Overwintering Success of a Softshell Clam Seeding in the Ogunquit River

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Abstract

Marine resources in the State of Maine continue to be threatened by an ever-changing marine ecosystem. Softshell clams (*Mya arenaria*) are an important marine resource throughout the coast of Maine and have been commercially managed since the issuance of the first commercial harvest licenses in 1947 (Maine Shellfish Handbook, University of Maine, 2021). One approach to stock enhancement of softshell clams is to seed the mudflats with juvenile clams and install protective netting to guard against mortality from predation. This project examined the overall success of a softshell enhancement activity in the Ogunquit River in Maine and found that the survival rate of juvenile softshell clams in a treated area was not significantly different that in an untreated area of the mudflat. The timing of the enhancement activity may have influenced the overwintering survival rate because the juveniles were spread in the flat *after* the growing season, limiting the amount of time the clams had to feed before temperatures dropped for the winter months.

Background and Rationale

The State of Maine is unique in its approach to intertidal resource management, utilizing a co-management strategy called municipal management that was first introduced by the Maine legislature in 1963. This legislation authorized municipalities to enact shellfish ordinances that are subject to the approval of the Marine Resources Commissioner (Maine Department of Marine Resources, 2016). Municipal shellfish management allows towns, through the enactment of shellfish ordinances, to set license allocation numbers, define which species are managed by the town, design and implement conservation activities for shellfish flats, and enforce the laws and regulations governing the harvest of shellfish through a Maine Department of Marine Resources (DMR) certified shellfish warden.

One of the most utilized conservation tools in municipal shellfish management is the stocking of mudflats with juvenile softshell clams, referred to as seed or spat. This process involves prepping the mudflat by scoring the surface with hand implements, scattering the seed into the area, and then covering the seed with mud. In addition to spreading the seed across a scored area of the flat, predator exclusion netting may be placed over the top of the seeded area to protect the spat from potential fish, bird, and crustacean predators (Beal, 2010). The use of predator netting as an exclusion method has been shown to be relatively easy to apply and maintain in a seeded area (Beal et al., 2016), therefore making it an accessible option for many shellfish committees. Municipalities may opt to include mudflat seeding in their conservation

measures because it is assumed that by seeding the mudflats, the harvesters will see an increase in harvestable resources in the following years, ensuring a sustainable resource for all.

The Town of Ogunquit's Shellfish Committee elected to seed a section of their flats in the Ogunquit River during the early summer of 2023 as a conservation measure, utilizing softshell spat purchased from the Downeast Institute in Beals, Maine. However, a mortality event at the Downeast Institute hatchery resulted in a delay of delivery for the spat to the Shellfish Committee, which meant that the enhancement took place later than expected, in the fall of 2023. There was potential that the timing of the fall seeding in the Ogunquit River would not be conducive to overwinter survival for the spat, as seeding any flat during the fall is highly discouraged (Beal, 2011). The growth of softshell clams is seasonal, and studies have shown that additional shell growth rarely occurs after October in Maine (Beal et al, 2016).

Softshell clams exhibit a faster growth rate when they can feed on phytoplankton suspended in the water column, versus phytoplankton that has been resuspended in mud (Maine Shellfish Handbook, University of Maine, 2021). The phenology, or timing, of phytoplankton blooms is dependent on a range of factors, including light exposure and temperature, and in the Gulf of Maine there is a seasonal shift in the concentrations of blooms during the colder, darker winter months (NOAA, Integrated Ecosystem Assessment, ND). The temperature of the water also plays a crucial role in the feeding activity of softshell clams, with an ideal temperature range between 60.8°F-68°F (16-20°C) (Harrigan, 1956). A fall mudflat seeding of softshell spat, when water temperature frequently dips below 60.8°F (16°C), would result in small juvenile clams sitting dormant for six months or longer at very shallow depths. At those shallow depths with little feeding activity occurring, seed clams become vulnerable to predation by diving ducks and green crabs, as well as mortality from ice flow movement across the flat.

