Apr 30th, 3:30 PM - 5:00 PM

Rapid deterioration of sediment surface ecosystems in Bellingham Bay as indicated by benthic foraminifera

Elizabeth A. Nesbitt
University of Washington, lnesbitt@u.washington.edu

Ruth A. Martin
University of Washington

Jude K. Apple
Western Washington University

RAPID DETERIORATION OF SEDIMENT SURFACE ECOSYSTEMS IN BELLINGHAM BAY AS INDICATED BY BENTHIC FORAMINIFERA

Elizabeth Nesbitt[1], Ruth Martin[1], Jude Apple[2], Adrienne Sorenson[1]

[1]Earth & Space Sciences Department and Burke Museum
University of Washington, Seattle

[2]Shannon Point Marine Center
Western Washington University, Bellingham

What is a foraminifera?

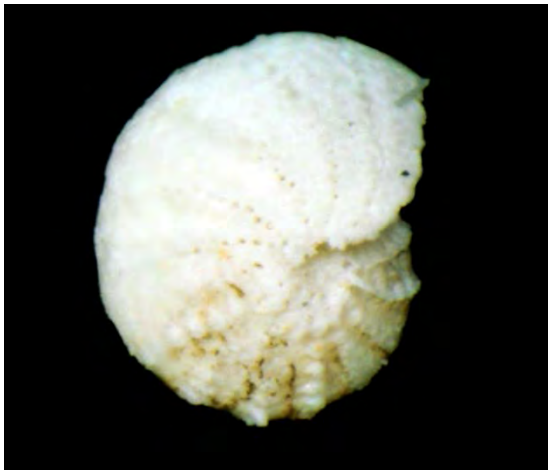
Foraminifera (forams) are shelled, microscopic, single-celled, amoeboid protists. They are

- are ubiquitous in marine and estuarine settings
- around 0.5 mm in size
- benthic or free-floating planktonic
- the shells are usually multi-chambered and are constructed with $CaCO_3$ or they are agglutinated

Forams offer an independent assessment of ecosystems

Benthic foraminifera are excellent indicators of the environmental status because of

- their fast turnover rates
- the preservation of dead assemblages in the fossil record
- sensitivity to physical parameters and to stressors
- some are very tolerant of organic pollutants
- calcareous shells are vulnerable to dissolution



Studies using benthic foraminifera have been done in many estuaries world wide. But no comprehensive studies had been done in the Salish Sea.

Our sample are provided by the WA Dept of Ecology–subsamples from their annual sediment monitoring program (since 1997)

The top 2 cm of sediment are taken by a Van Veen grab sampler. Sub-samples are used for a) chemistry and pollutant analyses, b) invertebrate fauna, and c) micro-biota

http://www.ecy.wa.gov/programs/eap/psamp/index.htm

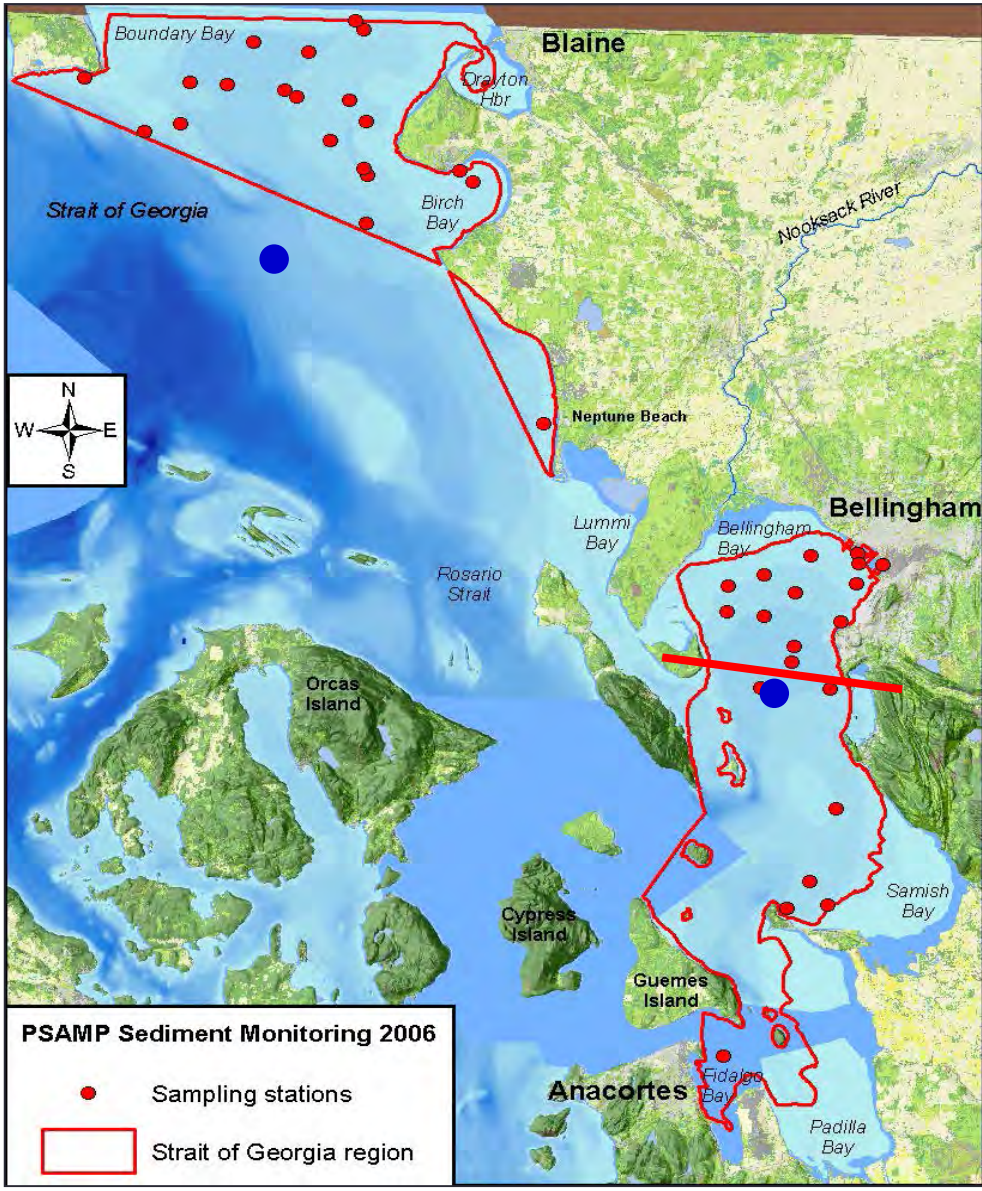
Bellingham Bay

Sampled in by DOE

- June/July 1997, 2006, 2010
- 55 samples analyzed

For comparison:13 sites in Straits of Georgia (Puget Sound) from 1997 and 2006.

