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Recommendations for Establishing a Market for Invasive Green Crabs in New England

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Green crabs are one of the most invasive marine species in the world. Their populations in New England have grown significantly due to climate change, increasing their environmental and socioeconomic impacts. Green crabs are voracious predators of soft shell clams, and have had a detrimental impact on the region's valuable clam fisheries. They also prey on juvenile lobsters and other shellfish and compete with native crab species for resources. Green crabs burrow into and damage eelgrass beds, which are a vital habitat for many marine species and an important "blue carbon" sink. Due to their rapid rate of reproduction as well as other biological characteristics, green crabs are essentially impossible to eradicate. Attempts to remove them have therefore been largely unsuccessful. A more promising solution to the green crab invasion is to establish a culinary market. A culinary market would support continuous harvest of the crabs, keeping their population in check without devoting resources to futile eradication attempts. A green crab fishery would diversify New England's fisheries and make use of a highly abundant resource that is presently underutilized. Although there are challenges to developing a viable green crab fishery, it is likely the best strategy to combat their environmental impacts while simultaneously benefiting human communities. *Key Words: climate adaptation, fisheries management, invasive species, market-based solutions, sustainable food systems*

Messages for Policy

- Market-based solutions can be the most cost-effective ways to reduce the environmental and economic harm from fully established invasive species
- Interstate communication and coordination is required to permit transportation of live green crabs across state lines, a practice that is currently not aligned within New England
- New England states should encourage green crab trapping via a regulated fishery
- Expanded culinary markets for invasive

crabs requires fishery education on harvest techniques, including identifying valuable pre-molt crabs for the soft shell market

- States should support innovations that incorporate green crabs into novel products and markets (e.g., green crab meat processing machinery, biodegradable plastics bait, and compost)
- New England states should improve communication about green crabs to better facilitate market development

The Policy Problem

European green crabs (*Carcinus maenas*) are one of the most insidious invasive species in New England. The crabs pose a stark threat to soft shell clam and lobster industries and their population has grown rapidly in the wake of climate change. The species first arrived in Long Island Sound in the early 1800s via ballast water in ships from Europe and extended their range into Maine by the early 1900s (Carleton and Cohen 2003). Green crabs feed on soft shell clams and are the principal cause of the dramatic decline in clam landings in the Gulf of Maine (Downeast Institute 2020). Green crabs cause habitat destruction by burrowing into eelgrass beds, which many marine species rely on for shelter and as critical nursery habitat. Green crabs are incredibly fecund, with female crabs laying as many as 185,000 eggs per year (Perry 2011).

Between habitat destruction, high rates of predation, and rapid reproduction, green crabs outcompete native crab species and pose a growing threat to lobster and clam populations. Clamming and lobstering are two of New England's most valuable marine industries, and the serious threat from green crabs must be addressed through policy interventions. As the Gulf of Maine warms, marine resource management will require

adaptive responses to both preserve existing values and to manage environmental change (Pershing et al. 2021). Policy-based adaptation to environmental change should incorporate the creation of markets for underutilized and invasive species such as green crabs. Further, market-based invasive species control mechanisms have the advantage of causing the least impact on state budgets and limited public resources while simultaneously growing taxable economic activity that can be directed towards environmentally positive outcomes.

Attempts to control green crab populations have historically focused on total eradication via physical removal, with the aim of protecting threatened native species and habitats. Eradication efforts have devoted little attention to economic development that utilizes invasive species, probably because of the moral and policy complexity surrounding responsible and “sustainable” use of damaging invasive species (Larsen et al. 2011). If elimination of invasive species is the goal, then economic development based on those species poses a set of challenges that policymakers are likely loath to consider. Additionally, it can be argued that eradication policies stifle business investment into new products and markets, because the overarching eradication policy would undercut any sustainable business case that makes use of invasive species (Fischer et al., in prep).

Beyond eradication, other mechanisms of invasive species control do exist. One proactive example is the Maine Clammers Association's project in Freeport, Maine, which involved installing fenced barriers in clam flats (Beal et al. 2016; Hagan and Wilkerson 2018). While exclosures are an effective method of reducing localized predation, it is labor-intensive, limited in geographic scope, and does not reduce the further encroachment of green crabs into soft shell clam habitats. To date, the most notable action Maine has taken against green crabs is the governor-appointed

Green Crab Task Force, which concluded its report in 2015 (Maine Department of Marine Resources 2015). Maine has been slow to implement the Task Force's solutions, with state policy continuing to mostly focus on physical removal strategies which are costly, labor intensive, and generally ineffective.

