University of Florida Cooperative Extension Service

THE BIVALVE BULLETIN

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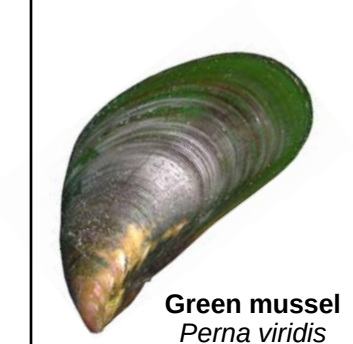


Green mussel
Perna viridis

Species Diversity in Florida's Shellfish Aquaculture Industry

Over the past several years there has been an escalating national campaign by scientists and growers organizations alike to educate the public about the positive benefits and virtues of filter-feeding bivalve shellfish—clams, oysters, mussels, and scallops. Not only does shellfish culture represent a legitimate use of the marine environment for sustainable food production, but shellfish are key players as environmentally sensitive monitors and water purifiers. Recent studies have revealed that shellfish farming can improve species abundance and diversity. Culture equipment and gear act like reefs and provide habitat for a myriad of marine organisms, serving as nursery grounds for fish, crabs, and others. They provide protection from predators, increased surface area for fouling (a benefit for many micro-organisms and grazers, but not to the growers), and an increased food supply for other species. Just released is a web-based publication (also available as a CD-ROM) called *What's in the Clam Bag?*, which showcases the diversity of organisms found in, on, and around clam culture bags in Florida. On pages 3 and 4 of *The Bivalve Bulletin*, you can find out how to access this pictorial guide.

The shellfish culture industry in Florida is a monoculture industry, based on one bivalve—the hard clam. To diversify and expand this industry, several native molluscs, such as the angel wing, bay scallop, and blood ark, have been studied to determine their culture and market potential. Currently, the sunray venus is being investigated as a new aquaculture species. This attractive clam is similar to the hard clam and was previously the target of a commercial fishery in Florida. An update on this research project is provided on page 5 of this newsletter.

Successful diversification of bivalve aquaculture in other parts of the U.S., in particular the Pacific Northwest, has been achieved through the use of non-native species, such as the Pacific oyster and Manila clam. The recent introduction to Florida of the green mussel, which is an important fishery and aquaculture species in the Indo-Pacific, has some speculating on its prospects for commercialization in the U.S. The following article will allow you to better understand the green mussel's future role in our coastal environment. Sources of information: Sandra Shumway et al., *Shellfish aquaculture-In praise of sustainable economics and environments*, World Aquaculture, Dec.2003; East Coast Shellfish Growers Assoc., *www.ecsga.org*

Green mussel invasion of the U.S.: What does it mean for Florida? *by Drs. Patrick and Shirley Baker*

The green mussel, *Perna viridis*, is a tropical species known to most of Southeast Asia. The shell is smooth and covered by a bright green coating, especially in juvenile specimens. The color may fade to brown in some habitats, but the shell margins are almost always green. The inside of the shell is pearly white. Like all mussels, green mussels attach to objects by a cluster of tough byssal threads. Specimens over 3 inches in shell length are common and the largest may get twice that size. Juveniles and adults have limited mobility but primary dispersal is by planktonic larvae, which can stay in the water column up to several weeks. Green mussels are often confused with other members of the genus *Perna*, particularly the New Zealand green-lipped mussel which is found in seafood markets and restaurants throughout the world.

Green mussels were observed in Trinidad in 1989. This was the first reported Atlantic occurrence. The source of the Trinidad invasion is unknown, although ballast water is a possibility. By 1992, the species was present in Venezuela, where it became a local fishery, and in Jamaica by 1998. In 1999, green mussels were reported in the intake filters of a Tampa Bay power plant. Various local research groups mapped the early spread of the species and found that, by late 2000, it had spread south to Charlotte Harbor. Northward expansion was slower, possibly reflecting dominant coastal current patterns that tended to carry larvae south.

