NRAC Publication No. 215-2010

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Nursery Culture of the Bay Scallop

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As wild populations of bay scallops become scarcer along the East Coast of the United States, increasing their commercial value, the demand for hatchery-reared juveniles to be used in restoration efforts and culture trials has become increasingly more important.

Bay scallop aquaculture involves three basic stages: hatchery, nursery and grow-out. This NRAC Fact Sheet provides a summary of nursery culture methods for the bay scallop.

Nursery culture involves raising scallops from post-set spat (200 µm) to 5+ mm juveniles. Nursery culture is usually broken into two phases: an early post-set period to 1-2 mm in size, and a subsequent juvenile phase to about 5 mm, at which time the scallops are transferred to grow-out systems (Figure 1).

Early Post-Set: This phase is generally an extension of the hatchery/setting system in which the spat are reared in a controlled, closed environment of filtered seawater and cultured phytoplankton. When held in static systems, the spat require regular feedings. Feeding rates are determined through trial and error as the scallops clear the water. To maintain appropriate cell densities, the microalgae are supplied in batches multiple times during the day or continuously via a gravity flow, drip system or metering pump.

Figure 1. The bay scallop *Argopecten irradians.*

Scallop spat are conventionally set on spat collector bags or in downweller sieves. Spat bags are small-mesh (0.75-3.0 mm) plastic bags (about the size of onion bags) manufactured for the collection of wild spat. They are typically stuffed with monofilament or Netron®, a specialized plastic net material that expands the bag's interior and provides increased surface area for spat to attach.

Downweller sieves are constructed from 18 inch diameter PVC duct pipe cut into 3 inch rings with fine (100 – 3,000 µm) plastic screening glued to one end.

Figure 2. 35 day-old post-set scallop.

Scallops in spat collector bags are cultured in the same static, aerated larval tanks they where set in. Standard protocol recommends draining and rinsing the tanks every two days. As the tank is being drained, the bags can be gently sprayed with seawater to flush off feces, but it is necessary to use a catch sieve to collect any spat that become detached.

Spat set on sieves are likewise initially kept in closed systems (Figures 2 & 3). Air lifts or submersible pumps are used to circulate water to the scallops on the sieves, allowing the spat to be held at much higher densities than in the spat bags. Because the spat are contained on the downweller sieves, they can more easily be removed from the larger culture system, allowing for daily rinsing and more frequent cleaning of the entire system.

Figure 3. Downweller sieves receiving recirculated flow through a manifold.

When exposed to air during rinsing, spat detach from the sieves facilitating grading by size and thinning to larger mesh sieves. The spat are routinely cultured indoors on downweller sieves for about a month post-set or to a size of approximately 1 mm (Figure 4).

Figure 4. Post-set scallops in downweller sieve.

As the scallops grow larger, the capacity and cost of producing enough microalgae to feed them becomes a problem. Economics dictate moving the seed to a natural source of food as soon as possible. Once the ambient seawater is warm enough (>15^{o} C), the spat can be weaned onto a natural diet via a flow of filtered raw seawater. Early post-set and even swimming eyed larvae have been successfully cultured in downweller sieves receiving a trickle flow of ambient seawater filtered through a 5µm bag filter. As the spat grow, they are moved to larger mesh downweller sieves and supplied with a greater flow of water filtered through larger mesh bag filters (25-50 µm) (Figure 5).

When the spat reach about 1mm in size, they are generally moved to either land based nursery systems or placed in the field. Land based systems provide greater control and protection than open water field systems; however, because they require a pumped source of seawater, they are more costly to operate.

There are two common land based nursery systems, raceways and upwellers.

Raceways: Raceways are particularly well suited for scallop seed culture. The scallops naturally distribute themselves evenly around the sides and bottom surfaces to maximize their exposure to available food and oxygen (Figure 6).

Figure 5. Downweller flow delivered via 50 micron bag filters.

When held at proper densities and unstressed, the scallops adhere strongly to raceway surfaces with byssal threads, making the system easy to clean. General cleaning protocols involve draining the tanks daily and rinsing the scallops with seawater to remove accumulated feces and silt. A catch sieve is positioned under the outlet pipe to catch any loose scallops.

