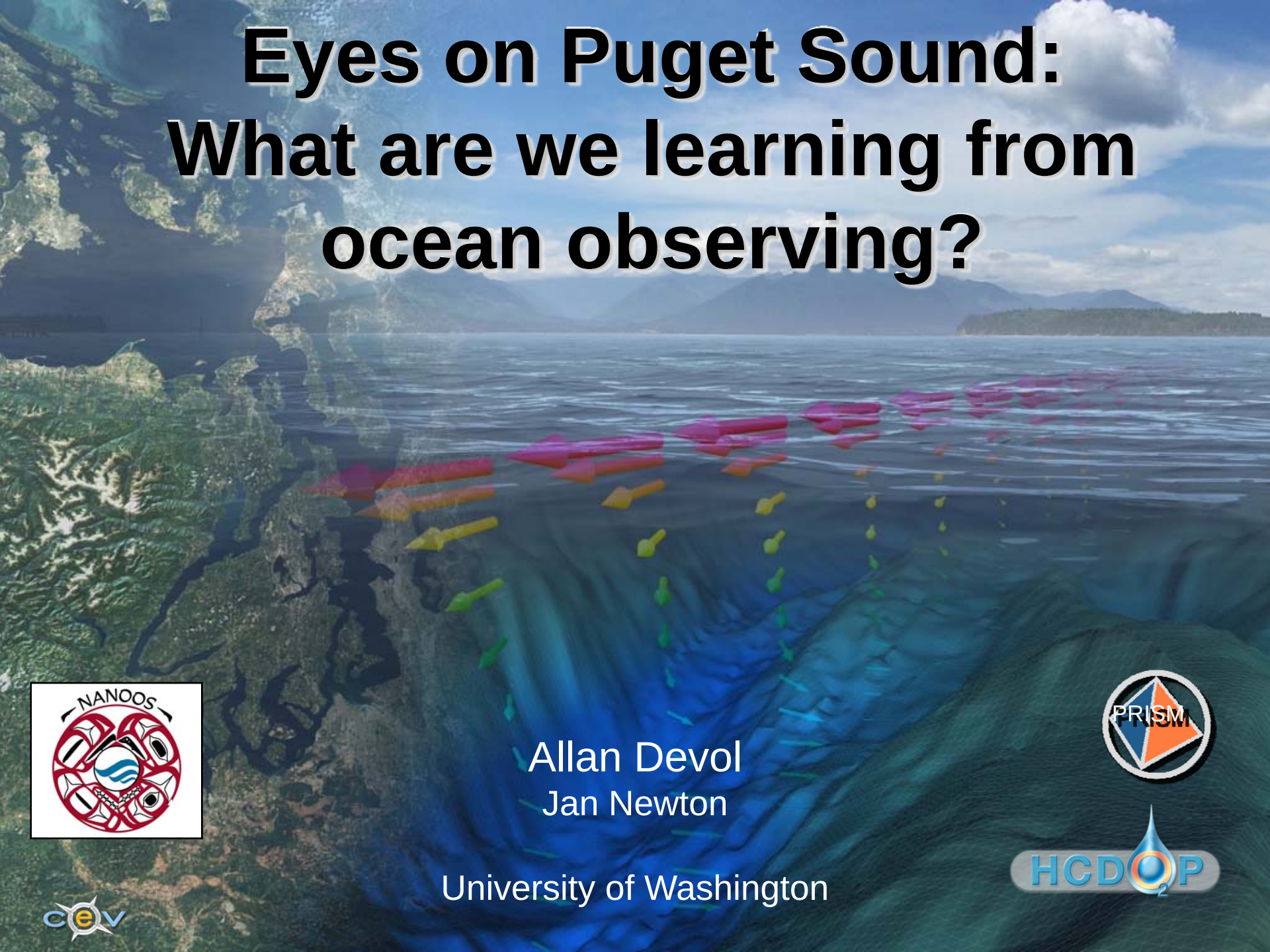
Eyes on Puget Sound: What are we learning from ocean observing?



Allan Devol

Jan Newton

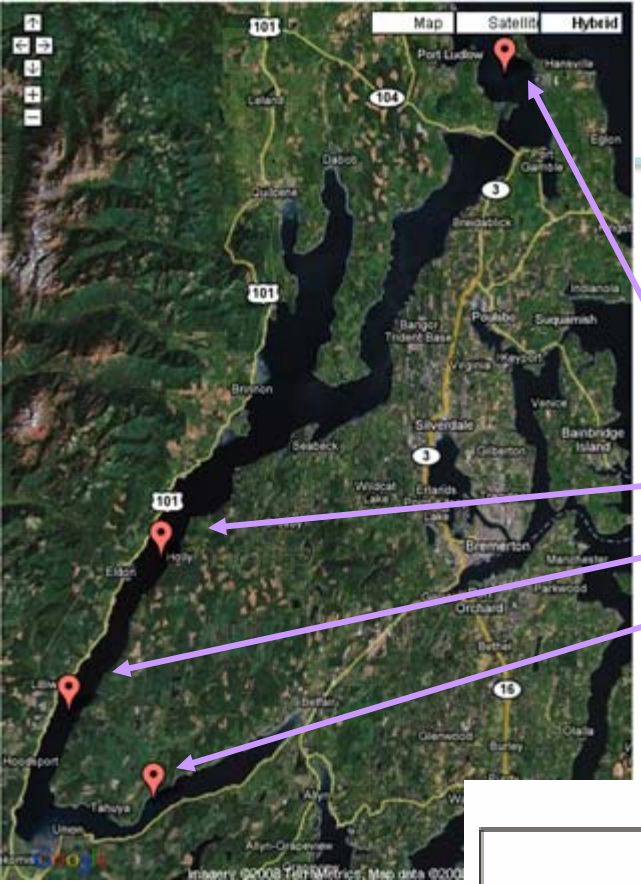
University of Washington

How can we Observe Puget Sound ?

- Shortcomings of sampling with a bottle:
  - Usually only once a month or week
  - Usually only at one or a few depths
- Shortcomings of sampling with a ship:
  - Usually only daytime
  - Usually only fair weather

This has led to technology development…

ORCA buoys



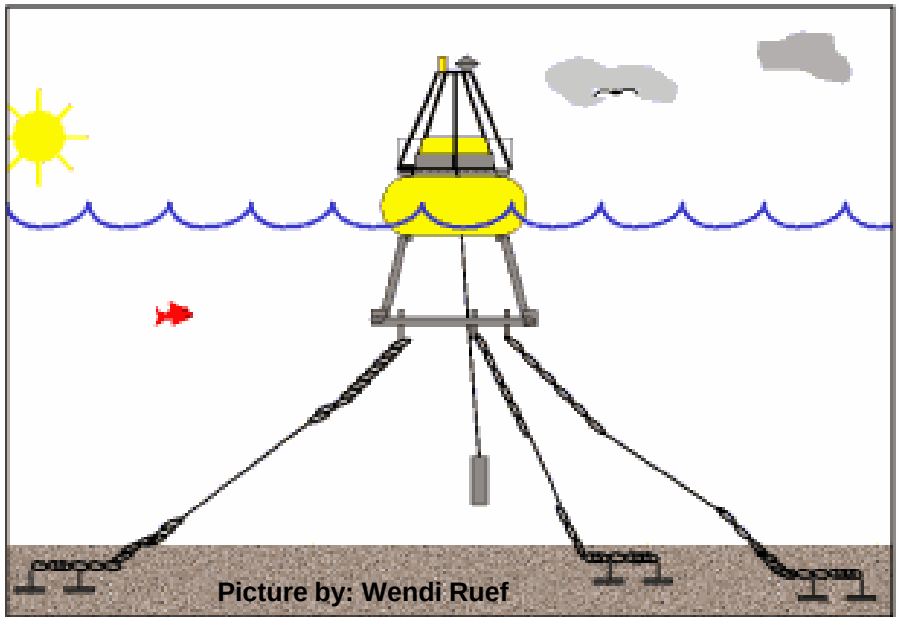
4 buoys, 4 locations…

1) North of HC Bridge
2) Hama Hama River
3) Hoodsport
4) Sister's Point

http://orca.ocean.washington.edu

"O.R.C.A."

Oceanic
Remote
Chemical-optical
Analyzer

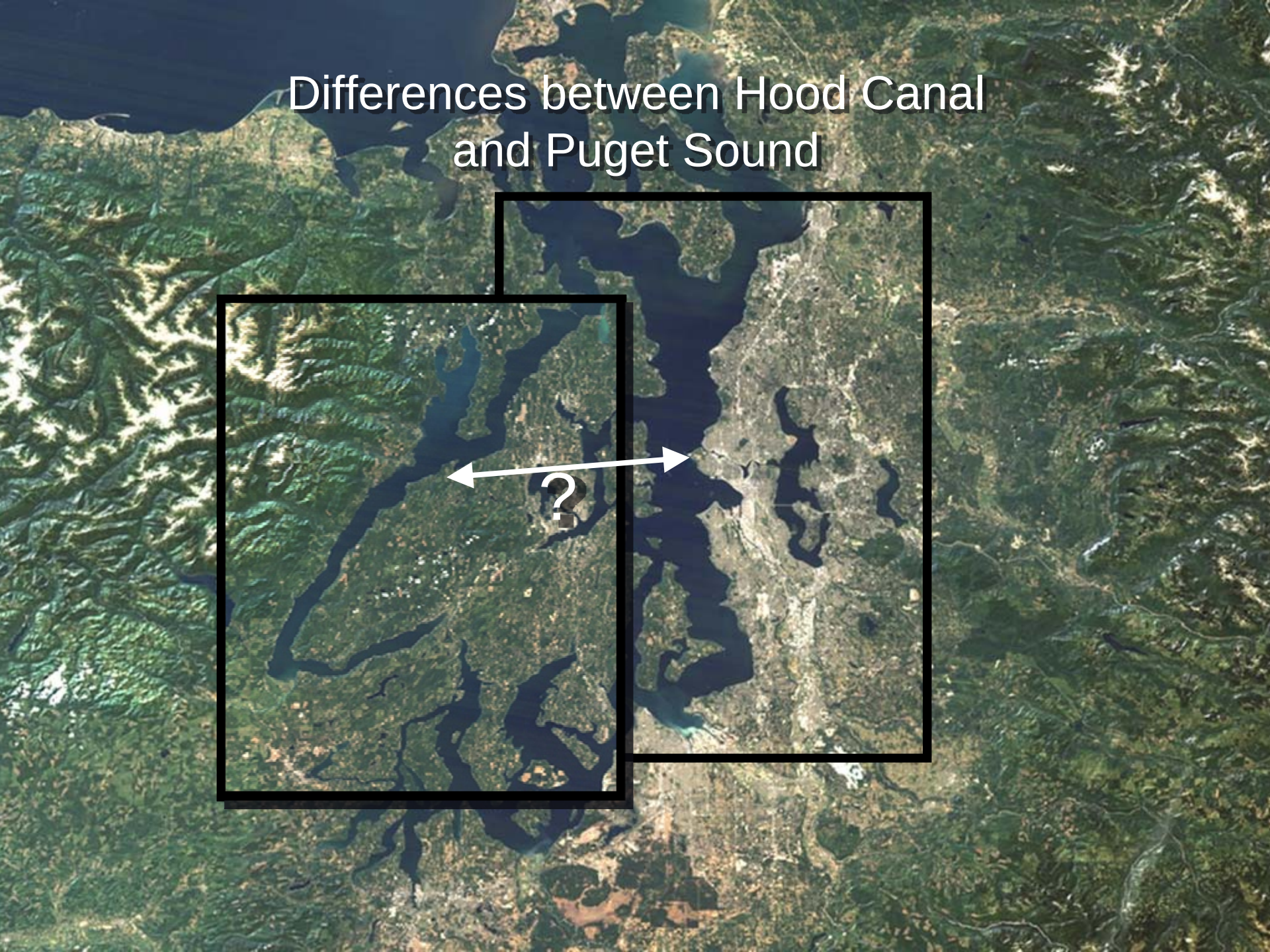


Picture by: Wendi Ruef

Part of NANOOS Observing System

NANOOS

Differences between Hood Canal and Puget Sound

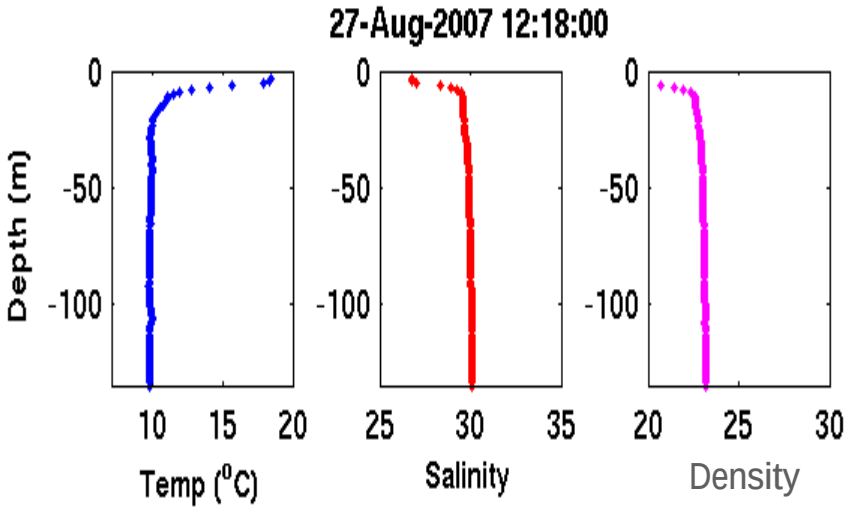


"ORCA" buoy data
Devol, Ruef (UW)

