Quantifying Nitrogen Removal by Oysters: What Do We Know?

In January 2013, the NOAA Chesapeake Bay Office sponsored a workshop that brought scientists together to discuss their research on nitrogen removal by oysters. Participants agreed that while much is known about how oysters remove nitrogen from the water, more specific information about how much nitrogen oysters (both on reefs and in aquaculture) can remove from water is needed. While several studies of denitrification rates of restored oyster reefs are under way or funded, there are major data gaps on potential nitrogen removal by aquaculture. Even less is known about nitrogen removal by natural oyster reefs, especially in the Chesapeake Bay.

Oysters filter phytoplankton and other particles that contain nitrogen from the water column. This nitrogen can be removed from the water column for a significant amount of time if it is:

- assimilated into animal tissue or shell,
- converted to nitrogen gas that is returned to the atmosphere, or
- incorporated into biodeposits that become buried deep in the sediments.

Of these, the incorporation of nitrogen into oyster tissues and shell is the most easily quantified way oysters can, at least temporarily, remove nitrogen from the water column.

Research shows that the nitrogen content of soft tissues and shells is quite consistent along the Atlantic coast of the US. This means that the amount of nitrogen removed by the oyster harvest can be estimated with reasonable accuracy in that region. But workshop participants noted that because the ratio of oyster tissue to oyster shell dry weight varies widely with location, growing conditions, and physiological status, precise measures of oyster abundance and biomass are needed to accurately estimate nitrogen removal by harvest.

Not as well understood, however, is the amount of nitrogen that is either sequestered via deep burial in bottom sediments or returned to the atmosphere via denitrification. Determining rates of sequestration and denitrification is much more difficult than estimating nitrogen removal by harvest.

- Data collected so far on denitrification associated with either intensive oyster aquaculture or restored oyster reefs show much greater variability than data on nitrogen content of shells and tissues.
- No study to date has shown that intensive oyster aquaculture significantly enhances denitrification. Thus, at present, the workshop participants recommended assigning a value of zero for nitrogen removal via denitrification associated with aquacultured oysters.
- Although data suggest that restored oyster reefs significantly enhance denitrification rates, the degree of enhancement is highly variable. Denitrification rates vary with season, tidal regime, environmental conditions, oyster biomass density, and other unidentified factors, possibly including differences in microbial communities. Additional studies are needed to better understand the sources of this variation before assigning a value to the nitrogen removal capacity of oyster reefs attributable to denitrification.
- Scientists know little about nitrogen sequestration via deep burial; to date, no measurements of nitrogen burial rates associated with oyster reefs or oyster aquaculture have been published.

This table summarizes what is known and what remains to be determined about nitrogen removal by oysters in the Chesapeake Bay.

Oyster growth setting	What is known	What is not known
All settings	• Limited data; see below	• Impact of reproductive state on the nitrogen content of oyster soft tissue • Percentage of nitrogen in the soft tissues and shells of intertidal oysters, and its geographic and seasonal variation • Sequestration rates via burial of biodeposits or shells • Nitrogen removal via anammox or nitrous oxide release • Factors controlling the relationship between oyster biomass density and denitrification rates
Floating aquaculture	• Nitrogen content of shell and tissue • No enhancement of denitrification found in sediments under floats	• Rates for any denitrification that occurs inside floats
On-bottom aquaculture (in cages or not)	• Very little (studies needed)	• Nitrogen content of shell and tissue • denitrification rates, inside cages and in sediments under them, and how they vary by season and by oyster density
Restored oyster reefs	• Nitrogen content of shell and tissue • Some enhancement of denitrification found	• Exactly how denitrification rates vary by season and by oyster density (more studies are under way)
Natural oyster reefs	• Very little (studies needed)	• Whether nutrient assimilation or denitrification rates differ in natural and restored reefs of equal oyster density

Prepared in September 2013 by NOAA Chesapeake Bay Office staff.
For more information, see "Quantifying Nitrogen Removal by Oysters: Workshop Report," by M. L. Kellogg; M. W. Luckenbach; B. L. Brown; R. H. Carmichael; J. C. Cornwell; M. F. Piehler; M. S. Owens; D. J. Dalrymple; C. B. Higgins; and A. R. Smyth, submitted to the NOAA Chesapeake Bay Office in August 2013.