LESLIE N. STURMER

ANNUAL REPORT OF ACCOMPLISHMENTS FOR 2013

SUBMITTED TO UNIVERSITY OF FLORIDA, IFAS COOPERATIVE EXTENSION SERVICE

1. BRIEF DESCRIPTION OF JOB DUTIES

The Extension Agent IV position is responsible for program design and implementation in all areas of shellfish production aquaculture for a multi-county area, including Brevard, Charlotte, Dixie, Franklin, Indian River, Lee, Levy, and Volusia Counties. Programming includes all phases of production management, such as cultural practices, seed quantity and quality, product quality, animal health, marketing, regulations, and implementation of agricultural assistance programs. Commodities include hard clams, oysters, and alternative molluscan shellfish species, such as ark and sunray venus clams. Additional programming in shellfish aquaculture through workshops and training for new growers fosters economic development in rural coastal communities. Programming in the area of water quality includes a broad range of subject matter as it relates to shellfish aquaculture, such as water quality monitoring, shellfish harvesting waters classification, restoration, and citizen stewardship. Programming in 4-H and youth education provides exposure of shellfish aquaculture activities to youth in the multi-county area through clam farming demonstrations and field days.

2. AREAS OF SPECIALIZATION

Production Aquaculture / Molluscan Shellfisheries and Restoration
Rural Economic Development / Water Quality

3. CREATIVE WORKS OR ACTIVITIES

Exhibits and displays

Sturmer, L.N. 2013. "What's in the Clam Bag?" A "hands-on" display which showcased the species diversity associated with shellfish aquaculture while providing interaction with common marine organisms. Presented at the grand opening of the *Surfing Florida and Surf Science* exhibit, Florida Museum of Natural History, Gainesville, FL. http://www.flmnh.ufl.edu/photopreview/surfingflaopening/

Sturmer, L.N. 2013. Designed a billboard featuring clam farming with the message "*Fresh from the Gulf to your Plate*" and pictures from UF IFAS. Funded by the Cedar Key Aquaculture Association and installed on State Road 24, north of Cedar Key.

Sturmer, L.N. 2013. Assisted in setting up a display highlighting the Cedar Key clam industry, Cedar Key Clams: Fishermen Farming the Sea," which was part of a UF exhibit, *Water: Discovering and Sharing Solutions*. Presented at the Sunbelt Ag Expo, Moultrie, GA.

Sturmer, L. N. 2013. "Celebrate Cedar Key Seafood," a special educational venue showcasing the community's fishing and aquaculture industries held in conjunction with the 44th Annual Seafood Festival, Cedar Key, FL. With funding from the FL Department of Agriculture and

Consumer Services' Division of Marketing, over 15,000 visitors were provided with *Fresh from Florida* promotional materials and seafood recipes. Designed colorful banners and posters, which were displayed at the City Park, where educational booths and touch tanks were featured in collaboration with the Lions Club and Fish and Wildlife Commission staff. In addition, organized culinary demonstrations with five local chefs and seafood processors, who cooked/prepared their seafood specialties for the public.

Sturmer, L. N. 2013. "Clam Farming Exhibit/Demonstration," a 10' by 20' display with multiple educational posters, which are updated annually, and a "mini" clam farm. Presented this year at the Levy County Fair, Williston, FL; Maritime Festival, World Oceans Day, Ft. Pierce, FL; and, 44th Annual Seafood Festival, Cedar Key, FL.

Instructional Multi-Media Presentations

Power Point Slide Sets

Sturmer, L.N. 2013. Clam Culture in Florida: An overview of background, status, components, and considerations for Brevard County. 58 slides.

Sturmer, L.N. 2013. Clam Culture in Florida: An overview of background, status, components, and considerations for Pinellas and Manatee Counties. 53 slides.

Sturmer, L.N. 2013. Status of the Florida Hard Clam Aquaculture Industry. 27 slides.

Sturmer, L.N. 2013. Florida Aquaculture: Organizational development. 32 slides.

Sturmer, L.N. 2013. Florida Clam Culture: An overview of background, status, components, and challenges. 70 slides.

Sturmer, L.N., Scarpa, J., Adams, C., Otwell, S., Ellis, R. and Osborne, T. 2013. Eliminating barriers to commercial production of the sunray venus clam *Macrocallista nimbosa* in Florida. 34 slides.

Sturmer, L.N., and Colson, S. 2013. Cedar Key *Everlasting*: An educational tool to inspire public appreciation for shellfish aquaculture. 32 slides.

Sturmer, L.N., Baker, S., Grogan, K., and Larkin, S. 2013. **"**Green" Clams: Assessing, Quantifying, and Promoting the Value of Ecosystems Services Provided by the Hard Clam Aquaculture Industry in Florida. 17 slides.

Sturmer, L.N., Baker, S., Grogan, K., and White, W. 2013. Evaluating the Efficacy of Several Net Coatings in Reducing Biofouling on Culture Gear and Increasing Hard Clam Production in Florida. 17 slides.

Sturmer, L.N., Ohs, C., Martinez, C., Creswell, L., and Adams, C. 2013. Florida Sea Grant Work Action Group Report for Aquaculture. 30 slides.

Sturmer, L.N. 2013. What's in the Clam Bag? 9 slides.

Sturmer, L. 2013. Overview of U.S. East Coast oyster culture operations and Florida's experiences. 33 slides.

Sturmer, L. 2013. Welcome to Clamelot: the Cedar Key story. An additional six (6) slide sets of 35-45 slides were modified for specific audiences; for example, Florida Humanities Council's Gathering, Florida Natural Resources Leadership Institute, Suwannee River Water Management District's Governing Board, Hidden Coast Paddling Festival, Florida Museum of Natural History's Science Café, Sarasota Sister Cities International Conference on "Sustainability through Renewable Energy & Aquaculture," and other groups.

Power Point Poster

Sturmer, L., Adams, C., Baker, S., Ellis, R., Osborne, T., Otwell, S. and Scarpa, J. 2013. Florida hard clam aquaculture: From business development to a sustainable industry.

Radio and TV

Sturmer, L.N. 2013. Interviewed by the WUFT-FM radio station in Gainesville on multiple occasions on the following topics: net ban, impact of tropical storm to clam culture industry, oyster fishery, and shellfish aquaculture sustainability.

Web-based Communications and Teaching

Sturmer, L. N., and Pouder, D. B (webmaster). 2013. "Online Resource Guide for Florida Shellfish Aquaculture," http://shellfish.ifas.ufl.edu/. Continued to add resource information and reformat website making it more user friendly. The site, hosted by UF/IFAS, provides information about clam farming, supplier lists, and a variety of other educational materials. Numerous state and national publications addressing shellfish aquaculture are directly accessible through this site. Also presentations and summaries of industry workshops are provided.

Knickerbocker, K., Whitehouse, J. (webmaster), and Sturmer, L. N. 2013. "CLAMMRS Weather/Water Quality Web Pages." http://sondes.floridaaquaculture.com/sondes/. Posting of "real time" water quality and weather data collected from two (2) monitoring stations at shellfish aquaculture lease areas at the Department of Agriculture and Consumer Services, Division of Aquaculture's website.

Sturmer, L. and White, W. 2013. UF Shellfish Aquaculture Extension. Facebook, https://www.facebook.com/friends/requests/?fcref=rup#!/pages/UF-Shellfish-Aquaculture-Extension/155029591271294

Other

Sturmer, L. N., Sapp, P., Zajicek, P., Norgren, K., and Walton, W. 2013. An Introduction to Intensive Oyster Culture. A DVD video documenting presentations and discussion at the September 26 workshop.

Sturmer, L. N., Supan, J., Walton, W, and suppliers. 2013. An Introduction to Oyster Culture Gear and Suppliers. A DVD video documenting presentations and discussion at the December 4 workshop.

4. PUBLICATIONS

Refereed Publications

Hargrove, J.S., **Sturmer, L.**, Scarpa, J., and Austin, J.D. 2013. Genetic Diversity in Wild and Aquaculture Populations of the Hard Clam *Mercenaria mercenaria* in Florida. In preparation.

Sturmer, L. 2014. Consumer Information Series: Hard Clams. USDA Southern Regional Aquaculture Center publication.

Non-Refereed Publications

County Fact Sheets

Sturmer, L. N. 2013. Annual Clam Seed Suppliers List. UF Levy County Extension, 1 pp.

Sturmer, L. N. 2013. Annual Clam Bag Suppliers List. UF Levy County Extension, 1 pp.

Educational Brochure

Sturmer, L. N. 2013. Hard Clam Aquaculture in Florida. Brochure on industry and extension updated annually. UF Levy County Extension, 2 pp.

Technical Papers and Reports

Sturmer, L., Scarpa, J., Adams, C., Otwell, S., Ellis, R., Osborne, T., and Creswell, L. 2013. Eliminating barriers to commercial culture of the sunray venus clam in Florida. Final report to Florida Sea Grant College Program, Project # R/LR-A-46A, submitted electronically via Online Activity Reporting System (OARS).

Sturmer, L., Petty, B. D., Creswell, R.L., Ellis, L.R., Osborne, T.Z., Scarpa, J., and Encomio, V. 2013. Enhancing Florida Hard Clam Production through Broodstock Development, Improved Harvest Practices, and Species Diversification. Final CRIS report to USDA NIFA, submitted electronically.

Baker, S., Scarpa, J., and **Sturmer, L.N.** 2013. Preparing for Climate Change: Increasing Hard Clam Production and Survival in the Southeastern United States Using Biomarkers of Thermal Tolerance. Interim report to Florida Sea Grant College Program, Project # R/LR-A-47A, submitted electronically via OARS.

Sturmer, L., Ellis, L.R., Osborne, T.Z., and White, W. 2013. Advancement of Sunray Venus Clam *Macrocallista nimbosa* Aquaculture through Evaluation of Alternative Growout and Harvesting Methods. Quarterly reports submitted to Florida Department of Agriculture and Consumer Services, Division of Aquaculture, Contract #00089910.

Sturmer, L., and Colson, S. 2013. Cedar Key Everlasting. Final report to the Florida Humanities Council, Mini-grant program, Grant # GR_0112_3764_2260.

Newsletter Edited

Sturmer, L. N. (contributor). 2013. *Ebb and Flow*. Florida Sea Grant Extension Newsletter, "Cedar Key *Everlasting* promotes shellfish aquaculture industry" Vol. 4(1):3; "New horseshoe crab display in Cedar Key," Vol. 4(2):4.

Sturmer, L. N. (contributor). 2013. *Florida Aquaculture Association Newsletter.* "Cedar Key *Everlasting* promotes shellfish aquaculture industry," "Clam Suppliers Lists," "Shellfish Aquaculture Industry Workshop Announcements," Winter, Spring, Summer issues.

Sturmer, L. N. (contributor). 2013. *WaterWorks*. Newsletter of the UF SFRC Fisheries and Aquatic Sciences Newsletter, Summer.

Newspaper Articles

Sturmer, L. N. 2013. Over six articles written for the local weekly newspapers (Cedar Key Beacon [circulation 1,000], Cedar Key News [circulation 1,500]), Dixie County Advocate [circulation 5,000]) on the status of the clam farming industry, shellfish restoration, workshop and meeting announcements, or other projects, such as Coastal Cleanup.

Sturmer, L. N. 2013. Contributed to two articles in The Gainesville Sun (daily circulation, 43,000) on clam farming in Cedar Key.

Trade Journal Articles

Sturmer, L. 2013. Shellfish aquaculture: Florida hard clam farming industry a unique success story. Fish Farming News 20(5):17-19. http://fish-news.com/ffn/

Stephenson, F. and **Sturmer, L.** 2013. Saving Cedar Key. Explore: Research at the University of Florida 18(1): 23-26. http://research.ufl.edu/publications/exploremagazine/spring-2013/saving-cedar-key.html

Abstracts

Sturmer, L.N. and Colson, S. 2013. Cedar Key *Everlasting*: An educational tool to inspire appreciation by the public for shellfish aquaculture. Aquaculture 2013 Conference Proceedings: 454. https://www.was.org/meetingabstracts/ShowAbstract.aspx?Id=28826

Sturmer, L.N., Scarpa, J., Adams, C., Otwell, S., Ellis, L.R., and Osborne, T. 2013. Eliminating barriers to production of the sunray venus clam *Macrocallista nimbosa* in Florida. Aquaculture 2013 Conference Proceedings: 456. https://www.was.org/meetingabstracts/ShowAbstract.aspx?Id=28828

Sturmer, L., Adams, C., Baker, S., Ellis, R., Osborne, T., Otwell, S. and Scarpa, J. 2013. Florida hard clam aquaculture: From business development to a sustainable industry. Sustaining Economics and Natural Resources in a Changing World: Key Role of Land Grant Universities, Symposium Poster Abstracts. https://www.certain.com/system/accounts/register123/uofflaifas/events/events/201322a/userfiles/Abstract_Sturmer_03.08.13.docx

Scarpa, J., Baker, S.M., **Sturmer, L.N.**, and Krebs, W. 2013. Preparing for climate change: Increasing hard clam survival in Florida using biomarkers of thermal tolerance. Aquaculture 2013 Conference Proceedings: 185. https://www.was.org/meetingabstracts/ShowAbstract.aspx?Id=28558

5. LECTURES, SPEECHES OR POSTERS PRESENTED AT PROFESSIONAL CONFERENCES/MEETINGS

International

Invited

Sturmer, L.N. (co-presenter), and Colson, S. Cedar Key *Everlasting*: An educational tool to inspire appreciation by the public for shellfish aquaculture. Aquaculture 2013, World Aquaculture Society Triennial Conference, Nashville, TN, 21-25 February 2013.

