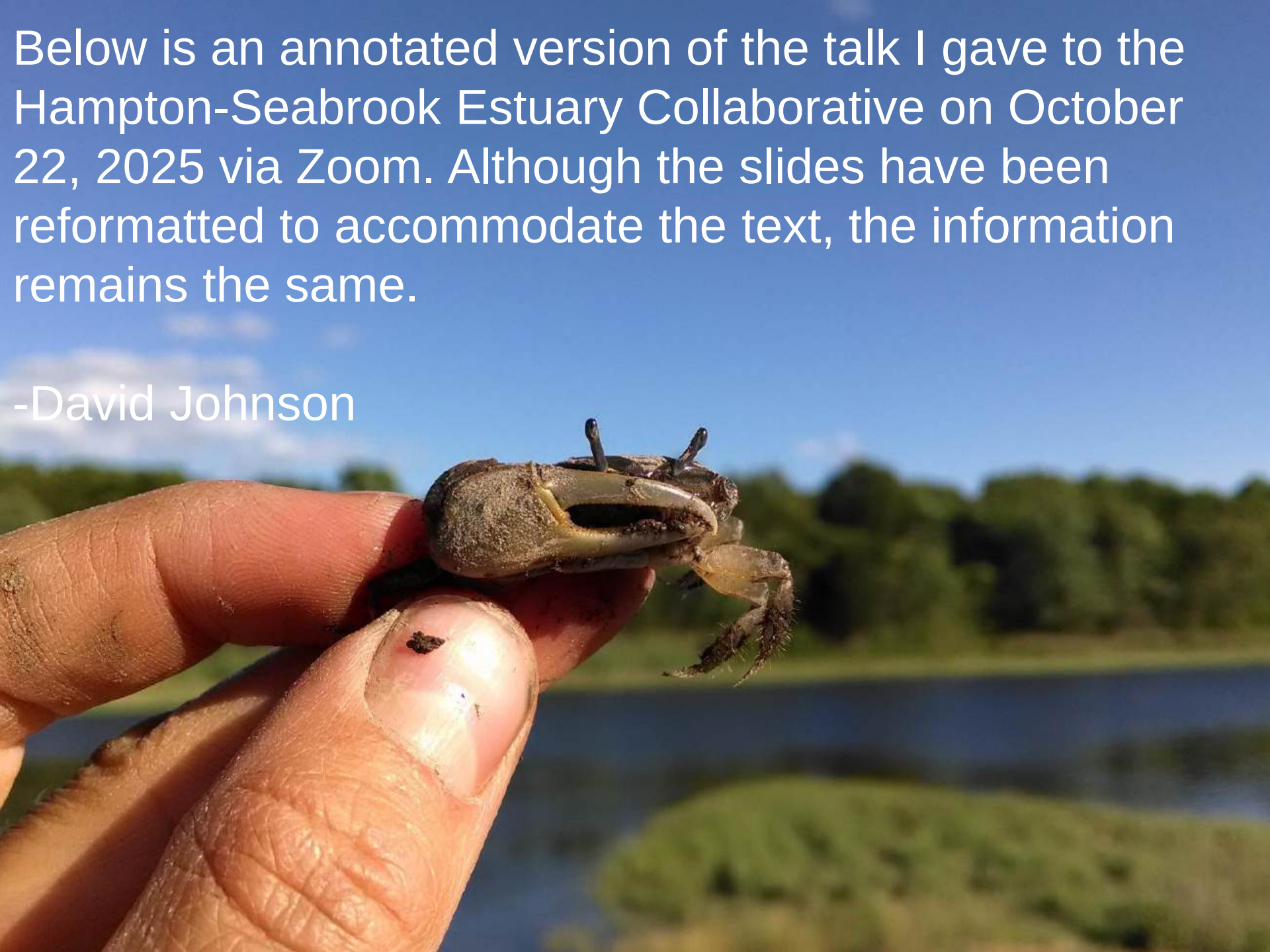
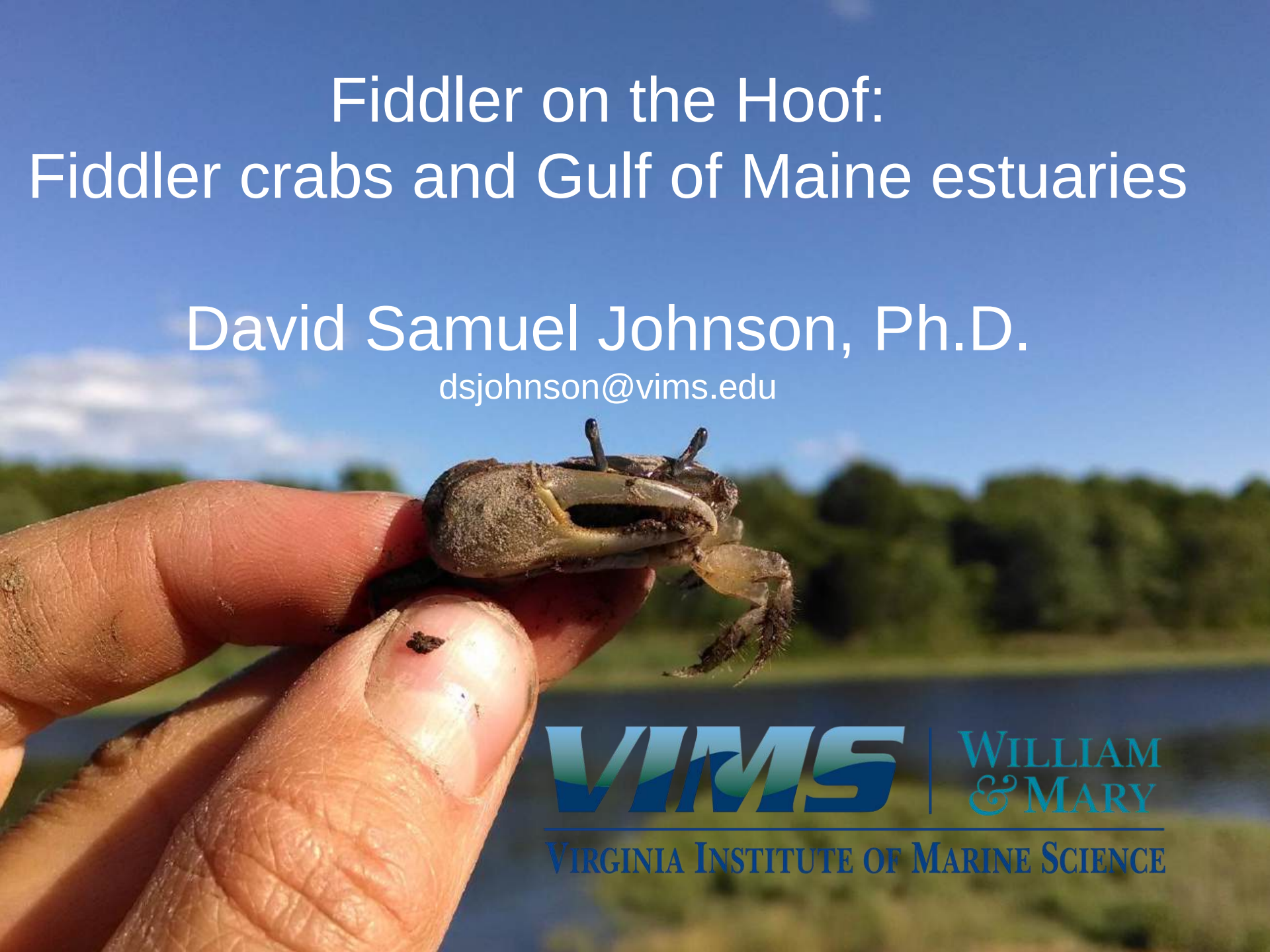
Below is an annotated version of the talk I gave to the Hampton-Seabrook Estuary Collaborative on October 22, 2025 via Zoom. Although the slides have been reformatted to accommodate the text, the information remains the same.

