FINAL REPORT

Revitalizing the Hard Clam Aquaculture Industry in the Southeastern U.S. through Transferring Technology on the Sunray Venus Clam

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Project Goal and Objectives

Briefly describe the project goal and objectives

The goal of the project was to provide the impetus needed for the shellfish aquaculture industry to advance the production and distribution of a promising new aquaculture species, the sunray venus clam *Macrocallista nimbosa*. Revitalization of an industry that is currently based exclusively on one bivalve species may be achieved by facilitating technology transfer to the various industry sectors (seed suppliers, growers, wholesalers) of the established hard clam industry in Florida, geographically diversifying culture areas within the southeastern United States, and promulgating market development. Specific objectives of the work plan were to: 1) Ensure shellfish hatchery operators are capable of producing sunray venus clam seed, 2) Educate current and potential clam aquaculture growers about culture and handling methods suitable for sunray venus clam production, 3) Characterize bottom sediment properties using a soils-based approach to assist growers in determining compatibility of existing leases and siting future leases for sunray venus clam culture, 4) Evaluate protocols for freezing sunray venus clams to ensure microbial integrity, product quality and flavor stability that can be implemented by shellfish wholesalers, and 5) Educate consumers and seafood buyers about the availability, high quality, and environmentally sustainability of a new aquaculture product.

Methodology

1. Briefly describe methods for implementing the project and satisfying project objectives

One of the first steps of the project was to ensure adequate seed availability for growers to purchase and plant at the demonstration site as well as other growing areas in Florida and the southeastern U.S. To do so, sunray venus (SRV) clam broodstock maintained from previous Florida Sea Grant (FSG) projects were provided to shellfish hatchery operators. In addition, project funds assisted these businesses in expanding and modifying their hatchery facilities to accommodate SRV clam seed production. On-site visits were conducted as needed to assist hatchery personnel with site-specific questions and to review SRV clam broodstock maintenance, spawning, larviculture, and early juvenile rearing methods.

The prior hard clam aquaculture retraining programs for former Florida fishermen provided a successful model for the second project objective. A portion of a submerged sand spit located off of Cedar Key was established as a demonstration site. Test plots, conducted prior at this site, resulted in viable SRV production. Individual training plots within the demonstration site were of the size to allow for as many interested growers to participate as possible. Grower selection, cultivation requirements, and other criteria were determined by the Cedar Key Aquaculture Association. Participating growers were engaged in a classroom curriculum and “hands-on” field training. Information on various principles of SRV culture and results from prior projects was presented at workshops. In addition, alternative culture and harvesting methods were demonstrated. SRV clams originating from the commercial demonstration site provided visibility of this new culture product and allowed market potential to be evaluated. The classroom curriculum was also delivered to interested growers in other parts of the state via workshops and individual consultations. Workshop materials were made available online. In addition, we worked with aquaculture Extension specialists in Georgia, South Carolina, and North Carolina in providing information about SRV culture to interested growers in their states.

High-resolution bathymetric and soil maps have provided a useful science-based tool for identifying submerged lands suitable for shellfish aquaculture leases. Depth soundings, soil cores, and associated positional coordinates were collected throughout a 35-acre submerged sand spit nearby Cedar Key; soil cores were analyzed for particle size distribution and organic matter content. The bathymetric and soils data were spatially interpolated and presented as high-resolution maps, suitable for fine-scale visualization and assessment of the site. To determine the compatibility of existing shellfish aquaculture leases and future lease sites for the potential of SRV clam culture, soil characterization information derived from prior FSG projects was used as a tool to aid growers in determining the suitability of aqueous soils. Interested growers from Florida to North Carolina were sent a soil sampling kit; each kit contained soil sample containers, shipping box and information, and a fact sheet informing growers on how to evaluate the soils on their leases and sample those that may be suitable for SRV clams.

To ensure consistent market supply without compromising product quality and demand, an option was evaluated which would allow the shellfish wholesale dealer and distribution sectors to utilize frozen SRV clam product as a feasible complement to fresh product. Cultured SRV clams were provided to several commercial processors who had the capability of freezing molluscan shellfish. Frozen product from each processor was evaluated at 0, 3.5 and 7 months for taste (ranking) and sensory characteristics and compared to fresh SRV clams. Sensory profile results from prior FSG-funded research were used in developing the sensory evaluation of frozen SRV clams with respect to product appearance, aroma, basic tastes, flavors, and texture. In addition, microbial consequences were analyzed over time for product quality evaluation.

Marketing expertise was utilized to educate consumers and seafood buyers of the SRV clam's superior attributes and to allow this clam to be properly positioned for sales as a highly desirable, new aquaculture product. Promotional materials for consumer and buyer awareness were designed, printed, and made available. Awareness was also increased through participation in several venues—television cooking episode and culinary tasting events. Point-of-purchase materials, photographs, and artwork were posted on the UF website for growers, wholesalers and retailers to access, customize with their business information, and use for their own promotional efforts.

2. Briefly describe methods for measuring social, economic and/or environmental benefits of the project

The short-term outcomes targeted for each project objective to be adopted by the shellfish aquaculture industry were identified in the extension work plan and consisted of the number of 1) hard clam hatchery operators who would participate in the project, modify their facilities, and expand their production protocols to accommodate SRV seed production; 2) shellfish growers who would participate in the demonstration project and educational workshops, and diversify their businesses by incorporating SRV clam culture; 3) shellfish growers who would utilize a comprehensive soil analyses in their lease site selection process; 4) certified clam wholesaler/dealers who would establish markets for frozen SRV product utilizing protocols evaluated; and, 5) consumers and seafood buyers who would be informed of the availability, high quality, and environmentally sustainability of a new aquaculture product. Methods used for measuring each project objective follow. By working with each industry sector (seed suppliers, growers, wholesalers), production and marketing constraints to establishing SRV clams as a feasible complement to existing hard clam culture and markets were addressed, allowing the

industry to have a forward momentum and head start towards commercialization. However, the long-term outcomes of this integrated technology transfer project may not be realized for several years. Ultimately, the desired outcome will be an established product supply and enhanced demand for the SRV clam that will constitute a viable compliment to the hard clam culture industry. It is anticipated that a geographically diverse and viable sunray venus clam culture industry will be developed in the southeastern United States within 3-5 years, providing a unique farm-raised seafood product to local, regional, and national markets.

