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Nitrogen Removal From Shellfish Aquaculture

Nitrogen Removal Is Minimal, Must be Taken in its Entirety and More Research Is Needed To Determine Meaningful Marine Applications

The shellfish industry has recently been claiming that adding millions of shellfish in Puget Sound will significantly reduce nitrogen. Upon reviewing the limited scientific research available on this issue, the following documentation proves that this industry claim has been inflated and that the nitrogen removal is in fact minimal. Deep sea upwelling and benthic flux are major factors which are not fully understood and yet have a far greater impact. Without a great deal more peer reviewed research on this issue that incorporates both benefits and impacts, nitrogen reduction from shellfish aquaculture should not be a deciding factor for wastewater treatment decisions or the approval process for additional shellfish aquaculture densities or sites.

For years, Washington decision makers have allowed unlimited expansion of shellfish aquaculture based on the unfounded shellfish industry claim that they "cleaned the water." Scientists are now pointing out that there is no scientific evidence in Puget Sound that shellfish aquaculture "clean the water," but that shellfish do strip the water of Fisheries Resources such as fish eggs/larvae, crab zoes and other important components of the food web. Litigation brought by citizens is now pending that documents that aquaculture operations such as geoduck installations in fact degrade water quality essential for the life cycles of other aquatic life. Whether the industry claim is "cleaning the water" or "nitrogen reduction," the Shoreline Management Act clearly states "no net loss of ecological functions." If an activity results in loss of standing stocks of fisheries, then there's a net loss of ecological function associated with that activity as defined in the following link: http://apps.leg.wa.gov/wac/default.aspx?cite=173-26-241

Section 1-Modeling Nitrogen and Carbon Removal by Pacific Oysters in Hood Canal—New 2012 Study-Ashley Echols, Chris Prigmore, Erin Thatcher-University of Washington Department of Civil and Environmental Engineering

http://www.caseinlet.org/uploads/Final_Report_Oysters_CEE547_2012_clean.pdf

Conclusion

Our results indicate that even at very high densities, the Pacific oyster's capacity to remove total nitrogen and carbon flux from Hood Canal is limited throughout most of the year. More importantly, our sensitivity analysis identifies the grazing rate and its response to water temperature (the theta value) as the two most important factors in making these predictions. The oyster habitat area could also be estimated from Hood Canal bathymetry, tidal information, and oyster depth ranges. We suspect this area would not be substantially different than the area we calculated from the DOH commercial shellfish areas, based on a quick visual comparison of these areas with a NOAA bathymetry map.
Our recommendations for future study and modeling efforts related to Puget Sound bivalve effects on water quality are to:

- Confirm the Pacific oyster's grazing rate & determine theta with field measurements
- Confirm the fraction N lost (buried and denitrified)
- Incorporate other Puget Sound bivalves
- Incorporate hydrodynamics
- Account for other means of N loss (such as oyster harvest)
- Confirm the appropriate oyster population and density to assume

Michael Brett's Seattle Times Editorial- November 27, 2012
http://seattletimes.com/html/opinion/2019776551_michaelbrettopedxml.html

Section 2—Hood Canal Nitrogen Research-Interesting Findings-October 2010
The Influence of Watershed Characteristics on Nitrogen Export to and Marine Fate in Hood Canal, Washington, USA, Peter D. Steinberg, Michael T. Brett, J. Scott Bechtold, Jeffrey E. Richey,Lauren M. Porensky, Suzanne N. Smith, October 21, 2010
http://www.caseinlet.org/uploads/Steinberg_et_al._2011.pdf

"Hood Canal, Washington, USA, is a poorly ventilated fjord-like sub-basin of Puget Sound that commonly experiences hypoxia. This study examined the influence of watershed soils, vegetation, physical features, and population density on nitrogen (N) export to Hood Canal from 43 tributaries….Domestic wastewater discharges and red alders appear to be a very important N source for many streams, but a minor nutrient source for the estuary as a whole."

