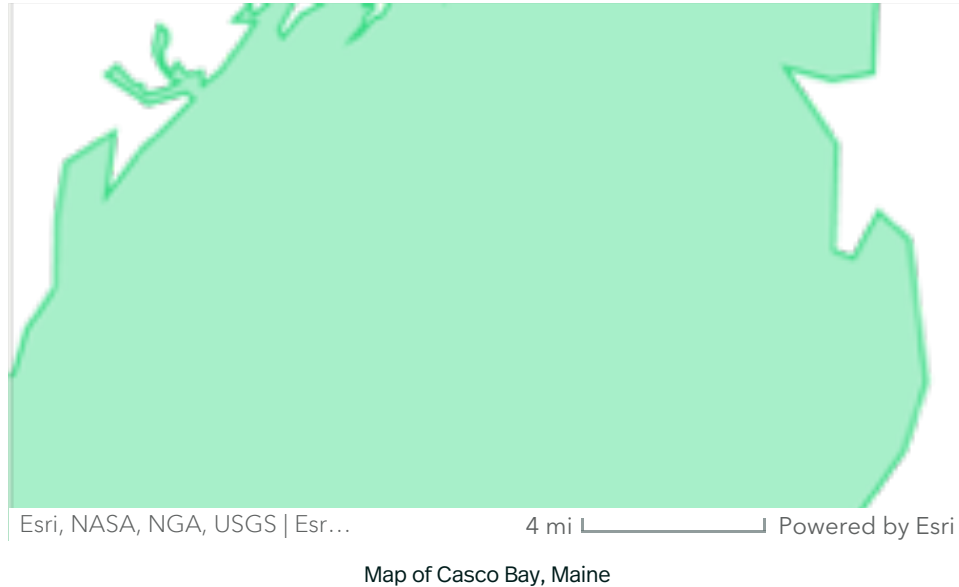
Based in Portland, Maine, [Team Zostera](#) officially launched at the 2022 Casco Bay Bioregional Learning Journey. Led by Glenn Page (CEO of SustainaMetrix and Global Lead of COBALT) and other core Team Zostera members, the COBALT Learning Journey focused on the intersection of food systems, wastewater treatment, and the current health and future trajectory of seagrass meadows in Casco Bay. Additionally, COBALT Learning Journeys focus on the critical importance of stewardship action and good governance across many dimensions.

Team Zostera believes it takes a village - to see, connect, and accelerate positive change for the bioregion that supports the lives and livelihoods of the village.

### **DIGGING DEEPER**

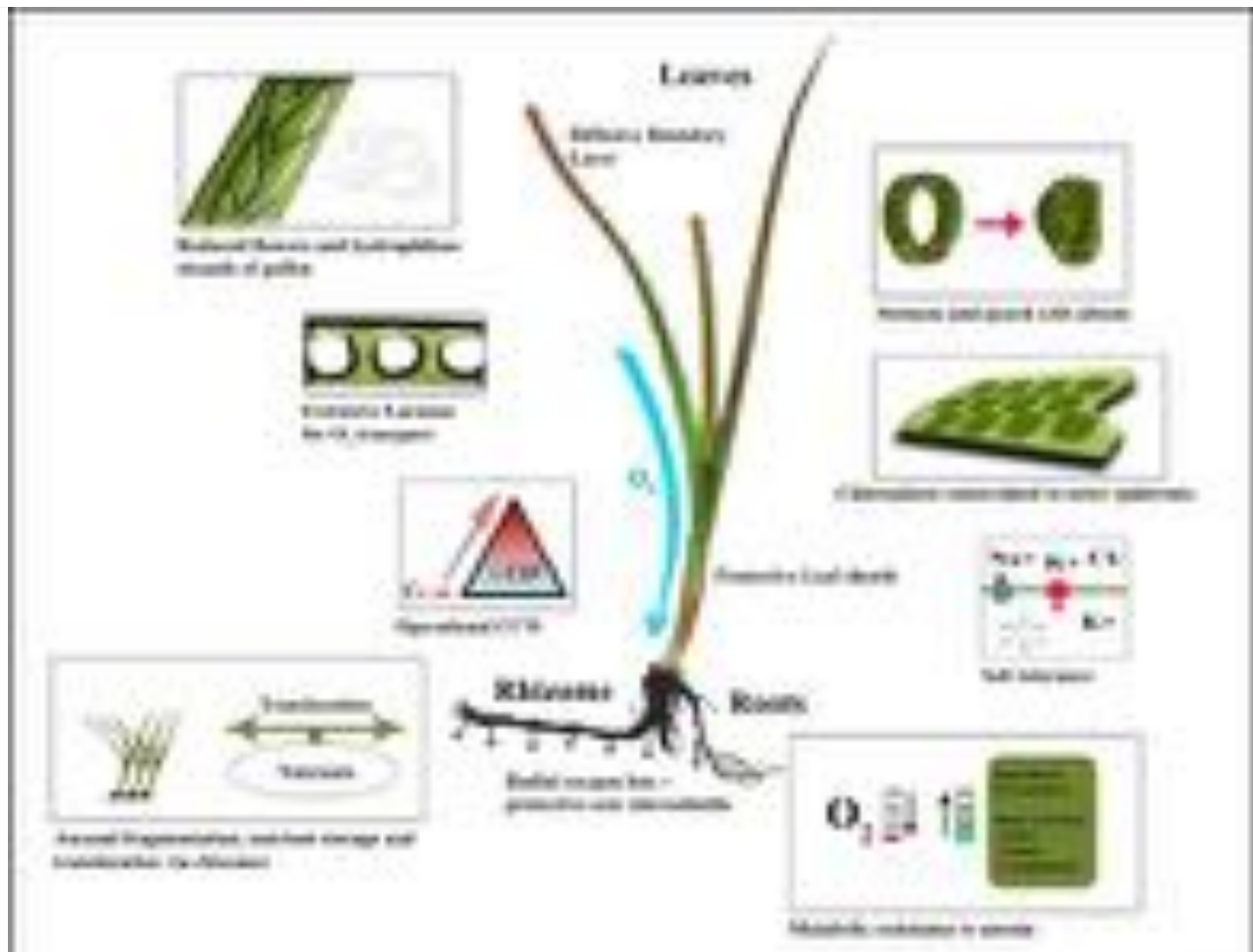
*The number of non-profit organizations (NPOs) in the United States, like Team Zostera, has grown*

*significantly in the last 30 years. This has vastly increased the amount of competition in the industry.*



