

What are Green Crabs Eating in Willapa Bay?

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What resources do green crabs threaten?

- European green crab (*Carcinus maenas*) is one of the most widespread marine invasive species, and has been associated with declines of clam and crab populations outside of its native range
- Since around 2017, European green crab populations in Willapa Bay, WA, have been observed at greater densities than ever before, since their first detection in the Bay in 1998.
- The expanding invasion in Willapa Bay has raised concerns that **green crabs could threaten the region's productive harvest** of clams, oysters and Dungeness crabs.



Diet DNA analysis identifies more prey types

- WSG Crab Team and partners collected green crabs from four sites in Willapa Bay, in May, July, and September 2021. Two collection sites had commercial Manila clam beds, and two were natural slough sites without active aquaculture.
- We conducted DNA-based diet analysis on 86 larger, primarily male crabs because we assumed that the greater crushing strength of their claws would make it more likely these individuals were capable of eating Manila clams.
- DNA-based diet analysis uses the DNA left behind by food items in a crab's stomach to simultaneously identify many prey species. We specifically conducted DNA metabarcoding of the COI gene region, which involved (1) extracting DNA from green crab stomach contents, (2) sequencing short regions of DNA known as "barcodes," and (3) matching those sequences to the National Center for Biotechnology Information's large database of potential prey species.
- We used presence/absence data from the DNA-based analysis to describe the diet, and tested for significant differences between collection sites with a PERMANOVA / PERMDISP and an index of relative prey abundance ("eDNA Index").



Dried stomach contents from green crabs

Green crabs eat from a big menu

- European green crab in Willapa Bay have a generalist, omnivorous diet which varies between locations and across individuals. We identified **56 unique food items** in the stomach contents of 86 crabs.
- Green crab stomach contents from the two Manila clam bed sites were **significantly different from those at one of the natural intertidal slough sites** (Stackpole; $p < 0.05$). Additional work is needed to determine whether this significant difference is driven by differing prey communities between sites, versus differing prey selectivity by crabs between sites.
- We only observed **one instance of Manila clam consumption**, by a green crab collected at the Oysterville clam bed site. This indicates infrequent predation of larger, male European green crabs on Manila clam during the summer and early fall.
- Six crabs had Zosteraceae DNA in their stomachs**; this family includes surfgrasses (*Phyllospadix* spp.) and eelgrasses (*Zostera* spp.). More research is needed to determine what our results mean for specific species of these two habitat-forming groups.

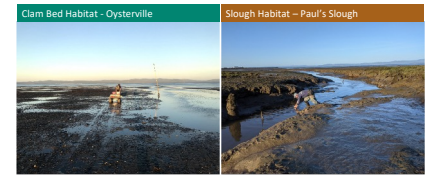
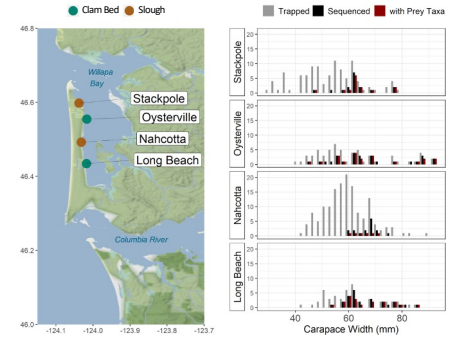
How do we scale to impacts?

- Diet data can be scaled to **estimate the impacts of green crabs on populations of prey species**. However, doing this with data from DNA-based diet analysis requires additional information on how laboratory methods and the process of green crab digestion bias DNA-based detection of different prey species. We have already addressed the first consideration with additional laboratory and modeling work.
- Further diet studies might also investigate the **change in green crab diet over seasons and across the life history** (size) of crabs, and the **role of cannibalism** in green crab diets.

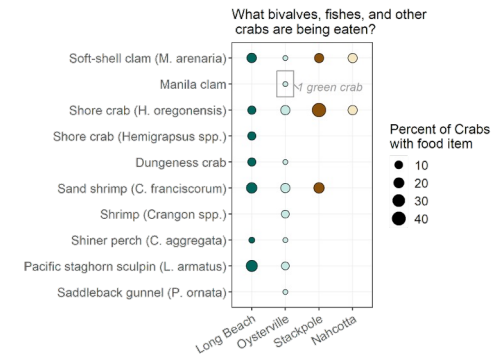
Green crabs have a wide diet, including fish, insects, and algae. The most common invertebrates in their stomachs were:

- Hairy shore crab 
- Sand shrimp 
- Amphipods 
- Softshell clam 

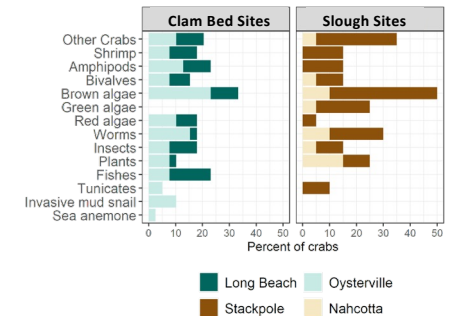
Study Sites and Specimens



Top Food Items



Full Diet



Acknowledgements:

Funding was provided by the Washington Department of Fish and Wildlife (WDFW No. 21-18297) as part of the Willapa Bay Oyster Reserves Grant Program (RFP No. 21-0009). Mary Fisher was also supported by the NSF's Graduate Research Fellowship Program (Grant DGE-1762114) while conducting this work. Green crab collection was conducted by Washington Sea Grant Crab Team and the Willapa-Grays Harbor Oyster Growers' Association under a WDFW Aquatic Invasive Species Permit. We would like to thank Friday Harbor Laboratories and the University of Washington's Burke Museum Fish Collection for their assistance in obtaining individuals and tissue samples used for mock communities. Thank you also to Heckler's Clam Company, Taylor Shellfish, and Kim Patten for providing property access for sample collection. Bettina Thallinger, Georgina Cordova, Ely Allen, Erin D'Agnesse, Megan Schaffer, and Maya Garber-Yonts shared invaluable lab and bioinformatic knowledge and assistance, and Eric Ward provided help troubleshooting the R package zoid. Invert icons from FlatIcon.com

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Fisher et al. 2024. (In review)