Selected

Sturmer, L.N. (co-presenter), Scarpa, J., Adams, C., Otwell, S., Ellis, R. and Osborne, T. Eliminating barriers to commercial production of the sunray venus clam *Macrocallista nimbosa* in Florida. Aquaculture 2013, World Aquaculture Society Triennial Conference, Nashville, TN, 21-25 February 2013.

Scarpa, J., Baker, S.M., Sturmer, L.N. (co-presenter), and Krebs, W. Preparing for climate change: Increasing hard clam survival in Florida using biomarkers of thermal tolerance. Aquaculture 2013, World Aquaculture Society Triennial Conference, Nashville, TN, 21-25 February 2013.

Regional

Invited

Sturmer, L.N. (presenter) Florida Aquaculture: Organizational development. 4th Annual South Carolina Seafood Summit, Charleston, SC, 19 March 2013.

Sturmer, L.N. (presenter). Florida Clam Culture: An overview of background, status, components, and challenges. 4th Annual South Carolina Seafood Summit, Charleston, SC, 19 March 2013.

Sturmer, L. (presenter). Florida Shellfish Aquaculture. Sarasota Sister Cities International Conference on "Sustainability through Renewable Energy & Aquaculture," Sarasota, FL, 15 November 2013.

State

Invited

Sturmer, L.N. (presenter). Clam Culture in Florida: An overview of background, status, components, and considerations for Brevard County. Introduction to Aquaculture Workshop, Cocoa, 4 February 2013.

Sturmer, L.N. (presenter). Clam Culture in Florida: An overview of background, status, components, and considerations for Pinellas and Manatee Counties. Introduction to Aquaculture Workshop, St. Petersburg, 12 June 2013.

Sturmer, L.N. (presenter). Status of the Florida Hard Clam Aquaculture Industry. Florida Senate Agriculture and Natural Resources Committee, Tallahassee, 13 March 2013.

Sturmer, L. (presenter). Welcome to Clamelot: the Cedar Key story. Florida Humanities Council's Gathering, Cedar Key, 16 March 2013.

Sturmer, L. (presenter). Welcome to Clamelot: the Cedar Key story. Florida Natural Resources Leadership Institute, Cedar Key, 13 September 2013.

Sturmer, L.N. (presenter). What's in the Clam Bag? Florida Sea Grant Annual Extension Faculty Meeting, Cedar Key, 24 September 2013.

Sturmer, L. (presenter). Overview of U.S. East Coast oyster culture operations and Florida's experiences. Introduction to Intensive Oyster Culture Workshops, St. Teresa and Cedar Key, 26-27 September 2013.

Sturmer, L.N. (co-presenter), and Colson, S. Cedar Key *Everlasting*: An educational tool to inspire public appreciation for shellfish aquaculture. Florida Humanities Council's Gathering, Cedar Key, 15 March 2013.

Sturmer, L.N. (co-presenter), Baker, S., Grogan, K., and Larkin, S. **"**Green" Clams: Assessing, Quantifying, and Promoting the Value of Ecosystems Services Provided by the Hard Clam Aquaculture Industry in Florida. FDACS Aquaculture Review Council, Winter Haven, 26 June 2013.

Sturmer, L.N. (co-presenter), Baker, S., Grogan, K., and White, W. Evaluating the Efficacy of Several Net Coatings in Reducing Biofouling on Culture Gear and Increasing Hard Clam Production in Florida. FDACS Aquaculture Review Council, Winter Haven, 26 June 2013.

Sturmer, L.N. (co-presenter), Ohs, C., Martinez, C., Creswell, L., and Adams, C. Work Action Group Report for Aquaculture. Florida Sea Grant Annual Extension Faculty Meeting, Cedar Key, 24 September 2013.

Selected

Sturmer, L. (co-presenter), Adams, C., Baker, S., Ellis, R., Osborne, T., Otwell, S. and Scarpa, J. Florida hard clam aquaculture: From business development to a sustainable industry. Sustaining Economics and Natural Resources in a Changing World: Key Role of Land Grant Universities, University of Florida, Gainesville, 2-3 April 2013.

Scarpa, J., Baker, S.M, and Sturmer, L.N. (co-presenter). Climate change issues for clam aquaculture in the Indian River Lagoon. 2013 Indian River Lagoon Symposium, Ft. Pierce, 7 February 2013.

Baker, S.M., Sturmer, L.N. (co-presenter), and Scarpa, J. Breeding a better clam: Preparing the Florida hard clam aquaculture industry for climate change. University of Florida Marine Biology Symposium, Whitney Laboratory for Marine Bioscience, Marineland, 17-18 January 2013.

Local

Invited

Sturmer, L. (presenter). Clamelot: the Cedar Key story. Hidden Coast Paddling Festival, Cedar Key, 5 October 2013.

Sturmer, L. (presenter). Farming the Sea: the Cedar Key story. Florida Museum of Natural History's Science Café, Gainesville, 28 October 2013. http://www.flmnh.ufl.edu/calendar/grid/science-cafe-farming-sea/

EXTENSION PROGRAMS

Role and Activities of Advisory Committee

My advisory committee is made up of members of the Statewide Clam Industry Task Force which consists of representatives from each clam producing area of the state, as well as the various business sectors (e.g., grower, wholesaler, seed supplier). Extension is an agenda item at each meeting, as well as numerous conference calls, allowing for timely reporting of activities and industry input. In addition, I receive ongoing input from the Board of Directors of the Cedar Key Aquaculture Association. Extension is a routine agenda item at their monthly board meetings and general membership meetings.

Titles of Programs

Programming includes all phases of production management, such as cultural practices, seed quantity and quality, product quality, animal health, marketing, regulations, and implementation of agricultural assistance programs. Commodities include hard clams, oysters, and alternative molluscan shellfish species, such as ark and sunray venus clams. Programming in the area of water quality includes a broad range of subject matter as it relates to shellfish aquaculture, such as water quality monitoring, shellfish harvesting waters classification, restoration, and citizen stewardship.

	Program title
I.	Sustainable Hard Clam Aquaculture Production
II.	Statewide Shellfish Aquaculture Extension Support: An Industry Approach
III.	Genetic Issues in Hard Clam Culture
IV.	Evaluation of Alternative Bivalve Species for Aquaculture
V.	Awareness of the Clam Aquaculture Industry in Florida
VI.	Gulf Awareness, Restoration and Enhancement
VII.	Youth Education in Shellfish Aquaculture

I. SUSTAINABLE HARD CLAM AQUACULTURE PRODUCTION

Situation

Situation statement: During the 1990s successful job retraining programs placed hundreds of former fishermen impacted by regulatory closures into shellfish aquaculture businesses. Production of hard clams has increased from 9 million (41 growers) in 1991 to 136 million (over 300 growers) in 2012. In the first aquaculture census conducted by the U.S. Department of Agriculture in 1998, Florida was

identified as a leading producer of clams in the nation. Efforts must be placed on other aspects than growout production technology in support of this rapidly growing industry. Emphasis on product quality, water quality, health, marketing, and risk management should be integrated into a total management plan to allow for advancement of farming practices and sustainable production. A new emphasis has been placed on the role of aqueous soils in bivalve aquaculture and how management practices can be refined using a soils-based approach.

Target audience(s): Shellfish aquaculture industry, including seed suppliers, growers, and wholesalers, and resource managers

Program Objectives

1. At least 25% of the clam seed suppliers and growers to make timely and informed decisions on management practices through utilization of continuous water quality data.
2. At least 25% of the clam growers and shellfish wholesalers to be informed of alternative marketing strategies, promotional efforts, product quality standards, economic and environmental impacts, or sustainability programs.
3. At least 10% of the clam growers to refine management practices, such as bottom planting and harvesting, based on studies determining effects of farming activities on aqueous soil properties.
4. At least 25% of the clam growers to be informed of the performance of net coatings in reducing biofouling on clam culture gear.
5. At least 25% of clam growers to be made aware of federal financial and crop disaster assistance programs and 25% of insurance specialists to better understand the risks to clam crops.

Educational Methods and Activities

Objective 1

- Operation of water quality monitoring equipment at two lease areas in Levy County was continued through an informal partnership agreement with FDACS and grower volunteers to deploy and retrieve equipment. Additional funds have not been solicited to expand this monitoring program to other lease areas. Refurbishing of equipment was supported through other grants in which the water quality data was utilized for field trials.
- Resulting "real-time" data was posted to web pages established at the DACS Division of Aquaculture's website, http://sondes.floridaaquaculture.com/sondes/.
- Water quality data were corrected using quality control protocols previously developed. "Farmer-friendly" monthly graphs were created for selected parameters per station, archived, and posted to the website, http://shellfish.ifas.ufl.edu.
- Participated in 28 office visits, telephone conversations, and e-mail discussions with clam farmers and crop insurance agents for the purpose of providing archived data and information on how to access and interpret the water quality values.
- Distributed on 21 occasions EDIS publications on the effects of temperature, salinity, and dissolved oxygen on hard clam production. These three fact sheets were provided to growers upon request as well as received 4,713 hits on the UF IFAS Solutions for Your Life website.

Objective 2

- Worked with the seafood technology specialist (Otwell) in developing an educational program

for shellfish (both oyster and clam) harvesters per a recent mandate through the Interstate Shellfish Sanitation Conference. The program delivery is based on a new software program *Storyline* by Articulate. Reviewed several draft versions as well as field tested the beta version with several clam industry members. Once completed, the program will be delivered by handouts, presentations, and innovative touch-screen training stations, one of which will be located at my office.

- Upon request of the Clam Industry Task Force, worked with the marine economist specialist (Adams) in conducting an economic impact of the cultured clam industry. The most recent (2007) assessment of the total economic activities associated with hard clam culture indicated that the industry generated $53 million in economic impact to Florida. This finding suggested a significant increase from the economic impact of $34 million estimated in 1999. A more current estimate is now needed to better assess the economic values generated by this important sector of the Florida aquaculture industry. To do so, a list of certified shellfish wholesalers who handled cultured clams in 2012 was generated. A modified version of the survey instrument utilized in the prior studies was mailed to 70 firms. Follow-up phone calls were made to assist in the survey implementation and data collection process. Currently, 87% of the wholesalers surveyed have responded.
- Worked with SFRC Fisheries Program faculty (Shirley Baker) and FRED faculty (Sherry Larkin, Kelly Grogan) in submitting upon request by the Aquaculture Review Council (ARC) a full proposal to FDACS for consideration of funding in 2014. Also gave a presentation to the ARC describing the proposal, entitled "Green Clams: Assessing, Quantifying, and Promoting the Value of Ecosystems Services Provided by the Hard Clam Aquaculture Industry in Florida." The goal of the proposed project is to quantify the economic value of ecosystem services provided by bivalve culture by determining the net carbon and nitrogen sequestration and water clearance activities of clam farms. The proposal was ranked 10^{th} by the ARC.
- A magazine-style publication, entitled *Cedar Key Everlasting*, was produced last year to educate the public through a series of essays on the environmental, economic, and sociological benefits of clam farming in Cedar Key. Upon request of organizers of a special session on working waterfronts at Aquaculture 2013, gave a presentation to over 100 session attendees on this project and how the magazine is used as an educational tool to inspire public appreciation for shellfish aquaculture. Also gave the same presentation at a Florida Humanities Council (FHC) Gathering, in which 35 participants attended a 3-day cultural heritage session in Cedar Key. The FHC assisted in providing funding for printing the magazine. A final report for the mini-grant was submitted to FHC.

