Sugar kelp and triploid oyster production to promote sustainable integrated multitrophic aquaculture

Final Report for FNE13-790

Project Type: Farmer
Funds awarded in 2013: $14,970.00
Projected End Date: 12/31/2013
Region: Northeast
State: Massachusetts
Project Leader:

Dr. Daniel Ward
Ward Aquafarms, LLC

Project Information

Summary:

This project was designed to test triploid oyster culture in Megansett Harbor, North Falmouth, MA as compared to typical diploid oyster culture, and evaluate the culture of sugar kelp in Massachusetts state waters. Both triploid and diploid oysters were purchased from two different hatcheries in MA and ME. Overall the triploid oysters survived and grew as well as their diploid counterpart throughout the nursery phase. Therefore, triploid oysters are a viable choice for oyster aquaculture in Buzzard's Bay through nursery phase. Sugar kelp seed string was both purchased from UCONN, and produced in a hatchery set up through this project. The nursery phase was very successful, and the seed string was installed at the site in December 2013. However, at the growout site, the kelp never grew to a harvestable size, and therefore more research is necessary to determine why the kelp stayed small throughout the entire culture period. Future work in 2014 will investigate alternative protocols to improve sugar kelp culture in Massachusetts in the future.

Introduction:

Our aquaculture company is named Ward Aquafarms LLC, and is located in North Falmouth, in an area known as outer Megansett Harbor (Fig. 1). The grow-out site is 2.60 acres, and is permitted to grow Eastern oysters (*Crassostrea virginica)* and hard clams (*Mercenaria mercenaria*), and bay scallops (*Argopecten irradians*). Additionally, we have an upweller nursery site, located in Fiddler's Cove Marina, North Falmouth, MA, where we grow shellfish from seed (~1mm) prior to moving the seed to the grow out site (~25mm). There is a mooring field lining the southern edge of the lease site, and the channel entering Rand's Canal lines the western edge of the site. The eastern and northern edge is open to the rest of Megansett Harbor. The benthic habitat within the confines of the 2.60 acre site is comprised of essentially barren flat sand, with occasional seaweed and common slipper snails (*Crepidula)* attached to small rocks throughout. The operation is currently a family business, and is operated solely by the husband and wife team of Dan and Jen Ward.

This project was completed entirely by owner/operator Dan Ward with assistance with 1 seasonal employee from May through September. Diane Murphy of Cape Cod Cooperative Extension and Woods Hole Sea Grant served as technical advisor for this project and assisted with technical questions on implementation and data analysis. In this project we added sugar kelp (*Laminaria saccharina*) culture to our existing oyster farm to increase economic viability, while diversifying risk and increasing nitrogen removal from the ecosystem. We also investigated the advantages of growing triploid oysters to increase yield and improve growth year-round, while bringing a consistent product to market.

- Farm location

Project Objectives:

1) Investigate the entire process of producing sugar kelp, and evaluate the appropriateness of culturing sugar kelp in southern Massachusetts. This includes sourcing parental stock, producing seed string, securing permits for production, installing growout lines, harvesting mature sugar kelp, and finally selling to commercial producers.

2) Investigate triploid oyster culture in a southern Massachusetts subtidal location. This includes comparing to triploid oysters of the same strains, as well as strains from multiple hatcheries throughout New England.

Cooperators

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Research

Materials and methods:

Sugar kelp culture:

Sourcing parental stock:

We were told by numerous sources that in Buzzard's Bay there are many naturally occurring sugar kelp beds and they start to produce spores annually in the late fall, dependent on when water temperatures fall below 50°F. However, I (Dan Ward) dove over a dozen times throughout the summer and fall to find mature sugar kelp, and was not able to find any in any areas I was able to access with my boats. I had

two backup plans in case this happened, and both were successful. I had previously communicated my concern that I would not be able to source mature kelp with the two sugar kelp farming professionals in New England; Paul Dobbins of Ocean Approved (Portland, ME), and Dr. Charles Yarish of the University of Connecticut (UCONN, Stamford, CT). Paul Dobbins was able to find mature kelp in Portland, ME, and he was willing to give it to me to all for me to produce my own kelp seed string. I also talked with Dr. Charles Yarish, who produces kelp seed string in his lab at UCONN. He produced an extra string for me to purchase, so that I will have both the seed string spools which I produced, and a side-by-side comparison with professional kelp seed string which Dr. Yarish produced.

On October 25, 2013, I traveled to Portland, ME and transported the mature kelp sorus tissue back to my house in Falmouth, MA (Fig. 2). I produced 800' of kelp string according the the protocol outlined below. I also drove to Stamford, CT and purchased 200' of kelp seed string from Dr. Yarish on December 16th, 2013, and installed the seed string on my farm the following day.