Key Findings

The green crab invasion is a complex issue with implications for fisheries, markets, communities, and ecologies. Because of the biological and ecological life-history traits of green crabs, the environmental and economic problems that they pose do not have any straightforward solutions. If no additional actions are taken, their populations will continue to explode, putting further pressure on soft shell clam, lobster, and native crabs, as well as critically important coastal habitats. Green crabs have been established in New England for over 200 years. Therefore, responsible policy solutions must incorporate the species into marine resource management, markets, and food systems. Adaptation is not optional, and our historical trajectory will lead to collapse of vital ecologies and the economies that rely on them.

Because green crabs cannot be eradicated, efforts that rely on removing them from the water without establishing a system to perpetuate their removal will be unsuccessful. Therefore, New England states should pursue strategies that contain mechanisms to incentivize continuous and ongoing green crab harvest and removal. The clear option for implementing such a mechanism is to establish markets for green crabs.

There are several potential markets for green crabs. Green crabs can be used as bait in existing and emerging fisheries. Green crabs can be composted for use as a soil amendment, and crabs can be processed into value-added products such as pet food or novel materials

such as bioplastics. Finally, green crabs can be used for human consumption in culinary markets, either as soft-shelled crabs or value-added products like broth or mince (Galetti et al. 2017). Of these market possibilities, the culinary market has the greatest potential value, with fishers receiving upwards of \$30 USD/lb for soft shell crabs (Pers. comm. M. McMahan). In addition, culinary processing creates waste streams that can be directed into compost and pet food, adding additional value to the harvested crabs and building new ancillary business opportunities. Establishing a culinary market is the best solution to the invasive green crab problem, because markets for pet food, compost, and other products that make use of processed crabs can be supported by culinary market waste streams or in addition to culinary use.

Within New England, Massachusetts has implemented several policy solutions to combat the green crab invasion that other states can look to for inspiration. Massachusetts state policy focuses on easy access to green crab fishing to spur population reduction above all else. State law allows anyone to trap green crabs commercially or recreationally, as long as they give notice to the Department of Marine Fisheries, which grants a Letter of Authorization (Massachusetts Division of Marine Fisheries 2021). The process is free and easily available. Massachusetts also removed green crabs from its classification list of "edible crabs." Paradoxically, this switch keeps green crabs from being subject to the more intensive permitting associated with lobstering and crabbing, while expanding the market possibilities for an invasive but edible crab. Massachusetts is closely tied to the bait market in southern New England and New York, which encourages trapping and removal of green crabs. Further expanding the use of green crabs as bait would increase the number of people fishing for green crabs, which would simultaneously help solve supply chain

shortages that are currently hindering their culinary use.

Implications for Policy

A culinary market for green crabs will make the best use of a harmful invasive species as an underutilized resource, while simultaneously being the most effective long-term way to reduce its population and environmental impacts. Multiple policy actions are required to support the growth of a green crab fishery.

First, New England states must encourage green crab trapping via a regulated fishery. Maine has already made obtaining a green crab license fairly easy, and there are no restrictions for recreational green crab fishing. From here, the most useful step is support for publicity and education about green crab licenses and green crab fishing techniques. The centuries-old culinary market for green crabs in Italy relies on harvesting premolt green crabs to produce a soft-shell product (St. Hilaire et al. 2016). The soft shell crab market avoids the problem of processing meat from small crabs, as the entire body is eaten. In New England, the soft shell crab market could operate by either directly catching recently molted crabs, or trapping premolt crabs and holding them until they molt. Teaching identification of premolt crabs to people entering the fishery will be key to supporting culinary market establishment. Green crab fishing techniques and premolt crab identifiers can be taught through a series of workshops and expanded web-based information and will be crucial to expanding the green crab fishery.

To cement a robust and reliable fishery and supply of green crabs for culinary use, further support should go towards research and development of innovations that incorporate green crabs into novel products. Research on processing machinery for extracting hard shell green crab meat will grow the lump-meat

industry and is essential to expanding culinary use of an invasive and underutilized marine species. Investment into existing research into biodegradable plastics made with green crab shells will yield new environmentally friendly business opportunities. The most important effort is garnering public awareness of green crabs as a food source, and making the knowledge of how to fish for, process, and cook with them widely available. Once green crabs enter public consciousness as a culinary item, we can finally take advantage of this highly abundant resource and grow marine and shore-based economies in the process.

As climate change progresses in the Gulf of Maine, it is increasingly necessary to adapt and prepare for the future. As soft shell clams decline from predation and lobster landings shift eastward into Canadian waters, New England must diversify its fisheries by incentivizing harvest of underutilized invasive species. This will in turn remove pressure from clam, lobster, and native crab populations while growing new markets and businesses. Coastal New England is well known for its seafood and restaurants, which will be extremely beneficial when marketing green crabs and expanding their culinary use. By incorporating green crabs into New England's vibrant culinary scene, we can support shellfish harvesters who have been affected by the clam decline while introducing exciting new products that will draw tourism. If states can properly incentivize using this resource that has been greatly overlooked, our economies and marine environments will become more resilient and show how inventive we can be in facing the challenges of climate change.

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