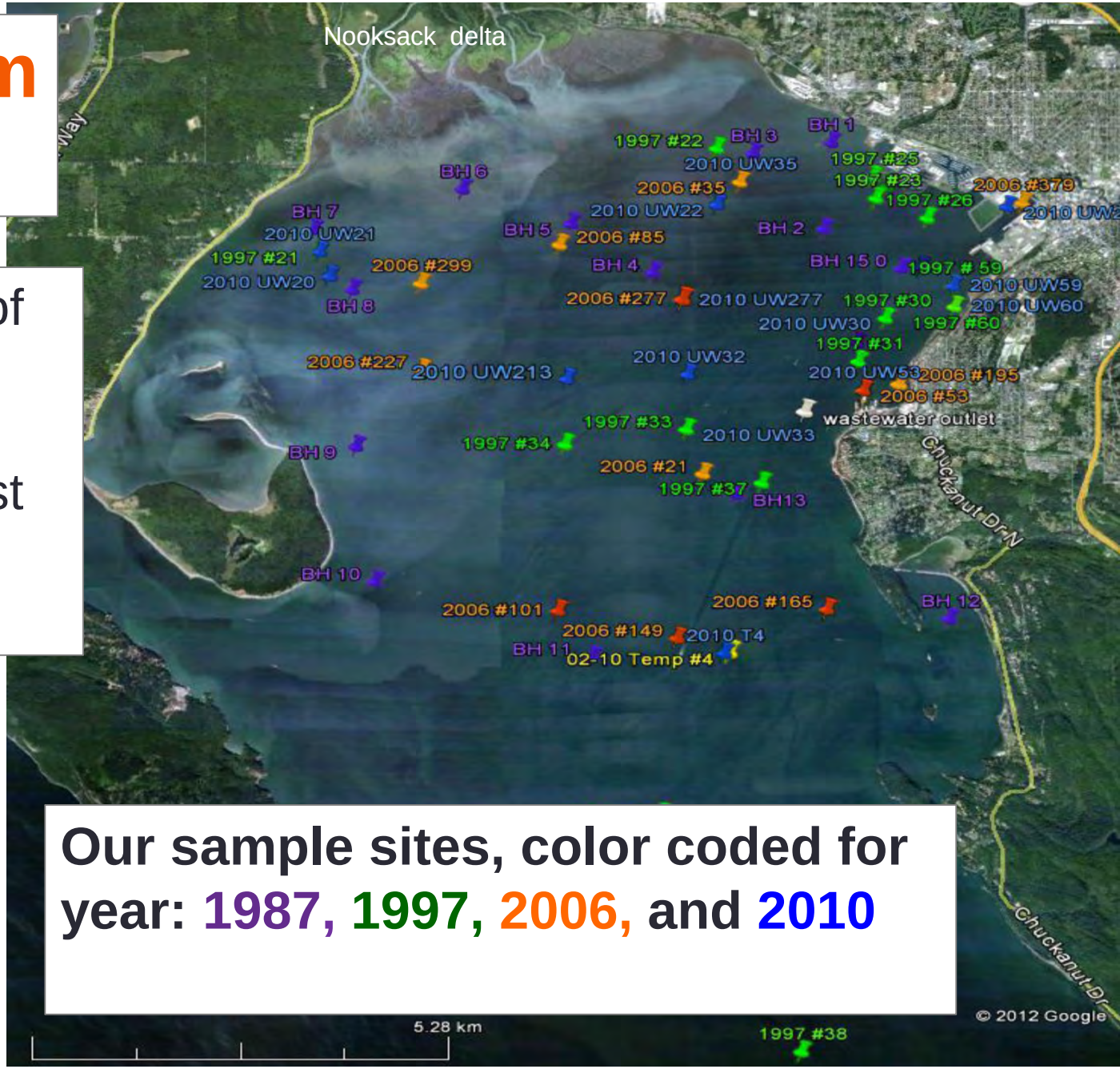
10 additional samples from Bellingham Bay from a donation to the Burke Museum by Robert Harmon (Shoreline CC) collected in 1987