Our group began study of the Florida green mussel invasion in 2001. The southern spread along the Florida west coast has continued, but not as dramatically as in its first two years. We have not found any specimens south of the Ten Thousand Islands, which is well north of the ecologically diverse Florida Keys. Northward, the species has been observed as far as Anclote Key, 30 miles above Tampa Bay. This is good news for the comparatively pristine Big Bend region, the heart of the state's shellfish industry. In late 2002, we discovered green mussels in the Daytona Beach area. The species has subsequently become abundant in the Jacksonville and St. Augustine areas and has been reported in Savannah, Georgia and, recently, in Charleston, South Carolina. These cities are important harbors for coastal barges and marine traffic is a reasonable vector for this secondary invasion. →

Green mussel invasion (continued from Page 1)

Impacts of green mussels on habitats and native fauna: We have found green mussels to be very abundant on many habitats in Tampa Bay. However, its distribution is far from even and more complex when one compares habitats within salinity and tidal ranges. The species survives indefinitely in full seawater in the laboratory, but it is uncommon to rare in full marine natural habitats. Within estuaries like Tampa Bay, green mussels are common from salinities of 30 to 14 ppt, but are most abundant between 20 and 28 ppt. Green mussels appear to be limited to the lower two thirds of the intertidal, but form a solid coating from there on down. Exposed artificial structures, like bridge pilings and navigation structures, are reliably covered with green mussels. Identical structures in quiet waters are less likely to be covered.

In any marine environment, there are many fouling species. Not only do ships and industries have to deal with fouling communities, but so do native hard-shelled animals, from oysters to sea turtles. One might presume that marine bivalves like the economically and ecologically important eastern oyster would be well-adapted to fouling species. We already knew that oysters had once occupied the bridge piers and pilings in Tampa Bay that were now coated with green mussels, but these were artificial habitats. Of more concern were several oyster reefs in the bay. Early in the invasion, we saw few green mussels on these reefs. By 2002, they coated the reefs and oysters beneath were dead. The only living oysters were juveniles growing on the mussel shells.

Green mussels on pier

We were able to compare the impacted reefs in Tampa Bay to oyster reefs near Cedar Key. Although barnacles and native mussels were present on both reefs, the reef surfaces at both sites were dominated by either living oysters, living green mussels, or "reef matrix," a mixture of shells, mud, and mud-dwelling animals. At Tampa Bay, green mussels were strongest in the intertidal and appeared to displace about half of the oysters. The 1-year class oysters were rare and adults absent, with juveniles growing on top of green mussels. At Cedar Key, in the absence of green mussels, living oysters covered half the reef with a typical age-class distribution, skewed towards juveniles but adults reasonably abundant.

This does not mean that oysters are endangered in Florida, or even rare in green mussel areas. On bridges, oysters survive in a narrow band in the intertidal above the mussels. Oysters also thrive in quiet habitats like mangroves and seawalls that green mussels mostly avoid. Even on the reefs, some adult oysters appeared to persist in the subtidal with green mussels. Also, oysters tolerate lower salinity than green mussels, so some reefs may avoid infestation. If some unforeseen event were to eradicate the green mussel invasion, the oysters would probably recover. Nonetheless, impacts by green mussels on oysters are serious. Mussels form aggregations, but they don't form reefs; they are held together by byssal threads, not cemented like oysters. Green mussels cannot replace oysters; but we may expect to see degradation of oyster reef habitat.

Forecasting the spread of green mussels: Green mussels are a tropical species. Our own laboratory tolerance tests bear this out; they die in a week at 50°F, and in ten days at 57°F. Using average January water temperatures, we predict that the northern Gulf of Mexico and South Carolina will be marginal habitat. Field observations from Georgia and northeast Florida suggest that even those areas may be marginal; green mussels appear to have died back subtidally as well as intertidally in those areas, while remaining strong in Tampa Bay. Texas will probably be warm enough for green mussels; but they will not be a problem for most U.S. coastal waters.

