Ecology's Marine Monitoring Program

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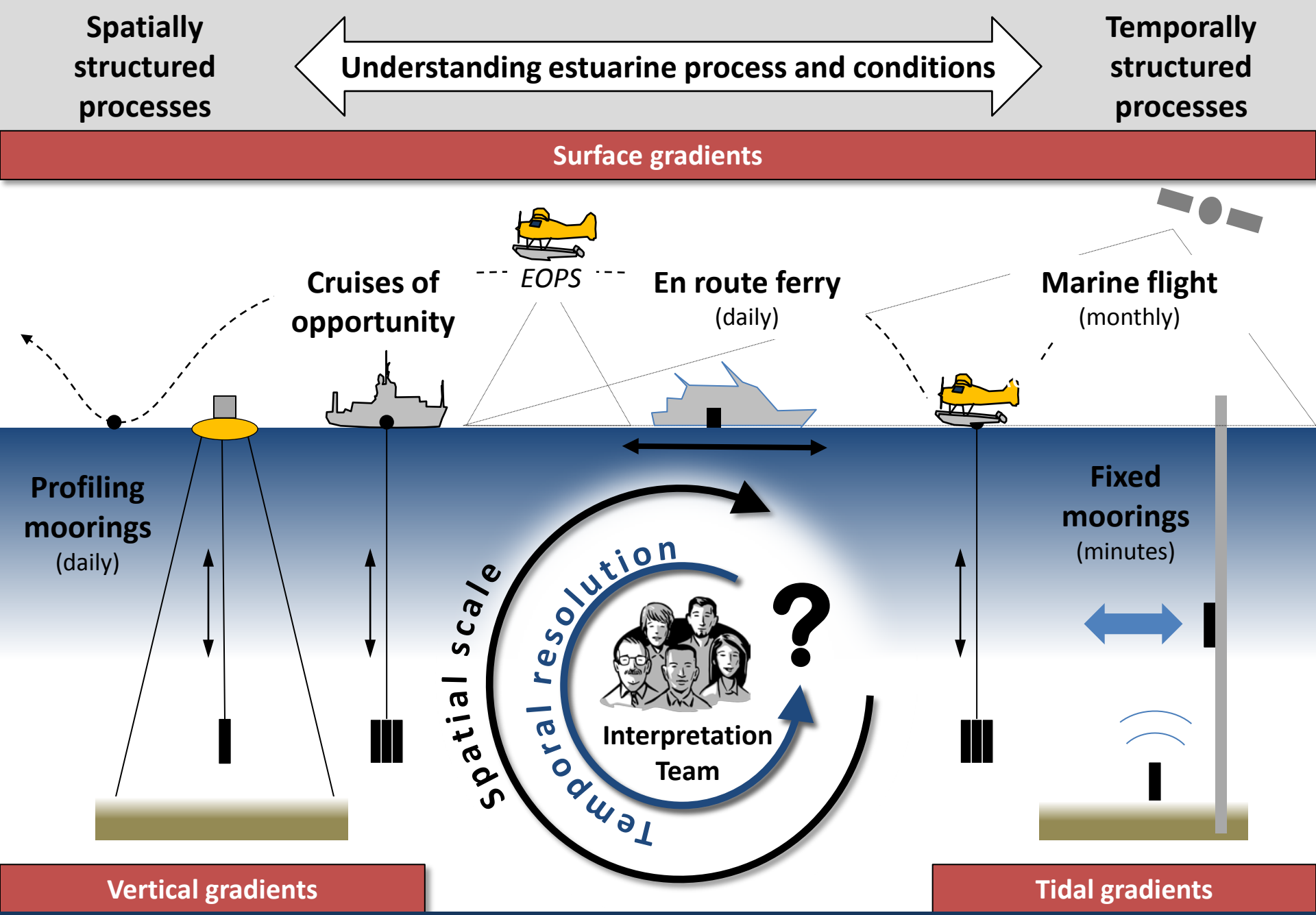
WA State Dept. of Ecology

1. **Puget Sound's low dissolved oxygen can't be understood in isolation of oceanic processes (same for pH).**

2. **Despite a sizable oceanic influence on the DO-deficit, nutrients in Puget Sound continue to increase (effect on pH expected).**