Bellingham Bay

Sample depths of 3.5 to 31.3 m

Grain size – most sites with >80% silt+clay size

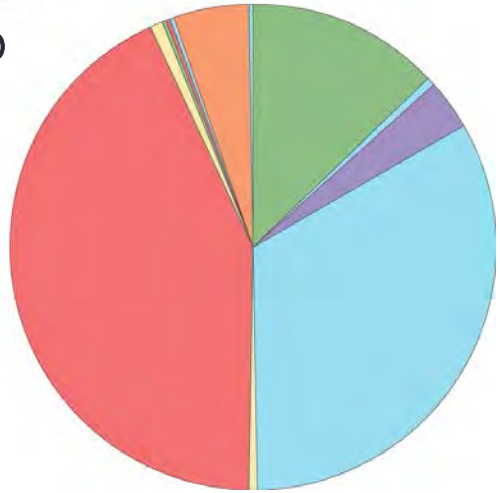


Species composition for BB samples (n): total of 18 species

300 individuals/sample

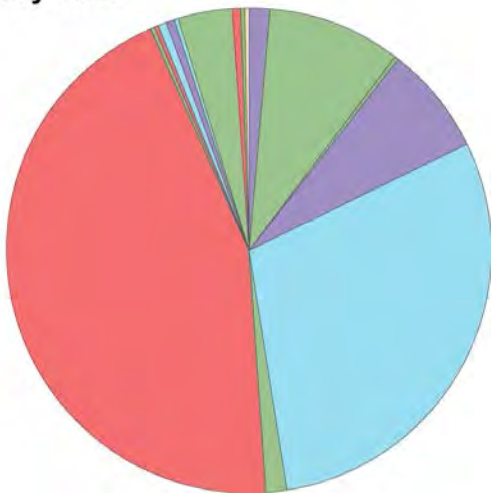
1987

n=10



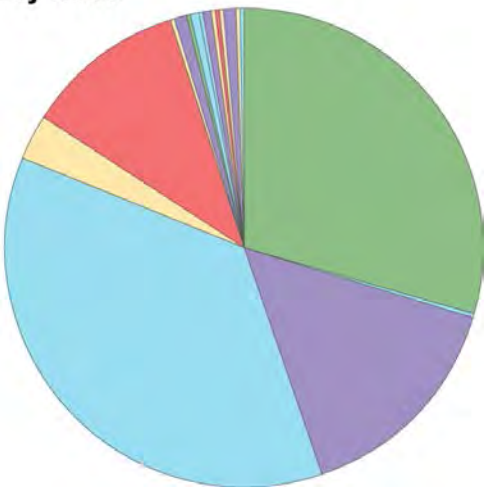
Bellingham Bay 1997

n=18



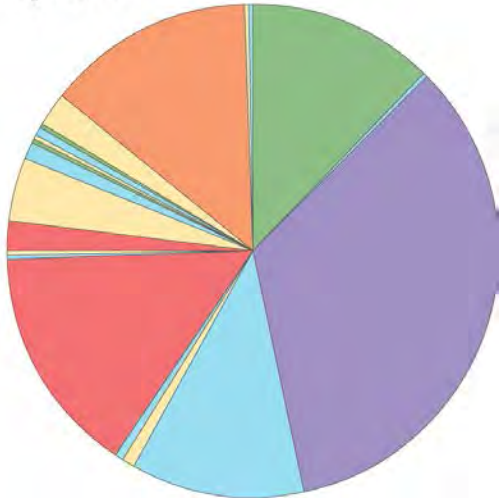
Bellingham Bay 2006

n=12

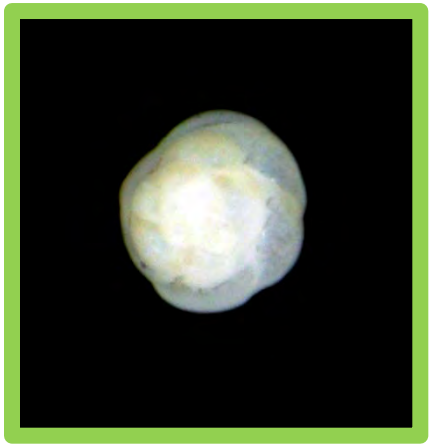


Bellingham Bay 2010

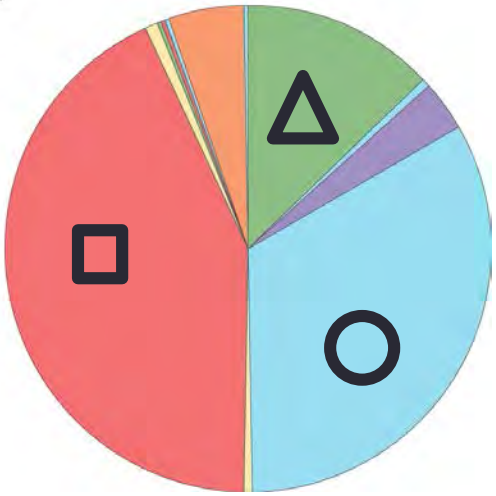
n=25



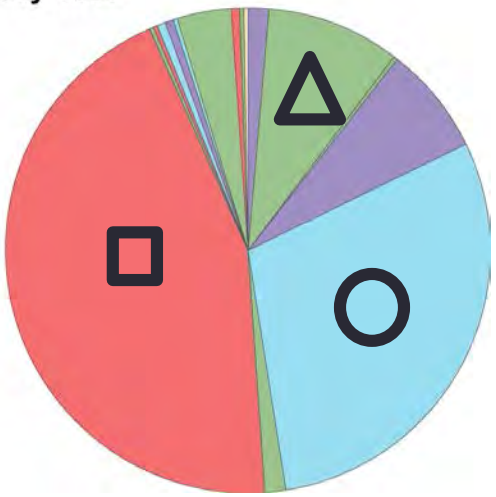
Calcareous species



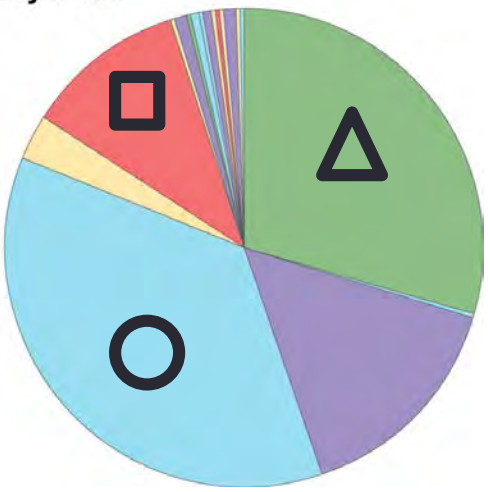
1987



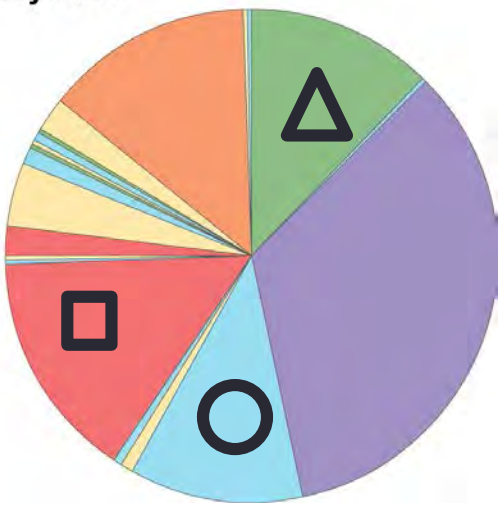
Bellingham Bay 1997



lingham Bay 2006



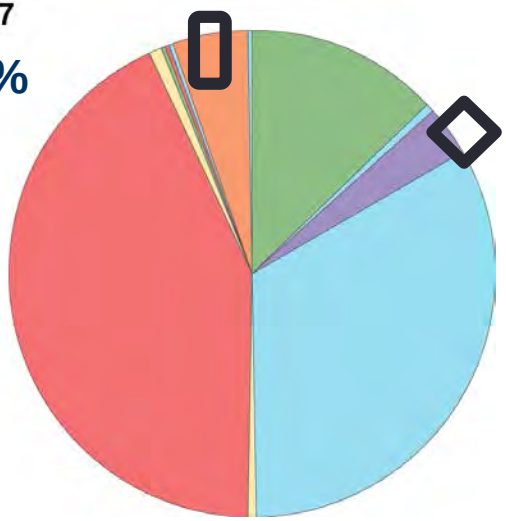
Bellingham Bay 2010