There is an intriguing exception to this thermal limit, and it is illustrated by the invasion of green mussels in Japan. Most of Japan, like the U.S., is too cold for green mussels. Nonetheless, they have persisted in Tokyo Bay and other harbors due to thermal pollution, or thermal effluents. The generation of electrical power creates vast amounts of waste heat that must be dissipated. Most of this is dumped into a local body of water, producing large, continuous thermal oases even in the most frigid waters. Green mussels in Tokyo Bay die back each year, except in the thermal effluents, and spread out again each summer. Similar thermal plumes exist in U.S. estuaries and, if green mussels manage to reach those oases, there is no reason why they couldn't persist. Green mussels are not particularly tolerant of high temperatures (95°F) in the laboratory, but we have not seen any heat-related kills in Florida. We have observed summer mortality of green mussels in both Tampa Bay and Sarasota Bay, but this is correlated with blooms of toxic dinoflagellate (red tide).

Conclusions: The green mussel is a valuable fishery or aquaculture species in some parts of the world. It is similar enough to the New Zealand green-lipped mussel to possibly share some of the U.S. market, valued at $40 million annually. These factors, plus the fact that the species is already present in Florida, will doubtlessly encourage some to promote the green mussel as the next commercial U.S. shellfish product. On the other hand, the eastern oyster is of known importance not only as a commercial species, but also as an ecosystem engineer, in coastal environments from the Gulf of Mexico to New England. Florida has healthy oyster reefs but green mussels present a danger to those reefs. There is a clear conflict of interests in the making. It is possible that green mussels will spread where they will despite our best efforts, but it is also possible that there are management options to reduce the impacts or at least slow the rate of spread. Management decisions that affect all of Florida's coastal ecosystems belong to resource managers and should be guided by the user groups, from culturists and fishermen to conservationists and recreational users who might be affected. One thing is clear—green mussels are coming and they will make themselves noticed.

This is excerpted from an article published by the authors in the World Aquaculture Magazine, December 2006. For a complete copy or more info, contact Drs. Patrick or Shirley Baker, UF Dept. of Fisheries and Aquatic Sciences, at (352) 392-9617.

WHAT'S IN THE CLAM BAG? A guide to marine organisms found in, on, and around a clam bag

Farming of hard clams supports many small businesses in Florida with over 100 million clams produced each year. Farms are located on submerged lands in inshore coastal waters leased from the State of Florida. In siting a shellfish aquaculture lease, the state requires the proposed area to undergo a resource survey and in essence, be devoid of sea grasses and other marine life. Once in production, a clam farm may have over 1000 culture bags planted per acre of lease bottom. When a farmer harvests clams, there are many more "critters" that inhabit the bags than just the crop. The clam bag creates a favorable environment and provides habitat and protection, both inside and outside, for a myriad of plants and animals. The diversity and abundance of marine organisms stimulated through farming activities is one of the positive benefits that shellfish aquaculture provides to the coastal environment.

A pictorial guide has been developed to assist clam farmers and others in identifying these organisms. The guide also provides information on effects of the organisms on the clam crop and what a farmer might do to lessen those effects. For now, the guide is limited to those marine organisms commonly found in the Suwannee Sound area, where clam leases in Levy and Dixie Counties are located. There are over 150 organisms featured. Many of these organisms can also be found at clam growing areas in other parts of the state. The following contributed to the development of this guide: Jonathan Fajans, Florida Institute of Oceanography; Leslie Sturmer, Shirley Baker, and Eric Cassiano, UF/IFAS; and, Kevin Hulen, UF Dept. of Biological Sciences. Images, identification, and classification of the marine organisms were completed by Jon Fajans.

To use What's in the Clam Bag?, go to the website, http://shellfish.ifas.ufl.edu. Then click on the picture you see above. CDs are also available, call 352-543-5057 .

How do I use this pictorial guide?