According to Beukema and Dekker (2014), annual recruitment, or settlement in the mudflat, of the major bivalve species including softshell clams, tends to be most successful after severe winters with low average temperatures. That success is due to the potential impacts on predator populations, including European green crabs, that more severe winters tend to have (Beukema and Dekker 2024). Temperature loggers at a seeded site allow continuous temperature monitoring, providing valuable data on how lower temperatures affect softshell clam overwintering success and mortality in relation to predation by green crabs. By tracking temperature fluctuations, a timeline can be established for when the average temperature drops below 44.6°F (7°C) in the fall causing green crabs to move to deeper water and stop feeding, and when it rebounds above 44.6°F (7°C) in the spring—signaling the green crabs' return to the intertidal zone to resume feeding (Berrill, 1982). A mild winter may lead to higher softshell clam mortality due to increased predation by green crabs, which are less affected by mild winter conditions. Deployment of four HOBO temperature loggers at the Ogunquit River seed site aimed to collect such data for analysis. However, due to extreme weather conditions and strong tidal flow during the timeframe of the project, all four HOBO temperature loggers were lost, resulting in a lack of temperature data.

To determine the effectiveness of this conservation activity for municipal shellfish programs, it is important to establish a baseline of success for individual mudflats across the

State of Maine. Determining the success of seeding activities involves surveying the area to be seeded prior to the seeding activity, then surveying the same area again after the seed has overwintered in the mudflat. For this research project, a survey of the Ogunquit River area prior to a fall 2023 spat seeding was conducted, as well as a follow up survey in the spring of 2024 (Figure 1). By comparing the number of softshell clam seed found after overwintering in the seeded and netted plots with the number of seed found in the untreated plots, it was possible to gain a better understanding of the effectiveness of seeding as a conservation measure for enhancement of wild resource.

Methodology

The Ogunquit Shellfish Committee elected to purchase ~200,000 softshell clam seed from the Downeast Institute hatchery in Beals, Maine, for a cost of ~$5,000. The Committee utilized 10 people that worked for 2.5 hours to prep the flats, spread the seed, and install predator netting on seven 8 ft x 8 ft plots on the southeast side of the Ogunquit River channel. The removal of the predator netting required two Shellfish Committee members to work for six total hours over the course of three separate dates beginning in December 2024 and concluding in January 2024.

The area that was seeded consisted of the portion of the Ogunquit River south of the footbridge and following the edge of the mainland down to the inlet in front of the Ogunquit Tides Hotel (Figure 1, right frame). This area was surveyed during the fall of 2023 using the Belding 1930 survey methodology and incorporated 100 ft transects with 2 ft x 1 ft^2 survey plots (Maine Shellfish Handbook, 2021). A wooden 1 ft x 1 ft survey box with ¼ in wire screen on the bottom was placed randomly onto the clam flat at 100 ft intervals. After pushing down to create an impression of the outline, the box was picked up and placed on the flat again next to the outline to create a total survey area of 2 ft x 1 ft^2 (Figure 2). The mud was flipped from this outlined area using a metal clam rake to dig out the plot to a depth of 12 in and all clams found within the plot were counted, measured, and marked on a field data sheet. All other species present were noted on the data sheet for qualitative purposes.

Figure 1. Map of Maine coast showing Ogunquit River site (left) and magnified image showing Ogunquit River site (right).

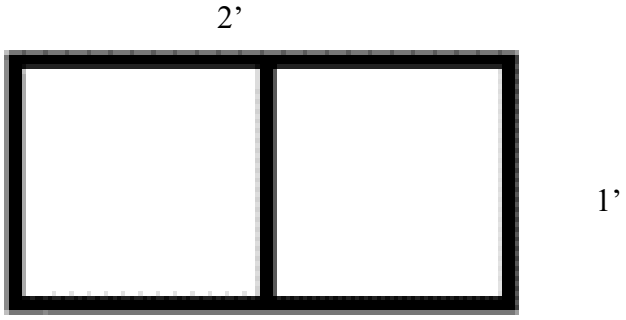

Figure 2. 2ft x 1ft^2 survey plot outline.

The 2 ft x 1 ft^2 survey plot was repeated every 100ft across the part of the mudflat that the Ogunquit Shellfish Committee considered to be the harvest area, utilizing two teams of two samplers and one member of the Shellfish Committee. The area surveyed in the fall included plots that were not seeded with softshell spat (controls) as well as areas that were seeded subsequently in September 2023. The seeded plots consisted of seven 8 ft x 8 ft squares in the mudflat, approximately 50 ft apart, in which the flat surface was roughed using hand tools to

create texture on the surface in which the seed clams might settle (Figure 3). GPS coordinates were taken for the northeastern corner of each seeded plot to provide orientation for the direction of the spring 2024 survey.