-David Johnson



Fiddler on the Hoof:
Fiddler crabs and Gulf of Maine estuaries

David Samuel Johnson, Ph.D.
dsjohnson@vims.edu



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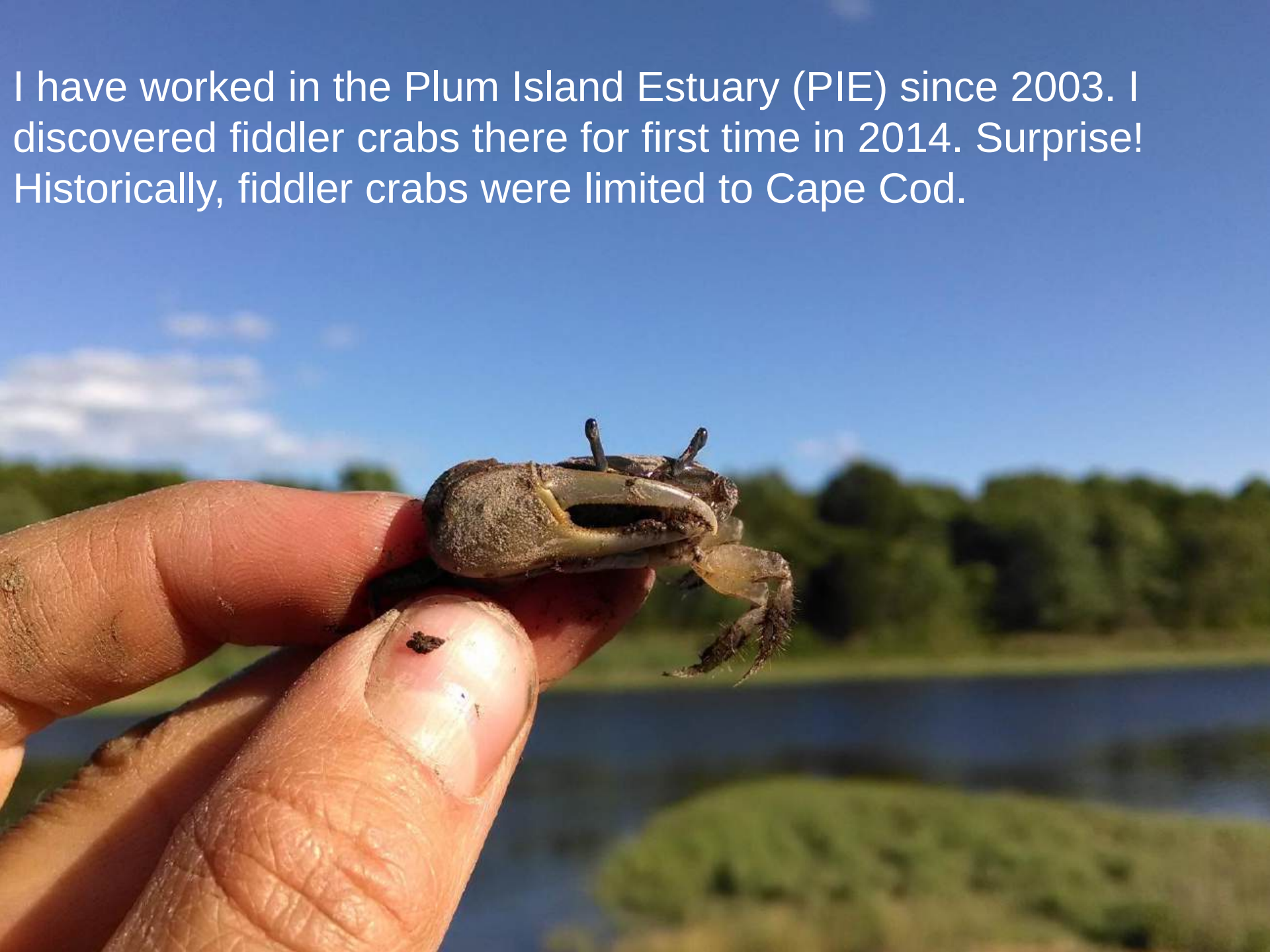
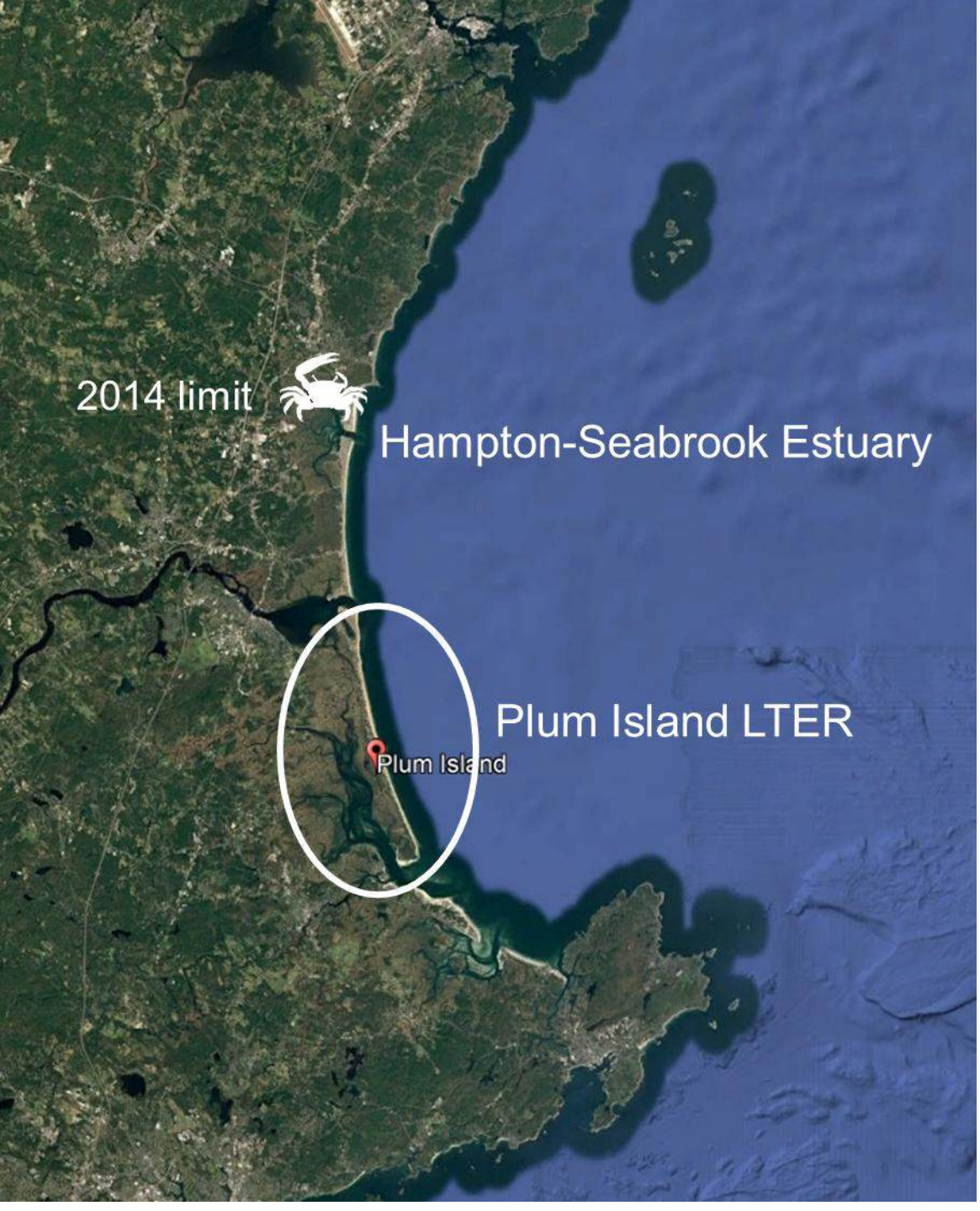
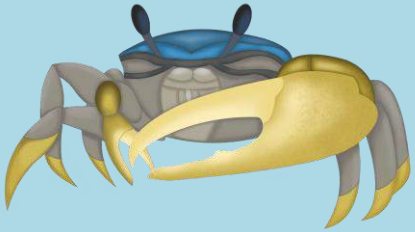
I have worked in the Plum Island Estuary (PIE) since 2003. I discovered fiddler crabs there for first time in 2014. Surprise! Historically, fiddler crabs were limited to Cape Cod.





I found fiddler crabs as far north as Hampton, NH in 2014, suggesting a range expansion into the Gulf of Maine. (Johnson 2014)

Fiddler crabs are now found as far north as central Maine (Phippsburg) (Martínez-Soto & Johnson 2024)