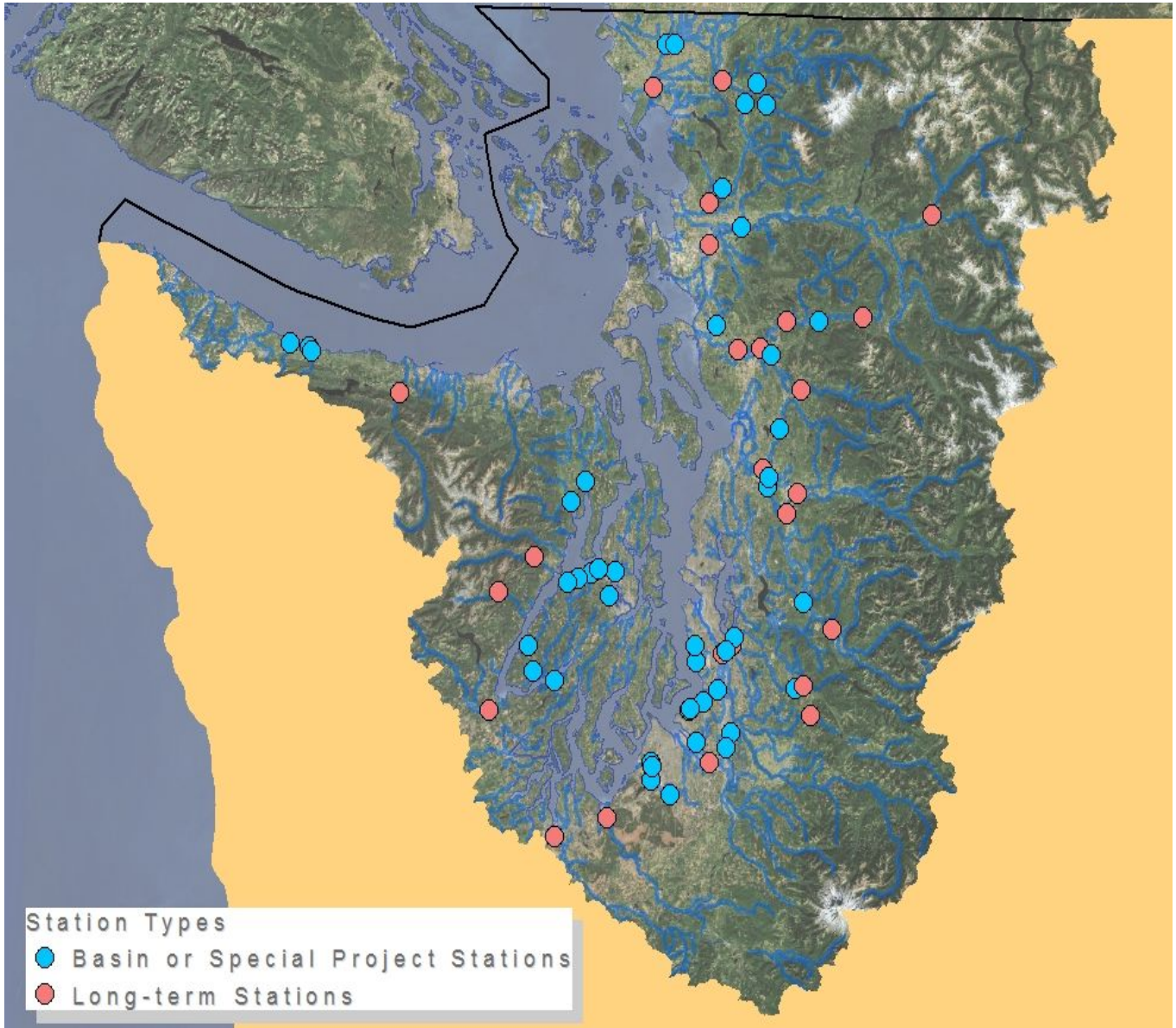
Better in situ information through combined strategies and data interpretation

Ambient monitoring stations, Freshwater Program

DEPARTMENT OF ECOLOGY
State of Washington

Parameter
Ammonia, total
Conductivity
Fecal coliform bacteria
Nitrate + nitrite, total
Nitrogen, total
Oxygen, dissolved
pH
Phosphorus, soluble reactive
Phosphorus, total
Suspended solids, total
Temperature
Turbidity

Ecology has measured pH in many river tributaries since 1970

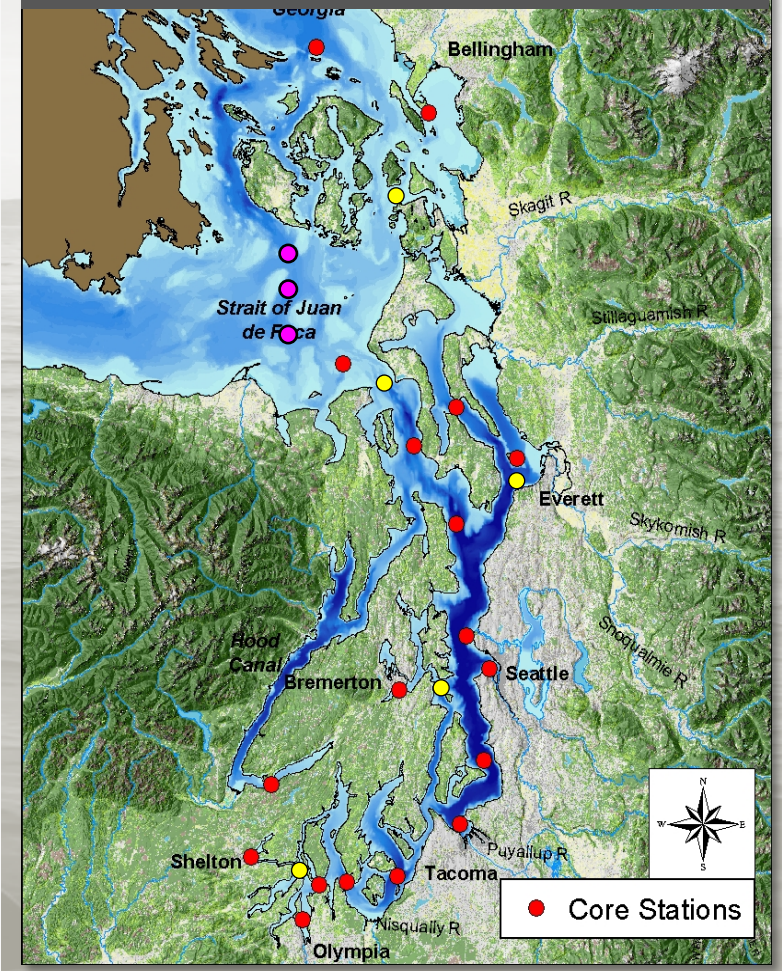


Long-term trends in Eutrophication and Dissolved Oxygen in Puget Sound?