Following each hatchery site visit, communications were maintained with hatchery personnel to confirm that the necessary culture system design modifications were achieved and the broodstock clams were successfully acclimated to their host hatchery. The project team also coordinated with hatchery operators to receive relevant information with respect to spawning frequency and fecundity, larviculture success, and number of post-set seed reared. SRV clam seed production was documented when possible.

Shellfish growers adopting culture methods taught or demonstrated was determined by direct contact and via the Florida Department of Agriculture and Consumer Services (FDACS), Division of Aquaculture, who certifies all aquaculture operations in the state. Participants of workshops and demonstrations were surveyed to determine if there was an increase in knowledge of SRV clam production. The number of people who downloaded the curriculum and publications from the webpages created was quantified. The increase in production numbers and sales (farm gate) value to measure the economic revenue of SRV clam culture is not easily determined as a state aquaculture survey has not been conducted since 2012. However, the USDA National Agricultural Statistical Service is currently conducting a national aquaculture census for the year 2017. SRV clams were added to the Florida aquaculture survey for the first time in 2012, which will provide baseline information for comparison over a 5-year period.

Aqueous soil maps of the Cedar Key demonstration site provided an important context for interpreting yields from individual training plots. Results of aqueous soils analyses were presented to all growers who provided soil cores for testing. Printed materials and online resources were also provided so that growers would have the proper tools to evaluate their sites for SRV production. A follow-up with growers in Florida and Extension specialists in other states was conducted by phone and email to confirm that the soil results were incorporated into the site selection process. Beyond the scope of this project, additional interviews will be conducted of selected growers to collect information regarding growth, survival, and general appearance of SRV clams grown at their farms and to confirm the utility of soil characterization in optimizing SRV clam growout performance.

A survey of FDACS Division of Aquaculture shellfish plant inspectors, who oversee the certification process for molluscan shellfish wholesalers in the state, determined that only those dealers who had participated in the project incorporated frozen SRV product into their inventory. At the time of the survey, information on the proportion of sales of frozen product relative to fresh SRV clams, and the seasonal characteristics of their market was unavailable. In the future, additional follow-up will be conducted to collect specific information regarding market response, volume produced and distributed, and, if possible, economic gain. Sensory results, as well as the parameters for freezing processes, were presented in fact sheets distributed to interested shellfish wholesalers and posted to the UF webpage.

Results from each marketing and promotional activity were measured by documenting the number of seafood consumer and buyers who requested materials and information, number

reached through culinary venues, number of point-of-purchase materials distributed, and number of downloads on the UF website.

Outcome/Impact Summary

1. Relevance (Describe why the project was desired/needed?) Include any statistics or measures that can help to quantify the need for the project.

Over the past two decades, Florida has experienced a dramatic increase in aquacultured shellfish production. Grower revenue associated with the clam industry grew from $1.2 million (41 farmers) in 1991 to $19 million (132 farmers reporting) in 2012. In addition, the industry supports many other small businesses, including seed suppliers, equipment suppliers, and shellfish wholesalers, with an economic impact of $39 million in 2012. However, the industry is reliant upon a single clam species *Mercenaria mercenaria*, which has led to market problems. The industry value fell to just under $13 million in 2003 and to $10.7 million in 2005, as dockside prices plummeted from 13¢ to 9¢ per clam during the 2001-2004 economic downturn, which was not observed for other bivalve species, such as oysters. This trend occurred again in response to the recent economic recession. Further, hard clams are widely farmed along the entire U.S. East Coast, which has driven national wholesale market prices to an all-time low. To meet increasing national and global demand for seafood products, the clam culture industry, whose product sells for pennies at the farm and is faced with increasing production costs, must increase efficiencies and profitability. Diversifying the industry by developing farming technology and markets for other bivalve species and products may mitigate production and market risks, thereby enhancing economic viability and stability, as well as overall growth of the industry.

Since 2006, the culture and market potential of the sunray venus (SRV) clam *Macrocallista nimbosa*, an attractive venerid clam distributed from the Carolinas to Florida and Gulf of Mexico states, has been evaluated. The existence of a latent market and potential growth rate of the SRV clam along with being a native species made it a logical choice as a new species to diversify the Florida hard clam industry. In previous Florida Sea Grant-supported projects, the project team successfully spawned wild-collected adults and cultured larvae to produce seed. These seed were reared to marketable size using methods similar to hard clams. Variation in survival, growth, and the presence of shell deformities at growing sites led us to examine differences in substrates among these sites. Results suggested that soil properties, such as particle size distribution and organic matter content, affect SRV clam productivity. Other studies demonstrated acceptance of both cooked and raw SRV clams by consumers, chefs, and restaurant managers in Florida markets. Attributes of cultured SRV clams were also determined with respect to the wholesale/ distribution sectors of the market. Hundreds of buyers at the 2011 International Boston Seafood Show sampled SRV clams, revealing an overwhelming, positive assessment of the product across a range of attributes and willingness to purchase.

During 2010–2012, SRV seed were provided to growers to evaluate existing hard clam leases on Florida's west coast. Promising results from plantings in southwest Florida resulted in several growers and wholesalers moving forward with culturing and marketing SRV clams to upper-end restaurants in the area. However, these leases are subject to periodic harvest closures due to harmful algal blooms (red tide), resulting in loss of sales and market disruptions. In Cedar Key (Levy County), where over 80% of the hard clams are produced in the state and 50% of the

certified shellfish wholesalers are located, the majority of leases are not optimally suitable in terms of soil properties and salinity regimes for farming SRV clams. Working with the Florida Department of Agriculture and Consumer Services, the agency which administers the aquaculture leasing program for the state, sites off Levy County were evaluated for the potential of SRV clam culture. To address the need for geographical diversification of growing areas and obtain full adoption of this species by the industry, this integrated technology-transfer project utilized a development strategy that was successfully applied during the 1990s in transitioning underemployed fishermen to shellfish farmers on Florida's west coast.

2. Response (Describe was done and with what partners to address the specified need?) This can be a summary of the description of the methods stated above.

This project provided the necessary infrastructure via a public-private partnership with researchers, Extension specialists, agency staff, growers organization, and industry to commercialize the sunray venus (SRV) clam through large-scale demonstration, education, and "hands-on" training. Five integrated project objectives were addressed in an effort to eliminate barriers to full adoption of SRV culture by the various industry sectors.

