



FINAL REPORT

*Current and historical trends in the shellfish resources
of the upper Damariscotta River estuary*

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Executive Summary

This project emerged from a desire by the Damariscotta-Newcastle Joint Shellfish Committee to develop current baselines of wild shellfish resources, and to understand past changes in the Damariscotta River estuary, in order to inform management of the wild shellfishery. It represents a collaboration between the Damariscotta-Newcastle Joint Shellfish Committee, Town of Damariscotta and University of Maine's Darling Marine Center. We conducted this study thanks to a grant from the Broad Reach Fund awarded to the Town in early 2019 through the Shellfish Restoration and Resilience Fund. In kind support from the Town of Damariscotta, UMaine's Darling Marine Center and many individuals, including members of the Joint Shellfish Committee, also was critical in generating this information.

We aimed to answer the following questions:

- 1) What is the current state of shellfish populations (including softshell clams, quahogs, and oysters) in the Damariscotta River estuary?
- 2) Are young shellfish (i.e., seed) actively recruiting to the estuary?
- 3) How have shellfish populations in the estuary changed over time?

To answer these questions, we conducted shellfish population surveys, a recruitment experiment, and semi-structured interviews with local harvesters. We found:

- 1) Shellfish populations vary among locations and by tidal height, with higher densities of shellfish in high intertidal zone than in the low zone.
- 2) Recruitment of young softshell clams varied with tidal height, with more recruits found in predator-protected nursery boxes in the high intertidal zone than in the low zone. Also, very few seed clams were retrieved from the mud next to the boxes, indicating that protection of the seed enabled more to grow and thrive.
- 3) Harvesters we interviewed noted that shellfish populations in the estuary have changed over the last 20 years. They have observed an increase in wild oyster abundance and a simultaneous decrease in softshell clam abundance. They have responded to these changes by shifting fishing effort between species, in some cases starting to harvest species that they had not previously harvested (i.e., oysters).

Motivation

The Damariscotta River estuary in Maine's midcoast region is a unique ecosystem whose tidewater flats support a variety of shellfish, including softshell clams (*Mya arenaria*), quahogs (*Mercenaria mercenaria*), razor clams (*Ensis directus*), blue mussels (*Mytilus edulis*), American oysters (*Crassostrea virginica*), and European oysters (*Ostrea edulis*). Clams and other shellfish have historically provided income to more people in Maine than any other marine species, and fishermen from Damariscotta, Newcastle, and surrounding towns continue to rely on income from shellfishing year-round. Local harvesters have recently noted interannual fluctuations in shellfish resources, and the Damariscotta-Newcastle Joint Shellfish Committee has expressed concern that observed fluctuations indicate a mismatch between the number of licenses issued and shellfish population abundances in the Damariscotta River. Without the resources to conduct population surveys, the Joint Shellfish Committee and the Towns of Damariscotta and Newcastle have had to update shellfish management without critical scientific data. There was an urgency to conduct formal studies of shellfish beds in this region to fill this data gap and to inform the development of strategies that enhance productivity of the wild shellfish resource and coastal community resilience more broadly. This project establishes an important ecological baseline, strengthens civic partnerships, and contributes to co-management of Damariscotta and Newcastle shellfish resources.

In addition to a lack of current information on shellfish populations in the Damariscotta River, local managers are also hindered by a lack of geographically specific historical data. Current and retired shellfishermen in this region have experienced changes in shellfish populations over the past 20 years or more, and are now the only source of this valuable local ecological knowledge. The rich historical information they hold has never been collected or archived, and will soon be lost if action is not taken to preserve it.

To address these problems, we undertook a two-part project that involving municipal and state leaders, local researchers, students, shellfish harvesters, marine managers and community members.



University of Maine students hold, from left to right, quahogs, razor clam, oyster, and softshell clams from the Damariscotta River estuary. Photo by Jessica Stumper.