Figure 3. Ogunquit Shellfish Committee members prepped seven 8 ft x 8 ft plots to receive softshell clam seed by roughing the surface with a hand implement.

The softshell clam spat, sized between 0.16 – 0.31 in (4 – 7.9 mm) (Figure 4), was scattered by hand evenly across the surface of each of the seven 8 ft x 8 ft plots, approximately 21,400 – 28,500 seed clams per plot, or 334 – 445 clams/ft^2, for a total ranging between 150,000 – 200,000 clams. Each of the plots were then covered with predator netting (Figure 5) that had an opening of 0.17 in (4.2mm) and was anchored into a small furrow around the perimeter of the plot using sand and mud to hold it down. Each net also had five toggle floats on it to assist with buoyancy and allow water movement through the plot. Temperature loggers were placed at the Northeastern corner of four seeded plots, using wooden stakes hammered into the ground, with holes drilled through them to accept zip ties which held the logger in place. The predator netting was removed from all seven plots between mid-December 2023 and January 2024, which was vital to allow the seeded clams the ability to move unrestrictedly through the substrate, and to prevent damage to the nets from storms and ice build-up, as well fouling with marine debris.

Figure 4. Softshell clam spat ranging in size betweeS 0.16 – 0.31 in (4.0 – 7.9 mm).

Figure 5. Softshell clam spat being spread by hand and covered with floating predator netting.

The spring 2024 survey, utilizing five DMR staff, surveyed four of the seeded 8 ft x 8 ft plots from the previous fall, as well as four 8 ft x 8 ft areas outside of the seeded plots to serve as control samples. Each of the seeded plots and control plots had four samples taken from within the 8 ft x 8 ft boundary. For the spring 2024 survey, GPS points from four of the seeded plots were used to identify the northeastern corner of each plot, which was marked with a wooden stake hammered into the mudflat. The survey consisted of a coffee can method, which utilized a six in diameter metal coffee can that was pushed into the sediment six in (15 mm) deep at the Northeastern corner of each plot. The sediment from the coffee can for each location within each plot was placed separately in a 1 ft x 1 ft wooden survey box with PET screen on the bottom, which has an opening of 0.028 – 0.074 in (0.7 x 1.9 mm), and rinsed with water from the channel running through the flat, one sample at a time. The other three samples were taken by haphazardly, tossing the metal coffee can within the 8 ft x 8 ft boundary, recording the GPS coordinates of where the can landed, and repeating the sampling process for each subsequent toss.

Any clams found were enumerated, measured, and recorded on the field data sheet. That process was repeated 16 times total within the 8 ft x 8 ft area of the selected four seeded plots.

General observations including counting and recording any green crabs present, along with observations of the weather, harvester activity, presence of birds or other predators on the flat, were also recorded, as well as observations of the type of sediment and any standing water on the flat. Only one set of general site observations was required per site visit.

The control areas outside of the selected 8 ft x 8 ft plots were chosen by haphazardly tossing the metal coffee can to the left or right of an 8 ft x 8 ft seeded plot boundary, recording the GPS coordinates for the place where the coffee can landed, and repeating the same sampling process. The initial toss of the coffee can represented the Northeastern corner of an 8 ft x 8 ft unseeded control plot, which was measured using a measuring tape. The haphazard tossing of the coffee can was repeated a total of 16 times in four areas that were approximately 50 ft apart, moving north to south along the channel parallel to the 8 ft x 8 ft seeded plots.

The spring 2024 survey methodology differed from the methodology for the fall 2023 survey, given that the fall survey included both the northwest and southeast portions of the flat, where it was indicated that the seeding would occur, and the spring survey was focused on the southeast side of the channel, where the seeding activity actually occurred. The data were analyzed by comparing the initial seeding density applied to the study area in the fall of 2023 with the density gathered from the survey of the seeded area in the spring of 2024.