## What is seagrass?

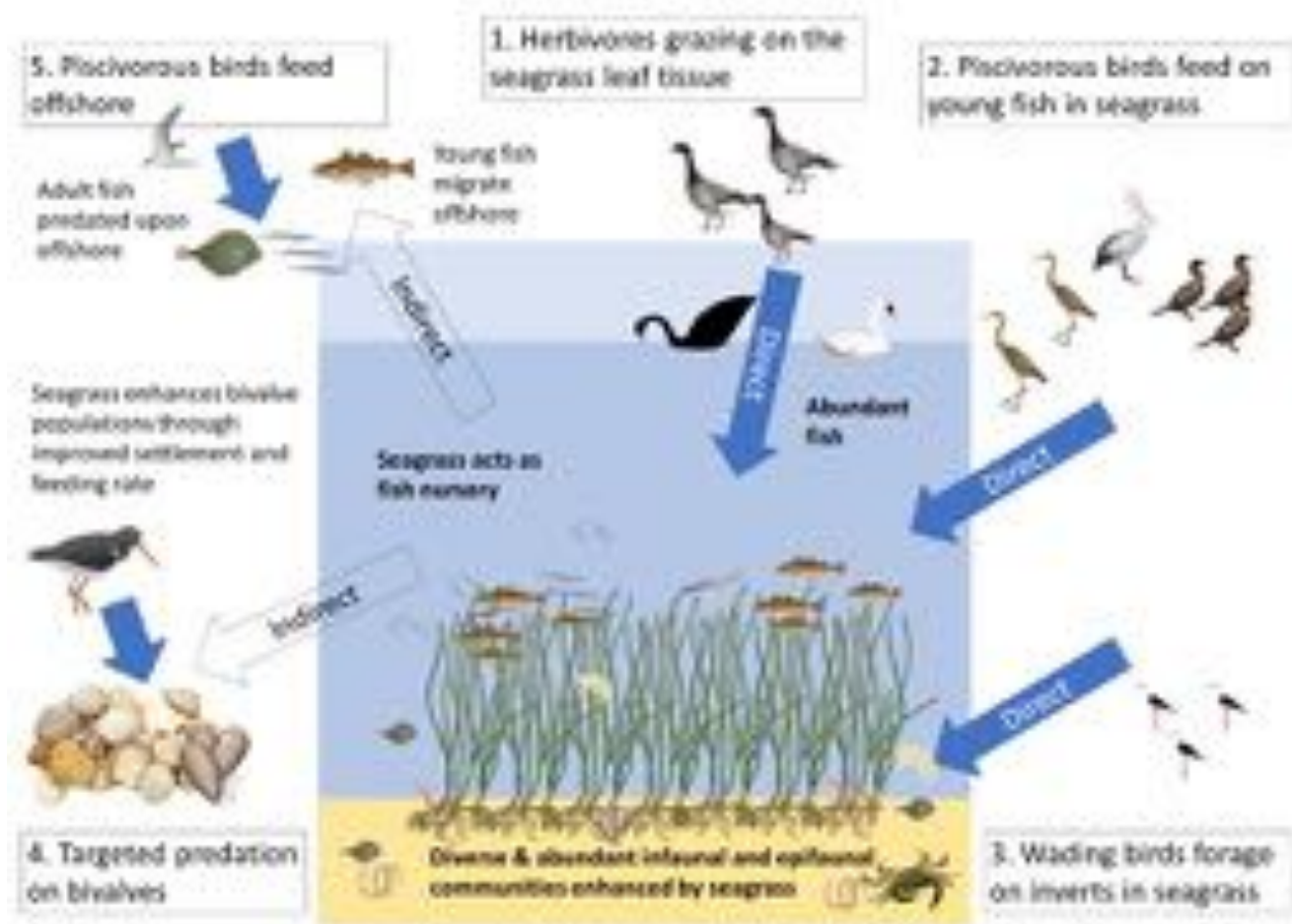
Seagrass are flowering marine plants that grow entirely underwater. In fact, they are the **only** flowering plants to grow in marine environments!



**Seagrass is an amazing organism!**

Seagrass have spectacular adaptations that allow them to not only survive in salty environments, but absolutely thrive.

**Anatomy + adaptations diagram**

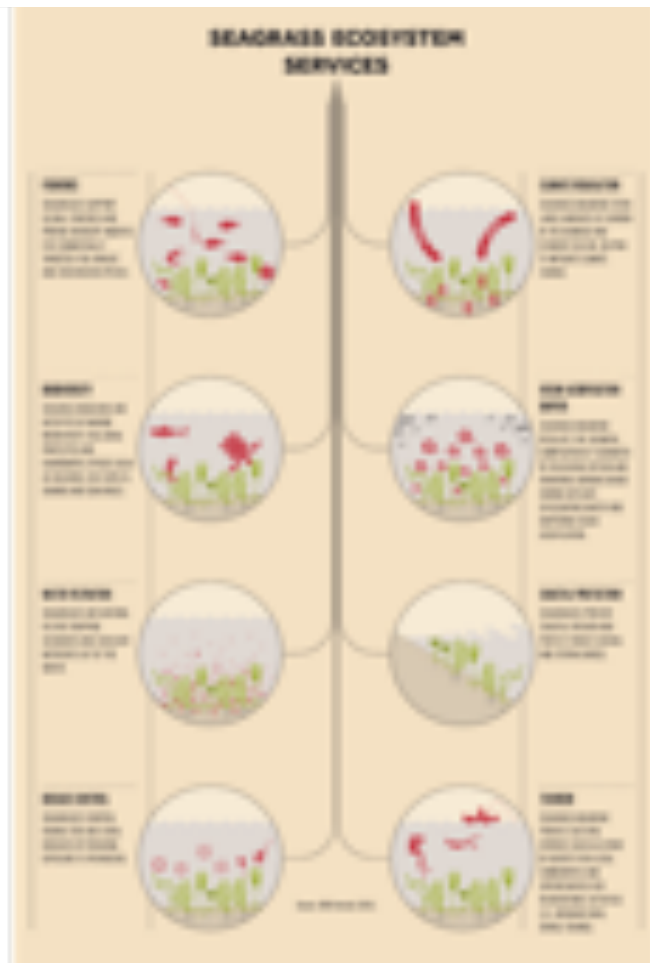


## Seagrass provides crucial habitat!

Countless organisms depend on seagrass meadows – for nursery habitats, for food, and for protection from predators. These meadows also act as buffers that reduce the effects from waves, storms, and erosion. This helps humans, too! Especially in the face of a rapidly changing climate where weather events are expected to become more and more extreme.

