APPLICATION OF THE LARVAL PHASE IN MARINE INVERTEBRATE POPULATION RESTORATION

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In Florida and throughout the United States, the coastal zone is being developed at a rapid pace to the detriment of many nearshore marine species including bivalve mollusks such as scallops, clams, and oysters. Rebuilding and maintaining these populations requires that we first identify the ecological basis of the collapse and then design a restoration strategy that is responsive to those ecological issues.

Bay scallops (*Argopecten irradians*) are distributed as a metapopulation (i.e. a population of populations) in Florida coastal waters. Because bay scallops are an annual species (life span < 18 months), local populations experience substantial interannual fluctuations in density even under the most pristine conditions. When the density of a local population becomes depleted to the point that reproductive potential is compromised, allochthonous larval input from neighboring populations is required to rebuild that population. Thus, the stability of the metapopulation depends upon the existence of many local populations to provide adequate larval supply for the maintenance of healthy populations and for the reestablishment of collapsed populations. Historically, the discrete local populations that comprised this metapopulation were abundant and were distributed from southeast Florida through the panhandle. As local scallop populations in Florida have been exterminated by human population growth and resultant degradation of coastal water quality, that mutual support system has been eroded to the point that the stability of the entire metapopulation is threatened. Even sites with adequate habitat and water quality have experienced almost complete loss of the scallop population because allocthonous larval inputs are not available to replenish the population following a local nadir in population abundance. Our goal has been to rebuild as many of those local populations as possible in an attempt to stabilize the metapopulation.

Initial attempts to rebuild scallop populations exploited aquaculture technology to breed juvenile scallops in a hatchery setting and to then plant those scallops into cages at preselected sites. The planted scallops then grow to adulthood and spawn, thereby maximizing fertilization success and increasing larval supply to the neighborhood. Problems with that approach include the substantial labor and expense involved, lack of survival of planted scallops, and difficulty assessing results.

We have developed and are refining a novel approach that continues to exploit hatchery technology but considerably reduces the investment in labor and money, allows the scallops to grow and reproduce in a completely natural setting, and provides pathways of assessment that are simple and direct. We continue to collect scallop broodstock from the area targeted for restoration and to spawn those scallops in a hatchery setting. However, rather than raising the scallops to a size at which they are suitable for field planting, we instead raise them only to the end of their larval life span (either the pediveliger or early post-set stage). We then transport the larvae to the field and release them into enclosures (Figure 1) at sites with apparently adequate water quality and habitat. The larvae attach to their preferred settlement substrate (seagrass contained within the enclosure) during the next 1-4 days, after which the enclosure is removed and the larvae grow to adulthood under natural conditions.

Figure 1. Containment enclosure for bay scallop larvae deployed in Pine Island Sound, southwest Florida, during November 2003.

We have tested this approach to scallop restoration in Pine Island Sound in southwest Florida. That area once supported one of the most abundant bay scallop populations in the United States but in recent years scallop abundance rarely has exceeded 5 scallops 600 m^{-2}. During November 2003 we established four enclosures in the Sound and released bay scallop larvae within three of those enclosures. Assessment sampling revealed an increase in scallop abundance within the experimental enclosures relative to the control at each of the early juvenile, late juvenile, and adult life stages. Recruitment of early juveniles to artificial collectors deployed within the experimental enclosures averaged over eight recruits per collector whereas no recruits were detected on collectors deployed within the control enclosure. We detected on average > 21 late juvenile scallops (mean size = 21 mm) within the experimental enclosures compared with no late stage juveniles within the control enclosure. Abundance of adult scallops within the experimental enclosures averaged 160 per 600 m^2 compared with 24 scallops per 600 m^2 within the footprint of the control enclosure. In contrast, natural scallop density in Pine Island Sound has averaged less than two individuals per 600 m^2 during the 11 years preceding our enhancement efforts.

Scallops that we released as larvae within the enclosures during fall 2003 achieved adult size during summer 2004 and spawned during fall 2004. Thus, we would expect to detect any secondary effects in the natural scallop population of Pine Island Sound during summer 2005. Results of our June 2005 scallop survey revealed a general population density exceeding 93 scallops 600 m^{-2}, ranking Pine Island Sound as the most densely populated scallop population in Florida during that year.

We are continuing our studies in various estuaries along the west coast of Florida both in a continuation of our efforts to rebuild and thereby stabilize the bay scallop metapopulation and to further assess the effectiveness of this approach. During the last year we have conducted larval releases in three additional estuaries with physical assessments to be conducted in summer 2006.