Both the fall 2023 survey and the spring 2024 survey included a control survey area that was larger than the seeded area, to capture a broad representation of the resource across the entire Ogunquit River harvest area. The control plots allowed for a comparison of the density of small clams in the seeded area versus the density of small clams in a non-treated area of the flat and provided some insight into the movements of the seeded juvenile clams over the winter, as well as wild resource levels. The northwestern side of the channel was unable to be sampled at the same time as the spring 2024 survey on the southeastern side due to tide constraints, though this side of the channel did not receive a seeding treatment.

Results

The fall 2023 survey of the Ogunquit River took place on September 9, 2023, and utilized one team of two samplers and one team of three samplers, which included a member of the Ogunquit Shellfish Committee who had knowledge of the area to be seeded that same fall. A total of 37 2 ft x 1 ft^2 survey plots were sampled using the ascribed protocol and following 100 ft intervals, for a total area sampled of 8.5 acres. (Figure 6).

Figure 6. Ogunquit River fall softshell clam survey area (2023).

General observations from that survey noted presence of Canada Geese, as well as Herring Gulls and other waterfowl. There were more geese along the southwestern shore than along the steeper banks of the northeastern side of the channel, where minimal signs of goose activity were present. No green crabs or milky ribbon worms were found during this survey and the surveyors noted the presence of some brown macroalgae on the surface in places. Field datasheets are stored internally with the DMR Nearshore Marine Resources Program.

The seeded plots were located on the southeastern side of the Ogunquit River channel in an area previously seeded by the Ogunquit Shellfish Committee (Figures 7 and 8). These same plots were also the plots used for the spring 2024 survey that included sampling for softshell seed using the coffee can survey method.

Figure 7. Ogunquit River fall softshell clam seed plots (southeast side, 2023).

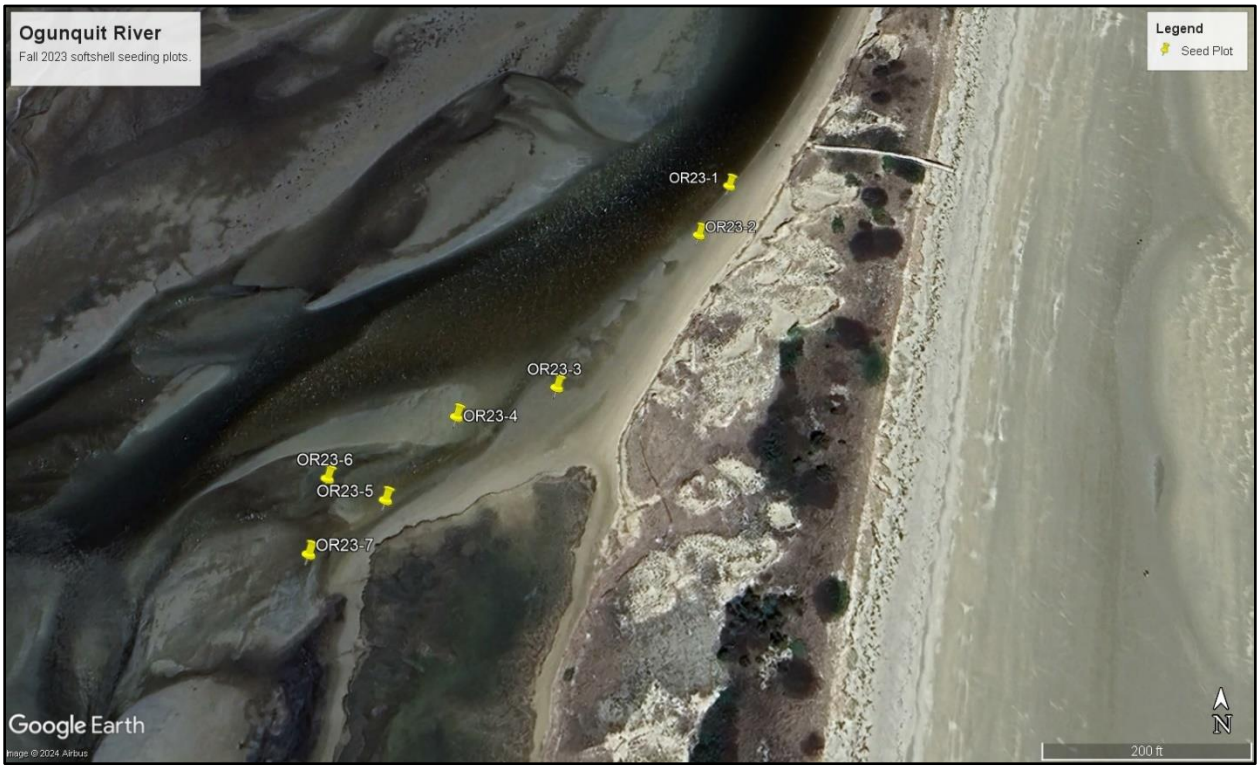

Figure 8. Ogunquit River fall softshell clam seed plots, magnified image (southeast side, 2023).