### Habitat diagram

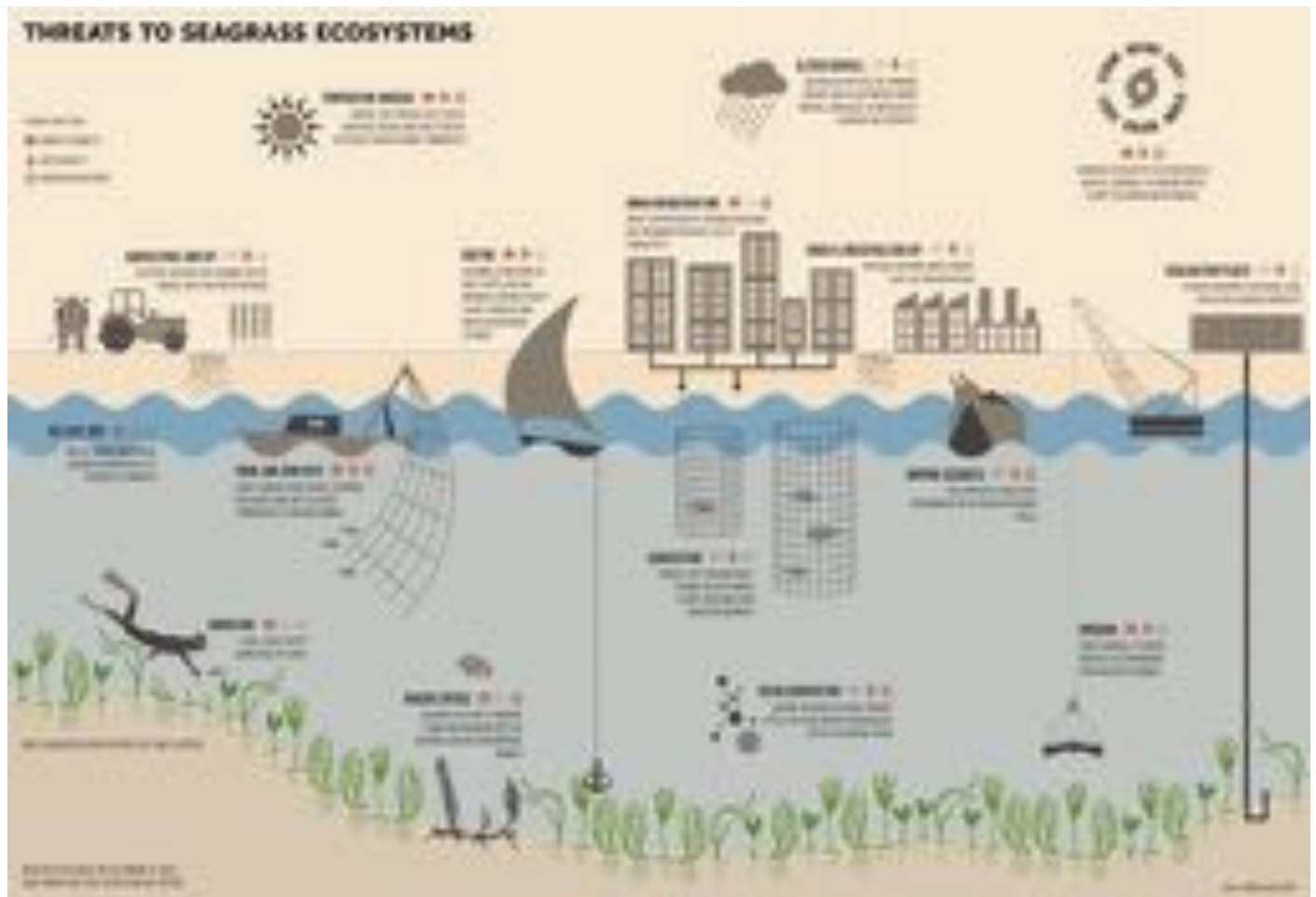




### Seagrass affects your daily life!

Things like storm buffering, climate regulation, erosion protection, carbon sequestration, disease control, fishery habitats, and water filtration all affect humans.

#### Ecosystem services diagram



**Seagrass is being threatened.**

Seagrass has been declining at a rate of about 7% per year. That is equivalent to a football field of seagrass lost ever 30 minutes!

**Seagrass threats diagram**



Team Zosteria wants to help this keystone species! **And you can too!**

## **How can you get involved?**

### ***Merchandise***

In purchasing any of the below merchandise, you can directly support Team Zosteria and their efforts to preserve and protect Casco Bay's precious meadows. But the true contribution comes from wearing and showing off your Team Zosteria gear.

When you sport Team Zosteria gear, you are putting this organization on the minds of your friends and family -

the people who trust you most to give them recommendations. This creates a domino effect of more people being interested in and supporting this amazing organization.

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### ***DIGGING DEEPER***

*Our research showed that an animal or team mascot leads to strong positive public opinion and brand recognition. Mascots strengthen brand identity by allowing an organization to stand apart from the crowd.*

The focal point of the redesigned logo is centered around a unique seahorse design, specifically *Hippocampus erectus* or the Lined seahorse - a resident of Casco Bay. Lined seahorses rely heavily on camouflage and the cover of seagrasses to avoid predation from crabs, sharks, skates, and rays, and other larger fish.



*The simplicity of the design was also intentional - clean lines, consistency in color, and complementary typefaces all create an attention grabbing and memorable image.*

## **Social Media, Websites & More!**

*Follow Team Zostera's efforts on social media and go to their [website](#) for updated community events, partner organizations, Team Zostera merchandise, and even more ways to get involved!*

### **DIGGING DEEPER**

*When used effectively, social media can increase a brand's name recognition and consumer engagement while forming a strong community with shared values. Team Zostera hopes to accomplish this by providing a space that inspires thoughtful discussion, motivates users to take action and highlights upcoming events that the public can be involved in.*

## **Seagrass Summer**

### A Bioregional Exploration of Seagrass

Grab your passport and get exploring! Learn how you can save the seagrass!

**Seagrass Summer** is a proposed month-long effort to rally community members around the cause of protecting and

conserving seagrass meadows in Casco Bay. We hope Seagrass Summer will become an annual event for Portland natives to look forward to and spread the word about to their friends and family, near and far. By leveraging our partner organizations, the Team Zostera mission can reach a broad audience and engaging events will get people talking about all things seagrass! Seagrass Summer, with your support, will potentially demonstrate a concentrated effort to educate others and raise awareness about the factors threatening seagrass meadows in the area and what we can do to combat this loss.



**To make Seagrass Summer as interactive and engaging as possible, community members will be given a “Passport” with pages corresponding to the participating partner organizations and community events occurring over the course of the month.**



**Children's Museum and Theatre of Maine** // //



Play, Imagine, and Discover at the Children's Museum and Theatre of Maine. Located in Portland, it is the perfect spot for family fun! Check out the Seagrass Exhibit to learn more about the species and their impacts on the local ecosystem in Casco Bay. While you're at it, locate some Team Zosteria merch in the gift shop. Write about your experience at the Children's Museum and Theatre of Maine in the space below!

**Notes**

**Map**



As you attend events, visit local businesses and complete challenges, you will receive stamps on your pages.

These stamps (potential design, right) serve to commemorate your experience, and, if you collect enough, will earn you some Team Zostera merch!

### ***DIGGING DEEPER***

*The Passport concept is modeled off the National Park Passport, a popular guest experience that helps visitors explore and protect the natural, cultural, and historical treasures of America. We hope that Seagrass Summer and the accompanying Seagrass Passport will encourage people in the community to look for ways to appreciate the ecosystem services provided by seagrasses in their daily life.*

### **Potential Partner Organizations**

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Esri, USGS | Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS

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### The Abbe Museum

"In recent years, the Abbe has grown from a small trailside museum, privately operated within Acadia National Park, to an exciting contemporary museum in the heart of downtown Bar Harbo...