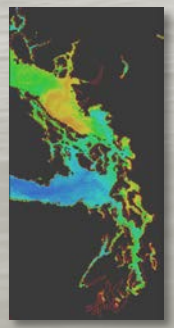
DEPARTMENT OF ECOLOGY State of Washington

Marine Monitoring Program

Greater Puget Sound region



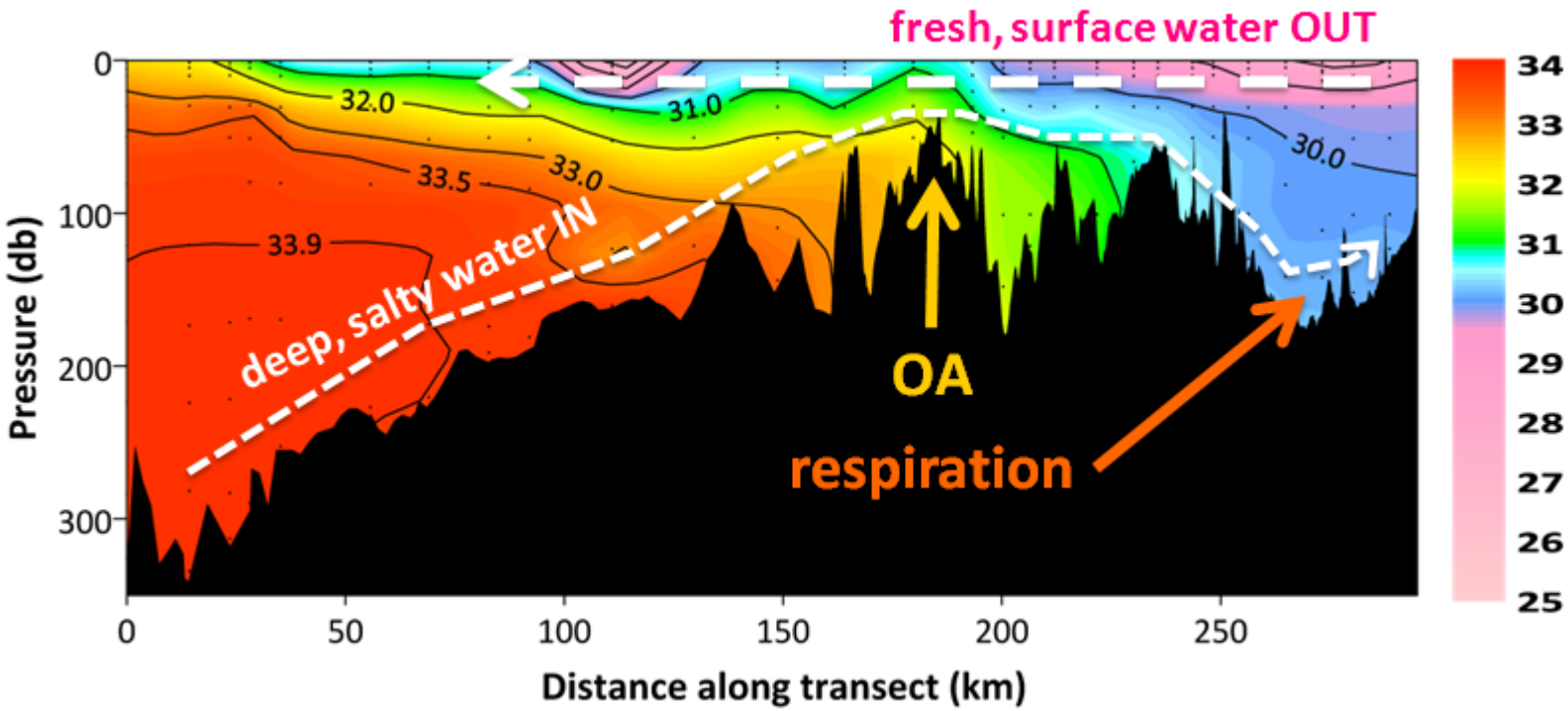
Water Quality indicators measured monthly at 27 stations



1. Temperature
2. Salinity
3. Density
4. **<u>Oxygen</u>**
5. <u>pH (no alkalinity)</u>
6. Nitrate
7. Silicate
8. Phosphate
9. N:P
10. Si:N
11. Ammonium
12. Water clarity
13. Chlorophyll a
14. Euphotic depth
15. Fecal coliform bacteria
16.…

First estimate of the oceanic contribution for Hood Canal, now needs to be refined and broadened to Puget Sound

Question: How much of the corrosive conditions in Hood Canal result from ocean acidification?

