

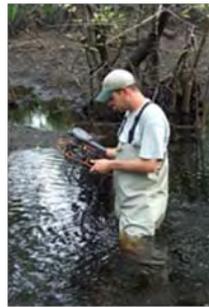
WA Shellfish – Economic Value of Water Quality Improvements

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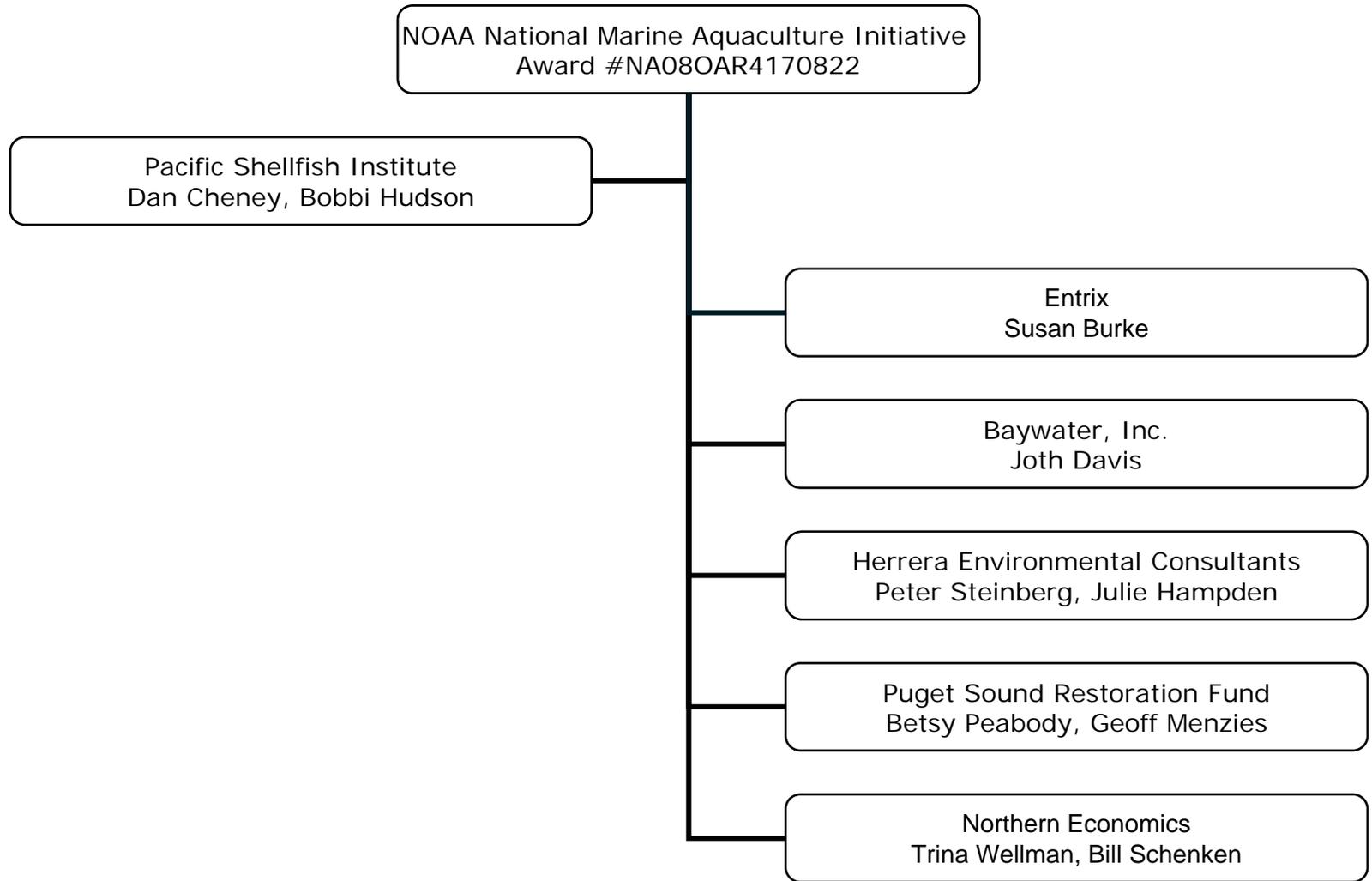
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ENTRIX

