Range expansion of the Sea Nettle (*Chrysaora quinquecirrha*) and impacts on pelagic food webs

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Summary

Urbanization of estuaries has dramatically altered shorelines through habitat removal and destruction, as well as construction of permanent structures like docks, bulkheads, and piers. Concomitantly, water quality degradation has occurred from various pollutants and excess nutrients derived from anthropogenic sources. Excessive nutrients result in coastal eutrophication and reduced oxygen concentrations, substantially altering the environment for living organisms. Specifically, the rise in jellyfish populations on global and local scales benefit greatly by urbanized landscapes, because of their tolerance of degraded water and the increased hard substrate for their polyp life history stage. In coastal New Jersey, we have witnessed the range extension of the Atlantic Sea Nettle (*Chrysaora quinquecirrha*) from the Chesapeake Bay to a full-fledged member of the pelagic food web. Their abundance has altered pelagic community structure as they assume the role of top-predator. Our investigations have documented significant density differences among our sites, driven principally in regions where development is high, relative to regions with modest development, and those receiving substantial runoff from developed watersheds. The rise in sea nettle populations has altered the pelagic food web, as sea nettles exert substantial top-down pressure, especially upon the comb jelly, *Mnemiopsis leidyi*.

Introduction

Increasing coastal development has created environments which favor species that are tolerant of various pollutants and degraded water quality. Additionally, the hardening of shorelines and elimination of natural vegetated regions create the potential that tolerant fouling organisms can colonize and expand in these degraded systems. Many coastal estuaries are plagued by poor water quality and increasing inclusion of non-native species. As such, developed coastal estuaries are being defined by lowered species richness and diversity as invaders monopolize available space (Ruiz *et al*. 1997), loss of natural habitats, and simplification of food webs through redirection of energy, species introduction, and overfishing (Byrnes *et al*. 2007). In particular, the relative increase in gelatinous zooplankton in many regions of the ocean has led to a phase shift from 'text-book' planktonic communities dominated by zooplanktivorous fish and higher apex predators to ones dominated by ctenophores, cnidarians, and pelagic tunicates (Purcell *et al*. 2007). While the apparent global increase in gelatinous zooplankton is actively debated, many specific regional locations have strong documentation of elevated abundances (Fuentes *et al*. 2010) often leading to food web disruption and fisheries crashes (Roohi *et al*. 2010).

Materials and Methods

Lift Nets: Gelatinous zooplankton were sampled bi-weekly from May through September 2012 at eight designated paired sites in Barnegat Bay, NJ USA. Ten lift net samples were collected from each site during sampling events (N=1394). Lift nets ($0.836m^2$, 3.2mm mesh) were then raised directly through the water column and all organisms were lifted to the surface. Samples were transferred to a holding bin where they were identified and enumerated. Water depth was recorded and the lift net area was then multiplied to determine the volume of water sampled. All samples were then standardized to # m^{-3} and compared among sites and dates of collection.

Zooplankton Tows: During each sampling event, triplicate 363µm zooplankton nets (30cm diameter) were towed at each location (N=370). Tows were conducted at minimally engaged engine speed for one minute. Length of tow was standardized using a mechanical flow meter and the known cross section of the net allowed for volume quantification of each sample. After collection, ctenophores were coarsely sieved (4mm), washed and counted. Zooplankton were then preserved in ethanol and were returned to the lab for identification and enumeration. All samples were standardized to # m^{-3} and compared among sites and dates of collection.

Results and Discussion

This study provides the first quantification of *C. quinquecirrha* population distribution in this region and documents the successful release of ephyrae verifying the now self-sustaining invasion. However, it has yet to be resolved whether the establishment of *C. quinquecirrha* is a range extension or an anthropogenically driven invasion of a non-native species. Regardless, their presence in the system has the potential to restructure pelagic food webs and community structure. *Mnemiopsis leidyi* and *C. quinquecirrha* are both voracious predators with significant top-down potential. Purcell *et al.* (2001) reviewed distribution and predator-prey interactions of *M. leidyi* in native systems and compared impacts with regions that have seen recent introductions. They identify that unrestricted *M. leidyi* populations have the potential to severely reduce zooplankton abundance by their rapid and relatively indeterminate consumption. Additionally, Purcell and Decker (2005) have demonstrated significant top-down influences of both *M. leidyi* and *C. quinquecirrha* with a resulting trophic cascade in the Chesapeake Bay.

Our results demonstrate the predation potential of the native *M. leidyi*, as their distribution showed significant negative correlations with calanoid copepods, fish eggs, fish larvae, and cladocerans, and substantial copepod cropping. Additionally, the disjoint distribution observed in our results indicates that *C. quinquecirrha* is having a significant top-down impact on *M. leidyi*, but its restrictive distribution within the bay means that its' impact is localized. As an emerging top predator in this system, the long-term impacts on community structure are difficult to predict. However, the significant top-down pressure exerted on *M. leidyi* did not result in a trophic cascade as expected. Rather, the generalized control of numerous zooplankton, and specifically copepods, by *C. quinquecirrha* demonstrated a broad predatory influence in structuring the overall temporal planktonic community. As a result, within Barnegat Bay the individual and combined impacts of gelatinous zooplankton structure the temporal and spatial patterns of the pelagic community. If *C. quinquecirrha* continues to expand, it will likely exert significant top-down control, but may merely act as a replacement apex predator for *M. leidyi*.

References

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