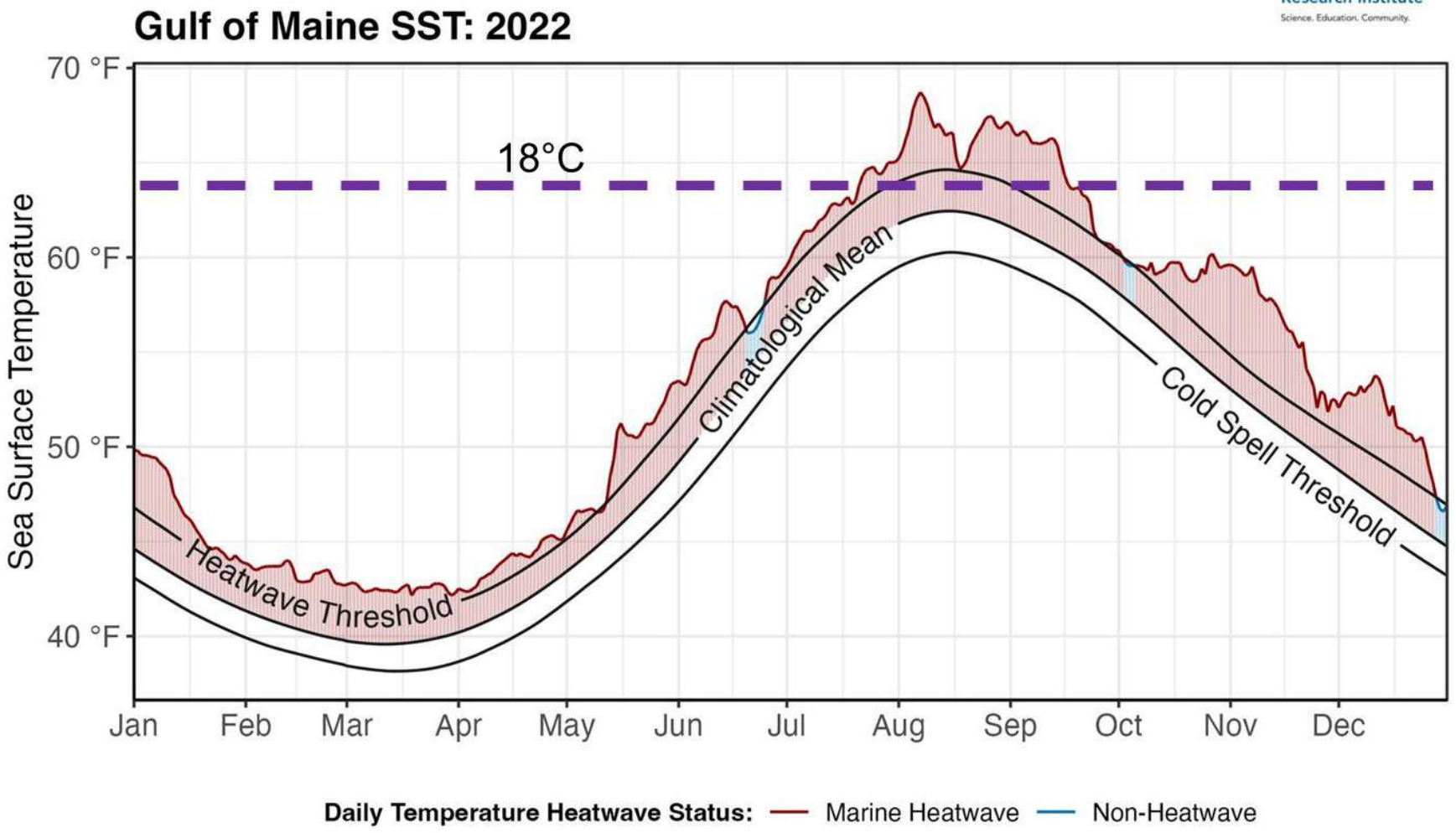
Minuca pugnax
known range

Expanded

Historical

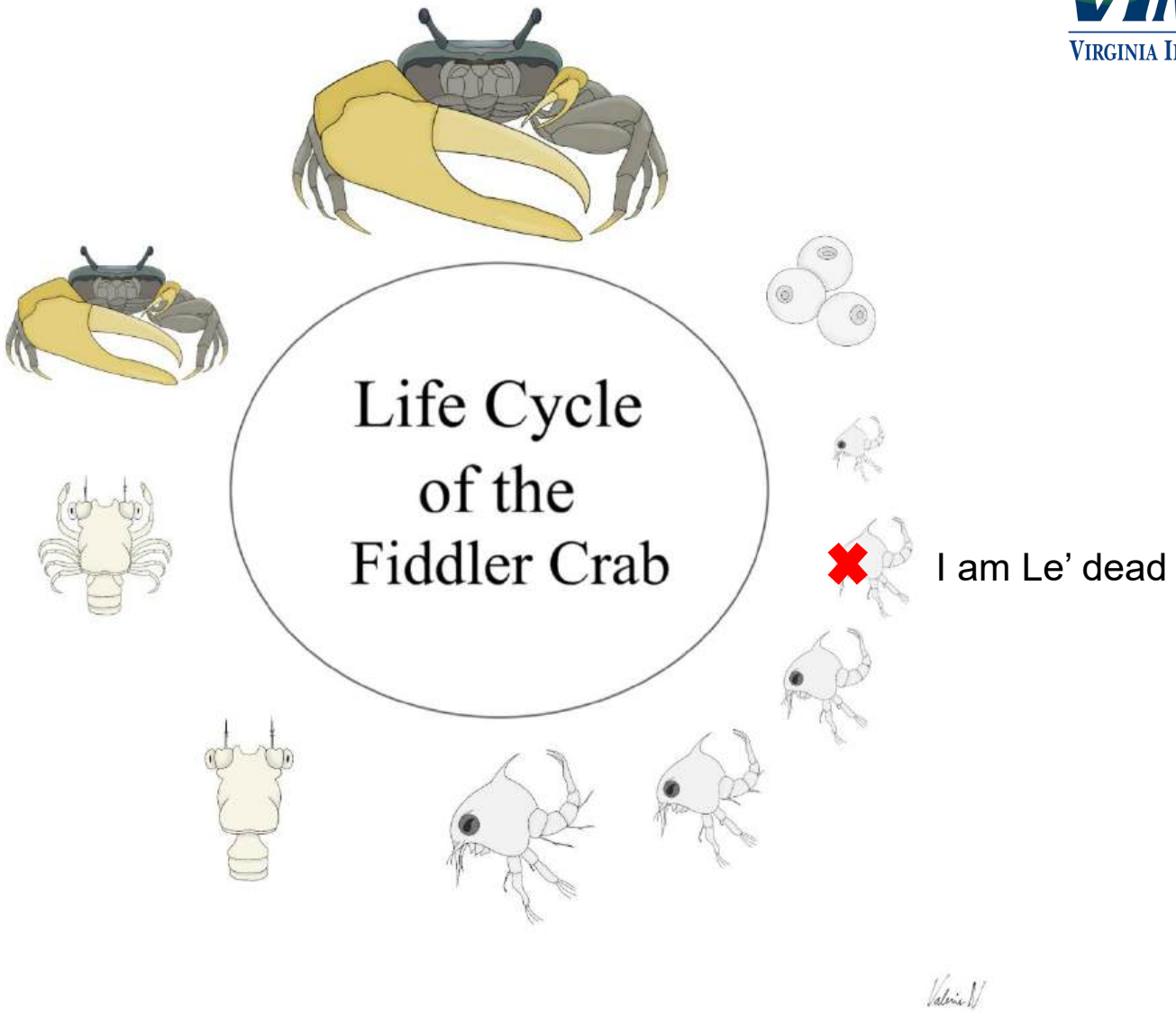
Atlantic Ocean

N



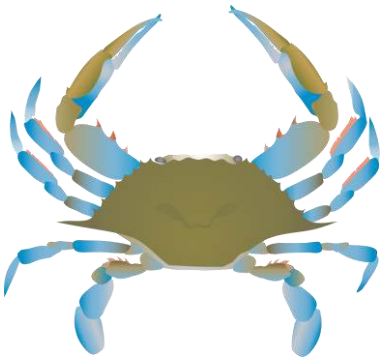
Recent Gulf of Maine warming due to climate change is likely driving this expansion based on thermal tolerance of larvae. Pelagic larvae (see next slide) are found in the open ocean and need water temperatures > 18°C during the summer to complete their life cycle.

Modified figure from Gulf of Maine Research Institute: See Figure 7 for figure legend: https://gmri.org/stories/warming-22/



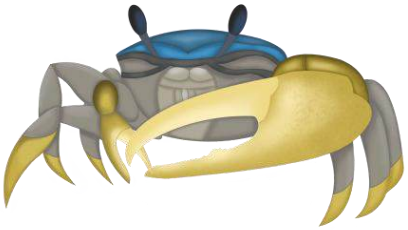
Life cycle of *Minuca pugnax*. At water temperatures < 18°C, most crabs do not live past zoeal stage 2. (Sanford et al. 2006)

As a result of warming, the Gulf of Maine is getting crabbier (and fishier).



