Publication No. 14-03-070

DEPARTMENT OF ECOLOGY State of Washington

Eyes Over Puget Sound

Surface Conditions Report

February 4, 2014

Guest Contribution: Brandon Sackmann, Integral

Start here

Up-to-date observations of visible water quality conditions in Puget Sound and the Strait of Juan de Fuca

Marine conditions from 2-4-2014 at a glance

LONG-TERM MARINE MONITORING UNIT

Mya Keyzers
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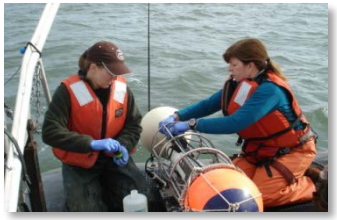
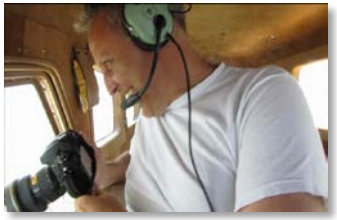
Joe Leatherman

Skip Albertson

Julia Bos
Suzan Pool



Dr. Christopher Krembs



Dr. Brandon Sackmann

Personal flight log p. 3

Let your passion become your greatest qualification and don't lose sight of your dreams. Learn more about our program from our video.

Weather conditions p. 5

Air temperatures have plummeted in the past week; winds have been weak and from the north, which is atypical. River flows are below normal.

Water column p. 6

A dry winter brings new Puget Sound conditions! Colder, saltier conditions are developing in the northern regions. Oxygen has stabilized within expected ranges. The recent fall in air temperatures likely will further cool Puget Sound.

Aerial photography p. 10

Suspended sediment seen along wind and wave exposed beaches and mud flats. Tidal eddies carry suspended sediment. Long lines of foam follow convergences, currents, and eddies. Jellyfish in Eld Inlet. Oil sheen in Commencement Bay.

Ferry and satellite p. 35

Clear skies and cooler temperatures over much of Puget Sound and the Strait of Georgia. High resolution MODIS imagery reveals widespread sediment transport off the coast.

A fresh perspective from our WCC intern

We are lucky to have Clifton Herrmann on our team through the WA Conservation Corps. Whether you aspire to be a marine ecologist, fisheries biologist, or physical oceanographer, making it in the field can be a challenge. **Clifton shares some tips!**

1. **Find your passion and stick with it!**
   Science is not a job, it's a way of thinking. Let your passion become your greatest qualification, and don't lose sight of your dreams. If you don't care about it, you won't be good at it!

2. **Study, Study, Study!**
   I hate to say it, but science is competitive. Never miss an opportunity to learn. Actively engage yourself in all classes! Even if it doesn't feel important, you will want that knowledge someday. It's not just a degree, it's everything you'll need to know!

Advice for aspiring scientists

3. **College graduation is only the beginning!**
   Keep an eye out for internships and volunteer work you might like. You have to prove you're willing to do it for free before anyone will pay you. Your education is valuable, but professionals want to see you in action.

4. **Build your skills!**
   Spend time building new skills and honing your interests. My position is through AmeriCorps, a federally funded professional development program. Opportunities like mine are designed for young professionals transitioning out of school into the real world.

5. **Ask questions!**
   Always. In every situation, even if there's nobody around to answer. Scientists are curious beasts. Never assume you already know the whole answer to something, because there are always new underlying questions. The world is an unknown, and that's what is so exciting about it! Have fun, and never settle for less than your potential.

Weather of the past two weeks before 2-4-2014

Meteorological conditions typically explain up to half of the variance in observed marine variables (Moore et al. 2008), particularly in shallower waters like those of south Puget Sound. I summarized the specific conditions prevalent during the past two weeks, from north to south. Source: http://www-k12.atmos.washington.edu/k12/grayskies/nw_weather.html

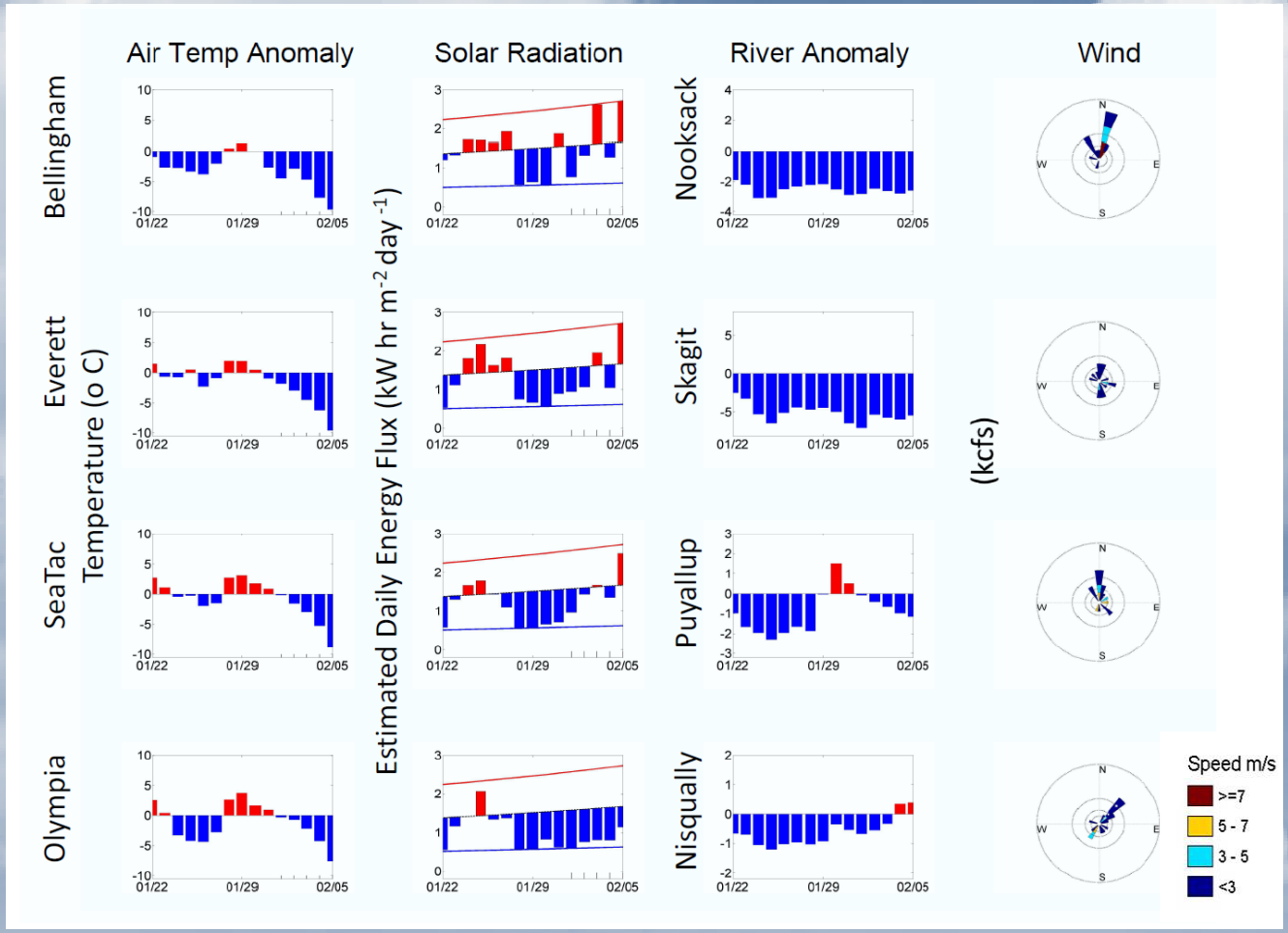
Two week summary:

Air temperatures. Daily average air temperatures have plummeted during the past week!

Sunshine is increasing after weeks of clouds.