Objective 3

- At industry's request and with approval from the FDACS Division of Aquaculture, who regulates activities on state-owned submerged lands, initiated a pilot project with SWS faculty (Ellis, Osborne) and funding by Florida Sea Grant Program Development to test the utility of mechanical harvesting in shellfish aquaculture and evaluate the effects of using a pump-driven "box" harvester in recovering bottom-planted clams versus harvesting clams cultured in bottom bags. Currently, a special lease provision limits the use of mechanical harvesters.
- Large hard clam seed (about 30,000; 33 mm in shell length), obtained from a genetics study, were bottom planted in triplicate under cover nets (8' x 10', 80 ft^2) and in growout bags (3 rows of 5 bags each, 16 ft^2 per bag, 80 ft^2 per row) at commercial densities on the UF experimental lease in winter. Harvesting of replicated plants occurred this summer. A pump-driven, modified "box" harvester was tested on the bottom-planted clams. At harvest, production characteristics for each culture unit were measured. Product quality of harvested clams was also assessed to determine the effects of both culture and harvest methods on shell breakage and shelf life (survival of shellstock in

refrigerated storage). A Before-After, Control-Impact, Paired sampling design was employed to examine effects of culture methods and harvesting practices on various parameters, and to differentiate natural changes from those caused by harvesting. Water quality, including turbidity, dissolved oxygen, water temperature, and salinity, were measured continuously 48 hours prior to harvest, during harvest, and 48 hours post-harvest using YSI sondes to assess short-term impacts to the water column. Subaqueous soils were sampled prior to planting, then repeatedly post harvest at time = 0, 14, and 28 days to evaluate soil properties (organic matter content, soil particle size distribution, bulk density) and changes in soil elevations.

- A biological scientist, partially funded through the grant, has begun statistical comparisons utilizing established repeated measures tests to evaluate between before and after treatment, as well as determinate the temporal aspect of recovery.
- In addition, a full proposal submitted to FDACS for an expanded study to determine the effects of alternative culture methods (bottom planting) and harvesting methods (modified "box" harvester) with the sunray venus clam was funded by the 2013 Florida legislative session.
- Harvesting of replicated bottom plants and bags of sunray venus clams planted in a prior Florida Sea Grant-funded project recently began.

Objective 4

- Biofouling is a major impediment in all areas of aquaculture, including clam farming. Fouling organisms, such as tunicates or "sea squirts," can compete with clams for resources, impede harvesting efforts, and intensify equipment upkeep. Two commercial companies either provided coatings or coated clam bags provided to them to test the anti-fouling properties under commercial conditions at the UF experimental lease. Two treatments (photo-active release coating, silicone-based) were compared to uncoated clam bags (control) and a standard alkyd-based coating used by industry, which has no antifouling properties.
- The replicated (n=4) plants were harvested; at which time, production parameters (survival and growth) and biofouling coverage was assessed. Immediately after harvest, area coverage of fouling organisms on each clam bag replicate was estimated. Clam bags were weighed, then placed on trays for an hour to allow any excess water to drain, and weighed again. Using weights of the clam bag treatments prior to deployment, the weight of the fouling organisms per treatment was determined.
- At a professional conference, met with researchers who are developing a biocide-free antifouling coating that contains block copolymers whose structures and amphiphilicity hinder adhesion of fouling organisms. Provided polyester net pieces for researchers to coat and placed on PVC racks at the UF experimental site during the summer to observe and compare with untreated pieces of netting. Unfortunately, strong winds associated with a tropical storm resulted in the racks being overturned and affected the study.
- Worked with FRED faculty (Kelly Grogan) in submitting upon request by the Aquaculture Review Council (ARC) a full proposal to FDACS for consideration of funding in 2014. Also gave a presentation to the ARC describing the proposal, entitled "Evaluating the Efficacy of Several Net Coatings in Reducing Biofouling on Culture Gear and Increasing Hard Clam Production in Florida**.**" The goal of the proposed project is to evaluate biocide-free, foul-inhibiting coatings under commercial conditions to determine if biofouling on bottom bags can be reduced and, in turn, if hard clam production can be increased. This will be achieved by working with growers at a minimum of three shellfish aquaculture leases areas, determining production performance of clams cultured in bags treated with net coatings versus untreated bags, assessing and comparing biofouling levels on culture bags, documenting the effort associated with bag maintenance (after harvest), and conducting

a cost-benefit analysis. The proposal was ranked 1st by the ARC.

Objective 5

- Kept clam growers informed of important dates regarding when to sign-up for crop disaster assistance programs (e.g., NAP and pilot crop insurance) and program revisions through industry meetings, office visits, and email blasts.
- On nine occasions met with growers, insurance providers, and loss adjusters to review various crop losses and policy provisions associated with a pilot crop insurance program.
- Provided information to the USDA Risk Management Agency and Farm Service Agency (FSA) representatives on clam prices, current market supply and demand, and other information (e.g., acceptable crop survival rates) to use in adjusting actuarial values for the upcoming crop year. Also began worked with RMA regional staff in considering other insurance options for clam growers.

Outcomes and Impacts

Objective 1

- Water quality monitoring stations provided timely, continuous information on water temperature, salinity, dissolved oxygen, and turbidity to clam growers in Cedar Key and seed suppliers, allowing them to make informed management decisions.
- Over 33% of the clam growers in Levy County, or about 50 growers, accessed water quality data either by viewing online or visiting the extension office. With this information, clam growers have refined and improved management practices, compared crop losses with water quality events, and identified trends in environmental conditions critical to clam health and production. For example, this summer Tropical Storm Andrea resulted in coastal flooding in Levy and Dixie Counties. Growers were able to use salinity and water temperature information in planning when to nurse, plant, or transfer seed to minimize losses associated with low salinities.
- Mortalities of adult "marketable" clams at several lease areas in Levy and Dixie Counties occurred during the summer and were associated with low salinities. Growers and insurance adjusters were provided with archived water quality data as part of the claims process in documenting crops losses. Over $200,000 in indemnity payments have been made this year to affected growers enrolled in the pilot clam crop insurance program. By associating clam crop mortalities with water quality events, substantive evidence was provided to insurance agents and loss adjustors.
- A counter on the FDACS web pages, http://sondes.floridaaquaculture.com/sondes/, where the "real-time" water quality information is posted recorded 6,746 visits and 9,058 views, indicating this information was being accessed.
- The UF website, http://shellfish.ifas.ufl.edu, provided access to archived water quality data electronically as well as to interpretative materials; the online resource guide provided utilitarian and accurate information for growers. According to the IFAS web statistics, page views for archived water quality data were 3,189.

Objective 2

- The intent of the educational program for shellfish harvesters is to upgrade the minimal standards for compliance by incorporating advanced, voluntary actions by the industry, which may result in special recognition, reduced inspections and liability, and increased promotional status.

- The economic survey will solicit data on numbers of clams purchased, grower price paid, source of product supply, wholesale price received, type of buyer, destination of sales, and other related information. These data can then be utilized to generate economic impact assessments for the cultured clam industry. The study builds on previous studies and will provide a more timely assessment of the numbers of clams sold, grower sales, wholesale sales, pricing, product destination, economic impacts, associated jobs, business taxes generated and other measures that emanate from the commercial hard clam industry in Florida.
- To continue to inform visitors and new residents of Cedar Key and inspire them to appreciate the community's aquaculture and fishing industries, over 5000 copies of *Cedar Key Everlasting* were distributed to real estate agencies, condo owners, rental management businesses, lodgings, builders, and the local chamber of commerce and tourism bureau. The publication has become an educational tool to inform many others, whether it is local, state or federal agency representatives, government officials, legislators, or others, about the clam farming industry. The local bank included a copy in their "welcome" basket given to all new accounts. Copies were provided to graduating seniors at Cedar Key High School. There have been many "unintended" uses of this publication; for example, the owners of a large tract of private land in Levy County, which has been designated a Florida Forever project, used the publication in their continued land preservation efforts.
- The *Cedar Key Everlasting* publication continued to be distributed to clam wholesalers, distributors, and retailers and used as a marketing tool. Five (5) local shellfish wholesalers, or 25% of the industry sector in Cedar Key, incorporated information on the environmental, economic, and sociological benefits of shellfish aquaculture in their ongoing promotional materials or marketing campaigns.

Objective 3

- Preliminary data analyses revealed that shell measurements and total weight of clams harvested from the bottom plants (26 mm width, 49 mm length, 37 g weight) were significantly greater than clams cultured in bags (24 mm width, 47 mm length, 33 g weight). Survival was higher for clams cultured in bags (95%) but not significantly different from clams cultured under bottom nets (82%). The average number of broken clams was <1% for each harvest treatment.
- The water quality parameter of most concern in these harvesting trials is turbidity. Turbidity values recorded at a sonde located five feet down current from the bottom net replicates averaged 64 $\pm$ 30 NTU over a 54-minute harvest period with a maximum value recorded of 185 NTU. The average turbidity recorded during the 14 minutes of harvesting the five-bag replicates was 85 $\pm$105 NTU with a maximum value recorded of 389 NTU. Both harvesting methods resulted in pulse disturbances that were short-lived and returned to background levels of around 50 NTU immediately after harvesting terminated. Other water quality measurements and soil characteristics are still being analyzed.
- Preliminary findings in the FSG-funded project were also used in identifying additional data needed and refining procedures to be used in the current FDACS ARC study.
- The prohibition of mechanical harvesting on shellfish aquaculture leases has clam growers limited to manual methods (hand raking) if they use bottom planting culture methods. This is not commercially viable or acceptable to the industry. The ongoing work focuses on eliminating regulatory barriers to production that serve as constraints to establishing alternative growout (bottom plant) and harvesting technologies for the hard clam and other potential bivalve species, such as the sunray venus clam.

- If mechanical harvesting is found to be similar or less disruptive to sediments in lease areas as harvesting bottom bags, then a different culture method for hard clams and other bivalve species would be available to the industry. If bottom planting is adopted by industry, then the culture of species that are not amenable to bag culture, such as the sunray venus clam, will be made possible.

Objective 4

- Results from a preliminary evaluation of two biocide-free, foul-release coatings on hard clam production in a field trial conducted at the UF experimental lease were encouraging. Survival was similar among all treatments ranging from 72% in silicone coated bags to 82% in the uncoated bags. However, growth (width, length, total weight) of clams reared in silicone coated bags (average total weight, 55 g) was significantly greater than clams reared in the photo-active release coated bags (40 g) and control bags (37-42 g). In turn, production was also significantly greater in the silicone coated bags (47 kg/bag) versus photo-active release coated bags (37 kg/bag) and control bags (36-41 kg/bag).
- Average total biofouling weight on the control (uncoated) bags (4.4 kg) was significantly greater than biofouling weight on the silicone coated bags (2.3 kg) and photo-active release coated bags (2.5 kg), but not for the alkyd-based coated bags (4.0 kg). Macroalgae (*Gracileria* and *Ulva* spp.) accounted for 9% of the fouling weight in the silicone coated bags and up to 45% of the biofouling weight in the alkyd-based coated bags.
- The performance of both biocide-free, foul-release coatings in the preliminary study warrants further evaluation of their application at multiple commercial hard clam aquaculture lease areas. Further, a cost-benefit analysis to compare potential benefits (higher clam yields, increased dockside value due to larger clams, lower maintenance costs in terms of man-power) with the costs of the coating application is necessary before growers can make informed decisions about incorporating antifouling net coatings into their management practices.

Objective 5

- By providing information to growers, USDA agency representatives, and insurance specialists, contributed to a risk management program for the clam farming industry in the event of catastrophic losses, and, ultimately, adoption of a permanent viable program to benefit shellfish aquaculture.

Success Story

Copies of the *Cedar Key Everlasting* magazine placed in condominium units (over 300) included evaluation forms in an effort to capture responses of the intended audiences. Unfortunately, not many completed forms have been returned. Those that were confirmed that the objectives of the publication were indeed being met. Responses came from visitors from Georgia, Connecticut, Indiana, Ohio, Oregon, New York, and Florida. All responded "yes" when asked if they knew more about a working waterfront community after reading the publication. Many shared their thoughts on what they learned about the benefits of the clam farming industry and what it may mean to be a good neighbor. Some examples were: "We think it’s wonderful how conscience you are of maintaining a healthy environment for futures to come." "Impressed with the community's recycling and for their care." "Eat more clams!" and "RESPECT." Further, one of the projected outcomes of this project was to inform the public on how one may contribute to keeping the area’s coastal waters and environment clean, which is necessary for continued growth and success of the water-dependent industries. These responses indicate the educational messages were heeded.