Agglutinate species

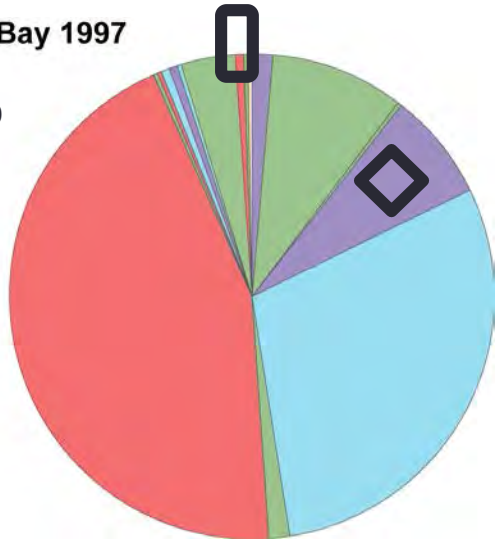
1987

9.2%



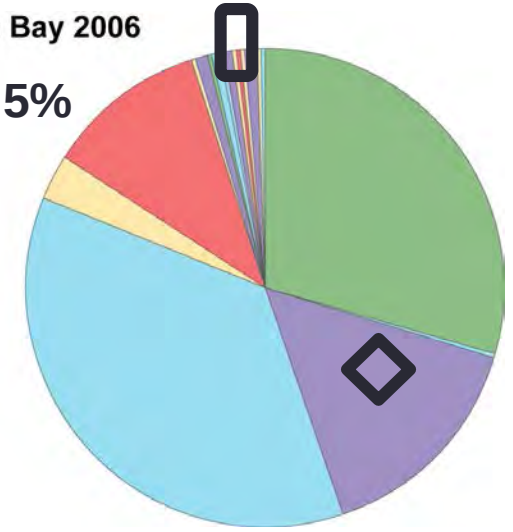
Bellingham Bay 1997

14.6%



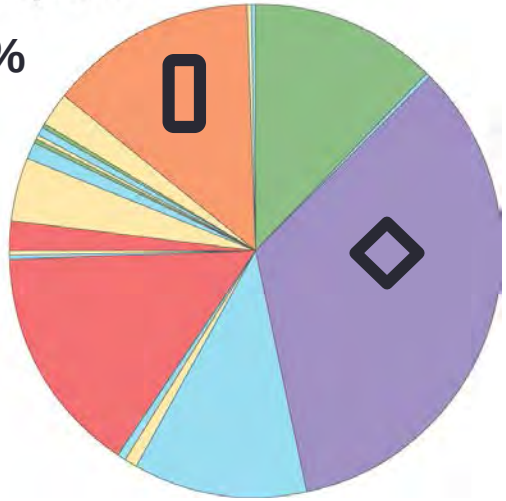
Bellingham Bay 2006

17.5%

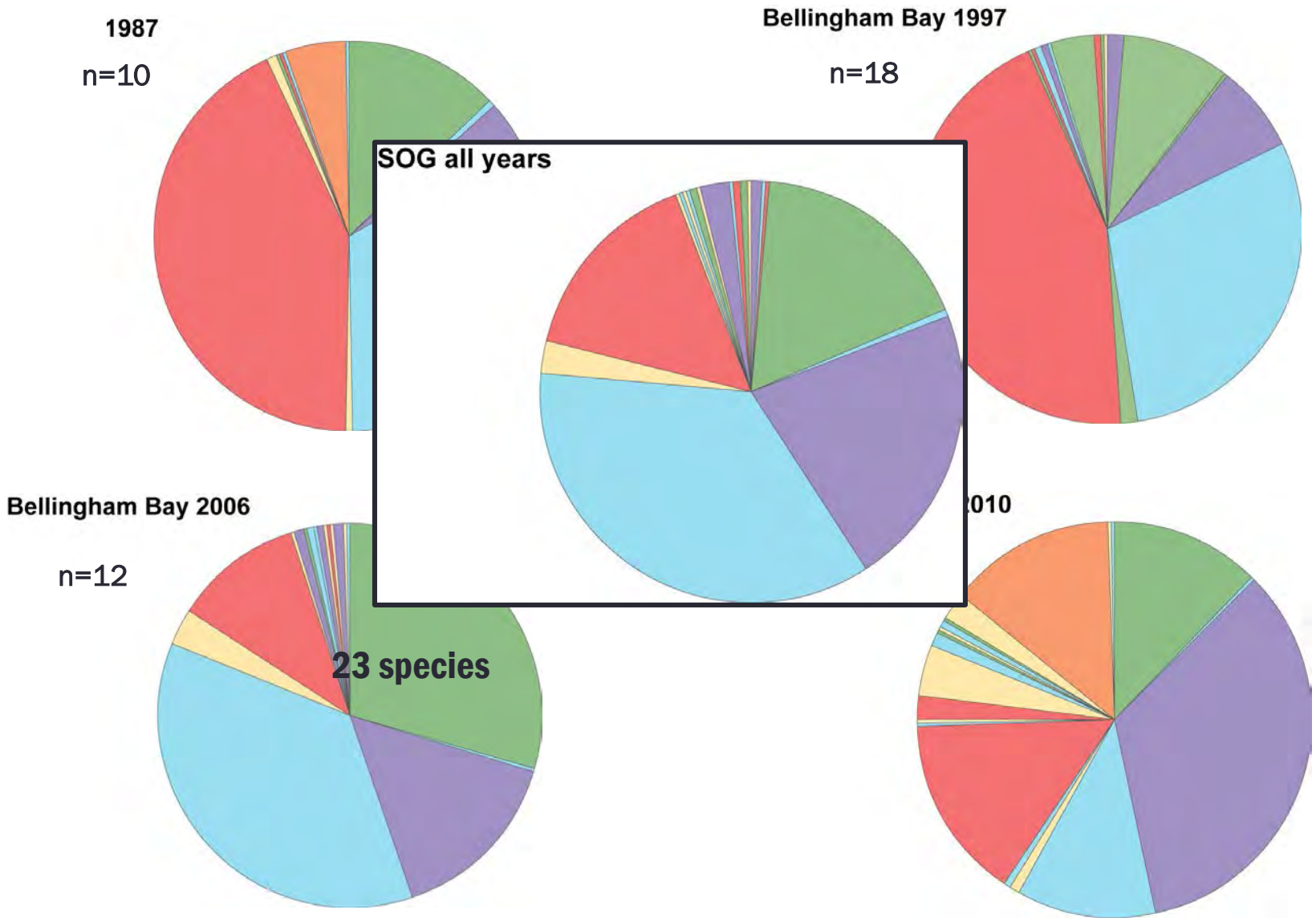


Bellingham Bay 2010

58.2%

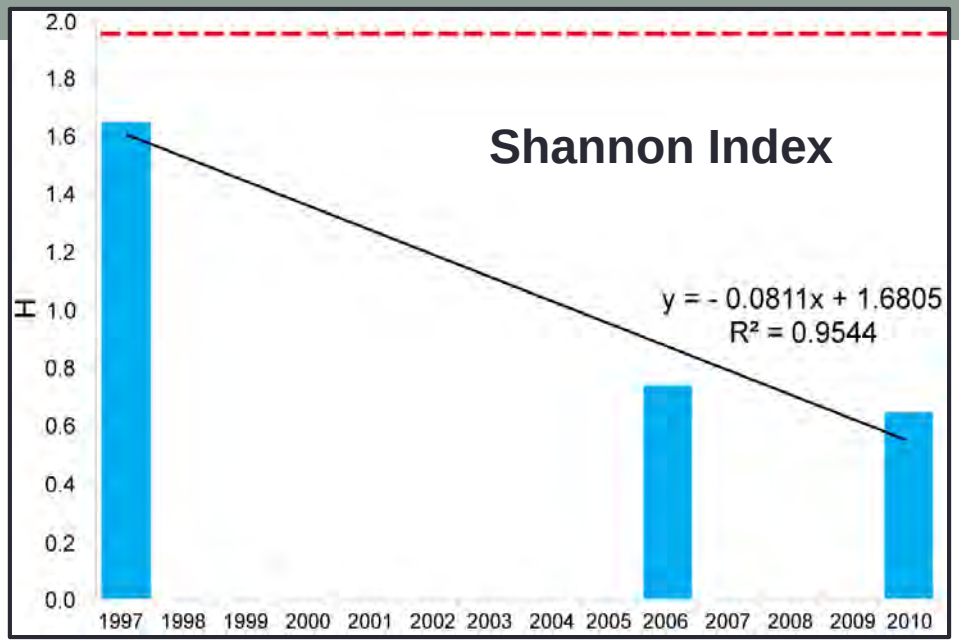


Species composition for BB samples (n): total of 18 species



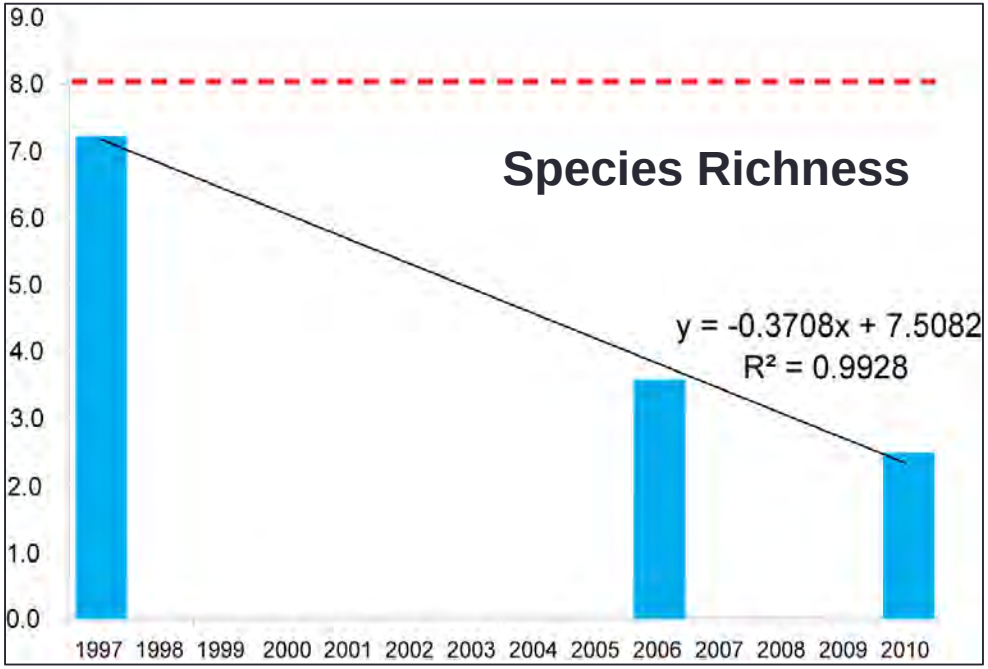
Bellingham Bay samples

- 1987 and 1997: all samples had forams. In 1997 very high densities (# individuals/gm washed sediment)
- 2006: 6 of 12 samples in were barren, one sample with only 3 specimens (agglutinates)
- 2010: 14 samples of 25 in were barren, all from the central and eastern part of the bay. Five samples with 98-100% agglutinate species

