

# THE EFFECT OF GASTROPOD DIVERSITY AND DENSITY ON MACROALGAE DIVERSITY IN THE MASSACHUSETTS ROCKY INTERTIDAL

Hillary Sullivan  
Department of Biology, Clark University, Worcester, MA 01610  
([hisullivan@clarku.edu](mailto:hisullivan@clarku.edu))

**Abstract** Rocky intertidal tide pools of New England are home to many sessile, and slow moving organisms that are able to withstand the harsh conditions that characterize the environment, such as heavy wave action and desiccation. I studied patterns in diversity and abundance of macroalgae and gastropod species in individual tide pools. The average number of snail species in each pool increased with increasing diversity of macroalgae. The percent cover of algae decreased with decreasing average number of snails. In all tide pools combined, there was a positive correlation between increasing numbers of snail species and increasing numbers of macroalgae species. These results may be due to competition among snails for food, as well as the elimination of a competitive dominant species. Understanding the organization within individuals pools helps understand the organization of the overall rocky intertidal community.

**Key Words:** *competitive dominant species, rocky intertidal, species diversity*

## **Introduction**

The New England rocky intertidal zone is a harsh habitat characterized by high plant and animal diversity (Lubchenco and Menge 1978). Most organisms living there are sessile and slow moving, making them subject to daily fluctuations in biological and physical conditions that limit their habitat capabilities. The upper limit of many organisms is often determined by desiccation, higher temperatures, and solar radiation (Connell 1972). Unfavorable physical conditions may prevent organisms from settling in turbulent water of the lower intertidal (Connell 1972). Algae are specifically limited by physiological stresses such as decreased light intensity available for photosynthesis (Connell 1972). Because of these various stressors, the intertidal zone is a habitat with individual pools, each with their own species compositions and characteristics.

The rocky intertidal is characterized by tide pools fluctuating daily with diurnal tidal patterns. The community of the rocky intertidal is subject to competitive processes, predominantly competition for space (Dayton 1971; Lubchenco 1978). Competitive dominance is exerted through the use of space (Dayton 1971). Organization within the community is dependent on consumer-prey interactions, physical disturbances, and space competition (Lubchenco and Menge 1978). To understand overall community organization, it is important to understand small-scale species diversity (Lubchenco and

Menge 1978). To measure the dynamics between organisms, we must look at changes in abundances and distributions (Connell 1972).

An important interaction regarding space is the consumer-prey relationship between herbivorous gastropods and benthic macroalgae. Algae such as *Ascophyllum nodosum* and *Fucus vesiculosus* provide habitat for many species of gastropods, crustaceans, and other sessile invertebrates (Lubchenco 1983). Of the gastropods, *Littorina littorea* and *Littorina obtusata* are the most abundant. Previous studies are inconclusive about the relationship herbivores have on algal abundance and diversity in the rocky intertidal. Herbivores may either increase plant diversity, decrease plant diversity, or both (Lubchenco 1978). This study examined how the diversity and abundance of four species of gastropod influences macroalgae composition. It is hypothesized that the greater number of snails and snail species present, the greater the algal diversity will be within a tide pool.

## **Materials and Methods**

### *Study Organisms*

Four mollusks and five macroalgal species that are found in the Northeast rocky intertidal were observed for this study. The common periwinkle, *Littorina littorea*, has a dark, pointed shell and is found in the mid to high intertidal (Berger 1973). This is a generalist feeder, feeding on a range of algal species (Long et al. 2007). The flat periwinkle, *Littorina obtusata*, has a flatter, more colorful shell and is usually found in the lower intertidal (Berger 1973). Unlike *L. littorea*, *L. obtusata* is a specialist feeder (Long et al. 2007), feeding mostly on furoid algae (Watson and Norton 1987). The rough periwinkle, *Littorina saxatilis*, is lighter in color than *L. littorea* and has a more swollen spire. This gastropod inhabits the upper intertidal (Berger 1973). Dog whelk, *Nucella lapillus* is the fourth mollusk in the study. This is a predatory snail that has a pointed spire and a crenulated aperture to facilitate feeding.

Rockweed, *Ascophyllum nodosum*, is a brown macroalgae common throughout the rocky intertidal. Its fronds are attached to rocks and boulders and have pneumatocysts that aid in buoyancy. Bladderwrack, *Fucus vesiculosus*, also have air bladders and are distinguished from *A. nodosum* by its dichotomous branching. Irish moss, *Chondrus crispus*, is a red algae found in the lower intertidal zone attached to holdfasts. *F. vesiculosus* is dominant in mid intertidal zone while *C. crispus* is dominant in low intertidal zone (Lubchenco 1978). Bubblegum algae, *Lithothamnion corallioides*, is a dark pink or white crusted algae found in all zones of the intertidal. *Ulva lactuca* is flat and green, resembling lettuce, and is found at all levels of the intertidal.

### *Study Site*

The study was conducted at the Northeastern University Marine Science Center in Nahant, Massachusetts (42.420038°N, -70.906235°W). This is a rocky intertidal habitat with fluctuating tide pools and organism distribution due to diurnal tide patterns.

