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Assessing the potential benthic–pelagic coupling in episodic blue mussel (*Mytilus edulis*) settlement events within eelgrass (*Zostera marina*) communities

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Abstract

Coastal marine seagrass ecosystems are important nursery grounds for commercially and recreationally important species, and they serve as key settlement and recruitment sites for other species. We investigated several years (2001–2003) where episodic settlement events of blue mussels (*Mytilus edulis*) occurred in Barnegat Bay, NJ, USA. Population assessment indicated that blue mussels settled in eelgrass beds (*Zostera marina*) in late spring with peak densities exceeding 170,000 m^{-2}. Based on calculated filtration rates of *M. edulis*, we determined that for at least 53 days in 2001, the density and size distribution of *M. edulis* were sufficient to filter the water column volume in excess of twice a day, with maximum calculated filtration rates exceeding 8 m^3 water m^{-2} day^{-1}. While the settlement event in 2001 was very localized, in 2003, the settlement event was considerably more widespread throughout the bay, with maximum settling densities exceeding 175,000 individuals m^{-2}. Associated with these high densities, maximum calculated filtration rates exceeded 15 m^3 water m^{-2} day^{-1}. This filtration potential may have impeded the localized development of a brown-tide (*Aureococcus anophagefferens*) bloom in 2001, which occurred in other regions of the bay, but the widespread settlement event seen in 2003 may have impeded the development of any brown-tide blooms in Barnegat Bay during that summer. The decline in mussel densities throughout the summer may be a result of elevated water temperatures in this back bay, but at one site, the high settlement of *M. edulis* was followed by a substantial migration (>40 individuals m^{-2}) of small sea stars (*Asterias forbesii*). In 2001, *A. forbesii* was a significant factor in reducing *M. edulis* density by the end of the summer at the Barnegat Inlet site and a community level assessment showed significant positive correlations between mussel aggregations and sea star densities (r=0.68–0.73, P<0.001). At this same site in 2003, the sea stars were again present in high densities (26 m^{-2}) and were a potential mechanism for mussel decline. In other regions of the bay, sea star densities are very low, but numerous other predatory species exist, including blue crabs (*Callinectes sapidus*), green crabs (*Carcinus maenus*), spider crabs (*Libinia* spp.), and several Xanthid crabs. Given the high mussel densities seen in this

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study and the considerable predation by sea stars and other benthic predators, the benthic–pelagic coupling which these mussels provide in this system contributes to the high secondary production in these grass beds.

Keywords: *Asterias forbesii*; Benthic–pelagic coupling; Blue mussel; Eelgrass; *Mytilus edulis*; *Zostera marina*

1. Introduction

The blue mussel, *Mytilus edulis*, is a widely distributed boreo-temperate species occurring in the Arctic, North Pacific, and North Atlantic Oceans (Seed, 1976). It is a semisessile epibenthic bivalve often attached to hard substrata via byssal threads (Newell, 1989). While *M. edulis* is most frequently associated with hard substrata as adults it will utilize *Zostera marina* as a primary recruitment site and secondarily recruit to hard substrates (Bayne, 1964; Newell et al., 1991). Additionally, *M. edulis* can form dense aggregations in sedimentary habitats where the byssal connection among mussels creates a stable habitat (Committo, 1987).

A typical pattern of *M. edulis* recruitment includes mass settlement to a primary settlement site with secondary recruitment to preferred adult habitat (Bayne, 1964). While predation on these individuals is highest during the 3-week planktonic larval stage (Newell, 1989), predation during the early settlement phase may dictate generalized adult population structure. Predation pressure by asterids has been shown to be a driving factor in the distribution of adult *Mytilus* and overall community structure (Paine, 1966). Additional mortality of adult blue mussels may depend on site-specific environmental factors, such as storms, salinity, and temperature (Seed, 1976).

Research on *M. edulis* has focused on the ecology of these individuals within a hard substrate community, but *M. edulis* may play an important ecological link between pelagic and benthic systems in soft substrates (e.g., seagrasses) as well. Valentine and Heck (1993) demonstrated that mussels (*Modiolus americanus*) increased secondary production in a seagrass system, presumably through increased structural complexity as well as increased benthic–pelagic coupling. Additionally, Peterson and Heck (1999) showed that mussels positively influenced the growth of seagrass. It could be surmised that similar results may occur for *M. edulis* in *Z. marina* communities. The goal of this research was to assess the distribution and abundance of settling *M. edulis* within an eelgrass (*Z. marina*) system and their potential link between pelagic phytoplankton and benthic predators. Specifically, we investigated the temporal settling densities of *M. edulis,* their spatial distribution within *Z. marina* beds, calculated the potential benthic–pelagic coupling in the system, and the spatial and temporal distribution of a major predator (*Asterias forbesii*).

2. Study site

Research was conducted in Barnegat Bay, NJ, U.S.A. (39°47.70′ N, 74°08.10′ W; Fig. 1), which is located in the central portion of the Mid-Atlantic Bight. Barnegat Bay is a polyhaline estuary protected by a barrier island to the east. It is a relatively shallow bay (average depth at mean low water 1.7 m; Durrand, 1984) with seasonal water temperatures ranging from −2 to 28 °C (Able et al., 1992). Water quality data collected on the site showed that temperature ranged between 19.6 and 26.7 °C; while salinity remained fairly stable (26.4–32‰). Primary research sites included Barnegat Inlet, Shelter Island, and Marsh Elder Islands in 2001–2003 (Fig. 1). Additionally, samples were collected throughout the bay in 2003 to characterize the spatial extent of the settlement event during that year.

3. Material and methods

3.1. M. edulis population assessment

Assessment of *M. edulis* was assessed by collections of benthic cores in *Z. marina* beds in 2001 through 2003 (n=3 cores/site/sampling date) at Barnegat Inlet, Shelter Island, and Marsh Elder