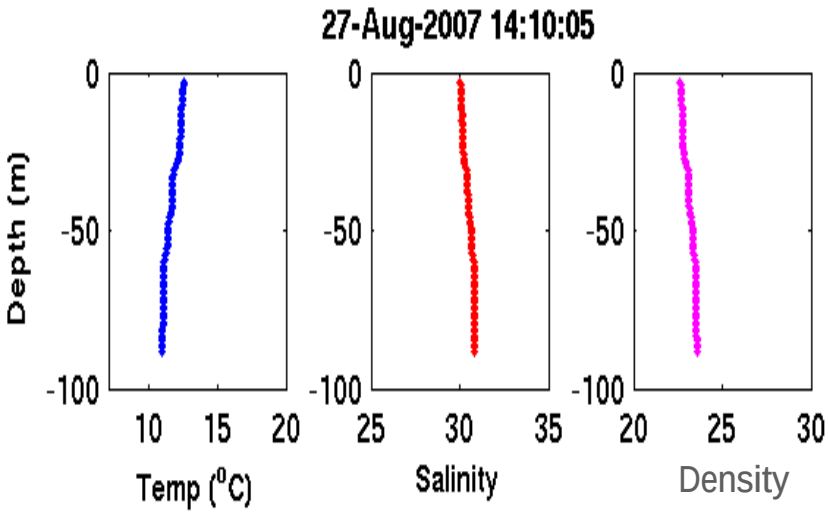
http://orca.ocean.washington.edu

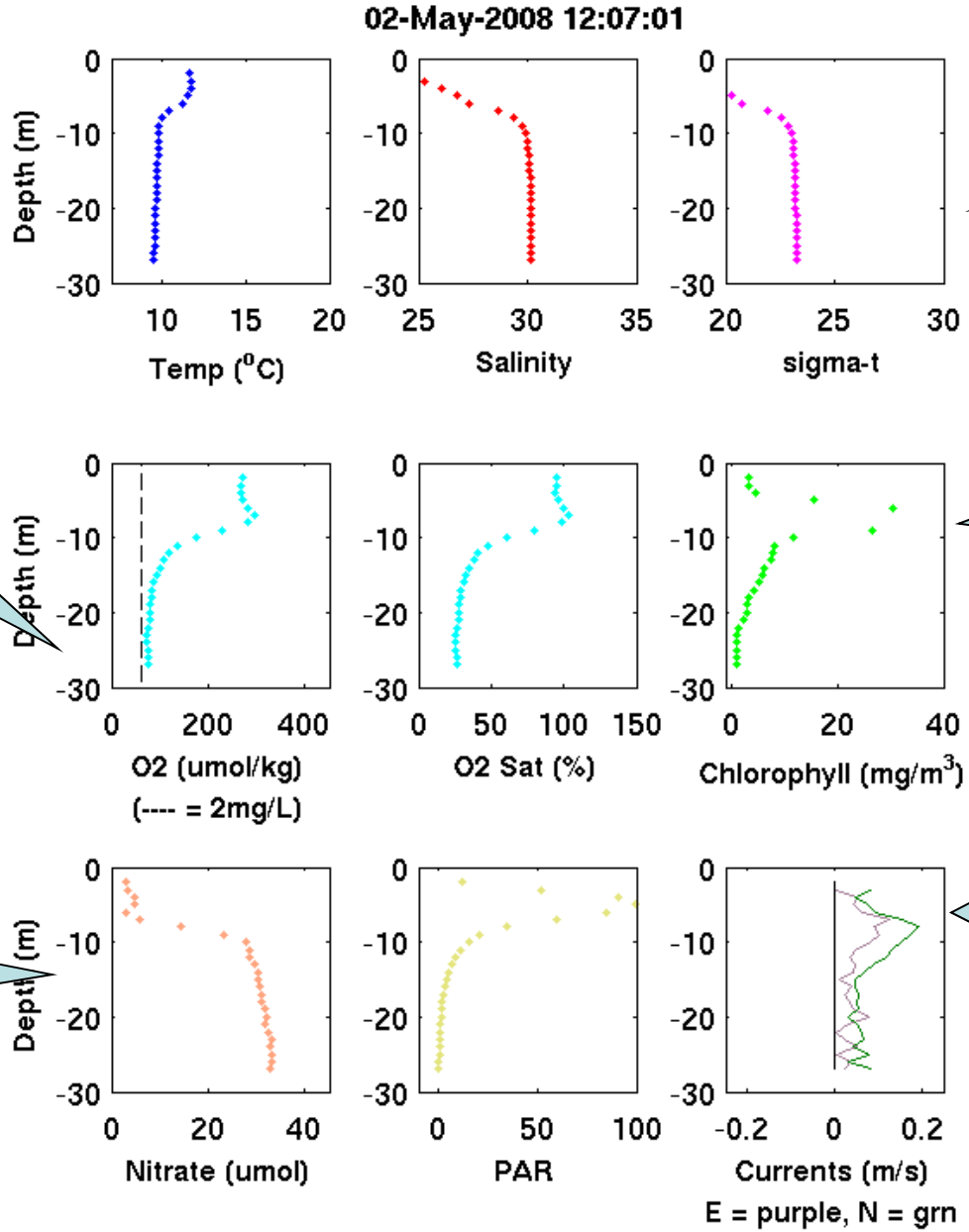
HCDOP

Within Hood Canal



Near Admiralty Inlet





Strong stratification

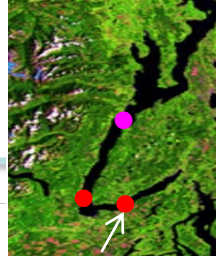
Deep chlorophyll max

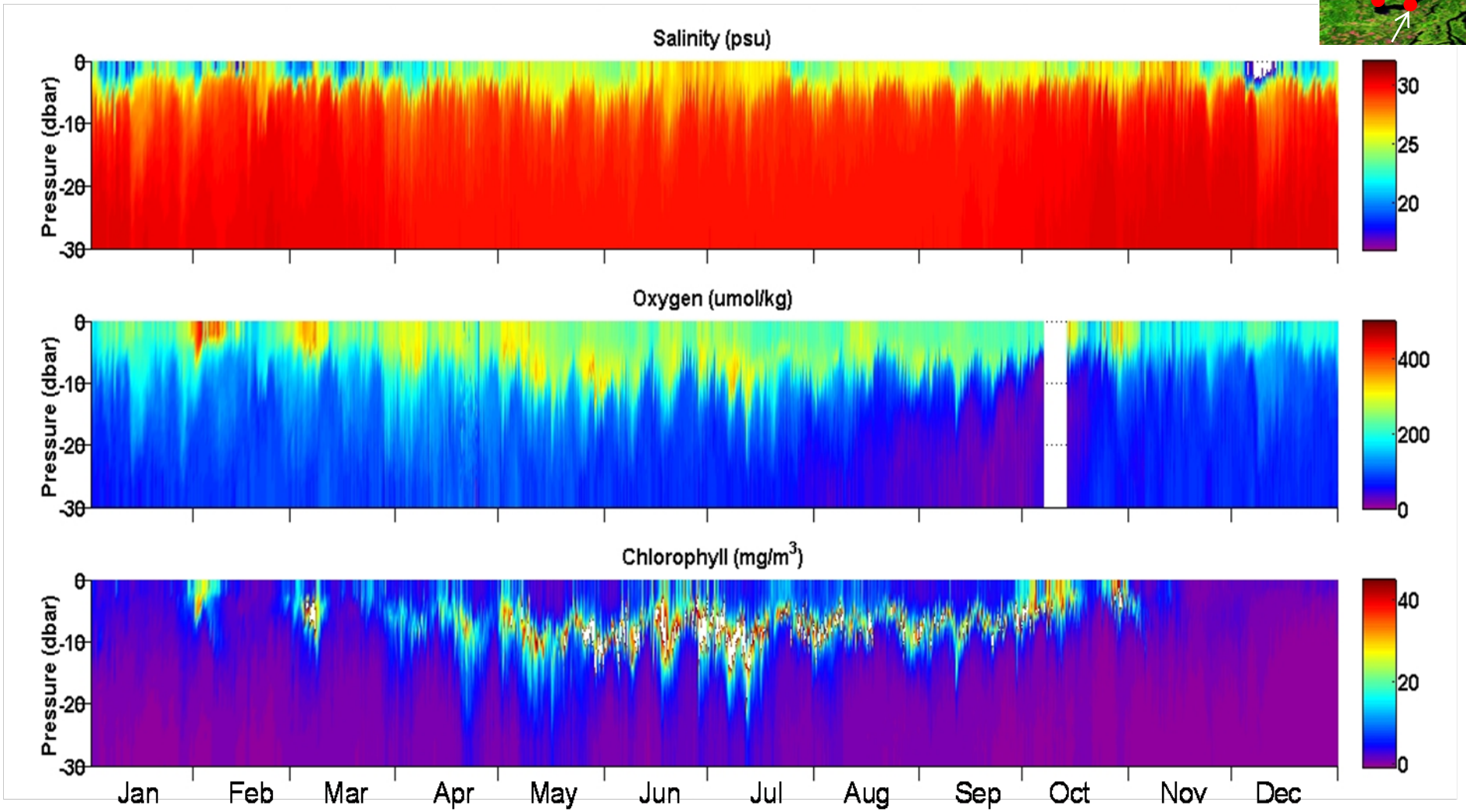
Hypoxia at depth

Nitrate profile

Water column current profile

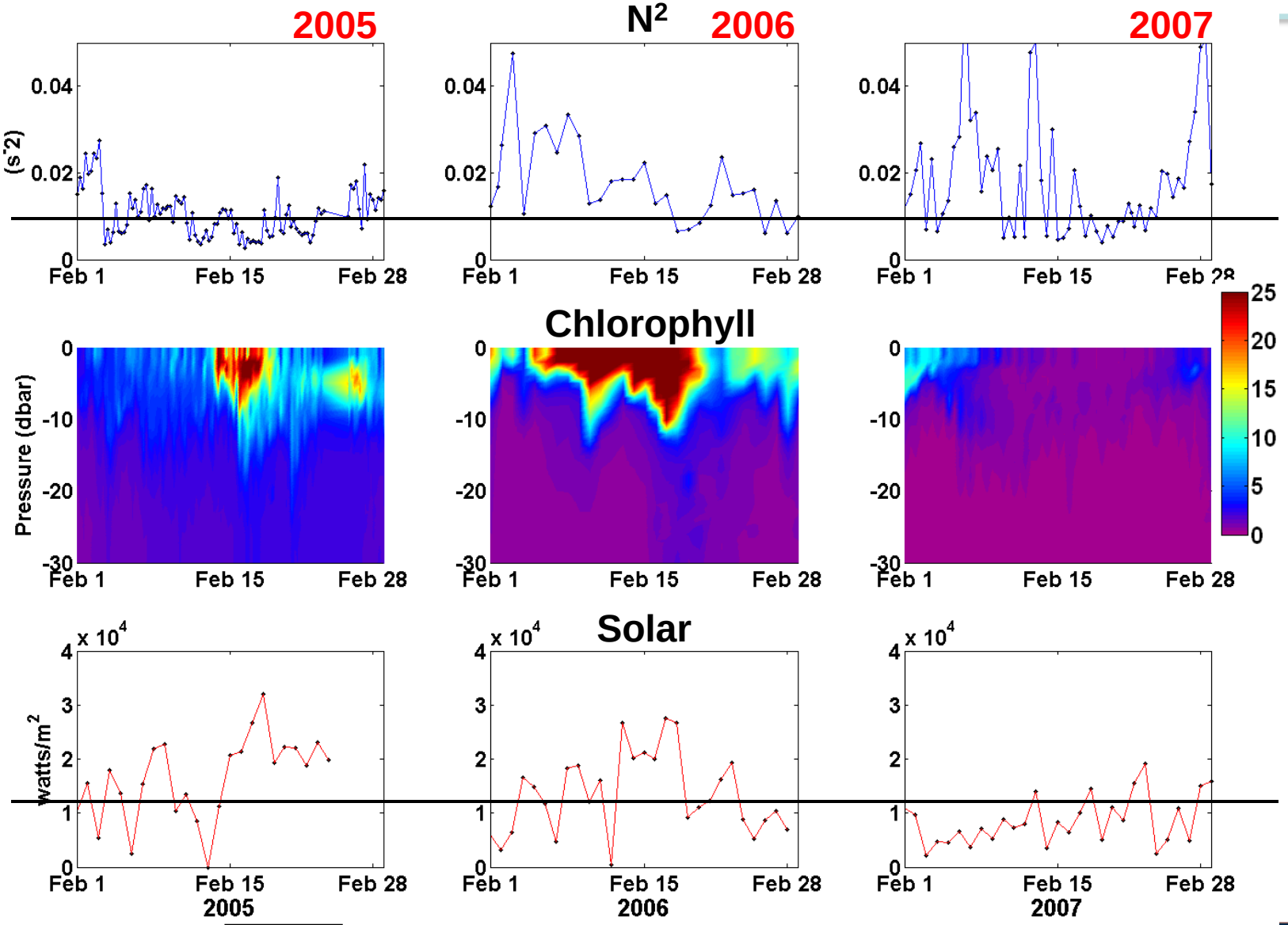
Information over the year





2006

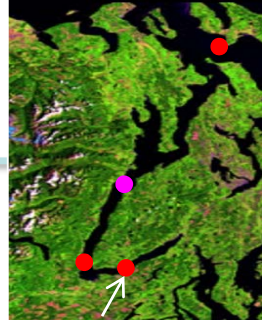
Info on processes: variation in spring bloom

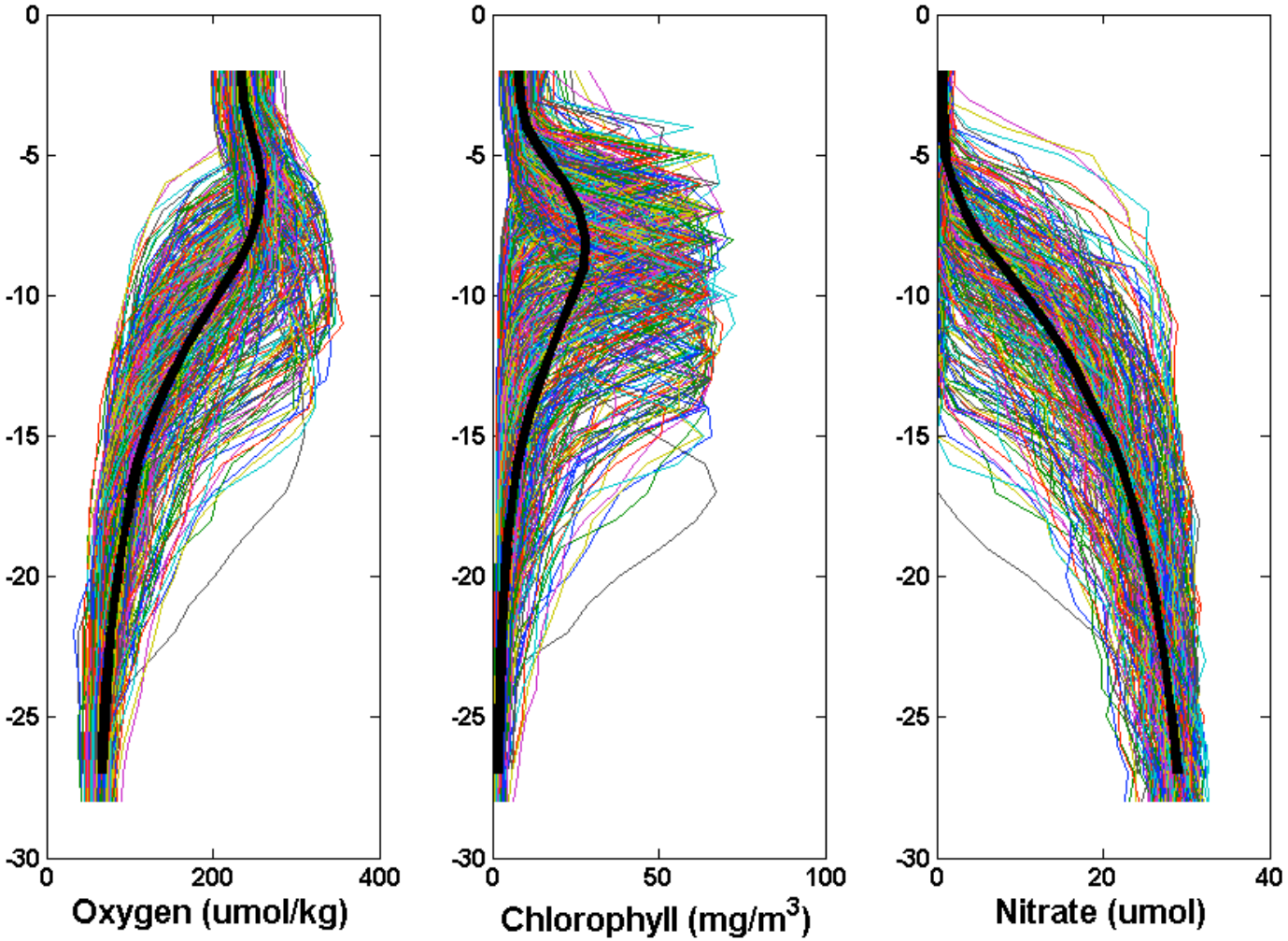


What have we learned from ORCA in Puget Sound ?