Proper seed density is largely a function of available surface area and inflow rate. Generally, the scallops prefer to be one layer deep. However, when provided with large volumes of flow, they can be grown at higher densities. Stressed scallops will detach from the raceway walls and swim about the tanks seeking more suitable environs, eventually ending up in the catch sieves. This is a clear indication to the culturist to reduce scallop densities and clean the raceways.

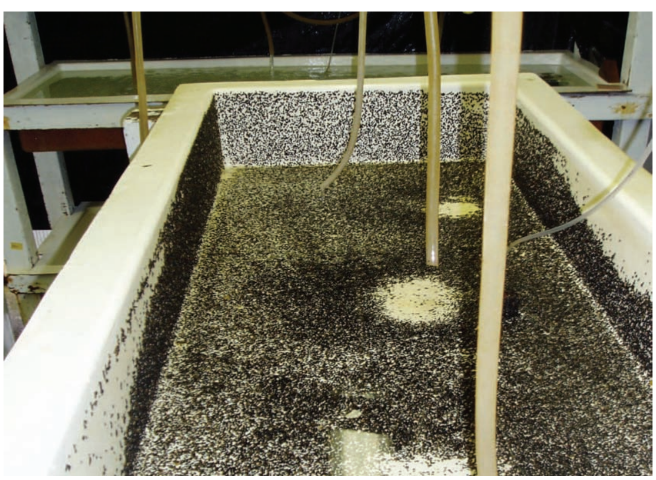

Figure 6. Spat attached to raceway surfaces.

Raceways generally need to be cleaned weekly. Following draining and rinsing, the scallops are scraped off the tank walls using a plastic card. Soft plastic auto body putty spreaders work well. As in all phases of shellfish culture, when the opportunity presents itself, it is important to sieve the shellfish and segregate them by size. Because the raceway system is generally an intermediate step between nursery and field systems, removal of larger seed serves to maintain proper scallop densities in the raceways.

Upwellers: Upweller technology involves holding the seed in deep, usually cylindrical, sieves called silos (Figure 7). As the name implies, upwellers direct the flow of incoming seawater up through the mesh bottom of the silo instead of down onto the sieve. Upwellers offer several distinct advantages over downwellers; in particular, they eliminate the need to filter the seawater supplied to the shellfish. However, because the seawater is unfiltered, mesh sizes smaller than 500 µm will clog, which limits the use of upwellers to seed smaller than 1mm.

In nursery operations where silt load is a problem, upwellers offer a better method than raceways since they keep the seed above the silt. Because seawater enters an upweller through a screen, it prevents seaweed and large detritus from smothering the seed when the source water is not coarsely pre-filtered. Also, when space is a premium, upwellers may enable the culturist to hold the scallops at higher densities.

Figure 7. Land based upweller.

Upwellers, however, do not work as well for culturing scallops as they do for oysters and quahogs. Because scallops swim, it is necessary to equip the outflow pipe with mesh to prevent the scallops from escaping. Also, unlike oysters and quahogs, scallops do not like to be cultured on top of each other, rather preferring to distribute themselves in a single layer. Their densities are thus limited by the surface area within the culture vessels. To increase the limited capacity of a conventional silo, the three-dimensional surface area may be increased by adding materials like monofilament or Netron®; however, this also increases cleaning frequencies and adds to labor costs.

Field Nurseries: The decision of when to move seed from onshore facilities to field nurseries is usually a balancing act between production costs and product losses. Although more likely to result in greater loss of shellfish, the economic advantages gained in culturing seed scallops in open water field nurseries often favors their use over the more protected onshore nurseries. Eventually, limited onshore holding capacity and the high costs of providing adequate water flow to an increasingly large biomass of animals necessitates the transfer of shellfish to open water and less intensive nursery systems. A variety of methods are used including FLUPSYS, spat bags, pearl nets, floating nursery cages, and bottom racks or cages.