The guide is divided into easily recognizable, but not taxonomic, categories. You will first click on an identification category that most closely resembles the organism you want to find. The link will take you to a category page which features several species and their pictures. From there, you can navigate to pages that provide descriptions of the individual organisms. These biographical sketch pages describe the organism, as well as characteristics that make it a **friend**, **foe**, or **neighbor** to clam farming. This information is provided to help you identify organisms, particularly those that are foes, and begin to find possible solutions, such as alternative growing methods or sites, treatments, and control measures.

What is a "**friend**"? Organisms that are friendly, or positive, to clam farming:

- Consume predators of clams
- Consume organisms that foul clams or clam bags
- Burrow and aerate the sediment
- Consume clam waste

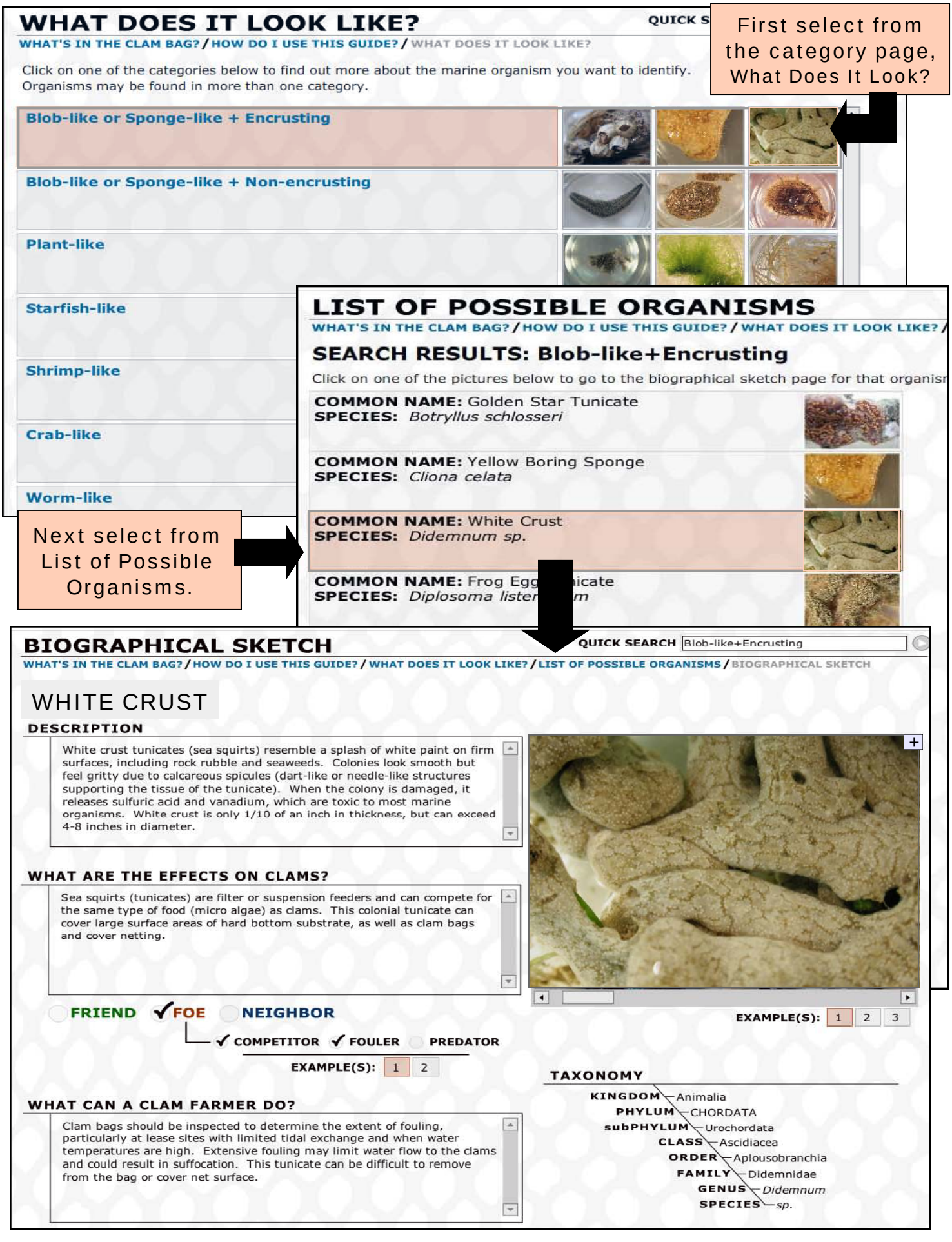
What is a "**foe**"? Organisms that are foes, or pests, to clam farming:

- Predators — Organisms that can penetrate the clam shell and consume the clam
- Foulers — Organisms that encrust or attach to the clam bags or cover netting and obstruct water flow to the clams, or organisms that encrust or attach to the clam shells, making them undesirable for market, or impeding their opening
- Competitors — Organisms that compete with clams for food or space, for example other filter-feeding organisms

What is a "**neighbor**"? Organisms that are neighbors have neither positive nor negative effects on clam farming. They do not consume clams, foul clam bags extensively, or compete with clams, but neither do they provide any positive services.

So let's see how this guide works....

The pictures on the left are of marine organisms commonly found attached to either clam bags (far left) or cover netting (left). To identify this organism, you would first select "Blob-like or Sponge-like + Encrusting" from the category page, then select "White Crust" from a list of possible organisms. Continue on to the next page to see how this works.


WHAT DOES IT LOOK LIKE?
QUICK S
WHAT'S IN THE CLAM BAG? / HOW DO I USE THIS GUIDE? / WHAT DOES IT LOOK LIKE?
Click on one of the categories below to find out more about the marine organism you want to identify.
Organisms may be found in more than one category.
Blob-like or Sponge-like + Encrusting
Blob-like or Sponge-like + Non-encrusting
Plant-like
Starfish-like
Shrimp-like
Crab-like
Worm-like
First select from the category page, What Does It Look?
LIST OF POSSIBLE ORGANISMS
WHAT'S IN THE CLAM BAG? / HOW DO I USE THIS GUIDE? / WHAT DOES IT LOOK LIKE? /
SEARCH RESULTS: Blob-like+Encrusting
Click on one of the pictures below to go to the biographical sketch page for that organisr
COMMON NAME: Golden Star Tunicate
SPECIES: Botryllus schlosseri
COMMON NAME: Yellow Boring Sponge
SPECIES: Cliona celata
COMMON NAME: White Crust
SPECIES: Didemnum sp.
Next select from List of Possible Organisms.
BIOGRAPHICAL SKETCH
QUICK SEARCH Blob-like+Encrusting
WHAT'S IN THE CLAM BAG? / HOW DO I USE THIS GUIDE? / WHAT DOES IT LOOK LIKE? / LIST OF POSSIBLE ORGANISMS / BIOGRAPHICAL SKETCH
WHITE CRUST
DESCRIPTION
White crust tunicates (sea squirts) resemble a splash of white paint on firm surfaces, including rock rubble and seaweeds. Colonies look smooth but feel gritty due to calcareous spicules (dart-like or needle-like structures supporting the tissue of the tunicate). When the colony is damaged, it releases sulfuric acid and vanadium, which are toxic to most marine organisms. White crust is only 1/10 of an inch in thickness, but can exceed 4-8 inches in diameter.
WHAT ARE THE EFFECTS ON CLAMS?
Sea squirts (tunicates) are filter or suspension feeders and can compete for the same type of food (micro algae) as clams. This colonial tunicate can cover large surface areas of hard bottom substrate, as well as clam bags and cover netting.
FRIEND FOE NEIGHBOR
COMPETITOR FOULER PREDATOR
EXAMPLE(S): 1 2
EXAMPLE(S): 1 2 3
WHAT CAN A CLAM FARMER DO?
Clam bags should be inspected to determine the extent of fouling, particularly at lease sites with limited tidal exchange and when water temperatures are high. Extensive fouling may limit water flow to the clams and could result in suffocation. This tunicate can be difficult to remove from the bag or cover net surface.
TAXONOMY
KINGDOM Animalia
PHYLUM CHORDATA
subPHYLUM Urochordata
CLASS Ascidiacea
ORDER Aplousobranchia
FAMILY Didemnidae
GENUS Didemnum
SPECIES sp.