For a final report to the Florida Humanities Council on the *Cedar Key Everlasting* publication, I asked the Levy County Visitors Bureau to comment on the distribution and value of

the magazine in supporting their mission. The bureau's executive director responded with a letter, which was included in the report package. Following is an excerpt from that letter, "The *Cedar Key Everlasting* Magazine is an inspiring documentary of what was, is and what the future holds for the clam industry and the 200 year old fishing village of Cedar Key. It is an amazing piece of collateral that speaks well of our ecological area. The magazine assist us in many ways by setting the standard for how our waters, land and peoples live in harmony, thus producing a pristine place where visitors can come and learn about nature, biology and the circle of life. Our office values these publications as being a wonderful way of getting the message out that we are one of the best places in Florida to come and experience eco-tourism because we have a bright star like the aquaculture industry that visitors can truly experience."

II. STATEWIDE SHELLFISH AQUACULTURE EXTENSION PROGRAMMING: AN INDUSTRY APPROACH

Situation

Situation statement: The hard clam aquaculture industry supports over 600 small businesses with shellfish aquaculture leases and upland support businesses located in 12 coastal counties throughout Florida. Prior to 2000, programming efforts in support of this emergent industry were limited to the Big Bend area. There was a need to expand industry interaction to other coastal regions of Florida - east central, southwest, and the Panhandle. Interest in this industry is also developing in new areas and lease expansions are being considered in selected counties. Programmatic efforts are now addressing the overall industry needs, not just those from a geographical perspective. In doing so, comprehensive extension activities are industry focused. Further, this year worked in developing and implementing an UF IFAS aquaculture initiative in partnership with the shellfish culture industries to increase commercial production, create additional jobs, provide locally-produced food, restore coastal marine populations and habitats, and improve water quality.

Target audience(s): Shellfish aquaculture industry members statewide, new farmers, county marine agents, and interested citizens

Program Objectives

1. To develop and present current and timely educational information to the statewide industry and public so they may be able to make informed decisions regarding clam aquaculture.
2. To maintain a network within those counties where clam farming is ongoing by working with county marine agents.
3. To provide 75% of the new growers and those interested in the prospects of clam farming with technical support and assistance so they may be able to make informed decisions as they initiate their businesses.
4. To foster and support organizational efforts of the shellfish aquaculture industry.
5. To develop and implement a state initiative to address factors that stand in the way of shellfish aquaculture and restoration efforts, and to expand UF’s research and extension commitment to the aquaculture industry.

Educational Methods and Activities

Objective 1

- Continued to post new information to my renovated website, "The Online Resource Guide for Florida Shellfish Aquaculture in Florida," http://shellfish.ifas.ufl.edu. This site provides information about clam farming and related activities for the general public, growers, and others involved in shellfish.
- Continued posting information to the UF Shellfish Aquaculture Extension Facebook page, https://www.facebook.com/friends/requests/?fcref=rup#!/pages/UF-Shellfish-Aquaculture-Extension/155029591271294.
- Compiled annual fact sheets, listing current sources of clam seed, equipment suppliers, and wholesalers, and published online.
- Updated an annual brochure with current information about hard clam aquaculture in Florida and the shellfish extension program, which was distributed at county extension offices, festivals, chamber of commerce offices, and other locations.

Objective 2

- Continued to serve as co-group leader of the Florida Sea Grant (FSG) Aquaculture Work Action Group. Hosted and participated in the FSG annual extension faculty meeting held this year in Cedar Key. Provided presentations on aquaculture activities, conducted industry tours, and held a clam bake for 42 marine agents, specialists, and staff. Also submitted reports highlighting activities to FSG via their *Ebb and Flow* Newsletter.
- Continued participating in the School of Forest Resources and Conservation (SFRC) extension committee. Submitted a report of extension activities to SFRC.
- Worked with the following marine agents on shellfish activities within their counties:
    - Betty Staugler in Charlotte County and Joy Hazell in Lee County on highlighting their area's seafood (with a focus on cultured shellfish) culinary attributes for visiting travel writers.
    - Geoff Wallat in Taylor County on developing bay scallop programs and Restore Act projects,
    - Bill Mahan in Franklin County on clam aquaculture in Alligator Harbor and oyster culture interests in Apalachicola,
    - Chris Verlinda in Santa Rosa County on oyster-related questions, and
    - LeRoy Creswell in St. Lucie County on shellfish aquaculture and restoration efforts.

Objective 3

- Provided information on the biological, economical, marketing, and regulatory aspects of clam farming to five people interested in the prospects of this small business.
- Assisted eight people in transferring aquaculture leases and acquiring their aquaculture certifications through DACS. In addition, provided on over 20 occasions to individuals the forms and information on how they may obtain an authorized user agreement through DACS.
- Taught in two "Introduction to Aquaculture" workshops held at the Brevard County extension office in Cocoa and the Weedon Island Preserve in St. Petersburg, during which over 80 people attended the day-long sessions where they learned about opportunities in aquaculture. I presented current information on clam farming activities in the Indian River and Tampa Bay water bodies, and as well as the pros and cons of entering the business, and discussed resources available.

Objective 4

- Provided support and served as an advisor to the following local, state, and regional growers associations and organizations:

a) Cedar Key Aquaculture Association (CKAA) – Participated in nine (9) monthly board of directors meetings and one general membership meeting of this local growers organization. Meeting agendas included a section for extension reporting and updates and minutes for each meeting were compiled. Provided technical assistance to several committees, for example, water quality, promotion, and regulation. This year assisted the organization in developing recommendations to the Department of Agriculture and Consumer Services (DACS) regarding lease expansion in the county, as well as assisted in the operation of the local boat ramp and parking lot for clammers, and participation in community events.

b) Statewide Clam Industry Task Force (CITF) – Participated as an ex-officio member at two meetings, during which 12 industry representatives addressed key issues. The meeting agenda included an item for reporting and input of extension activities.

c) Florida Aquaculture Association (FAA) – Participated as an ex-officio member at three board of directors meetings of this state growers organization. Served on the educational committee, assisted in organizing a reception in Tallahassee for the state legislature, and reviewed proposals for an educational grant program for secondary schools to augment their aquaculture programs.

d) East Coast Shellfish Growers Association – Served as the Florida representative for this regional growers' organization and presented industry updates via their newsletter.

e) Florida Farm Bureau – Served as an ex-officio member and representative of the shellfish aquaculture industry on their aquaculture advisory committee. Provided input into the Bureau's annual policies for aquaculture.

f) National Shellfisheries Association – Began serving as a member-at-large director of this national organization for the term 2013-16.

- Working through these local and state organizations, continued to respond to the DACS Division of Aquaculture initiative for lease expansion in the state. Participated in meetings with DACS staff and members of the CITF and CKAA to discuss considerations and make recommendations. Provided information to the Levy County Board of County Commissioners, state legislative delegation, and congressional representative on the status of the clam farming industry.

Objective 5

- Worked with the IFAS VP office, School of Forest Resources and Conservation (SFRC) director, and SFRC Fisheries and Aquatic Sciences program chair in developing the rationale and needs for an aquaculture legislative budget request.
- Upon request, provided pertinent information to the IFAS lobbyist during the 2013 Florida legislative session.
- Informed industry groups, e.g., FAA, CKAA, about this request as growers were instrumental in contacting their legislative delegation. Both organizations supported a lobbyist in this effort.
- Assisted SFRC director and FAS chair in developing personnel and operating budgets as well as worked with staff in setting up the fiscal administration.
- Developed faculty position descriptions (assistant professor, biological scientist) for approval and identified a search and screen committee. Also identified advertising venues to announce job positions.
- Currently, serving on search and screen committee in reviewing applicants for the new tenure-track faculty position.

Outcomes and Impacts

Objective 1

- All members of the clam farming community in Florida were provided with information on current culture practices and information on new issues affecting their industry through access to electronic documents via a website and through personal communication via phone calls, e-mails, or office visits.
- According to IFAS web statistics, the total hits reported for my website this year was 372,926 (38,760 total sessions), suggesting that information posted to the site is being utilized.

Objective 2

- A network has continued to be established in counties where clam farming occurs by working with six county marine agents. This network strengthens the interaction between extension and the clam aquaculture industry by providing a "local" contact as well as providing resources to the agents and their clientele.
    - For example, the information, PPT presentations, handouts and sunray venus clams provided to Staugler and Hazell for their culinary tours resulted in 16 outdoor writers "strongly agreeing" that the program increased their awareness of the region's local seafood industry, enhanced their understanding of how the aquaculture industry is operated in the state, and shellfish aquaculture's role in maintaining estuary health. Participants were also asked to complete a consumer evaluation of the sunray venus clams as part of an ongoing UF market research project. Overall, results were very favorable with all respondents ranking the sunray venus clams good to excellent in appearance, taste, texture and tenderness. Favorable reviews were also posted on several foodwriters' blog sites: http://www.solotravelgirl.com/sunrayvenusclams/?utm_source=rss&utm_medium=rss&utm_campaign=rss; http://blog.ronagindin.com/2013/01/13/punta-gorda-on-a-plate.aspx

Objective 3

- Of the 32 individuals who attended the Brevard County workshop, 23, or 72%, completed an evaluation. Of these, their responses follow:
    - Overall, all were moderately satisfied (average response of 6.4) with the workshop, based on a scale of 1 (extremely dissatisfied) to 7 (extremely satisfied).
    - Of these, the average knowledge before the workshop on the topic of shellfish aquaculture was little (average response of 1.8), whereas after the workshop knowledge gained was increased (average response of 3.1), based on a scale of 1 (no knowledge) to 4 (a lot of knowledge).
    - Some of the comments included: "Overall a very good presentation. I feel like we learned several things about many topics." "This was much more than I imagined it would be." "Very well done." "This was much more than I imagined it would be." "Investing in Florida aquaculture, good food for thought."
- Of the 51 individuals who attended the Pinellas County workshop, 32, or 62%, completed an evaluation. Of these, their responses follow:
    - Overall, all were satisfied with the workshop with an average satisfaction level of 6 based on a scale of 1 (extremely dissatisfied) to 7 (extremely satisfied).
    - Of these, the average knowledge before the workshop on the topic of shellfish aquaculture was little, whereas after the workshop knowledge gained was increased.

- Two participants were current aquaculture producers and planned to continue and expand their operations, five participants stated that they definitely planned on starting an aquaculture operation, while another 15 participants were thinking of starting an aquaculture operation, and six reported that they had no intentions in starting an aquaculture operation.
- It was noted that most useful were the website links provided to access the workshop presentations and materials.

- The overall goal of the Introduction to Aquaculture workshops was to provide participants with a realistic overview of the aquaculture industry in Florida and potential aquaculture products. From the participant feedback, it seems the goal was met.

Objective 4

- Through continued support of a local growers association, have helped to ensure that over 40% of the clam growers in Levy County recognized the benefits of working cooperatively. Administrative support has allowed the Cedar Key Aquaculture Association to succeed with a strong volunteer base, development of industry leaders, monthly board of directors meetings, and accomplishments in resolving local issues and needs. For example, more than half of the membership has access to their leases through a dedicated parking lot for boat trailers nearby a launch site. Further, the association took a leadership role in representing the industry and reaching consensus regarding a controversial issue this year (agency-proposed lease expansion).
- Currently, the statewide clam task force is serving as an umbrella organization for the industry. In doing so, representatives collectively address common needs, issues, and concerns affecting profitability and sustainability.
- Working with local and regional growers associations, and with the statewide clam industry taskforce, has facilitated this agent's efforts in obtaining statewide input for extension programmatic development and reporting.

Objective 5

- The UF IFAS aquaculture initiative developed in partnership with the ornamental and shellfish aquaculture industries is specifically designed to increase commercial production, create additional jobs, provide locally-produced food, restore coastal marine populations and habitats, and improve water quality. This initiative invests recurring state funding to address factors that stand in the way of aquaculture and restoration efforts, to fill gaps in research and extension education programs that have been identified by industry, and to provide the aquaculture industry with new science-based information.

Success Story

Florida's shellfish aquaculture industry was facilitated through federally-funded (over $10 million) job retraining programs in the 1990s for fishermen facing increasing regulations. In less than two decades, the state has become a leading producer of farm-raised hard clams in the nation. The growth of this industry is a dramatic success story. However, challenges, such as future climate change, global competition, and marketplace pressures, must be addressed to allow for sustainable development and to increase production, farm efficiency, and profitability. To advance the shellfish aquaculture industry, funding for applied research and education, which traditional agricultural industries have benefited from for years, was requested in this year's state legislative session. The aquaculture LBR was successfully passed; recurring funds will support new faculty positions, technical staff positions, and operating funds for the Ruskin and Cedar Key facilities. If shellfish

production can be increased by 10-15% through this initiative, the annual farm gate value and economic impact of the Florida industry will increase $2-3M and $5-8M, respectively.