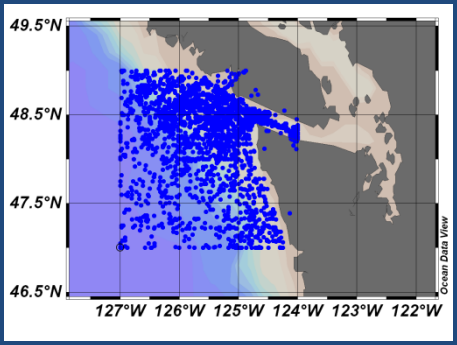


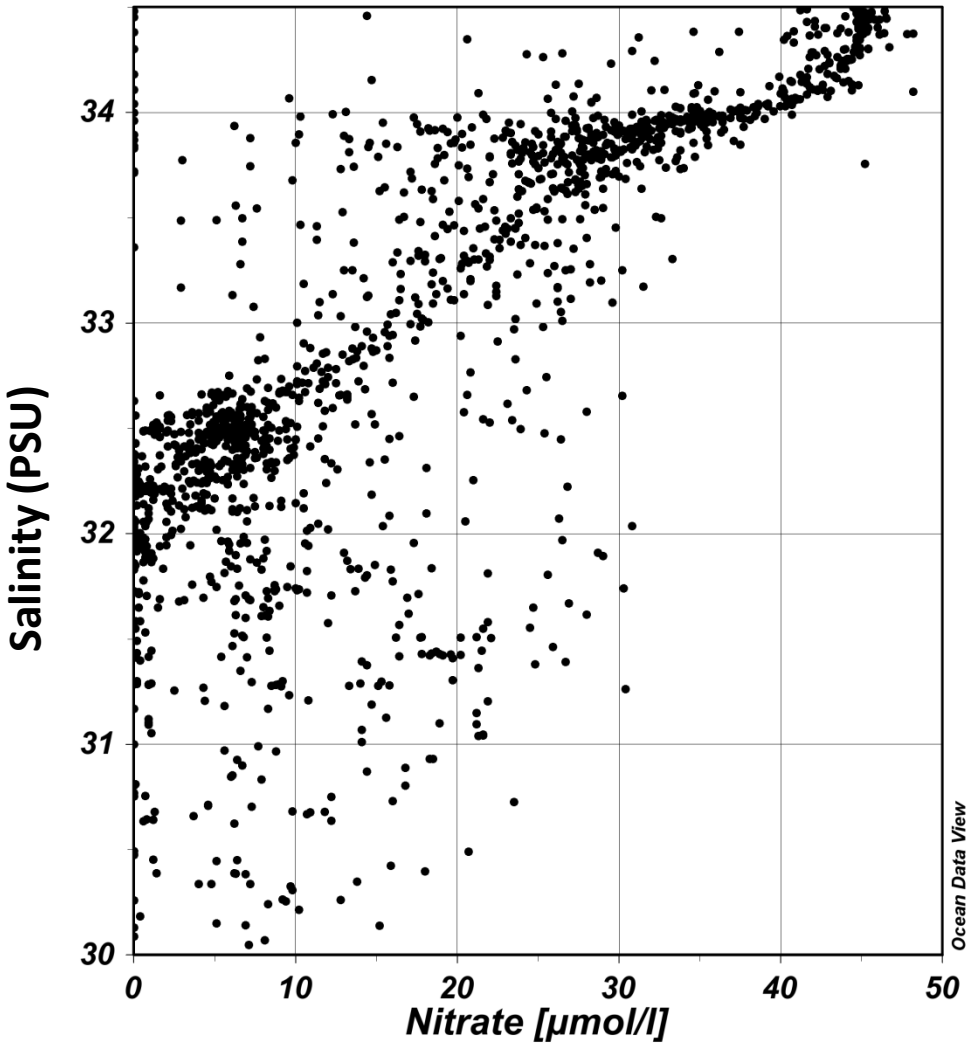
Richard A. Feely, Simone R. Alin, Jan Newton, Christopher L. Sabine, Mark Warner, Allan Devol, Christopher Krembs, Carol Maloy (2010)

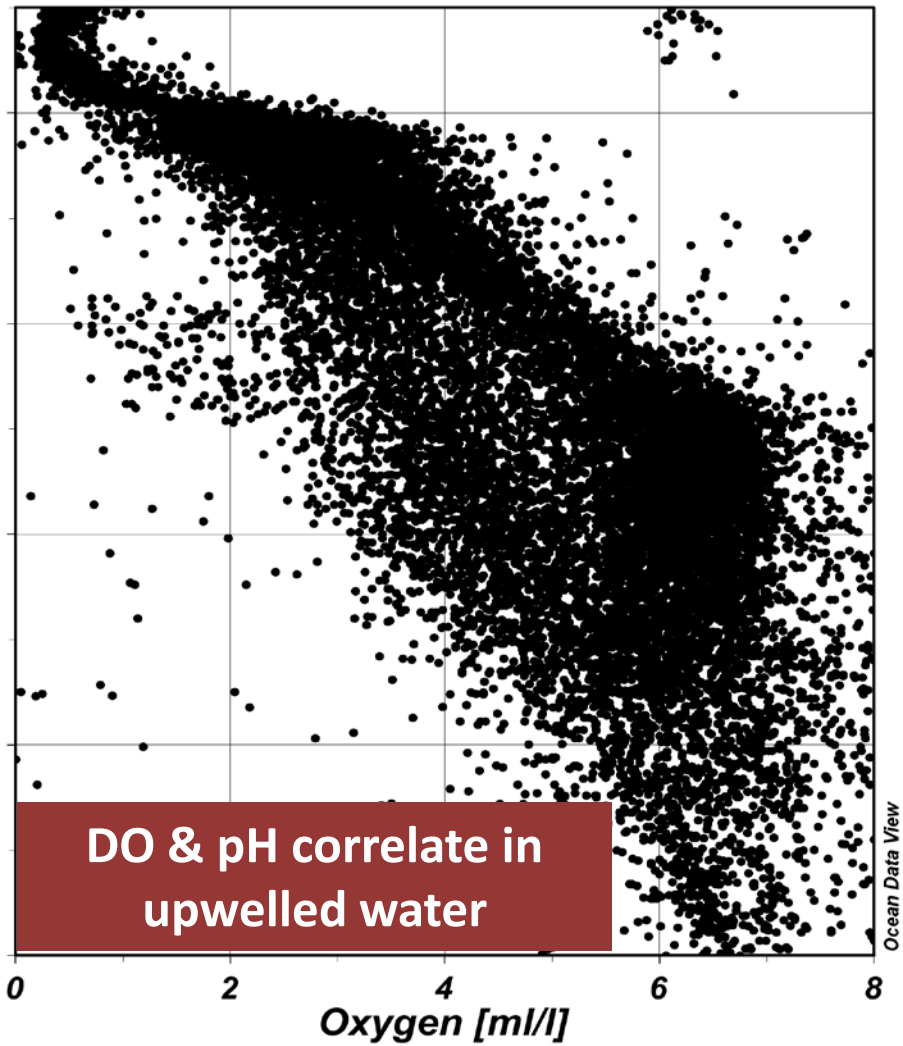
The combined effects of ocean acidification, mixing, and respiration on pH and carbonate saturation in an urbanized estuary. Estuarine, Coastal and Shelf Science

