

NRAC ANNUAL PROGRESS REPORT

INSTRUCTIONS: An annual progress report for each funded project must be provided to NRAC by June 30 of each year.

Project Title	Expanding green sea urchin production by removing key aquaculture challenges
Reporting Period	05/31/2020- 6/30/2021
Author (Chair)	Coleen Suckling
Key Word	
Funding Level	\$77,280
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Project Objectives	<p>The project objective is to improve settlement success by optimizing cultivation conditions:</p> <ul style="list-style-type: none"> • Optimal settlement conditions (via chemical cues, algal substrate types and temperatures) and; • settlement feeds will be identified to address issues with low hatchery settlement success and post settlement survival. • This work will be supported with extensive outreach to the shellfish and seaweed stakeholder community in order to increase awareness of hatchery seed supplies and to identify potential interest for future hatchery seed uptake across the Northeast.
Anticipated Benefits	<p>State briefly how the project will benefit the aquaculture industry – directly or indirectly.</p> <p>This project will adapt and improve upon existing technology to improve the success and lower green sea urchin seed production costs in the Northeastern US. This will therefore make sea urchins a more competitive seed choice to growers in the region which will facilitate increased uptake. In tandem we are working to increase awareness of the availability of hatchery seed and growth by engaging and working with regional industry and extension staff. This will increase grower confidence and knowledge in sea urchin aquaculture leading to increased new uptake and production. Indirectly, this will lead towards a more reliable and accepted form of aquaculture, greater seed availability, increase in regional production and therefore an increased regional economy as well as greater stability and perhaps growth of the Portland based processing sector with expansion into other states.</p>
Project Progress	<p>Overall, our project progress has achieved the accomplishments outlined in the proposal but has been subject to minor delays due to COVID. In January 2021, the University of Maine’s (UME) Center for Cooperative Aquaculture Research (CCAR) and the University of Rhode Island (URI) both received Green Sea urchin broodstock. Due to COVID limitations in workplaces across the USA, there has been a delay in receiving diatom species needed for project work (originally outlined at Dec. 2020, received in Jan/Feb. 2021) which has caused a minor delay in the timing of when our milestones were achieved but not affected our ability to deliver the project.</p> <p><u>Milestone 1 (Creating a stock supply of sea green sea urchins; URI)</u> has been successfully achieved using the broodstock collected from Maine. Animals were transported to URI and held under quarantine to achieve larvae towards settlement needed for milestones 2 and 3.</p> <p><u>Milestone 2 (Laboratory controlled settlement trial)</u> has been successfully achieved. Larvae were settled onto petri-dishes which either had no biofilm treatment (controls) or were pre-coated with a single benthic diatom species of <i>Nitzschia sp.</i> or <i>Cylindrotheca closterium</i>. Each coated or uncoated settlement Petri-dish contained UVFSW either without pretreatment of macroalgae, or pre-treated (for 24 hours) with the presence of the macroalgae <i>Saccharina latissima</i> or <i>Ulva</i>. In our original proposal we planned to also utilize the macroalgae <i>L. digitata</i> but CCAR determined not to use this species because it is known to accumulate inorganic arsenic, making it less desirable as a commercially harvested species for human consumption in the US. In addition, <i>L. digitata</i> is a deeper water species found at more exposed locations, and the lack of commercial harvesting activity would mean increased effort and cost on our part to obtain live plants. Since one objective of the project was to reduce production costs, we decided to limit the trials to <i>Ulva sp.</i> and <i>S. latissima</i>, which are more readily available from land-based seed nurseries. The GRA conducting the URI lab trials had conducted pilot trials by precoating settlement plates in tanks where sea urchin broodstock were held and found that this gave rise to high settlement success (up to 50%) during larval rearing training with PI Suckling, also supported in literature. Therefore, it was</p>

decided that this adult biofilm and seawater treatment would replace *Laminaria digitata* in the trials thus ensuring that we maximized the opportunity for gaining data towards optimization.

