

THE CHESAPEAKE BAY BLUE CRAB (*CALLINECTES SAPIDUS*): A MULTIDISCIPLINARY APPROACH TO RESPONSIBLE STOCK ENHANCEMENT

Yonathan Zohar*, Anson H. Hines, Oded Zmora, Eric G. Johnson, Romuald N. Lipcius, Rochelle D. Seitz, David B. Eggleston, Allen R. Place and J. Sook Chung
Center of Marine Biotechnology, University of Maryland Biotechnology Institute
701 E. Pratt St., Baltimore, MD, 21202, USA
zohar@umbi.umd.edu

The Chesapeake Bay has traditionally been one of North America's most productive fishing grounds. However, during the last several decades the Bay's commercial fisheries have severely declined. Blue crab catches, the major remaining harvest (over \$100 M in value), dropped over 70% from record highs in the early 1990s. Over-fishing and environmental degradation led to a sustained decline of 84% in the blue crab breeding stocks, which in turn resulted in historically low levels of juvenile recruitment and in nursery habitats being under carrying capacity. This situation makes the Chesapeake Bay blue crab an excellent candidate for stock enhancement that targets replenishment of the declining breeding stocks. A multidisciplinary program was therefore developed to (1) study the basic biology and life cycle of the blue crab, (2) develop hatchery and nursery technologies for the mass production of blue crab juveniles, and (3) assess the potential of using hatchery juveniles to enhance the blue crab breeding stocks and, in turn, Bay-wide abundance and harvests.

Understanding the environmental regulation of the reproductive cycle led to full photo-thermal control of the timing of ovulation and hatching of wild-caught inseminated females. Intensive larval rearing (60-140 larvae/liter) using microalgae species of high nutritional value and omega-3 enriched rotifers and *Artemia* nauplii, resulted in 30-80% survival from hatch to megalopae in three to four weeks. Megalopae were reared to 20 mm juveniles (mean carapace width) at lower densities (5-20/liter) in four weeks at survival rates ranging from 10-30%, depending on rearing density. From 2002 to mid-2006, 256,000 hatchery-reared juveniles were experimentally released into nursery habitats of the Chesapeake Bay; 176,000 in the upper Bay and 80,000 in the lower Bay. All released juveniles were individually tagged with coded micro-wire and/or elastomer tags and monitored to study survival, growth, migration patterns, field performance and enhancement. Optimal release sites, habitats, density, timing, and size of release were examined. Simultaneous releases and monitoring of hatchery and wild crabs demonstrated that performance of hatchery-reared juveniles did not differ from wild juveniles in most variables, including survival, growth, feeding, and habitat use. Some differences in behavior (burying ability) and morphology (spine length) of hatchery crabs could be rectified quickly via pre-release conditioning in the laboratory. Enhancement doubled to tripled the wild population in release sites, and survival from release to sexual maturity averaged 15% (range 6-26%). Survival varied among years, depending on environmental conditions such as salinity and temperature, and was inversely dependent on stocking density. Optimal juvenile release size was found to be 20 mm and above, which corresponds with change in dispersal behavior of smaller juveniles. Release habitats require adequate benthic food resources (infauna), shallow water adjacent to salt marshes, aquatic vegetation and/or woody debris as refuge for molting. Hatchery crabs grew rapidly to maturity, and were observed mating in as few as two months after release. Inseminated female crabs migrated in the fall along the Bay's main deep-water channel from nursery/mating habitats to the spawning sanctuary in the lower Bay, suggesting that hatchery crabs can contribute to the spawning stock as soon as several months post-release. This, together with evidence showing the

effectiveness of the spawning sanctuary, suggests the importance of implementing protected migratory corridors linking nursery habitats with the spawning grounds.

Using genomic approaches, blue crab microsatellites and mitochondrial DNA were sequenced. Mechanical tags are now being replaced by mitochondrial DNA genotypes, thereby alleviating the need to manually tag hundreds of thousands of juvenile crabs and facilitating future assessments of the impact of hatchery releases on next generation crab populations and abundances. Population genetic studies, using molecular approaches, are underway to determine the genetic diversity of the blue crab in the Chesapeake Bay and to ensure a genetically-responsible enhancement program.

In summary, using a multifaceted approach, the feasibility of releasing hatchery-produced juvenile crabs to restore the dwindling blue crab breeding stocks has been demonstrated. Working with watermen, the production of juvenile crabs is now being scaled up to allow for larger releases and to optimize release strategies, which will be ultimately recommended to and implemented by the Chesapeake crabbing industry.