ACES Annual Report Summary 2003

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Title: Shelter bottlenecks and self-regulation in blue crab populations: Assessing the roles of nursery habitats and juvenile interactions for shelter dependent organisms
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Research Category:
Project Period: January 2001 to December 2002

Background and Objectives of the Research Project:

In many marine fish and crustaceans, young juvenile stages are vulnerable to predation, and their survival may be dependent on the availability of habitats that provide shelter from predators. In areas where the supply of the larval stages is high, such nursery habitats may become overcrowded and limiting for juvenile populations, resulting in density-dependent processes that can regulate their numbers. However, little is presently known regarding processes that can act as regulating mechanisms in juvenile marine organisms.

In the present project we studied the blue crab *Callinectes sapidus* in the Mobile Bay Estuary, Alabama, an area with documented high supply of blue crab postlarvae. The aim of the project was to determine if the availability of seagrass habitats can become a limiting resource for juvenile populations of blue crabs, and to test if competition and cannibalism between juveniles within seagrass beds can be important population regulating mechanisms. We hypothesized: (1) that competition for space or food within grass beds will result in density-dependent emigration from these habitats into unvegetated areas where mortality is higher, and (2) that cannibalism between juveniles is common and increases with either cannibal or prey densities. These hypotheses were tested at Dauphin Island Sea Lab and the surrounding area, and assessed on several spatio-temporal scales using both laboratory and field experimental techniques.

We believe this work could significantly improve our basic understanding of recruitment regulation in benthic organisms, and be broadly applicable to the management of shelter-dependent fishery species. Understanding whether a marine population is limited by the supply of larvae, or regulated by density-dependent processes after settlement is central for efficient conservation and management of marine habitats and organisms. If juvenile blue crabs are limited by nursery habitats, and not by larval supply in the Mobile Bay Estuary, the species may be better managed by protecting the seagrass and marsh habitats in the area, than by increasing the regulations on the fishery.

Progress Summary/Accomplishments

In the first year of the project (2001) the results from two extensive laboratory mesocosms experiments did not provide support of the hypothesis that competition within grass beds creates density-dependent emigration from the nursery habitats, but suggested that density-dependent juvenile cannibalism may act as a regulating mechanism. To further investigate the effect of

cannibalism and also to test the influence of different juvenile habitats on the recruitment of juvenile blue crabs, two field experiments were performed in 2002.

In the first study a cage experiment was performed to assess the relative importance of postlarval habitat selection and predation on abundance and distribution of juvenile blue crabs among 4 different habitats: live oysters, seagrass (*Halodule wrightii*), artificial seagrass, and open mud. The experimental setup consisted of empty habitat patches provided with or without cages that would allow settling megalopae and the smallest juvenile crabs to pass through the mesh but stop predators. After a period 3 d the number of crabs that had colonized the habitats were sampled. High and similar numbers of blue crab settlers (megalopae and first instar crabs) colonized the oysters and natural and artificial seagrass habitats (140-350 settlers m^{-2}) whereas significantly lower numbers were found on the open mud habitat (35 to 70 settlers m^{-2}). This habitat specific settlement pattern was found also in cages where predators were excluded, suggesting that active habitat selection at settlement was responsible for the distribution. Similar settlement and survival in the three structurally complex habitats demonstrated that oysters constitute a potential important habitat for juvenile crabs, and that artificial grass could be used in the second experiment as a substitute for natural grass.

In the second experiment we enclosed different densities of juvenile blue crabs and assessed density-dependent effects on blue crab recruits (megalopae and first to third instar crabs) that colonized artificial seagrass patches inside the cages. High densities of blue crab recruits colonized the predator exclusion cages (466 recruits m^{-2} $3d^{-1}$), whereas densities of recruits were up to 7 times lower in cages containing cannibalistic crabs, in uncaged seagrass plots and in natural seagrass. A negative correlation was found between the number of enclosed cannibals and number of new recruits suggesting that early juvenile mortality is directly related to cannibal densities, and therefore to the survival of earlier cohorts. Further, proportional losses of megalopae and J1 crabs in cannibal inclusion cages were higher during periods of high compared to low settlement (70-86% and 31-54% loss $3d^{-1}$, respectively), indicating that the functional response of juvenile cannibals may decrease cannibalism at low prey densities. Laboratory experiments demonstrated that blue crabs settlers did not emigrate in response to juvenile cannibals, suggesting that the high loss rates in the field experiment represent settlement mortality.

The study demonstrates that density-dependent cannibalism between juvenile blue crabs can be a major source of early benthic mortality with large effects on local recruitment patterns. These results suggest that juvenile crabs can regulate new cohorts by cannibalizing more efficiently when smaller crabs are abundant, and by creating higher mortality rates on new settlers when cannibal densities are high. This regulating mechanism would limit the densities of crabs within nursery habitats, making the availability of seagrass, marsh, and oysters habitats a critical factor in the recruitment of juvenile blue crabs.

Publications/Presentations: (none yet)

Future Activities: Presentation of the results at the Benthic Ecology Meeting 2003. Publication of three manuscript from results of the project.

Supplemental Keywords: Habitat bottlenecks, Recruitment regulation, Post-settlement processes

Relevant Web Sites: None

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