### Experimental/Observational Methods

Data collection took place on September 15 and October 26, 2012 during the second low tide, around 2-5 pm. A range of tide pools were chosen at random throughout all intertidal zones. A 0.25 m<sup>2</sup> quadrat was placed arbitrarily in randomly selected pools. Once the quadrat was placed, the percent cover of five macroalgae species and rock was evaluated. Percent cover was estimated by the macroalgae canopy, not the number of holdfasts in the quadrat. All snails found within the quadrat were collected, placed in a plastic container, identified, and counted. Once the snails were counted, they were returned to their pool. Regression analyses were run using JMP version 6.0 to test for significance.

### Results and Discussion

A total of 39 quadrats were sampled during the two-day study period. A total of five different macroalgae species were found, as well as four different species of snails. As the number of macroalgae species within a tide pool increased, so did the average number of snail species found in that pool (Fig. 1). Results from the regression analysis show a close to significant relationship ( $R^2=0.1884$ ;  $p= 0.0599$ ). The data have a slight positive correlation. We might expect significant results if the sample size is increased. Long et al. found that the predation of *F. vesiculosus* by *L. obtusata*, this reduces feeding pressure of *L. littorea* on the algae (2007). Because *L. obtusata* is a superior grazer, this could significantly impact densities of *L. littorea* (Long et al. 2007). Highest macroalgae species diversity occurs at moderate *L. littorea* densities (Lubchenco 1978). Moderate densities means that there are less snails and perhaps more snail diversity.

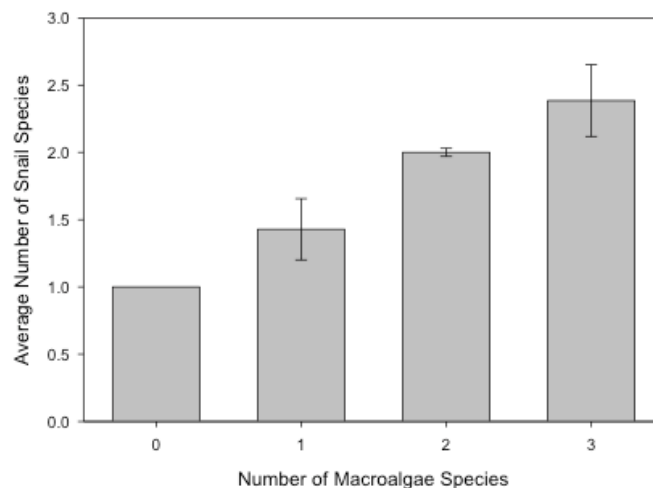
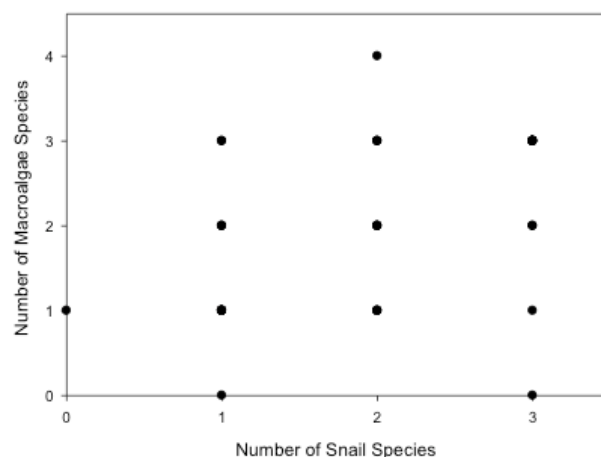


Fig. 1 The average number of snail species found at different levels of macroalgae species presence within all tide pools. Bars represent  $\pm 1$  standard error.

There was a positive correlation between the raw number of snail species and number of macroalgal species found in the tide pools (Fig. 2). A regression model shows that this is a weak but significant correlation ( $R^2 = 0.1866$ ;  $p = 0.006$ ). As the number of snail species increased, so did the number of macroalgae species. Herbivores can affect performance of other herbivores by grazing on shared plants (Long et al. 2007). Low algal diversity can be a result of competitive exclusion in the absence of herbivores or from overgrazing (Lubchenco 1978). Ephemeral seasonal algae are the preferred food species for snails (Lubchenco 1978). When a consumer feeds on a competitive dominant prey, diversity increases (Harper 1969). More snail species means a greater mix of generalist and specialist feeders. This controls the algal population instead of having one snail species feeding on specific algae. Consequently, this eliminates the presence of a neither an herbivore nor an algae competitive dominant species. Lubchenco found that when *L. littorea* is low in abundance, diversity of macroalgae increases (1978). Low abundance of *L. littorea* decreases competition and allows for the growth of other snail species. This diversifies the herbivorous feeding pressure on algae, thus increasing diversity of algae species within a tide pool.



**Fig. 2** The number of macroalgae species present compared to the number of snail species present for each 0.25m<sup>2</sup> quadrat. All 39 quadrats are represented, however there is overlap with many of the points.  $R^2 = 0.1887$ ;  $p = 0.006$

Organisms in the rocky intertidal compete for resources, primarily space. The herbivore-macroalgae relationship is important because each can influence the abundance and diversity of each other. By excluding the competitive dominant species, this allows for an increase in diversity. This complicated relationship between an herbivore and algae is important to understand because it helps understand community organization of the intertidal on a broader scale.

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