OPTIMIZING ENHANCEMENT STRATEGIES: PREDICTING GROWTH AND SURVIVAL OF HATCHERY-REARED BLUE CRABS UNDER VARYING RELEASE SCENARIOS

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The blue crab is both economically and ecologically important along the Atlantic and Gulf coasts of the United States, particularly in Chesapeake Bay. Despite significant management efforts to reduce fishing pressure and improve habitat quality, the blue crab population remains at an all-time low in the Bay's most lucrative fishery. Both the sustained period of decline and the persistence at low levels are unprecedented for the Chesapeake blue crab stock. Spawning stock biomass has declined by 84% since 1991, with concurrent declines in mean size of mature females at spawning grounds, and larval recruitment (Lipcius and Stockhausen 2002) providing additional reason for concern. Further, current evidence indicates that the stock is now recruitment limited. Recent declines in the blue crab population in Chesapeake Bay have prompted the scientific investigation of alternative restoration strategies, such as stock enhancement, to complement traditional fishery management for stock recovery.

The feasibility of stock enhancement depends on the ability of hatchery-reared juveniles to survive and grow in the natural environment. A critical step toward optimizing enhancement is to identify release strategies that reduce predation and enhance growth to maximize the performance of hatchery-reared individuals released into the field. Two key considerations for optimizing the success of enhancement are 1) size at release and 2) timing of release. Size at release is an important consideration since releasing hatchery crabs at a small size is advantageous to avoid cannibalism in rearing tanks and the increased costs associated with a prolonged growout phase. In practice, release size represents a tradeoff since predation in the field is often size dependent (Hines and Ruiz 1995; Litvak and Legett 1992) with smaller individuals suffering higher mortality. Similarly, the optimal time of release may vary with seasonal fluctuations in abiotic factors and predator abundance. We present the results of a production model, parameterized from field growth and survival data, designed to predict the relative effectiveness of enhancement, measured as the production of mature females, under varying sizes at release (10-40 mm carapace width) and times of release (March-October).

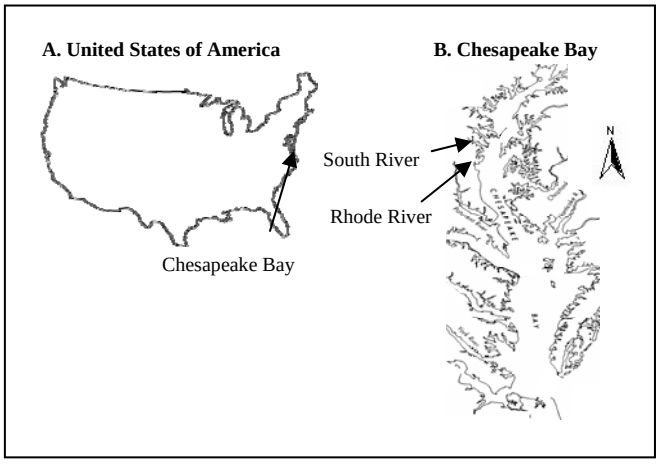

Figure 1. Locations of release sites in the Rhode and South river subestuaries of upper Chesapeake Bay

To assess growth in the wild, we analyzed data from large-scale field releases of

hatchery-reared blue crabs which provide a unique opportunity to follow individual cohorts of known age as they grow from juveniles to sexually mature adults in the wild. A wide range of release dates both within (April-October) and between years (2002-2005) allowed for estimation of seasonal and annual changes in growth. Cohorts of juveniles released early in the season grew to maturity within the season of release; whereas cohorts released late in the season over-wintered and grew to maturity in the second year (similar to wild juveniles). Field growth data was then used to parameterize a seasonal growth model that predicted size-at-age for hatchery-reared crabs under varying release scenarios.

Seasonal and size-dependent patterns of mortality were assessed using long-term (1989-2005) field tethering data with juvenile blue crabs (25-70 mm carapace width) conducted during April-September within the Rhode River. Relative mortality rates of tethered juvenile crabs were lowest in early spring, peaked in summer, then declined through the fall. Relative mortality was significantly and negatively correlated with size until a size of 50 mm, after which relative mortality was not affected by size.

Field growth and survival data were then integrated and used to parameterize a model to predict the relative production of mature females for hatchery-reared crabs under varying release scenarios. Production increased with increasing size at release independent of season; however, size at release was most important for summer releases when predation rates were highest indicating that optimal size at release may vary seasonally. Production of mature females was maximized in early spring releases, which allowed hatchery-reared crabs to attain a relative size refuge before peak predation in summer. Further, hatchery-reared juveniles from spring releases matured during their first growing season, indicating these individuals may contribute to the spawning stock in their first year, and suggesting that hatchery releases early in the season have the potential for rapid input to the blue crab reproductive stock. The results of this study provide critical information for identifying optimal stock enhancement strategies for the blue crab in Chesapeake Bay, and provide necessary inputs for both stock assessment and ecological models.

References

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