III. GENETIC ISSUES IN HARD CLAM AQUACULTURE

Situation

Situation statement: Clam farming has developed rapidly over the past two decades in the state. Annual seed plantings have increased from an estimated 108 million in 1992 to over 350 million in 2005. In 2012, operations reported 255.8 million clam seed were planted (FASS 2013). A consistent supply of seed was a major concern of this emergent industry, but in recent years growers have not been faced with seed shortages. However, concerns have been expressed about seed quality and the need for a hardier stock as increased mortalities have been experienced by growers during summer months. Several integrated studies are being conducted by research and extension faculty to improve seed quality and survival of stocks in subtropical conditions through investigation of standard breeding techniques.

Target audience(s): Shellfish aquaculture industry, in particular seed suppliers and growers, and state agency representatives

Program Objectives

1. To complete field trials with marker-assisted selection of hard clam strains examining the effects of biomarker levels and family on production characteristics and evaluate the shelf life of these stocks in refrigerated storage.
2. To engage at least 3% of the Cedar Key clam growers in participating in these field trials for examination of production characteristics under commercial conditions at multiple lease sites.
3. To assess the genetic diversity of wild and cultured hard clam stocks using recently developed microsatellite markers.
4. To compile and provide results of these genetic selection studies to the scientific and clam farming communities as well as state agencies.
5. To operate and maintain the UF Shellfish Aquaculture Research and Education (SARE) Facility in Cedar Key in support of these genetic projects and other industry-driven projects.

Educational Methods and Activities

Objective 1

- This breeding project was funded through a competitive grant program administered by the NOAA National Sea Grant. The funding provided partial support for a biological scientist and OPS technician to be located at the Sen. Kirkpatrick Marine Lab in Cedar Key under my supervision. The project team also included Dr. John Scarpa with the Harbor Branch Oceanographic Institute at FL Atlantic University, who was responsible for spawning the stocks, and Dr. Shirley Baker with UF SFRC, who conducted controlled laboratory environmental challenges.
- The project team targeted particular genetically distinct groups to assess if biomarkers (heat shock proteins, Hsp) can successfully be used in selective breeding programs for thermal tolerance in cultured hard clams. Three families from high-Hsp expressing parental stock and three families from low-Hsp expressing parental stock were produced in 2011.
- My role in this project was to conduct the land-based nursery, field nursery, growout and shelf life evaluations of these marker-selected clam strains, and act as a liaison with participating industry

personnel (growers and wholesalers) to examine the effects of heat shock protein levels on production characteristics.

- Over 77,000 growout-sized seed were planted in 2012 at the UF lease to test stocks under commercial conditions and comparison of stocks in replicated (n=12) field trials.
- These plants were sampled at 4 and 8 months (3 replicates per sample period) and harvested in October (6 replicates at harvest) to determine growth and survival over a 13-month culture period. Samples were provided to both Scarpa and Baker to test Hsp levels of the different groups and conduct thermal challenges. Hsp may be considered a biomarker for selective breeding of heat-tolerant hard clams if Hsp levels in progeny are correlated with parental Hsp levels and the high-expressing Hsp families exhibit higher survival in the field and laboratory challenges.
- At final harvest, "littleneck-sized" clams from each stock were evaluated for survival and gaping in refrigerated storage for 10 days. This evaluation was conducted at commercial shellfish processing plants.

Objective 2

- About 38,000 growout-sized seed of high- and low-expressing Hsp parental stocks were distributed to two clam growers in 2012 for planting at two commercial clam areas allowing for a comparison of growing locations. The amount of available seed limited the number of participating growers.
- These plants were recently harvested by growers and sampled by UF staff. Survival and production estimates were obtained for each plant and growing site.

Objective 3

- There has been limited documentation of the genetic diversity of cultured hard clam stocks in Florida. Samples of hard clams collected for the heat shock protein project were analyzed for genetic diversity at the Austin laboratory in Wildlife and Ecology Conservation using microsatellite markers developed through the Genomics Division of the Interdisciplinary Center for Biotechnology Research at UF. Six strains of cultured clams produced in commercial hatcheries in Florida were analyzed. In addition, samples included clams from natural assemblages along the east coast of Florida at four sites where "wild" harvesting is known to exist.
- To begin the process of sequencing the transcriptome of selected individuals of the northern hard clam, worked with a local commercial hatchery to spawn clams from known parents. The parents and progeny at selected sizes were provided to Dr. Jim Austin to sequence using low cost PCR-based assays. Approximately 50,000 are being field nursed.

Objective 4

- Production characteristic data obtained from replicated comparisons of high- and low-expressing Hsp parental stocks and shelf life were compiled.
- Sampling results were compiled for an interim report to Florida Sea Grant (FSG) and submitted electronically through OARS.
- Preliminary results were presented by the project team at a conference session on improving shellfish aquaculture production to over 110 attendees in conjunction with an international conference, Aquaculture 2014. The abstract was published in the conference proceedings and made available to over 3,000 conference attendees.
- Results of the genetic diversity assessment of hard clam stocks were submitted in a final CRIS report to USDA NIFA. In addition, a manuscript is in preparation.

Objective 5

- With OPS technicians, maintained operation of the UF Shellfish Aquaculture Research and Education (SARE) Facility in Cedar Key. This year the system ran continuously to support the various applied research projects.
- On-farm use of best management practices (BMPs) for marine bivalve facilities, such as hatcheries and nurseries, are displayed and demonstrated at the SARE facility. The permanent exhibit provides a continuous and "hands-on" source of information for clam farmers to learn about BMPs to achieve the State of Florida's environmental management goals for commercial aquaculture. Educational posters were displayed to provide visitors and industry members with information about the clam farming industry and current results of applied research and extension projects.

Outcomes and Impacts

Objective 1

- A large-scale examination of progeny from six clam families produced from high- and low-expressing heat shock protein (Hsp) broodstock was undertaken and compared. The integrated research-extension project is yielding data to determine if this breeding approach may offer improved survival and production of hard clams.
- No significant differences ($p<0.05$) in survival or growth between treatment means at the 4- and 8-month sampling periods were found. At eight months, average survival ($p=0.60$) for the high-expressing Hsp treatment was 99.9 $\pm$ 7.1%, while the low-expressing Hsp treatment averaged 94.3 $\pm$ 15.4%. The growout rearing trials were terminated after 13 months, which is the typical culture time required to reach a marketable size (littleneck product size) in Cedar Key. Harvesting began in October, which allowed clam stocks to be subjected to high water temperatures during the latter part of their culture cycle.
- After 13 months in the field growout, the remaining replicates were harvested. Average survival of the high-expressing Hsp families was 85.1 $\pm$ 1.9%, while average survival of the low-expressing Hsp families was 70.0 $\pm$ 26.7%. Results were similar for yield, which is a function of both survival and clam weight. The high-expressing Hsp families averaged 77.2 $\pm$ 4.1 lb/bag, whereas average yield of the low-expressing Hsp families was 65.9 $\pm$ 38.4 lb/bag. These production data have not yet been statistically analyzed. The high variation (as seen in the standard deviations) among replicates in the latter treatment most likely will result in no significant differences between treatment means. Two of the low-expressing families were produced from "wild" clam stocks. Survival and production for these two families averaged 54.8 $\pm$ 5.9% and 43.8 $\pm$ 5.4 lb/bag, respectively. The third low-expressing family was produced from cultured parental stock obtained from a commercial hatchery. The highest survival (100%) and production (110 lb/bag) amongst all families was obtained from this family.
- The shelf life evaluation was terminated on day 10 with survival in refrigerated storage averaging 99 $\pm$ 1.0% and 100% for the high-and low-expressing Hsp treatments, respectively. However, gaping of clams at day 10 averaged 69 $\pm$ 10% in the high-expressing Hsp families and 54 $\pm$ 26% in the low-expressing families. These results are comparable with baseline data obtained for Florida cultured hard clams in previous studies.
- These efforts are among the first to examine the effects of basic breeding techniques used in agricultural crops on hard clam culture in Florida waters. The current project was the next step in a breeding program to develop animals that perform better under local environmental and handling conditions, such as increasing survival in response to Florida growers' comments of low survival and

unreliable production during the summer.

- This integrated project will provide the necessary data to assess if cognate Hsp may be useful as a biomarker, or indicator, for thermal tolerance in cultured hard clams, which then could be successfully used in selective breeding programs. It is hypothesized that one or more of the biomarkers will be significantly associated with hard clam thermo-tolerance and with particular families, indicating heritability. Therefore, use of one or more of the biomarkers will allow the project team to target particular families for selective breeding, greatly reducing the time and resources needed for strain development.

Objective 2

- Two growers, or 2% of those in Cedar Key, participated in field trials this year, which allowed for comparison of clam stocks at various growing locations. In addition, two wholesalers, or 10% of those in Cedar Key, volunteered the use of their facilities to grade clams at harvest and evaluate shelf life of clam stocks in refrigerated storage. Their voluntary actions reflect the commitment of the industry in assisting applied research efforts to develop a hardier clam stock.
- By engaging the assistance of growers and wholesalers in this project, a sense of ownership has been created and the level of communication between industry and researchers increased.

Objective 3

- The northern hard clam is the most commercially important bivalve species produced via aquaculture in the eastern US. Selective breeding practices associated with large-scale hatchery production may result in unintended, negative consequences such as inbreeding and reduced levels of genetic diversity. The project team used seven microsatellite markers to compare levels of genetic diversity in six hatchery and four wild stocks from Florida. Wild stocks displayed a greater number of alleles (N_A = 9.28) and higher levels of allelic richness (A_R = 3.34) relative to hatchery produced individuals (N_A = 8.14, A_R = 3.18). Differentiation was highest among hatchery stocks (G_{ST} = 0.018, s.d. = 0.008; P < 0.001), and similar among hatchery + wild comparisons.
- These results suggest that drift has occurred within hatchery populations, though the divergence between wild and hatchery stocks are not yet at the scale seen in some other aquacultured bivalve species. The findings also suggest that hatchery production of hard clams is done in such a manner that differences in genetic diversity and differentiation between wild and aquaculture stocks are limited. As aquaculture production of hard clams expands, maintaining genetic diversity in cultured stocks via broodstock selection techniques will be important in order to limit potential deleterious effects associated with mass production of seed from few, related individuals.
- Variation in traits like heat tolerance and growth rate is due to genetic and environmental factors. Identifying the underlying genes and alleles of this natural variation would prove useful for the hard clam culture industry, as it has in other important natural resources industries like forestry or fisheries. This can also lead to the ability to genetically engineer clams that over express favorable genes to determine whether this increases survivability without affecting other favorable traits. By identifying the combination of genes responsible for these, or other suites of traits, we can improve clam productivity.

Objective 4

- Over 3,000 people were informed of the results of these clam stock improvement projects at an international meeting. Findings provided science-based information necessary for commercial clam culturists and entrepreneurs to make an informed decision regarding the incorporation of biomarker-

selected stocks into a hatchery or growout operation.

- Development of more robust clam strains represents an important gain over the present reliance on unselected stocks and should have a positive impact on production of cultured clams in Florida, improving production and cash-flow for clam farmers and ancillary businesses.

Objective 5

- A shellfish research and education facility in Cedar Key provided support for several applied research projects. In addition, the facility was used by university faculty and students as a remote field station and provided educational opportunities for youth groups, visitors, and industry. There were 37 entries in the guest log this year with addresses from Belgium, Kansas, Illinois, New York, Missouri, Ohio, Tennessee, and Florida. Remarks ranged from "awesome," "great information," "cool," "excellent learning experience," to "love the clams – keep on researching."

Success Story

Awareness of the need for a hardier clam strain through genetic improvement to meet increasing national demand for aquaculture products resulted in the Cedar Key Aquaculture Association taking a leadership role in procuring federal research funding (USDA-NIFA) over four years to support these genetic stock improvement projects. This support has allowed for development of a research and extension project team who has begun to address the industry's needs. Further, this support has allowed the project team to solicit competitive grant funding. An integrated partnership among the clam farming community, research and extension faculty has been developed. The partnership continued through these current projects focuses and leverages available resources to enable the sustainable development of molluscan shellfish aquaculture in Florida.

