ACES Annual Report Summary 2002

Period Covered by the Report: January to December 2001
Date of Report: April 5, 2002
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: Estuarine Studies
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 are studying 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 is 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 hypothesize: (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 will be 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 two extensive laboratory mesocosms experiments have been performed to assess if juvenile blue crab compete over space or food during naturally occurring densities, and if these interactions can result in density-dependent feeding, emigration or cannibalistic interactions. The experimental setup in both experiments consisted of large tanks

(2.4 x 0.5 m) with an artificial seagrass patch at one end of the tank, and a trap at the other end. Juvenile blue crabs of different size classes and at different densities were introduced to the seagrass patch that contained different amounts of food (snails). After a 12 h period, the number of crabs that had emigrated from the grass patch, and the number of crabs and snails that had been eaten were quantified. Measurements of the behavior of the crabs was obtained using time-lapse video techniques with infra red light to be able to film in complete darkness.

In the first experiment, young juvenile crabs of similar sizes were assessed in 40 different trials to test the effect of crab density and food levels on aggressive behaviors and emigration. The result demonstrated high emigration rates from the seagrass patch (25 to 55% 12 h^{-1}) and significantly higher rates at low food levels compared to high food levels. However, proportional emigration rates did not increase with crab density. The videotapes are presently being analyzed to assess the effect on the behavior of crabs within the grass bed.

In the second experiment, 4 different size classes of juvenile crabs and adult crabs were assessed at different densities in 56 different trials to test if emigration and cannibalism between juveniles were affected by crab densities and by predation risk from adult crabs. The results demonstrated that, consistent with the first experiment, emigration rates were not affected by crab densities in any of the 4 different size classes of juvenile crabs. Only smaller effects of adult crab presence or absence were seen on juvenile emigration rates. Cannibalism on first juvenile instars (J1) was very high (27-65% mortality 12 h^{-1}) and the proportional mortality of J1 crabs increased both with J1 density and cannibal crab density, but was not affected by the presence of adult crabs. Cannibalism on third to eighth instar juvenile crabs (J3-8) also increased with crab density, and decreased from 16 to 1% with increasing size class. Cannibalistic rates on J3-4 were lower when an adult blue crab was present whereas cannibalism on the larger juveniles occurred almost exclusively when the adult crab was present.

These results suggest that juvenile blue crabs may migrate at high rates between seagrass patches, and that this emigration is related to foraging and affected by food level, but not affected by densities of juvenile crabs. Thus, the laboratory study provided little support of the hypothesis that competition within grass beds creates density-dependent emigration from the nursery habitats. In contrast, the results provided strong support of the hypothesis that cannibalism between juvenile crabs may act as a regulating mechanism. Cannibalism between juvenile crabs of different size-classes created very high mortality rates on the smallest crabs, although other prey sources were present in the tanks, and the crabs had the opportunity to emigrate from the grass bed. Importantly, this cannibalism created density-dependent mortality rates on newly metamorphosed first instar crabs, both in response to prey and cannibal densities. 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 and marsh habitats a critical factor in the recruitment of juvenile blue crabs.

Publications/Presentations: (none yet)

Future Activities:

In the second year of this project we will assess the same hypotheses regarding density-dependent emigration and cannibalism in the field using cage experimental techniques and field sampling.

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

Relevant Web Sites: None

Acknowledgments and disclaimers

This research has been supported by a grant from the U.S. Environmental Protection Agency's Science to Achieve Results (STAR) program, and by a fellowship provided by the Hellmuth Hertz' Foundation, The Royal Physiographic Society in Lund, Sweden, which are kindly acknowledged.

Although the research described in the article has been funded in part by the U.S. Environmental Protection Agency's STAR program through grant (**Carolyn ?**), it has not been subjected to any EPA review and therefore does not necessarily reflect the views of the Agency, and no official endorsement should be inferred."