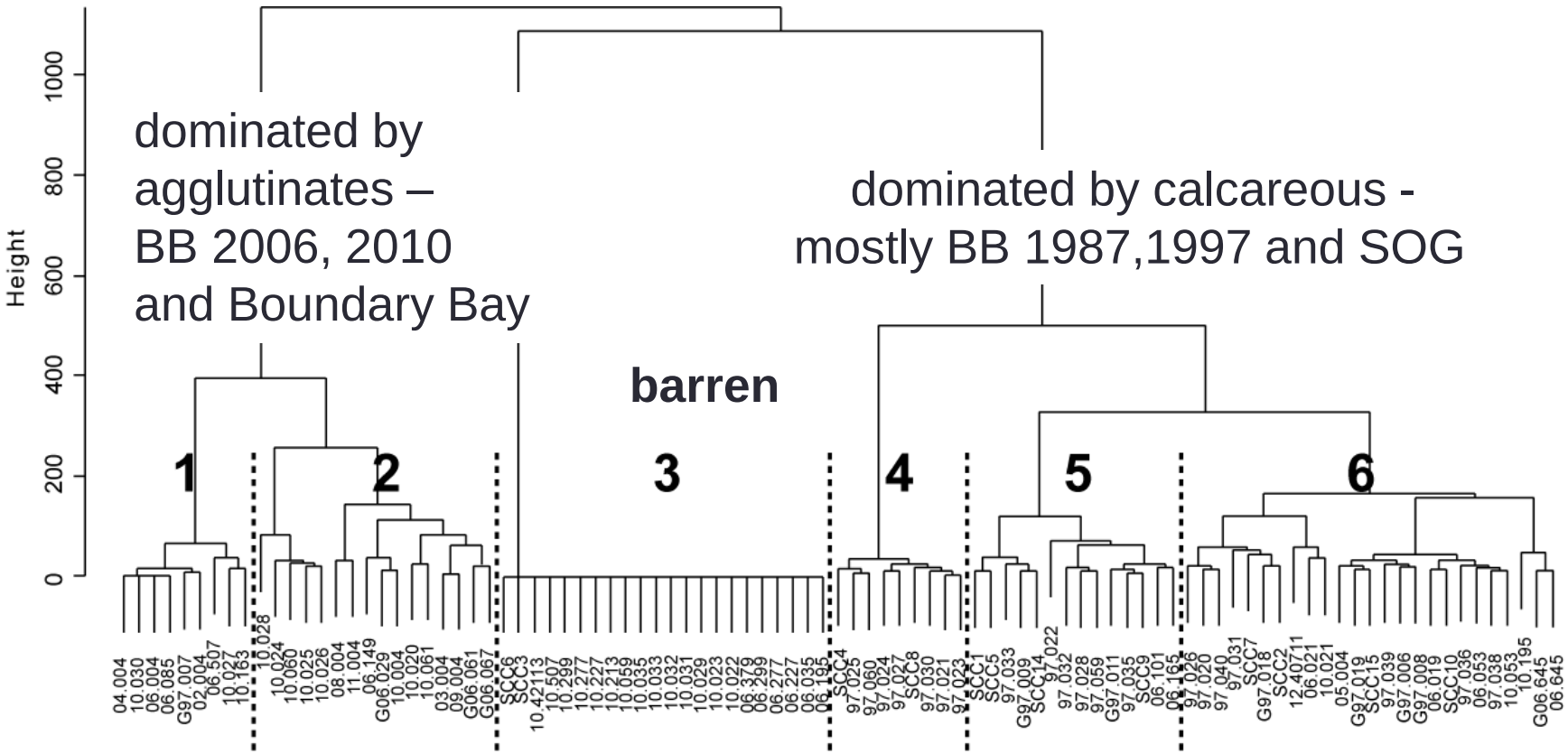


And same numbers for Straits of Georgia are higher for each year

Shannon Index (species diversity) and Species Richness for Bellingham Bay: 1997, 2006, 2010

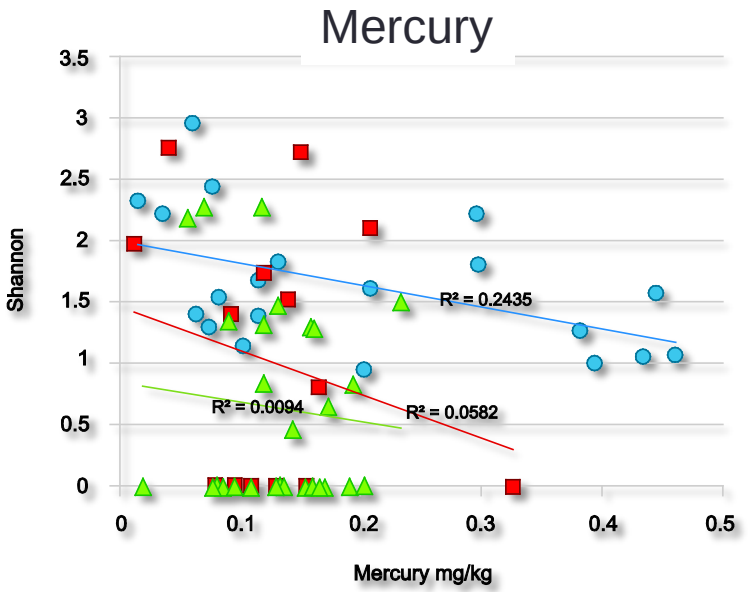


Cluster Analysis of assemblage from BB and SOG



What is driving the loss of overall diversity?

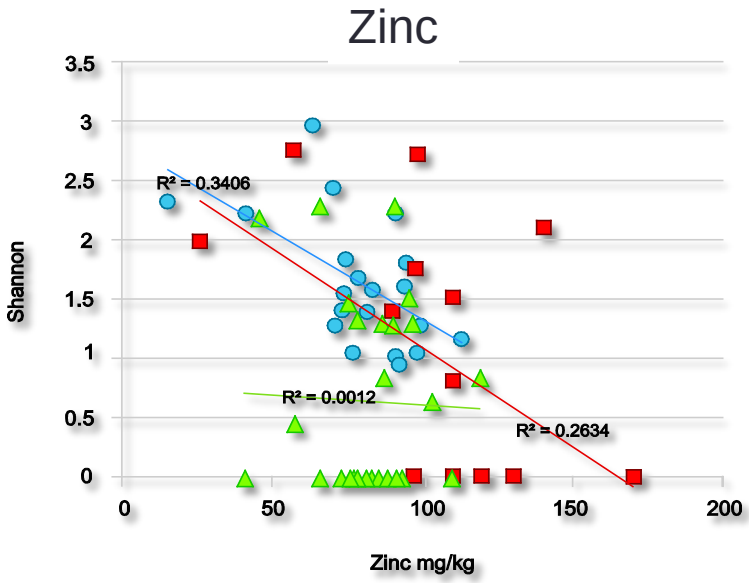
and the increased dominance of agglutinate taxa?