We are currently analyzing the data for the settlement trial, but an initial assessment indicates that *Nitzschia* benthic diatoms did not notably enhance settlement success. Settlement success was increased (by between 10-50%) when petridishes were pre-coated with a biofilm developed within adult broodstock tanks or with *Cylindrotheca* in combination with macroalgae or seawater pretreated with adult green sea urchins (~15-35%).

Milestone 3 (Laboratory post-settlement food trial; URI) has been successfully set up and is currently in progress. Larvae competent for settlement were introduced into 3L tanks (three independent replicates for each treatment) in May 2021 comprising the following treatments: control plates (no biofilm) or pre-coated with *Nitzschia sp.* or *Cylindrotheca closterium*. Each tank will contain UVFSW either without macroalgae, or containing the macroalgae, *Saccharina latissima* or *Ulva sp.* at temperatures of either 12°C or 14°C (temperature incubators) to determine whether elevated temperatures promote enhanced success of larval settlement and post-settlement growth. These trials are currently still running and will terminate in July 2021. Results will be collated and then a knowledge exchange meeting will occur in Aug./Sept. with CCAR to plan towards year 2 (2022) industrial production method modification.

Although we have not yet developed recommendations to improve CCAR hatchery methods, we plan to conduct a full knowledge exchange in Aug./Sept. 2021. At that time we will discuss our results and make recommendations to be adopted for scaled up production in year 2 (2022) to test the method changes at ‘industry scale’.

Frequent communication between URI and CCAR helped inform CCAR hatchery methods to meet year one production targets. A number of protocols were adjusted based on feedback from Suckling. The CCAR completed four larval production cycles in spring 2021 to produce seed for our collaborating growers (Ocean Resources, Winnegance Oyster Farm, Springtide Seaweed) and for new growers interested in conducting pilot growth trials at leased sites (Oct. 21). Although the first run was unsuccessful, the 2nd and 3rd runs produced approximately 1.3 million competent (ready for metamorphosis) larvae (the 4th run is still underway). At this point it is still too early to know whether survival rates through settlement will improve over previous years, but if the rate is improved to 5%, we anticipate producing 65,000 seed urchins. We should be able to estimate survival through this critical stage by September of 2021. This will provide invaluable information for scaled up production in Year 2. We are targeting production of 2.6 million competent larvae in year 2 with only a small increase in total production costs enabled by findings and method improvements from year 1.

One of the objectives for this milestone was to reduce phytoplankton production costs by using a continuous bioreactor (Industrial Plankton machine) to produce microalgae for larval feed. Unfortunately, the pandemic affected equipment supply chains and we were unable to source all components in time for spring 2021 production. In addition, the cost to refurbish the machine exceeded by \$2,000 the \$4,000 allocated in the budget. Fortunately, we worked with an oyster grower (Mat Nixon) to source the remaining \$2,000 so that he can also use the machine for his oyster seed production. We anticipate having the unit on-line by the end of July 2021 and available for year two (2022) sea urchin hatchery production.

Its’ also worth reporting at this point that Luz Kogson (CCAR sea urchin hatchery manager) was awarded a grant from the Atlantic States Marine Fisheries Commission to fund additional sea urchin aquaculture development in 2022. This award will help fund hatchery production in Year 2, most importantly by providing salary for a hatchery technician. We believe our engagement in the NRAC project was instrumental in allowing us to apply for and ultimately receive ASFMC funding.