In field nursery systems, food is supplied from the natural productivity in the water. As most field nursery methods involve containing the scallops within a mesh structure, biofouling becomes the primary technical obstacle. Frequent brushing of the mesh is required to maintain the all-important flow of seawater. Fine mesh systems generally require daily cleaning, which can be a problem for less accessible field deployments. As a result, seed smaller than 2-5 mm requiring containment in fine mesh enclosures is not usually cultured in field nursery systems.

Predation also becomes a much greater concern when the seed is moved into field nurseries. Mesh enclosures are not 100% effective against predators; crabs can easily tear through soft meshes. Even the security of suspended enclosures can be breached when microscopic larval forms of crabs and starfish swim through the mesh. Once inside, they metamorphose into juveniles, grow quickly and prey heavily on the captive shellfish.

Figure 8. Floating upweller system or FLUPSY.

FLUPSY: The floating upweller system is a field version of the land based upweller that provides almost the same degree of protection for the seed (Figure 8). Although still dependent on a pumped source of water, it is far more energy-efficient. The silos are located in open water and can be supplied with stronger flows of water without the energy losses involved in pumping water long distances and to high elevations. Tidal and solar powered renderings offer even greater energy savings and the added option of locating the nursery away from the electrical grid.

Spat Bags: Bay scallop larvae set in spat bags in the hatchery or wild collected are normally left in the bag through part or all of the nursery period. During the early post-set culture period in the hatchery, density within the bags ranges from 10,000 to 30,000 seed. Once spat reach a size that prevents them from falling through the mesh, the bags can be transferred to the field where they are suspended from floats on a moored long-line (Figure 9).

Eventually, the fine mesh bags become fouled and require brushing, and the scallops must be transferred to cleaner, larger mesh bags to ensure adequate water flow. At 5mm, scallops are moved to 1-1.5 mm mesh bags and thinned to a density of about 2,500 per bag.

Pearl Nets: Pearl nets have long been used in Japan to culture scallops and remain a trusted field nursery method. Pearl nets are single compartment, pyramidal net enclosures with flexible sides and a rigid frame holding the bottom panel flat and level (Figure 10). They are commonly available in mesh sizes from 1.5 to 9.0mm and deployed in the field in series suspended from a

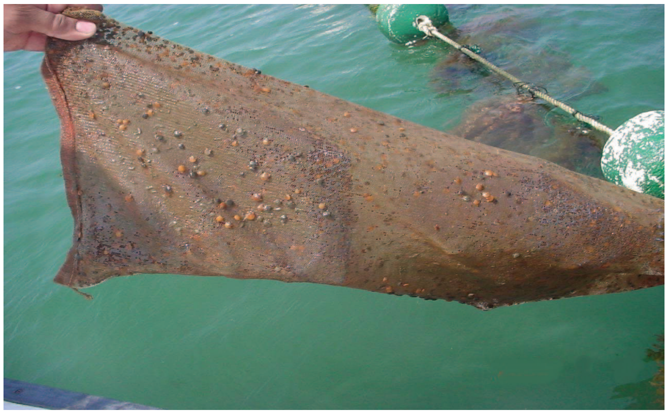

Figure 9. Fine mesh spat bags require brushing.

Figure 10. Large mesh pearl nets.

buoy or longline system very similar to that used for spat bags. Like the spat bags, they require regular brushing.

Seed scallops grow faster than most cultured shellfish. To prevent overcrowding which leads to stunted growth, the seed needs to be thinned and transferred to clean, larger mesh pearl nets on a regular schedule. In general, 2 to 10mm seed scallops grow well when held at densities of 70 to 80 scallops per net (700/m^2). The requirement to maintain clean nets at proper densities, however, needs to be tempered with the knowledge that over handling and exposure to air can also lead to stunted growth.

Floating and Bottom Cages: Cages, which have larger capacities than spat bags and pearl nets, are generally constructed with larger and stiffer mesh for the nursery culture of larger seed.

Wood-framed floating cages have been successfully used to field culture bay scallops from 2.5- 25mm.