Blue crabs

Johnson 2015



Fiddler crabs

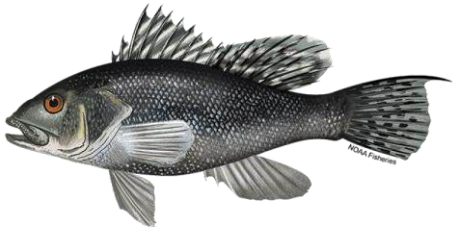
Johnson 2014

Lady Crabs

Johnson et al. 2025

Ghost crabs

McDermott & Kraeuter 2014

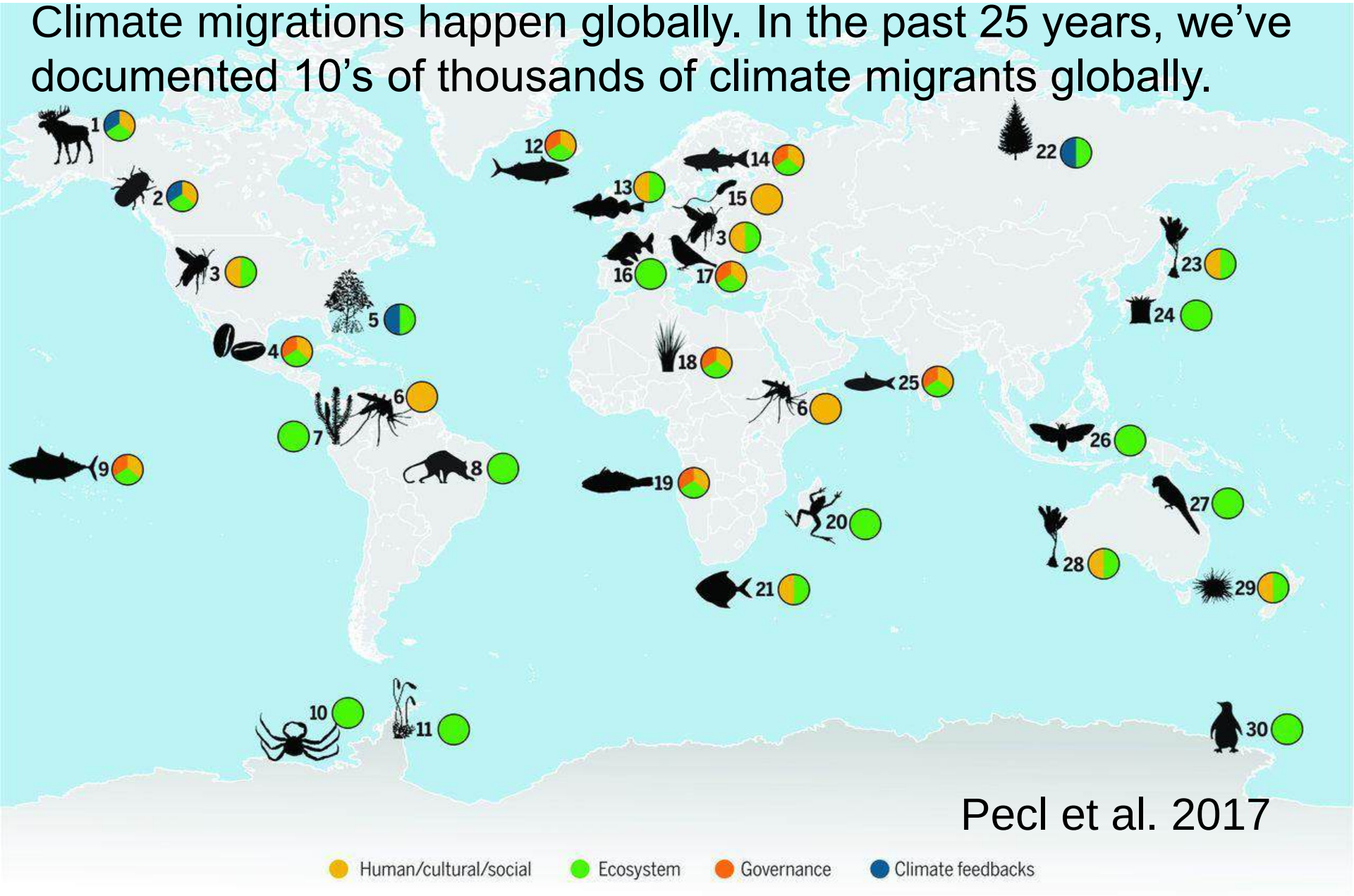


Black Sea Bass

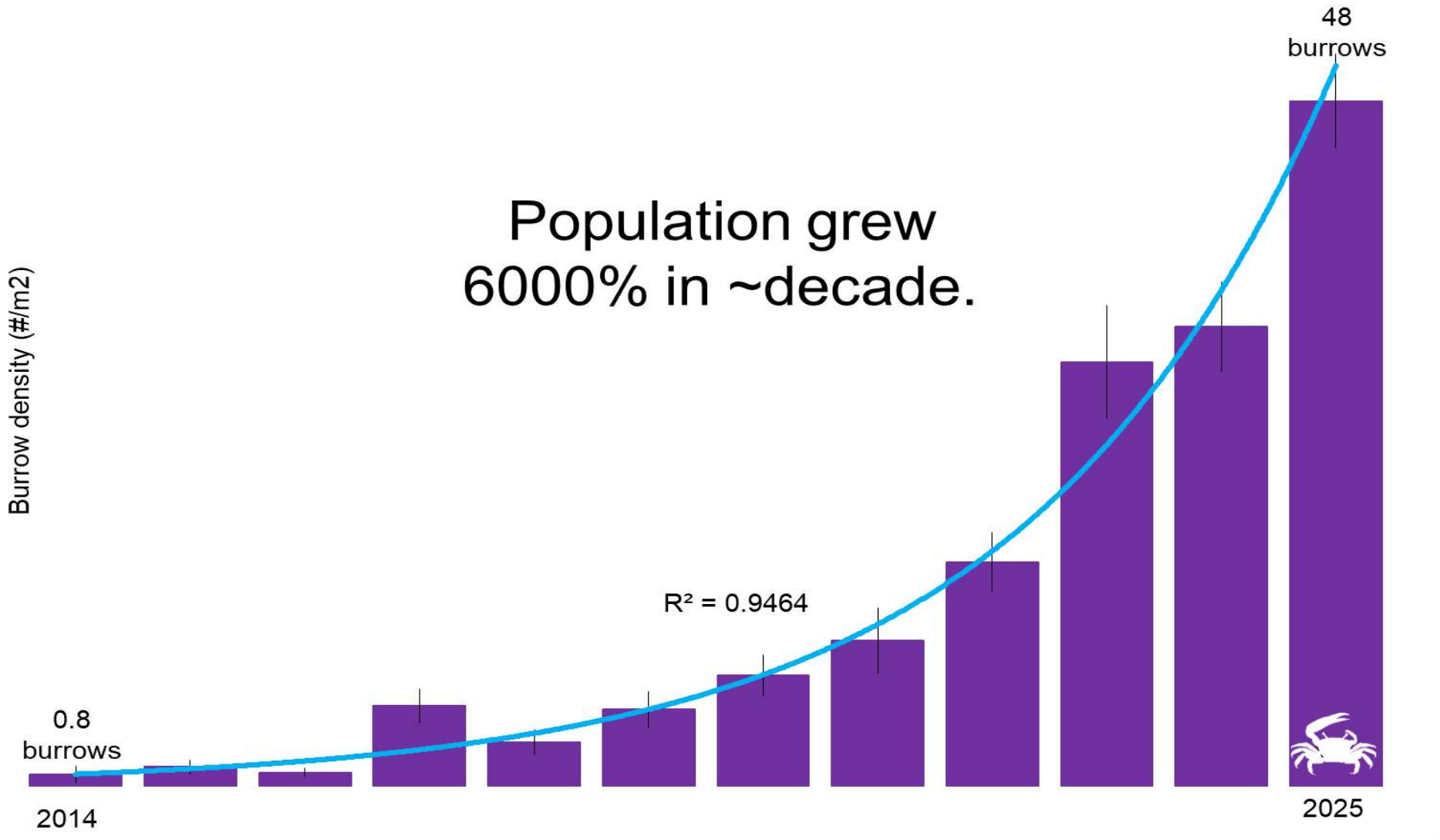
McBride 2018

Fiddler crabs and other crabs are examples of climate migrants: species that shift or expand their ranges due to climate change.

Climate migrations happen globally. In the past 25 years, we've documented 10's of thousands of climate migrants globally.

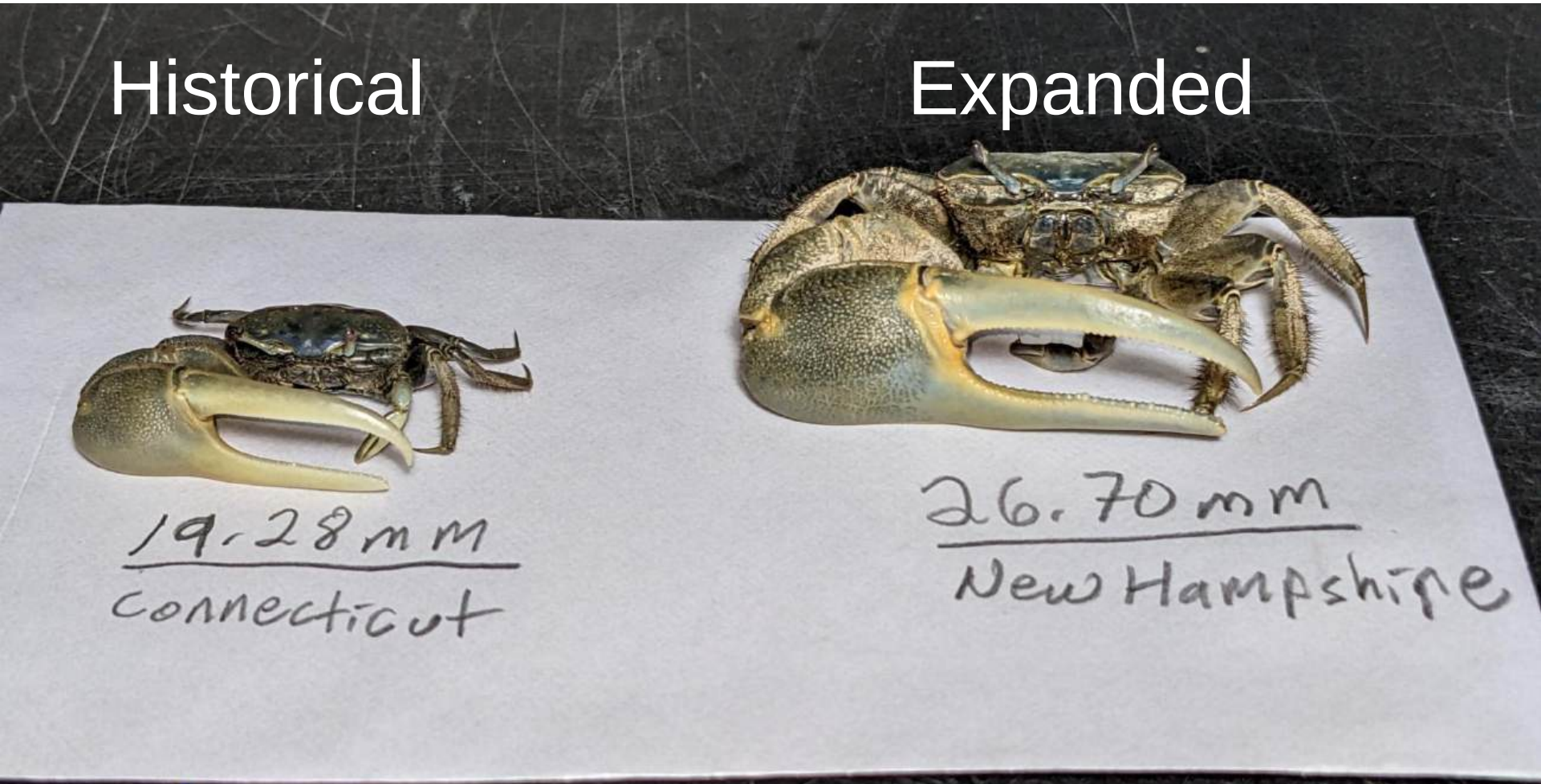


Pecl et al. 2017



Are fiddler crab populations persistent and growing? Yes. In the Plum Island Estuary, they have increased exponentially since I first discovered them in 2014. They are, however, still lower than densities we find in the historical range (e.g., 100-150 burrows/m2) (Martinez-Soto & Johnson 2020/Johnson, *unpublished data*).

We have found compelling differences in crabs between ranges. For instance, crabs are, on average, ~30% larger in the expanded range compared to the historical range.



Johnson et al., unpub.