Down to Earth. Down to Business.™

Organization





Research Goals - Overall

1. Assess shellfish harvest nitrogen removal
2. Estimate value of N sequestration
3. Analyze shellfish production and restoration benefits and costs
4. Gather stakeholder input on shellfish production and restoration



Research Goals – This presentation

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Motivation

“Excess loadings of nitrogen and phosphorus, commonly referred to as nutrient pollution, are one of the most prevalent causes of water quality impairment in the United States”

- US EPA, 40 CFR Part 13, 2009

Motivation

Mississippi dead zone

More than 30 years after the passage of the Clean Water Act, in 2008 the Gulf hypoxic zone was the second largest on record – 20,720 square kilometers – bigger than the State of Massachusetts.”

- Mississippi River and Gulf of Mexico Watershed Nutrient Task Force



Motivation

Florida - EPA's pending numeric nutrient criteria

“Federal numeric nutrient criteria for Florida surface waters will cause ... Florida municipal wastewater treatment utilities will spend an estimated **\$24.4 to \$50.7 billion in capital costs** for additional treatment facilities and incur an estimated **\$0.4 to \$1.3 billion dollars per year** in additional operating costs”

*- Florida Water Environment Assoc.
letter to Florida Gov Crist re EPA's numeric nutrient standards for Florida surface waters*

Motivation

Chesapeake Bay – nutrient reduction targets

- Nutrient control actions reduced the amount of nitrogen entering the Bay annually to about 283.5 million pounds
- To achieve Bay water quality standards, models estimate nitrogen needs to be **reduced to about 200 million pounds a year.**

- *Alliance for the Chesapeake Bay, Bay Journal, Oct 2009*

NITROGEN LOADS TO THE BAY BY STATE (Annually, in millions of pounds)			
State	1985	2008	Target
District of Columbia	12.57	3.54	2.37
Delaware	9.10	9.91	5.25
Maryland	89.07	58.01	41.04
New York	18.09	16.71	10.54
Pennsylvania	156.11	114.79	73.64
Virginia	102.28	72.82	59.22
West Virginia	10.02	7.78	5.71
Total	397.24	283.55	197.76

Motivation

Chesapeake Bay – nutrient reduction targets

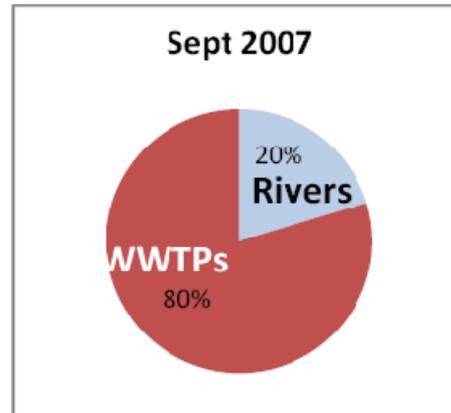
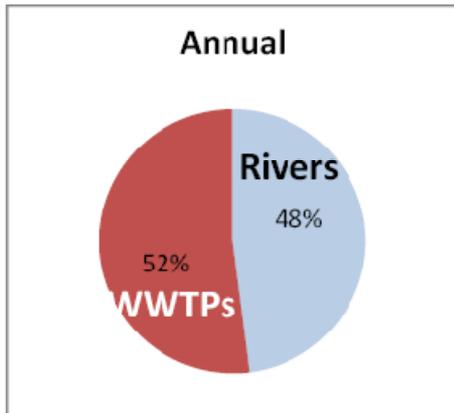
\$8.3 billion would be needed in capital to reduce WWTP N loads to 3.0 mg/L – *Chesapeake Bay Foundation, 2002*



