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

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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
Differences between Hood Canal and Puget Sound
Near Admiralty Inlet

Within Hood Canal

“ORCA” buoy data
Devol, Ruef (UW)

http://orca.ocean.washington.edu
Deep chlorophyll max

Strong stratification

Hypoxia at depth

Deep chlorophyll max

Nitrate profile

Water column current profile

02-May-2008 12:07:01

Depth (m)

Temp (°C)

Salinity

sigma-t

O2 (umol/kg)

O2 Sat (%)

Chlorophyll (mg/m³)

Nitrate (umol)

PAR

Currents (m/s)

E = purple, N = green
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

Oxygen (μmol/kg)

Chlorophyll (mg/m³)

Nitrate (μmol)
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)

Chlorophyll (mg m\(^{-3}\))

Julian Day of Deployment

- All Data
- daily
- weekly
- every other week
- once a month
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

HOODSPORT ORCA buoy wind data

Devol (UW) and HCDOP IAM Team
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):

- Freshwater input (incl. 2.4 from septics): 3.2
- Transport in*: 84
- Transport out*: 28.5
- 9 dNO3/dt
- 39.5 dPN/dt
- 65.5
- 9.5 Denitrification removal

Union

Lower Hood Canal

Belfair
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
Conclusions
Buoy network for Puget Sound

A private-public partnership between industry and UW
Networked Buoy Project

“surface buoys”
IC Mobilisa lead

“profiling buoys”
APL-UW lead

Surface:
potential for oil and other pollution
harbor security

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
The NANOOS Visualization System

http://www.nanoos.org
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

<table>
<thead>
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<th>2003</th>
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<th>2005</th>
<th>2006</th>
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<td><strong>Fish kill</strong></td>
<td>2003</td>
<td>2004</td>
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<tr>
<td><strong>Odd behavior</strong></td>
<td>2003</td>
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<tr>
<td><strong>Fish kill</strong></td>
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<td>Low DO</td>
<td>X</td>
<td>X</td>
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<td>Shallow/weak density gradient</td>
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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

ORCA Schematic View

- Platform and housing for Winch, electronics etc
- Platform and housing for Winch, electronics etc
- Atlas float (cut away view)
- Ballast ring
- Anchoring (break in scale)
- Solar panel
- Solar panel
- Solar panel
- Radar reflector
- Weather station
- Superstructure

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.
ORCA gives information about now

Hoodsport

Twanoht
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*
UW PRISM cruises

[Image of a map and data visualization tool]

NANOOS Home
UW PRISM cruises
UW PRISM cruises
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??

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.