Seeding kelp string in the nursery:

The mature sorus tissue was transported from ME to MA is a chilled cooler. Paul Dobbins recommended leaving the collected tissue overnight as it was, in order to stress the kelp into releasing the spores the following day. The following day, the kelp was cleaned with iodine to reduce introduction of pathogens to the spore mixture. The kelp was then cut into 5"L x 5"W pieces, and two pieces put into spore culture medium (50°F filtered seawater [0.25 micron], with germanium dioxide and PES macroalgae culture media added). The kelp was then left for one hour to allow for the spores to release (Fig. 3). The water became cloudy, and after one hour spore-density counts were performed (under a microscope at 40X), and the culture was adjusted to 10,000 spores per milliliter with filtered seawater (Fig. 4). This procedure was repeated several times in order to produce enough spore-mixture for 1000' of kelp seed string.

Prior to sourcing the mature kelp tissues, ten, 15 ¼" x 2" PVC pipes were constructed, and were each tightly wrapped with 120' of #18 100% nylon mason twine (Fig. 5). Additionally, ten, 16" x 4" PVC pipes were also constructed, sealed on one end. All of these materials were soaked in freshwater for 3 days, switching for fresh, filtered water every 24 hours to allow for any potential leaching of residue manufacturing chemicals. Once the spore-mixture was diluted to the proper density, one of the spools was put into one of the 4" PVC housings, the entire 4" tube was filled with the spore-seawater mixture, and a Styrofoam circle was attached at the top to make sure the seed string spool did not touch the sides. Each of the 4" pipe with the kelp seed spool inside was inserted into a chilled seawater bath at 50°F overnight. The next day after the spores have attached, the 2" PVC pipes were removed and put into 2 separate, 20 gal aquaria with air, chilled, filtered seawater, as well as germanium dioxide and PES macroalgae growth media in each tank.

The tanks were maintained at 50°F for 40 days, with sunlight-equivalent UV lighting located 18" laterally on either side of the tanks.. For the first 7 days, the light was filtered through 1mm screen to reduce the intensity, at 14 days the screen was increased to 9mm, and at day 21 the screen was removed entirely (Fig. 6). Every 7 days all of the water was exchanged with fresh, filtered sea water and new growth media. The tanks were monitored twice daily, temperature was noted, aire entering the system was checked, and weekly the spore attachment was monitored through clipping pieces of the seed string and evaluating under a microscope at 40X (Fig. 7). At the conclusion of 40 days, the kelp was sufficiently attached and the lines were

ready to be moved to the ocean for growout.

In late November, 2013, a total of five, 200’ lines were installed at the current Megansett Harbor oyster farm. The lines were installed starting at the northwest corner, leading from north to south, spaced 25’ apart, with a marker buoy, and floatation at every 100’. Each line is anchored by a 12” helical anchor, which is then attached to rope leading to a marker buoy on the surface (Fig. 8). At each buoy, there is a shackle in the buoy line at 7’ to ensure the line does not go below that depth, as well as a 25 lb. concrete weight to ensure the line does not rise above 7’. Connecting the three moorings per line (spaced 100’ apart) is 100’ of 3/8” rope connected at a depth of 7’ with a shackle on either end (the head rope or longline on which the kelp grows). The floatation and weight was monitored monthly throughout the winter as the kelp continues to grow.

On December 9th, 2013, following the 40 day nursery period, the kelp seed string was brought to the site, and wrapped around the 200’ 3/8” rope. On December 17th, the line from UCONN was installed at the site in the same manner. The line was then sunk to 7’ (as described above), and checked monthly and adjusted as necessary to remain at 7’ depth. The kelp was monitored monthly from December through May for biofouling, growth and any potential adjustments to the culture method.

Triploid oyster culture:

Four different strains of oysters were purchased in spring, 2013:

Aquacultural Research Corp., Dennis, MA

100,000 1.5mm Cape x Cape Triploid

100,000 1.5mm Cape x Cape Diploid (picked up June 11, 2013)

Muscongus Bay Aquaculture (Bremen, ME), was originally planned to produce the diploid and triploid oysters for this project. However, due to circumstances outside of their control, the parental broodstock was not available in 2013, and therefore they were unable to produce any triploid oysters. As a backup plan, the hatchery on Cape Cod, MA was producing triploid oysters of their “Cape”-specific strain, and they were able to supply both diploid and triploid oysters for this project.

Mook Seafarms, Walpole, ME

100,000 1.6mm Damariscotta x VIMS Triploid

100,000 1.6mm Damariscotta x NEH Diploid (shipped May 10, 2013)

The Damariscotta line has been selected over many years by the Mook Aquaculture growers. This line was crossed by a VIMS disease resistant stock, which has also been shown to possess excellent growth characteristics. Tetraploidy in the VIMS broodstock was induced through the VIMS method, which was then crossed with diploid Damariscotta broodstock in order to produce Damariscotta x VIMS triploids. Diploid strains were produced from normal Damariscotta and NEH disease-resistant diploid stock.