Newer floating cage designs, like the Taylor float, substitute PVC pipe for the wood framing. These floats are more likely to be constructed with a large-mesh PVC-coated metal screen basket into which smaller mesh spat bags or other small mesh plastic culture units are inserted.

Rack and bag cage designs, borrowed from oyster culturists, are also used to grow bay scallops for both nursery and grow-out stages. They involve a wire mesh frame with shelves/racks that are designed to contain semi-rigid plastic mesh bags, such as ADPI-OBC®. The bags are stocked with 150 to 250 scallops depending on their size. In one strategy, the cages are suspended in the water column, either beneath marina docks or floated independently using PVC pipe flotation similar to the Taylor float.

In another approach, they are constructed to sit on the bottom (Figure 11). Cages are designed with single or multiple tiers and columns. The size of the unit is determined by both the depth of the water and the grower's ability to lift and tend the system

Figure 11. Wire frame cage with bags for growing scallops on the bottom.

New Innovative Methods

Labor costs, especially in the U.S., are a major constraint to bay scallop culture. In recent years, attempts to economize have included eliminating entire culture phases. Routinely, hatchery production results in millions of post-set juveniles, far more than are needed or could ever feasibly be grown to larger sizes. Under such circumstances, the culturist can afford to adopt new cost saving protocols even if it means reduced scallop survival.

One such innovation involves moving post-set spat directly to open water culture systems, thereby eliminating costly onshore nursery operations. Post–set spat in downweller sieves are deposited on small swatches of fibrous materials (e.g., cheesecloth, burlap, Handiwipes®) to which the spat strongly adhere with byssal threads (Figures 12 and 13).

The swatches, which contain thousands of attached spat, are carefully removed from the sieves and wrapped in bundles of tissue paper in preparation for transfer to spat bags or pearl nets in open seawater. Once the bundles are returned to the water in the field nurseries, the tissue paper dissolves and the spat are free to spread within the spat bag or pearl net. Even though the mesh size is large enough for many of the small spat to escape, enough remain and grow large enough to fill the nursery structures.

Some restoration programs have taken this strategy a step further and demonstrated some success directly seeding wild beds with sticky post-sets and even eyed larvae.

For an expanded version of this bulletin, please refer to: Leavitt, D.F. and R.C. Karney. 2005. Cultivation of the bay scallop. Pages 25-109 *in* A.M. Kelly and J. Silverstein (eds.) *Aquaculture in the 21st Century*. American Fisheries Society Symposium 46, Bethesda, MD.

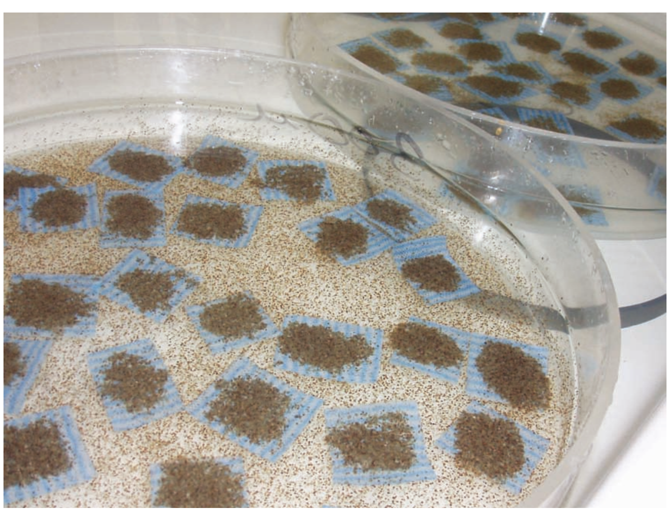

Figure 12. Handiwipe® swatches with post-set scallops.

Figure 13. 27 day-old scallops attached to burlap.

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Acknowledgements

This work was conducted with the support of the Northeastern Regional Aquaculture Center, through grant number 2006-38500-17605 from the National Institute of Food and Agriculture (NIFA), U.S. Department of Agriculture. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the U.S. Department of Agriculture.