RESEARCH UPDATE: Sunray Venus Clam Seed Production *by LeRoy Creswell, Florida Sea Grant*

Background: Like most boys growing up along the Chesapeake Bay in the 1960s, I spent most of my free time catching blue crabs, shucking oysters, and collecting seashells. Back then there were three Florida shells that were sought after by avid collectors – the queen conch (representing the Florida Keys Conch Republic), the horse conch (state seashell of Florida), and the sunray venus clam (a beautiful glossy, striated clam found along Florida's sandy beaches). These large clams (4–7 inches) were also prized for their meat; a commercial dredge fishery developed in the Panhandle during that time with the meats processed for the fried clam strip market. Over time commercial harvesting was halted due to the limited size of the fishing grounds and low catch per unit effort. During those years, growth experiments using marked individuals suggested that these popular clams attained a length of three inches (40 grams whole weight) within 12 months; similar in time to hard clams in Florida. The prior fishery, market, and potential growth rate of the sunray venus clam, along with being a native species, make it a logical choice as a new species to diversify and expand the Florida clam industry.

Objectives: With financial support from Florida Sea Grant, scientists from the University of Florida/Institute for Food and Agricultural Science and Harbor Branch Oceanographic Institution (HBOI) have spent the past year evaluating the sunray venus clam for aquaculture purposes; specifically, hatchery and nursery techniques. As Florida bivalve culturists work almost exclusively with the hard clam, it was important to identify what culture methods used for hard clams could be used for sunray venus and what modifications might be required for seed production.

Results to date: Broodstock collected from near St. Teresa Beach (Franklin County) and Seahorse Reef (Levy County) were shipped overnight to HBOI (shipped in-water or dry/cooled) and arrived in good condition (with no difference in shipping method…except cost). A few cracked clams resulted in mortalities over the next few days, but still represented less than 10%. These clams didn't spawn after shipment, but after being held in a conditioning system at HBOI (cooled, dark, and well-fed cultured algae), the clams were successfully spawned on two occasions using standard methods (temperature cycling and addition of stripped sperm). Although not as easy to spawn as hard clams (the literature indicates that the venus clams are notoriously difficult to spawn), we conclude that conditioning and spawning will not be a significant impediment to the process.

Larviculture was straightforward and similar in process as for hard clams. Larvae reached the pediveliger stage and settlement in eight days (200x170 microns) with high survival to set (around 80%). Settlement experiments were conducted to determine if substrate was required for successful metamorphosis and subsequent survival. Typically, this is a critical time in the culture process; some bivalves (e.g., angel wings) require a substrate in which to burrow–hard clams do not. Although sunray clams did not need substrate for metamorphosis and settlement, after two months of culture there were almost twice as many juveniles in wellers with quartz sand as compared to no substrate.

Sunray venus clam
Macrocallista nimbosa

Now that we had a good idea of hatchery protocol and performance, the next step was to further evaluate the performance of sunray venus clams in commercial hard clam nurseries. Project partners Kevin Reinecke (Blue Acres) and Ewan Leighton placed sunray seed either in upwellers (no substrate), in sand-filled trays (1,600 clams/ft^2), or in troughs that could silt in. At both facilities, clams that had the opportunity to bury grew more rapidly than those without substrate. This perhaps is where the nursery culture of sunray venus clams might differ from hard clams. Kevin commented that as the shape of sunray clams is different (i.e., oblong versus round) the clams may need to spend more time in the hatchery before transferring to nurseries. As the height to length ratio is less for sunray venus clams as compared to hard clams, they tend to move through standard mesh openings commonly used for hard clams. Sieved sunray clams may be retained on a certain mesh size when first sieved as they are horizontal, but once allowed to settle they turn vertical and move through the mesh openings. Therefore, sunray venus seed may need to be a larger size (e.g., 5-6 mm shell length, which would hold up on a 2.0 mm mesh) for stocking land-based nursery systems to avoid losses. Ewan commented that the smaller sunray venus seed he received required using up-wellers with a smaller mesh size than for hard clams resulting in clogged wellers and more cleaning. Although we have not calculated survival for the nursery seed, both project partners considered the seed to be hardy and handled similarly to hard clams. The nursed seed have been transported to lease areas in Alligator Harbor for further nursery and growout culture.