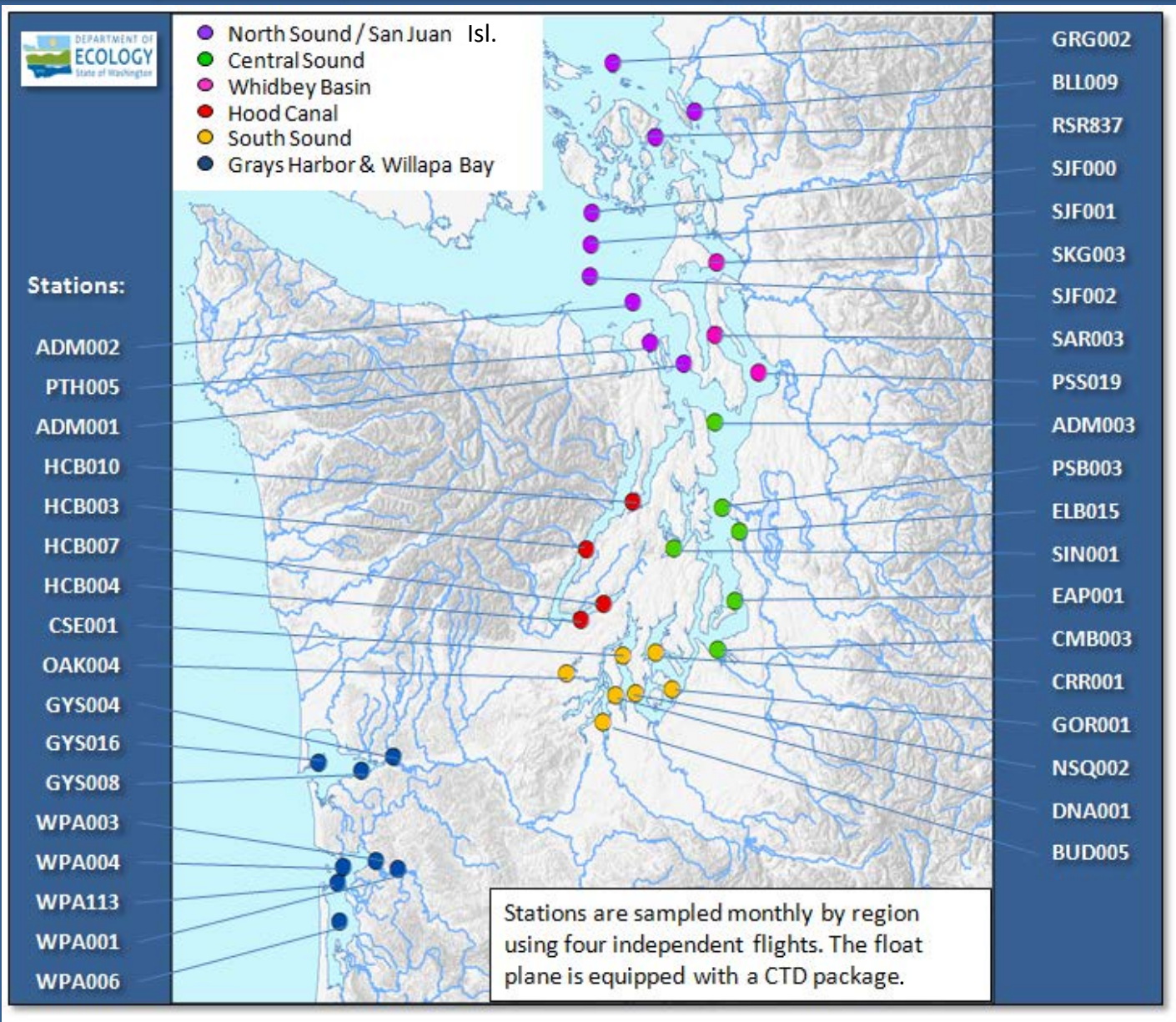
River flows are below normal.

Winds have been weak and from the north for the past two weeks, which is unusual for winter time.



Moore et al. 2008. Local and large-scale climate forcing of Puget Sound oceanographic properties on seasonal to interdecadal timescales. Limnol. Oceanogr., 53(5), 1746–1758

Our long-term marine monitoring stations in Washington



We use a chartered float plane to access our monthly monitoring stations most cost effectively.

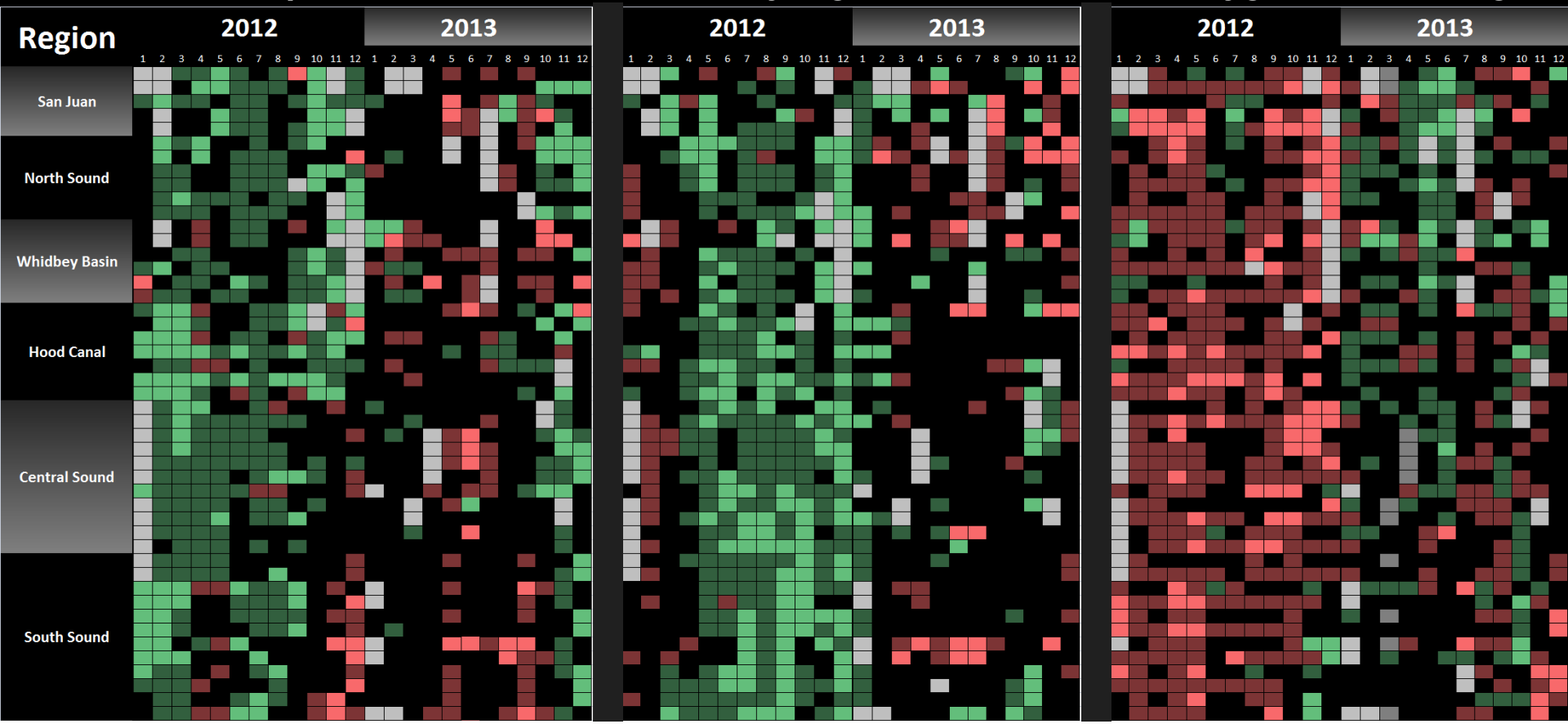
Start here

We communicate data and environmental marine conditions using:

1. **Marine Water Condition Index (MWCI)**
2. **Eyes Over Puget Sound (EOPS)**
3. **Anomalies and source data**

Physical conditions over the last two years

Dec. 2013: Temperature lower | Salinity higher northward | Oxygen normalizing



= higher than expected (>IQR, n=13)
= higher than previous measurements
= expected (=IQR, n=13)
= no data
= lower than expected (>IQR, n=13)
= lower than previous measurements

A dry winter brings new Puget Sound conditions! The 2011-2012 colder, fresher, higher oxygen conditions are gone. Colder saltier conditions are developing, particularly in the northern regions. Oxygen has stabilized again within expected ranges. The recent fall in temperatures will likely further cool Puget Sound, particularly in the shallower regions.