Ocean water as a large potential contributor to nitrate and low dissolved oxygen for Puget Sound

NATIONAL OCEANOGRAPHIC DATA CENTER (NODC)
UNITED STATES DEPARTMENT OF COMMERCE

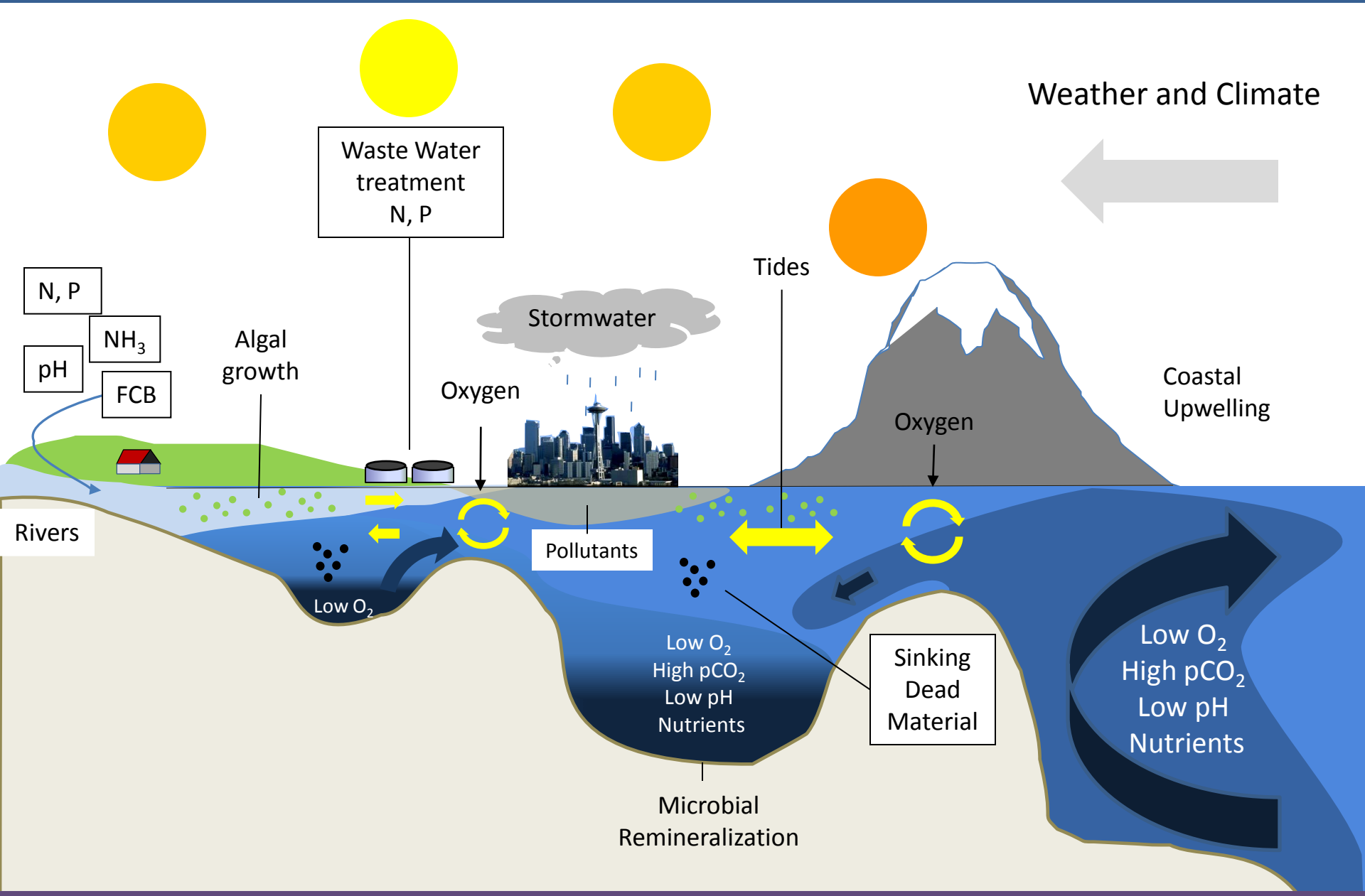






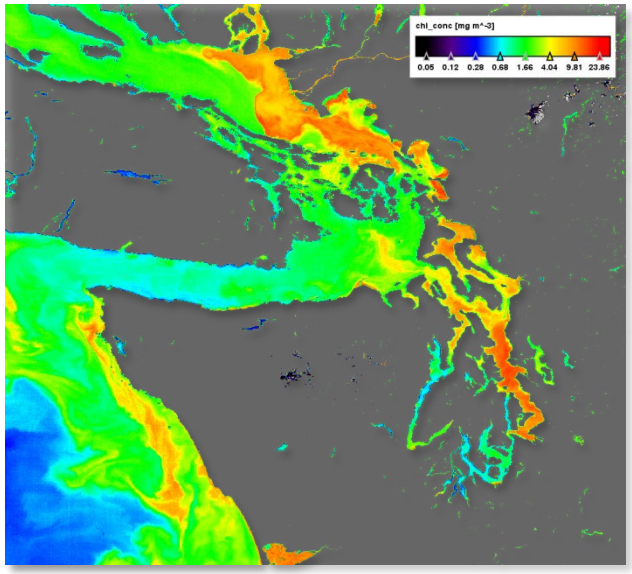
DO & pH correlate in upwelled water

Puget Sound is highly variable in space and time



Ecology relies on sophisticated water quality models to evaluate human contribution