Some stories from Hood Canal…

High variability

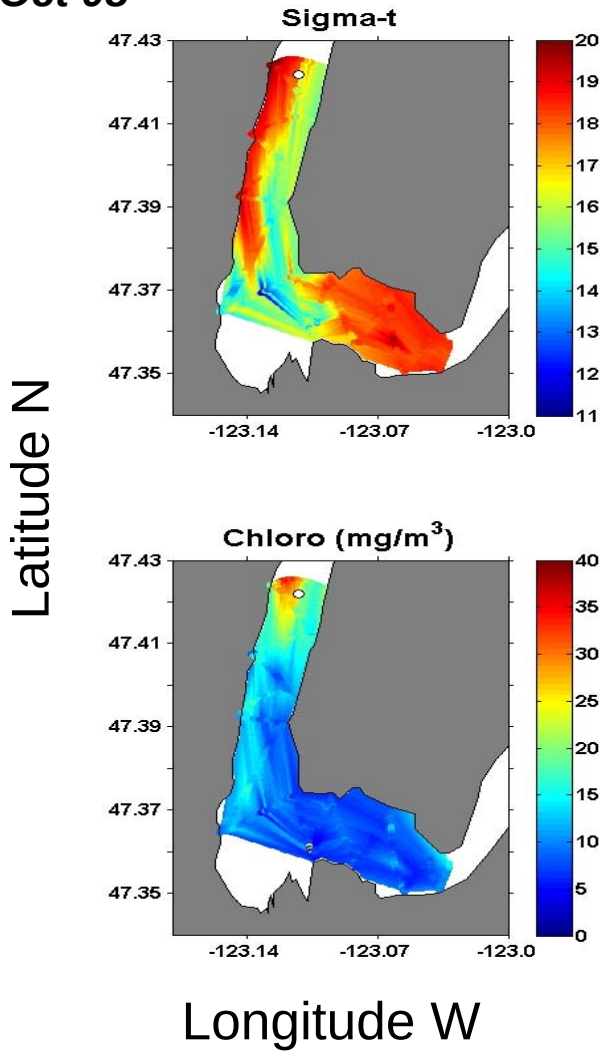


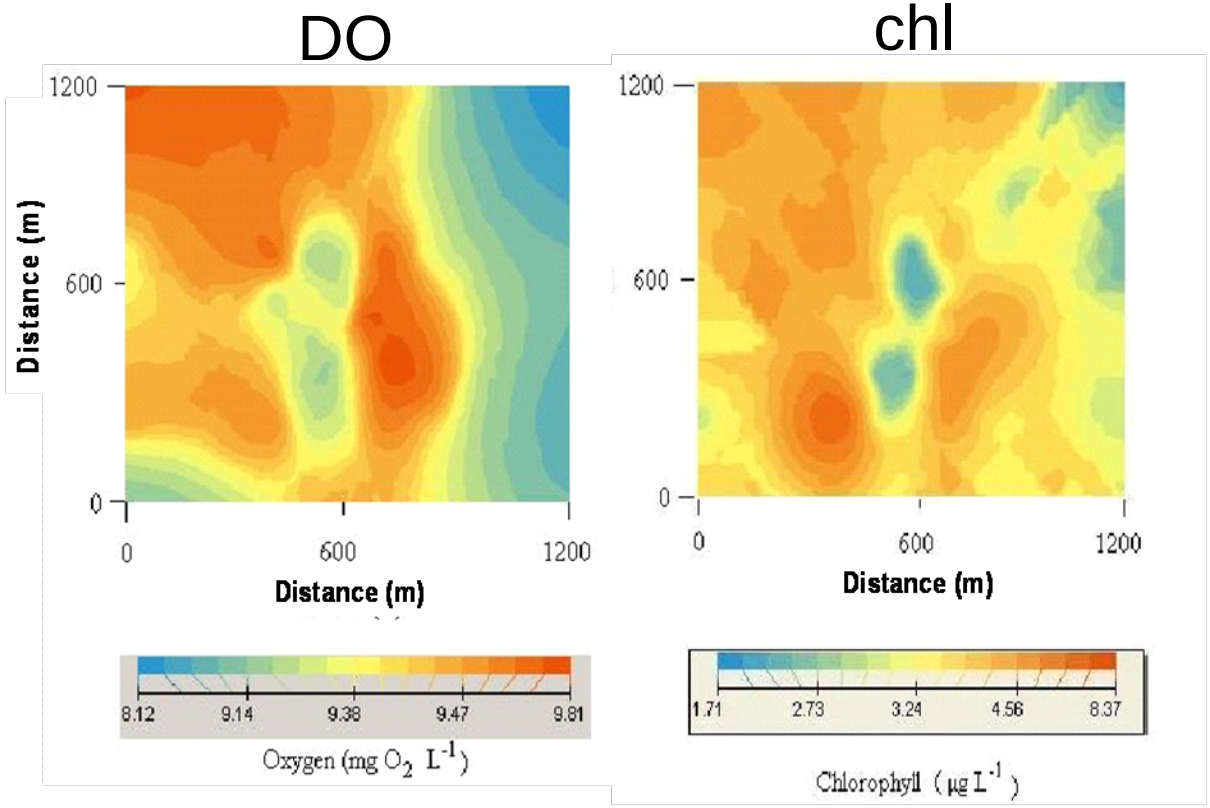


July 08

Strong spatial variation

Oct 08

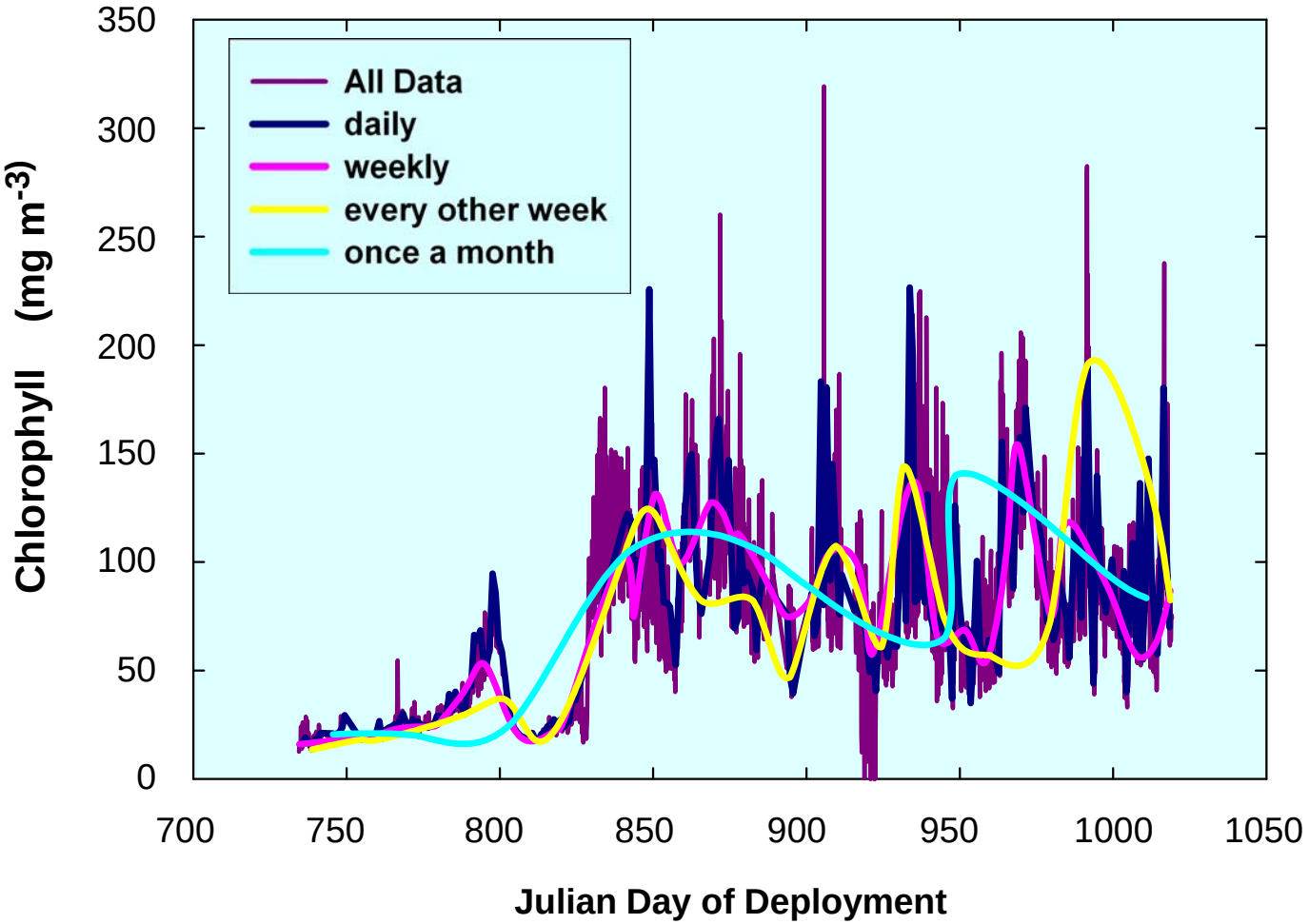




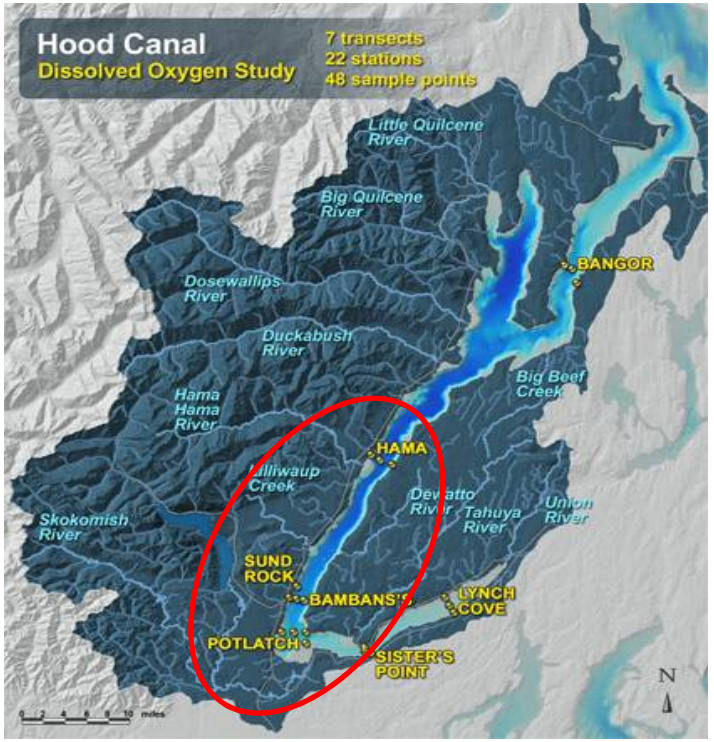
Surface maps of dissolved oxygen and chlorophyll concentrations around the ORCA mooring in April 2007.
Note correlations of concentration fields.

What trends will you see ?

Twanoh (Jan – Oct ’05)



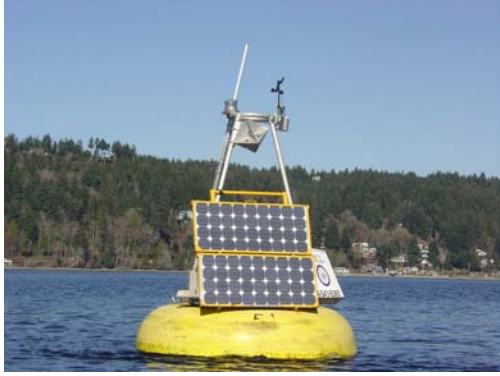
Fish Kills:

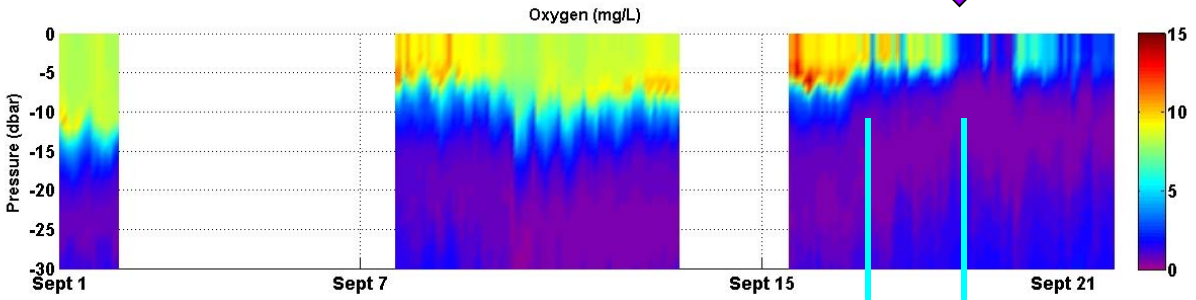


19 Sept 2006

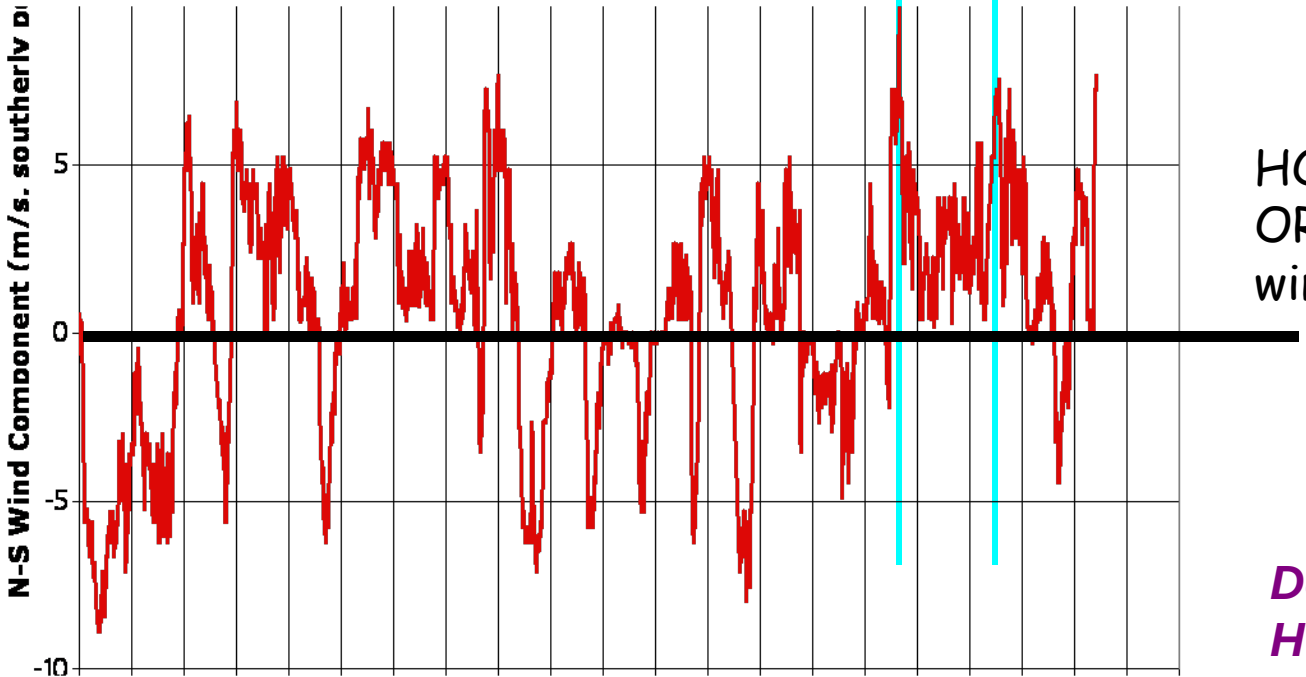
“Several reports of dead fish, including flounder, sticklebacks, wolf eels and shrimp were observed from beaches including Tahuya, Lilliwaup, Hoodsport, Annas Bay, and North Beach off Highway 101.”