### Waponahki Museum Resource Center

The museum has on display Maine Native tools, baskets, beaded artifacts, historic photos, and arts and crafts. Mannequins, whose features are designed from actual Passamaquoddies, are...



### The Children's Museum & Theatre of Portland

From their website:



### Color Me Mine

Color Me Mine is committed to providing a space for kids and adults to express their creativity, relax, have some fun and learn in a creative and pressure-free environment!



### Portland Paddle

Portland Paddle offers sea kayak and stand-up paddleboard (SUP) rentals, tours and lessons in Portland, ME. They cater to adventurers of all skill levels, including complete beginners. Portland...



### Maine Craft Portland

Maine Craft Portland is a retail gallery + resource center in the historic Mechanics Hall downtown Portland, Maine. It promotes craft in Maine through exhibitions and public programming and...



### Portland Pottery Cafe

Portland Pottery & Metalsmithing Studio offers a wide range of classes and opportunities for artists of all levels. They offer 8-week clay and jewelry classes for adults that run consecutively...



### Smalls



Open since January 2022, Smalls is an all day cafe/bar and marketplace located in Portland Maine's West End neighborhood. We offer a full coffee and food menu as well as cocktails, wine...



### Coffee ME Up

From their website:



### Bissell Brothers Brewing

Bissell Brothers was founded in 2013 with a mission to change people's perceptions of what beer and the beer experience can be, while always staying dedicated to our home state of Maine....

## ***DIGGING DEEPER***

*Collaboration with local organizations will be crucial for keeping seagrasses and stewardship in the minds of community members, in addition to helping inspire the public with ways to get involved. Community Stewardship engagement programs can improve community trust in institutions, increase environmental awareness, and benefit ecosystem health.*

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10. Original Designs by Alina Moreno, for Team Zostera

11. Mock passport design by Mia Hedengren, for Team Zostera & Seagrass Summer

12. [National Parks Passport](#)

13. [The Abbe Museum](#)

14. [Waponahki Museum Resource Center](#)

15. [The Children's Museum & Theatre of Portland](#)

16. [Color Me Mine](#)

17. [Portland Paddle](#)

18. [Maine Craft Portland](#)

19. [Portland Pottery Cafe](#)

20. [Smalls](#)

21. [Coffee ME Up](#)

22. [Bissell Brothers Brewing](#)

## Credits

Brought to Life by: Alina Moreno, Lauren Smith, Mia Hedengren

With endless and crucial support from Dr. Jennifer Bowen, Glenn Page, Sydney Hay, and all of our Capstone Comrades in ENVR 4050: Solving Emerging Environmental Problems

# Below the Surface

Casco Bay in Maine is beautiful to look at as boats float on by, but below the surface there is an amazing story to be told.

Melanie Guzman, Chris Lee, and Akshaya Venkateshwaran  
April 4, 2023

**Welcome to Casco Bay, Maine!**



There's a vibrant community waiting for you in Casco Bay!

Known as Vacationland, Maine is a vibrant state filled with new adventures and experiences. One of the best spots is Casco Bay! Casco Bay is an inlet in the Gulf of Maine located on the southern coast. The Bay encompasses 14 coastal communities, including the city of Portland. It is a key location for cruise ships and aquaculture (Friends of Casco Bay, 2018). A vacation here can include hiking, exploring old lighthouses, discovering the rich Art District, and enjoying the exciting and diverse dining options (Visit Maine, n.d.). It's clear to see that there is a vibrant and welcoming community in the Bay.

***But did you know that the community below the surface is just as vibrant as the one above?***

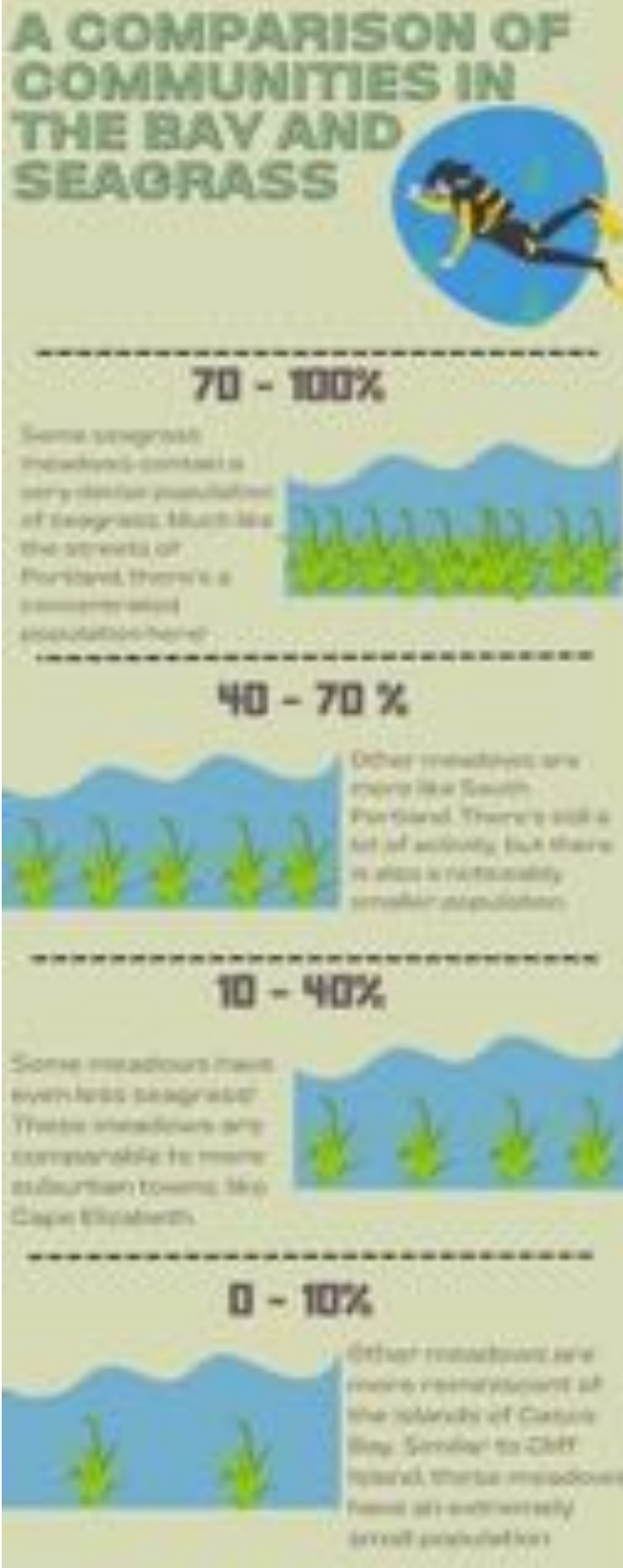


Casco Bay is home to an extremely important ecosystem - the seagrass meadows! While often hidden from human eyes, seagrass, which is a flowering marine plant, is home to a bustling array of organisms and plays a vital role along the coastline.