Methods

Shellfish population surveys

Five sites for tidewater flat surveys were identified in collaboration with local harvesters Ryan Fraser and Paul Muse. All are sites that are actively harvested in the Damariscotta River (Figure 1). Surveys were conducted at low tide. At each site, two to fifteen 25x25m plots were sporadically placed along the flat at a range of tidal heights. Square plots of 25x25m, with one edge parallel to the tide line, were measured using transect tape and marked with wooden stakes. GPS coordinates for each plot were taken from approximately the center of the 25x25m square, and relative tidal height (low, mid, or high) of the plot was also recorded. Prior to surveys, coordinates for five quadrats were generated using a random number generator for coordinates x and y between 0 and 25. At the location of each predetermined quadrat sample, a 1-ft by 2-ft wooden quadrat frame was pushed into the mud and then removed to make an imprint. Mud was dug out from the edges of the quadrat to create a clearly delineated rectangle, within which all shellfish would be counted and measured. A top sample of 1" was collected in a ziplock bag for later processing, and an additional 11" was raked through carefully with a clam rake and by hand. All shellfish found alive within each quadrat were identified and their posterior-anterior length measured with a Vernier caliper before being returned to the mud next to the quadrat. Predators, including green crabs, oyster drills, and horseshoe crabs, were also recorded for each quadrat. This process was completed for each of five quadrats within a 25x25-m plot.

Processing of the top samples occurred at the Darling Marine Center Flowing Seawater Lab in Walpole. The contents of each ziplock bag was thoroughly emptied into a 2mm mesh sifter box, and a hose was used to wash away the mud. Any shellfish found were identified and their length measured using Vernier calipers. Additional predators found in top samples were also recorded. We performed a two-way ANOVA with interaction to determine the effect of location and tidal height on shellfish density. Density data were normalized using natural log transformation.

These methods are consistent with those recommended by the Maine Clam Handbook published by Maine Sea Grant (1998).



Figure 1. Map showing the five survey sites, with blue circles showing locations of survey plots.

Shellfish recruitment experiment

Recruitment boxes were constructed as 1-ft by 2-ft wooden frames with a depth of 4". Durable plastic pet screen was then secured across the frames on both sides. A small piece of laminated paper containing study information and researcher contact information was attached to one corner of each box.

In June 2019, nine recruitment boxes were deployed at the Chadbourne site in Newcastle, Maine. Three boxes along a transect running parallel to the tide line were placed at each of low, mid, and high intertidal zones. Recruitment boxes at each tide zone were placed with one screen-side down on the sand or mud surface at intervals of 2m. Boxes were secured using wooden stakes driven into the mud just outside either 1-ft side of the box. These stakes were then secured to the box with nails. The recruitment boxes remained on the flats until late

November 2019, when they were collected and brought to the Darling Marine Center for processing. At the same time as recruitment boxes were being collected, a core sample using a 0.1963-ft² coffee can was taken next to each recruitment box and brought to the Darling Marine Center in Walpole for processing, in order to test for treatment (*i.e.*, box) effect. Recruitment boxes and cores were processed by sieving the contents through 1-mm mesh and counting clam recruits.

We performed a two-way analysis of variance (ANOVA) with interaction to determine the effects of tidal height and sample type on recruit density. Density data were normalized using natural log transformation. We also performed a Tukey test to determine differences in shellfish recruit densities between all combinations of intertidal heights.

These methods are consistent with those recommended by the Maine Clam Handbook published by Maine Sea Grant (1998).

Interviews with harvesters

Potential interview participants were identified from a list of current shellfish license holders in the Towns of Damariscotta and Newcastle. All interview participants were adult harvesters over 18 years of age. Participants were recruited by phone and asked to participate in an anonymous, in-person interview at a time and location of their choosing.

Semi-structured interviews ranged from 12 to 60 minutes, and questions asked about participants' socio-economic characteristics, their experience in the Damariscotta River estuary generally, their experience with shellfish harvesting in the estuary, and their observations of change generally and in shellfish populations over time. Each interview was audio-recorded and transcribed. Responses were then coded for each question, with themes emerging from participants' responses and identified by the researchers who conducted the interviews (Jess Woodall, Cassandra Strauch, and Kara Pellowe). Pellowe supervised Strauch and Woodall, who were undergraduate interns based at the Darling Marine Center in summer 2019 and recruited specifically to work on this project.

Results

Shellfish population surveys

Across all sites and species, mean shellfish density was 34.91 individuals per square meter (see Table 1 for full results by site and species). We found a significant effect of location ($p=0.006$), and tidal height ($p=0.001$) on shellfish density (all species combined and log-transformed data; Fig. 2). The interaction effect location*tidal height was insignificant ($p=0.926$). The size structure and diversity of shellfish species also varied among sites (Fig. 3). For softshell clams, we found many more small (2-30mm) recruits than adult clams, across all sites.