Originally, the oysters were going to be grown out in small mesh bags, and tended as per normal oyster operations. However, in the spring of 2013, we were able to purchase a nursery upweller, and therefore have a much better environment for the seed oysters to be produced in. When the oysters arrived in May (Mook), each of the 100,000 of each strain was distributed to an individual upweller. Each silo can

handle 100,000, and therefore it was an excellent comparison. When the oysters arrived in June (ARC), they were handled in an identical manner. Counts and measurements were performed every 14 days to track mortality and survival throughout the nursery period. Once the oysters could be graded on a 5/8" screen, they were moved from the upweller to ½" grow out cages on the grow out site. Unfortunately, a problem arose with the 100,000 triploid oysters from Mook. The oysters would not grow at a comparatively similar rate as the rest of the oysters which were purchased and delivered at the same time. When I communicated this to Mook, they sent another 100,000 triploid oysters, which immediately replaced the original stunted shellfish. The replacement oysters immediately began to grow at an excellent pace, and it was clear that the issue was not due to genetics, and that there was an issue with that particular batch which was originally sent.

- Figure 2: Mature kelp tissue
- Figure 3: Kelp releasing spores
- Figure 5: Seed string spools
- Figure 6: Nursery setup
- Figure 8: Kelp growout site
- Figure 4: Spores under magnification
- Figure 7: Kelp spool under magnification

Research results and discussion:

Sugar kelp culture:

The initial stage of producing seed string in the nursery was very successful. There was an excellent release of spores from the mature sorus tissue, and attachment was successful overnight. The entire nursery phase went according to plan, and the resultant seed string was relatively easy to produce. There were no complications, and seed string was installed for growout successfully in December 2013.

All five kelp longlines were brought to the surface monthly from installation (December) through May to check for biofouling and growth. During the routine inspection for biofouling, once per month each line was sampled to quantify growth and plant attachment. Three locations were randomly chosen on each of the five lines, and the number of plants attached in a 12" section were counted and measured for total length. Biofouling was quantified on a scale of 1-5 (1 being no biofouling, 5 being so bad that it is restricting growth) on each line during inspection.

Unfortunately, even with diversifying the source kelp seed string from UCONN and from seed string produced in our nursery, none of the kelp attached or grew to a significant extent. The kelp was initially installed in December at 2.4±0.9 mm (all values mean±SD), and throughout the entire study period did not grow past 20 mm at any point (Fig. 9). Biofouling over the entire study period was very low, and on average was not significant enough to have an impact until May (Fig. 10). At the May sampling, the biofouling had overtaken the kelp, and was throughout the entire length of all of the lines, at a much greater total length than any of the kelp. I have discussed this result with both Paul Dobbins (Ocean Approved) and Dr. Charles Yarish (UCONN), and both have stated that it may be due to several factors.

One cause may have to do with the winter of 2013/2014 being unusually cold, and

water temperatures being colder than average (Fig. 11). This may have prevented growth from achieving the harvestable length which was anticipated, but may not explain why there was very little growth, and no attachment to the longline in the initial months following installation. Another possibility may be that there are not enough nutrients in the water to allow for good growth. However, Megansett Harbor has been monitored for nutrients by the Buzzard's Bay Coalition for many years, and the "Bay Health Index score" has decreased since 2011 due to increases in nitrogen and decreases in water clarity and dissolved oxygen. There are also annual algae blooms in Megansett outer harbor where the kelp was located, which at least partially, are due to increased nitrogen content. Therefore, it is unlikely that low nutrients are an issue. Depth of culture, and lack of light for growth is another potential cause. However, I used SCUBA to confirm that the lines were at the desired 7' depth, and throughout the entire culture period (December-May), the water was very clear and the lines could be seen at depth from the surface. Lack of light penetration may be an issue, and will be explored in future years.

Both Mr. Dobbins and Dr. Yarish noted that the issue may have to do with the timing of installation for growout. Ocean Approved began installing seed string at their farms in ME in October, however, we could not get sorus tissue to start the hatchery until the end of October. This then necessitated another 40 days of setting the spores, nursery phase, and then subsequent installation at the site for growout in mid-December. Sugar kelp naturally takes up nutrients in the fall for subsequent growth in the spring, and given the cold water temperatures and late installation for growout, the kelp may have never taken up the nutrients necessary for exponential growth in the spring. In 2014 we will be installing lines again, with much earlier installation, seed string from multiple sources and varying depths.

