RELEASE STRATEGIES FOR ESTUARINE SPECIES WITH COMPLEX MIGRATORY LIFE CYCLES: STOCK ENHANCMENT OF CHESAPEAKE BLUE CRABS

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Many declining coastal fisheries rely on estuarine species that use multiple habitats during their complex migratory life cycles. Enhancement of recruitment-limited stocks for these species requires release strategies that consider optimizing nursery habitats linked by migratory corridors to spawning areas. This talk will summarize on-going research on release strategies for blue crabs in Chesapeake Bay, where the spawning stock has declined by >80% over the past 15 years and now appears to be recruitment limited. The marked decline has proceeded despite sustained efforts to reduce fishing pressure. In combination with improved management strategies, we believe that our research strategy provides a model for responsible approaches to stock enhancement for other species.

We focused initially on sites where we have extensive background information on the population and community ecology of juveniles and adults. Using replicated batches of 1,000 to 10,000 tagged hatchery-reared juveniles produced by the Blue Crab Advanced Research Consortium, we demonstrated that we can successfully stock juveniles into small (1-10 ha) coves in typical nursery habitats. We tested spatial and temporal variation in growth, survival, enhancement, and production with 25 juvenile cohorts released in multiple sites over 4 years. Depending on fluctuations in predators, wild crab levels and water quality conditions, release outcomes varied annually from 5 to 25% in survival, 50 to 200% in enhancement, and from 150 to 550 adult crabs per hectare in production.

The replicate cohorts were also used to test the effect of time of season, juvenile size, and stocking density on release strategy. Cohorts released early in the season grew rapidly to maturity within as little as 2 months to mate and migrate from the nursery habitat in their first season, thus supplementing the spawning stock within one year. By contrast, crabs released in late season over-wintered and grew to maturity in their second year, before supplementing the spawning stock in their third year, the same schedule as wild crabs. Field experiments showed that 20 mm carapace width was the optimal release size to reduce predation/cannibalism and to stabilize benthic behavior of the post-dispersal stage, as in wild crabs. Survival was inversely related to release density. Analysis of instantaneous growth in release cohorts and of mortality in tethering experiments provided analytical models for predicting the seasonal trade-off of increasing growth rate and decreasing survivorship over the summer season.

Combinations of laboratory and field experiments showed that hatchery-reared crabs did not differ significantly from wild juveniles in most traits, such as growth rates, feeding and diet, habitat use, and movement. Although hatchery-reared juveniles initially had shorter lateral spines and did not bury into sediment as frequently as wild crabs, these differences soon disappeared and did not result in differences in survival. Thus, release strategies required minimal pre-conditioning in the hatchery.

Experiments are assessing optimal release sites throughout the large estuary based on an array of characteristics. Lower and upper bay nursery areas differed in composition and density of predator guilds, with predation by fishes and cannibalistic adult crabs causing higher mortality in the lower bay than upper bay sites, where the declining adult crab population and little fish predation resulted in much higher survival. Further, disease mortality (especially associated with *Hematodinium*) may be high at high salinities and negligible at low salinity sites. Throughout the estuary, shallow fringing water and structural components of the habitat, particularly submerged vegetation and coarse woody debris, provided crucial refuges for molting crabs to avoid cannibalism by adults and predatory fishes. Optimal nursery habitats included fringing marshes that provide detrital enrichment of infaunal food resources for crabs. The crabs showed marked aggregative response to these food resources, resulting in increased production in these sites. Analysis of juvenile dispersal behavior is being used to predict sites where habitats are supplied with low abundances of wild juveniles and may be below carrying capacity. Analysis migratory behavior is being used to identify sites which maximize connectivity of nursery habitats with spawning sanctuaries. Tag-reward systems with watermen participation are used assess fishing pressure on migrating females and to predict optimal migratory corridors for inseminated females to reach the spawning sanctuary.

Next research steps include increased scale of experimental releases (30,000 to 50,000 juveniles per cohort in 500 hectare sites) combined with molecular tagging to compare production of females in stocked and non-stocked sub-estuaries. These tests will supply parameters for models assessing the potential to provide for significant enhancement of the blue crab spawning stock.

This large multi-faceted program provides the most detailed experimental analysis available for release strategies for stock enhancement of a crab species. We suggest that our approach can be used effectively for assessing the feasibility to enhance stocks of other estuarine species with complex migratory life cycles.