Section 2— Nitrogen Removal with Shellfish Harvest in Oakland Bay and Puget Sound Herrara Consulting, February 5, 2010

http://www.caseinlet.org/uploads/Herrara_Hammersley_Inlet_NitrogenCyclingReport.pdf

"Shellfish harvest removes more of the nitrogen input to Oakland Bay than Puget Sound, but it removes no more than 1 percent of the dissolved nitrogen load in either location. In

Oakland Bay, shellfish harvest was 5.0 percent of the load from terrestrial sources, excluding the marine nitrogen load. Shellfish harvest represents a larger proportion of dissolved nitrogen load to Oakland Bay than Puget Sound because the average depth is lower in Oakland Bay and, thus, the shellfish harvest rate per volume of water is greater in Oakland Bay.

In part, shellfish nitrogen removals appear small because marine nitrogen loads in both Puget Sound and Oakland Bay are relatively high. Waters outside of the Strait of Juan de Fuca exhibit a strong correlation between salinity and nitrate concentrations, i.e., the nitrate concentration increases with depth. Upwelling of these deep waters off the Strait of Juan de Fuca is the largest nitrogen source to Puget Sound (Mackas and Harrison 1997). Within Puget Sound, areas having relatively uniform salinities with depth experience vertical mixing and overturning circulation that contributes additional nitrogen loads to surface waters.

Importantly, this set of calculations does not include shellfish impacts on water quality, other than through harvest. For example, shellfish may reduce the release of ammonium resulting from sediment diagenetic processes and also favor the conversion of ammonium to nitrate, an essential step before denitrification (Cerco and Noel 2005). These difficult-to-quantify higher order water quality effects are neglected in looking only at nitrogen removal through harvest. A deterministic shellfish and water quality modeling study in the northern Adriatic Sea found nitrogen loss to sediment processes could be a flux twice as large a nitrogen removal from harvest (Brigolin et al. 2009). If this pattern were realized in Puget Sound, the combined nitrogen removal due to aquaculture and harvest would be closer to 3 percent of the total input nitrogen load."

The following study is important to review along with the Herrara comments provided above:

Ecosystem Influences of Natural and Cultivated Populations of Suspension-Feeding Bivalve Molluscs—A review, Dr. Roger Newell, 2004

http://www.hpl.umces.edu/faculty/newell/ecobivalve2.pdf

"Environmental conditions at bivalve aquaculture sites should be carefully monitored, however, because biodeposition at very high bivalve densities may be so intense that the resulting microbial respiration reduces the oxygen content of the surrounding sediments. Reductions in sediment oxygen content can inhibit coupled nitrification-denitrification, cause P to become unbound an released to the water column, and the resulting buildup of H2S can be toxic to the benthos." Abstract

Section 3—Mussel Rafts—Examination of Data Regarding Removal of Nitrogen

Taylor Shellfish has proposed additional 48-58 rafts with mussels on grow out lines that would be placed in water depths of 15-70 ft MLLW in 16+ acres of public waters.

The Taylor Shellfish Mussel Raft Environmental Impact Statement included numerous studies. While there is a great deal of information presented on the issue of nitrogen, these studies show the nitrogen removal number varies widely, there are various factors that change the net nitrogen removal statistic, some of the data is based on a Hood Canal study that is a different water body and the discharge of nitrogen back into the inlets from the

shellfish waste handled upland is not included in the analysis. What is important from all of these reports, is that Newfield's and Rensel's numbers are not correct nor are they inclusive of all nitrogen inputs into Totten Inlet.

The data from these studies was presented at the Taylor Totten Inlet Mussel Raft hearing before the Thurston County Hearing Examiner in February 2012. According to the APHETI Closing Brief: "When asked whether the (nitrogen) reduction would have a significant difference on the health of Totten Inlet, Mr. Rensel (Taylor's scientist) responded squarely: "not measurably." This information is contained in the following APHETI closing brief: http://www.co.thurston.wa.us/permitting/devactivity/totten/hearing/APHETI.closing.argument.pdf

In later testimony, Rensel then reversed his statement and said it would be meaningful, but also said it would not be useful because it did not include marine water sources. Example:

An Assessment of Potential Water Column Impacts on Mussel Raft Culture in Totten Inlet, Newfields, November 2009

http://www.co.thurston.wa.us/permitting/devactivity/totten/eis-eport/Final%20Technical%20Reports/9-NewFields-2009-AssessmtOfPotentialWaterColumnImpacts.pdf