	<p><u>Milestone 4 (Increasing awareness of hatchery seed for potential uptake; UME, University of New Hampshire (UNH), URI).</u></p> <p>At the start of the project, information regarding this project was posted on the CCAR information website about sea urchin production and seed as well as on Suckling’s lab website. Morse (UME) reached out to regulatory bodies in states where green sea urchins naturally reside (ME, NH, MA) as well as RI, where there are likely to be green urchins along Block Island and cooler open coastal areas outside of the bay. This information has been documented within a shared team file between URI and CCAR and will be used to help advise any growers potentially interested in growing sea urchins.</p> <p>Our original proposal outlined that in year 1 we would conduct active outreach (talks on the project, the sea urchin industry and conduct an educational workshop for stakeholders with a booth to further support outreach and identify stakeholder interest in sea urchin production) at the 2021 Northeast Aquaculture Conference and Expo (NACE; Portland, ME) but due to Covid, this event has been postponed to Jan. 2022. We aim to still conduct this at the 2022 NACE but have made adjustments during this reporting period to ensure we maintained strong outreach to increase awareness for the project by hosting a virtual stakeholder workshop instead in Mar. 2021 to discuss the project goals, common methods for growing sea urchin seed and to address questions stakeholders had about producing sea urchins. Suckling also presented a talk at the National Shellfisheries Association conference in Mar. 2021 to disseminate the project and highlight the need to reach out to interested stakeholders.</p> <p>Morse (UME) led an outreach campaign using a press release to advertise the project goals and to highlight that hatchery seed could be made available for free to new growers interested in experimenting with hatchery produced seed. This effort was also used to generate a ‘sea urchin interest group’ email list who we could reach out to directly to report project outcomes and inform of seed availability and workshops on production methods to support prospective new growers. We had major success in this outreach effort, reaching multiple local, regional, national and international outlets such as the Boothbay Register, Fox Bangor, Aquaculture North America and Global Aquaculture Advocate (see outputs below). This outreach effort resulted in 74 stakeholders (additional to those named in our proposal) across the New England region states of ME, NH, MA and RI stating a strong interest in learning more and potentially experimenting with growing green sea urchin seed, with some individuals wanting to begin dedicated production with other species (e.g. oysters) in ME.</p> <p>Additionally, the team as a whole have been providing free technical advice for site selections and grow out methods to stakeholders through direct email, phone enquiries as well as through the online workshop.</p> <p>Suckling (URI) has started collecting video footage for a short informational video aimed for YouTube to describe the project goals and results, the hatchery process as well as any pilot growth trials and sites and is continuing to build this together. This will be used in year 2 to further reach out to potential new growers and to advertise a year 2 CCAR based workshop to further support new uptake and address stakeholder questions.</p>
Accomplishments:	
Outreach Overview	<p>Describe in general how your results have been extended to the intended users. OR, if they haven’t yet, explain when & how this will occur.</p> <p>Pandemic restrictions on in-person gatherings and meetings limited our ability during the first half of 2021 to host CCAR hatchery tours, where we could demonstrate seed production activities to potential growers. In addition, the long hatchery cycle for sea urchins from egg to 1-5mm seed (about 6 months) means we have no meaningful results to report at this point (June 2021). However, we can report that 1.3 million competent larvae were produced and that we are</p>