September 19 2006 Fish Kill Event





HOODSPORT ORCA buoy oxygen data



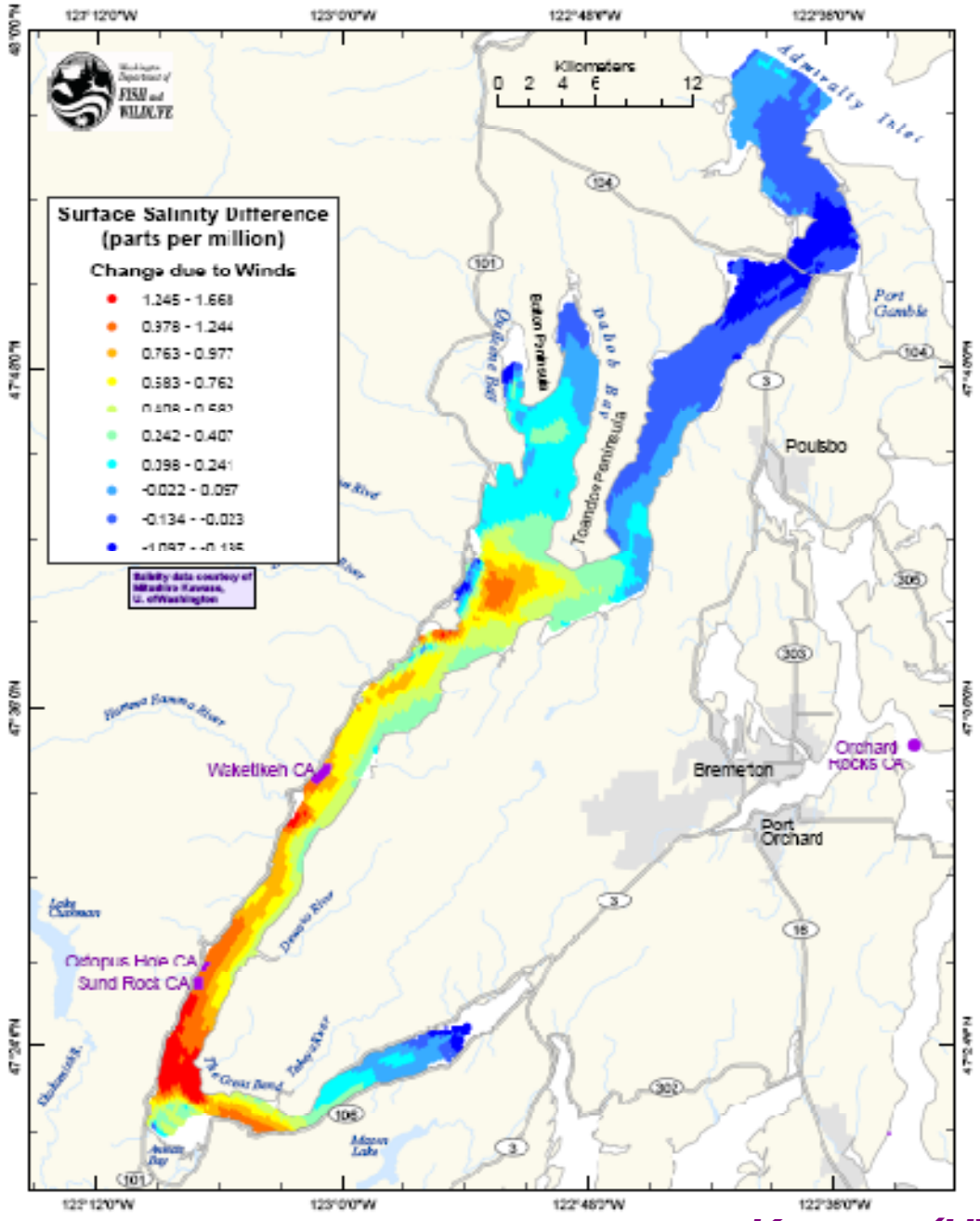
S

N

HOODSPORT ORCA buoy wind data

HCDOP

Devol (UW) and HCDOP IAM Team



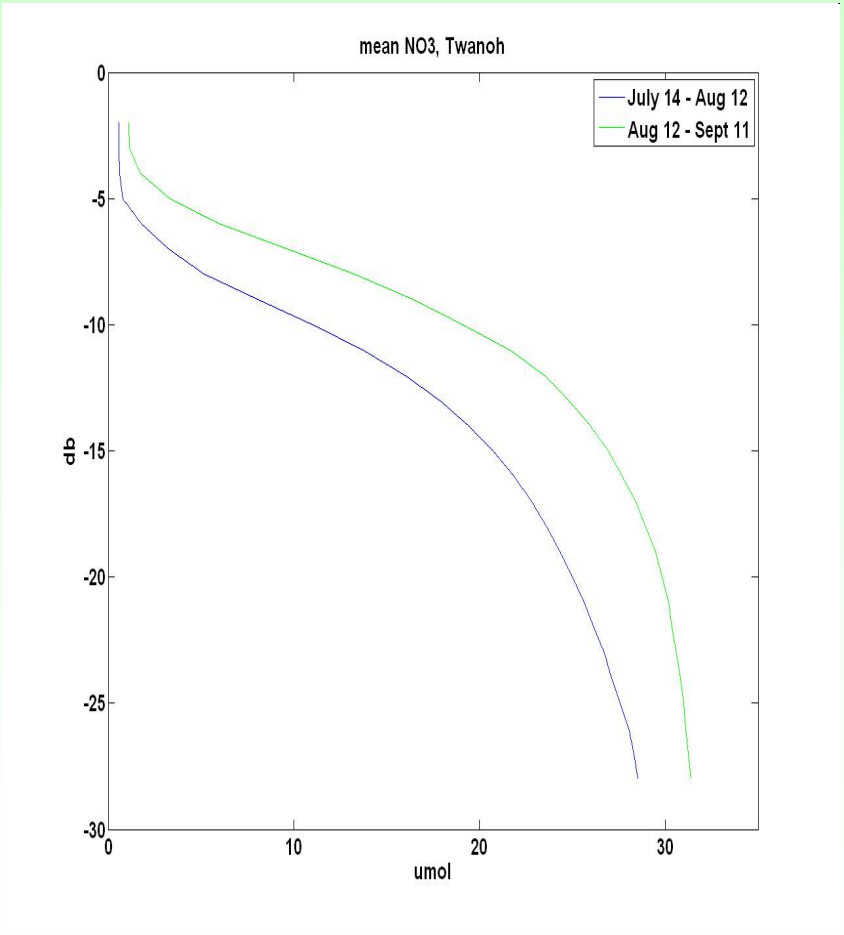
Episodic Oxygen Stress

- Areas where risk of exposure to episodic low oxygen conditions caused by wind-mediated upwelling is greatest.
- Intensity of red indicates where deep water rises to surface most effectively during southerly wind events.
- This indicates where highest risk of biota stress and mortality due to episodic wind-driven low oxygen events occurs.

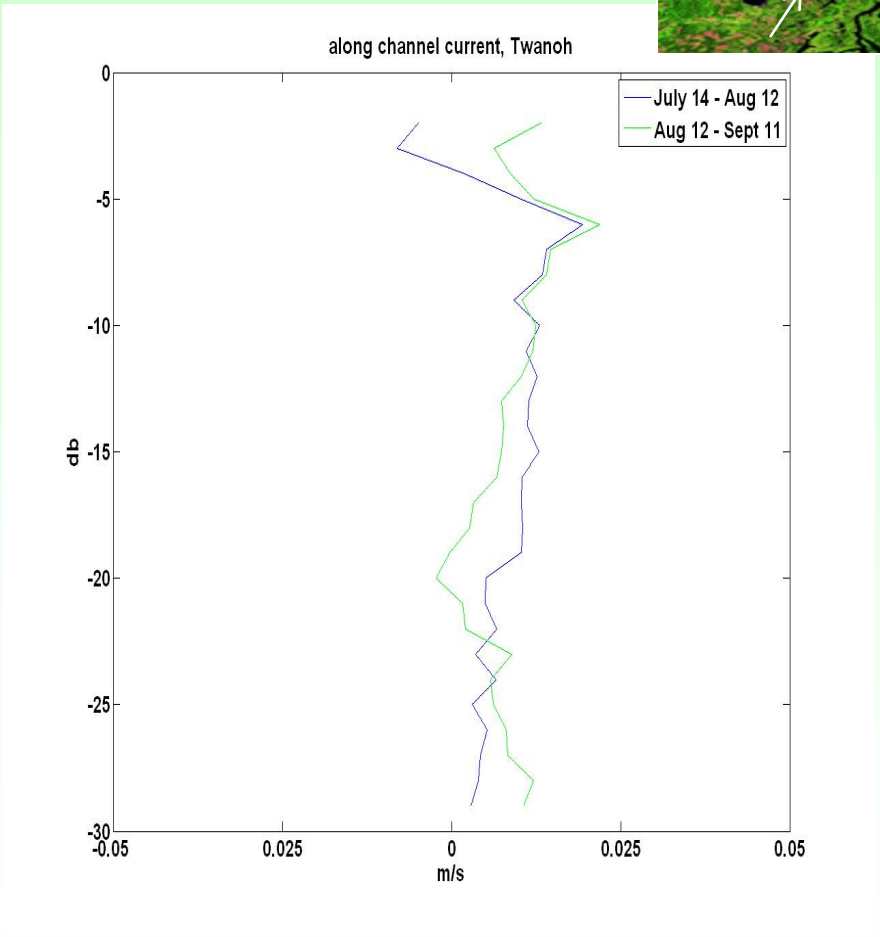
Kawase (UW) model output, WDFW projection

Concentration x flow = flux !

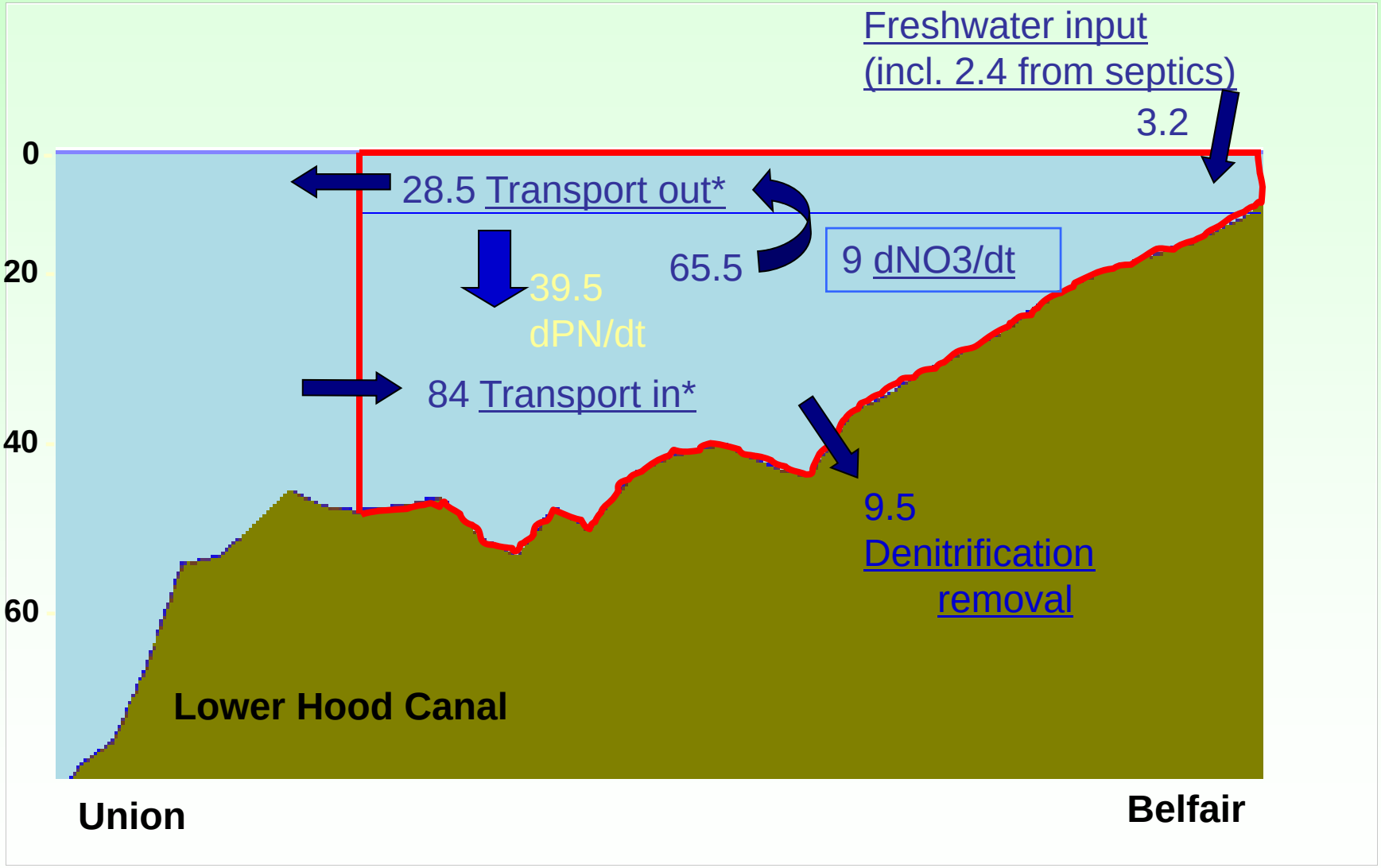
Nitrate



Currents



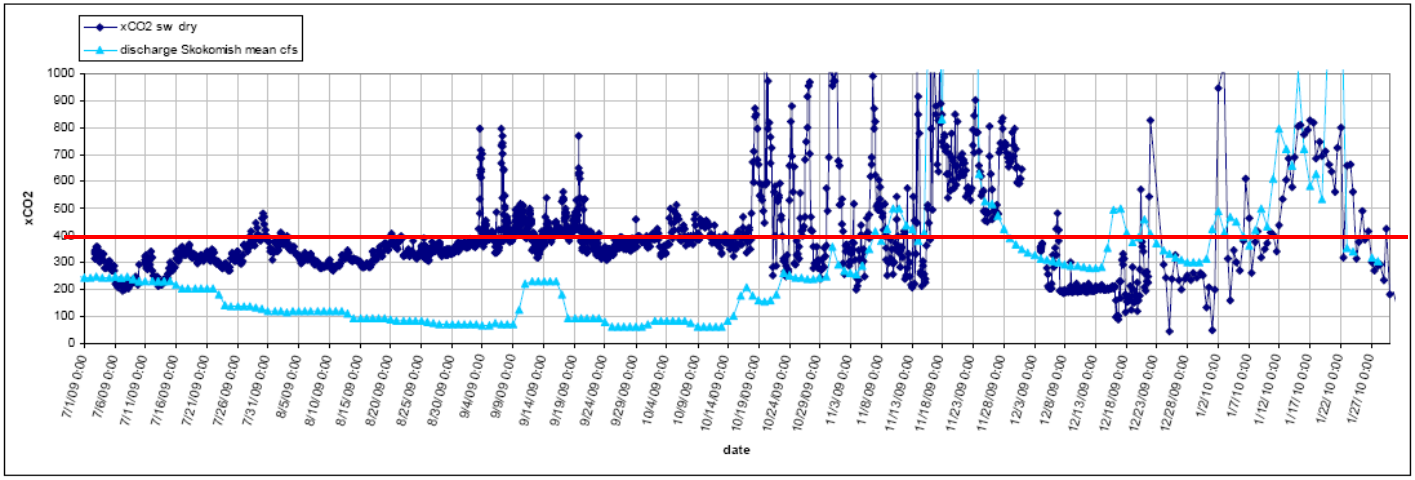
Lower Hood Canal N-Budget (Mt/mo; JJAS):

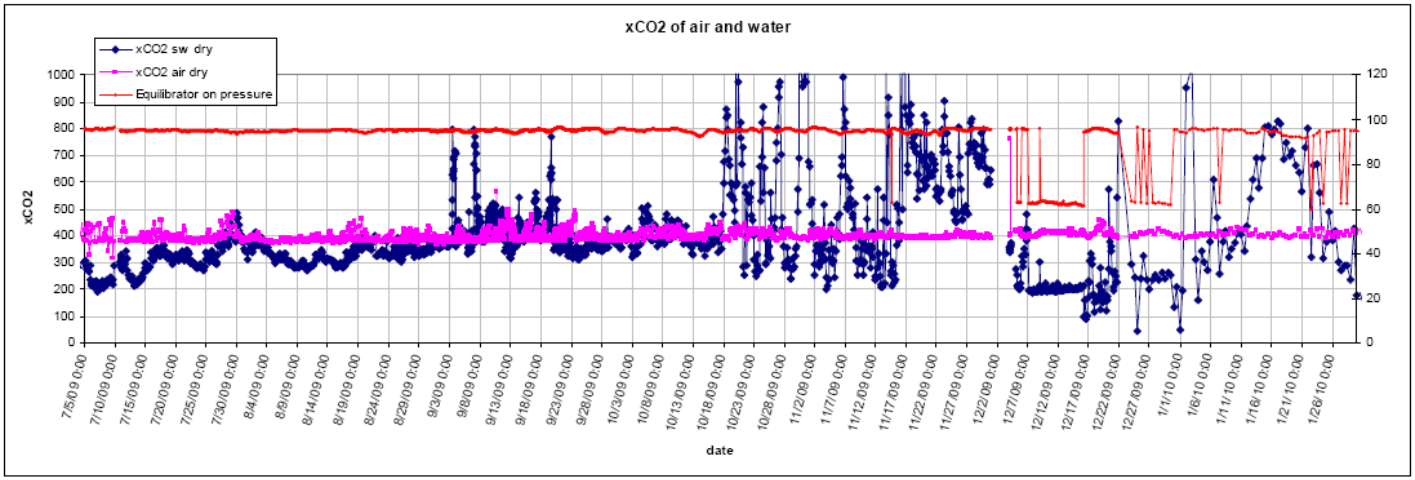


What can we still learn ?