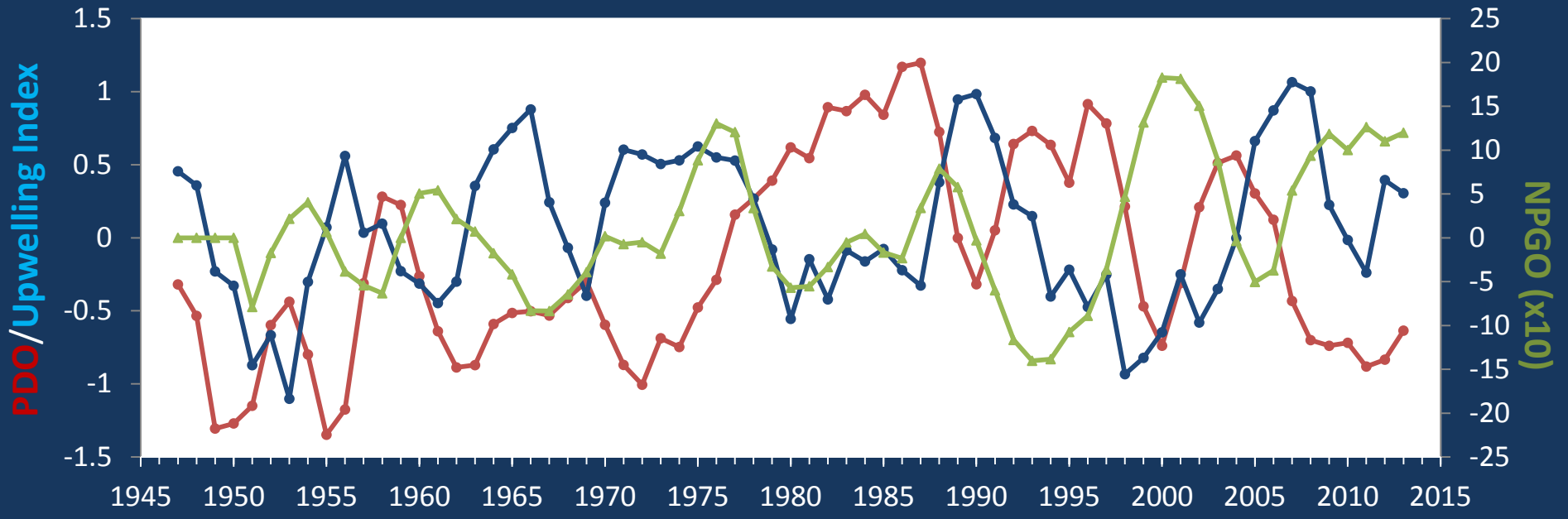
The ocean affects water quality: Ocean Climate Indices

a) *Pacific Decadal Oscillation Index (**PDO, temperature**)* *(explanation)*

b) *Upwelling Index (anomalies) (**Upwelling, low oxygen**)* *(explanation)*

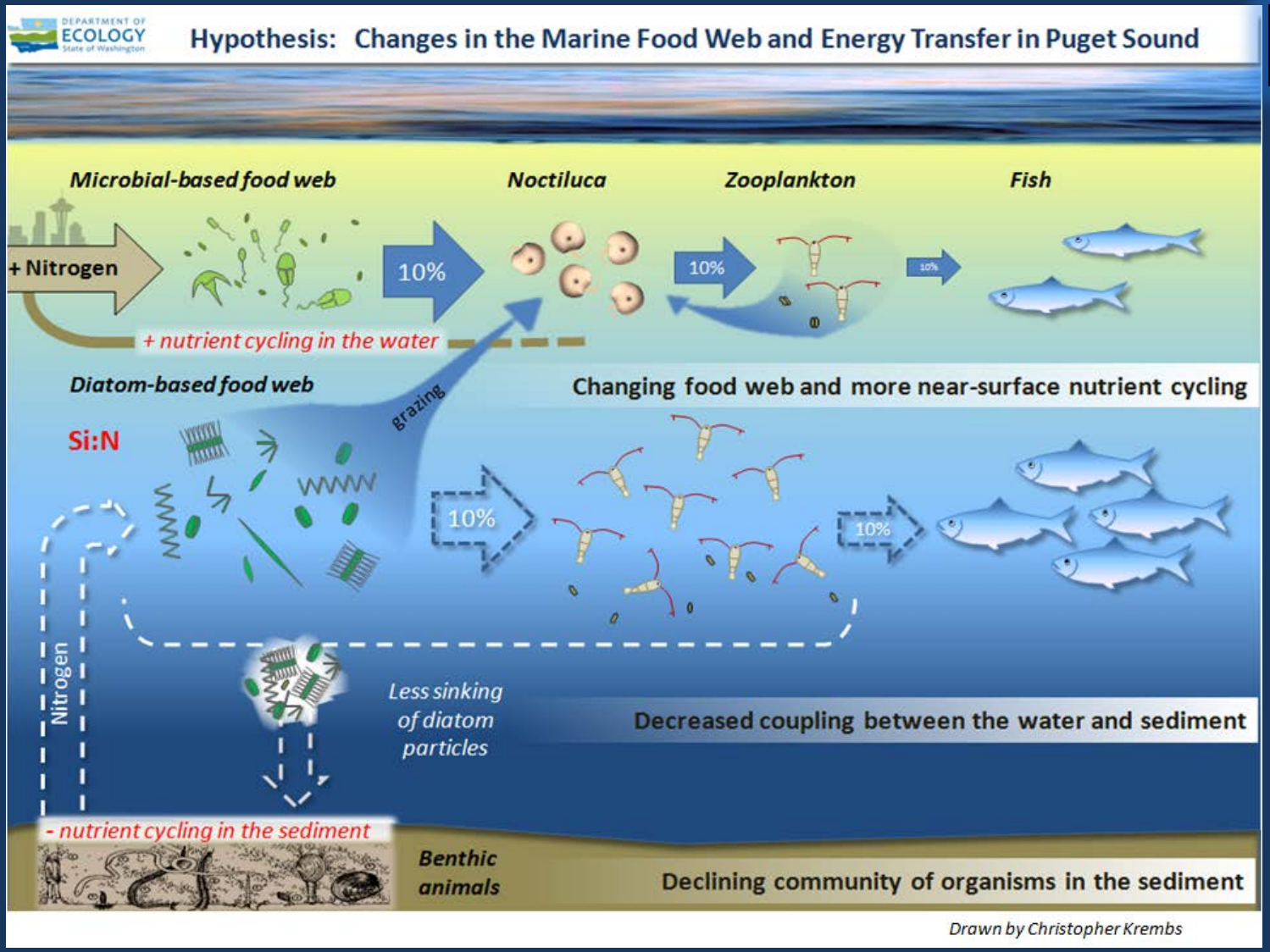
c) *North Pacific Gyre Oscillation Index (**NPGO, productivity**)* *(explanation)*

Three-year running average of PDO, Upwelling, and NPGO indices scores



Ocean boundary conditions have been favorable for water quality in Puget Sound: (a) colder water (PDO), (b) less upwelled low oxygen and high nutrient ocean water reaching Puget Sound (Upwelling Index), and (c) higher surface productivity along the coast (NPGO). Where are we heading next?