	<p>reasonably confident we can offer seed to at least our industry partners (who have already been informed) and potentially other growers as well. We expect to have more concrete information by September of 2021, and at that point we will reach out to the 74+ stakeholders referred to earlier (recruited through our outreach activities).</p> <p>We expect findings from year two will show that the improved methods gained from year one will lower seed costs and improve hatchery reliability. We will communicate these results to our ‘sea urchin interest stakeholder group’ through directed email campaigns and extensive media outreach media, and by hosting a CCAR workshop event (with live recorded webinar) for stakeholders. We will also produce an online short video for YouTube and our dedicated webpages listed in the outputs section below.</p>
<p>Targeted Audiences</p>	<p>Provide information on the target audience for efforts designed to cause a change in knowledge, actions, or conditions.</p> <p>Our targeted audience are regional growers or stakeholders looking to start aquaculture effort (e.g. previous fishers, new growers). For those already involved in aquaculture production, we are targeting growers which already grow species where sea urchins could easily be integrated as a form of polyculture, as there is much literature and examples of growth (e.g. Canada, Norway, ME, NH) being successful in this manner. For example, seaweed growers are in a Good position to grow sea urchins because they can be successfully grown in lantern nets deployed onto existing gear and intermittent seaweed supplementation promotes strong marketable features (e.g. excellent color, size and texture) in urchins. Similarly, there has been an increase in experimentation of using sea urchins as an ecological solution towards keeping biofouling on oyster cages in check. Sea urchins can easily be kept with oysters within cages and literature and trials show that urchins can develop marketable features when grazing on biofouling species in this manner. We are also targeting growers who are looking to diversify their production.</p> <p>For those entering the aquaculture market as new growers we are targeting this audience too (e.g. Eddy (CCAR) provided a talk to new growers on the Maine Aquaculture Hub and Coastal Enterprises Inc (CEI) ‘Aquaculture in Shared Waters Course’ this year) to increase awareness of the available seed and potential for economic growth of sea urchins. We are providing free seed to growers with the appropriate permission to grow sea urchins to experiment with this species and are also providing free technical advice to support this effort. There has been interest from the whole range of this audience to take up sea urchin production and conduct pilot growth trials.</p> <p>Another target group is sea urchin fishermen who may want to transition to sea urchin farming or use it to enhance their wild harvest efforts. We expect to see a renewal of live meetings of the Sea Urchin Zone Council and when that occurs, we will use the opportunity to present the project to them. The CCAR hatchery was recently visited by Joe Leask, sea urchin diver and former Chairman of the SUZC (one of our first live visitors in 16 months!). Joe was able to view hatchery activities and it clearly motivated him to consider obtaining sea urchin seed for out-planting. Based on his observations, the grounds where sea urchins can be fished have moved north and much of southern Maine, which was once very productive for sea urchins, is no longer even fished. This demonstrates the urgency of developing sea urchin aquaculture to help maintain the processing and market infrastructure developed for the fishery since the mid 1990’s.</p>
<p>Outputs:</p>	<p>Outputs are tangible, measurable products (website, events, workshops, products [AV, curricula, models, software, technology, methods, websites, patents, etc.], trainees, etc.). Do NOT include publications as they’re listed separately.</p> <p>Websites: Center for Cooperative Aquaculture Research (CCAR) webpage - Sea urchin information pages to describe this project, highlight funders and provide general production</p>

	<p>information to growers and other stakeholders. https://umaine.edu/cooperative-aquaculture/sea-urchin-hatchery-seed/</p> <p>Suckling Lab webpage - Project and contact information for green urchin seed availability and production optimization. https://www.coleensuckling.co.uk/2020/12/new-sea-urchin-project/</p> <p>Workshop event: Suckling, Eddy, Kogson, Morse, 2021. ‘Expanding green sea urchin production – removing key aquaculture challenges’. A virtual ‘open-house’ webinar to outline the project goals, provide insights into sea urchin aquaculture and seed availability and address questions the community of growers have on how to grow seed. Mar. 31st 2021. Recorded session is available to view on the CCAR sea urchin informational webpages.</p> <p>Eddy, 2021. ‘Sea urchin production’, Maine Aquaculture Hub and Coastal Enterprises Inc (CEI) ‘Aquaculture in Shared Waters Course’, ~40 participants largely comprising new growers in Maine, Jan 25th 2021.</p> <p>‘Green Sea Urchin Interest Group’ Although this list cannot be made public due to it containing personal data, this is a major product from our project which at present contains at least 74 stakeholders across the region (ME, NH, MA and RI) who are interested in piloting or taking on production effort for Green Sea Urchins. This list continues to grow and being used to report project findings and share information and products related to this industry.</p>
<p>Outcomes/Impacts:</p>	<p>Describe how findings, results, techniques, or other products that were developed or extended from the project generated or contributed to an outcome/impact. Outcomes/impacts are defined as changes in Knowledge, Action, or Condition.</p> <p>Regarding our milestones for optimizing methods for seed production, we are still in the process of finalizing the laboratory data interpretations and to complete the post-settlement food and growth trials, but the data does indicate that settlement success can be enhanced beyond the typically low 1-5% success that CCAR experiences during production up to 50% within a laboratory controlled environment. More specifically, results from the URI lab indicate broodstock creates a strong chemical cue to encourage settlement of larvae, or using a combination of a single benthic diatom species of <i>Cylindrotheca</i> with local macroalgal species of <i>Ulva</i> or <i>S. latisima</i> thus highlighting a change in knowledge which could lead to action in year 2. This is yet to be tested at industrial production scale within CCAR (year 2; 2022) to determine whether it can effectively reduce the cost of producing seed.</p> <p>Our strong outreach and stakeholder engagement effort so far has yielded a change in knowledge which will lead to a change in action towards the end of 2021. Events and products such as our recorded virtual workshop, popular media articles and the development of the ‘Green Sea Urchin Interest Group’ contact list have contributed strongly towards this project increasing awareness of the availability of hatchery seed and the potential for green sea urchin aquaculture. The ‘Interest Group’ comprises of at least 74 stakeholders (growers, fishers, new growers) who want seed for either pilot trials or to start production effort through aquaculture.</p>
<p>Impacts Summary</p>	<p>Provide short statements (2-3 sentences) about each of the following: (pre-established fields for Researchers to complete short statement answers)</p> <ol style="list-style-type: none"> Relevance: Issue – what was the problem?