Motivation – the Study Area

South Puget Sound -

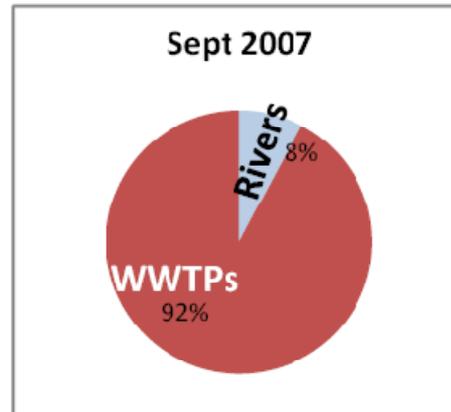
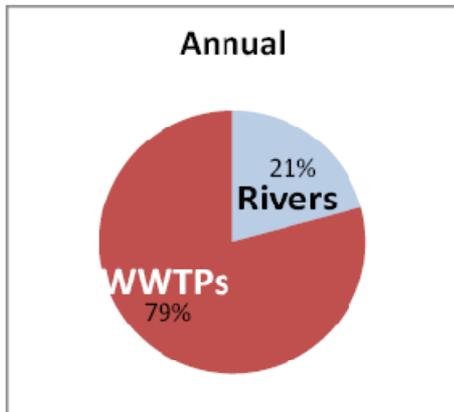
South Puget Sound (south of Tacoma Narrows)



WWTPs contributed a significant percent of the DIN load.

– *South Puget Sound Dissolved Oxygen Study, Dec 2008*

South and Central Puget Sound (south of Edmonds)

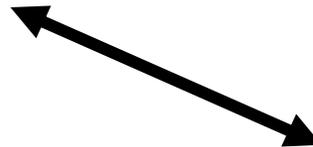


Motivation

Study question

How much N do shellfish sequester?

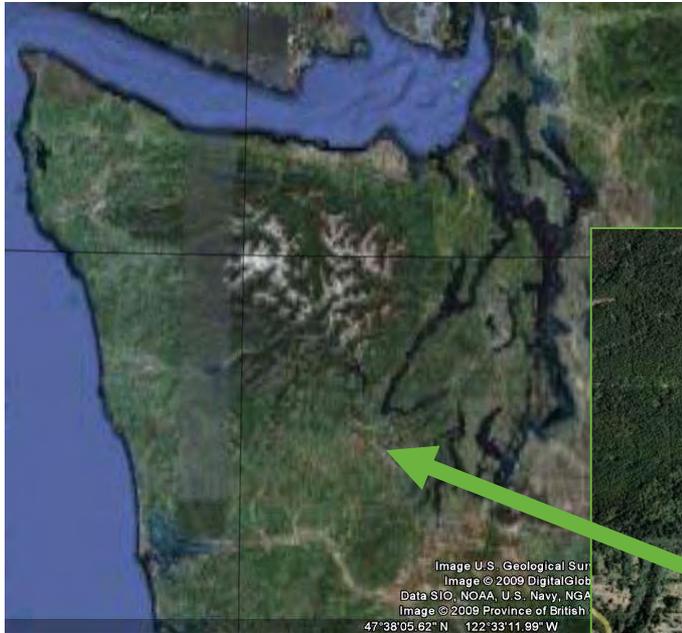
And what is the replacement cost of N removed by shellfish?



?????



