AQUACULTURE LECTURE II

A. Brief History

SCIENCE
Strand
- the nature of matter and energy
- processes that shape the earth
- processes of life
- how living things interact with their environment
- the nature of science

Standards
- understands that all water has observable, measurable properties
- recognizes that energy may be changed in form with varying efficiency

MATHEMATICS
Strand
- measurement
- data analysis and probability

Standards
- understands the different ways numbers are represented and used in the real world
- understands and uses the tools of data analysis for managing information

LANGUAGE ARTS
Strands
- listening, viewing, and speaking
- language

Standards
- writes to communicate ideas and information effectively
- uses listening strategies effectively

Scallops are some of the best known shellfishes; this is due mainly to their delicious adductor muscle. People have harvested bay scallops for hundreds of years. For example, Bay Scallops have been found in shell middens of American Indians, including the Timucuan Indians which inhabited Tampa Bay from 800-1300 AD.

The bay scallop has been an item of commerce in the United States since 1858 (Ingersoll, 1886). They were initially used as fertilizer when there were sufficient quantities to collect. However, commercial harvesting of the bay scallop for consumption did not begin until 1870. Until that time they were not popular with consumers (Belding, 1910). The introduction of the dredge in 1874 helped the industry immensely and most harvesting today is still reliant upon the dredge, or other mechanical harvesting technologies.

Massachusetts is the leading state in the harvest of bay scallops, producing between 50 and 80 percent of the national total. In this and producer states there are regulations for licensing, season of harvest, catch limits and minimum size allowable for harvest. Yet, even with these restrictions bay scallop landings on the West Coast of Florida have decreased dramatically in the last three decades. Tampa Bay supported a lucrative commercial bay scallop fishery in the early 1960s, now they are seldom found there. It is illegal to commercially harvest Bay Scallops in Florida.

The large market for bay scallops along with their short time to sexual maturity and high fecundity make them an ideal candidate for aquaculture. Many studies have been done on their life cycles and requirements, which also make this a worthwhile endeavor.

B. Spawning of Adult Bay Scallops

Water Quality Importance

As alluded to in the packet *BAY SCALLOPS: UNDERWATER CANARIES,* bay scallops may be used just as a canary is in a coal mine. When there is a gas leak the canary dies, it is very sensitive; likewise, the bay scallop is very sensitive to changes in water quality. Sewage effluent and increased sediment loads can lead to high mortality in scallop populations and in many cases even a total disappearance of the population. All scallops are sensitive to these water quality changes; however, the bay scallop may be even more sensitive because it is unable to sustain a prolonged valve closure. It also has a more rapid pumping rate and is a continuous feeder.

Temperature and Salinity Consideration

Temperature and salinity ranges greatly affect the growth and survival of the bay scallop. These two physical parameters often have a synergistic effect. Larval and embryonic scallops are much more sensitive to fluctuations in these parameters than are the adult bay scallops or immature scallops of other species.