What's next? Barring any unforeseen environmental or hurricane events, the first crop of sunray venus clams may be ready for market evaluation as early as this winter. Clams will be delivered to participating local chefs who will provide insight into the pros and cons of preparing them. Information collected will better determine the appropriate price ranges to be used in the financial feasibility analysis. We are optimistic that sunray venus clams will show similar hatchery, nursery, and growout requirements as the hard clam, and that their costs and markets will be similar (if not a different price structure). Then we can decide if sunray venus clams will find their place in Florida's shellfish farming industry.

For more information on this project, contact Dr. John Scarpa, HBOI, at (772) 465-2400, extension 404 or JScarpa@hboi.edu.

Sea Grant Florida

CLAMmunications

Water Quality Monitoring Stations are online at www.FloridaAquaculture.com

Wondering how hot the water temperature is or what direction the wind is blowing from on your lease? No more guesswork is involved. For "real-time" information on these parameters and others (salinity, dissolved oxygen, turbidity) at selected lease areas, simply click onto the Division of Aquaculture's website, www.FloridaAquaculture.com, and go to "Live Water Monitoring." Water and weather monitoring stations are located at the following lease areas: Dog Island and Gulf Jackson (Levy County), Horseshoe (Dixie County), Indian River (Indian River County), and Alligator Harbor (Franklin County). Additional battery-powered stations are to be placed at Body F (Brevard County) and Pine Island (Dixie County) soon. After several months, archived data will be posted as monthly graphs at the website, http://shellfish.ifas.ufl.edu. Funding for the operation and maintenance of these stations comes from the USDA Risk Management Agency through a cooperative partnership agreement with UF/IFAS Shellfish Aquaculture Extension and FDACS Division of Aquaculture.

Pilot Crop Insurance Program extended through 2011

Last summer listening sessions were held in four Florida counties and three other states for clam growers to comment on the pilot crop insurance program. Consultants from the Research Triangle Institute included those comments in a program review submitted to the USDA. Their report addressed the unique challenges associated with aquatic crops. Risks are more complicated and less well understood than those of more traditional agricultural crops. Vulnerability to mortality risks varies by size, age, and production practices. In addition, water quality is influenced by many factors, increasing the difficulty in attributing mortality to a specific cause, where some are covered by the insurance program and some are not. Further, live product inventory and size distribution is more complex than for nonaquaculture crops, leading to issues in determining the inventory to be insured and verifying losses in an event of a claim. This past April, the Federal Crop Insurance Corporation approved the continuation of the Cultivated Clam Crop Insurance Program on a pilot basis through the crop year 2011. The program extension will allow USDA to make technical changes to ensure the policy is legally sufficient and financially sound.

Sign-up deadline for NAP coverage is September 1

The sales closing date, or deadline, for the Noninsured Crop Disaster Assistance Program, or NAP, for crop year 2008 is September 1. This includes coverage for land-based nursery and field nursery in all counties, and growout in counties that are ineligible for the crop insurance program. Sign-up at your USDA Farm Service Agency county office.

INTRODUCING: *What's in the Clam Bag?* A pictorial guide to marine organisms found in, on, and around a clam bag at http://shellfish.ifas.ufl.edu

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This newsletter is published through the University of Florida Cooperative Extension Service. For more information, contact

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