Upwelling and ocean conditions can affect Puget Sound's water quality



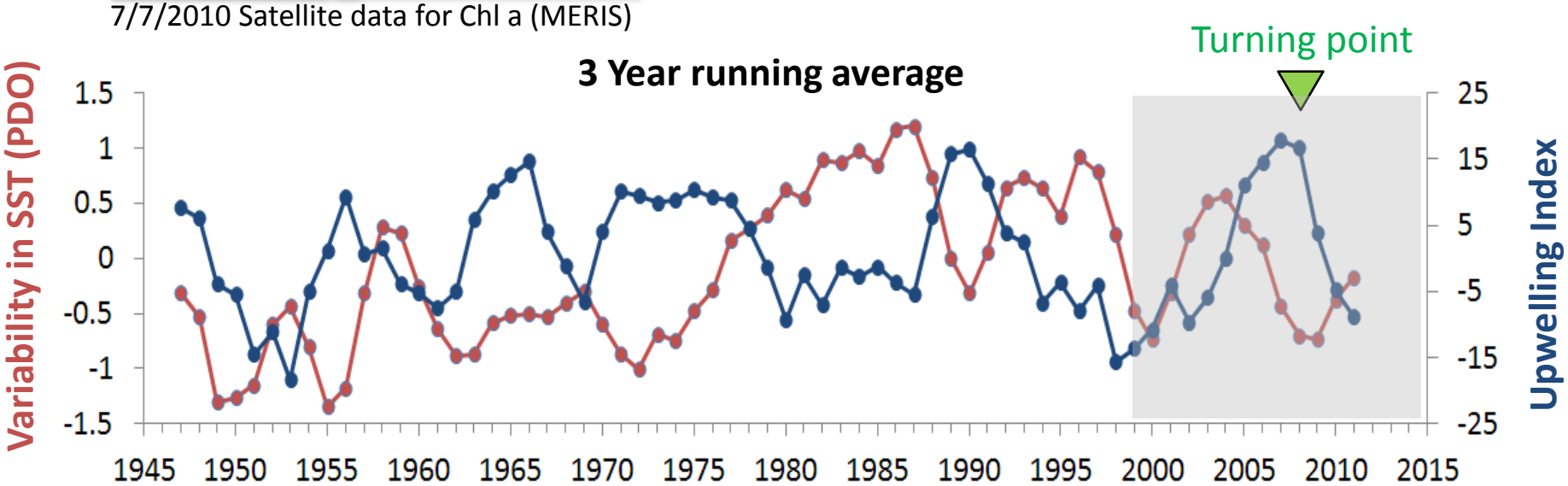
7/7/2010 Satellite data for Chl a (MERIS)

Pacific Decadal Oscillation (PDO)

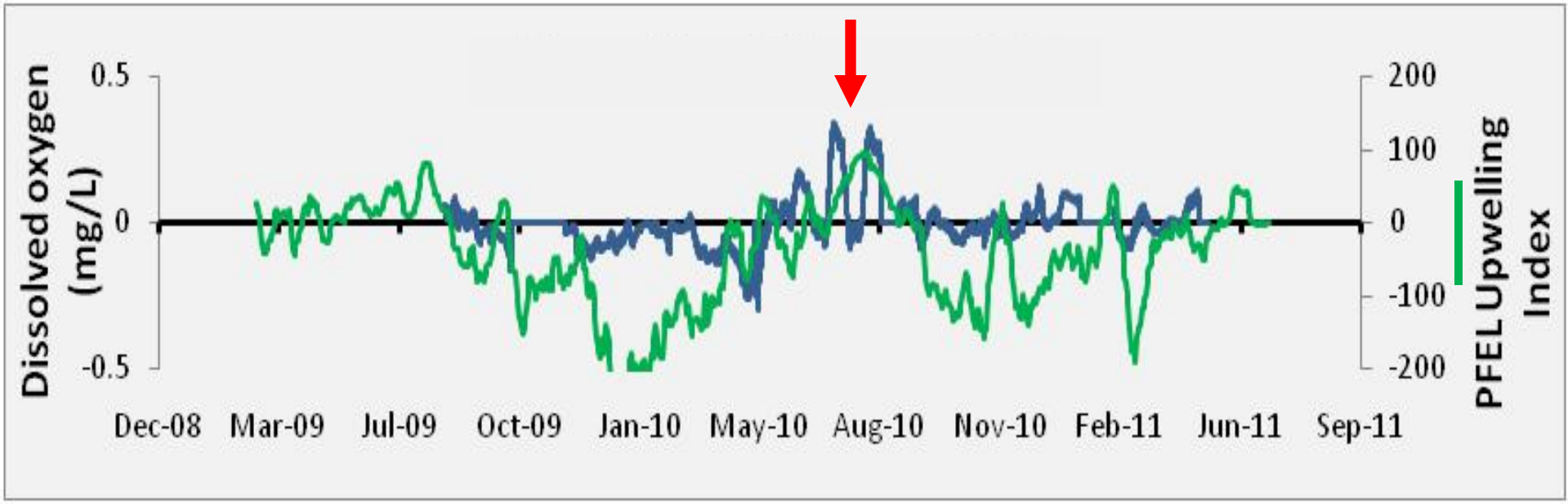
Leading driver of north Pacific monthly sea surface temperature (SST) variability.