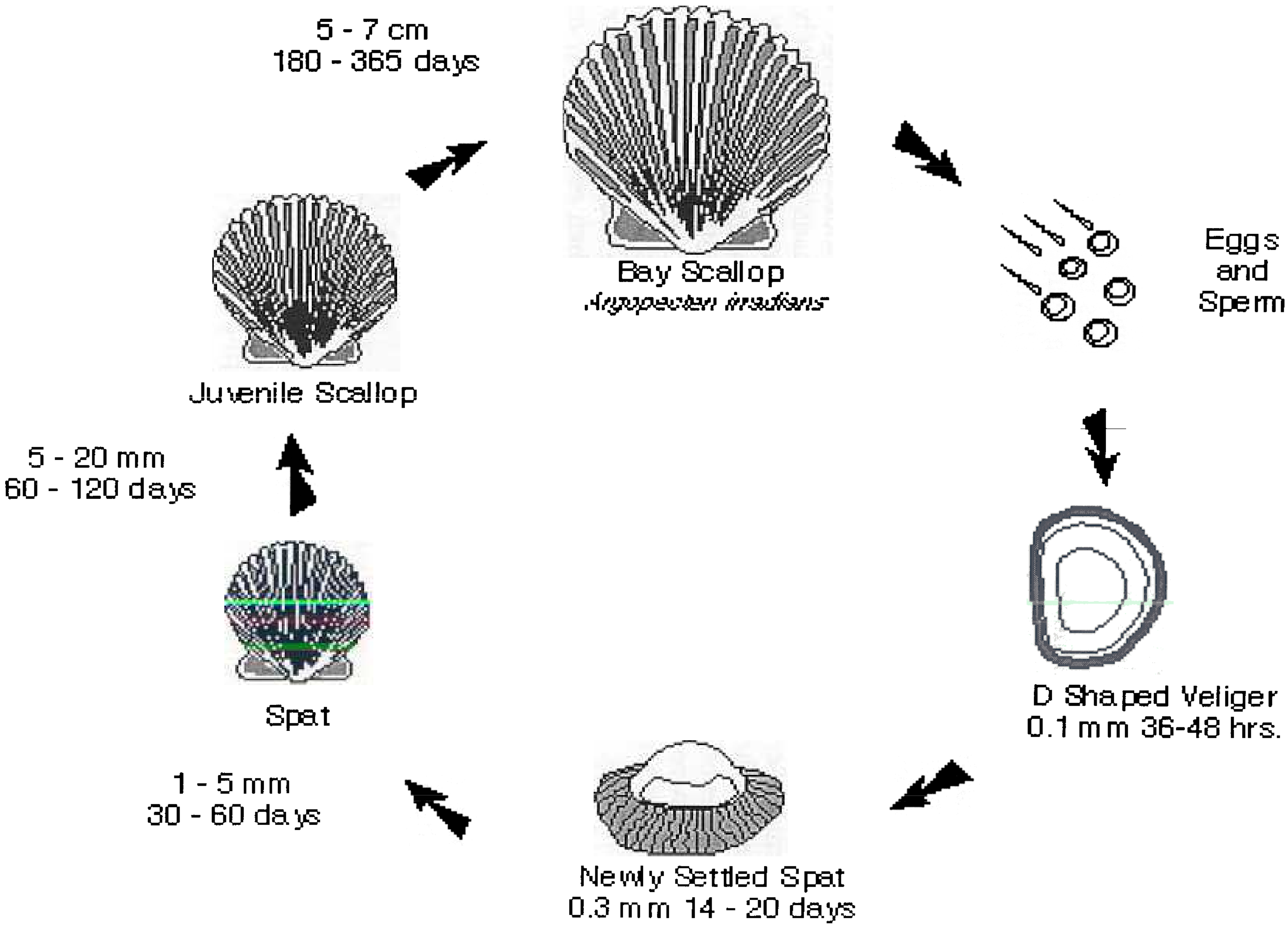
A study done by Tettlebach and Rhodes in 1981 showed greater than 70 percent embryo survival only in the temperature range of 20-25 degrees C with a salinity of 25ppt. The adult bay scallop can survive salinity as low as 7ppt for up to two hours by closing their valves (Duggin, 1975; Sastry, 1961), however, the minimum salinity at which they are found naturally is 14ppt. The upper limit to its salinity tolerance is unimportant as it can survive in salinities up to 38ppt throughout its range Gutsell, 1930).

Behavior of Spawning Adults

The time at which gonad development and spawning takes place is different at different latitudes throughout the range of *A. irradians.* **Gametogenesis** takes place from about April to July in Massachusetts, June through September in North Carolina, and July through September in Florida (Sastry, 1970; Barber and Blake, 1983). This latitudinal variance is thought to be due to food availability and ambient temperature. At the correct temperature and with adequate food availability gametogenesis and spawning will occur.

However, even at the optimal temperature if the food supply is inadequate both sperm and eggs will be reabsorbed. If the food supply is adequate but the temperature is low, food will be stored as a combination of lipid, glycogen and protein until the correct temperature is reached (Sastry, 1968; Barber and Blake, 1981). Also, if the temperature becomes too warm during the cycle, the gametogenic cycle will be halted and resorption will occur.

Life Cycle of the Bay Scallop



Sensitivities to these parameters lead to a variable population size of each year class and variable harvests throughout its range.