- pCO2 aka Ocean Acidification
- Harmful Algal Blooms aka Red Tides (HABs)

NOAA pCO2 atm sensor on NANOOS Hood Canal ORCA buoy





National Oceanic and Atmospheric Administration

Pacific Marine Environmental Laboratory

A leader in developing ocean observational systems to address NOAA's mission

School of Oceanography
University of Washington

HCDOP

NANOOS

Buoy network for Puget Sound

A private-public partnership
between industry and UW

Networked Buoy Project

.

“surface buoys”

IC Mobilisa lead

Surface:

potential for oil and other pollution

harbor security

“profiling buoys”

APL-UW lead

Profiling:

potential for low oxygen

climate change impacts

Networked Buoy Project

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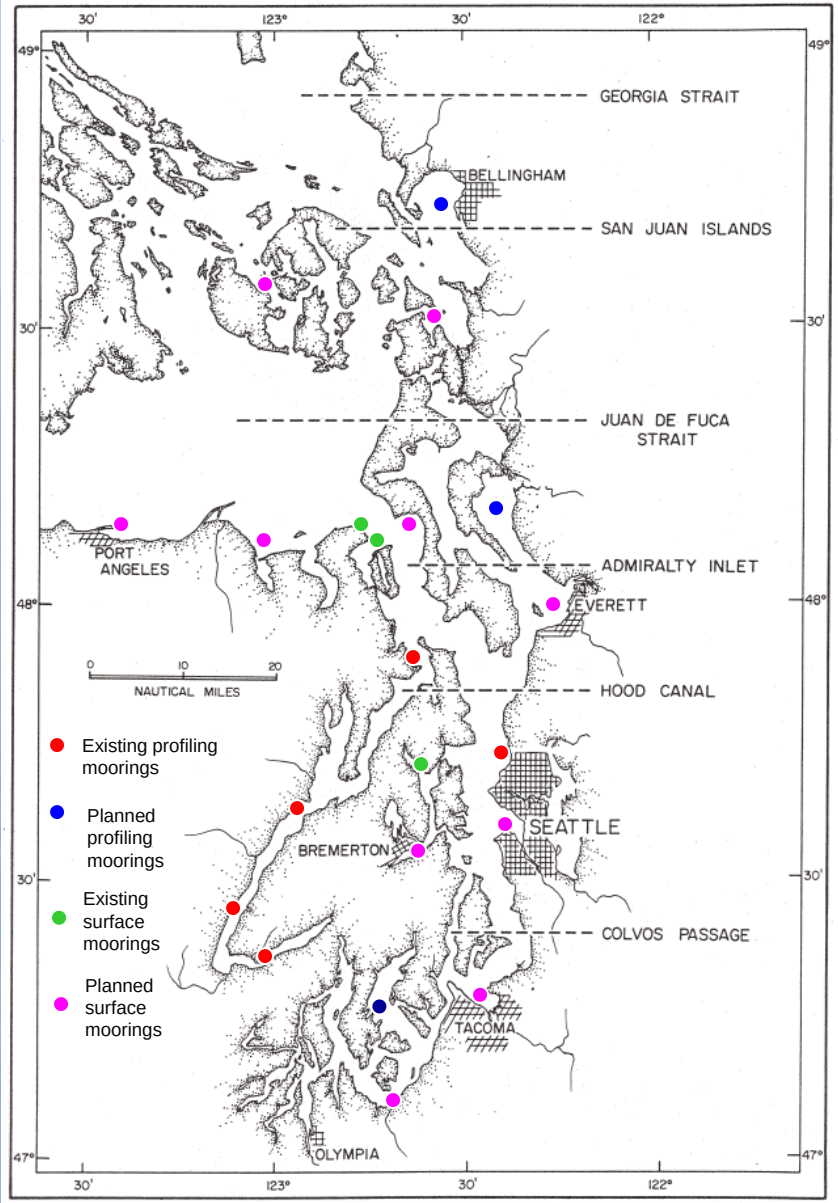


Location logic

Surface:

potential for oil and other pollution

harbor security

Profiling:

potential for low oxygen

climate change impacts

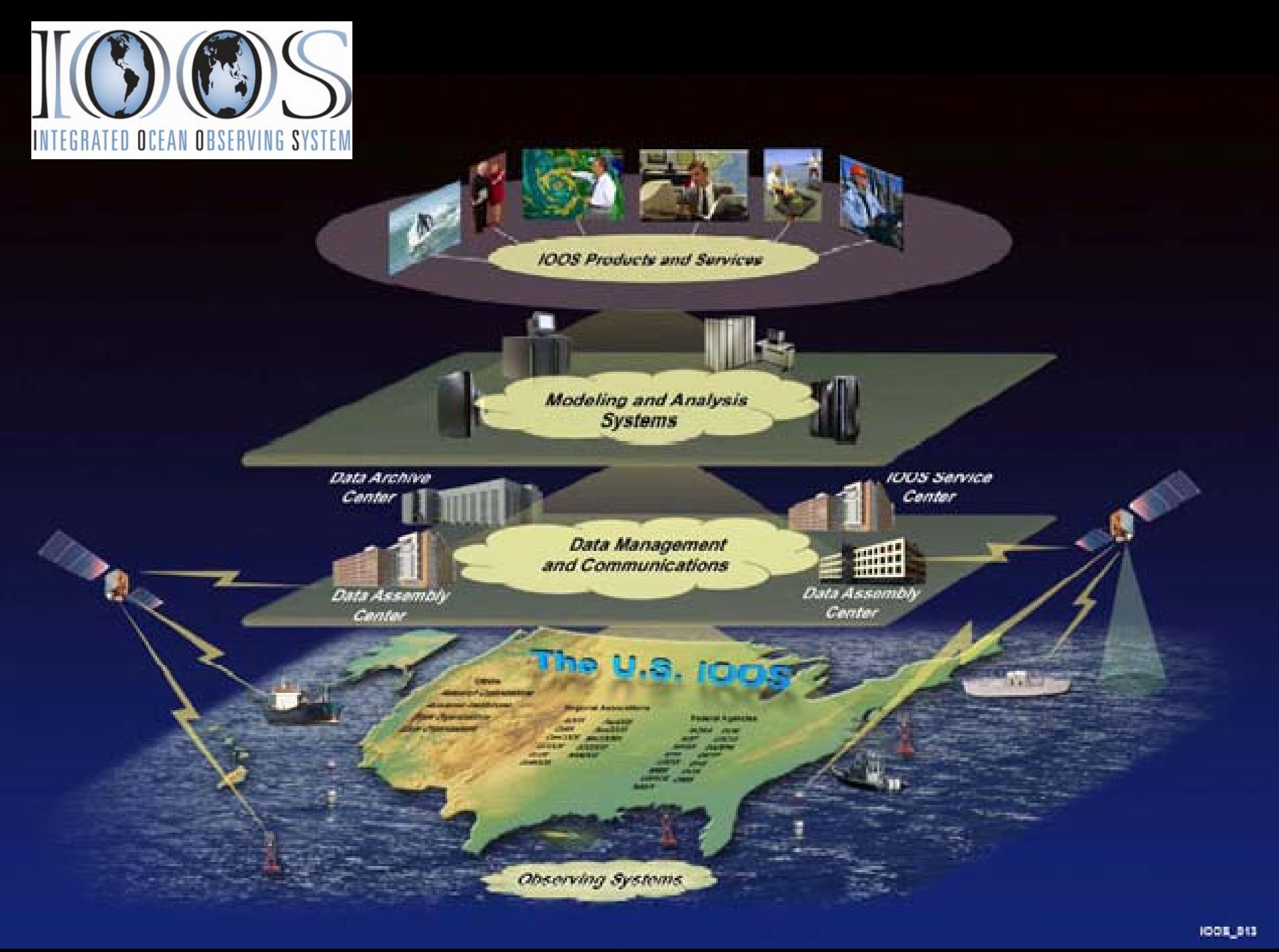
Northwest Association of Networked Ocean Observing Systems

The Integrated Ocean Observing System (IOOS)
Regional Association for the Pacific NW

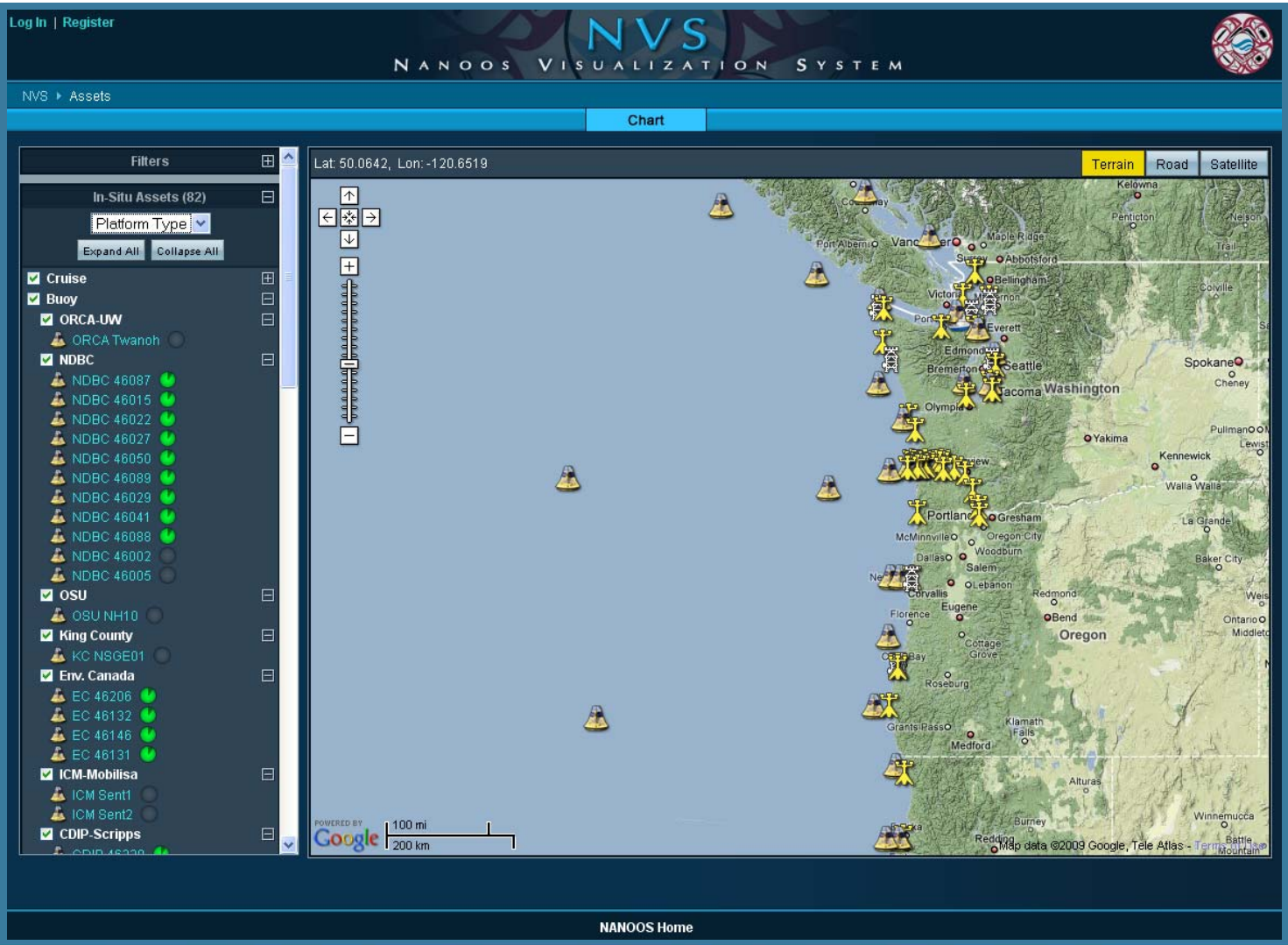
www.nanoos.org

IOOS
INTEGRATED OCEAN OBSERVING SYSTEM

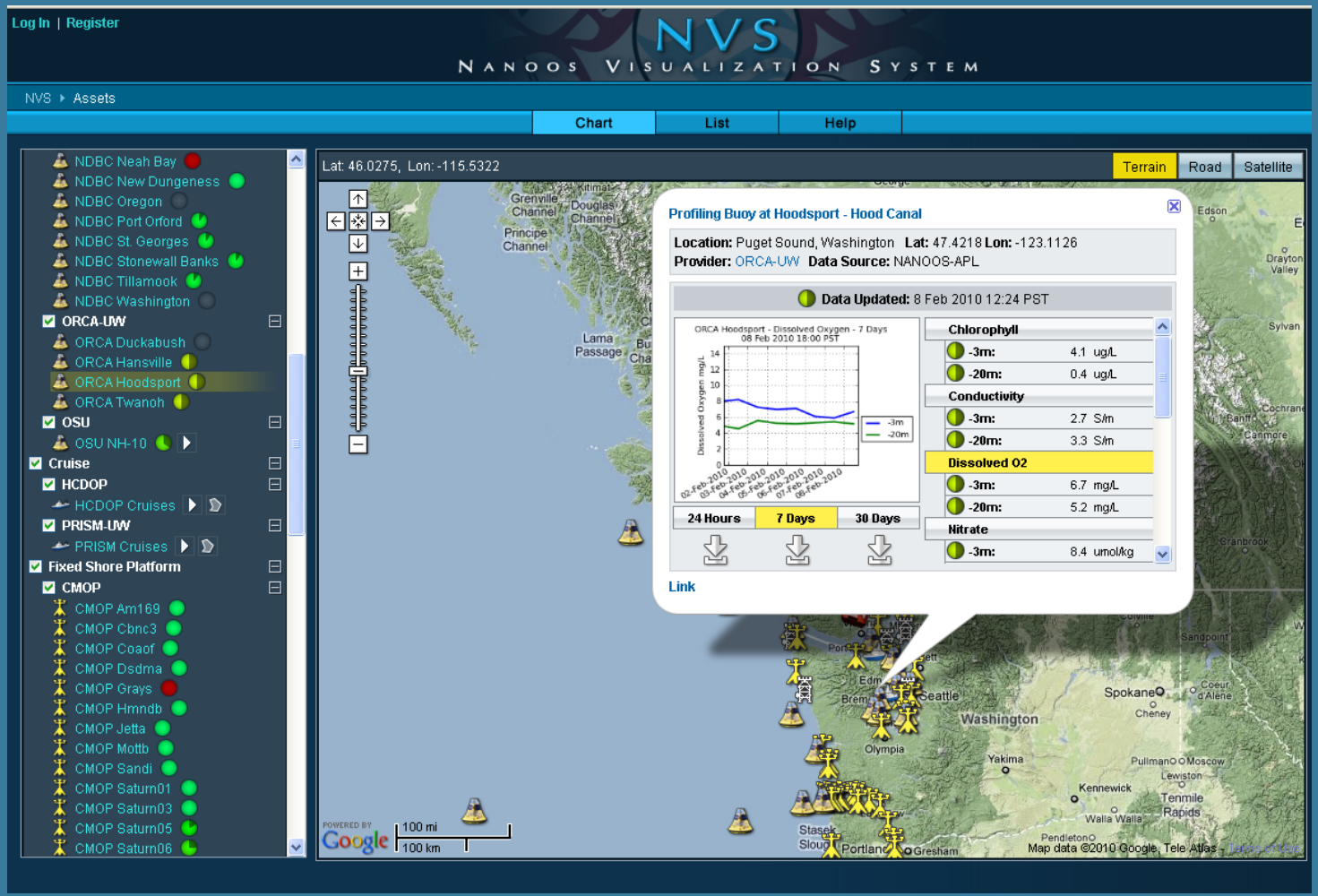
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE


IOOS
INTEGRATED OCEAN OBSERVING SYSTEM
IOOS Products and Services
Modeling and Analysis Systems
Data Archive Center
IOOS Service Center
Data Management and Communications
Data Assembly Center
Data Assembly Center
The U.S. IOOS
Observing Systems

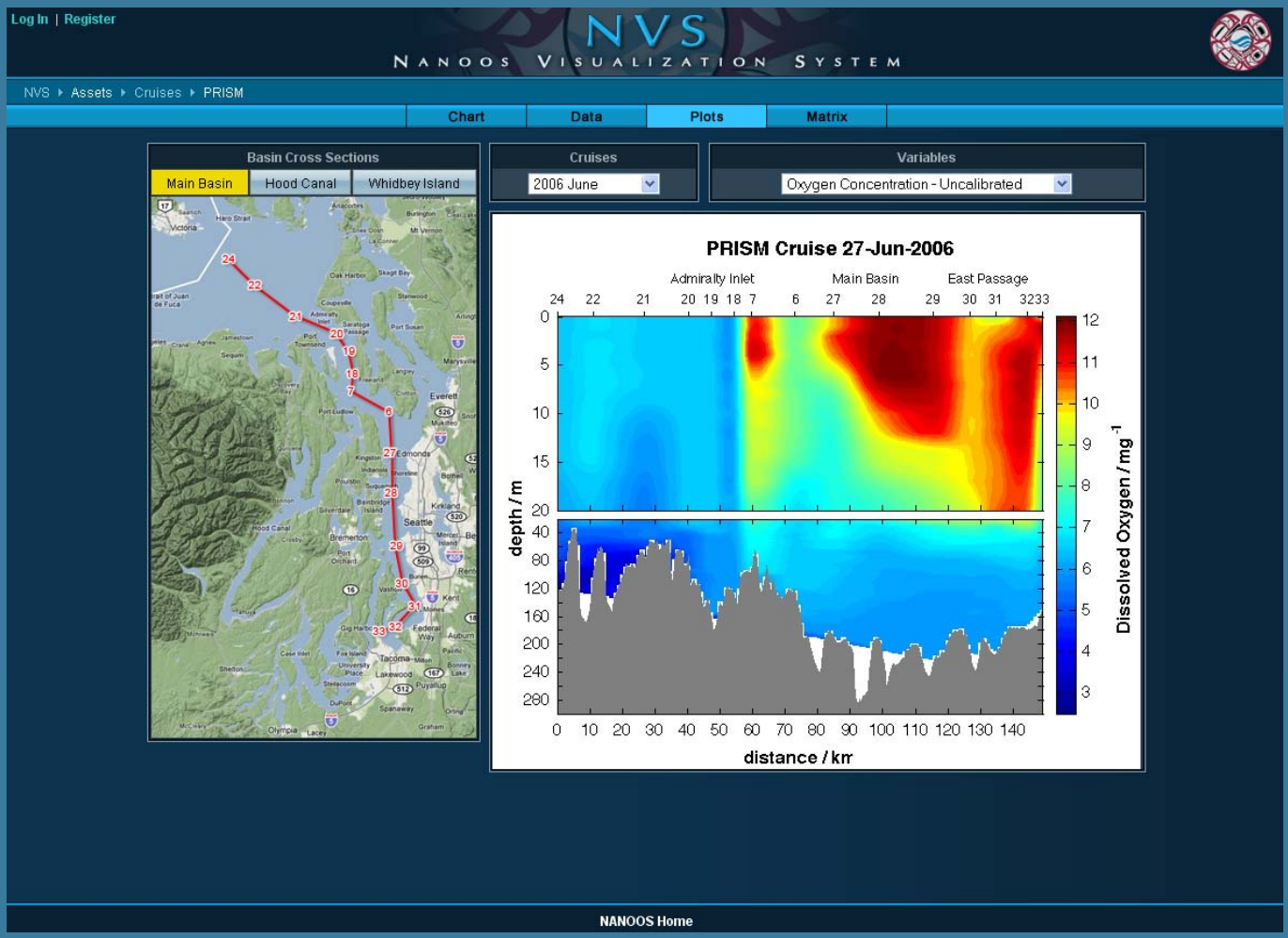
The NANOOS Visualization System



ORCA buoy data



UW PRISM cruises



Further Information

1) www.Nanoos.org
2) www.orca.ocean.washington.edu
3) www.hoodcanal.washington.edu

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QUESTIONS ?

Extras

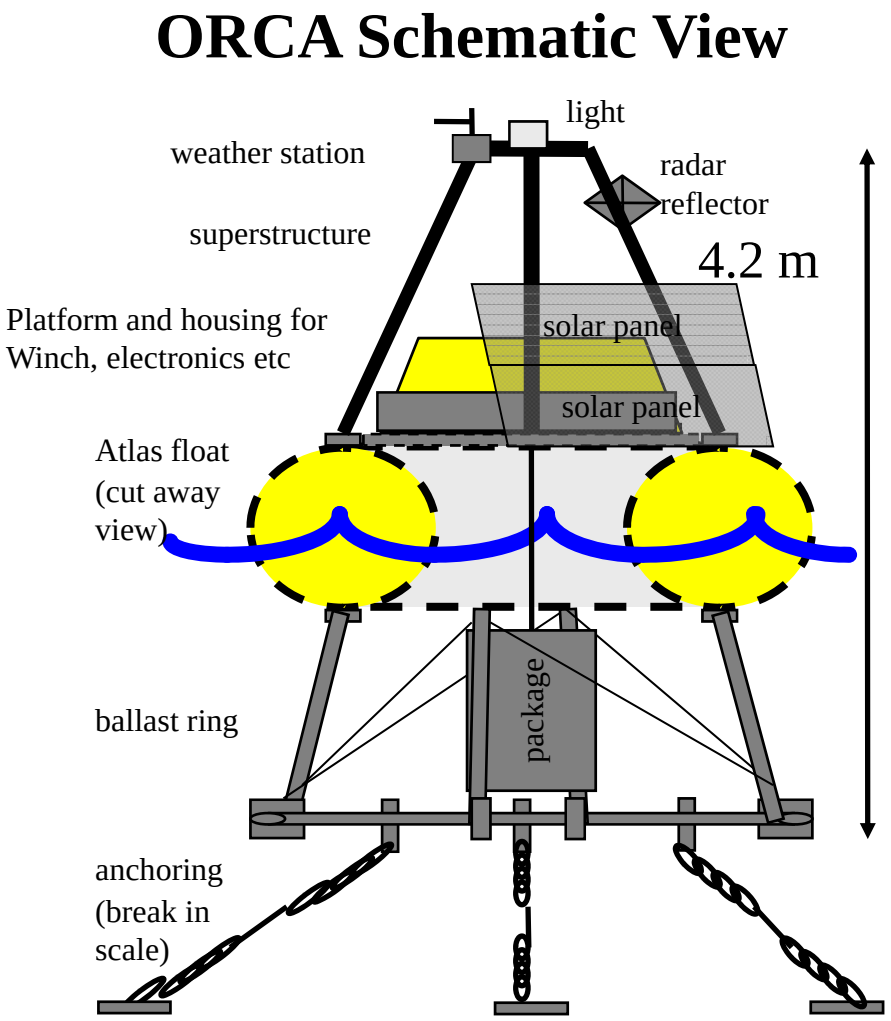
Recipe for a fish kill event

	2003	2004	2005	2006
	Fish kill	**Odd behavior**		**Fish kill**
S winds	X	X		X
Low DO	X	**X**	x	**X**
Shallow/ weak density gradient	X			X

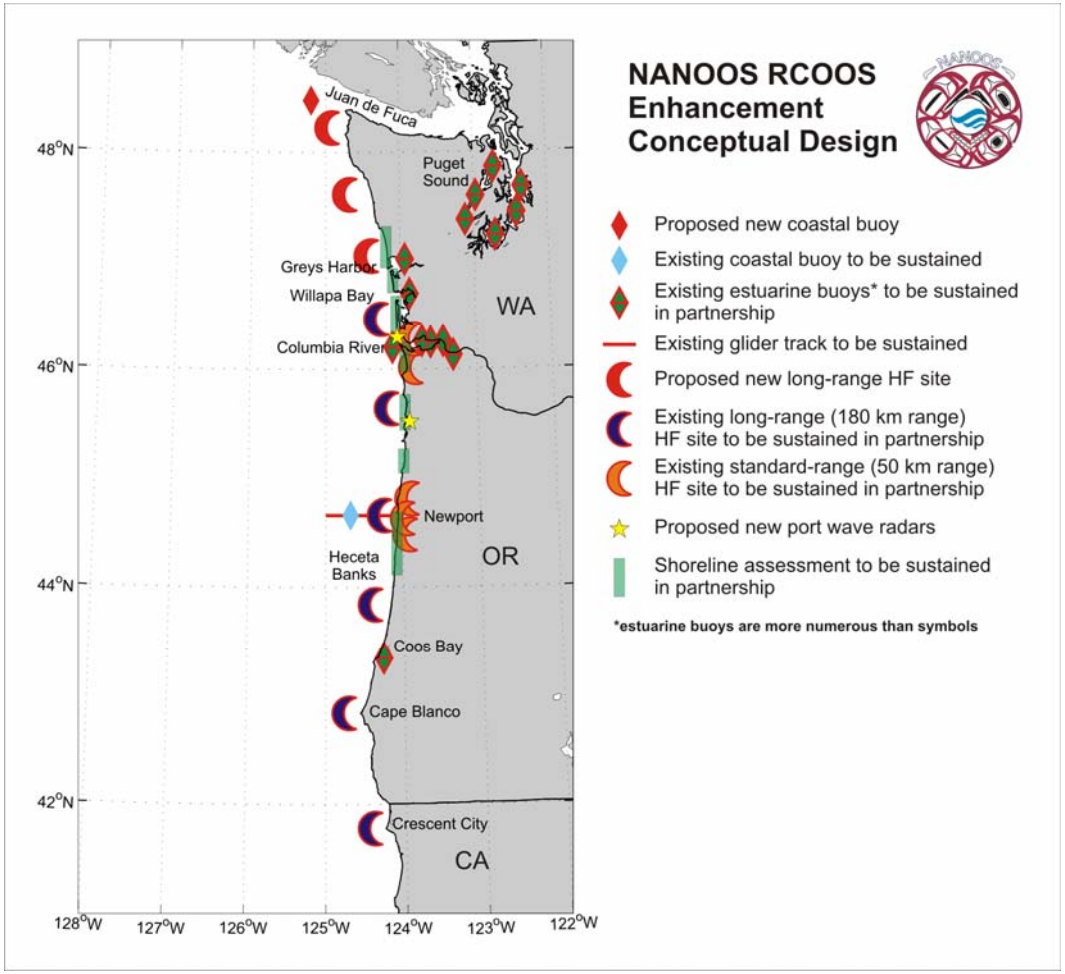
Conclusions

1) Many coastal and inshore waters have high frequency signals that are due to horizontal patchiness and tidal advection
2) Different variables/parameters require different measurement frequencies to discern seasonal or global change or anthropogenic influences, e.g gas exchange daily, chlorophyll concentration weekly
3) High frequency sampling reveals short term phenomenon

Oceanic Remote Chemical Analyzer (ORCA) buoy



Developed at University of Washington

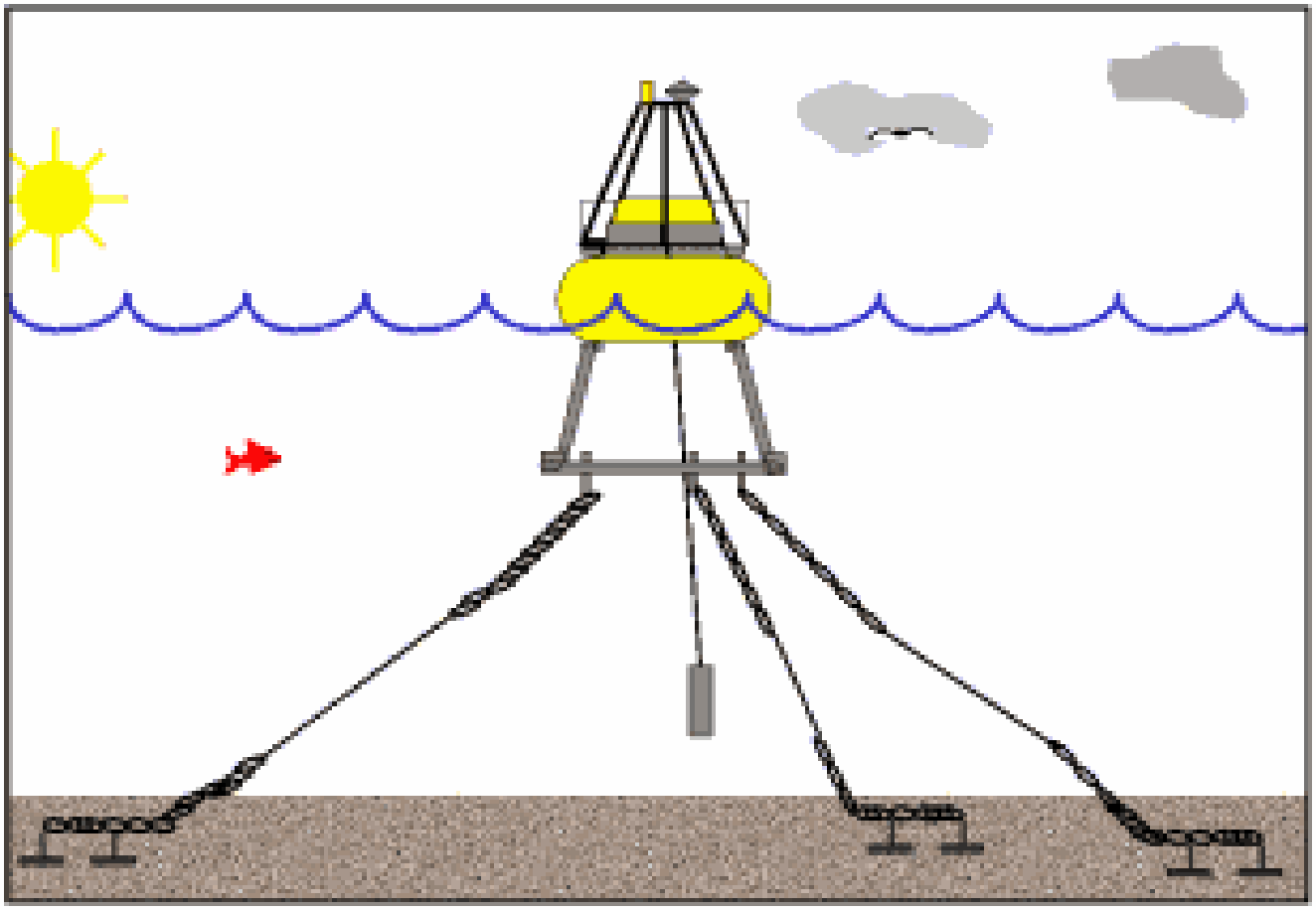


Observing assets NANOOS supports are:

- OR coastal shelf buoy and glider (Newport Line)
- OR coastal shelf currents (HF)
- Puget Sound, Columbia River, Willapa and Coos Bays, and Grays Harbor moorings/buoys
- WA and OR shoreline profiles

Grant from Murdock for WA buoy & glider

Profiling capability



ORCA buoys

4 buoys, 4 locations

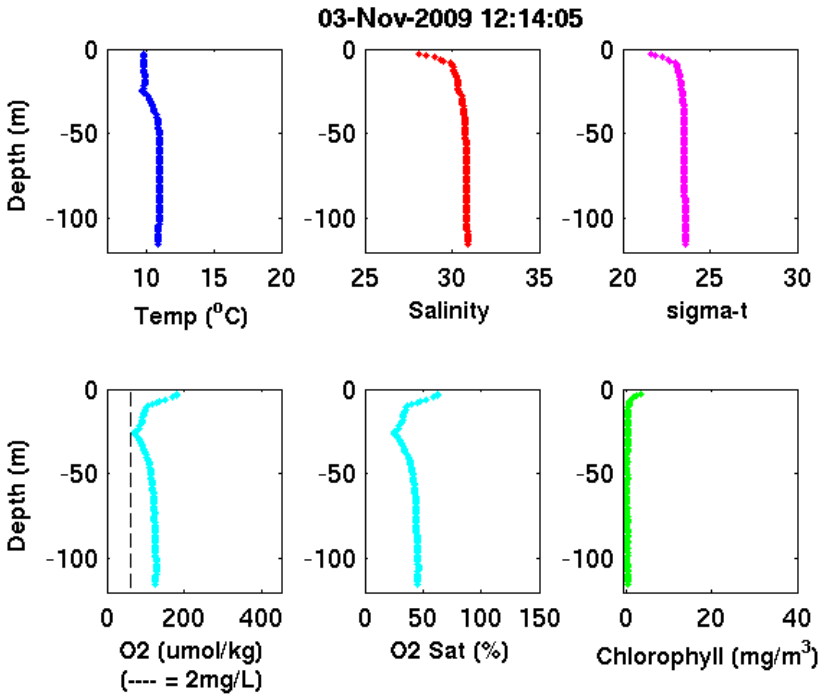
1) **Hansville**
2) **Duckabush**
3) **Hoodsport**
4) **Twanoh**

In southern Hood Canal, the buoy at Twanoh has recorded a total of 13071 profiles since January 2005.

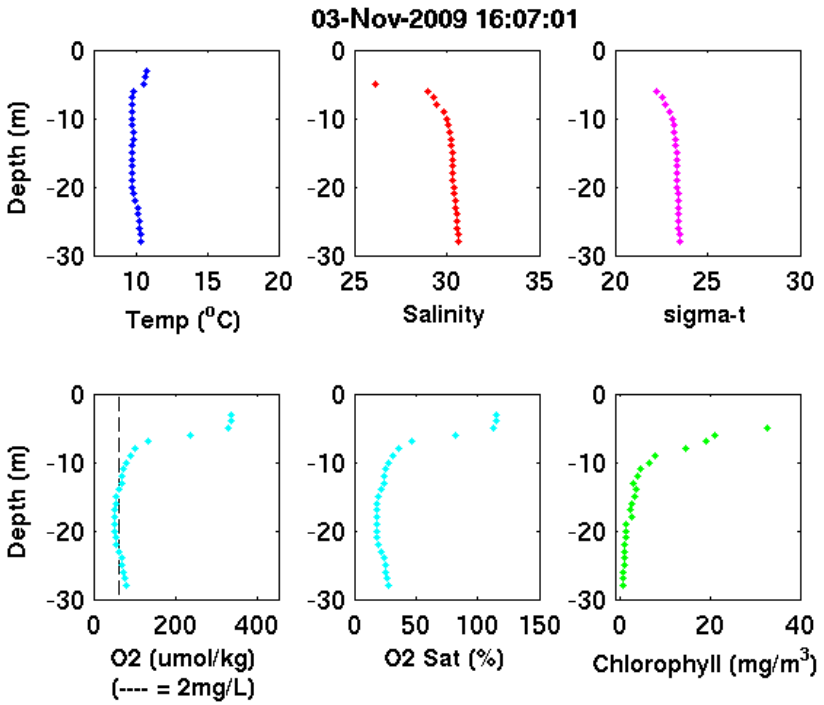
Part of the NANOOS Observing System

ORCA gives information about now

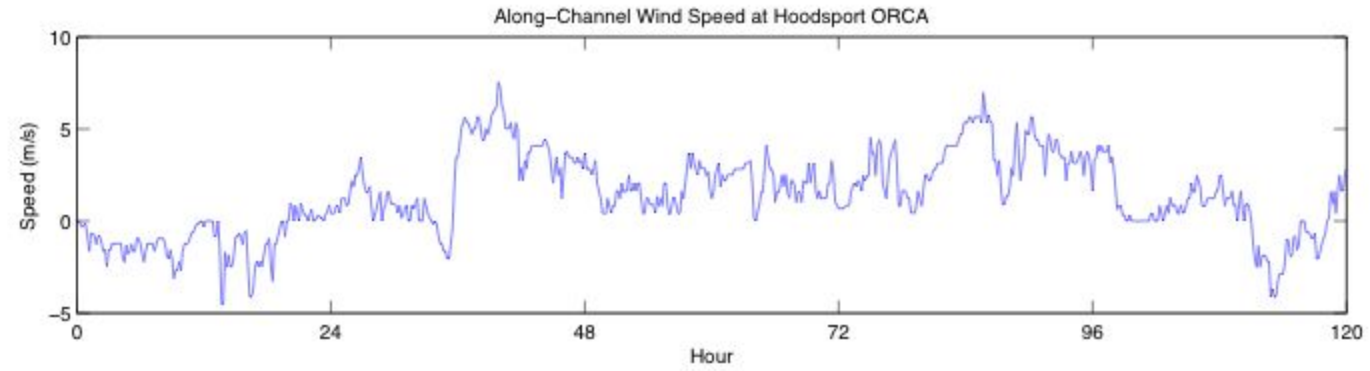
Hoodsport



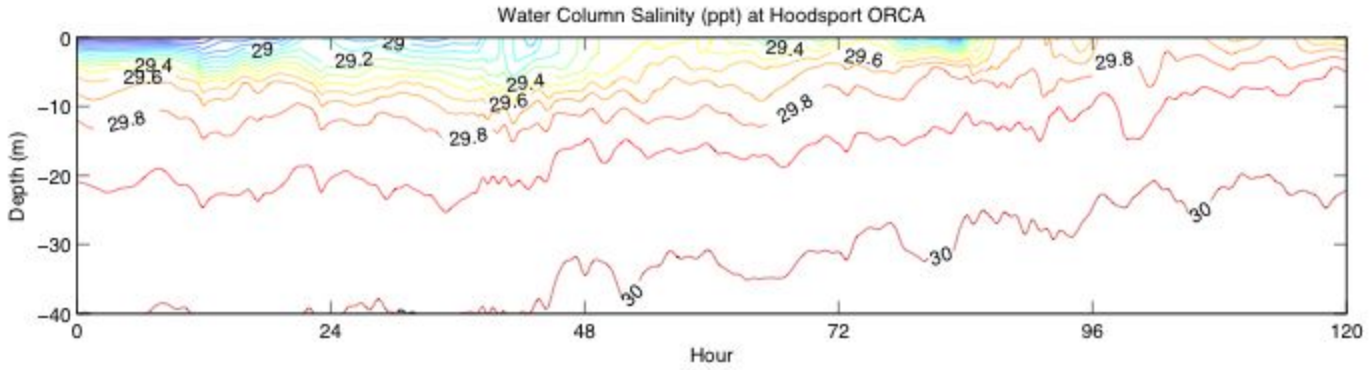
Twanoh



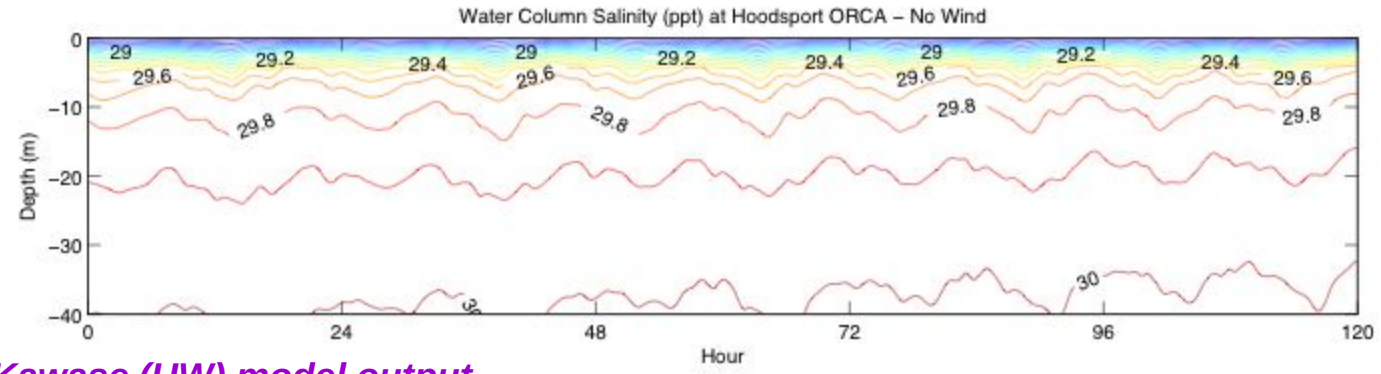
Marine model results show that winds do cause **outcropping** of deep waters to surface.



Observed wind at Hoodsport



Modeled salinity at Hoodsport ORCA, ***with wind***



Same, but ***without wind***

Kawase (UW) model output

Mitsuhiro Kawase, University of Washington


School of Oceanography
University of Washington

HCDOP

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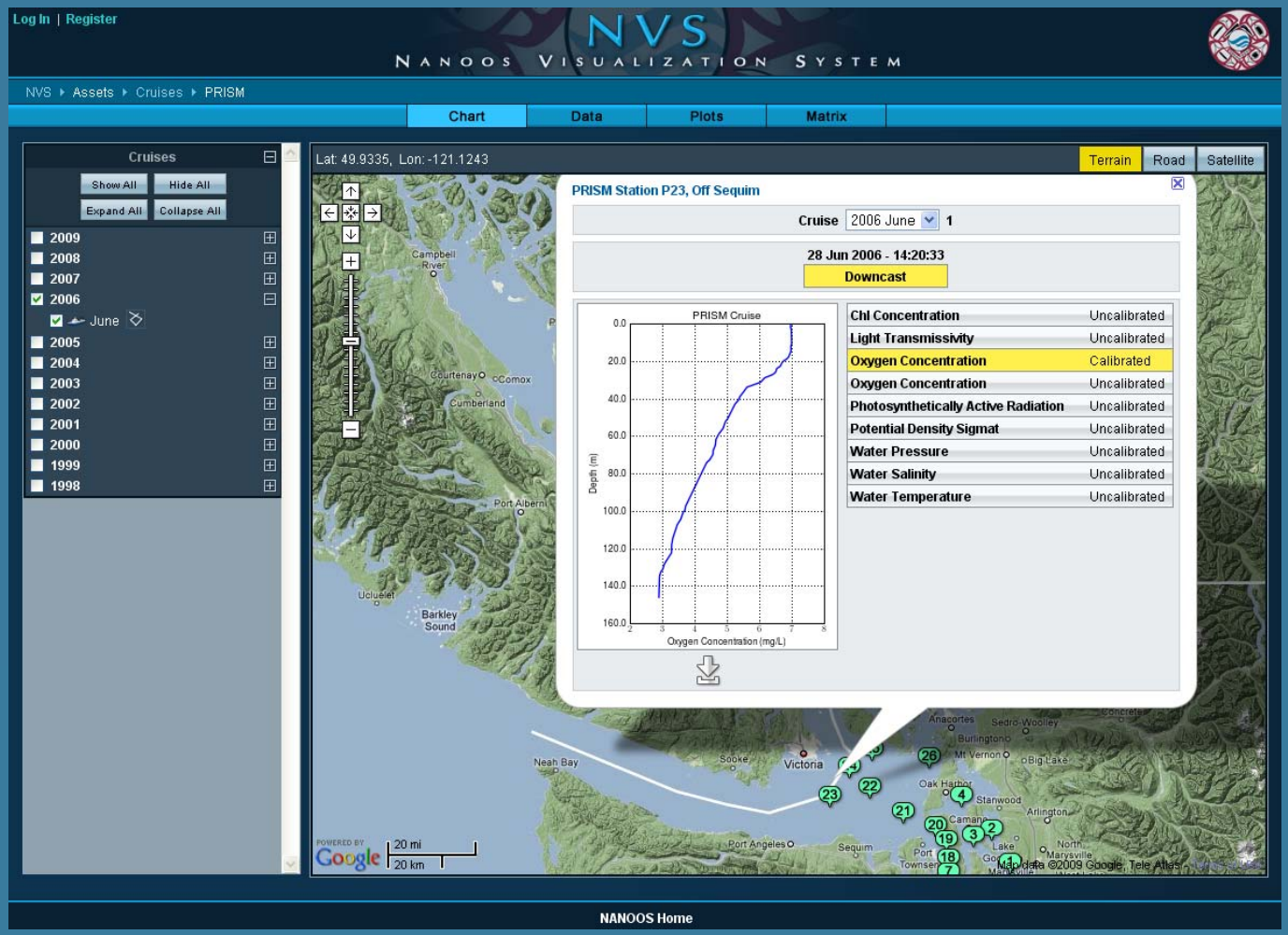
UW PRISM cruises