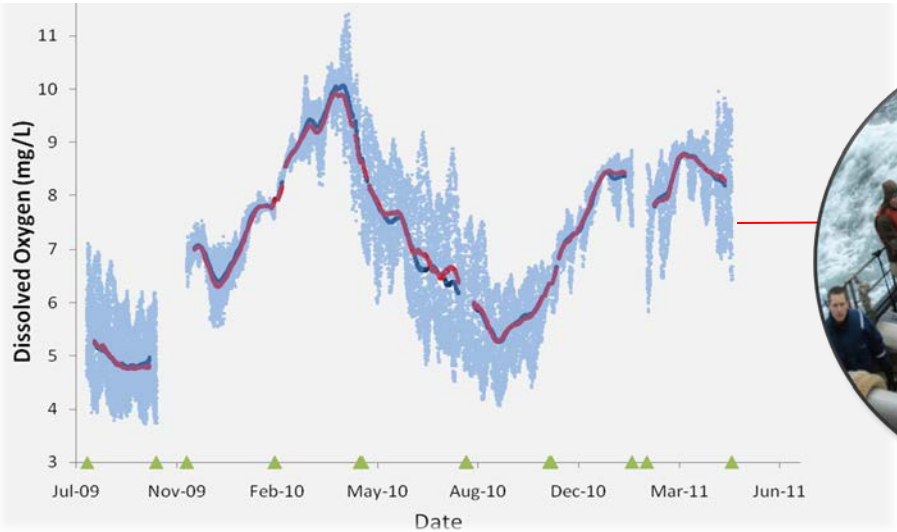
Coastal Upwelling Index (PFEL)

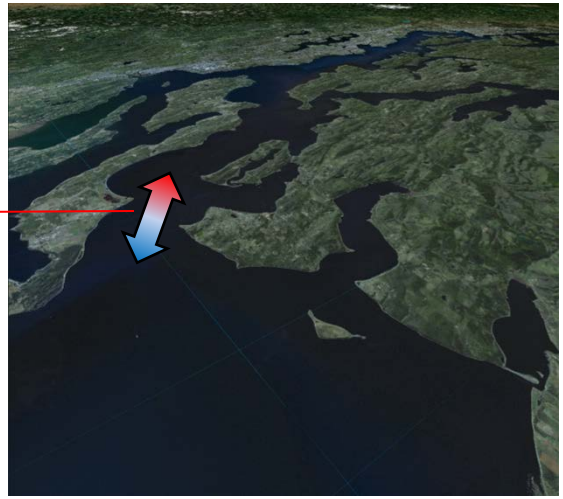
Pacific Fisheries Environmental Laboratory index of the intensity of large-scale, wind-induced coastal upwelling.