Location	Mean density (shellfish/sq-m)			
	All species	Softshell clams	Quahogs	Oysters
All sites	34.91	21.96	6.96	4.77
Chadbourne	23.47	17.94	5.17	0.36
Westview Acres	31.06	17.84	1.08	12.15
Jacks Point	8.61	7.53	0.54	0.54
Perkins Point	70.23	54.09	0.81	6.73
Hog Island	89.88	16.68	59.74	12.38

Table 1. Mean density of shellfish varies among sites and by species. Higher densities of softshell clams were found, relative to the other species, at all sites, except Hog Island, where quahogs were more abundant.

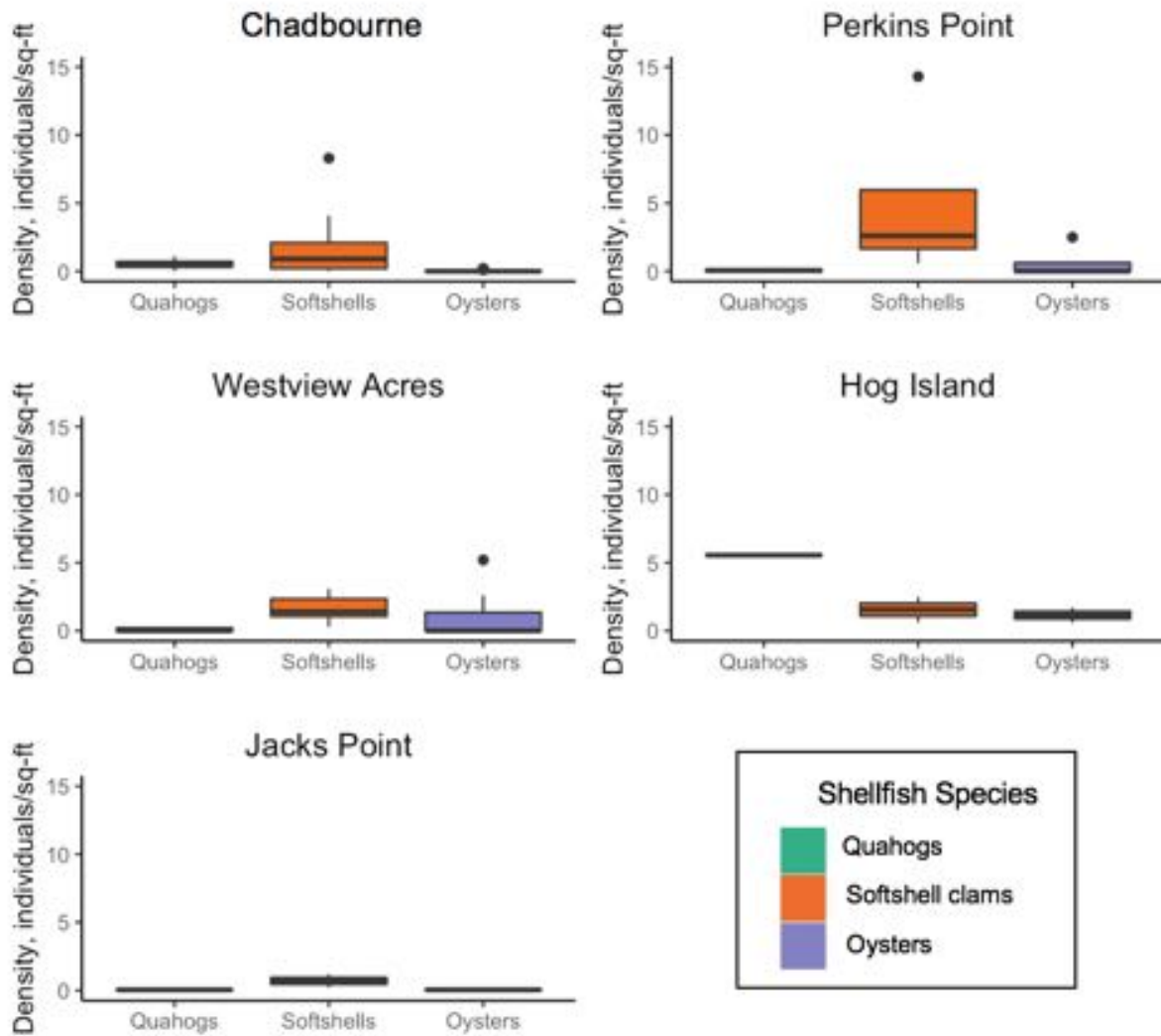


Figure 2: Shellfish density and species composition among locations in the Damariscotta River estuary. These box and whisker plots denote the mean of each sampled population as the black line in the middle of the rectangle and also show the 95% confidence intervals associated with each sample, as the lines above and below the rectangle. We sampled five different sites in the upper estuary; the locations are denoted on the map in Fig. 1.