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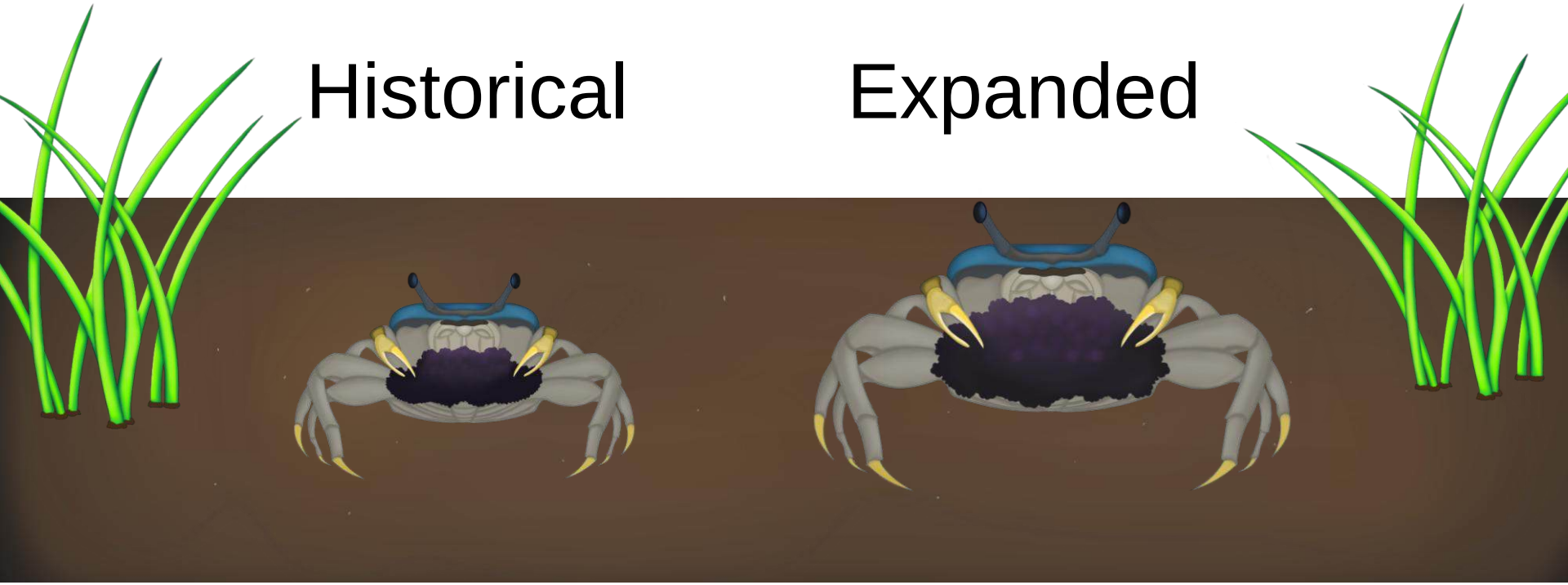
Crabs are almost more fecund in the expanded range, with females having almost 30% more eggs. This is true even when accounting for the larger size of the crabs.



Johnson et al., unpub.

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Larger, more fecund crabs in the expanded range suggests ecological/enemy release. We find that crabs have fewer parasites in the expanded (1) than the historical range (5). This parasite escape with climate migration may allow crabs to invest more energy into growth and reproduction instead of parasite defense.

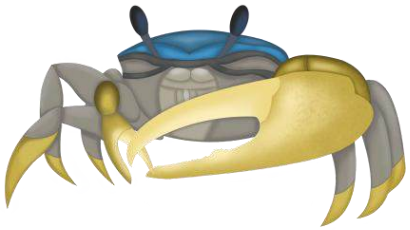
Historical

Expanded

Johnson et al. 2020, *MEPS*

Crabby thought #1

GoM fiddler crabs are released from enemy pressure, which enhances their fitness allowing their populations to grow and spread.



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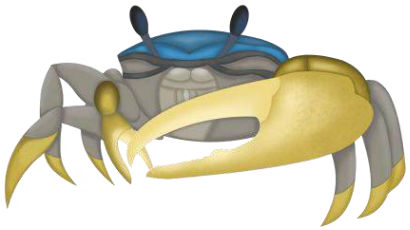
Crabby thought #2

Climate migrants are the clearest evidence of climate change.

Yet, we've overlooked their impacts.



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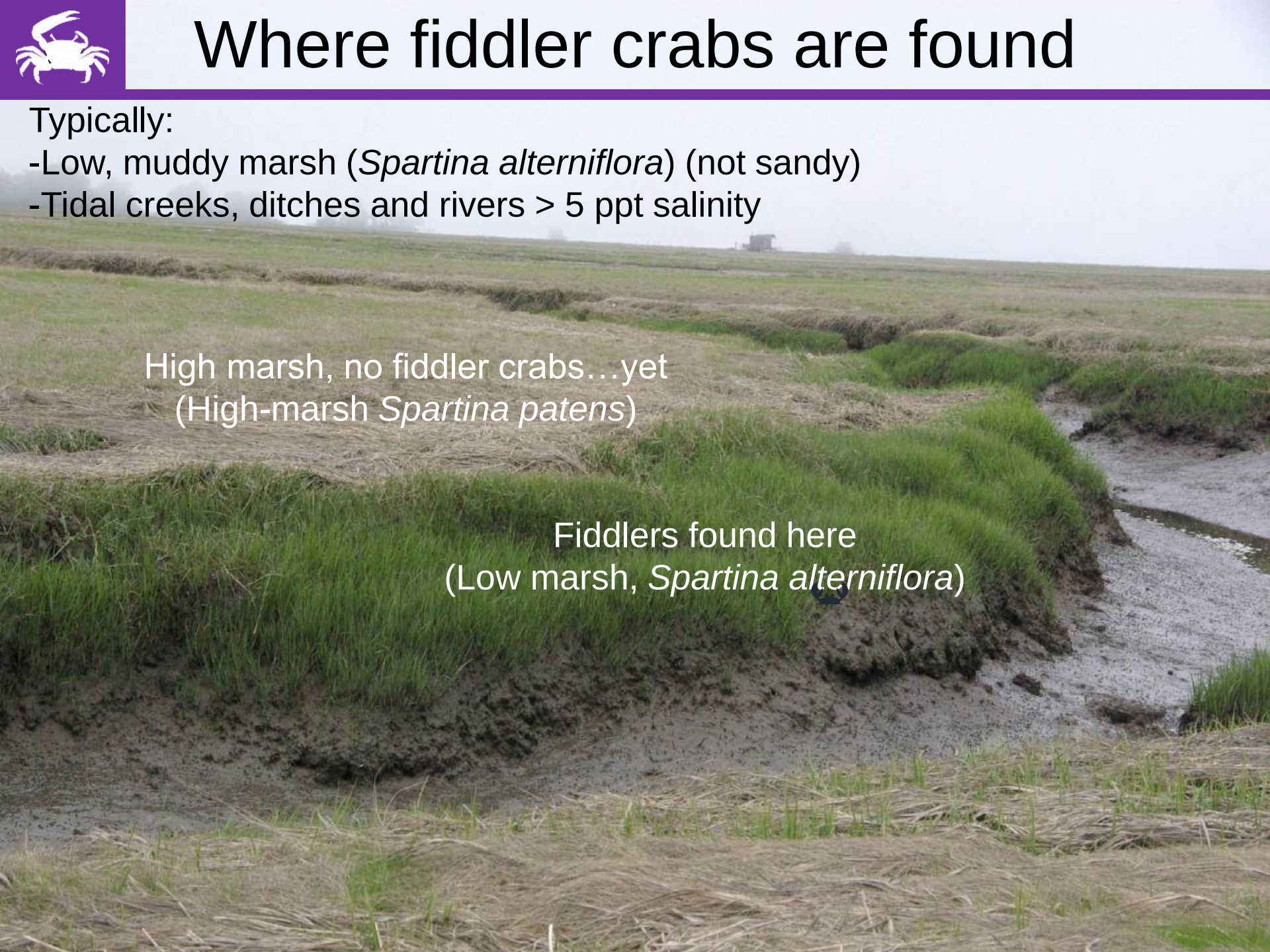
Where fiddler crabs are found

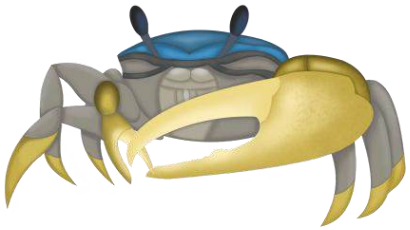
Typically:
-Low, muddy marsh (*Spartina alterniflora*) (not sandy)
-Tidal creeks, ditches and rivers > 5 ppt salinity



Fiddler crab impacts

Based on dozens of studies from marshes from Georgia to the Cape Cod National Seashore in the past half century, the paradigm is that fiddler crabs enhance aboveground biomass.

We tested this paradigm in the expanded range.