Low dissolved oxygen intrusion events are related to Upwelling and Neap Tides



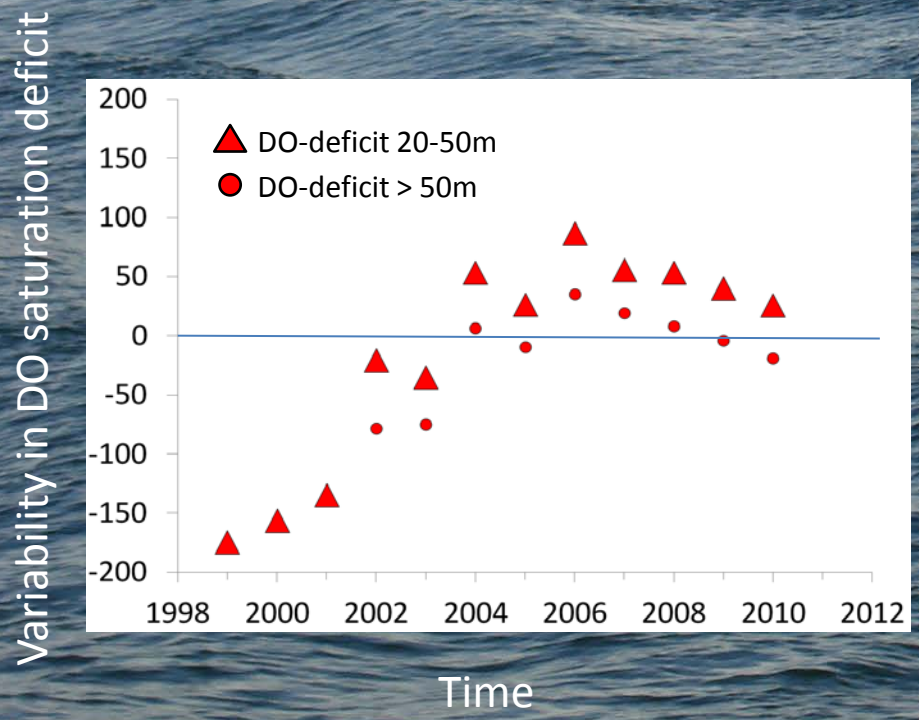


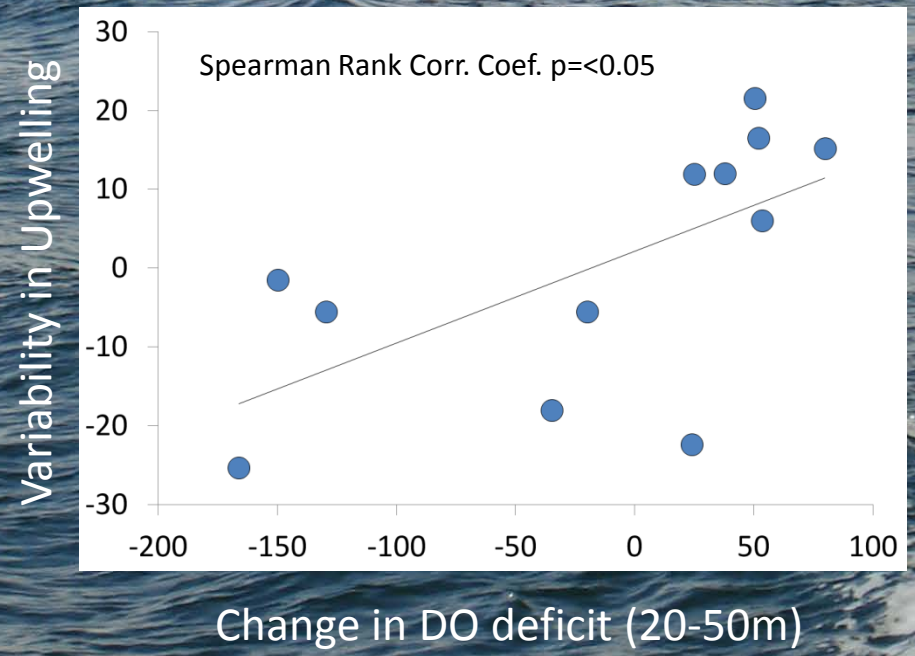


Thermal energy content (0-50m) and the PDO

Variability in thermal energy content (0-50m)

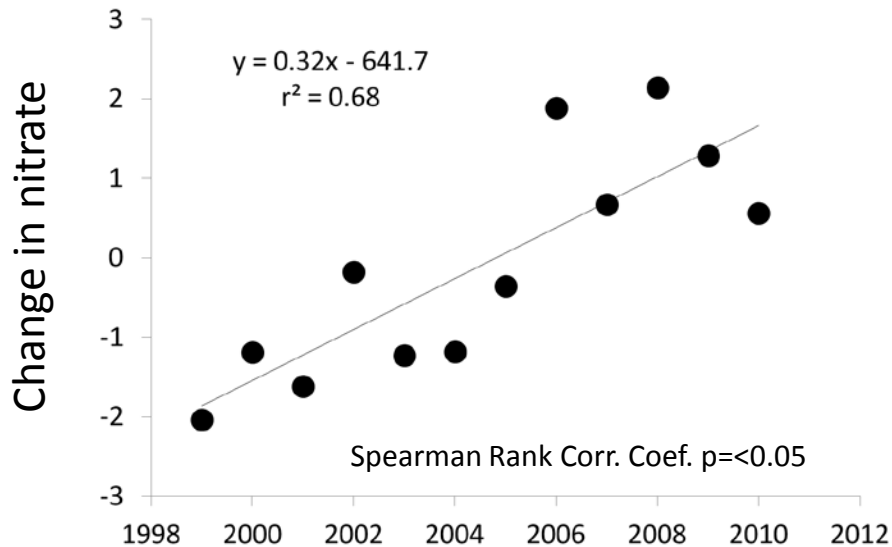
The DO-Deficit responds to differences in coastal upwelling (pH likely to do the same)





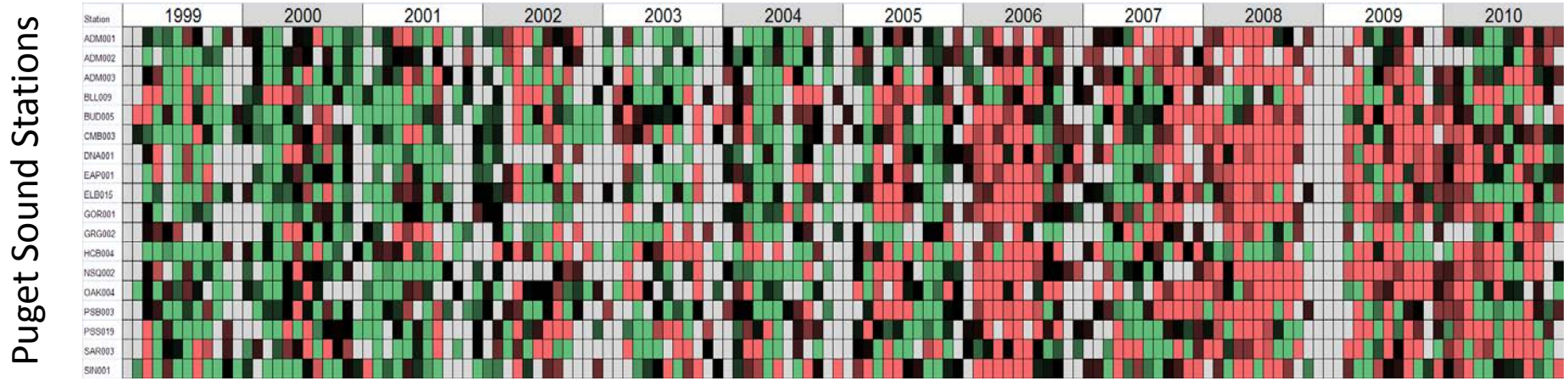
Is only the ocean to blame?

Increasing nitrogen concentrations



10-year nitrate increase in Puget Sound equals about 3 µM 10 yr^{-1}

Variability in nitrate



Monitoring and Assessment Needs

Taking better pH measurements at Ecology core stations is good for a new baseline. It is not a solution to quantitatively explore and separate natural and human contributions.

1. Separating oceanic from regional contributions to ocean acidification: boundary conditions needed. “Natural” oceanic background carries human signal!

2. Separating natural Puget Sound conditions from human influences requires expansion of existing water quality models (pH should be included).