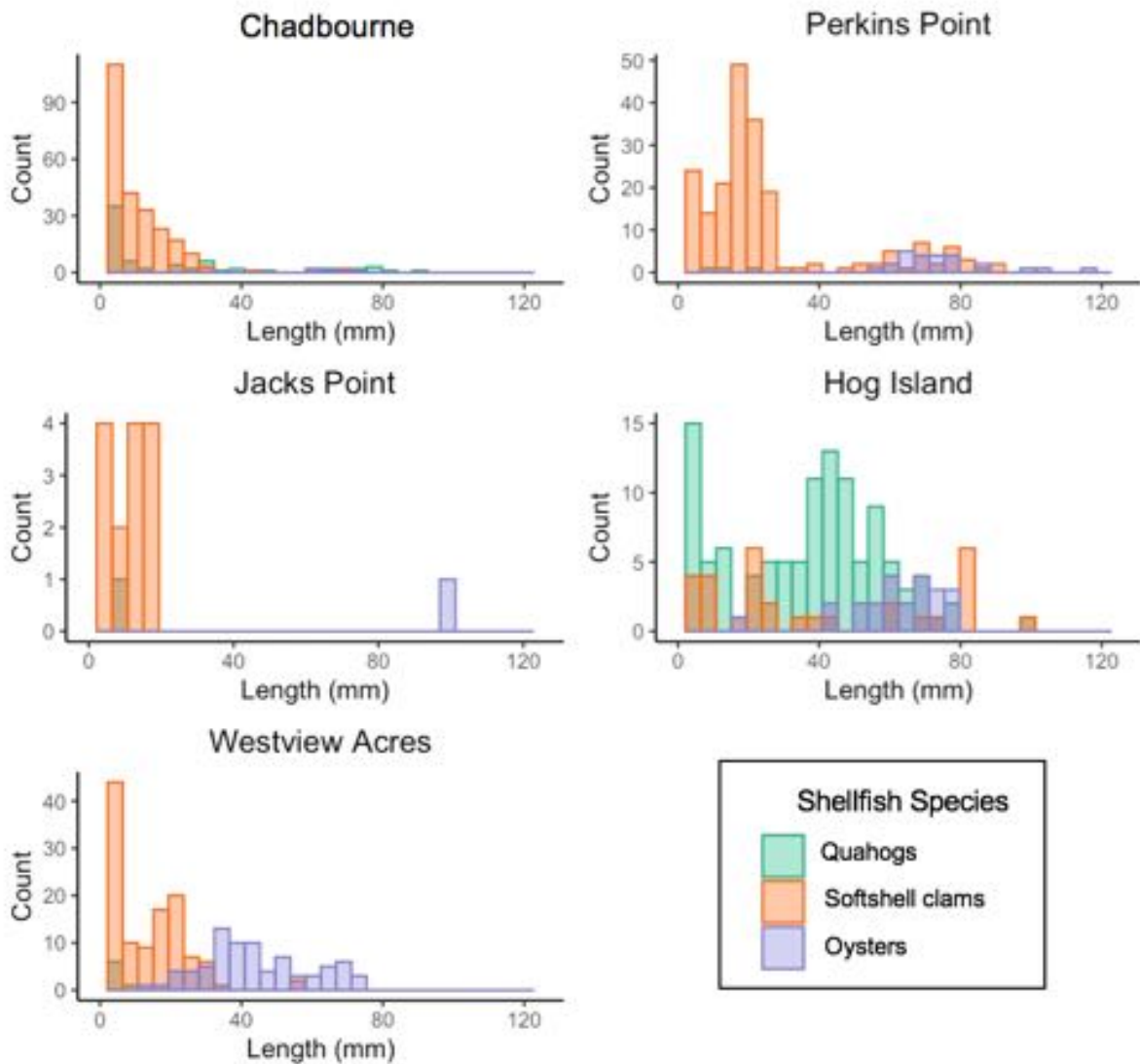


Figure 3. The size of shellfish varies among sites in Damariscotta River estuary. These histograms show the relative abundances of different sizes of shellfish at each of the five sites sampled in the upper estuary. The colors are associated with different types of shellfish: green for quahogs, orange for softshell clams, and purple for oysters. Note that the y-axes vary among sites, in part, due to greater sampling effort at certain sites.