Study Area



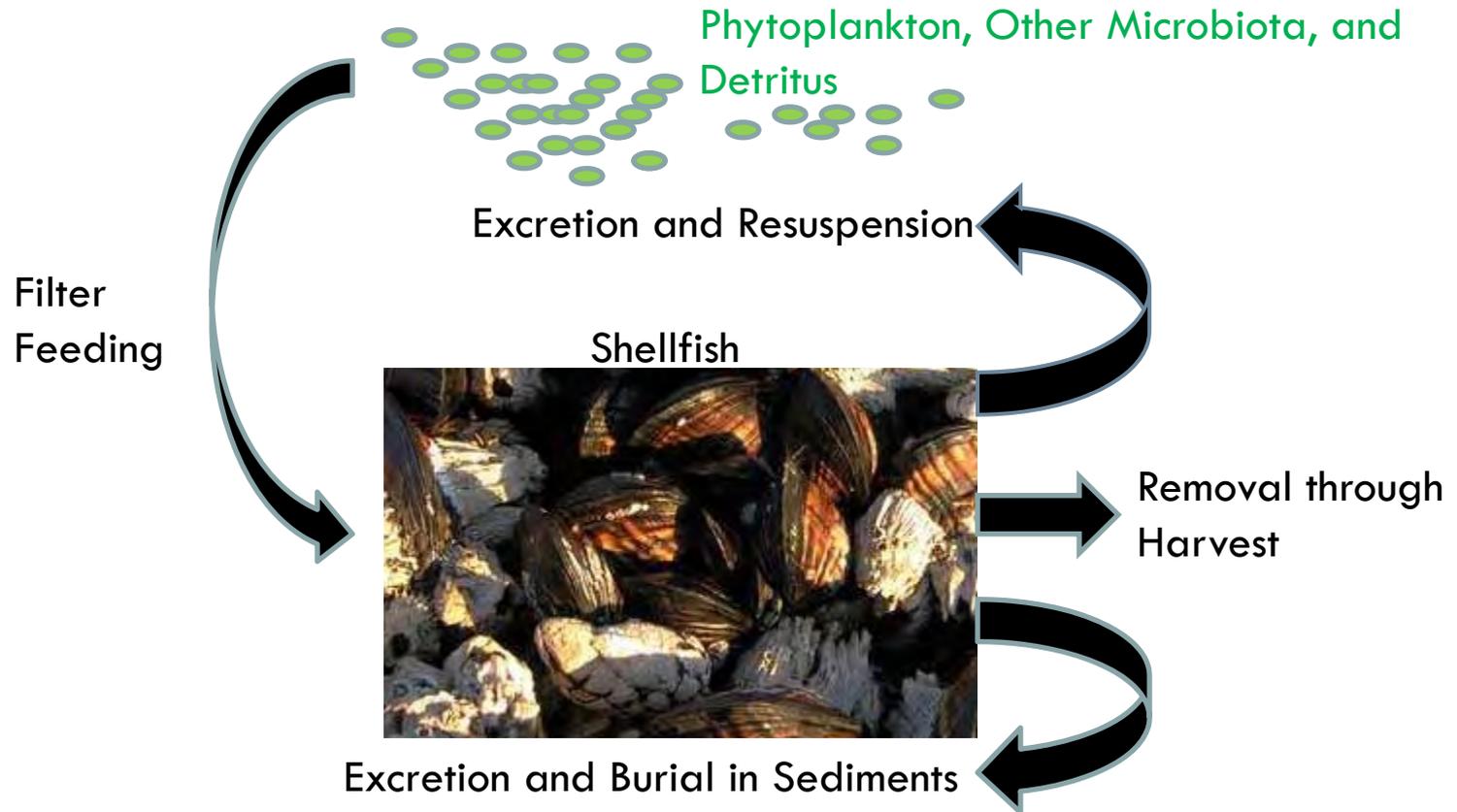
Puget Sound

Image U.S. Geological Sur
Image © 2009 DigitalGlob
Data SIO, NOAA, U.S. Navy, NGA
Image © 2009 Province of British
47°38'05.62" N 122°33'11.89" W



Oakland Bay

Simplified Shellfish and Nitrogen Cycle





Shellfish Nitrogen Cycle

- Shellfish remove nitrogen from the water column
 - How much becomes resuspended or buried is difficult to measure
 - Deterministic modeling suggests nitrogen burial in sediments under shellfish beds may be a flux twice as large as nitrogen removal through harvest (Brigolin et al 2009)
 - Nitrogen removal through shellfish harvest is more easily quantified
 - This study focuses on nitrogen removal through harvest
 - Looking at other nitrogen sequestration would require more input assumptions and data (e.g. growth kinetics)