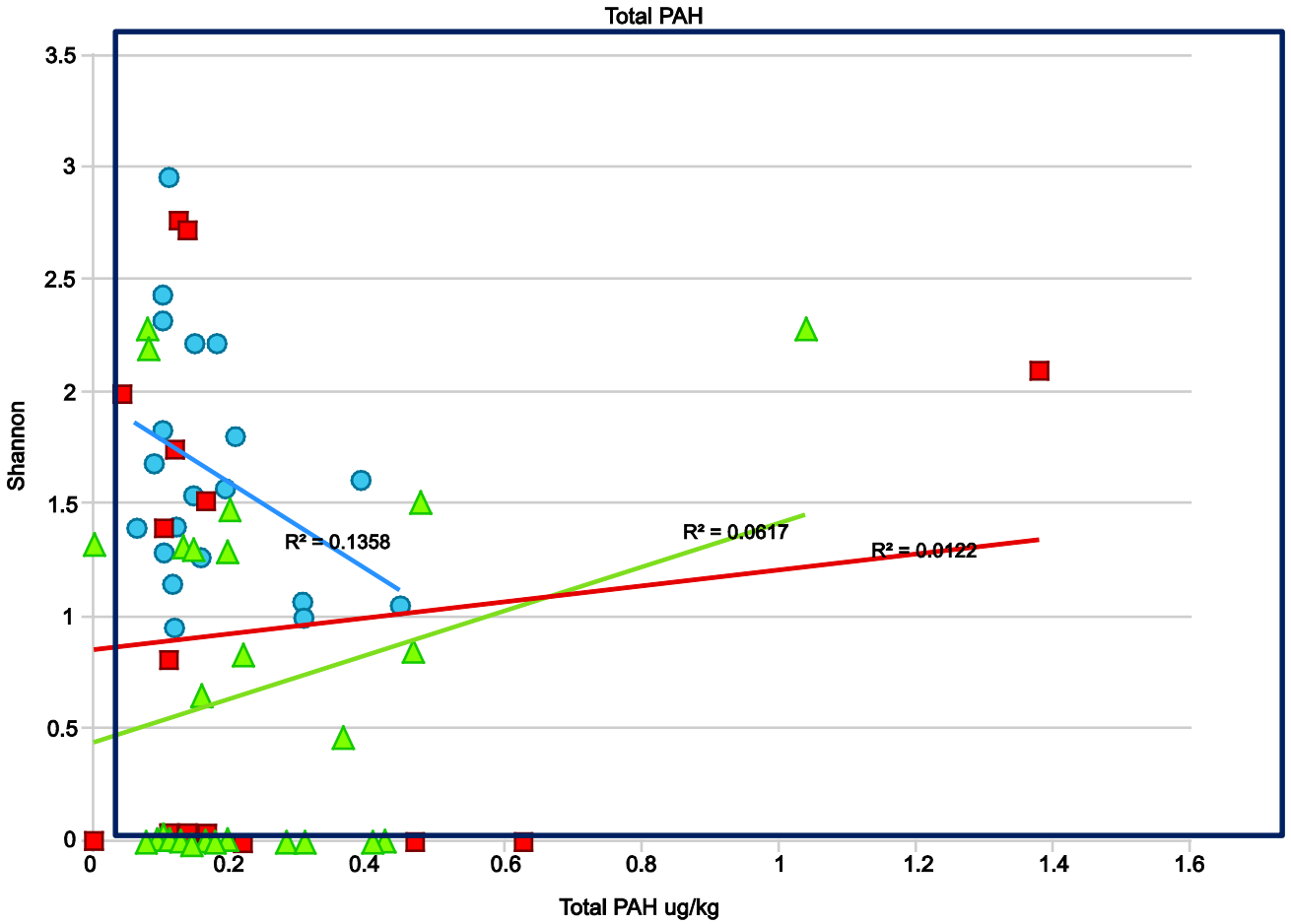
Regression analyses of all assemblages using Shannon Index with each metal pollutant

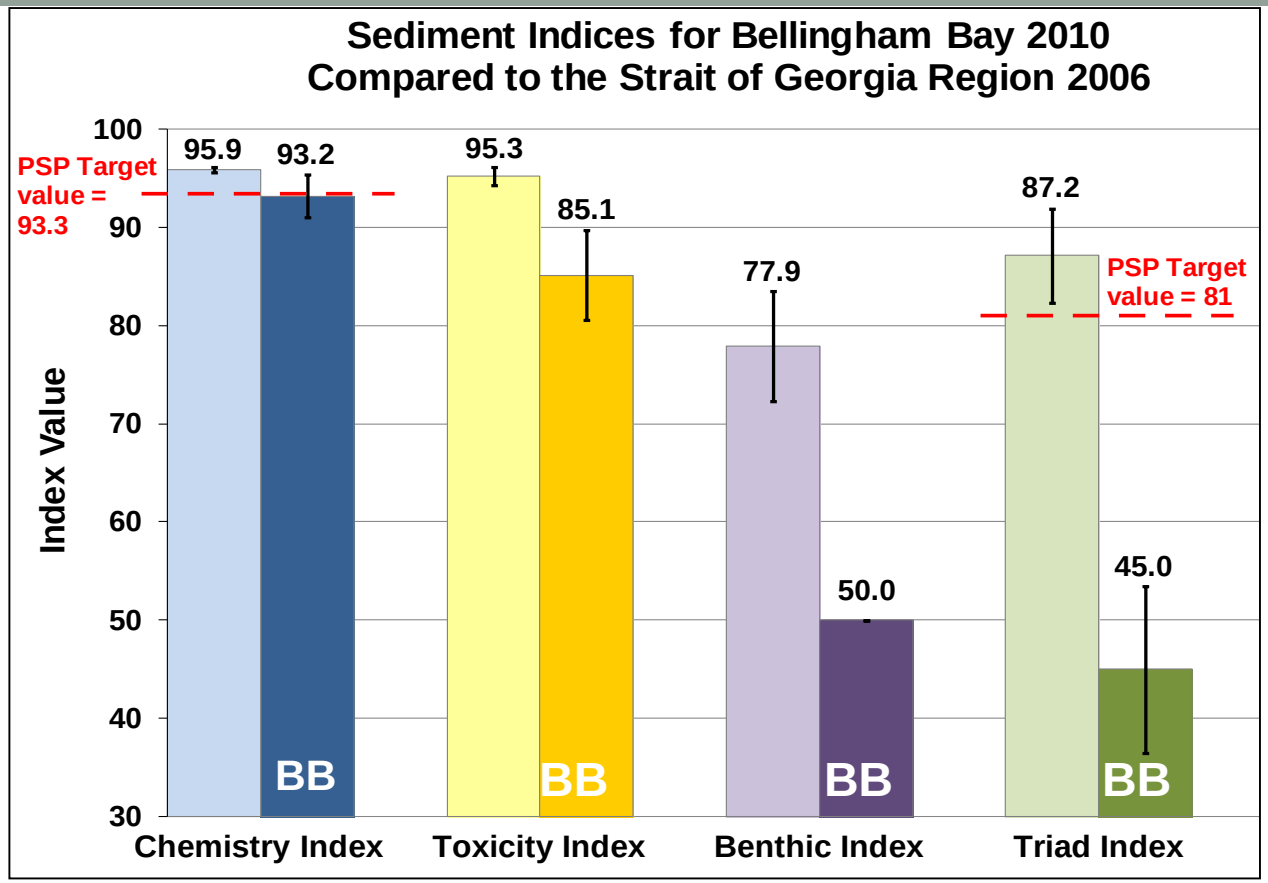
No significant correlation with metals in the sediments: mercury, zinc, lead, copper arsenic, cadmium.

Bioavailability is probably the answer to this.