Is the food web changing in Puget Sound?



Hypothesis!

Should we pay greater attention to nutrient ratios, energy transfer, and material cycling in Puget Sound?

Noctiluca blooms are a visible harbinger of a changing microbial food web in Puget Sound's waters.

[The story in 5 min]

[Explore the data]

[Follow the experts]

Summary: Aerial photography 2-4-2014

Suspended sediment along wind and wave exposed beaches and mud flats. Larger tidal eddies in many places which carry suspended sediment. Long lines of foam follow convergences, currents, and eddies. Jellyfish in Eld Inlet. Oil sheen in Commencement Bay.

Start here

Sunrise over Puget Sound starting the day

Cockpit temperatures warm as we take off

Front

Mixing and Fronts:
Many tidal eddies in Pitt and Pickering Passages and the entrance to Quartermaster Harbor. River plumes relatively small. 2 3 Click on numbers

Jellyfish: Infrequent large patch seen only in Eld Inlet. 19

Plume

Suspended sediment:
Abundant suspended sediment at wave exposed beaches and mud flats facing north in South and Central Sound. Suspended sediment in river plumes relatively small.

2 3 4 7 8 9 10 11 13 14 15 17 18 19

Bloom

Visible blooms: None.

Debris

Debris: 1 2 3 4 12 15 19
Abundant lines of foam in Budd Inlet, Oakland Bay, and Commencement Bay. Debris lines with driftwood and eelgrass near Gordon Point.

Aerial photography & navigation guide

Date: 2-4-2014

Click on numbers

Flight Information:

Morning flight, photo 1:
Low visibility, windy, and cold.

Afternoon flight, photos 2-20:
Good visibility, wind, waves, and cold.

Observation Maps:

Central Sound

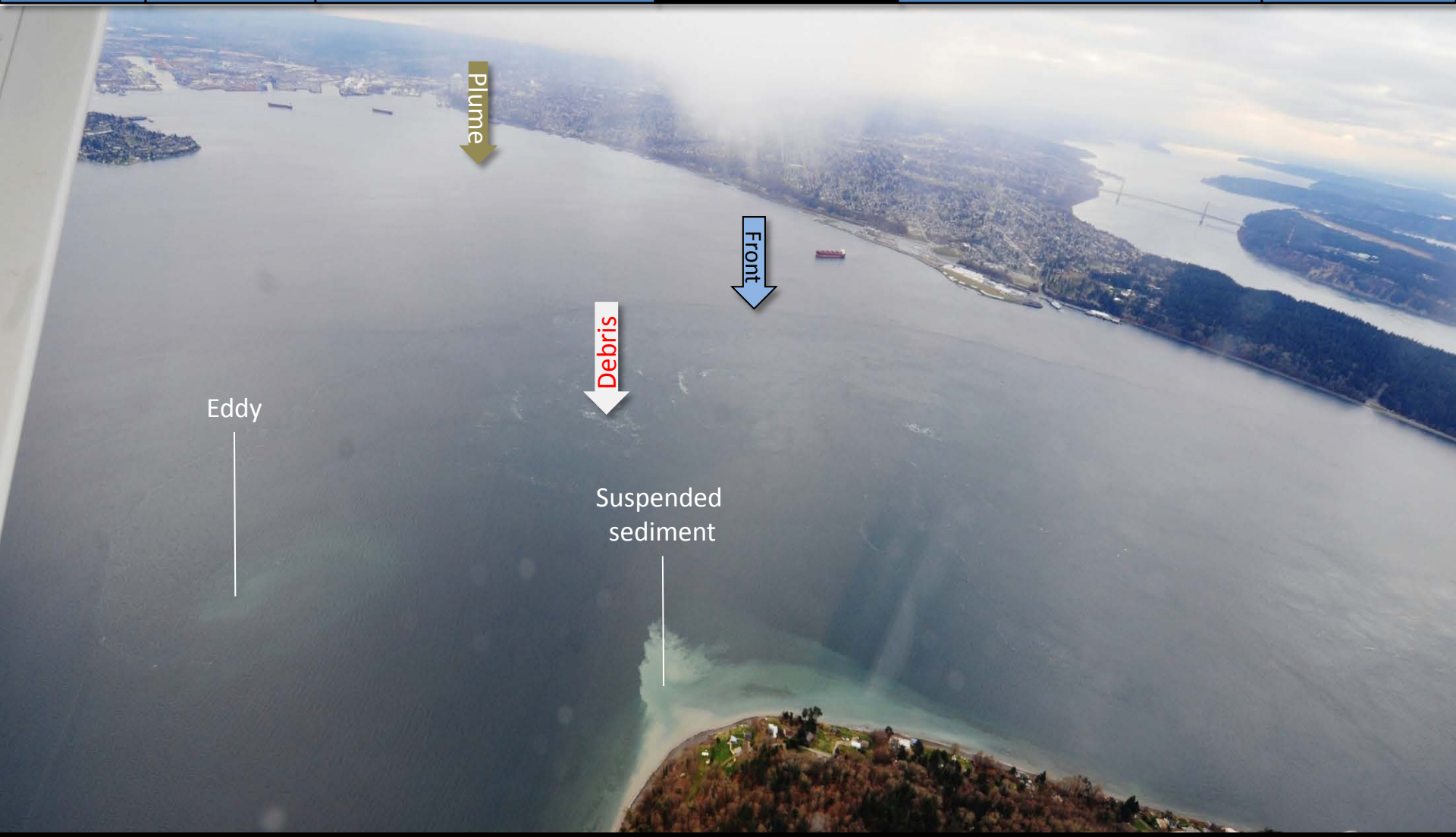
South Sound

Foam line parallel to shore leaving Budd Inlet and flowing towards Dana Passage past Boston Harbor.

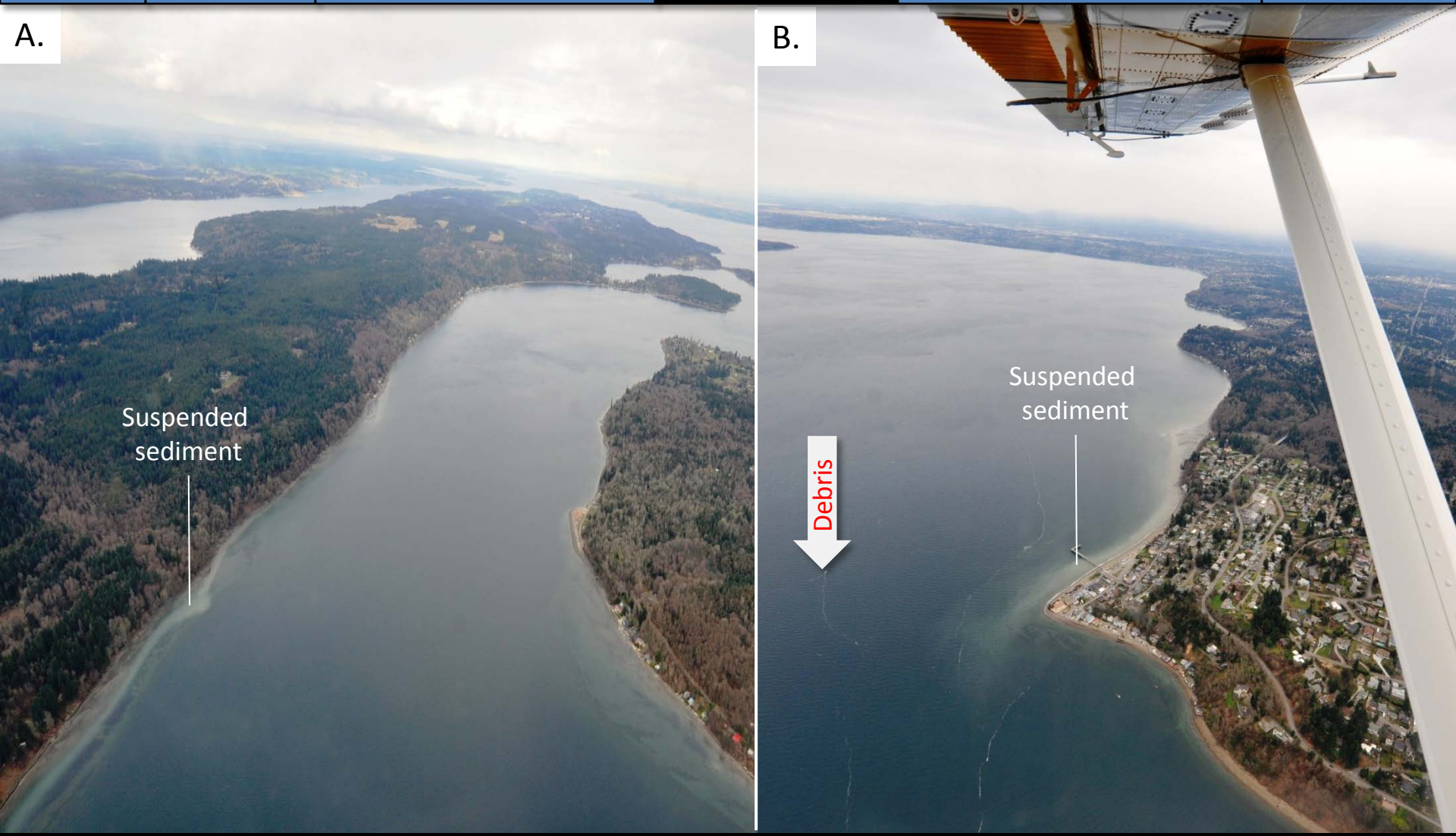
Location: Budd Inlet (South Sound), 10:46 AM.