Triploid oyster culture:

As explained in the methods section, there were issues with securing broodstock for triploid production in the Maine hatchery which was proposed to produce half of the triploid oysters for this study. Therefore, half of the oysters were purchased from ARC (Dennis, MA) instead, which meant delivery in June instead of May as proposed. Additionally, there was the issue with the first triploid oyster order from Mook Sea Farms being stunted for an unknown reason. Therefore, the comparison between strains was not completely identical, though there was enough comparison to judge performance over the culture period. The four strains were stocked in either May (Mook diploid and Mook triploid (1)), June (ARC diploid and ARC triploid) or July (Mook triploid (2)). Total volume and oyster counts per ml were taken monthly, as well as average shell height for a sub sample of 25 oysters per strain in order to determine survival and growth rates. As the diploid oysters were the same strains from the same hatcheries, with the only difference being the triploid sterility, they were handled and sampled following the same protocol described for the triploid study seed ensuring strong controls for comparisons.

Current was monitored at the growout site (Lowell Instruments; North Falmouth, MA), and was found to be quite low on average (4 cm/s), and therefore, utilizing the FLoating UPweller SYstem (FLUPSY) instead of "rack and bag" culture at the growout site, significantly improved growth and survival compared to past seasons (Fig. 12). The nursery upweller was installed in April 2013, and shellfish were initially stocked in May. The Mook diploid oysters grew the quickest to the size at which point they were moved to the growout site (graded on 5/8" screen) (Table 1). However, given that the first batch of Mook triploids (Mook triploids (1)) did not perform as expected, there was not a good comparison between diploid and triploid genetics. The second batch of Mook triploids (Mook triploids (2)), performed excellent, and

generally had high survival as well (Table 1). The oysters from ARC also survived very well in the upweller, and grew at approximately the same rate, and therefore were able to be moved to the growout site at almost the same rate as well. Given that the Mook diploids were stocked in May, and the ARC oysters were stocked in June, we cannot compare the two as far as growth rates, however, they can be compared for survival. Survival was very high among all strains, and therefore triploid culture in Buzzard's Bay is viable and advised for year-round growth and market acceptance.

- Figure 10: Kelp lines March 2014
- Figure 11: DO and Temperature
- Figure 12: Current at growout site
- Table 1: Oyster growth and survival
- Figure 9: Kelp growth

Research conclusions:

Throughout the rest of the Falmouth Shellfish Coop., and the farms in Falmouth in Buzzard's Bay, there are currently no farms growing triploid oysters. Based on the results of this trial, in the future more farmers may begin to produce triploids, and based on the excellent survival and growth, it would be advisable to do so. There were two usual aspects of the oyster project: 1) broodstock was unavailable for the triploid strains proposed, and 2) the first batch of triploids were stunted. Both of these occurrences were highly irregular, and I would not expect either to occur in normal production year.

There are still no other farms in Massachusetts producing sugar kelp, and based on the results of this project, perhaps the methods need to be refined further for southern New England culture. Given the fact that sugar kelp grows well in both ME and CT, the process is sound, however implementation may need to be modified for this new culture location. In 2014 we will try varying depths and earlier growout installation dates, in order to better determine what caused the lack of growth in 2013.

Participation Summary

Education & Outreach Activities and Participation Summary

PARTICIPATION SUMMARY:

Education/outreach description:

The results of this project were disseminated to the other growers in the Falmouth Shellfish Coop. We have bi-monthly coop meetings, and I presented the information to them there, and I also emailed them a draft version of the final report. An offer was made to the Falmouth Board of Selectmen to present the results of the study, and the Board is very interested in hearing more about kelp culture in general. The Board was apprehensive when they learned about the project, though they also were very interested in learning more about the process. As the Board's schedule allows, the results will be presented.

Technical advisor Diane Murphy has a copy of the report for dissemination to colleagues and to post findings on the Woods Hole Seagrant website. www.whoi.edu/seagrant

Project Outcomes

Assessment of Project Approach and Areas of Further Study:

Future Recommendations

In this study, as with many studies, we answered some questions but also generated many more. We can say conclusively that triploid oysters grow very well in Megansett Harbor throughout the nursery stage and survival very high. However, the growout phase remains to be explored, and will be monitored in subsequent years. In the kelp portion of the study, we were able to successfully produce kelp seed string in a nursery, and successfully implement and permit the growout site in Megansett Harbor. However, the growth was poor, and the reason for this is still unknown. Therefore in 2014, we will continue the study with the same protocol, except different depths and earlier (varied) installation dates. Kelp culture in viable in CT, and therefore it should be viable in MA as well, though the culture protocol needs to be modified. We still believe kelp culture is a great diversification strategy, and also is great method of producing a healthy crop for human consumption while reducing nutrient impacts. We will continue farming kelp, and continue to modify the growout protocol until the process works.