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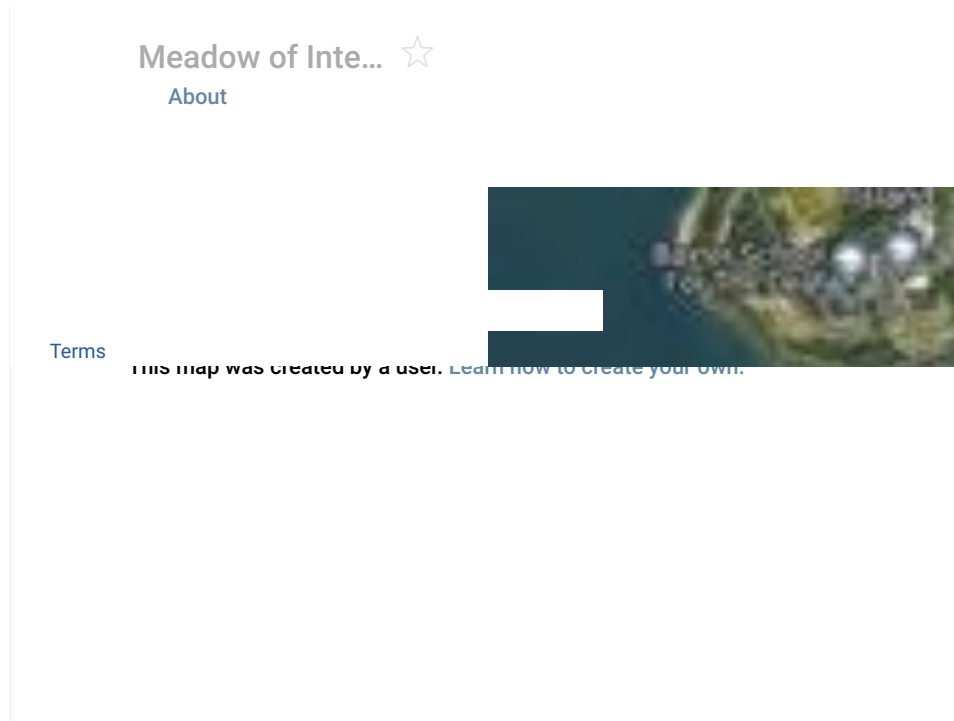
## Understanding Seagrass Meadows

Much like the communities of Casco Bay, there is a lot of variance in the population of seagrass meadows. These are known as the cover classes. They are typically used as an indicator of the health of the meadow, as they can be tracked through methods like satellite imagery.



The different cover class distinctions as defined by Orth et al. in 1991 and how they compare with communities in Casco Bay.

**To understand the seagrass meadows better, let's focus on a particular one!**



Meadow of Interest

This meadow is located near Mackworth Island and provides an ideal example of a seagrass meadow. In 2018, the Maine DEP identified that this meadow fell into the 70 - 100% cover class. As such, it was an extremely healthy meadow, and experienced many of the benefits that come with this distinction.



Our meadow falls into the 70 -100% Cover Class.

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## Organisms that call Seagrass Home

Numerous organisms are dependent on our meadow for a home. Here are a few!







The Eastern Mudsnow, Pipefish, Flounder, Soft Shell Clam (*Mya Arenaria*), Tellinids, Atlantic Silverside, Mummichug, and Fourspine Stickleback (From Top Left to Bottom Right) are most commonly found in our seagrass meadow.

Seagrass meadows are known for the diversity of species observed (Whitlow & Grabowski, 2012). A key species is the Atlantic silversides. These fish are known to use seagrass habitats for foraging, shelter, and spawning. In Maine, seagrass beds have been found to support high densities of juvenile Atlantic silversides, and the loss of seagrass habitats may have negative impacts on the abundance and distribution of this species in the region. One study conducted in New England, which includes the coast of Maine, found that Atlantic silversides showed a strong preference for seagrass habitats and that their abundance was positively correlated with seagrass cover (Whitlow & Grabowski, 2012). Seagrass beds are also an important spawning habitat for Atlantic silversides and their reproductive success was positively correlated with the density of seagrass (Scharf et al. 2016).

Seagrass habitats are also important for the survival and growth of soft shell clams in Maine. Seagrass beds provide suitable substrate and shelter for juvenile clams, which can improve their survival rates and overall growth. Seagrass beds also serve as important nursery areas for soft shell clams, where they can find food and refuge from predators (Beal, B.F., 2016).



Esri, NASA, NGA, USGS, FEMA | Esri, HERE, Garmi... 1 mi Powered by Esri

The Locations of Molluscs in Relation to Seagrass Meadows

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## The Benefits of Seagrass

In addition to being home to a bustling community, this seagrass meadow provides several ecosystem services that we directly benefit from.



## Protecting Biodiversity & Supporting Fisheries

Our seagrass meadow provides a home for so many of the marine organisms we love! The meadow provides food and shelter for threatened species as well as commercially important fish (Short et al., 2007; Unsworth et al., 2019). This means that they play an important role in preservation efforts and in ensuring the success of the aquaculture in the Bay.



## Protecting Coastal Communities

Our meadow can reduce energy from waves and currents and trap sediments in place. These mechanisms help to protect people living near the coast from storm surges and erosion (Short et al., 2007).



## Mitigating the Impact of Climate Change

Seagrass meadows are an effective method of storing carbon. Seagrass meadows can store carbon faster than many terrestrial systems and have the potential to sequester carbon for centuries (Macreadie et al., 2014). This means that they offer a promising method of mitigating climate change.

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**Our meadow is under attack!**



## Watch out for the Green Crab!

Green crabs (*Carcinus maenas*) are an invasive species of crab that were first introduced to Maine in the early 1900s. They have since become a major ecological problem, as they feed on a wide variety of marine organisms and compete with native species for resources. Green crabs have been known to damage eelgrass beds.



Oh no, the Green crab is notorious for ripping the rhizomes and eating them in their never-ending search for prey! Here is one caught in the act in our meadow!