South Sound water with different color leaving Tacoma Narrows and diverging at Vashon Island.

Location: Point Defiance (Tacoma), 12:52 PM.



Eddy and suspended sediment at entrance to Quartermaster Harbor with Puyallup River plume in the back.
Location: South Vashon Island, looking into Commencement Bay (Central Sound), 12:54 PM.



Long suspended sediment ribbons along beaches.

Location: A. Quartermaster Harbor (Vashon Island), B. Dash Point (Federal Way, Tacoma), 12:55 PM.

Sizable oil sheen in a marina. Location: Commencement Bay (Tacoma), 12:57 PM.

Diatom films growing on intertidal mudflats. Location: Cutts Island State Park (Carr Inlet), 2:44 PM.

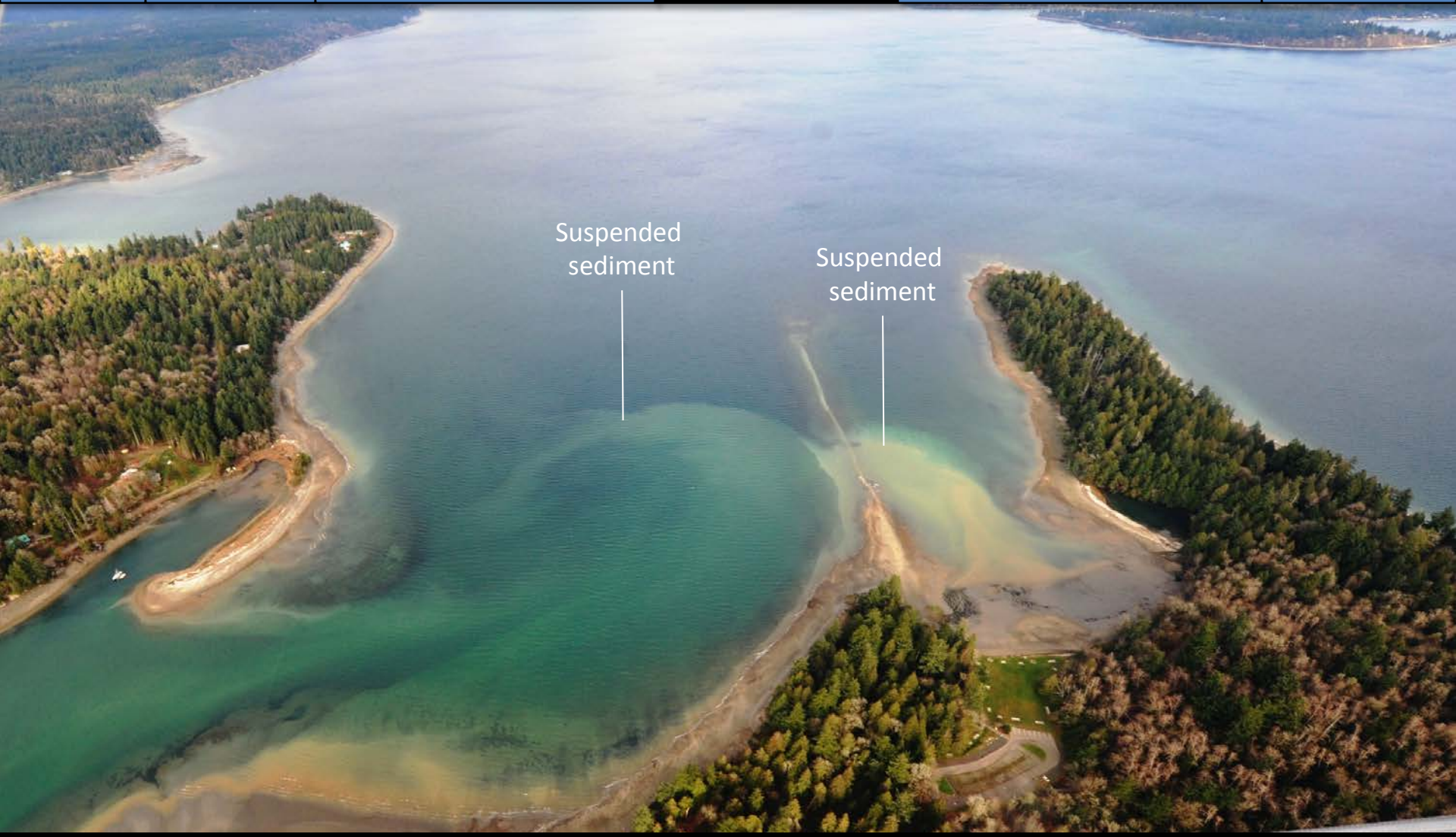
Large tidal eddy transporting suspended sediment from beach into Carr Inlet.
Location: Near Pitt Passage (Carr Inlet), 2:50 PM.

Large tidal eddy transporting suspended sediment from beach into Carr Inlet.

Location: Near Pitt Passage (Carr Inlet), 2:50 PM.

Large tidal eddy transporting suspended sediment from beach into Carr Inlet.
Location: Near Pitt Passage (Carr Inlet), 2:50 PM.

Aerial photography 2-4-2014



Suspended sediments washing off beaches. Location: Mayo Cove (Carr Inlet), 2:50 PM.

Suspended sediment near beach. Location: Von Geldern Cove (Carr Inlet), 2:51 PM.

Debris line and tidal eddy.
Location: Off Jarrell Cove, Pickering Passage (South Sound), 4:10 PM.

Aerial photography 2-4-2014

Very sediment-laden water near northern beach of Harstine Island facing Case Inlet.
Location: Harstine Island (South Sound), 4:13 PM.

Very sediment-laden water near northern beach of Harstine Island facing Case Inlet.
Location: Harstine Island (South Sound), 4:13 PM.

Aerial photography 2-4-2014

Foam lines, suspended sediment, and oyster beds become visible during ebbing tide.

Location: Oakland Bay (South Sound), 4:17 PM.