<u>Ensure shellfish hatchery operators are capable of producing sunray venus clam seed</u>

To ensure adequate seed availability for growers to purchase and plant at the demonstration site as well as other growing areas in Florida, a letter with participation guidelines and application form was sent each project year to all nine Florida shellfish hatchery operators. Each year, project funds were distributed to assist participating businesses in modifying their hatchery facilities to accommodate SRV seed production. For example, two hatcheries used the funds to purchase a chiller to expand their broodstock conditioning and maturation capacity. At the request of growers in southwest Florida, who had invested in SRV clam culture on existing leases off Lee County, additional funding was provided during the fourth project year to a shellfish hatchery in the area to assist in SRV seed production. An instructive DVD titled *Spawning and Early Culture of the Sunray Venus Clam* that reviewed seed production protocols, developed in a prior Florida Sea Grant (FSG)-funded project, was distributed to hatcheries. SRV broodstock, obtained from first and second-generation stocks reared in previous FSG projects and held at the UF experimental lease in Cedar Key, were shipped to participating hatcheries by the PI Leslie Sturmer. Gonadal development and sex ratios, as well as water temperatures, were monitored by sampling stocks and this information was provided to hatchery operators. Co-PIs Dr. John Scarpa, formerly of Harbor Branch Oceanographic Institute at Florida Atlantic University, and LeRoy Creswell, FSG extension agent, provided on-site visits as needed to assist hatchery personnel with site-specific questions and to review SRV clam broodstock maintenance, spawning, larviculture, and early juvenile rearing methods. In the first project year, site visits to hatcheries were arranged in January (i.e., prior to spawning attempts) and May/June (i.e., predominantly post-spawning attempts), with the project team making two visits to an east coast hatchery and four hatcheries in the Cedar Key area. A post-seed production follow-up meeting was held in Cedar Key, at which five of the six participating hatcheries had personnel attend the meeting. In the second project year, site visits were arranged during or after spawning attempts, again, with the one east coast hatchery and four hatcheries in Cedar Key. Dr. Scarpa arranged site visits to four participating and one non-participating hatchery in the third project year after spawning attempts.

Educate current and potential clam aquaculture growers about culture and handling methods suitable for sunray venus clam production

To advance the production of SRV clams, growers in Cedar Key, where over 80% of the hard clams are produced in the state, were allowed to learn and "experiment" with SRV culture practices without the investment and commitment of acquiring a lease. Many of the shellfish aquaculture leases in Cedar Key are not optimally suitable in terms of soil properties and salinity regimes for farming SRV clams. An application was submitted by UF in November 2013 to the Florida Department of Agriculture and Consumer Services (FDACS), Division of Aquaculture for five acres within a submerged sand spit located east of Cedar Key for use as a commercial demonstration site. Test plots harvested at this site from prior FSG-funded research resulted in viable SRV production. Grower selection, cultivation requirements, and other criteria for participating in the project were developed in conjunction with the Cedar Key Aquaculture Association. This information along with an invitation to attend an introductory workshop was mailed to 125 certified shellfish leaseholders in Levy County. A series of workshops for the Cedar Key project participants was developed to coincide with culture practices associated with producing a crop of SRV clams. Instruction at these workshops was conducted by PI Sturmer with assistance in demonstrations provided by a technician, funded through this grant. The classroom curriculum was also delivered to interested growers in other parts of the state via workshops, as well as individual consultations. In addition, we worked with aquaculture Extension specialists in Georgia, South Carolina, and North Carolina in providing information about SRV culture to interested growers in their states. A topic page on the *Online Resource Guide for Florida Shellfish Aquaculture* website, http://shellfish.ifas.ufl.edu/sunray-venus-clams/, was developed to provide information on each project objective as well as presentations and handouts from the classroom curriculum to all interested individuals. In addition, summaries, presentations, and reports from three FSG-funded projects on SRV clam culture and market potential were posted to the site. Resource materials and references were also posted to provide sufficient information for one to make an informed decision regarding SRV clam culture. In addition, a final technical report with a summary of activities conducted in this project is be posted to the web page.

Characterize bottom sediment properties using a soils-based approach to assist growers in determining compatibility of existing leases and siting future leases for sunray venus clam culture

To characterize bottom sediment properties and chemistry of submerged lands using a soils-based approach, depth soundings and associated positional coordinates were collected throughout a 35-acre sand spit nearby Cedar Key where the commercial demonstration site was to be located. To do so, a high accuracy Global Positioning Systems (GPS) was coupled to a high frequency sounder suitable for shallow depths. In addition, 130 soil cores (10 cm deep) were collected at 40-meter intervals during January 2014; locations of soil samples were recorded via GPS. Samples were analyzed for sand, silt, clay, and organic matter content. Bulk density was also determined. Using Geographic Information Systems (GIS) and geostatistical modeling, the bathymetric and soils data were spatially interpolated and presented as high-resolution maps, which allowed for fine-scale visualization and assessment of small parcels within the 5-acre demonstration area. This information was presented to participating growers at workshops in 2014, as well as provided as printed materials, so that they would have the tools to evaluate their

individual parcels sites for SRV production. To provide growers with guidance on the suitability of aqueous soils for culturing SRV clams at existing leases or in siting new leases, soil test kits were assembled. Each kit consisted of a soil corer, sample containers, pre-paid shipping box, and fact sheet informing growers on how to evaluate the soils on their leases and sample those for further analyses. Soil samples were analyzed for particle size distribution and organic matter content by co-PI Dr. Todd Osborne using standard methods of soil and sediment analysis at the UF Environmental Pedology Lab. A simplified analysis report was developed that placed growers' lease soils in a textural triangle with shaded regions signifying "optimal" and "suitable" soil physical characteristics. Combining organic matter results, a short narrative of the results with guidance on growout suitability for SRV clams was provided to all leaseholders willing to send samples for analysis. Clam growers expressing interest in culturing SRV clams nominated potential sites in four Florida coastal counties. Soil cores were collected at these sites during 2014-16. In addition to evaluating potential SRV lease sites in Florida, a total of 24 subaqueous soil test kits were shipped to Extension specialists with South Carolina Sea Grant and University of Georgia Marine Extension Service in 2014-15. These kits were distributed to growers with existing leases who were interested in SRV culture. In 2015-16, 18 test kits were shipped to the Extension specialist with North Carolina Sea Grant.