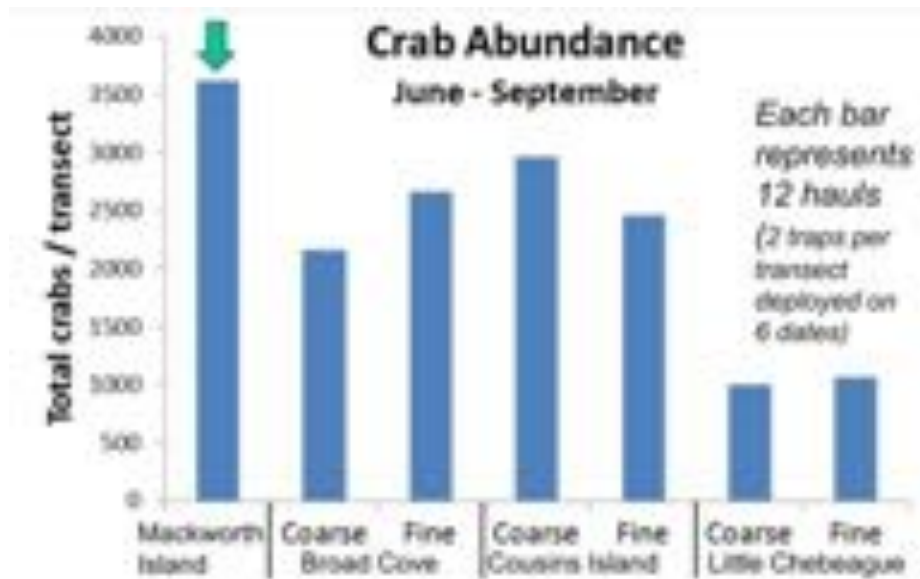
This causes seagrass to die and results in a significant decline in cover class.



Green Crabs are especially concerning as their population has exploded in Maine. In 1995, the average number of green crabs caught per trap was 1.5, whereas, by 2009, the average had increased to 18.5 (Garbary et al. 2014).

Studies have also indicated that green crabs are especially common near our meadow of interest (Neckles, 2014)

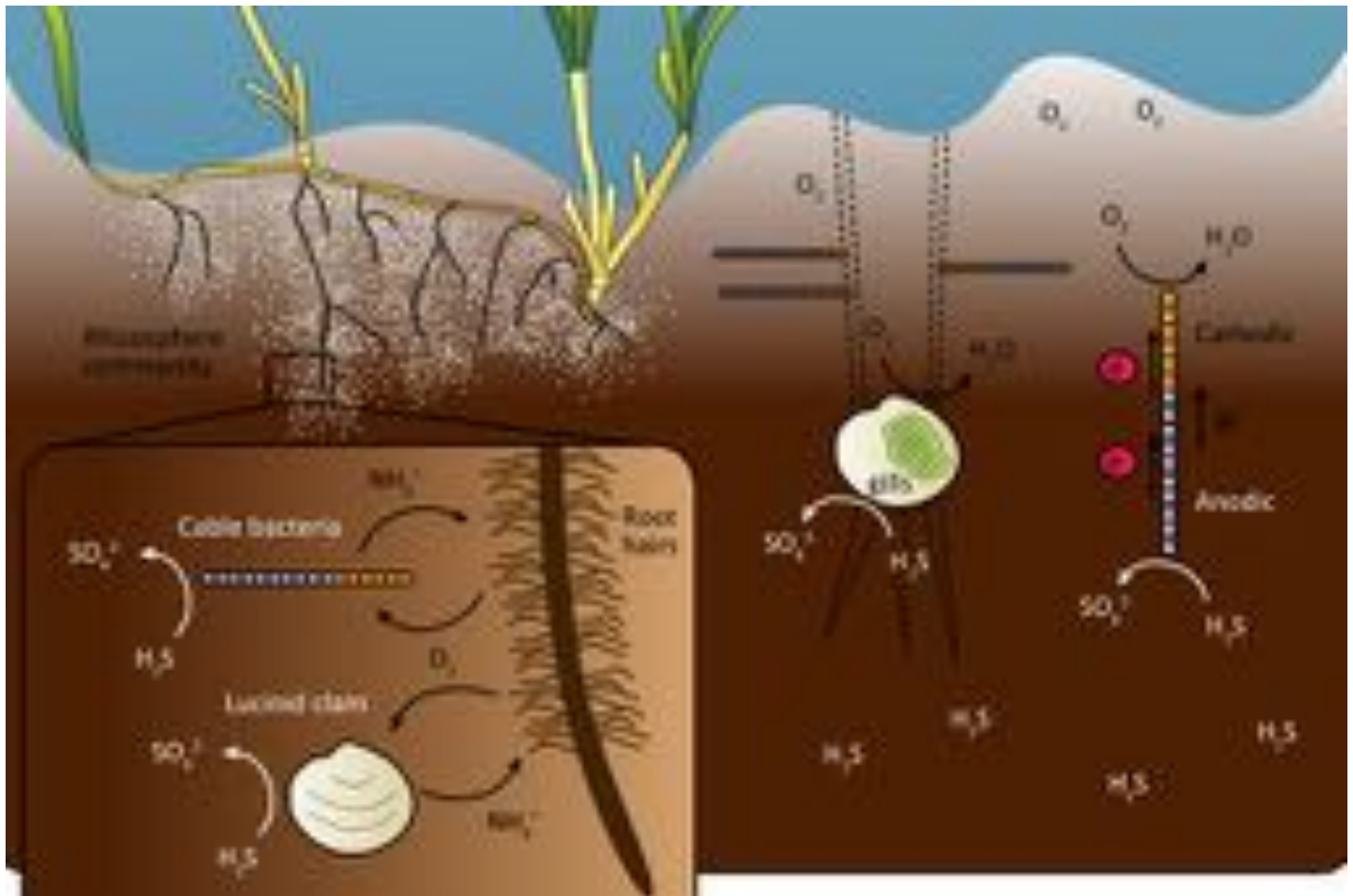




Exclosure experiments preventing access of green crabs in formerly vegetated areas of Casco Bay increased eelgrass survivorship by 400% when compared to unprotected areas and resulted in the re-establishment of 70% cover class

meadows (Neckles 2015). This indicates that reducing green crab populations can be beneficial for *Zostera*.

The state of Maine has implemented various measures to control green crab populations, including trapping and harvesting programs. Individuals are also working on other innovative solutions, like Crab Whiskey (Pomranz , 2022).