Aerial photography 2-4-2014

The southern extent of Puget Sound, Oakland Bay, and its port.
Location: Shelton Harbor (South Sound), 4:17 PM.

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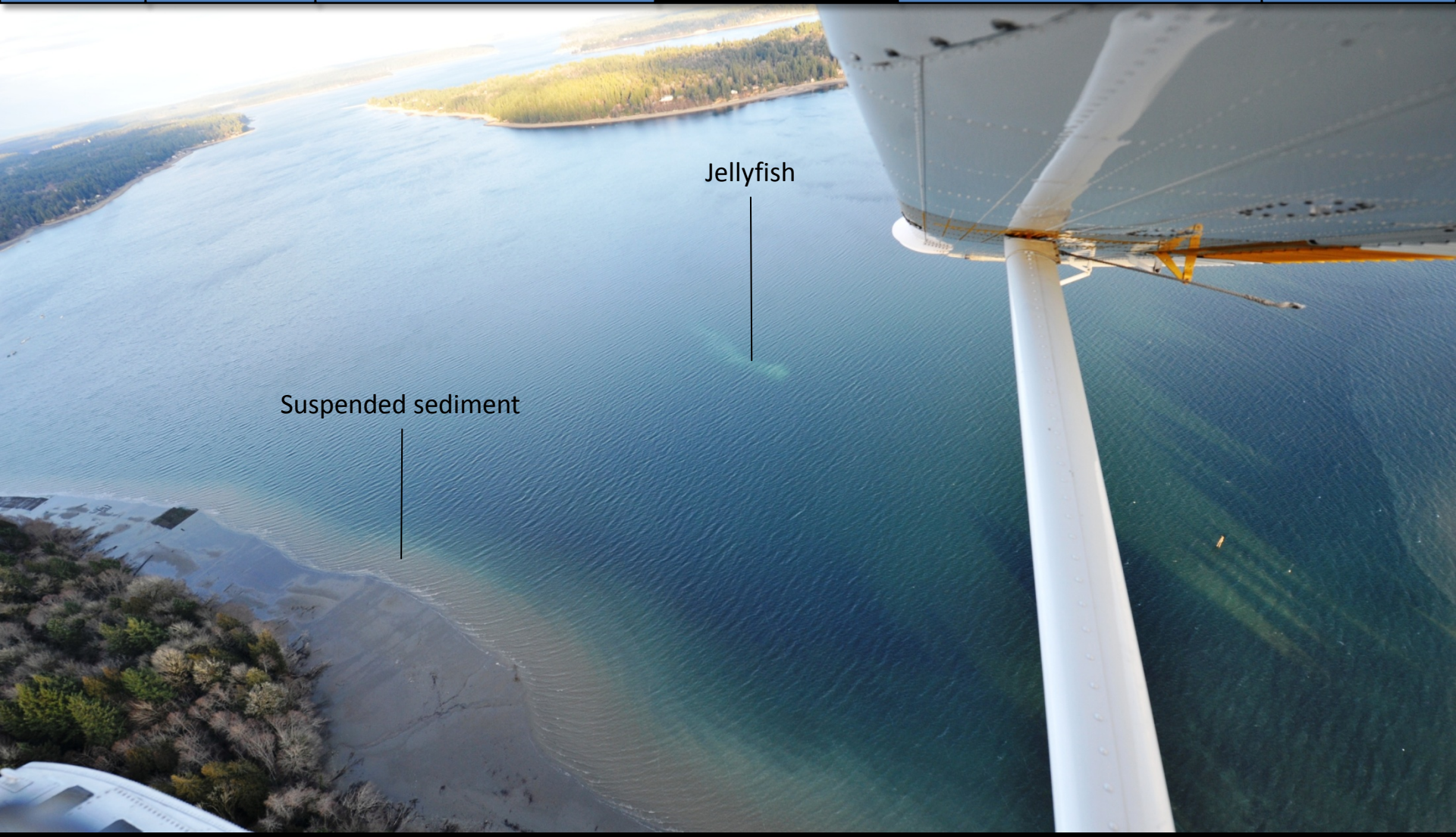
Aerial photography 2-4-2014

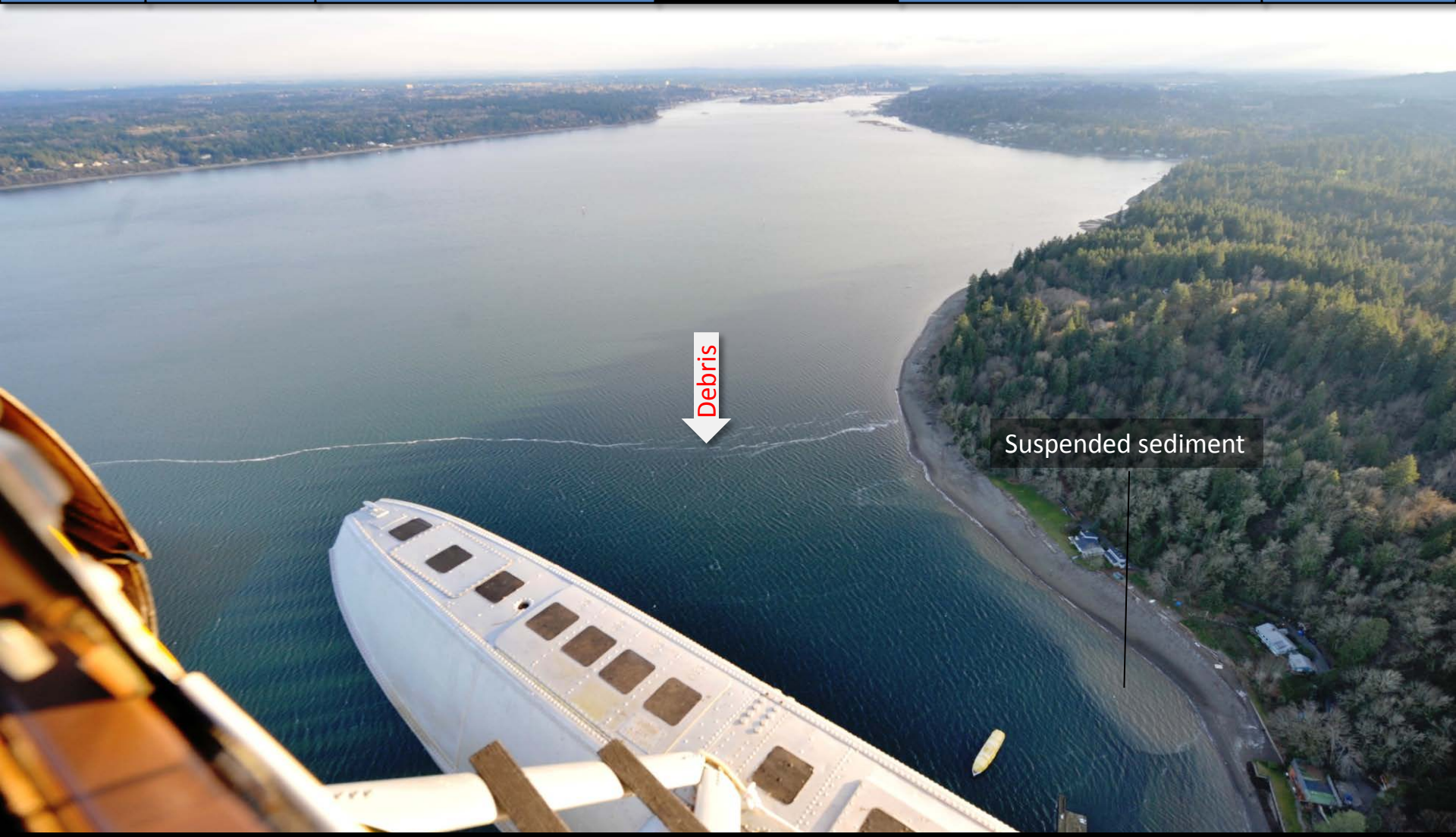
Sediment-laden water draining from mud flats.
Location: Totten Inlet (South Sound), 4:50 PM.