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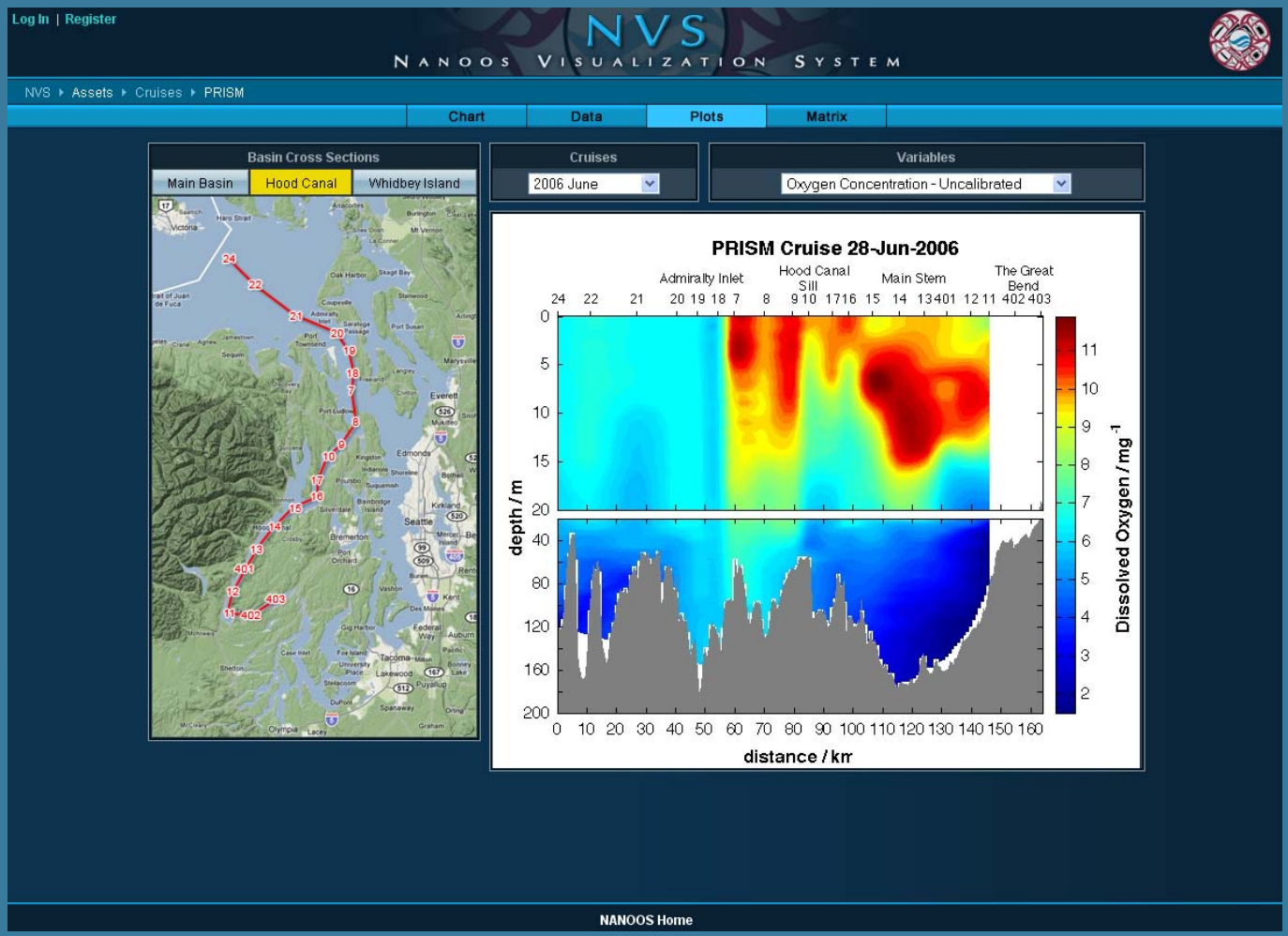

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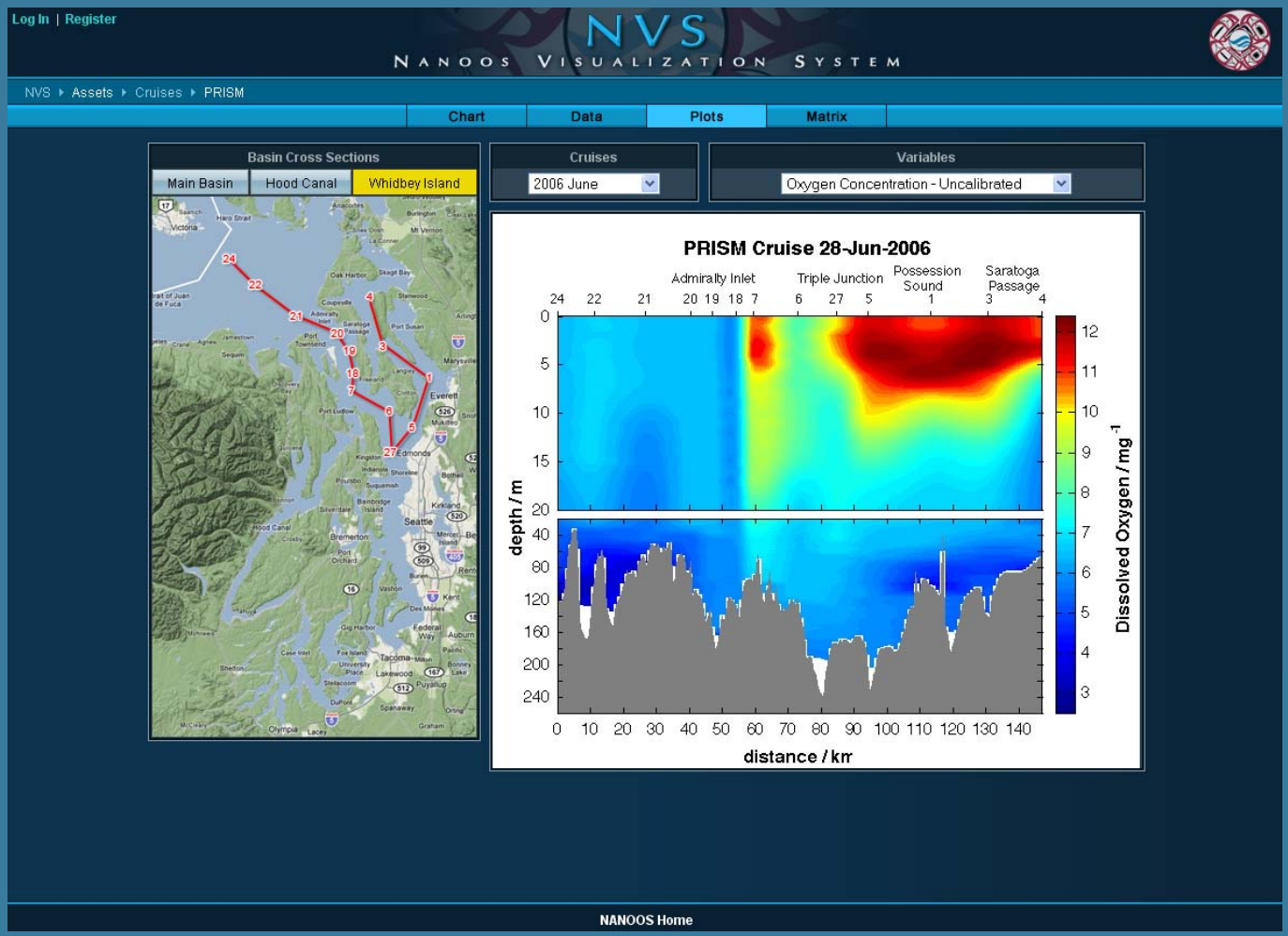
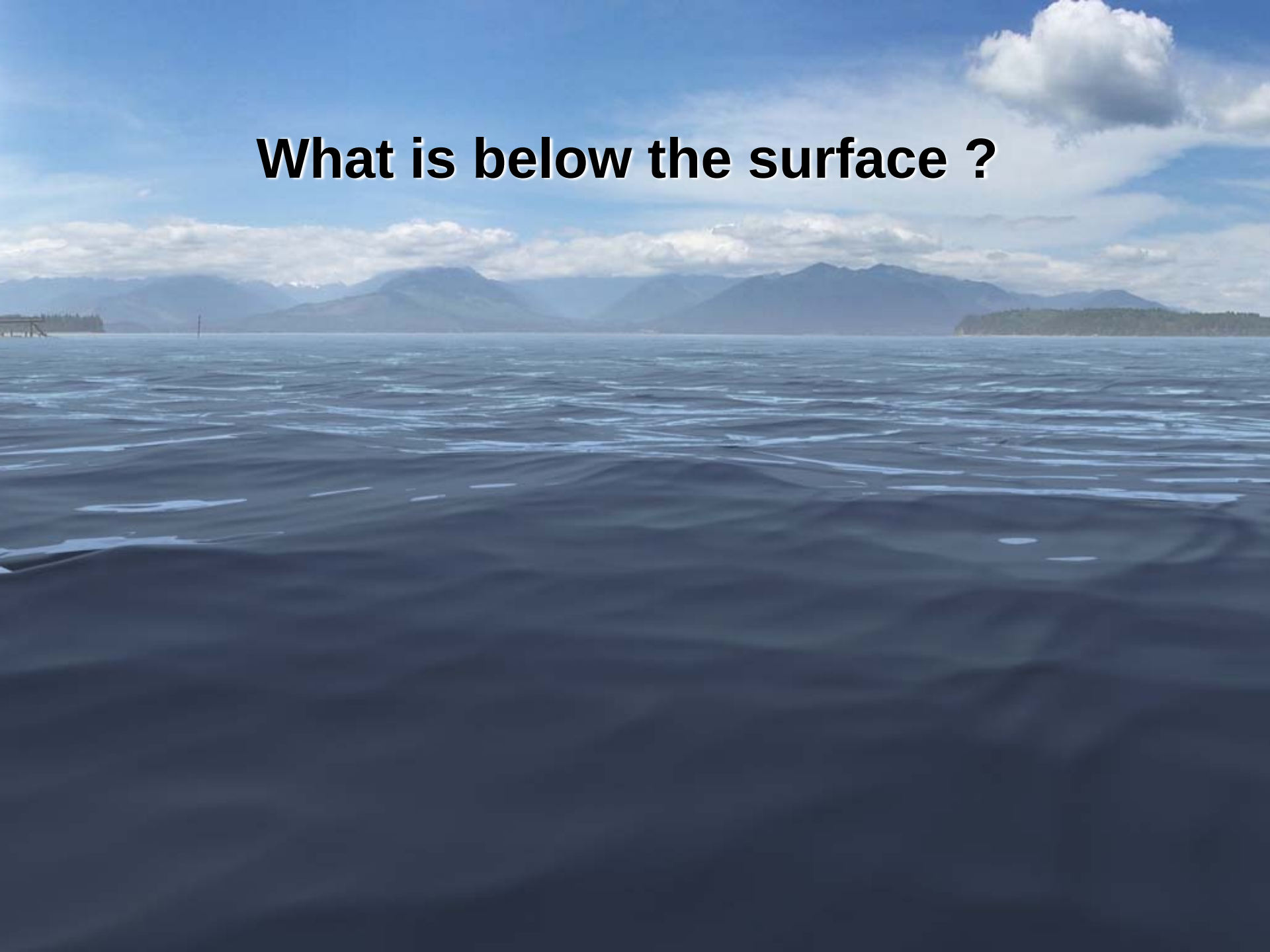


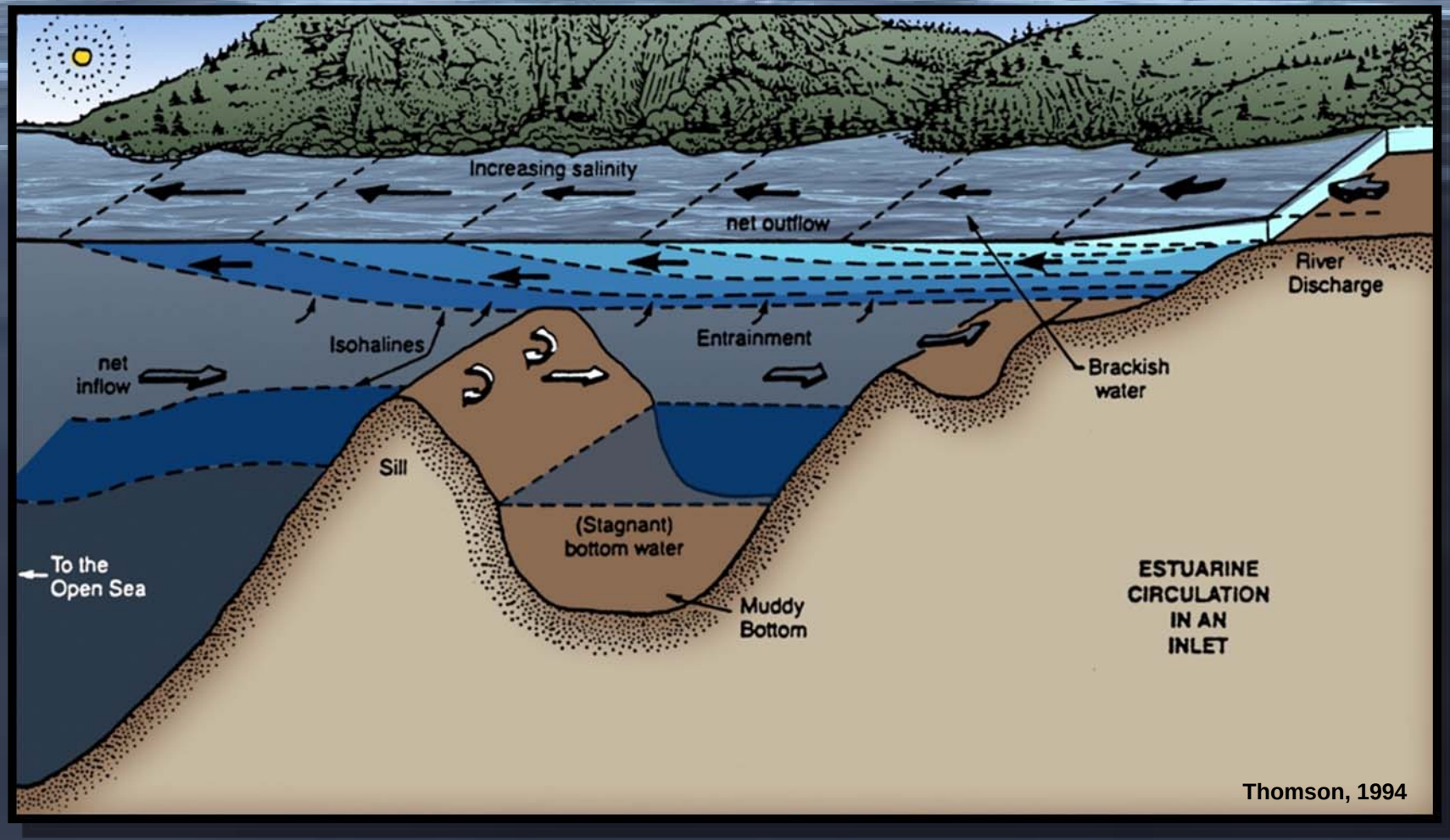
Conclusions for Hood Canal hypoxia

- NANOOS ORCA buoy data for nitrate and currents enabled construction of a nitrogen budget for area most subject to anthropogenic effects.
- The budget shows that, although the largest input to the euphotic zone is from oceanic nutrients, the input of nitrogen from anthropogenic sources was ~5-10% of the oceanic input.
- If all of this N is used to create oxygen demand it is enough to lower the deep water oxygen content by 0.6-1.2 mg/l, which in certain years is enough to produce a fish kill.


What is below the surface ?

What is below the surface ??

ocean



river

Buoyant river water flows out of an estuary on surface, dense ocean water flows in at depth, but there is mixing, and sills cause “reflux” of water back in to an estuary.