The analysis of the fall 2023 survey found that this area of the Ogunquit River contained mostly above-legal size softshell clams (greater than 2 in; (50.8 mm)), with very few clams in the sublegal size class (less than 2 in; (50.8 mm)). The estimated standing crop (bushels) was 258, with 257 of those bushels consisting of standing crop greater than 2 in (50.8mm). This breaks down into roughly 30 bushels/acre for both standing crop less than 2 in (50.8 mm) and standing crop greater than 2 in (50.8 mm). The fall 2023 survey did not include subsampling for seed clams due to a miscommunication with the planning team.

Using the average number of clams distributed per square foot within each seeded sample plot as the baseline for comparison, the average number of clams that survived overwintering in each seeded sample plot was calculated. For the netted plots, an average of 1.55% of the 334 – 445 seeded clams/ft^2 survived overwintering, which totaled 6.04 clams/ $ft^{2.}$ The average number of clams found in the unseeded, unnetted control plots was 4.27 clams/ft^2. A Wilcoxon signed rank test was performed in R-Studio to determine whether there was a statistically significant difference in the abundance distribution of clams between the seeded and netted plots versus the untreated plots. The Wilcoxon test showed a p-value of 0.559, which indicates that there was no significant difference in abundance between the two treatments. A p-value of less than 0.05 would confirm a statistically significant difference between the seeded and unseeded plots.

The fall 2023 survey of the Ogunquit River was focused on both sides of the channel, however the seeding that occurred in the fall was concentrated on the southeast portion of the channel. For this reason, the results of the fall softshell clam survey are considered separately in two distinct areas: the southeast side of the channel (Figure 9) and the northwest side of the channel (Figure 10).

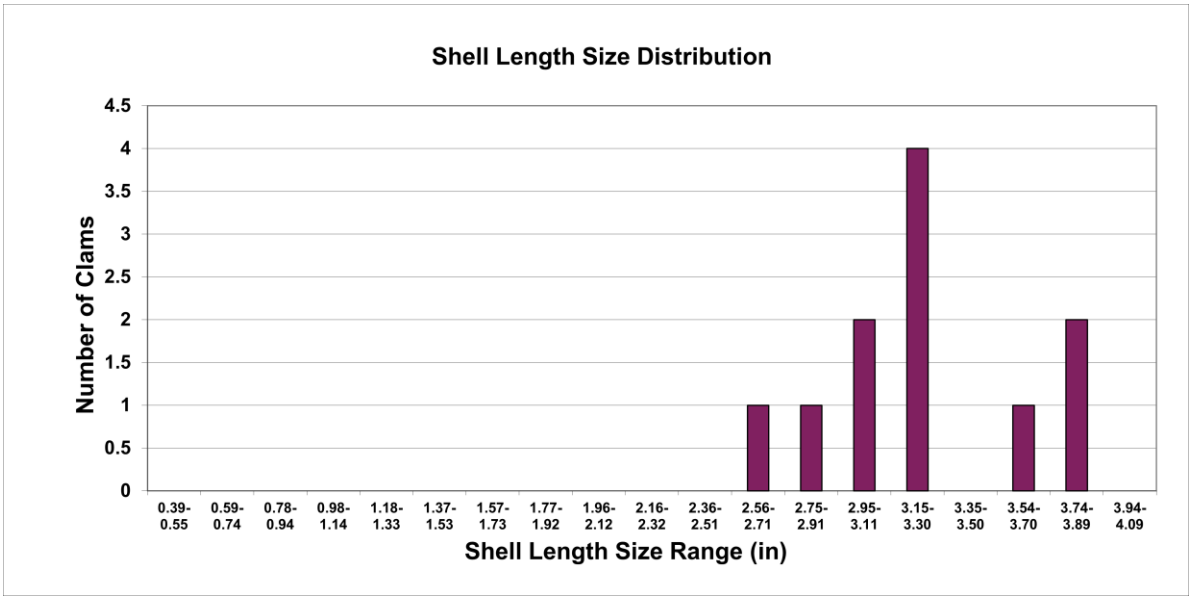

Figure 9. Size class (in) composition of softshell clams from the fall Ogunquit River survey (southeast side, 2023).