Aerial photography 2-4-2014



Jellyfish patch and suspended sediment near beach.
Location: Eld Inlet (South Sound), 5:18 PM.

Aerial photography 2-4-2014



Foam line and suspended sediment near beach.
Location: Budd Inlet (South Sound), 5:19 PM.

Picture Joe Leatherman

Cold air chills our crew while sitting on the water before takeoff.

Location: Lake Washington (Seattle), 8:00 AM.

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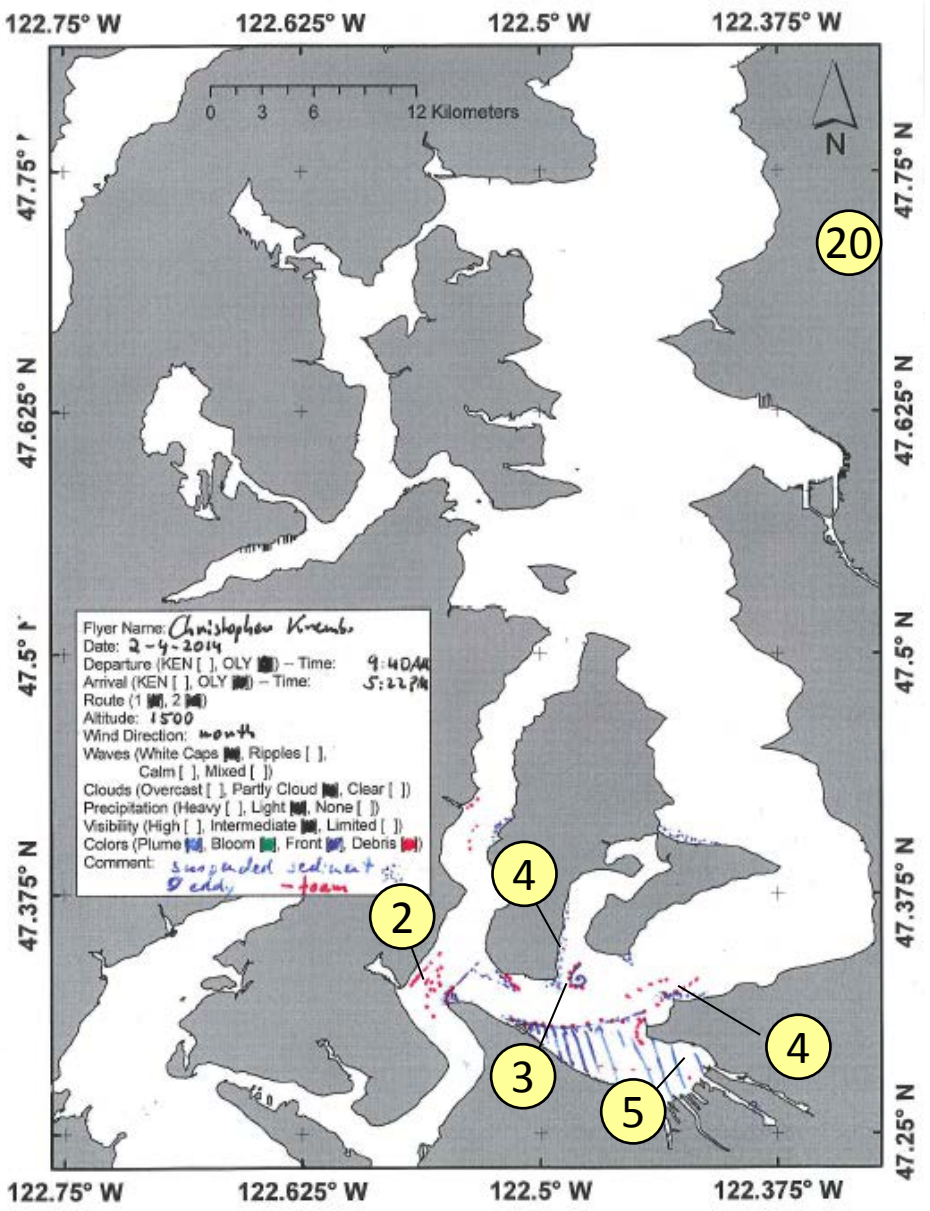
Observations in Central Sound