IV. DIVERSIFICATION OF A MONOCULTURE-BASED INDUSTRY THROUGH EVALUATION OF ALTERNATIVE MOLLUSC SPECIES

Situation

Situation statement: Although hard clam farming has developed into a major industry in Florida, diversification from a single species product may help stabilize and expand the molluscan shellfish aquaculture industry. The rapid recruitment of fishermen into shellfish aquaculture during the 1990s, along with the exceptional growth rates associated with the productive, subtropical waters of Florida, has encouraged producers to seek information on other bivalve species that would provide crop diversification and augment profit potential. Species diversification may also be one alternative to mediate losses associated with a monoculture-based industry and to spread production risks. Native molluscan species, which could be cultured and marketed along with clams, are logical options. Small-scale clam farm businesses have neither the time, experience, nor resources to investigate the feasibility of developing new aquaculture species. Integrated research and extension efforts have been undertaken to determine the production feasibility and market demand of the sunray venus clam, arks, and oysters.

Target audience(s): Shellfish aquaculture industry, including seed suppliers, growers, and wholesalers

Program Objectives

1. To determine production performance of sunray venus clams under commercial conditions by engaging a minimum of 5% of the hard clam industry members in culturing sunray venus clams, and to evaluate test sites for potential lease areas.

2. To create separate lines of broodstock sunray venus clams and distribute to 80% of the commercial shellfish hatcheries for maturation and future selection.
3. To provide at least 25% of the hard clam culture industry with information on the potential of sunray venus clam culture and marketing so members may consider diversifying their business plans.
4. To work with at least 10% of the hard clam culture industry in exploring the potential of other bivalve species for culture, in particular arks and oysters.

Educational Methods and Activities

Objective 1

- A Florida Sea Grant-funded project with the goal of demonstrating to the various sectors of the Florida shellfish aquaculture industry the potential of the sunray venus clam, *Macrocallista nimbosa*, as a new species to diversify and expand the industry was completed. Dr. John Scarpa with the Harbor Branch Oceanographic Institute (HBOI) at FL Atlantic University and I served as co-principal investigators on this project. Other UF investigators included Chuck Adams, Food Resource and Economics Department; Steve Otwell, Food Science and Human Nutrition Department; and, Rex Ellis and Todd Osborne, Soil and Water Sciences Department. Nonetheless, we continued to work with the industry and provided additional seed for commercial evaluation.
- Sunray venus seed planted in the field nursery at the UF experimental lease from a prior FSG-project during 2012 were harvested. Average survival of the three field nursery plants ranged from 29 to 52%, whereas survival of sunray venus clams in each nursery bag ranged from 6 to 85%, producing over 78,000 growout seed.
- Over 50,000 of these growout seed were supplied to five growers at four lease areas in three counties (Franklin, Lee, and Levy) to continue evaluating production performance at commercial sites, which supported promising results in prior field trials.
- Continued to work with the DACS Division of Aquaculture staff in planting sunray venus seed at test plots around Cedar Key to examine alternate lease areas for this molluscan species. To do so, another 14,000 growout seed were planted at seven locations for monitoring.
- To provide sunray venus clams for future projects and to obtain additional seasonal and annual culture data, John Scarpa conducted two more spawns at the HBOI hatchery. In one spawn, broodstock were selected from cultured stocks (CxC). In the other spawn, broodstock were selected from cultured and wild stocks and crossed (CxW). Over 100,000 seed from each of these spawns were nursed at the UF facility in Cedar Key. Of these, 72,000 were further nursed by planting in the field at the UF experimental lease. In addition, another 10,000 seed of each stock were provided to a grower to field nurse at a commercial lease. Further, seed from these spawns were provided to three nursery operators in two counties (Indian River, Lee) to continue evaluating production performance at commercial facilities.

Objective 2

- Sunray venus seed produced from broodstock collected from natural assemblages at two locations along the Florida's west coast (Anna Maria and Seahorse Key) were harvested from the field nursery located at the UF experimental lease in Cedar Key. This is a continuation of the last FSG-funded project in which the project team proposed to create initial founder broodstock lines for Florida hatcheries. In addition, these efforts continued to provide baseline information on the performance of sunray venus in the field nursery.

- Average survival of the five field nursery plants ranged from 40 to 66%, whereas survival of sunray venus clams in each nursery bag ranged from 23 to 77%, producing approximately 88,000 growout seed.
- Twelve thousand growout-sized seed from the Seahorse Key stocks and 17,000 growout-sized seed from the Anna Maria stocks were planted at the UF experimental lease for further rearing.
- Another 18,000 growout-sized seed from both stocks were supplied to eight hatchery operators to be reared for future broodstock.
- Over 750 adult sunray venus clams reared in prior FSG projects were provided to six hatchery operators to be used as broodstock in commercial spawning trials.

Objective 3

- A final report on the results of the 2010-13 project components was provided to the funding entity, Florida Sea Grant College Program, via their Online Activity Reporting System.
- Final project results were presented at a special clam session held in conjunction with Aquaculture 2013 during which over 90 attendees learned about the prospects of this new candidate culture species. An abstract was published in the conference proceedings and made available to over 3,000 attendees.
- An informational brochure providing pertinent information obtained from these studies was designed, printed and made available to wholesalers and retailers to inform consumers about this new seafood product.
- Summaries of presentations, as well as the PowerPoint presentations, given at the clam industry workshop in November (2012) were made available at the website, http://shellfish.ifas.ufl.edu/industry_workshop/.
- Took the lead in response to two funding opportunities (NOAA Sea Grant Aquaculture Extension and Technology Transfer, Florida Sea Grant under their new category of Research to Application projects) to solicit project team members, develop objectives, and submit full proposals for consideration of funding. The proposed project goal is to provide the impetus needed for the shellfish aquaculture industry to advance the production and distribution of the sunray venus clam.

Objective 4a - Arks

- The feasibility of establishing a commercial culture industry for ark clams, *Noetia ponderosa*, in Florida was addressed in a prior USDA-funded project. Results published in a technical report demonstrated that spawning, larval rearing, nursery and growout, harvest, marketing, and distribution of arks could be achieved (Sturmer et al., 2009). Although the number of ark juveniles produced was low, we were able to culture arks through to potential market size. Determining competency for setting was difficult and post-set survival was low. We concluded that improvements in setting and post-set survival were necessary for ark seed production to become commercially viable. To that end, funding from a recent USDA NIFA grant has allowed us to readdress this in collaboration with John Scarpa at HBOI.
- Ponderous ark clams collected from natural populations on Florida's west coast were shipped to the HBOI experimental molluscan shellfish hatchery for final maturation and spawning efforts. Arks spawned spontaneously and repeatedly in conditioning tanks and viable larvae were obtained from these spawns. Larvae were cultured similarly to hard clam larvae and reached setting size (~220 um) primarily at day 14-16. Initial attempts to "set" larvae using hard clam culture methods, e.g., downwellers, failed.
- Settling cues for ark clam larvae were further examined. Using larvae from spontaneous

spawns a simple trial was conducted to compare potential settlement of larvae on rectangular tank bottoms, as opposed to downwellers, with cues, such as attached microalgae and natural silt, added to the water. Microalgae were added daily, but no water changes were done. After 16 days, water was drained from each tank and metamorphose larvae were found attached to the *Ulva* sp. and to the tank bottoms. Two more groups of size-competent larvae were exposed to various treatments to further examine if settlement "cues" were necessary.

- Ark clams set from each spawn and treatment were cultured until they held on a 1.2 or 2.0 mm sieve before being transferred to the UF facilities for further nursery and growout culture. In addition, three seed suppliers have received approximately 100K ark seed to continue culture in their commercial systems.

Objective 4b - Oysters

- Increasing interest in the prospects of oyster aquaculture is in part due to stagnant clam prices, premium prices obtained by oyster culturists in the northeastern U.S., and current reduced landings from oyster fisheries in Florida and other Gulf coast states. Further, this year the Governor and Cabinet approved modification of 26 clam bottom leases, most of which are located at the Alligator Harbor lease area in Franklin County, for use of the full water column to take advantage of new oyster culture options.
- Was invited by the oyster recovery team to speak at a meeting of seafood industry leaders in Apalachicola to address the possibility of oyster aquaculture in Franklin County.
- With FDACS, planned, organized and taught in two introductory workshops (intensive oyster culture, oyster culture gear and suppliers) held in two locations (St. Teresa and Cedar Key) to clam culturists, oyster harvesters, and other interested people to provide current information on oyster cultivation.
- With state funding was able to provide travel funds for extension specialists from Louisiana State University and Auburn University, who have been developing off-bottom oyster culture methods for the northern Gulf of Mexico, to provide current information in the first set of workshops. In addition, I provided an overview of the intensive oyster culture operations along the U.S. east coast, as well as prior experiences in Florida. The second set of workshops allowed for a "hands-on" discussion of oyster culture gear types by the extension specialists. Information was also made available on where to buy the gear. Three equipment suppliers and two seed suppliers participated in these workshops.
- All presentations and handout materials were posted to my website allowing for others to access the workshop information.
- The workshops were also video recorded by FDACS. Over 40 DVDs have been sent upon request to workshop attendees as well as distributed to eight state and federal agency representatives and 19 marine extension agents.
- Continued to work with a local integrated clam business in evaluating several intensive culture systems designed to reduce maintenance due to fouling in Florida's subtropical waters. The pilot-scale evaluation is gathering information on growth and survival of oysters in these systems as well as documenting the amount of labor required in maintaining the various culture systems.
- Collaborated with extension specialists in five coastal southern U.S. states (NC, SC, GA, AL and LA) and submitted full proposals to two different agencies for consideration of funding. The goal of our proposed work is to allow demonstration and technology transfer of several off-bottom oyster culture techniques by working with new growers to provide training in construction and maintenance of these systems as well as training in methods used to assess quality of oysters destined for the half-shell market.

Outcomes and Impacts

Objective 1

- Three percent (3%) of the Florida clam growers and nursery operators (n~320) are engaged in rearing the sunray venus clam, thereby allowing for technology transfer to each of these industry sectors.
- Test plots harvested at a submerged sand spit approximately 30 acres in size located east of Cedar Key and west of an existing high-density shellfish aquaculture lease area have supported viable sunray venus production (>55% survival, 55mm shell length, and 21g weight in less than 12 months). This site will be established as an aquaculture management agreement and used as a demonstration and training site for Levy County growers; currently, I have an application pending with the FDACS Division of Aquaculture.
- Growers in Lee County, who have participated in field trials, have diversified their businesses and currently are culturing sunray venus clams on their leases.
- It has been six years since the Florida Agricultural Statistics Service conducted an aquaculture survey. Budget cuts were responsible. This year the FDACS Division of Aquaculture funded a survey of Florida aquaculturists to capture farm size, volume, value, and labor information in 2012. For the first time, sunray venus clams were included under mollusks in the survey. Of the 139 producers who reported sales of hard clams, three also reported sales of sunray venus clams at a farm gate value of $219,000. It's a start to the diversification of the industry!

Objective 2

- Our previous field trials utilized single- or double-parent crosses to produce replicate families for experimental culture of this species. However, commercialization requires multi-parent crosses to produce founder broodstock that retain as much genetic diversity as possible from wild local populations for future selection efforts. To ensure that Florida clam hatchery operators do not initiate genetic bottlenecks, which may result in inbreeding depression or limit genetic diversity in their product and future lines for selective breeding, separate lines were produced and juveniles made available to eight commercial hatchery operators, or 80% of the seed suppliers in the state.
- In addition, adult sunray venus clams provided to six commercial hatcheries were used as broodstock in commercial spawning trials. Results were variable in part due to the atypical climatic and environmental conditions experienced earlier this year. Nonetheless, 60% of the commercial seed suppliers were willing to diversify their businesses and several million seed were produced.

Objective 3

- Results were disseminated to the aquaculture industry in the form of several deliverables – reports, presentations, brochures, and website postings.
- Over 100 people were informed of the results of this integrated project. Findings provided science-based information necessary for commercial clam culturists and entrepreneurs to make an informed decision regarding sunray venus clam culture.
- Project VENUS (Vocational Education Network Using Sunrays) received high marks in a national competition and was awarded funding for 2013-15. The project team plans to provide the necessary infrastructure via a public-private partnership, as was accomplished two decades ago through shellfish aquaculture retraining programs for former fishermen in Florida, to commercialize the sunray venus clam through large-scale demonstration, education, and "hands-on" training. Revitalization of an industry that is currently based exclusively on one bivalve species will

successfully 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 U.S., and promulgating market development.

Objective 4a - Arks

- The settlement of arks from the first spawning trial yielded about 100K juveniles that held on a 1.2 mm sieve, which was approximately a 36% return from the number of larvae added to the tanks. Two other spawns produced about 10% return from larvae; we think the reduced return was a result of aggressive cleaning that dislodged many newly settled ark clams during drain downs without screens to retain the larvae.
- In all trials, successful metamorphosis of larval arks was attained as post-set arks were found in all treatments and controls. Therefore, the settlement system needs further examination (e.g., use of rope substrate as done for mussels) for mass production of arks as none of the treatments produced consistently more set as compared to the control treatment. Nonetheless, improvements in setting and post-set survival were achieved.
- This new information will assist shellfish hatchery operators, growers, and others who may be considering ark clams as an alternative or additional culture species. There is renewed interest in the prospects of ark clam culture. Two fact sheets on ark clam marketing opportunities received 998 hits on the UF IFAS Solution for Your Life website.