Nitrogen Removal in Shellfish Harvest

- Variables that need to be known
 - Mass of shellfish harvested each year
 - Mean nitrogen concentration in shellfish
 - A study in Henderson Inlet is being conducted to look at shellfish nitrogen concentrations by species and season
 - In the meantime, a shellfish nitrogen concentration of 1 percent of harvested mass was assumed based on the literature (Rice 2001; Ojea et al. 2004; Linehan et al. 1999).

Initial Results

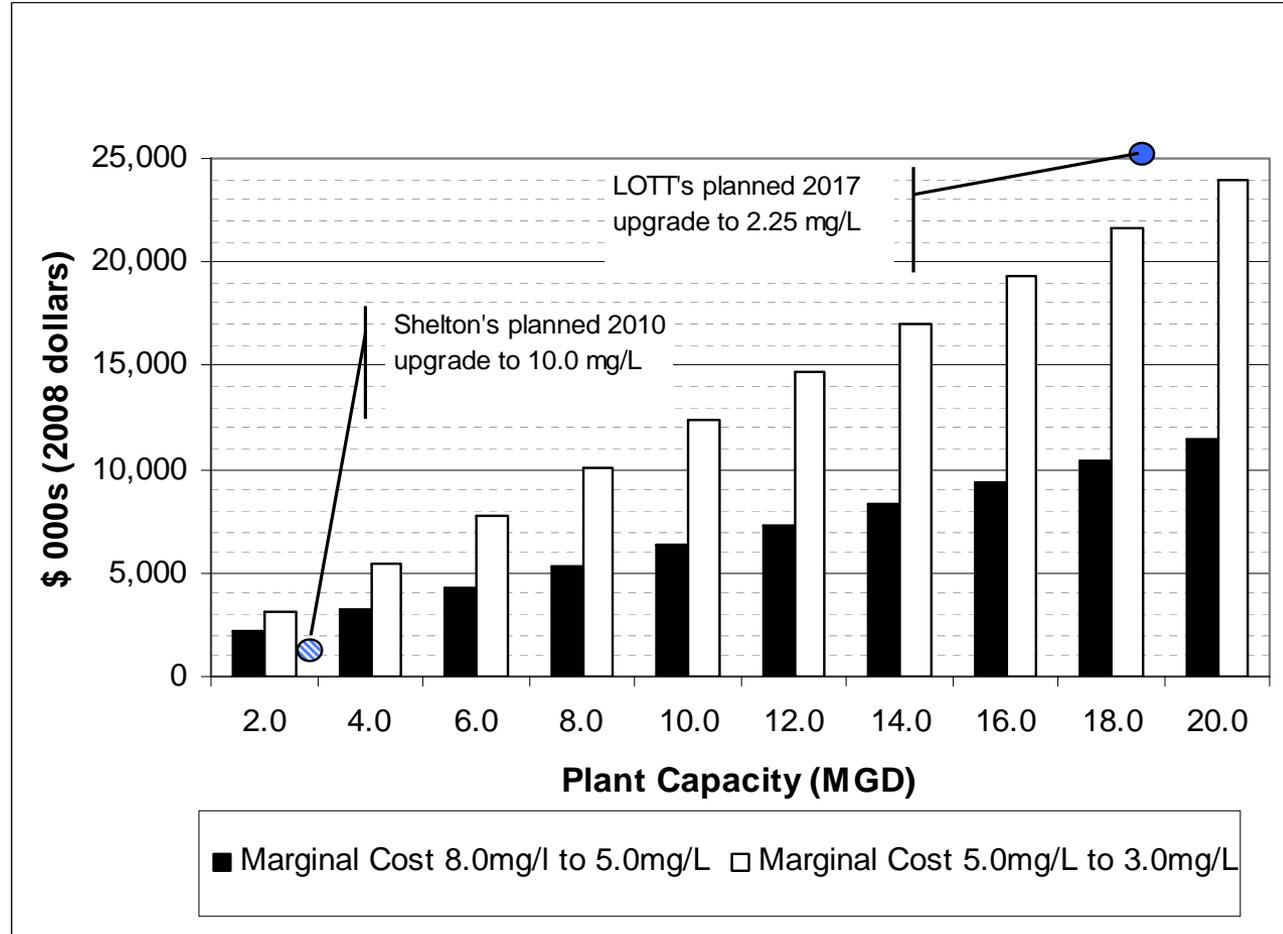
- Herrera's estimates **N removal at harvest is 11.7 MT/year (~25,800 lbs)** in Oakland Bay
- What is the replacement cost to remove ~25,800 lbs of N?
- **It depends -**