Evaluate protocols for freezing sunray venus clams to ensure microbial integrity, product quality and flavor stability that can be implemented by shellfish wholesalers

Three shellfish wholesale dealers/processors, who had the capability of freezing hard clams, participated in the project by freezing SRV clams for evaluation of their protocols over a seven-month period. In June 2015, about 1200 cultured SRV clams were provided to each of the processors. Each processor froze and packaged SRV products differently. The first processor (B) placed SRVs in a controlled salinity purification system designed to purge the SRVs and also regulate salinity levels to produce a consistent brine flavor. After which, SRVs were vacuum packed (12 SRVs per unit), partially cooked, and immediately quick frozen (IQF) using cryogenic freezers. The second processor (C) packaged 12 uncooked, purged SRVs on trays and froze the product, while the third processor (D) froze the purged product in bulk. Frozen SRVs from each processor were shipped to the UF Food Science and Human Nutrition Department and stored at -20°F until sensory testing. To compare with fresh product (control, A), SRVs were harvested and purged at the UF facility in Cedar Key prior to each sensory testing.

The sensory profiles of raw and fresh cooked SRV clams were developed in a prior Florida Sea Grant-funded project by a trained seafood sensory panel at the UF Aquatic Food Products Lab and used in developing the sensory evaluation of frozen SRV clams. The first sensory test was conducted in July 2015 at the UF Aquatic Foods Pilot Plant under the supervision of Co-PI Dr. Charles Sims. Panelists (n=90) were recruited to participate and indicated in a screening test that they were consumers of clams/mussels. SRVs from each processor were cooked in microwave ovens for 2-4 minutes (or until shells opened) and evaluated for taste (ranking) and sensory characteristics. The panelists received four SRVs samples (3 frozen treatments and fresh) within two minutes of cooking. Two clams from each treatment were presented to the panelists in plastic cups labeled with random numbers. Panelists first rated the shell and meat appearance on a 9-point hedonic scale, where 1=dislike extremely, 5=neither like nor dislike, 9=like extremely. The panelists were then instructed to eat a single SRV and rate overall acceptability, flavor and texture on the same 9-point hedonic scale. Once the panelists had evaluated all four samples, they were asked to eat the remaining SRV for each sample and rank

the samples for preference, where 1=most preferred sample and 4=least preferred sample. The rating data was subjected to a two-way analysis of variance and means were separated using Tukey's HSD (0.05). The ranking data was subjected to Friedman's analysis and rank total separated using Tukey's HSD (0.05). During the third project year, assessment of frozen SRV product was conducted at approximately 3.5 months (October 2015) and 7 months (January 2016) of storage using the same methodology previously described. The number of panelists ranged from 75 to 90. In addition, all four products were analyzed for microbial consequences over the same time period as the sensory tests. Measures were based on standard aerobic plate counts and fecal coliform counts utilizing U.S. Food and Drug Administration (FDA) analytical procedures for seafood. Aerobic plate count (APC) indicates the level of microorganisms in a product; APC on fish and fishery products generally do not relate to food safety hazards, but sometimes can be useful to indicate quality, shelf life, and contamination.

Educate consumers and seafood buyers about the availability, high quality, and environmentally sustainability of a new aquaculture product

The Florida Department of Agriculture and Consumer Services (FDACS), Bureau of Seafood and Aquaculture Marketing had to redirect their proposed marketing efforts based on the realization that participation in the Florida Restaurant Show was not timely due to limitation of available product. Bureau staff met with Indian River and Cedar Key growers at workshops conducted in 2015 to receive input on new directions for the marketing portion of the project. It was determined that marketing tools would be developed for growers, wholesalers, and retailers to use in educating seafood buyers and consumers about the availability, high quality, and environmentally sustainability of a new aquaculture product. The focus was on high-end marketing and included several elements—recipe development, point-of-purchase materials, and tastings at culinary events.

3. Results (Describe the social, economic and/or environmental benefits to the aquaculture industry)?

Ensure shellfish hatchery operators are capable of producing sunray venus clam seed

Most of the Florida hard clam seed producers agreed to participate in the project over the three-year period. The agreement was that they would give a bona fide effort to expand their production protocols to accommodate SRV seed production. At least two of these hatcheries produced enough seed to fulfill project requirements in the first year. During 2015-16, hatcheries experienced low seed production of hard clams, resulting in reduced efforts to diversify and produce SRV seed for project participants. This, in turn, thwarted efforts of growers in planting seed and adopting culture methods taught or demonstrated. As a result, development of this new aquaculture species may have been delayed; nonetheless, interest remains high among enough growers that commercialization of this species as an alternative crop may become a reality, but may exceed the timeframe of this project.

Six of the nine, or 67%, of the seed producers in the state agreed to participate in the first project year, modified their facilities, and expanded their production protocols to accommodate SRV clam seed production. About 2,800 SRV broodstock were shipped to these hatcheries. Assistance was provided to hatchery personnel with site-specific questions and review of SRV broodstock maintenance, spawning, larviculture, and early juvenile rearing methods. Following each site visit, communications were maintained with hatchery personnel via email or phone to

confirm that the necessary culture system design modifications were achieved and broodstock clams were successfully acclimated to their host hatchery. All hatcheries were able to spawn SRV from broodstock provided; however, there were variable results between hatcheries for production of larvae, post-set, and seed. In general, the hatcheries in Cedar Key had the greatest problem with seed production. From conversations with hatchery personnel, the major problem was low salinity; that year had a rainy winter and spring that depressed salinities. One hatchery operator produced seed early in the year, but later was unsuccessful. The other west coast, but more southerly, hatchery and the east coast hatchery were able to successfully spawn SRV, culture the larvae through metamorphosis, and produce seed that were made available to grower participants. These two hatcheries combined, produced 30-60 million larvae and at least 5 million SRV seed, which was more than enough to fulfill requirements in the first year and promote further production of this new culture species in other parts of the state. The major factor determined in their success was higher salinity throughout their attempts.