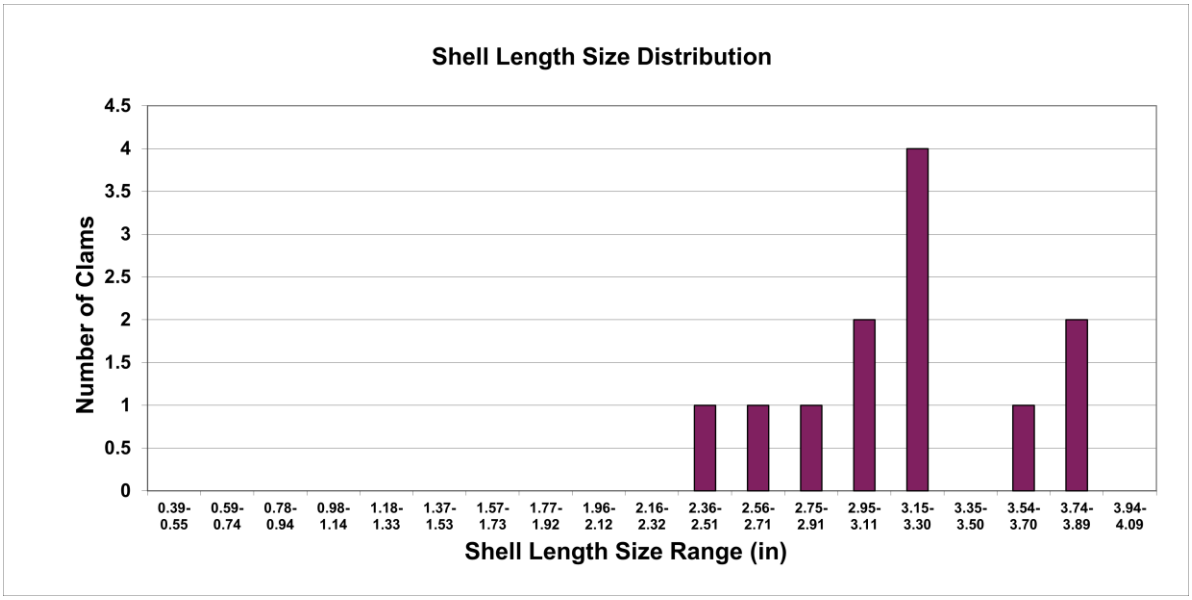

Figure 10. Size class (in) composition of softshell clams from the fall Ogunquit River survey (northwest side, 2023).

The survey of the southeast side of the channel in the spring of 2024 showed a mix of mostly spat-sized (less than 0.05 in (1.27 mm)) softshell clams with a few outliers measuring greater than 2 in (50.8 mm). Several of the seed clams found were small enough to have been from a late spawning clutch of wild softshell clams or were possibly some of the hatchery seeded clams that did not grow before the winter temperatures dropped (Figures 11 and 12).