Shellfish recruitment experiment

We found a significant effect of tidal height ($p=0.004$), and treatment (box vs. core) ($p=0.003$) on the density of clam recruits (Figure 4). However, the interaction effect tidal height*sample type was insignificant ($p=0.051$). A Tukey test revealed that the low zone has significantly lower recruit density than the high zone ($p=0.01$), but that the mid zone is not significantly different from either the low or the high. Mean recruit densities were found to be: 8.7 recruits/sq-m in the low tide boxes and core; 106.1 recruits/sq-m in the mid tide boxes and core; and 183.0 recruits/sq-m in the high tide boxes and core.

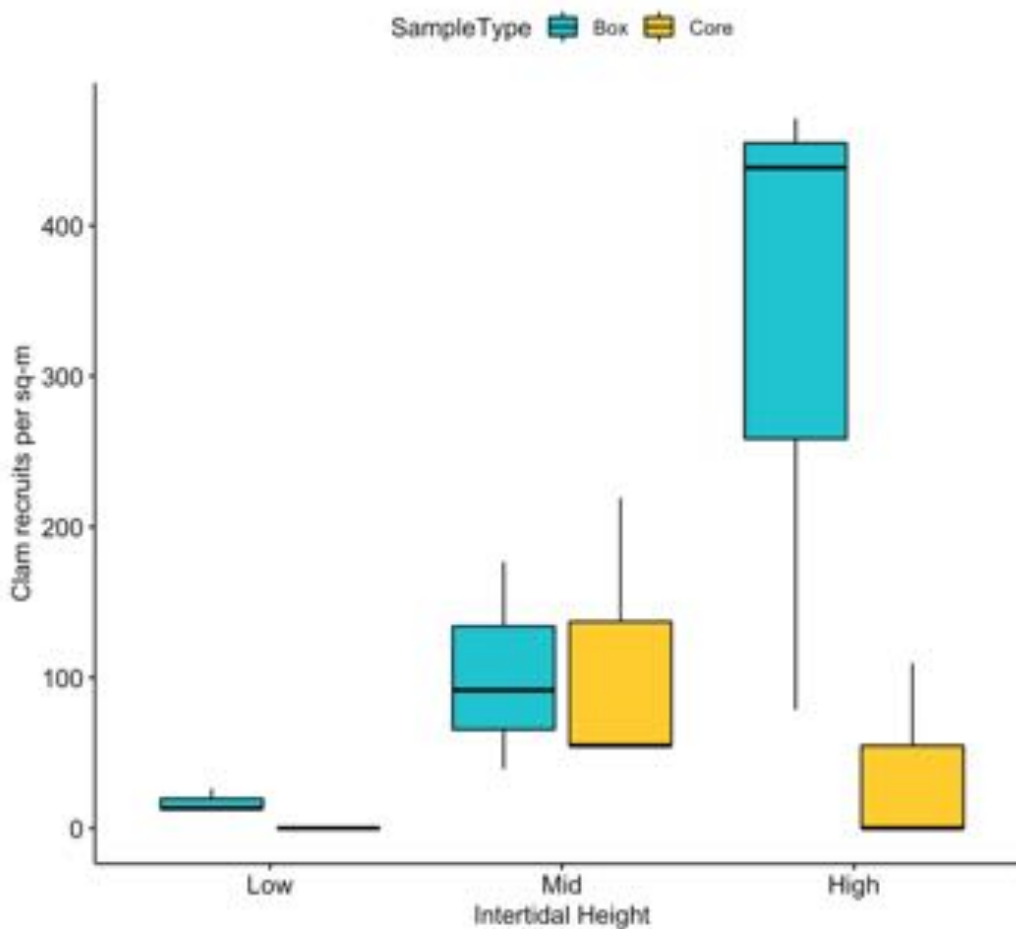


Figure 4. The recruitment experiment revealed that protection in the recruitment boxes, as well as intertidal height, influenced how many seed clams survived. More seed clams were found in the high than in the low intertidal zone.