In the second project year, only four seed producers indicated they would participate, although a fifth joined later. The primary reason for some hatcheries not participating was so they could concentrate on hard clam seed production as shortages over the past couple of years resulted in high seed demand. About 1,300 SRV clam broodstock were shipped to participating hatcheries. Project funds were again distributed to assist these businesses in modifying their hatchery facilities. During an on-site visit, Dr. Scarpa and Mr. Creswell were able to assist hatchery personnel with executing a spawn that resulted in 47 males and 33 females spawning, which produced about 63 million eggs that developed into viable larvae and early post-set. All five participating hatcheries were able to spawn SRV clams; however, there were variable results between hatcheries for production of larvae, post-set, and seed. In general, the hatcheries in Cedar Key had the greatest problem with seed production, although spawning was noted as not as easy as hard clams for some groups. The major problem was, once again, low salinity. Some hatchery operators were able to produce 1.0 mm seed, but these seed died either from salinity depression or unknown reasons. In one case, SRV seed died whereas hard clam seed in the same system lived. One hatchery sent post-set (0.3-0.8 mm) to other hatcheries when salinities were dropping; however, the majority of seed did not survive at the other hatcheries (no reason could be given for mortality). Other participating and non-participating hatcheries indicated they were able to successfully produce SRV seed (4.0 mm).

In the first two project years, successful conditioning of broodstock for spawning was a problematic area that hatcheries identified. Therefore, in the third year, in which five of nine Florida hatcheries participated, PI Sturmer assisted hatcheries by providing naturally conditioned SRV broodstock (over 800) during a five-month period. In the Cedar Key area, SRV broodstock seemed to ripen naturally anywhere from about mid-December to April. PI Sturmer and her team assessed visually the gonadal ripeness of SRV stocks maintained on the UF lease in Cedar Key during this time. Three of the hatcheries were able to spawn only a few of the broodstock, which resulted in none being able to produce seed. At one hatchery, only males spawned on two different attempts. At another hatchery, only a single male spawned. At the third hatchery, three spawns were induced with one producing approximately 5 million eggs, but no larvae resulted. As in prior years, Dr. Scarpa discussed with hatchery personnel their experiences with SRV and hard clam spawning attempts to understand the individual problems a hatchery may encounter as well as to determine if there was a common problem among the participating hatcheries.

In the final project year, a participating hatchery operator was able to produce two spawns in the summer (2016) after conditioning broodstock provided. For both spawns, there were no

problems during larval culture and setting, but upon moving post-set seed to the nursery, the majority died. The participating hatchery operator was also having nursery problems with hard clams at the time. He did not conduct any other spawns. As with other hatcheries, he was focusing on hard clam seed production as demand remained high and many of the Florida hatcheries were still experiencing production problems.

Meetings with hatchery personnel allowed them to share their successes and failures in order to assist in identifying problems for hatchery operations (adult holding, conditioning, spawning, larvae development/culture, and post-set culture). One meeting resulted in a two-page summary of identified problems and potential solutions. One problem noted for the Cedar Key hatcheries was low salinity, which inhibited feeding, conditioning, and spawning of broodstock and thus larvae/seed production. The salinity issue, occurring during "wet" winters, prevailed in the Cedar Key area during the project period, which may dictate that reliable seed production should occur in other parts of the state. There was no consensus as to what the single most important problem for the participating hatcheries was. There also may be more individual problems rather than a single or a few general problems. Each hatchery may have to determine and overcome its own unique set of problems for SRV seed production or research will be needed to identify a solution for each specific problem for a given hatchery or smaller set of hatcheries. Given that the spawning of seemingly ripe SRV broodstock was problematic for most of the hatcheries, there is a need to examine the reproductive cycle and spawning stimuli of natural populations. Defining maturation and conditioning protocols through further applied research and technology transfer that will result in year-round production of SRV seed may be necessary to move this promising new species forward to commercialization.

<u>Educate current and potential clam aquaculture growers about culture and handling methods suitable for sunray venus clam production</u>

A commercial demonstration site was established in Cedar Key, where interested growers were allowed to grow a crop of SRV clams and shellfish wholesalers obtained adequate production for market evaluation. The Florida Board of Trustees (Governor and Cabinet) approved an application submitted by UF in 2014 and a 5-acre area was established as an aquaculture management agreement for a period of three years with the understanding that no leases would be issued in the remaining acreage during the term of the agreement. The site was divided into 34 individual training plots, each 0.15 acres, to accommodate the number of growers who applied to participate in the project. The individual parcels were marked with PVC pipes; warning signs were placed at the corners and along the perimeter of the site to inform boaters and others of the area designation. Now that the project is completed, this area is being considered as a new aquaculture use zone by FDACS with up to 30 one-acre lease parcels proposed.

Six introductory workshops were held on four occasions in 2014 during which 44 people were provided with an overview of research and development efforts accomplished over eight years through FSG-funded projects. In addition, those attending were introduced to the goals and objectives of the project and participation guidelines. Thirty-eight of the 125 certified shellfish growers in Levy County, or 30%, applied to participate in the project (some shared parcels). A series of workshops introduced participants to 1) prior research efforts conducted to evaluate the culture and market potential of SRV clams, 2) participation guidelines, 3) soil maps and layout of the demonstration site, 4) SRV seed descriptors and suggested land-based, field nursery, and growout culture protocols, and 5) handling and post-harvest methods to assist them in harvesting

and marketing SRV clams. These workshops also provided a network for participants to share learning experiences and develop standards or guidelines for the industry to use in culturing, harvesting, handling, processing, and distributing cultured SRV clams. The first set of workshops held in May (2014) introduced project participants to the basics of SRV seed (e.g., suppliers, descriptors, sizes) and results of land-based and field nursery trials. At that time, participants were also introduced to the demonstration site and parcel selection was done by random drawing. It was anticipated that SRV seed would be available by participating hatcheries in June for growers to purchase and plant on their parcels. The next workshops were conducted in September (2014) to coincide with nursery seed being ready to transfer into growout culture systems. Information on methods, stocking densities, growth rates, harvest sizes, etc. was presented, along with project objectives planned for the second year. Attendees also learned about on-bottom planting and alternative harvesting methods. A brief survey was provided to participants asking them to indicate how much seed (e.g., 0, <50K, 50-100K, or >100K) had been planted on their plots within the demonstration site. Seventy percent (70%) of participating growers indicated they had planted SRV seed (estimated at about two million). In 2015, workshops were scheduled in September to coincide when participants began harvesting SRV clams to inform them of handling and post-harvest methods. Shellfish wholesalers were provided with results from prior FSG-funded projects on shelf life, consumer acceptance, wholesale market attributes, and sensory and nutritional profiles to assist them in marketing SRV clams.