The amount of nitrogen removed by harvest is estimated to be 4,549 kg N/yr, based on the total estimated harvest of 399,074 kg whole body wet weight and a total nitrogen content of 1.14%(includes both soft tissue and nitrogen sequestered in the shell; Haamer 1996). Page43

Since low dissolved oxygen is a serious threat to fish populations in Puget Sound, the following low dissolved oxygen impact of mussel rafts should be noted: "Our review of existing data and application of predictive modeling indicates that although DO may be significantly reduced within the raft, it will generally remain above the biological stress concentration of 5.0 mg/L. At periods of low ambient DO (late August and early September), dissolved oxygen concentrations below 5.0 mg/L would be expected to persist some distance downstream from the raft edge. However, once the water exits the raft, it will likely recover to ambient DO concentrations within 70 m to 200 m, due to entrainment of surrounding waters and from increased turbulence arising from the presence of the raft structure. Page 90

Mussel Raft Example: In order to raise the level of nitrogen removal to a significant level (say >5%, or 114 tons), an additional 67 tons of nitrogen would have to be harvested. This is an additional 6,700 tons of shellfish. If each mussel raft produces 20,000 pounds, it would require an additional 670 rafts to be added to Puget Sound inlets.

Section 5—Shellfish Industry Scientist Washington State Legislative Testimony
Jonathan Davis testified January 18, 2012 before the Senate Environment Committee on a proposal to implement a Nitrogen "cap and trade" program and stated a "general figure of around 1%" of the harvested weight would be how much Nitrogen could be used to determine how much Nitrogen would be removed.

Summary
At this time, nitrogen reduction claims by the shellfish aquaculture industry relevant to Washington State are not supported by scientific evidence. Further research is needed to determine whether a "nitrogen credit" program is viable. It should also be pointed out that the wild geoducks are not replanted so their nitrogen removal component is removed from the system.

There are proven ways other than adding millions of shellfish to reduce nitrogen without negatively impacting public fisheries resources. Improvements in reducing nitrogen sources from fertilizers and septic systems in addition to re-forestation along the shoreline with native firs should be encouraged for the overall health of our Washington waters.

The following information provides an opportunity to use published data to provide a general example of the increased tons of shellfish it would take to make a minimal change in Nitrogen without taking into consideration the other factors and impacts:

South Sound Dissolved Oxygen Study Data—Page 3
(It is important to note that the following figures do not include deep sea upwelling; benthic flux. It is also not clear whether on-site septic systems along the shorelines are included.)

DIN load from rivers: 6,000 pounds per day
DIN load from WWTP: 6,500 pound per day
Total from rivers/wwtp: 12,500 pounds per day
River and Waste Water Treatment Plant Annual DIN: 2,281 Tons DIN/yr
(12,500*365/2000)
2% = 45 Tons DIN
In order to remove this 2% DIN figure (45T) you would need to harvest 4,500 tons of shellfish (assumes 1% nitrogen).

2008 South Puget Sound WDFW--Shellfish harvest records of oysters, clams, and mussels
south of Tacoma: 3,970 tons
Wild geoduck: 750 tons (assumes 1/2 of estimated 3 million pounds are from SPS)
Total reported: 4,720 Tons of shellfish harvested
Nitrogen removed: 47 Tons/N = 2% (Example does not include all factors or impacts)

Ecosystem influence of natural and cultivated populations of suspension-feeding bivalve mollusks: a review— http://www.hpl.umces.edu/faculty/newell/ecobivalve2.pdf

According to this study by Roger Newell of Horne Point Laboratories in Chesapeake Bay, unnaturally high densities of bivalves can become toxic to the benthos:

"Environmental conditions at bivalve aquaculture sites should be carefully monitored, however, bivalve biodeposition at very high bivalve densities may be so intense that the resulting microbial respiration reduced the oxygen content of the surrounding sediments. Reduction in sediment oxygen content can inhibit coupled nitrification-denitrification, cause P to become unbound and release to the water column, and the resulting buildup of H2S can be toxic to the benthos."

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