	<p>Reliable and cost-effective hatchery production of sea urchin seed is vital for developing a sea urchin aquaculture sector in the Northeast US. Despite recent growing interest in uptake, there is still a lack of awareness of the availability of hatchery-sourced seed. This project addresses the major hatchery bottlenecks and knowledge gaps, of low settlement success and post-settlement survival, to optimize seed production and should lead to increased awareness of seed availability through extensive outreach activities.</p> <p>2. Response: What was done? Wide scale laboratory trials were conducted to identify the best methods for achieving increased settlement success and post-settlement survival and growth, which can be adopted and tested into industrial scale production towards reducing seed costs. Extensive outreach and engagement effort with relevant stakeholders were conducted to increase regional awareness of seed availability and aquaculture potential.</p> <p>3. Results: How did your work make a difference (change in knowledge, actions, or conditions) to the target audiences? Lab trials indicate that green sea urchin settlement success can be enhanced which shows strong potential for method optimization towards reducing the cost of seed. This work also increased the regional awareness of hatchery seed availability and methods for seed grow out with an increase in growers requesting seed for production and pilot growth trials.</p> <p>4. Recap: One- sentence summary Green Sea Urchin seed production method optimization was identified, which will likely reduce seed cost, and increased awareness of seed availability has led to much more grower interest, and likely participation, across the Northeastern Region.</p>
<p>Publications</p>	<p>Oral presentation:</p> <ul style="list-style-type: none"> ○ Suckling, 2021. ‘Expanding production method information for sea urchins’. National Shellfisheries Association 113th Annual Conference (>500 participants) Mar. 25th 2021. <p>Peer-reviewed:</p> <ul style="list-style-type: none"> ○ Non achieved yet but a manuscript is currently in preparation for the journal <i>Aquaculture</i> to report the laboratory based trials. <p>Non-Peer-reviewed popular/media articles:</p> <ul style="list-style-type: none"> • Global Aquaculture Alliance ‘An opportunity awaits in New England’, Apr. 2021. https://www.aquaculturealliance.org/advocate/an-urchin-opportunity-awaits-in-new-england/ • Aquaculture North America ‘New England eager to cash in on Japan’s hunger for sea urchins’, Apr. 2021. https://mydigitalpublication.com/publication/?m=53591&i=694361&p=32 • Boothbay register ‘Umaine and Maine Sea Grant support effort to boost sea urchin farming’ https://www.boothbayregister.com/article/umaine-and-maine-sea-grant-support-effort-boost-sea-urchin-farming-new-england/142863 • URI press release: ‘URI scientist to lead effort to boost sea urchin farming in New England’ https://today.uri.edu/news/uri-scientist-to-lead-effort-to-boost-sea-urchin-farming-in-new-england/