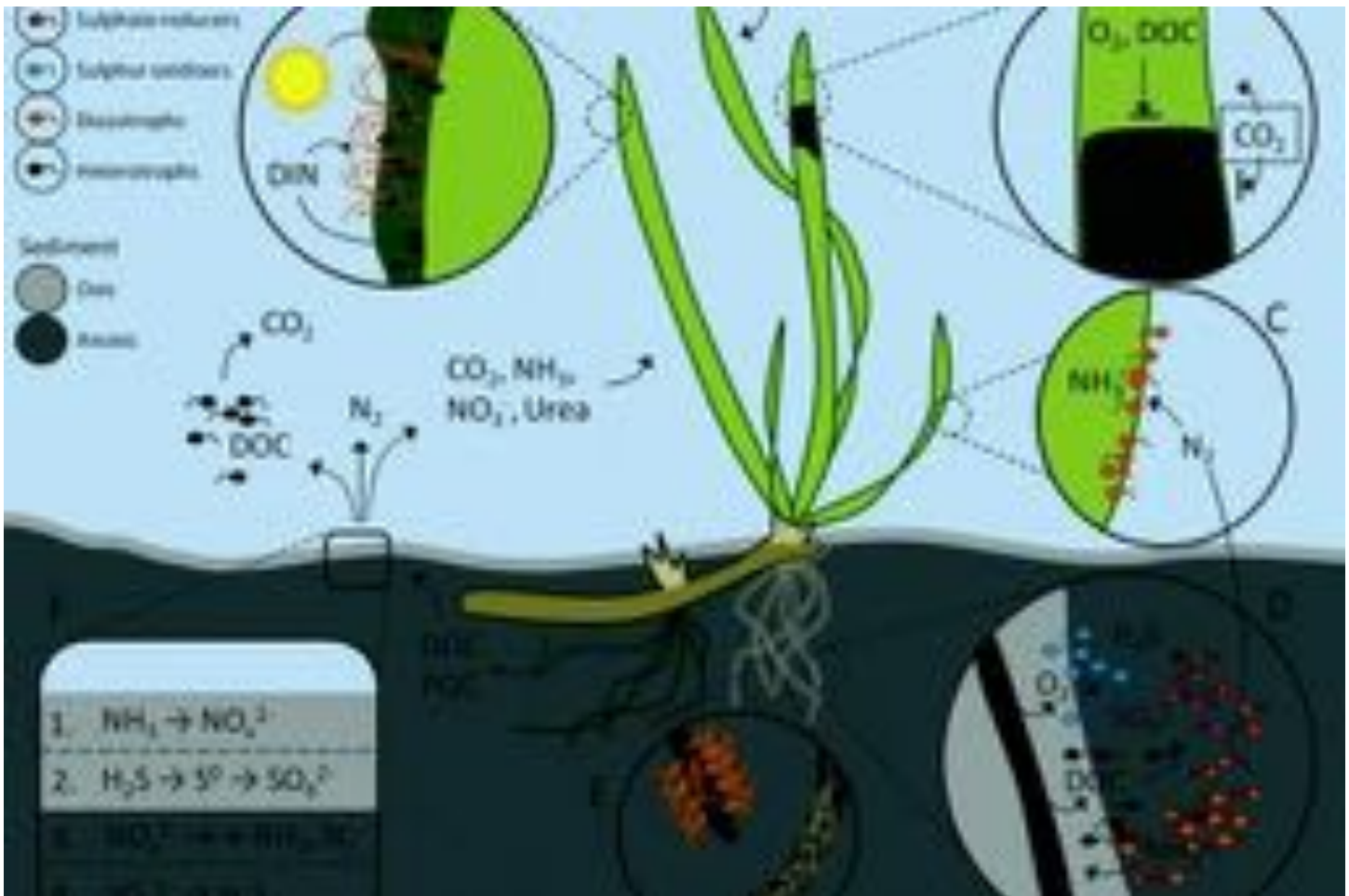


## Green Crabs indirectly impact the sediments *Zostera marina* needs

Green crabs also eat bivalves, which is concerning since bivalves contain important bacterial residents that are key in the process of sulfur cycling. The importance of this relationship has been especially prominent at Simpsons Point.

In seagrass meadows, sulfur cycling is important and is mainly carried out by sulfur-reducing bacteria (SRB). These bacteria use organic matter to produce hydrogen sulfide (H<sub>2</sub>S). Marine animals like clams and gutless worms provide organic matter for SRB. Sulfur-reducing bacteria (SRB) convert sulfate to sulfide in sulfur cycling, while other bacteria like sulfur-oxidizing bacteria (SOB) and sulfur-oxidizing archaea (SOA) help with sulfide oxidation, converting sulfide back to sulfate when oxygen is present. Examples of sulfide-oxidizing bacteria include *Thiomicrospira*, *Thiothrix*, and *Beggiatoa* (Cucio et al., 2018).

*Zostera Marina* shoots growing in enriched sulfide conditions showed reduced rates of photosynthesis, particularly in low-light conditions. The higher the sulfide and the lower the light, the slower the rate of photosynthesis.



The bacteria are also involved in other key processes. *Desulfocapsa* and *Desulfobulbus* are involved in nitrogen

fixation, and some bacteria can fix carbon dioxide for carbon cycling. These processes are important for the health and productivity of seagrass ecosystems and contribute to nutrient cycling and carbon sequestration in the marine environment.

## **Green Crabs aren't the only problem - we're contributing to the decline too!**

### Pollution



Location of Waste Water Treatment Plant Relative to Seagrass Meadows

The neighboring wastewater treatment plant releases nitrogen, phosphorous, and warm water into the Bay. This is not good for the well-being of *Zostera*, because it is sensitive to warm water and algae blooms are more likely to happen due to the nutrient-rich water from the treatment plant, decreasing the light available for *Zostera*'s growth

### Physical Disturbances



Humans can also cause physical disturbances that impact our meadow. Fishing activity, boat mooring, propellers, and anchors can all impact seagrass.

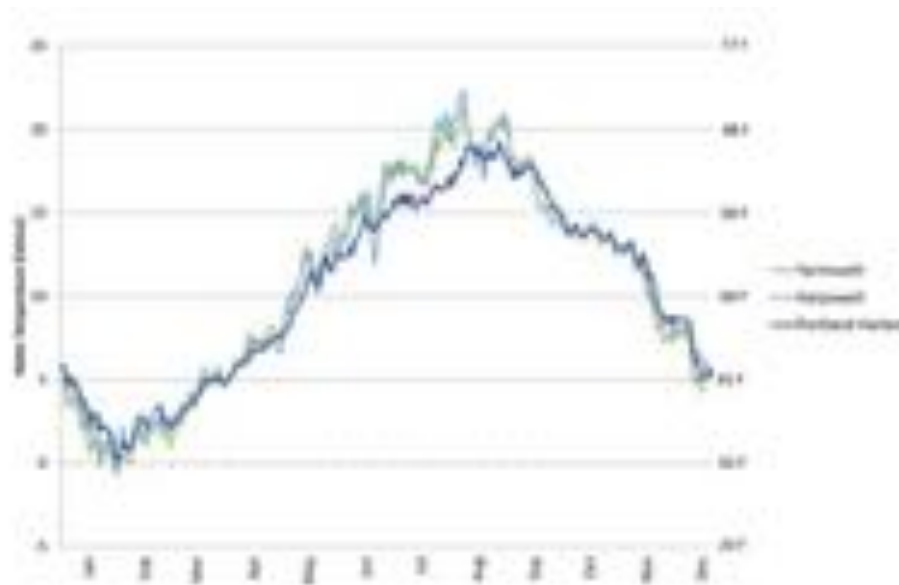
In particular, traditional moorings can be a cause for concern. These moorings eliminate seagrass from a circular area around the mooring block as boats swing around and the chain is dragged across the bottom. This causes distinctive mooring scars (Swan, 2012).



Mooring Scars in an Eelgrass Meadow

Luckily, there's work being done to limit this impact. In Portland, all new moorings must be conservation moorings, which do not impact eelgrass, and all moorings must be moved out of eelgrass beds (Board of Harbor Commissioners, n.d.).