Interviews with harvesters

We interviewed eight harvesters in June and July 2019. These eight included two respondents each in every license category available from the Damariscotta-Newcastle shellfish license program: commercial resident; commercial non-resident; recreational resident; and recreational non-resident. The shellfish harvesters we interviewed had a range of experience harvesting shellfish in the estuary, with the longest length of experience, 82 years, reported by a harvester with a resident recreational license. Respondents also varied in their years of experience harvesting shellfish (Table 2). In some cases, respondents had experience in the Damariscotta River estuary, as well as in other areas in Maine and New England. 100% of harvesters interviewed said that they had noticed changes in shellfish abundance in the Damariscotta River estuary over time. The changes noticed included an increase in oyster populations (88% of respondents), and a decline in softshell clam populations (75% of respondents). In addition, harvesters noticed other changes in the estuary and shellfishery (see Table 3 for full details). Harvesters responded to these changes by switching harvest species (38%), harvesting less (frequency and catch, (25%), looking for licenses elsewhere (13%), and depending more on income from other work (13%). Respondents reported that they believe the changes they have observed in shellfish populations in the Damariscotta River estuary could be due to a number of drivers, including aquaculture, over harvesting, predation from green crabs and sand worms, under harvesting, and dragging activities.

Measure	License type (number of respondents)			
	Commercial resident	Commercial non-resident	Recreational resident	Recreational non-resident
	(n=2)	(n=2)	(n=2)	(n=2)
<i>Average years of experience on the Damariscotta River Estuary</i>	14	29	74	58
<i>Average years of experience harvesting shellfish</i>	14	42	70	66
<i>Average percent income from marine-related activities</i>	58%	60%	0%	0%
<i>Average percent income from shellfish harvest</i>	55%	20%	0%	0%

Table 2. Shellfish harvesters interviewed carry all four license types and have varied levels of experience and economic dependence on the wild shellfishery.

Type of change	Percentage of respondents that have noticed changes	Description of changes noticed
Environmental	100%	<ul style="list-style-type: none"> • More green crabs (n=4) • Fewer seed clams (n=2) • More algae (n=2) • Warmer temperatures (n=1) • Changes to sewer system (n=1) • More sand worms (n=1)
Socio-economic	75%	<ul style="list-style-type: none"> • Increase in aquaculture (n=6) • Aging harvesters/ fewer harvesters (n=5) • Reduced access to river/ increased homebuilding (n=3) • General changes in fishing industry (n=1)
Governance	12.5%	<ul style="list-style-type: none"> • Changed town ordinance (n=1)

Table 3. All respondents have noticed environmental changes of various types in the Damariscotta River estuary, many of which affect the wild shellfishery.

Recommendations & Next Steps

Based on the findings of these studies, we recommend continued monitoring of adult shellfish populations in the Damariscotta River estuary in order to confirm that the trends we observed hold beyond the five sites and one year of our study. Confirming these trends through continued monitoring will ensure robust information is available to inform license allocation and other local management decisions. In addition, further information would be beneficial regarding several topics, including:

- 1) *How tidal height affects shellfish populations.* In particular, why are clams more abundant in the high zone than in the low zone? Is this difference due to predation, harvesting pressure, sediment conditions, or other factors?
- 2) *How ease of access (walk-in sites vs those accessible only by boat) impacts shellfish populations.*
- 3) *How the interview data we gathered relate to the Maine Department of Marine Resources landings data.* Additionally, study of the possible reasons for the observed shellfish declines in the estuary, including possible changes in recruitment of young clams and predation intensity, is warranted.
- 4) *Targeted surveys of oyster populations,* given the importance of this resource to shellfish harvesters in the area. Wild oysters are a unique resource that makes the Damariscotta River Estuary different from other most rivers in Maine.

We also recommend efforts to map sites of current and historical importance in the Sheepscot River, to complement studies in the Damariscotta River, and to provide a comparison between two different river ecosystems managed by Damariscotta and Newcastle.

Finally, we advise the Joint Committee to explore ways that municipal shellfish management and citizen science could work together to provide information on shellfish resources in the area, in collaboration with scientists at UMaine, Maine DMR and other institutions in the area. There are many communities in Maine engaged in similar work, and through the Maine Shellfish Learning Network (<https://umaine.edu/shellfish-restoration/>), there is a great opportunity to share what has been learned in this area with others, and to continue to enhance local capacity and activities.

References and Resources

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Left: Harvester and Shellfish Committee Chair Ryan Fraser and Dr. Kara Pellowe examine softshell clam seed in the Damariscotta River estuary. Right: Softshell clam seed.



Photos by Heather Leslie.

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