Most bivalves are **gonochoric** (separate, invariable sexes), however the family Pectinidae are usually sequential **hermaphrodites**, that is each individual may act as both a male and a female, but usually not at the same time. Generally, they are **protandrous** hermaphrodites, which means they function first as a male and then as a female. Sometimes determination of whether male or female gametogenesis occurs may be influenced by environmental factors such as food and temperature (Sastry, 1968).

Stage I is the juvenile stage when the gonads are empty. When the threshold temperature is reached gametogenesis begins and the follicles begin to expand, this is known as stage II. The gonad then begins to fill with spermatogonia and oogonia, in separate regions of the gonad, this is stage III. This stage may remain for a prolonged time while waiting for some environmental cue.

Stage IV is easily recognizable because the black membrane, which normally covers the gonad, disappears. The stage IV gonad has a bright orange ovary and a cream colored testis. These are tightly packed with spermatozoa and oocytes. Stage IV is normally found in water temperatures of 23 degrees C in Massachusetts, 26-28 degrees C in North Carolina and 30 degrees C in Florida (Barber and Blake, 1983).

Spawning is then initiated by increasing temperatures in the northern latitudes and decreasing temperatures in the southern latitudes (Taylor and Capuzzo, 1983). Though it has been induced in the laboratory simultaneous release from an individual of both sperm and eggs has not been observed in the field (Sastry, 1963). Partially empty follicles with a few mature eggs and sperm indicate the stage V gonad. The stage VI gonads are completely devoid of mature eggs and sperm but may have a few developing spermatogonia and oogonia attached to the follicle walls.

Fertilization in the bay scallop as in other Bivalvia is external. The gametes are released into the sea where fertilization and embryogenesis then occurs. They are simultaneous, broadcast spawners; they all spawn at the same time. This is actually necessary as this increases the chance of fertilization in the external environment.

Larval Rearing

Bay scallops are highly fecund; they have the capability of producing 12 to 18 million eggs in one spawn (Bricelj et al., 1987). However, the mortality rate is very high and only one, if any of these will survive to adulthood. The fertilized eggs develop rapidly. They become tiny larvae in less than 24 hours. These tiny **veliger larvae** eat and float for about 14 days before they attach to the base of a seagrass blade. They have now transformed into the juvenile or spat stage. The spat will gradually move up the blade of grass (Kirby-Smith, 1970).

Though they are now larger and hidden in the seagrass, they are still not safe from predators or adverse physical factors. While in the larval and juvenile stages they are much more sensitive to fluctuations in their environment, such as salinity or temperature changes. As many as 90% of the spat that make it through the precarious larval stage will die before reaching a size at which they can drop off of their seagrass blade (about 20 mm shell height) and begin their benthic existence as adults (Powell *et al.*,1984).

Many different techniques for rearing scallop larvae and juveniles have been utilized in the laboratory setting; these have met with varying degrees of success. The most common early larval development technique uses static, aerated water tanks (Castagna and Duggan, 1971; Castagna, 1975; Karney, 1991; Oesterling and DuPaul, 1993; Lu and Blake, 1996). Simple plastic strips suspended in aerated tanks (Lu and Blake, 1996) or troughs fitted with inserts (Oesterling and DuPaul, 1993) have been used in raising pediveliger and post-set spat. Another technique would utilize the natural environment as a nursery for early juveniles while keeping them enclosed in either flow-through upwelling systems (Oesterling and DuPaul, 1993) or in nylon-mesh bags (Lu and Blake, 1996).

Successful rearing of larval and juvenile scallops requires constant monitoring and control of the temperature, salinity, current speed, food supply, bacteria and turbidity. In the early stage of veliger development energy is derived from food supplied by the egg, but as this is quickly depleted and the veliger larvae become planktivorous. Food consumed by scallop larvae usually consists of marine flagellates and diatoms (Yousheng, 1991). Better results seem to be obtained when a mixture of phytoplankton is used rather than a single species. The mixture of species used is generally changed according to size and life stage of the scallops. The earlier life stages are generally fed with smaller unicellular algae while the latter stages are fed larger forms.