Objective 4b – Oysters

- Over 80 members of the seafood industry in Franklin County were provided answers to a series of questions on the prospects of oyster culture.
- A total of 84 attendees participated in the first set of introductory oyster culture workshops. Of these, 29 attendees completed a workshop evaluation form. The St. Teresa participants scored the workshop very highly (average responses = 4.7 to 5.0 on a scale of 5, where 5 = agree and 1 = disagree) on five out of the six questions, meaning that they agreed the workshop was worth attending, new/helpful information was presented, presentations and handouts were informative, and that the respondent would attend future workshops. Not surprisingly, Cedar Key participants did not score the workshop as highly (average responses = 4.0) on whether sufficient information was presented to evaluate intensive oyster culture as a business. These workshop participants were more critical, probably reflecting their greater familiarity of shellfish farming. For five of the six questions, the average scores were 4.5 to 4.6 and, similarly, attendees scored the workshop lower (average response = 4.4) on whether sufficient information was provided to evaluate off-bottom oyster culture as a business. A total of 67 attendees participated in the second set of introductory oyster culture workshops. Those that completed the evaluation form (n=32) demonstrated a high level of satisfaction with the workshops. However, the participant makeup was strikingly different between them. The majority of people present at the St. Teresa location had participated in the first workshop. The Cedar Key workshop attracted few participants from the first workshop so the majority of people attending possessed no prior information. As a consequence, slightly lower ratings at the latter workshop were due to the fact we had already covered the information these new participants were interested in. Overall, we felt the workshops achieved the goal of introducing people to the complex topic of intensive off-bottom oyster culture.
- The proposed pilot-scale demonstrations may serve as catalysts for decision-making in the state, both by industry and regulators, about whether they will pursue intensive methods of raising oysters. Adoption of oyster culture technology may have the potential to increase productivity, create jobs,

and provide a healthful local seafood supply.

Success Story

Given the results of seven years of applied research efforts and two decades or more of an established partnership between the land and sea grant university (UF) and private shellfish aquaculture businesses in Florida, it is an opportune time to extend these results to current and potential growers, seed suppliers, wholesalers and retailers, and marine extension agents. Project VENUS (Vocational Education Network Using Sunrays) is a concerted, integrated technology transfer project needed for the shellfish aquaculture industry to advance the production and distribution of the sunray venus clam. It is anticipated that a geographically diverse and viable sunray venus clam culture industry will be developed within 3-5 years, providing a unique farm-raised seafood product to local, regional, and national markets. Revitalizing the hard clam aquaculture industry in Florida through expanded transfer of technology (from research and development to implementation by end-users) of sunray venus clam production, enhanced aquaculture education and training, and communication that disseminates the best-available, science-based knowledge, tools, and technologies to stakeholders (e.g., industry, consumers, marine extension agents) will: 1) ensure the increased ability of the hard clam farming community to sustain their shellfish aquaculture-based economy, 2) enable former fishermen turned farmers a continued means of making a living on the water, and 3) allow fishery-dependent coastal communities to remain working waterfronts.

V. AWARENESS OF THE CLAM AQUACULTURE INDUSTRY IN FLORIDA

Situation

Situation statement: Clam farming is a relatively new agricultural industry in the state. Yet, it is an industry that has brought about economic revitalization to fishery-dependent communities on Florida's west coast. In order for the industry to remain viable and grow, coastal residents must recognize and appreciate its dependency on clean water. To increase consumer demand, Florida residents must become aware of a new seafood product harvested in their coastal waters – cultured clams.

Target audience(s): Florida residents and citizens, agency representatives, elected officials, other groups, and the media

Program Objectives

1. To educate Florida residents and visitors about the availability of locally produced shellfish and to celebrate the new shellfish aquaculture industry through festivals and exhibits.
2. To inform various groups and agencies about the environmental and economic importance of clam aquaculture to coastal communities through talks, tours, and other teaching events.
3. To work with the media in making them aware of the clam aquaculture industry by providing current information and creating publicity.

Educational Methods and Activities

Objective 1

o Updated a series of colorful posters, which provided current information on clam culture components, background and status, economic impact, environmental benefits, and other topics, and

a “mock” clam farm display. The educational exhibit, along with brochures, was presented at the following: a) 44th Annual Seafood Festival (est. 14,000 attendance) in Cedar Key, 19-20 October, b) Levy County Fair (est. 7,000 attendance) in Williston, 11-14 April, and c) Maritime Festival, World Oceans Day, (est. 1,500 attendance) 8 June, Ft. Pierce. It is on permanent display at the UF Shellfish Aquaculture Research and Education Facility in Cedar Key.

- Organized “Celebrate Cedar Key Seafood,” a special educational venue showcasing the community’s fishing and aquaculture industries held in conjunction with the 44th Annual Seafood Festival in Cedar Key. With funding from the FL Department of Agriculture and Consumer Services’ Division of Marketing, visitors were provided with *Fresh from Florida* promotional materials and seafood recipes. Also designed colorful banners and posters which were displayed at the City Park, where educational booths and touch tanks were featured in collaboration with the Lions Club and FL Fish and Wildlife Commission staff. Also organized and conducted culinary demonstrations with 5 local chefs and seafood processors, who cooked/prepared their seafood specialties for the public.
- Assisted in setting up a display highlighting the Cedar Key clam industry, Cedar Key Clams: Fishermen Farming the Sea,” which was part of a UF exhibit, *Water: Discovering and Sharing Solutions*. Presented at the Sunbelt Ag Expo (est. 15,000 attendance at the UF pavilion), Moultrie, GA, 15-17 October.
- Designed a “hands-on” display, “What’s in the Clam Bag?,” which showcased the species diversity associated with shellfish aquaculture while providing interaction with common marine organisms. Presented at the grand opening (est. 1,500 visitors) of the *Surfing Florida and Surf Science* exhibit, Florida Museum of Natural History, Gainesville, FL, 14 September. http://www.flmnh.ufl.edu/photopreview/surfingflaopening/
- Designed a billboard featuring clam farming with the message “*Fresh from the Gulf to your Plate*” and pictures from UF IFAS. Funded by the Cedar Key Aquaculture Association and installed on State Road 24, north of Cedar Key.

Objective 2

- Met with six (6) groups, including federal (USDA National Agricultural Statistics Service) and state agencies (Suwannee River Water Management District’s Governing Board), governmental officials (Congressman Ted Yoho, Florida Representative Charlie Stone, Florida Senator Charles Dean and their aides), and various organizations (Florida Natural Resources Leadership Institute), presenting them with current information about clam farming and conducting industry tours in Cedar Key.
- Invited to provide an update on the clam aquaculture industry by making a presentation to the Florida House Agriculture & Natural Resources Appropriations Subcommittee in Tallahassee on 13 March.
- Conducted a paddling tour to the Dog Island High-density Lease Area in the Gulf of Mexico near Cedar Key as part of the Hidden Coast Paddling Festival during which six kayakers learned about clam farming and actually harvested clams. Also gave an evening talk to 24 paddlers as part of the weekend program on 4-5 October.
- As part of the Florida Museum of Natural History’s Science Cafés, gave a presentation, entitled “Farming the Sea: the Cedar Key story,” to 85 people at the Blue Gill Café in Gainesville on 28 October. Each person also received a copy of the Cedar Key *Everlasting* magazine. http://www.flmnh.ufl.edu/calendar/grid/science-cafe-farming-sea/
- Assisted representatives of the FL Humanities Council in the logistical planning for The

Gathering, which was held in Cedar Key on 15-16 April. Provided 35 participants with a presentation about the clam farming industry, land and water tours, and a clam bake. http://www.flahum.org/Speakers/CedarKey_2012

- In addition, provided and cooked clams for the Levy County School Foundation's 4th Annual Beast Feast at which over 200 people attended.

Objective 3

- Provided current information to the media about clam farming and other topics, resulting in local, state, regional, and national exposure for the industry. This year wrote six articles (e.g., oyster workshops, oyster fishery, Coastal Clean-up, shellfish restoration) that were published in local weeklies (e.g., Cedar Key Beacon, Cedar Key News, Dixie County Advocate) with a combined circulation of over 7,500. Contributed to 2 articles in The Gainesville Sun (daily circulation of 43,000) on the small scale clam farming and oyster fishery decline in Cedar Key.
- A national trade magazine, Fish Farming News, featured Florida aquaculture in one of their issues. Contributed an article, "Shellfish aquaculture: Florida hard clam farming industry a unique success story," and photos for this issue, which reached 6,000 readers.
- Was interviewed and contributed to an article, "Saving Cedar Key," in the Explore: Research at the University of Florida magazine, which has a circulation of about 30,000. http://research.ufl.edu/publications/exploremagazine/spring-2013/saving-cedar-key.html
- Further, was interviewed by the WUFT-FM radio station of Gainesville on several occasions regarding the potential impacts of tropical storms on the clam industry and sustainability of the clam farming industry.

Outcomes and Impacts

- Through a) participation in festivals, fairs, and special events; b) presentations and tours; c) contribution to articles in magazines and newspapers; and d) interviews on radio and television exposed an estimated 110,000 people to the clam farming industry in Florida. In doing so, have increased a) public awareness of the economic and environmental impacts of this industry, b) communication and interaction with stakeholders, c) appreciation for goods and services from this industry, and d) consumer confidence in and demand for molluscan shellfish products.
- The UF water exhibit, which was developed for the 150th anniversary of the land grant university system last year, was featured at the UF pavilion at the Sunbelt Ag Expo this year. The exhibit's focus on the importance of water to life in Florida, and how UF/IFAS research and education programs help residents and agricultural/aquacultural producers alike ensure water quality and conserve water resources is achieved through the appealing and eye-catching displays. Approximately 15,000 exposition visitors from the southeastern U.S. who toured the UF pavilion had the opportunity to view this exhibit.

Success Stories

Every year, I am asked to give talks at various venues and events. It is a lot of extra effort, involving driving time, and usually occurring on evenings or weekends. You wonder, at least I do, if it is really worth it. Yet, it is always an opportunity for a "teachable moment." That is why receiving unsolicited feedback (beyond the surveys or results of pre- and post-tests) from the organizers and participants is very rewarding. Here's an email message from the Florida Museum of Natural History program director: "On behalf of the 85 participants in last evening's Science Café, thank you very much for a terrific program. The tremendous success of clam farming at Cedar Key is certainly

a tribute to your initiative, creativity, thoughtfulness, work as a scientist, and hard work. I thoroughly enjoyed reading *Cedar Key Everlasting* and everyone was very pleased to be able to take home a copy. As folks were leaving the restaurant, many commented to me about how much they enjoyed the program, how they had no idea about the development and importance of the clam farming industry in a community very close to Gainesville, and that this was the best Science Café yet." That kind of feedback makes it all worth it!

VI. GULF AWARENESS, RESTORATION AND ENHANCEMENT

Situation

Situation statement: The coastal communities of the Big Bend area of Florida are intrinsically linked to their marine and estuarine environments. In order to preserve and protect the area's natural resource-based economy and heritage, residents and visitors must be aware of the importance of these environments and be willing to conserve, restore and enhance them.

Target audience(s): Local residents, visitors, and youth / Shellfish harvesters, growers, and wholesalers

Program Objectives

1. Increase awareness of the importance and regional impact of Gulf of Mexico's marine resources on the coastal communities of the Big Bend.
2. Engage local residents and youth in becoming stewards and volunteering in programs, such as coastal cleanup.
3. Engage clam growers in implementing programs to minimize gear loss and incentivize cleanup.
4. Continue developing and implementing shell recovery programs, such as recycling and derelict clam bag removal, to restore oyster reefs and enhance fishery habitat.
5. As an appointed member of the Levy County RESTORE Act advisory committee, provide technical expertise in identifying, evaluating and recommending potential aquaculture/restoration projects, programs and activities that would be beneficial to the county.