Harvesting of SRV clams, which were planted by participants in 2014, began in 2015. Product was sold through local wholesalers with prices to growers high ($0.20-0.25 each) and wholesale prices exceeding $0.30 each. Although survival of seed planted in nursery bags was variable, survival of SRV harvested from growout bags ranged from 50 to 70% and exceeded 80% in the bottom plants. Further, bottom-planted SRV clams were larger than those grown in bags and more uniform in size. The increased production observed with the bottom-plant method was offset by the limitation of using hand rakes to harvest. This constraint was eliminated by a legislative bill, which passed in the 2016 state session, allowing for the use of handheld or hand-drawn hydraulically or mechanically operated devices in harvesting cultured clams from aquaculture leases. Applied research conducted by UF faculty (Sturmer and Osborne) on alternative harvesting methods, which would minimize impacts to natural resources and improve shellfish production, provided the science in support of this legislative change. With funding from FSG (2012-13) and FDACS (2014-15), replicated field trials evaluated the effects of harvesting bottom-planted hard clams and SRV clams on water quality and sediment properties in comparison to harvesting bottom bags and reference (unfarmed) conditions.

In a collaborative research project between Harbor Branch Oceanographic Institute at Florida Atlantic University (HBOI-FAU) and UF faculty, fatty acid profiles of SRV clams were evaluated to better understand maturation requirements. Researchers also conducted several spawns to compare fatty acid profiles of cultured broodstock with larvae from seasonal spawns. Due to the limited availability of SRV seed in 2015, it was decided to rear excess post-set from this research project to be able to provide to participants in the demonstration project. The CKAA advisory committee supported this decision. Approximately 342,000 SRV nursery seed were made available to 28 growers in September, allowing everyone an opportunity to work with this clam species. In December, another 245,000 SRV seed were distributed to 21 participants.

An assessment of the demonstration site was conducted in 2016 and it was determined that about 60% of the participants had SRV clams in various stages of production on their plots. In May 2016, a brief survey was sent to all participants to assess the anticipated level of

participation in the project and, in turn, to determine the future of this project and prospects of SRV clam culture in Cedar Key. Over half of the growers participating in the project reported they purchased SRV seed (estimated 3 million) in the first two years and planted on their plots within the demonstration site, in addition to the half million seed provided by the project. Twenty participants, or 60%, indicated that they were interested in continuing to participate in the project and invest in planting additional seed. Of those, 55% of the participating growers indicated they had 10-50,000 SRV clams on their plots, 15% had 50-100,000 SRV clams, and 20% had over 100,000 SRV clams. It was estimated that an additional one million seed were purchased and planted by growers during the fall of 2015.

During 2016-17, which encompassed the final year of the demonstration project in Cedar Key, participants who planted seed in 2015-16 continued to work their crops and harvest product. One grower reported he was about to harvest 60 growout bags (about 50,000 clams), but was unable to plant any more due to the limited availability of seed. Another grower in the project who was also a local wholesaler reported he had purchased 47,000 SRV clams from five participants during 2015-2016 at an average dockside price of $0.22 apiece. He also reported that he purchased an additional 136,000 SRV clams during that period from growers in southwest Florida. These SRV clams were sold to other wholesale distributers at prices ranging from $0.28-.38 apiece. Most of the SRVs were sold to high-end restaurants locally and in south Florida.

Of the 34 growers in Cedar Key, who originally signed up to participate in the demonstration component of the project, 62% remained in the project over the three-year period. Twenty-one certificates of completion were issued to project graduates, which represented about 17% of the certified clam growers in the Cedar Key area. A “wrap up” meeting was conducted prior to the end of the project to review what was learned and what was not and discuss what was next to accommodate continued interest in SRV culture. Seventy-six percent (76%) of these participants responded to a questionnaire provided at the meeting. This was an effort to gain an understanding of participants’ experiences culturing SRV clams at the demonstration site. The estimated number of seed planted during 2014-17 was wide ranging with 54% reporting from 10-50,000, 15% from 50-100,000, 23% from 100-250,000, and 8% greater than 250,000. Many commented they experienced problems with some of their bags burying resulting in high mortalities, others reported undipped soft bags were the most successful of culture methods used, while some suggested that a bottom plant method may be the most viable means for growing SRVs. The estimated number of SRVs harvested during 2014-17 was also wide ranging with 36% reporting less than 10,000, 29% from 10-50,000, 14% from 50-100,000, and 21% from 100-250,000. One grower summarized his experiences stating that he purchased 200,000 seed in the first year and sold 105,000, in the second year he purchased 150,000 and sold 50,000 as survival was poor, and in the third year he planted 50,000 but at the time of the questionnaire had not yet harvested these. The average farm gate (grower) price received for SRV clams was $0.25 apiece; while hard clam prices during this time period ranged from $0.09-0.12.

According to comments on the questionnaire, the primary limiting factor to culturing SRVs at the demonstration site was unreliable seed availability. This was at a time when most of seed producers in the state were also experiencing poor production of hard clam seed mainly due to environmental conditions that affected both hatcheries and nurseries. The project coincided with “wet” winters, which resulted in lower than normal and fluctuating salinities at the site, and certainly could have contributed to seed mortalities experienced. Conflicting reports were received from participants regarding site conditions with some indicating the site was good for culturing SRVs and others saying shifting sands resulted in buryment of seed. This site also

experienced prevailing winds associated with Hurricane Hermine in 2016. The participants were also queried to assess if there was an increase in knowledge of SRV clam culture. Their responses were summarized and follow. All agreed, average responses of 4.7, based on a scale of 1 ("strongly disagree") to 5 ("strongly agree"), that a) workshops and presentations, and b) handouts and notebook materials were informative. Responses to three other questions averaged 4.4 indicating that a) the project was worth the time and effort, b) sufficient information was presented at workshops allowed for increased knowledge of SRV culture methods, and c) the opportunity to interact with other participants also allowed for increased knowledge of SRV culture methods. The lowest response, average of 3.9, was to the question asking if sufficient activities were provided to determine whether to invest in SRV culture. When asked if they thought problems could be worked out with further grower experiences, better site selection, better seed quality or quantity, or continued research, 82% responded yes. When asked if they were still interested in culturing SRV clams, 70% responded yes. It is too early to tell how successful the project's integrated approach was in advancing SRV clam production. Yet, many of those Cedar Key growers, who participated in the demonstration component of the project, are optimistic. One participating grower reported that this was "a real opportunity to raise SRVs in commercial conditions…the product is likely to offer an excellent alternative shellfish crop". Another grower offered that he "liked growing a new shellfish species that if successful would generate tremendous interest from shellfish lovers across the country". Others commented that "they liked sharing information during the project for the greater good of the industry" and "they loved working with this clam".