	<ul style="list-style-type: none"> • Newport Buzz: ‘URI scientist to lead effort to boost sea urchin farming in New England’ http://www.thenewportbuzz.com/uri-scientist-to-lead-effort-to-boost-sea-urchin-farming-in-new-england/27484 • Mainebiz: ‘Overfished 25 years ago Maine sea urchins eyed as aquaculture candidate’ https://www.mainebiz.biz/article/overfished-25-years-ago-maine-sea-urchins-eyed-as-aquaculture-candidate • Fox Bangor: ‘Researchers look to expand sea urchin farming’ https://www.foxbangor.com/news/item/researchers-look-to-expand-sea-urchin-farming/ • The Westerly Sun: ‘URI scientist to lead effort to boost sea urchin farming in New England’ https://www.thewesterlysun.com/news/westerly/uri-scientist-to-lead-effort-to-boost-sea-urchin-farming-in-new-england/article_2c5e005a-633e-11eb-86d9-c3a310b1ced8.html • Village Soup, Waldo: ‘Umaine and Maine Sea Grant support effort to boost sea urchin farming’ https://waldo.villagesoup.com/p/umaine-and-maine-sea-grant-support-effort-to-boost-sea-urchin-farming-in-new-england/1882221 • URI news: ‘URI scientist to lead effort to boost sea urchin farming in New England’ https://today.uri.edu/news/uri-scientist-to-lead-effort-to-boost-sea-urchin-farming-in-new-england/?utm_source=urinewsfeb4_2021&utm_medium=email&utm_campaign=urinewsfeb4_2021 • URI student led newspaper ‘the Good Five Cent Cigar’: ‘Cracking into a new market the green sea urchin’ https://rhodycigar.com/2021/02/11/cracking-into-a-new-market-the-green-sea-urchin/ • Portland Press Herald: ‘Maine New England Scientists team up to boost regions sea urchin fishery’ https://www.pressherald.com/2021/02/15/maine-new-england-scientists-team-up-to-boost-regions-sea-urchin-fishery/ • Sun Journal: ‘Maine New England Scientists team up to boost regions sea urchin fishery’ https://www.sunjournal.com/2021/02/15/maine-new-england-scientists-team-up-to-boost-regions-sea-urchin-fishery/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+sunjournaltopheadlines+%28Latest+news%29&utm_content=Google+Feedfletcher • Central Maine: ‘Maine New England Scientists team up to boost regions sea urchin fishery’ https://www.centralmaine.com/2021/02/15/maine-new-england-scientists-team-up-to-boost-regions-sea-urchin-fishery/ • The Free Press Rockland, ME: ‘Researchers Seek Sea Urchin Farmers’ https://freepressonline.com/Content/Articles/-Business-News/Article/-span-style-font-weight-bold-Researchers-Seek-Sea-Urchin-Farmers-span-/130/68/72260?s=1
Students/P articipants :	Provide the following information for every student that worked with you during the reporting period: <ol style="list-style-type: none"> 1. Tara Plee (no), continuing student, anticipated PhD thesis title ‘Sustainable sea urchin production’, Approx. Grad. Date May 2024. 2. Hannah Haskell (no), continuing student, anticipated MS thesis title ‘Microplastics and pollutants in commercial species’, Approx. Grad. Date May 2022. 3. Kelsey Mudry (no), undergraduate student, Research course credit, graduated May 2021.

	<p>4. Cara Megill (no), undergraduate student, Research course credit, graduated May 2021 (now employed as a Research Assistant and partly support this project).</p> <p>5. Elli Madigan (no), continuing student, Research course credit, approx. graduation May 2024.</p> <p>6. Mallory Lentz (no), continuing student, Summer internship student, approx. Grad. May 2022.</p>			
Partnerships	List any partners that you worked with on your project. Provide the following information for each Partner:			
	Partner N/A	Specific Type N/A	Level N/A	Nature of Partnership N/A