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Understanding the influence of bivalve suspension-feeder populations on water quality in eutrophic coastal waters

Roger I.E. NEWELL*, Jeff C. CORNWELL*, Raleigh R. HOOD* and Evamaria KOCH*

Suspension feeding bivalve molluscs serve to couple pelagic and benthic processes because they filter particles with high efficiency from the water column and transfer undigested remains in their biodeposits to the sediment surface. This feeding activity, combined with their often high abundance as natural stocks and in intensive aquaculture farms, can make bivalves extremely important in regulating water column processes in shallow coastal waters. Of all bivalve species worldwide, eastern oysters are among the most powerful in this regard because of their unusually high weight specific filtration rates (7 to 10 L h^{-1} g^{-1} dry tissue weight at typical summer water temperatures of 25 ℃.) The eastern oyster is well adapted to living in estuaries where inorganic particles comprise a large fraction of the seston because it can sort filtered particles prior to ingestion and reject less nutritious particles as pseudofeces. Currently in the nutrient enriched Chesapeake Bay, where phytoplankton are in high abundance, eastern oysters maintain high filtration rates but now reject large amounts of undigested algal cells in their pseudofeces. Newell (1988) initially drew attention to the possible ecosystem benefits of the original huge stocks of eastern oysters in Chesapeake Bay by comparing water column turnover times before oysters were commercially exploited to the situation today when oysters are at an all time low abundance.

In contrast to Newell's (1988) proposition that oyster populations may once have exerted "top-down" control on phytoplankton stocks others claim that oysters may simply recycle inorganic nutrients rapidly back to the water column and hence there would not have been any long-lasting reduction in phytoplankton biomass. To help distinguish between these scenarios, Newell *et al.* (2002) explored in laboratory incubations changes in nitrogen fluxes and denitrification under anoxic and oxic conditions in response to loading by different amounts of phytoplankton cells, representing an experimental analog of oyster biodeposits. When organics were regenerated under aerobic conditions, typical of those associated with shallow water oyster habitat, coupled nitrification-denitrification was promoted, resulting in denitrification of ∼20 % of the total added nitrogen. In contrast under anoxic conditions, typical of current summertime conditions in main-stem Chesapeake Bay where phytoplankton is microbially degraded beneath the pycnocline, nitrogen was released solely as ammonium from the added organics. Such denitrification of particulate nitrogen remaining in the biodeposits of benthic suspension feeders will enhance nitrogen removal from eutrophied coastal waters (Newell, 2004).

It is likely that reduced oyster filtration by the much diminished oyster populations has contributed, in part, to observed higher turbidites in Chesapeake Bay and the consequent reduction in light reaching the sediment surface. In aerobic incubations of sediment cores with even low light levels (70 μmol^{-2} s^{-1}), Newell *et al.* (2002) found that a benthic microalgal/cyanobacterial community grew that not only absorbed the inorganic nitrogen released from oyster biodeposits but also fixed N2. This suggests that an

* Horn Point Laboratory, University of Maryland Center for Environmental Science, PO Box 775, Cambridge, MD 21631 USA
Email: newell@hpl.umces.edu

ecosystem dominated by benthic primary production may develop in shallow waters when reduced turbidity associated with bivalve feeding increases light penetration to a level that can sustain benthic microalgal production.

Over the last four decades seagrass beds have either declined or have disappeared throughout much of the Chesapeake Bay due to high water turbidity leading to reduced light availability for these benthic plants. In order to explore the possible interactions between oyster and seagrass declines we have developed a numerical model to simulate the interaction between wave-induced sediment resuspension, bivalve filtration, and seagrass growth. This model, which is parameterized based upon direct measurements of oyster filtration and seagrass wave dampening effects, shows that under high wave height conditions the presence of oysters can reduce suspended sediment concentrations by nearly an order of magnitude, which significantly increases water clarity and the depth to which seagrasses can grow (Newell, 2004).

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