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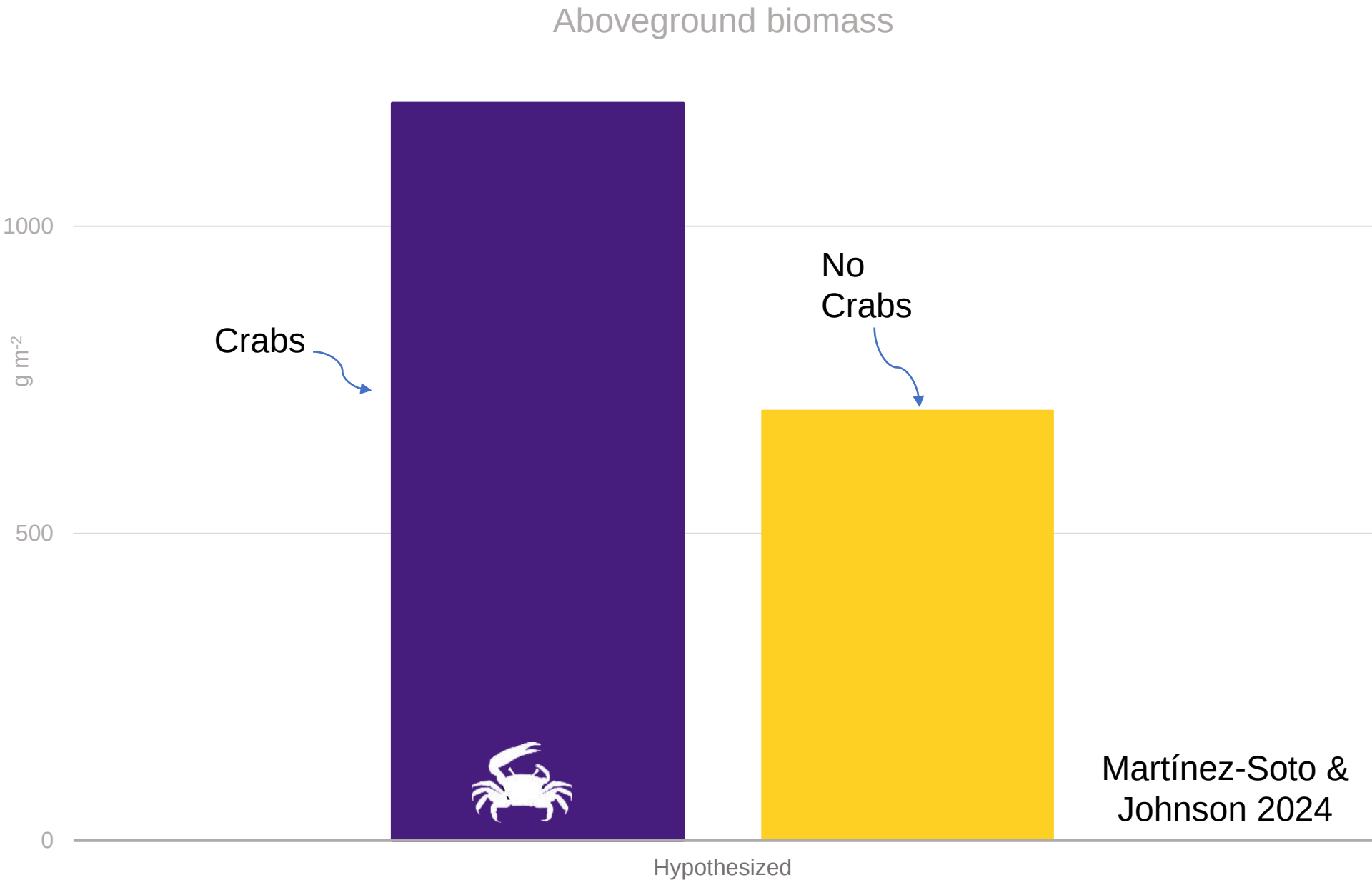
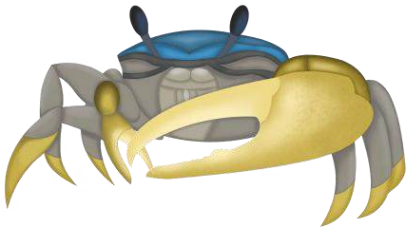
Fiddlers and AG biomass Paradigm



Fiddler crab impacts

We tested this hypothesis in the expanded range.

And found the opposite trend…



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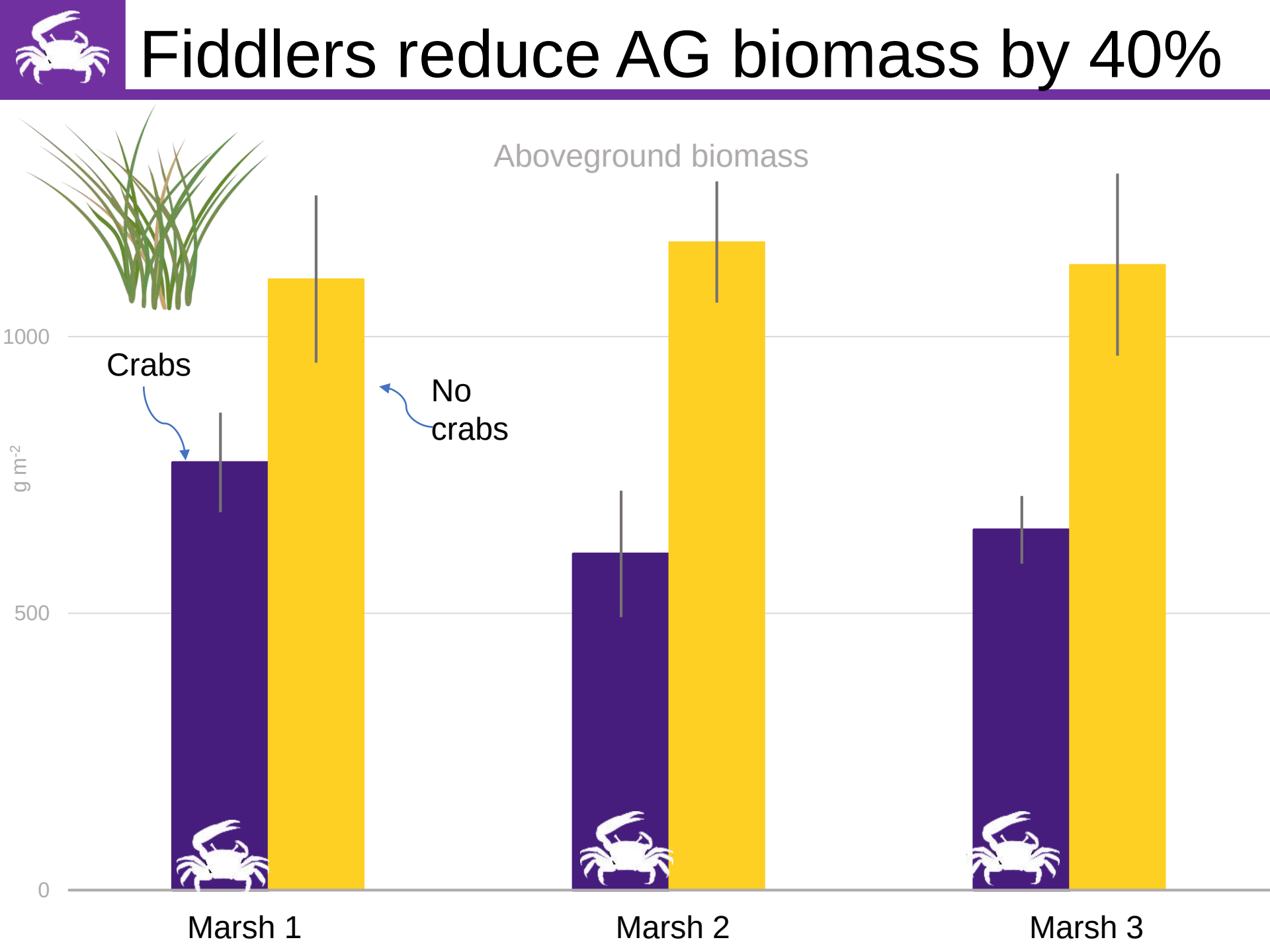
Fiddlers reduce AG biomass by 40%



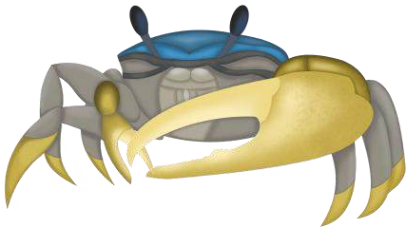
Fiddler crab impacts

We found that fiddler crabs reduced AG biomass by 40%, in contrast to what we see in the historical range (i.e., south of Cape Cod). This suggests the following:

-There was an ecological ‘flip’ in the crab-plant interaction after crabs migrated north

-We cannot predict the impacts of climate migrants based on historical trends.

This leads to more questions.



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Fiddler crab impacts

Known unknown: How do crabs affect marsh geomorphology?

This ecological flip *may* have consequences for saltmarsh accretion in the face of sea-level rise.

Plants are critical maintaining saltmarsh elevation with rising seas by trapping sediment (aboveground biomass) and adding soil volume with organic matter (belowground biomass) (see diagram on next slide). In the expanded range, fiddler crabs reduce both AG and BG biomass, potentially reducing a marsh's ability to keep up with SLR.

However, because GoM marshes are highly productive with a lot of elevation capital, its unknown if fiddler crabs will have significant impacts on accretion.