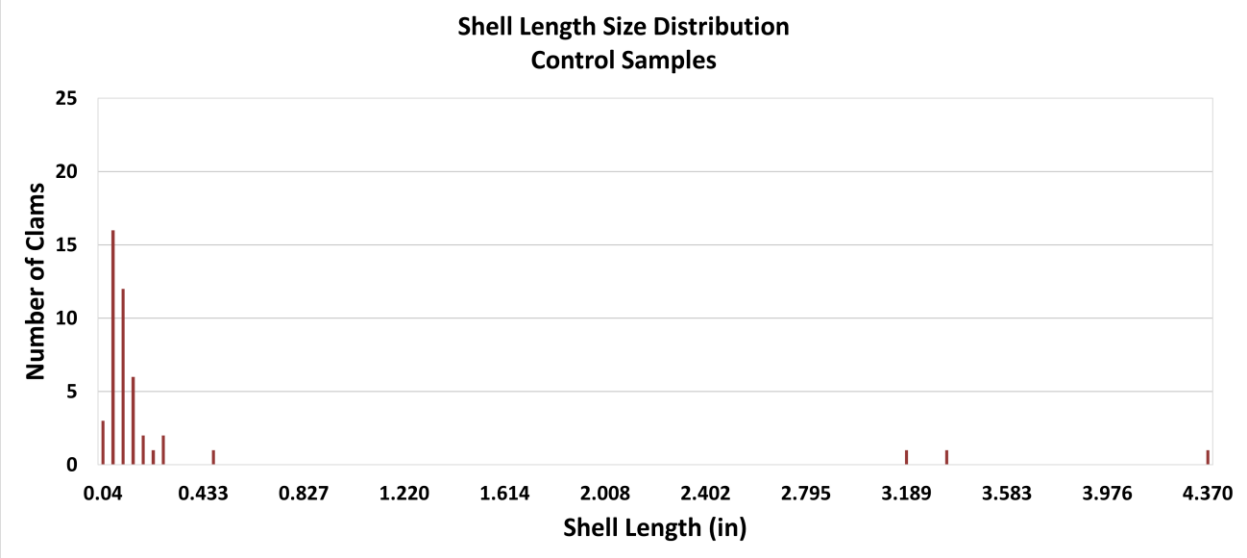

Figure 11. Shell length distribution (in) of softshell clams from the Ogunquit River spring seed survey, control samples (southeast side, 2024).

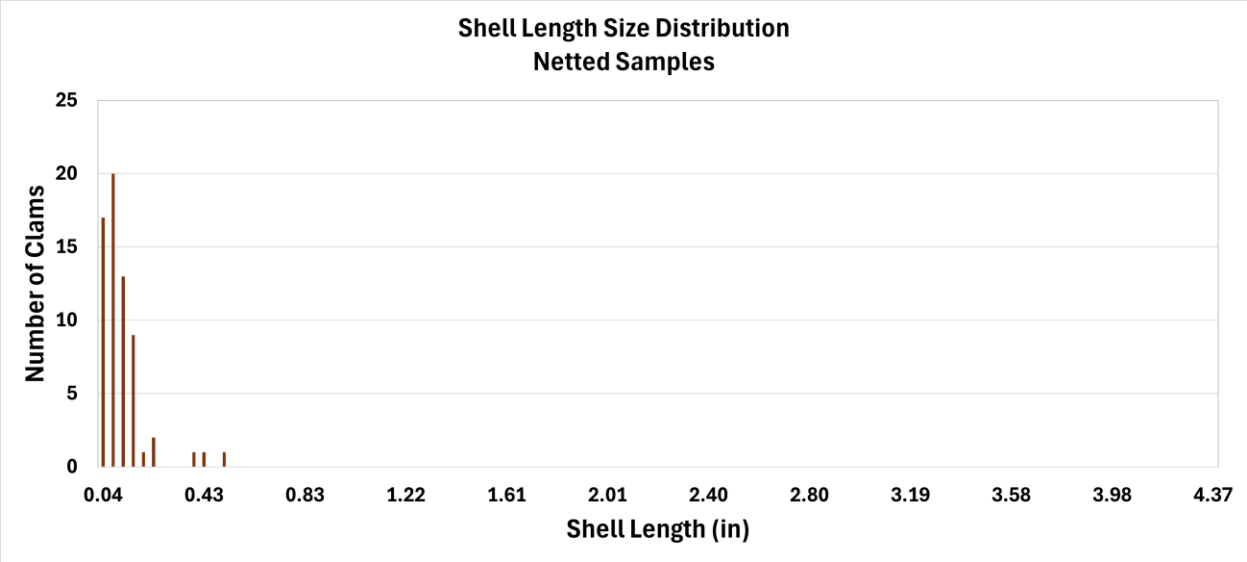

Figure 12. Shell length distribution (in) of softshell clams from the Ogunquit River spring seed survey, netted samples (southeast side, 2024).