In addition, 24 clam growers, or 27% of certified growers in five other counties, were provided with current information about the culture and market potential of SRV clams by participating in workshops, or by individual consultations. Interest was high as growers were already rearing SRV on their leases and shellfish wholesalers experienced high market acceptance and demand at local seafood retail shops and restaurants. At least 15% of the growers in southwest and east central Florida, diversified their businesses by incorporating SRV clam culture. Technology transfer was facilitated to interested clam growers South Carolina, North Carolina, and Georgia by working with Extension specialists in those states and individual consultations. Eighteen growers in Georgia, South Carolina, North Carolina were able to make informed decisions on whether to invest in SRV clam culture.

<u>Characterize bottom sediment properties using a soils-based approach to assist growers in determining compatibility of existing leases and siting future leases for sunray venus clam culture</u>

A relationship between subaqueous soils and SRV clam productivity determined in previous FSG-funded research was used as a tool to aid growers in evaluating the suitability of aqueous soils for the potential of SRV clam culture at the commercial demonstration site in Cedar Key, and at existing shellfish aquaculture leases and future lease sites in Florida and the southeastern U.S. This follows the approach of the USDA National Resources and Conservation Service in which physical and chemical properties of soils are used to survey lands best suited for various types of terrestrial crops. The aqueous soil maps of the Cedar Key demonstration site provided an important context for interpreting yields from individual training plots. In general, the entire area was conducive to SRV culture; the shallow site had high sand content and bulk density with low silt, clay, and organic matter content – all of which should support SRV growth and health (no shell deformities).

At least 50% of the new SRV clam growers in Florida utilized a comprehensive soil analyses in their lease site selection process. A clam grower expressing interest in culturing SRV clams in Collier County nominated potential sites. Soil cores were collected at two sites in 2014-15. Sand content of soils at one site averaged 74% and ranged from 58-94%, while soils at the second site were comprised of higher sand content (ave 86%, range from 82-89%). However, the average sand content of the soils at both sites were considered marginal for commercially acceptable SRV culture. In Indian River County, another grower was seeking submerged lands specific for SRV clam culture. Soil results confirmed suitability of soils (sand content of 97-98%). A 5-acre aquaculture lease was issued by FDACS to this grower based on criteria developed for SRV growout. Soil results were provided to an individual interested in SRV culture in southwest Florida, who had submitted samples at five locations in two counties during 2016.

Soil results were also made available to Extension specialists and growers in the southeastern U.S. Of the 12 soil test kits sent to South Carolina and to Georgia, one from each state was returned and analyzed in 2015. Growers were notified of results and recommendations of suitability for SRV growout on their leases (sand content ranged from 98-99%). Of the kits sent to NC, 15 were returned in 2015 of which 41 of the 50 samples from 14 leases and an experimental lease maintained by a community college were analyzed and reports sent. Eighty-eight percent (88%) of the samples had recommended soil conditions for commercial SRV clam culture with sand content ranging from 90-99% and OM less than 5%. Sand content (range of 49-88%) in the remaining samples (12%) was considered marginally suitable for SRV clams. The remainder of soil samples submitted were analyzed and results provided in 2016. This included a grower in North Carolina and a grower in South Carolina, who had submitted 14 samples from four locations. All samples had recommended soil conditions for SRV culture with sand content ranging from 93-95%. In 2017, growers in North Carolina planted SRV seed obtained from a Florida hatchery at eight of the sites that had soil samples verified for SRV clam culture compatibility.

<u>Evaluate protocols for freezing sunray venus clams to ensure microbial integrity, product quality and flavor stability that can be implemented by shellfish wholesalers</u>

The sensory results of frozen SRV clams after one week of storage showed that all samples were rated the same for shell appearance. The fresh SRVs (A) tended to have the highest rating for meat appearance, although they were only significantly higher than the bulk frozen SRVs (D). For overall acceptability, the fresh SRVs (A) were rated higher than B (pre-cooked), but equal to C (frozen on trays) and D (bulk frozen). All frozen samples had similar ratings for overall acceptability. The fresh SRVs (A) had similar flavor and texture ratings as C (frozen on trays) and bulk clams (D), but the fresh SRVs (A) had higher flavor and texture ratings than D (bulk frozen). For preference rankings, D (bulk frozen) tended to have the lowest preference, although the only significant difference was that C (frozen on trays) was preferred over B (pre-cooked). In general, SRVs from processors C (frozen on trays) and D (bulk frozen) had sensory acceptability and preference scores similar to the fresh SRV clams (A). SRV clams from processor B (pre-cooked) had the lowest sensory ratings and preference. Microbial counts were lowest in the pre-cooked SRV product (B) and bulk frozen SRVs (D), and highest in the frozen SRVs on trays (C), followed by the fresh product (A).

After 3.5 months of storage, shell appearance was rated the same for all four SRV clam samples, while the fresh clams (A) were rated higher than the three frozen samples (B, C, D) for meat appearance. The fresh SRV clams (A) and the bulk frozen clams (D) were rated the same

for overall acceptability, flavor, and texture, and both were rated higher than the other two frozen samples (B, C). The fresh (A) and bulk frozen (D) clams also tended to be more preferred over the other frozen clam samples (B, C). After 7 months of storage, the shell appearance was again rated the same for all four SRV clam samples. However, the fresh clams (A) were rated higher than the three frozen samples (B, C, D) for meat appearance, overall acceptability, flavor and texture, and were more preferred than the frozen samples. Of the three frozen SRV clam samples, the uncooked frozen samples (C, D) were slightly more preferred than the pre-cooked, frozen clam samples (B). After 3.5 months, both the fresh and pre-cooked, frozen SRV clam samples had microbial counts less than 5,000 cfu/gram, while both the uncooked, frozen samples had higher counts (C, 8,000 cfu/gram; D, 11,000 cfu/gram). After 7 months, counts for all but the bulk frozen SRV clam samples were less than 10,000 cfu/gram; the bulk frozen clam sample had a count of 19,000 cfu/gram.