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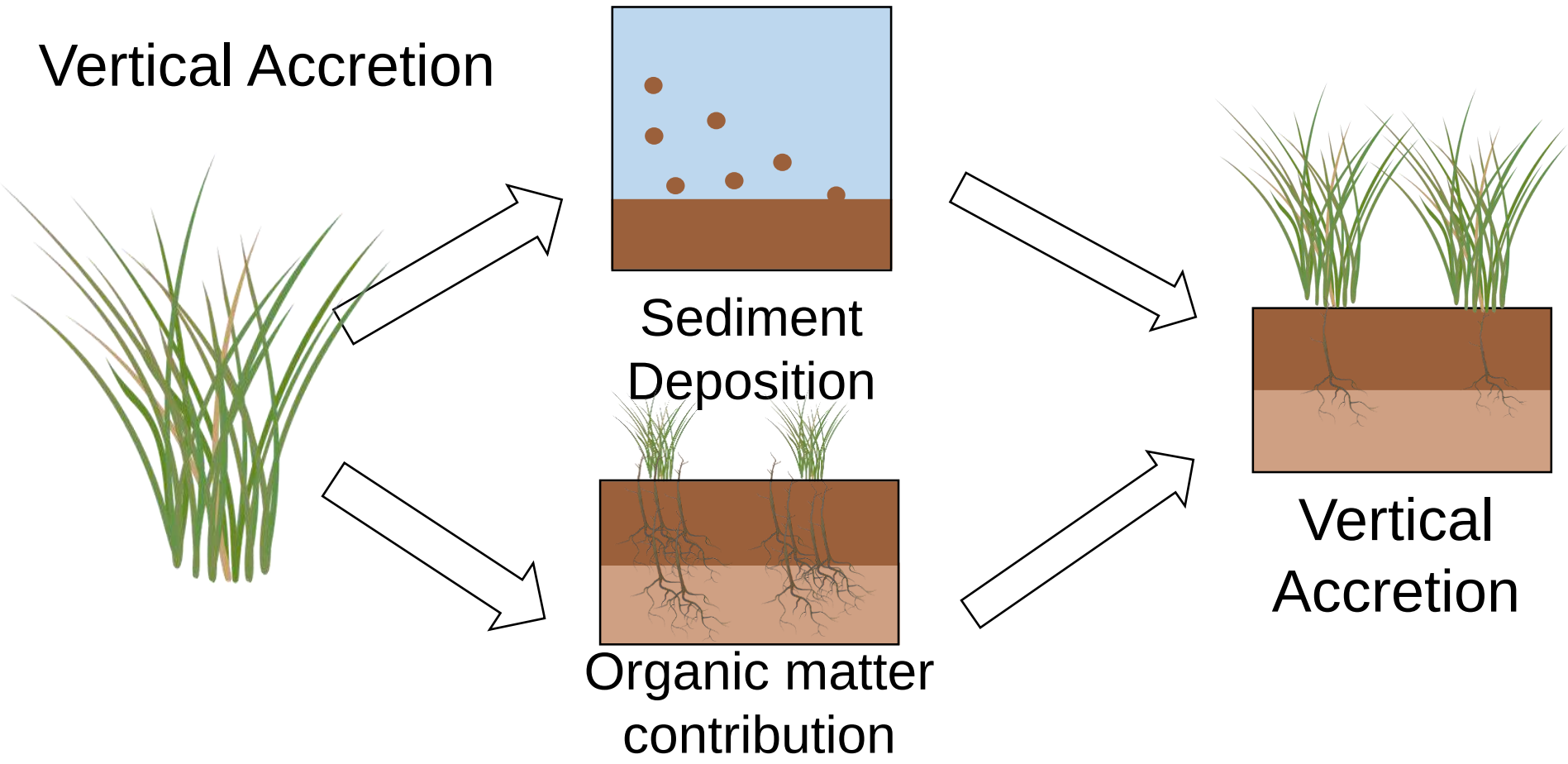
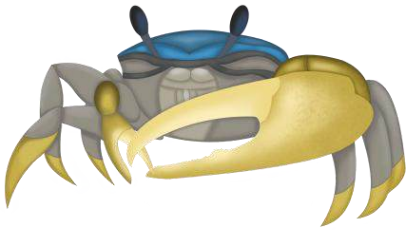
Keeping up with SLR



Fiddler crab impacts

Known unknown: How do crabs impact blue carbon storage?

Similarly, fiddler crabs may impact carbon storage in salt marshes by reducing carbon trapping (aboveground biomass) and storage (belowground biomass) and increasing release back to the atmosphere by enhancing decomposition through their burrowing. Burrows introduces oxygen to oxygen-limited, organic rich marsh soils. (see diagram on next slide).



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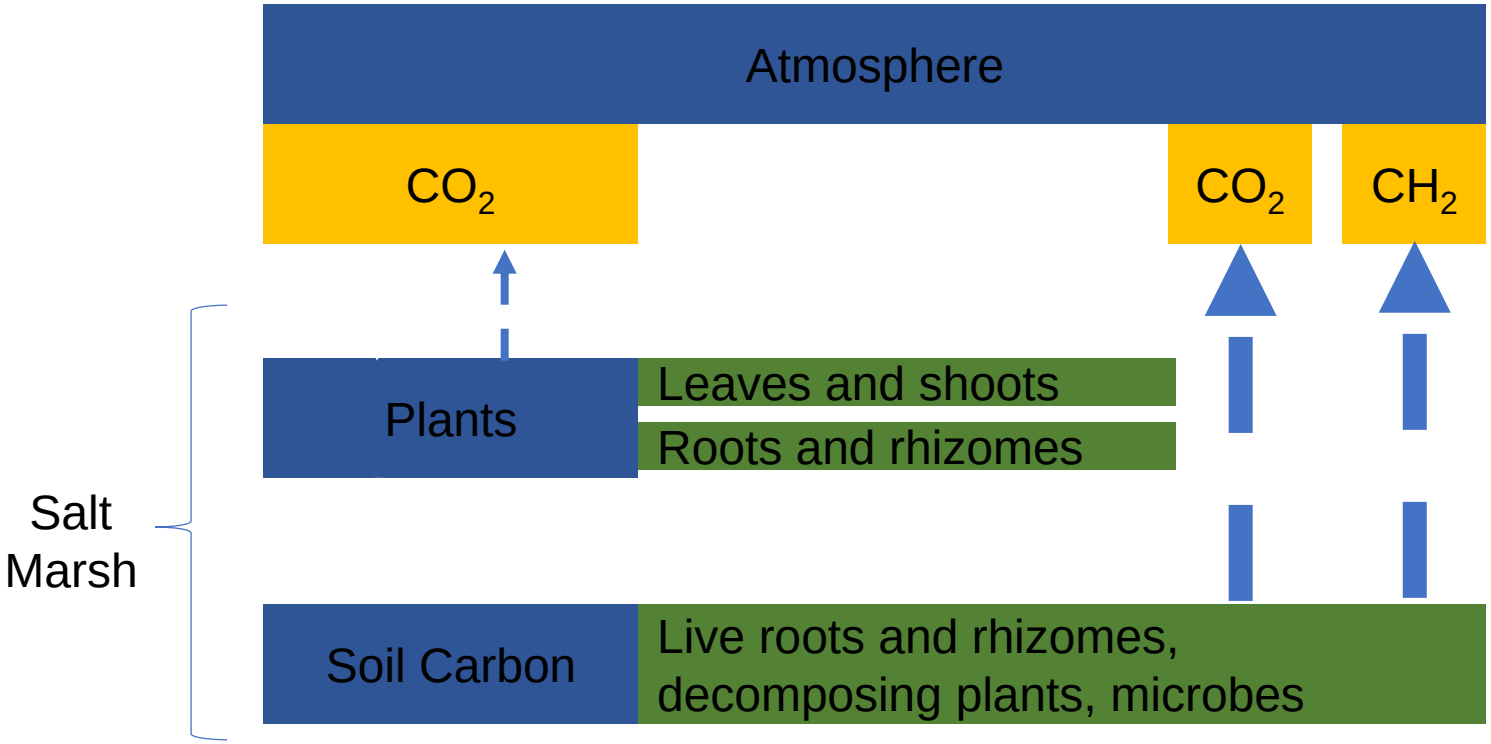
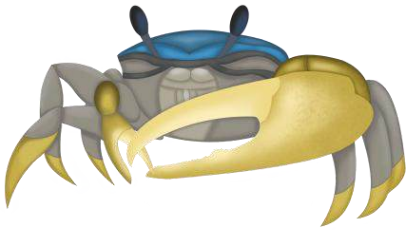
Carbon impacts



Fiddler crab impacts

Known unknown: How do fiddler crabs influence marsh food webs?

Fiddler crabs eat primarily benthic algae, but also fungi and detritus. They are eaten by many predators including birds, raccoons, eels, and larger crabs. How does this crab influence energy flow to higher trophic levels?



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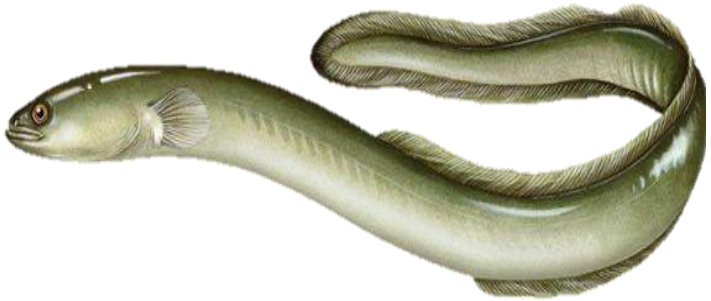
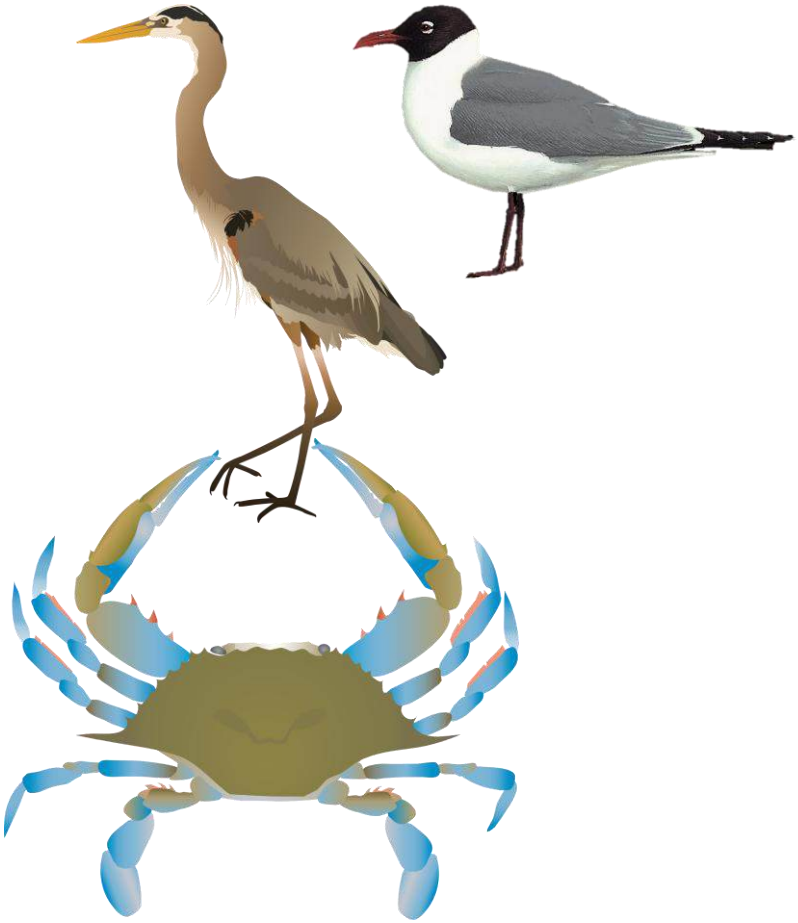
Predators