## Global Warming

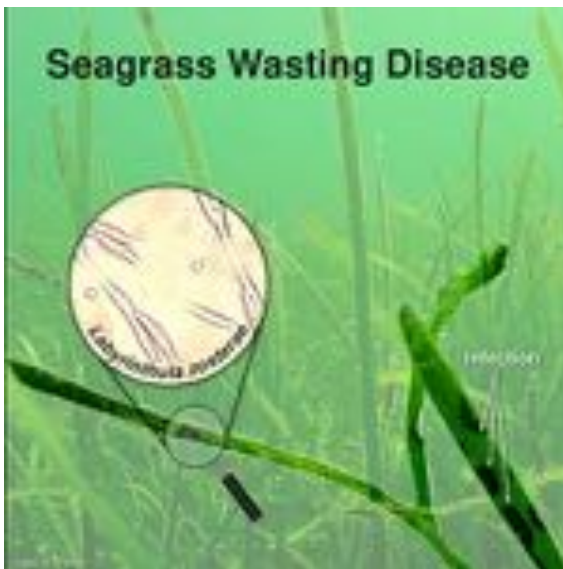


Sea Surface Temperatures in Casco Bay in 2022, collected through the Friend's of Casco Bay Continuous Monitoring Program

The sea surface temperature (SST) of water in the Bay has become increasingly problematic due to global warming. Based on 30 years of monitoring, it has been identified that the Bay is warming at a rate of 1°F per decade which could result in significant impacts on our seagrass meadow (Friends of Casco Bay, 2020)! Additionally, estuaries are vulnerable to rapid changes in temperature due to the shallow nature of these areas. Even short-term exposures to rapidly increasing temperatures in the summer months could lead to widespread diebacks of eelgrass (Moore et al., 2014).

## How Temperature Contributes to Wasting Disease

Wasting disease is an infectious disease affecting *Zostera* caused by *Labyrinthula*. *Zostera* leads to the wipe out of *Zostera Marina* in the 1930s. It can cause large-scale die-offs of eelgrass, leading to ecosystem cascading effects. Transmission occurs through water-borne spores and is more prevalent in warmer temperatures.



This can also lead to wasting disease!

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## As a result, our once beautiful seagrass meadow has decreased in cover class!

In 2022, the Maine DEP performed another analysis of seagrass cover in Casco Bay. The results are staggering. Seagrass in the Bay has decreased by 52% in just four years (Ferris-Olson, 2023). Where a small portion of the Bay near the Southern Coast had dropped from 5,012 to 2,286 acres (Ferris-Olson, 2023). As a result of the culmination of numerous factors, our seagrass meadow has experienced a significant decline in seagrass density.



Our seagrass meadow now falls into the 10 - 40% Cover Class!

Our once healthy meadow now contains areas falling into both the 10 - 40% and 40 - 70% cover classes! This means that we are starting to lose the benefits we once associated with this meadow and that many of the organisms that once lived in our meadow, no longer can.



Some parts also fall into the 40 - 70% Cover Class!

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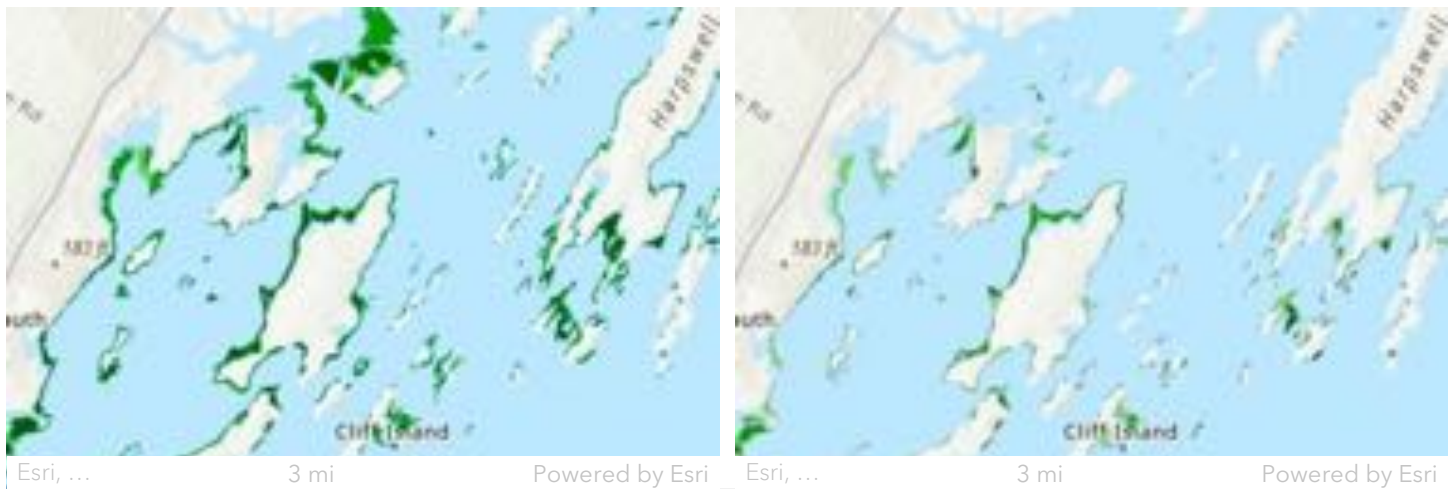
## This is happening all over the Bay!



Report finds "alarming" loss of eelgrass off Maine coast

From 2018 to 2022 more than half the Bay has disappeared (Ferris-Olson, 2023). *Zostera* beds have decreased at an alarming rate and the bay has also been warming. The Gulf is warming more than any other body of water (Ferris-Olson, 2023). It does not help that the wastewater treatment plant also discharges into the Bay and discharges warm nutrient rich water. The issue of declining beds of seagrass is not an anomaly. Seagrass is declining all over the world from the Mediterranean, Tropical Atlantic, and beyond (Dunic et al. 2021)





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## So how can you help?

Team Zostera is a local community science initiative that is currently working with different researchers, engineers, community members, and many other talented individuals. With that being said they are making great strides to help educate folk on the importance of Zostera and why it is important to protect it. If you would like to connect with Team Zostera and be up to date on current and future efforts please connect with them below!

**Visit Team Zostera's Website**

**Follow Team Zostera**

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**Image of Maine Vacationland Sign**

public domain image taken by Paula Agostino from flickr,

**Image Boats in Casco Bay**

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**Image of Street in Portland**

public domain image taken by Nathan Perli from flickr

**Image of Casco Bay Ferry and Lighthouse**

public domain image taken by John McLaughlin from flickr

**Image of Busy Street in Portland**

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**Image of 10 - 40 % Seagrass  
Meadow**

Maine DEP (2023)

**Image of 40 - 70 % Seagrass  
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Maine DEP (2023)



**Video Report finds "alarming"  
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**Maps of Casco Bay in 2018 and  
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