Overall, the pre-cooked, frozen SRV clams rated lower than all other samples after one week and this continued throughout the seven months of storage. The uncooked, frozen SRV clams were similar in quality to the fresh clams after one week of storage, and the bulk frozen clams remained similar in quality to the fresh clams after 3.5 months of storage. However, after 7 months of storage the fresh SRV clams clearly had better quality than all the frozen clam samples. Microbial counts for all SRV clam treatments over the seven-month evaluation period were well below levels recommended for safe shellfish by Florida and other states (maximum 500,000 cfu/gram). Further, all SRV clam samples had counts of <10 cfu/gm (below detection levels) of total coliform.

The shelf life of cultured SRV clams has been documented seasonally in prior FSG research to account for the influence of water temperatures at harvest. A shelf life expiration date of 7-8 days after harvest in the summer and 14 days in the winter was recommended to ensure SRV clams were suitable for consumption. Sensory evaluations showed that SRVs can be successfully frozen and held for at least 3.5 months in storage, maintaining quality similar to a fresh SRV clam. However, by seven months of frozen storage, the quality began to deteriorate. Thus, the recommended shelf life for frozen SRVs using protocols evaluated in this project would be between 3.5–7 months of storage. Having a frozen product inventory available in the summer or during harmful algae bloom closures will allow the seafood wholesaler and distribution sectors to provide SRV clams to markets year-round as a feasible complement to fresh product. At least 7% of the certified shellfish (hard clam) wholesalers in Florida have begun to establish markets for frozen SRV product utilizing the protocols evaluated.

Educate consumers and seafood buyers about the availability, high quality, and environmentally sustainability of a new aquaculture product

To educate consumers and seafood buyers about the SRV clam, FDACS Executive Chef Justin Timineri tested and developed five recipes to be used online and three to be used in a printed recipe brochure in 2015. Brochures (30,000 copies printed), provide information about availability, buying, handling, storage, and cooking tips, as well as recipes. The premium attributes of SRV clams obtained from prior consumer acceptance studies, sensory characterizations, and nutritional profiles were also featured. In 2016, Chef Justin did a cooking demonstration and television recording for an episode of *How to Do Florida* with Chad Crawford; episode 703 aired in December, see http://howtodoflorida.com/episode/703-how-to-do-the-florida-senior-games/. In May 2016, FDACS staff hosted a booth on Anna Maria Island at the *Dine on Pine* sampling event. Cultured SRV clams were prepared by three top local chefs

and samples were distributed to event attendees, while patrons were educated on the clam. FDACS marketing staff completed artwork for various "point-of-purchase" marketing materials that were made available for distribution. Completed marketing materials included a line art illustration of the SRV clam, which is used as the logo, and 10,000 printed copies of SRV clam bag tags, ice picks, stickers, and informational posters. In addition, 3,000 take home bags for restaurant use were purchased. These materials were made available on the FDACS website, *FreshFromFlorida.com*, and the UF website. Further, samples of each item were provided to certified shellfish wholesalers in Florida. At least 10,000 consumers and seafood buyers in Florida were informed of the availability, high quality, and environmentally sustainability of a new aquaculture product through this combination of "push and pull" marketing strategies and educational activities.

Further Recommendations

Describe future plans to build on the project and to monitor project benefits to the aquaculture industry.

Hatchery producers have met with varying success, particularly outside of the natural winter spawning season, in producing SRV seed. An applied research project led by Dr. Susan Laramore, a researcher at Harbor Branch Oceanographic Institute-Florida Atlantic University (HBOI-FAU), was funded in 2015-16 by the Florida Department of Agriculture and Consumer Services (FDACS). Results provided seed producers with a guide to the annual reproductive pattern (i.e., gametogenic cycle, sex ratios) of cultured and wild SRV broodstock from the west coast of Florida. Basic information, such as changes in gonadal development that occur throughout the year in response to varying environmental conditions, numbers of ripe males and females that can potentially be expected to be available for spawning, and photo-documentation of male and female clams in these stages was included in the educational materials developed. Although seed production was not the focus of the study, some parameters for success were defined leading the project team to believe that reliable production can be achieved through optimization of maturation and conditioning protocols.

A meeting was held with industry sectors (hatchery, nurseries, and growers) from east central Florida to discuss the status of SRV culture in the Indian River Lagoon. Industry members requested assistance in addressing the lack of SRV seed. They had each made an initial investment in culturing and marketing this bivalve and needed reliable seed availability to advance their business plans. Funding was sought to support building hatchery capacity by providing the necessary infrastructure via a public-private partnership with researchers, Sea Grant specialists, and industry members to commercialize SRV seed production. This research, to be led by Dr. Laramore with HBOI-FAU, will be funded by the Florida Sea Grant College Program in 2018.

Graduates of the demonstration component of this project sought assistance from the FDACS Division of Aquaculture in developing a leasing plan that would be equitable for interested shellfish growers. Their primary concerns were being able to continue to develop SRV clam farming on a commercial scale and how to obtain leases in the general area of the demonstration site, which was managed by UF as an experimental lease through 2017. In a letter to the Division, it was suggested that an evaluation of an applicant's experience growing SRV clams

should be a consideration in the lease application process, a suitable area large enough to accommodate as many project participants should be identified, and size of potential lease parcels should be determined. In response, the Division stated that the agency intends to create a new 35-acre aquaculture use zone in the location of the former demonstration site. Further, preferential treatment would not be given in assigning leases to those with more experience, but rather lease applications would be accepted on a "first come, first served" basis. It is anticipated that the notice to growers from the Division regarding details on how to apply for a shellfish aquaculture lease at this site will be forthcoming in 2018; assistance in developing the lease application will be provided to project graduates.