Engineering Cost - LOTT

- **Pre 1994**
 - Nitrogen (TIN) annual average load of 18 mg/L
- **Nitrogen Removal Upgrade – 1994**
 - Nitrogen related costs were approximately \$37 million
 - TIN load decreased to an annual average of 4.0 mg/L
 - Life cycle \$7.56/lb N removed
- **Process Control Improvements Project – anticipated 2017**
 - Nitrogen related costs estimated at \$25 million.
 - TIN loads expected to decrease to approximately 2.25 mg/L
 - Life cycle \$25.26/lb N removed

Marginal Cost of N Removal

Chesapeake Bay Foundation



N removal technology costs

LOTT and City of Shelton

Source / Case Study	Life-Cycle Unit Cost	Unit Cost		Relevant Design Criteria
		Capital	O&M	
	\$/lb of TN removed	\$/lb of TN removed	\$/lb of TN removed	Capacity (MGD) Post-Project N Concentration (mg/L)
City of Shelton (c)				
Planned 2010 upgrade	\$2.99	\$2.99	Not available	3.3 average MGD 10.0 mg/L N removes 365,000 lbs N
LOTT (d)				
1994 Upgrade	\$7.56	\$7.56	Not available	10 average MGD 4.0mg/L n removes approx 426,449 lbs N
Planned 2017 Upgrade	\$25.24	\$25.24	Not available	16.2 average MGD 2.25mg/L N removes approx 86,356 lbs N

Sources: Personal communications with John Ozga, City of Shelton and Allan Maas, Parametrix, 2009, (d) Personal communication with Karla Fowler, LOTT, 2009 and 2008 Annual LOTT Capacity Report

Estimates of Annual Value of Replacement Cost to Remove 25,800 lbs of N

- **City of Shelton**, (3.3 MGD, \$1.25M to 10.0 mg/L for a 365,000lb N reduction)
 - \$77,142 annually
 -
- **EPA Study range**
 - \$37,668 annually (Kalispell, MT - 3.0 MGD, \$4.3M to 10.6 mg/L for a 258,000lb N reduction)
 - to \$99,846 annually (The Fiesta Village, FL (3.2 MGD, \$13.2M to 1.7mg/L for a 303,000lb N reduction)

Estimates of Replacement Cost of N Sequestered by Shellfish

- **LOTT estimates**

- 1994 upgrade (18.0 MGD, \$37.0M from 18.0mg/L to 4.0 mg/L)
- \$195,058 annually
-
- 2017 planned upgrade (18.0 MGD, \$25.0M to 2.25 mg/L) \$651,708 annually

Conclusion and Extensions

- Conclusion-
 - WWTP face increase marginal cost of N removal
 - As the last mg/L of N is being removed it may be economical to look for creative alternatives, like taking \$650,000 annually to expand shellfish harvest – myriad of other benefits too
- Extensions
 - The Henderson Inlet study will help inform the timing of N sequestration



Thank you
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**Removal through
Harvest**