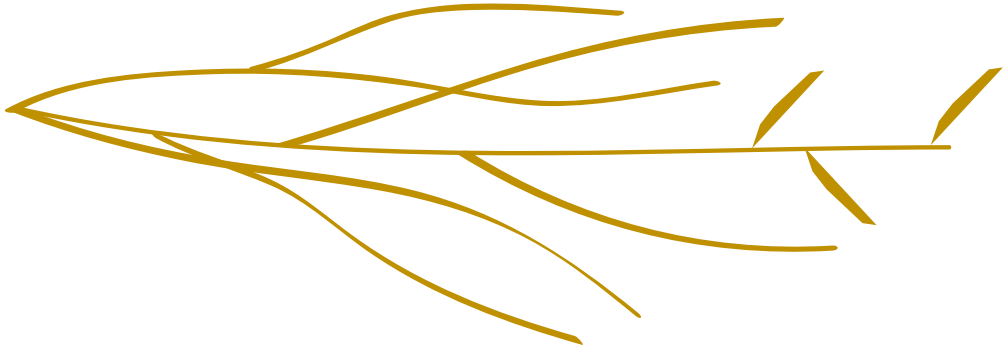


Fiddler food

Deposit feeders

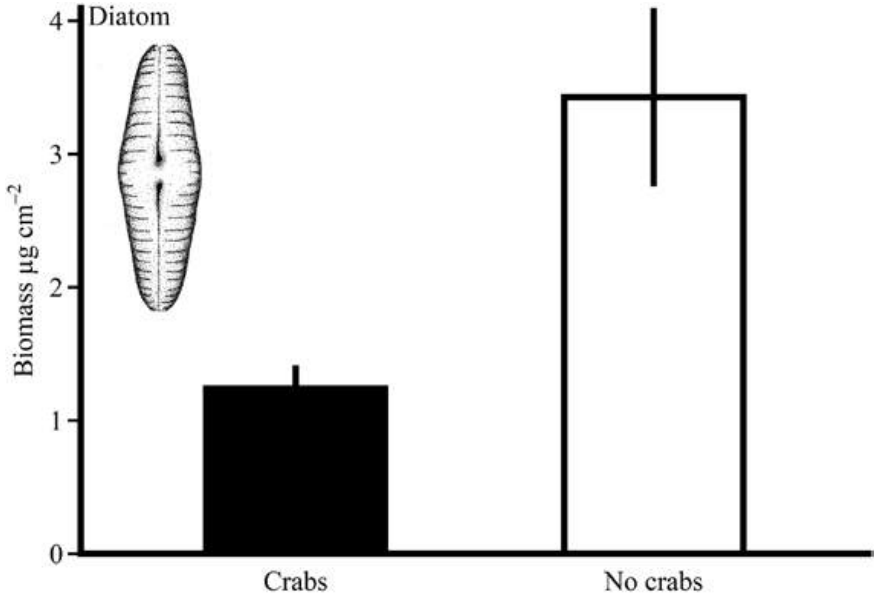
Algae

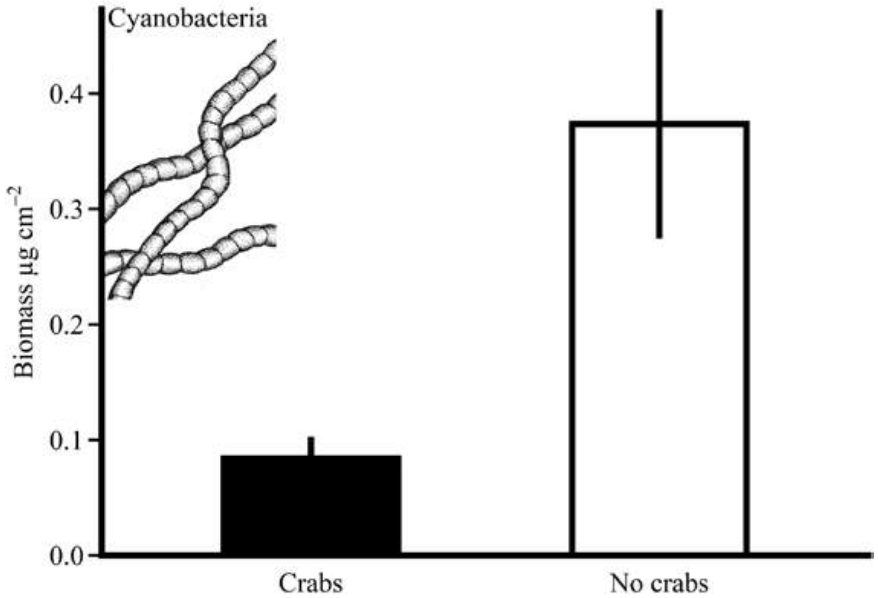
Fungi



Detritus

Fiddlers reduce BMA by 70%





Fiddler crabs can significantly graze down benthic microalgae (BMA) in the expanded range.

Johnson et al. 2020, *J. Crustacean Biology*

Fiddler crab call to action

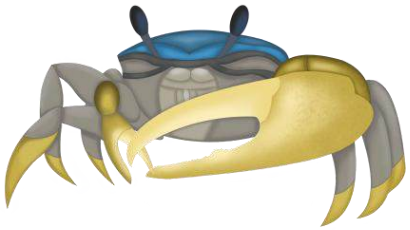
Next steps for fiddler crab research in HSE and GoM (illustrated on next slide):

1. Expand monitoring (currently monitoring in Plum Island Estuary, MA and Great Bay NERRS, NH)

2. Explore impact of crabs on marsh's ability to keep up with SLR

3. Understand carbon impacts of fiddler crabs

4. Explore how fiddler crabs integrate into marsh food webs



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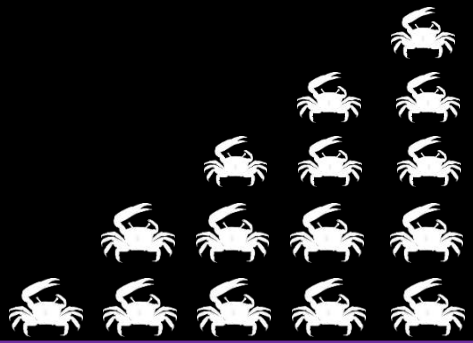
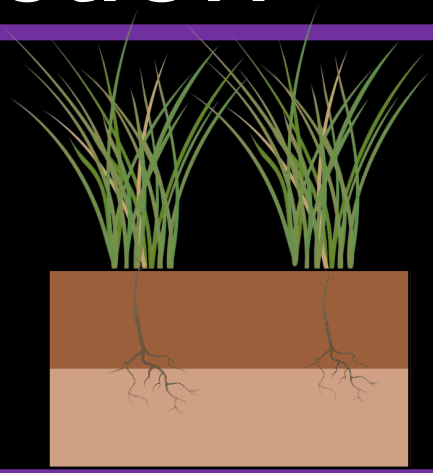
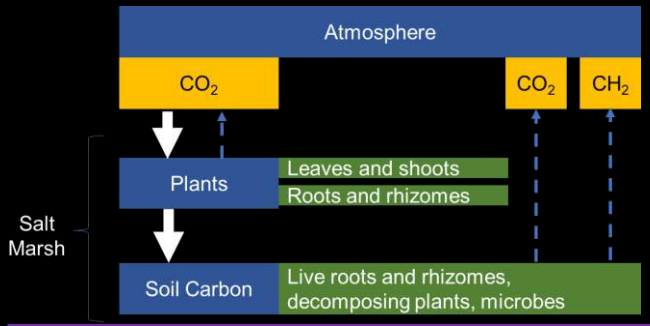
Call to Action



1. Monitoring



2. Marsh-crab-SLR interactions



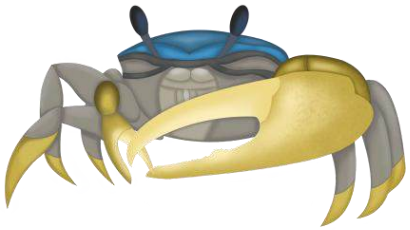
3. Carbon impacts

4. Food-web impacts

Final crabby thought

We cannot prepare for climate-change impacts without including climate migrants in our decision-making.

dsjohnson@vims.edu



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Credits

All images are my own except:

- Fiddler crabs, life cycle, marsh illustrations by Valerie Acosta Rodriguez
- Lady crab, Ghost crab: iNaturalist.org
- Black sea bass, eel: NOAA FishWatch
- Predators, grass, fiddler food slide: Integration and Application Network

References:

- Johnson et al. 2020. J. Crust. Bio. 40: https://doi.org/10.1093/jcbiol/ruaa073
- Martínez-Soto & Johnson. 2020. J. Crust. Bio. 40: https://doi.org/10.1093/jcbiol/ruaa049
- Johnson et al. 2020. MEPS 641. https://doi.org/10.3354/meps13278
- Johnson et al. 2019 Ecology Evolution 9 https://doi.org/10.1002/ece3.5883
- Pecl et al. 2017. Science 355:eaai9214 https://DOI:10.1126/science.aai9214

Sanford et al. 2006. Ecology 87
https://doi.org/10.1890/0012-9658(2006)87[2882:LTGFAT]2.0.CO;2

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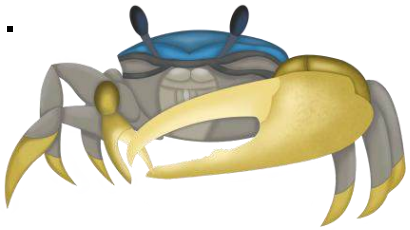

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