Educational Methods and Activities

Objective 1

- Participated in the City of Cedar Key's Hurricane Awareness Day providing educational materials for boaters, marina operators, and clam industry members, informing them on how to prepare for storms and hurricanes.
- Participated in a marine resource seminar series held annually for the public at the Cedar Key library. This year hosted speakers (Dr. Jane Brockmann, renowned expert on horseshoe crabs with the UF Biology Department, and Tiffany Black, crustacean biologist with the FWC Marine Lab), who provided information on horseshoe crab populations in the Big Bend area. Over 80 people attended this seminar.
- An educational display, consisting of a colorful, customized outdoor panel, was developed and installed at the city beach in Cedar Key to inform the public about mating and nesting activities of the horseshoe crab as well as the importance of this unique marine creature. The information in the panel was written in partnership with Brockmann and Black. A graphic designer at the Florida Museum of Natural History transformed the text and pictures into an eye-appealing display.

Objective 2

- Assisted the City of Cedar Key in conducting the annual Coastal Cleanup, sponsored by The Ocean Conservancy, and informed over 130 participants on the sources of and issues with marine debris.

Objective 3

- As a member of a steering committee established by the Department of Agriculture and Consumer Services (DACS), assisted in implementing a marine debris grant funded through the Department of Environmental Protection (DEP). This year begins a three-year project to remove, dispose, and prevent the loss of shellfish farming gear (cover netting, clam bags, PVC pieces, etc.) from the shellfish lease areas around Cedar Key. Of particular concern is the plastic netting used in predator protection of clam bags. The buoyant netting can become dislodged and is contributing to marine debris found along Cedar Key's shorelines.
- To this end, seven 8-yard marine debris collection containers were placed at properties of participating shellfish wholesalers and the Marine Lab so that clam farmers can have ready access to a disposal container. Placement and servicing of the containers are funded through the DEP grant.
- Signage for the containers was developed. Information provided summarizes the intent of the project, identifies the project partners, and cautions users not to deposit household garbage.
- Provided comments on a marine debris technical bulletin being developed by DACS.

Objective 4

- Continued working on a project in which oyster and clam shell was recovered and recycled as cultch materials for replenishing oyster reefs in Levy County. This year was responsible for the following:
  a) Setting up educational posters and recycling bins at area festivals near seafood vendors for the public to discard their oyster and clam shells.
  b) Assisting the oyster harvesters association in overseeing a project funded by DACS in which clam shell, a byproduct of the clam farming industry, was collected from local processing plants and stored at a county site.
  c) Assisting the DACS Division of Aquaculture staff in planning and staging the delivery of stored shell to their barge for planting at designated sites in the inshore coastal waters.
- Funding for the shell collection project was limited to four months this year. As part of a working group under the lead of Peter Fredericks and Bill Pine with the Wildlife and Ecology Conservation Department, began implementing a pilot restoration project, funded by The Nature Conservancy (TNC) and NOAA Restoration Center, to test experimental oyster reef structures near Lone Cabbage in the Suwannee Sound. This year was responsible for the following:
  a) Establishing an agreement with the Cedar Key Aquaculture Association (CKAA) to serve as project contractors under a purchase order with UF for the removal of damaged clam culture bags from leases and deposition of bags at designated recovery locations. The CKAA directly pays the subcontractors for number of bags removed. These bags make excellent oyster reef building bags as the clam shell serve as cultch materials for setting oysters.
  b) Solicited participants in this project by notifying 72 eligible leaseholders. Identified bag removers (sub-contractors) by contacting those who participated in prior projects. Provided coordination between the various partners – researchers, CKAA, growers, and bag removers.
  c) Assisted in writing an article distributed to the area's weekly newspapers informing the public of these restoration activities and the need for them.

- With the project team identified above along with the Levy County and Dixie County Soil and Water Conservations Districts, developed and submitted a restoration proposal entitled "Restoring Oyster Reefs through Reclamation of a Shellfish Aquaculture Industry in the Big Bend of Florida's Gulf Coast" to the Department of Environmental Protection (DEP) in consideration of funding through the RESTORE Act. The $3.6 million project proposes to restore approximately 62 acres of oyster reef habitat through cultching and stabilization techniques by deposition of over 20,000 oyster-encrusted clam culture bags within the Suwannee Reef and Corrigan Reef complexes, as well as providing an estimated 20 jobs over a six-year period.
- With Frederick, met with staff from the Suwannee River Water Management District and aides from the local state senator's office and informed them of the proposed restoration project.
- Participated in an in-service training on "Coastal Restoration," hosted by the Florida Sea Grant Work Action Group, in which about 25 people from extension agents to agency representatives learned about current restoration efforts in the state.

Objective 5

- Was asked to serve on the Levy County RESTORE (Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act of 2012) advisory committee as the aquaculture representative. This is in response to the funds which could come to Florida and Levy County as a result of fines levied against companies responsible for the 2010 Deepwater Horizon explosion and oil spill.
- The duties of the committee are to provide input to the Board of County Commissioners on the use of funds, to assist in the development and review of projects, programs or activities to qualify for funding, and to provide for a venue for extensive public participation in the process for development of such projects, programs or activities.
- Participated in monthly advisory committee meetings as well as six town meetings during which local residents were encouraged to provide input on the potential projects, programs and activities from individuals, businesses, and nonprofit organizations in the county.

Outcomes and Impacts

Objective 1

- The intent of this seminar series is to inform citizens and visitors to the Cedar Key area of the importance and regional impact of the Gulf of Mexico's marine resources on our coastal community. This year's presentation allowed attendees to learn about a) horseshoe crabs and their importance, b) UF's research at Seahorse Key on these unique marine creatures, and c) how to protect the local populations.
- Hundreds of people have stopped to read the messages provided in an educational display and discover what they can do to protect horseshoe crabs. There is ample room at the City of Cedar Key beach for additional educational panels. For example, visitors could learn about the various shore birds who visit in the summer and winter or about marine mammals.

Objective 2

- Over 130 volunteers collected trash along the shorelines of Cedar Key and offshore keys, resulting in cleaner beaches and waters and a sense of community pride. Approximately 265 cover nets (0.66 tons) used by the clam industry were recovered, up 54% from the previous year. In comparison with the highest number of items collected in 2012, this year's results showed a decrease

in plastic water bottles (down to 495) in part due to the placement of recycle containers around town. In addition, over 2,100 cigarette butts, 330 aluminum beverage cans, and 210 food wrappers were collected. The data compiled from the local cleanup was sent to the International Coastal Conservancy.

Objective 3

- A test container was placed at one wholesaler's property to evaluate how much marine debris could be collected. Over a one-week period, 0.46 tons were collected in a 20-yd container. It was also reported that clam farmers using the container respected the signs asking that they not deposit household garbage.
- A working partnership with state agencies, businesses, and the clam farming industry has been developed to implement the means and methods to remove and dispose of culture gear debris, resulting in a non-regulatory approach to improving the coastal environment.
- The intent of this project is not to solely focus on shellfish farming gear but work to benefit the Cedar Key area by thinking and acting to prevent and remove marine debris as defined in its broadest sense – any man-made object discarded, disposed of, or abandoned that enters the coastal or marine environment. Marine debris is a growing U.S. and global challenge. A broader approach taken by the project's steering committee is much more constructive and reflects the strong environmental ethic inherent to people who live and work around Cedar Key.

Objective 4

- An estimated 920 cubic yards, or 22 thousand bushels, of clam and oyster shells were recovered through voluntary actions and collection efforts at two processing plants and area festivals.
- Ten percent (10%) of the clam wholesalers in Levy County participated in the shell recovery project. This has provided a creative solution to regulatory concerns over increasing amounts of shells stockpiled at processing plants and the use of shell material as "fill."
- The shell recycling station and bins at local festivals resulted in local "buy in" as the public actively participated in discarding oyster and clam shells at these sites.
- Shell materials were used by the DACS staff for planting in the Big Bend area. Availability of adequate cultch materials in the area has limited use of this oyster fishery enhancement method in the past. About 292 cubic yards, or 7 thousand bushels, of dried clam shell were used in enhancing two oyster reefs, covering 1.2 acres.
- The Lone Cabbage pilot project will provide assistance in restoring and stabilizing rapidly declining oyster reefs in the Big Bend by using innovative, locally-sourced materials and proven community-based methods. The restoration goal is to create self-sustaining oyster reefs that are resilient to anticipated threats of sea-level rise, low freshwater events, and increased variability in weather.
- Eight clam growers are participating in this project and providing 10% of the costs to remove damaged clam bags from their leases. Two subcontractors have begun to remove the 320 culture bags funded by this project and use as structural components in constructing oyster reef habitat.
- The Lone Cabbage project won't restore the whole reef – it's a trial effort designed to see how well the techniques work. The pilot project will compare four restored reefs with four adjacent unrestored reefs. Success will be measured in oyster densities, elevation of the reefs, and recruitment of young oysters. If the project succeeds, the results may be used to attract funding for larger restoration projects along the coast.

- The large-scale oyster restoration proposal submitted to DEP for consideration of RESTORE Act funding has been endorsed by the Suwannee River Water Management District, The Nature Conservancy, and the U.S. Fish and Wildlife Service's Lower Suwannee National Wildlife Refuge.

Objective 5

- The Levy County advisory committee established an application and application procedure for potential projects, programs or activities to be funded by RESTORE Act funds
- In addition, the advisory committee began soliciting and accepting applications, reviewing and ranking each proposed project, program and activity based upon the guidelines provided in the RESTORE Act, federal rules, community and regional needs and desires, the best available science for natural resource protection or restoration projects, and other relevant factors.

Success Stories

It took a community… every spring and throughout the summer, horseshoe crabs visit Florida beaches to mate and nest. This year at the City Beach in Cedar Key, an educational display was installed to inform the public about these activities as well as the importance of this unique marine creature. The colorful, customized panel placed on the railing along A Street was the culmination of many efforts over the past year or so. The idea was formed as a tribute to a local resident, who dedicated countless hours conducting beach surveys and educating the public about horseshoe crabs. A memorial fund had been set up by her family for this purpose. In addition, I along with family members crafted shadow boxes with crab molts (for a horseshoe crab to grow, it must shed its shell) and made them available for purchase at several local shops. Over $600 was generated through sales of these boxes. Along with $500 provided by UF IFAS, enough funds were solicited to cover the costs of designing and fabricating the educational panel. In addition, volunteers constructed a cypress frame for the panel and a customized aluminum bracket was funded by the Cedar Key Aquaculture Association. It is fitting that so many people and groups were involved in making this happen as this special person was an advocate for all in this small island community. This past spring, the panel was "unveiled" by her sons and their families and dedicated in her honor.

VII. YOUTH EDUCATION IN SHELLFISH AQUACULTURE

Situation

Situation statement: Shellfish aquaculture is a relatively new marine agriculture industry. Acquainting youth with aquacultural projects is important in order to make them understand and recognize aquaculture as they become adult consumers and voters. Introduction to clam farming through hands-on demonstrations and field days was the primary venue for these efforts.

Target Audience(s): Youth, K-12, 4-H groups, and undergraduate students

Program Objectives:

1. Provide assistance through educational programs and demonstrations to all organizations and schools utilizing agricultural or marine education programming for youth and students.

Educational Methods and Activities

- Provided information and was interviewed by a high school student from Tallahassee for his senior project on the fishing net ban. His documentary entitled *From Nets to Clamelot* can be viewed

on YouTube, http://youtu.be/nheNRl5bjhA.

- Provided the middle school science teacher in Cedar Key with technical assistance in preparing six students for a Future Farmers of America aquaculture competition by dissecting and reviewing anatomy of marine fish and shellfish.
- Worked with three Cedar Key High School students, who volunteered at area festivals, to inform the public about clam farming as part of their community service requirements.
- Taught "hands-on" sessions on clam farming and provided tours of commercial facilities in Cedar Key to 1) 20 high school students from Keystone Heights, and 2) 15 high school students from New York City, who were part of a science consortium held at Seahorse Key Marine Lab.
- On behalf of the Florida Aquaculture Association, reviewed two applications for the "Aquaculture-in-the-Classroom" Grant Program and made an award of $500 to the Bok Academy in Lake Wales to augment their aquaculture curriculum for the school year 2013-14.
- Conducted lectures and tours of clam farming operations in Cedar Key to 1) 24 undergraduate students as part of a UF SFRC Foundations in Natural Resources and Conservation introductory class, and 2)18 students in a UF FRED Economics of Resource Use class.

Outcomes and Impacts

- Through "hands-on" sessions about clam farming and tours of commercial facilities in Cedar Key efforts, a minimum of 100 students, from middle school to college, have been involved in aquacultural educational projects, gaining knowledge and experience in clam farming.
- Introducing youth to the science of aquaculture will lay the foundation for a more aquacultural literate community in the future. It is vital to the future sustainability of this industry that we educate youth about local practices and their importance to our county and state. Engaging youth in aquaculture education will make them more likely to pursue degrees and careers in the field.