For the southeast area that was seeded in the fall of 2023, the predator netting was removed from the seven sites on three separate dates: December 18, December 31, and January 7 (Figure 13). The Ogunquit Shellfish Committee members who removed the nets noted that some of the material was fouled with organic debris, and there was some shifting in the substrate of the 8 ft x 8 ft plots. All four HOBO temperature loggers that were originally deployed in the experimental area were lost, likely due to storm surge through the channel over the winter.

Figure 13. HOBO temperature logger on a wooden stake near a seeded plot after netting removal (left). HOBO logger on a wooden stake during a routine check of the site (right).

Discussion

When reviewing the design and execution of this softshell clam seeding project, there was clear miscommunication of where the clam seed were projected to be planted and where they were planted. This highlights the importance of establishing clear and frequent communication between resource managers and the towns conducting conservation activities to avoid errors in methodology or implementation of such. While this discrepancy in the project execution does not completely prevent an analysis of the seeding from being conducted, it does necessitate that the results be considered in relation to the areas of the flat that were surveyed both prior to and after the seeding took place. For this reason, the results were presented as separate datasets in Figures 9 - 12.

Many municipalities elect to conduct mudflat seeding as a conservation activity, but their access to resources—such as labor and materials—can vary. This often affects a committee's ability to complete the seeding process and maintain any necessary predator netting that may be used to protect the seed. Problems arise with seeding activities, including changes in pick-up of the seed coming from shellfish hatcheries, which increases the challenges associated with this type of conservation activity. This was the case for the 2023 Ogunquit River softshell clam seeding, where the clam seed that was purchased ended up being delivered later than intended due to an issue with the hatchery. This meant that subsequently the seeding took place later in the season than is normally recommended for success. This seeding was conducted in September of 2023 and was considered late regarding time needed for the clam spat to grow enough to survive the winter, as evidenced by previous research focusing on the temperature effects of a late season enhancement activity for softshell clams (Beal, 2011).

The comparison of size classes of softshell clams in each area of the Ogunquit River that was surveyed shows a higher abundance of clams greater than 2 in (50.8 mm) on the southeast side than on the northwest side, which may indicate that seed projects from past years have been successful, though this is not able to be confirmed without prior surveys to compare population abundance and distribution before and after seeding. Given that the spring 2024 survey showed mostly clams that were still classified as seed, or less than 0.39 in (10 mm), it may be assumed that the late spreading of the seed, in conjunction with presumably decreasing temperatures from September through the winter, resulted in a seed set that did not grow after being spread in the flat. This would align with the recommendations for best seeding practices presented by Beal (2011) regarding temperature and growth. Because all four of the HOBO temperatures loggers that were deployed in the fall of 2023 were lost, we were unable to relate growth rates of the seed to temperature variations.

Considerations and Recommendations

Due to challenges with communication, along with a change in the timing of the seeding as a result of a die off at the hatchery, as well as a misunderstanding in the methodologies most appropriate for this project, it is suggested that another round of data collection from a future seeding would provide better insight into the effectiveness of softshell clam seeding in the

Ogunquit River. The seeded and netted plots contained a higher number of seed clams after the overwintering period compared to the untreated plots, suggesting that seeding a mudflat with juvenile clams may be an effective conservation strategy. With that, however, it must be considered that the results of Wilcoxon signed rank test showed that there was *no significant difference* between the seeded and unseeded plots.

To determine whether seeding mudflats is an effective strategy for conservation in the Ogunquit River, the surveys of this project would need to be repeated with a focus on data collection that does not include as many zeroes for each plot sampled. The number of zeroes contained in the dataset meant that is was not possible to analyze the data on a fine enough scale to determine whether this seeding event can be considered effective. A greater number of plots may be necessary to help limit the zeroes contained in the data set. Also, the costs and effort involved in this approach may not be feasible for every municipality. Local shellfish committees should assess their own desired survival rates of seeded clams in their specific flats to balance the investment with potential returns.

To effectively assess the success of future individual seeding events, it is highly recommended that the Ogunquit Shellfish Committee conduct pre-seeding surveys of each area to establish a better baseline of resource abundance. Also, best practices encourage shellfish enhancement seeding activities to be conducted during the growing season to allow the clams opportunity to grow and settle in the flat before temperatures drop. While there are many challenges in maintaining a shellfish ordinance and harvesting program, the efforts of the Committee and community volunteers should be commended.

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