No relationship with Total Polycyclic Aromatic Hydrocarbons





Weakland et al., 2013. *Sediment Quality in Bellingham Bay,* 2010. WA DOE Publication 13-03-034 (revised December 2013)

Figure 1. A comparison of weighted mean index values for Bellingham Bay in 2010 (dark bars) and the Strait of Georgia region in 2006 (light bars), with 95% confidence intervals. Also shown are the PSP target values for the Chemistry and Triad Indices (red dashed lines).

"The trends in benthos seem not to coincide with trends in the environmental parameters that were measured; therefore, other factors must be important." Ed Long, 2010

What about bottom water oxygen and pH levels?

How about eutrophication?

1. High levels of partially dissolves shells – even in 1997

2. TOC for all Bellingham Bay sample site:
   - lower (~1.2 mg/gm) at the sites closest to the sediment plume from the Nooksack River
   - to very high (up to 3.3mg/gm) at those sites on the southeastern side along the margins of the city

Modeling Estuary Flushing Time in Three Dimensions

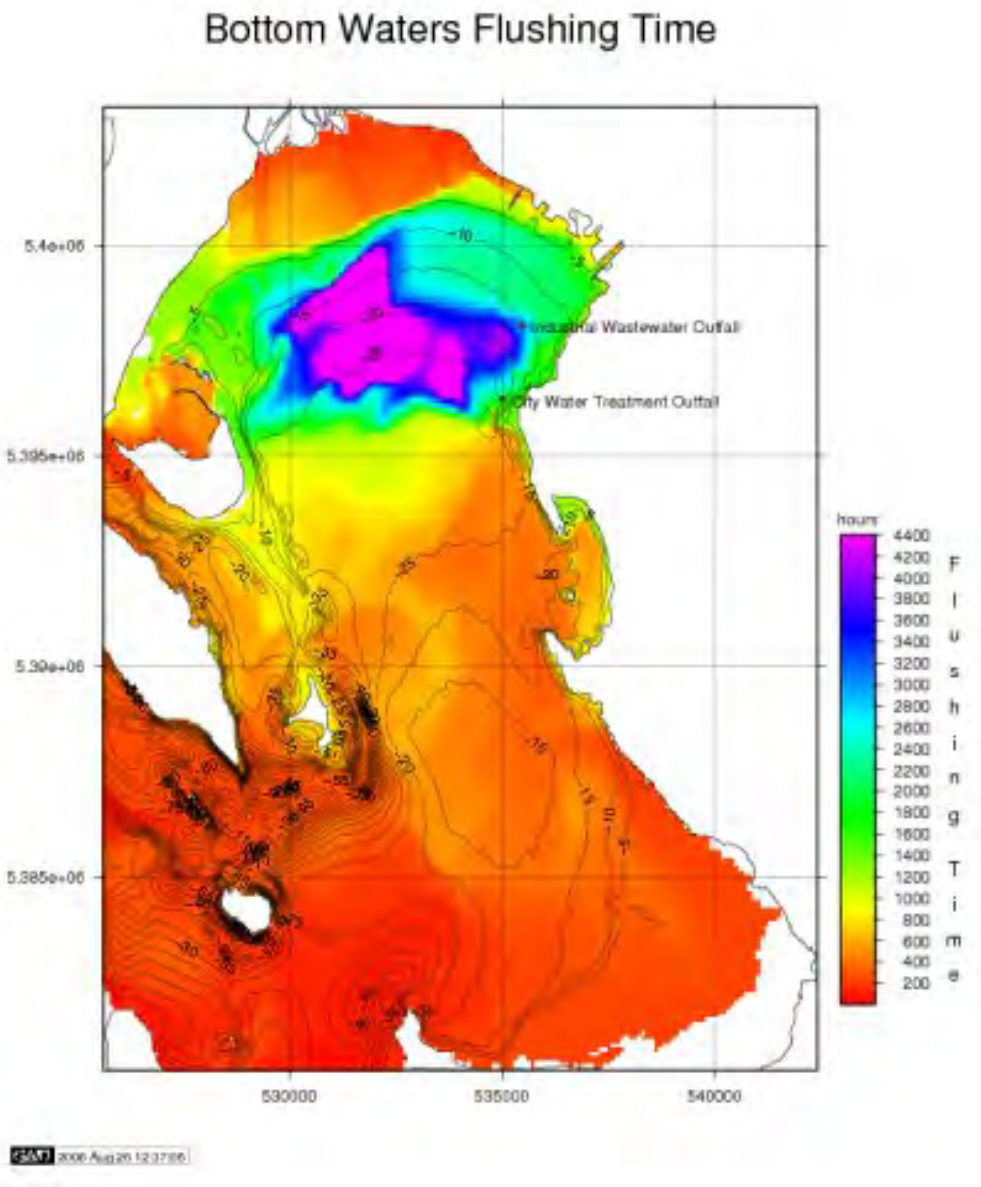
2007, Rubash & Kilanowski

25 days

66 days

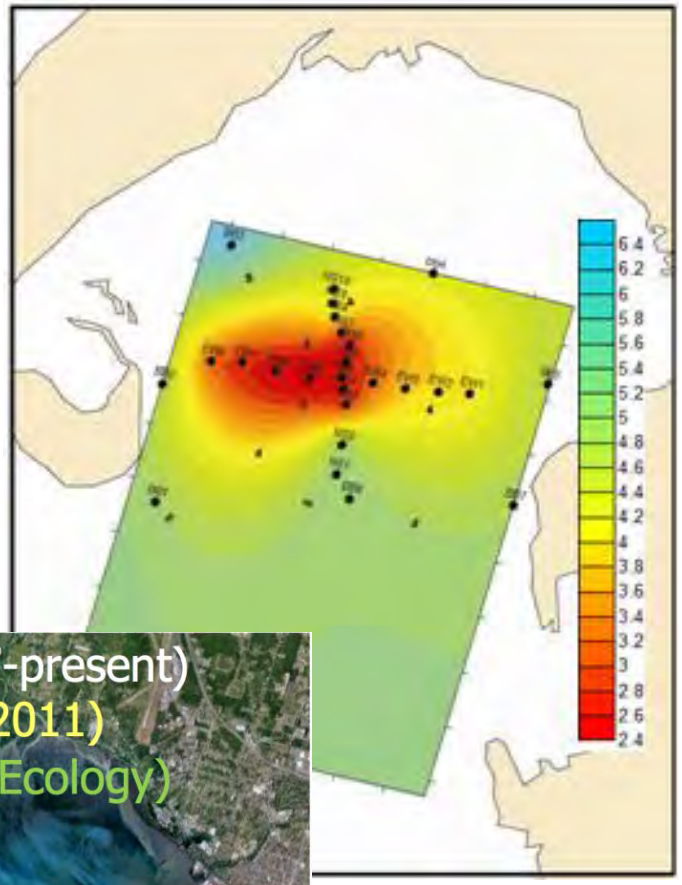
150 days

183 days



Dissolved oxygen for bottom waters in summer, Bellingham Bay

Annual bottom water samples summer 2007-2013

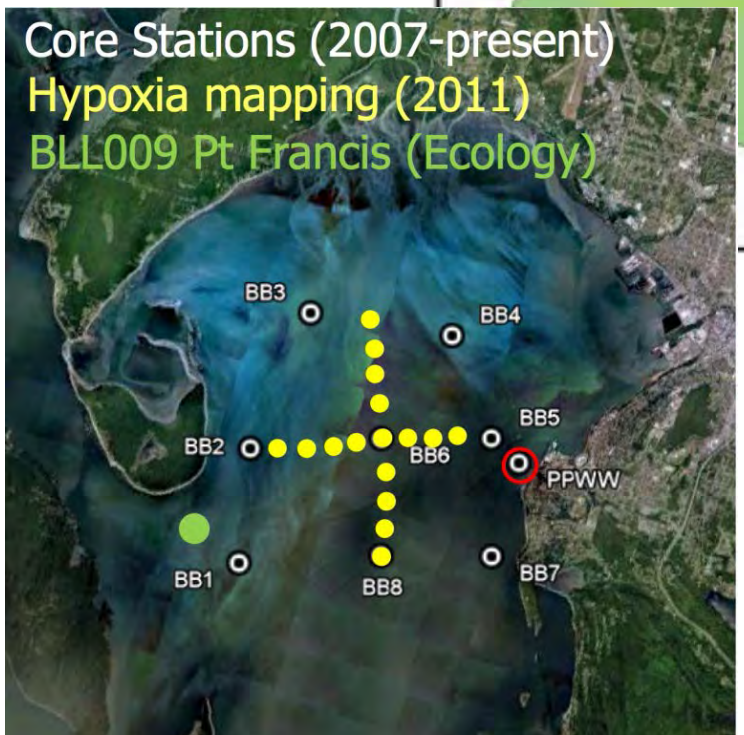


2009: pH down to 7.11

2010: pH down to 6.97

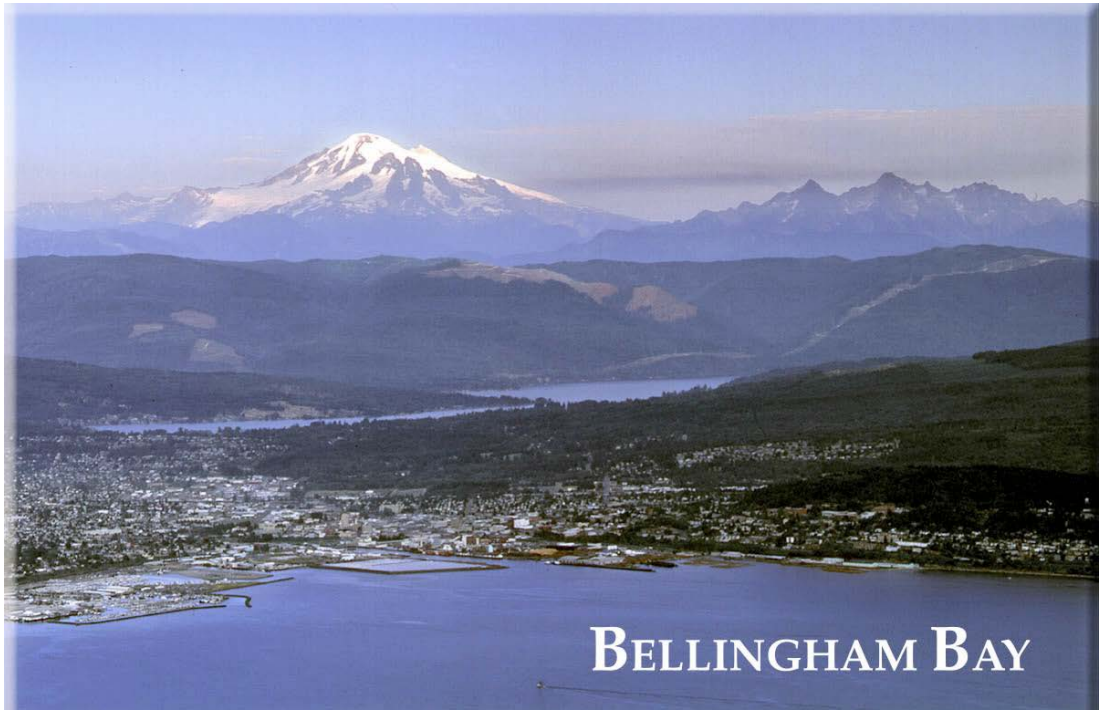
2011: pH down to 7.49

2012: pH down to 7.17

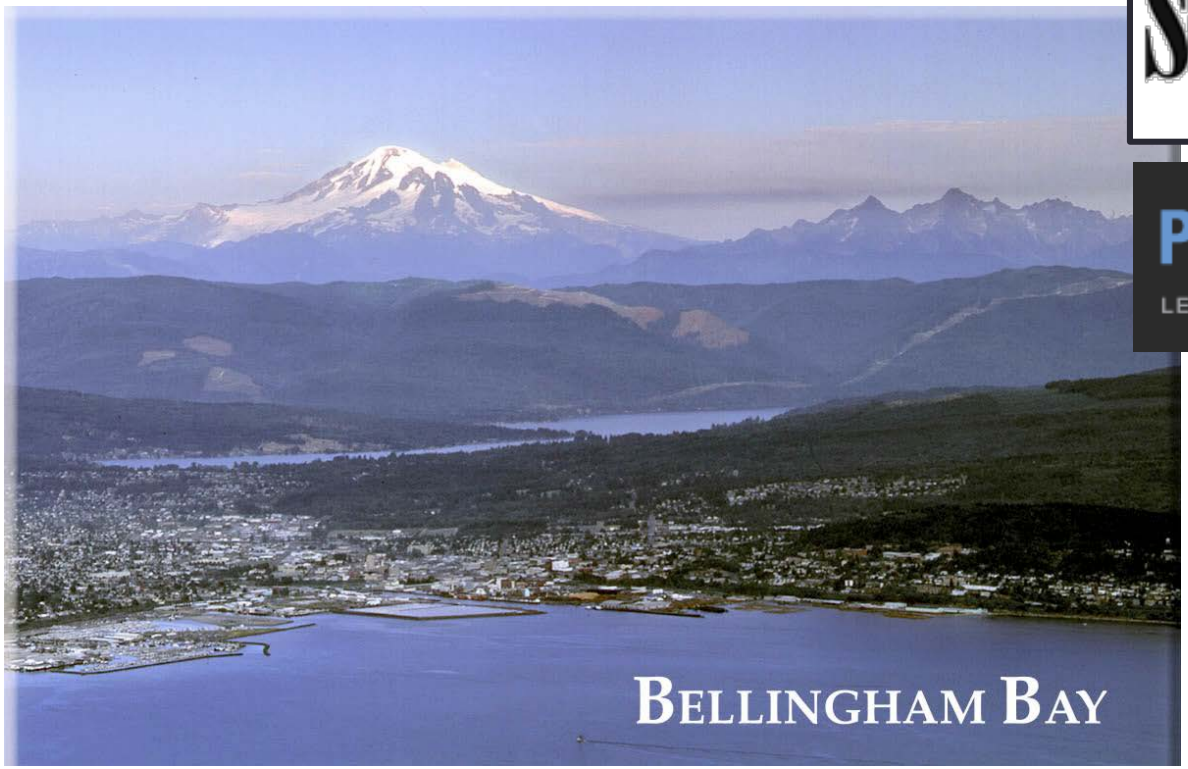


Conclusion

Causes of the deteriorating biota of Bellingham Bay are complex and may included dysoxia and acidification together with the compounding effects of the numerous pollutants present.



WE THANK OUR FUNDERS



Sea Grant
Washington

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
DEPARTMENT OF COMMERCE

PugetSoundPartnership
LEADING PUGET SOUND RECOVERY

DEPARTMENT OF
ECOLOGY
State of Washington

WESTERN
WASHINGTON UNIVERSITY

Burke
MUSEUM

UNIVERSITY OF WASHINGTON
1861