Navigate

Date: 2-4-2014

Numbers on map refer to picture numbers for spatial reference



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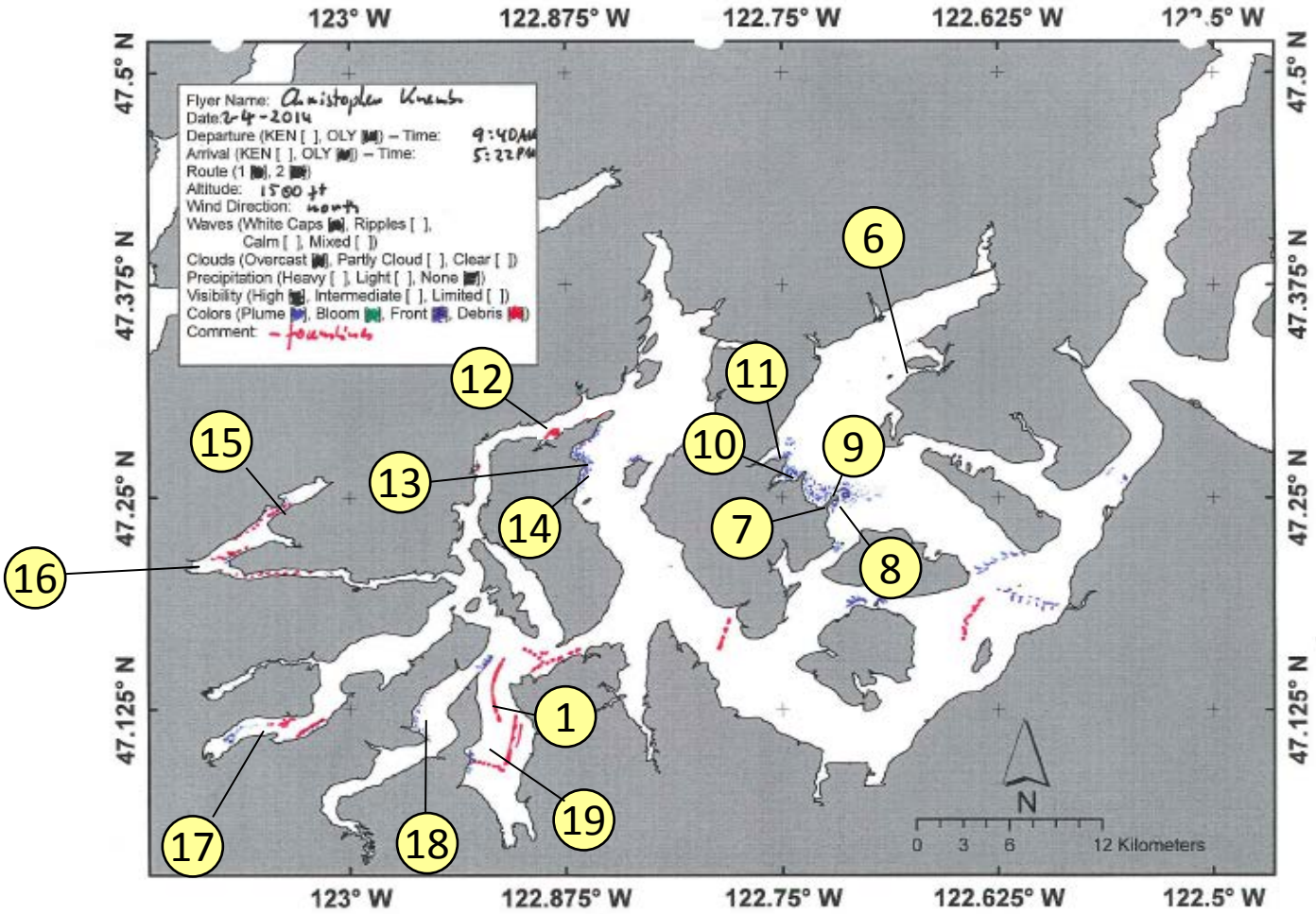
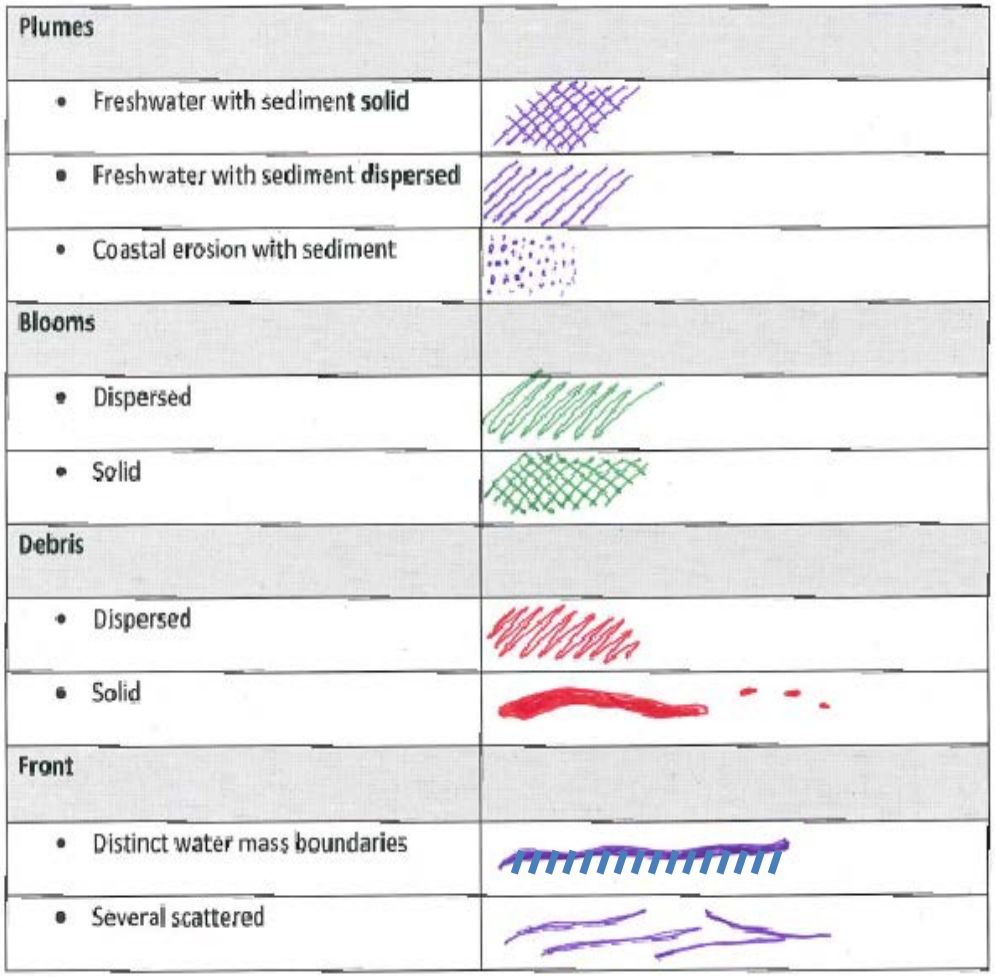
Observations in South Sound

Navigate

Date: 2-4-2014



Numbers on map refer to picture numbers for spatial reference



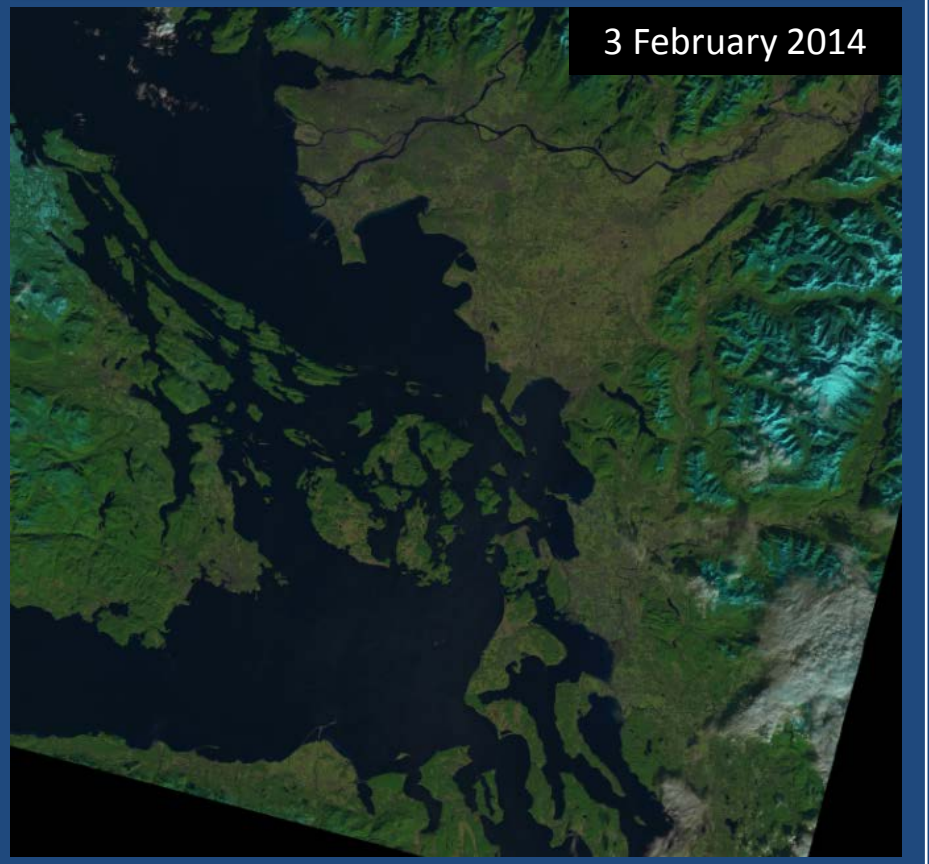
Comments:
Maps are produced by observers during and after flights. They are intended to give an approximate reconstruction of the surface conditions on scales that connect to and overlap with satellite images in the section that follows.

Debris:
Debris can be distinguished into natural and anthropogenic debris floating at the surface *sensu* Moore and Allen (2000). The majority of organic debris in Puget Sound is natural mixed with discarded man-made pieces of plastic, wood, etc. From the plane, we cannot differentiate the quality of debris at the surface and therefore, call it for reasons of practicality just “debris”.

S.L. Moore, M. J. Allen. 2000. Distribution of Anthropogenic and Natural Debris on the Mainland Shelf of the Southern California Bight. Marine Pollution Bulletin, 40(1), 83–88.

Guest: Ferry and satellite observations 2-4-2014

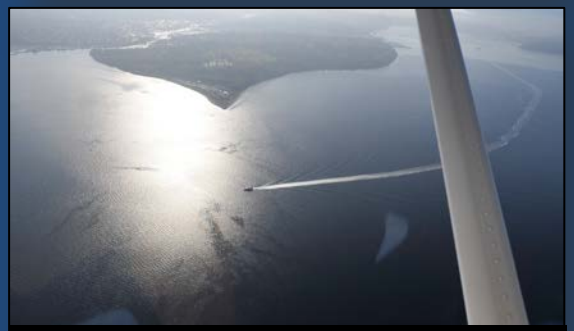
Clear Skies over Puget Sound and Strait of Georgia



Landsat 8 True Color (Operational Land Imager)

Brandon Sackmann
Contact:
bsackmann@integral-corp.com

Start here

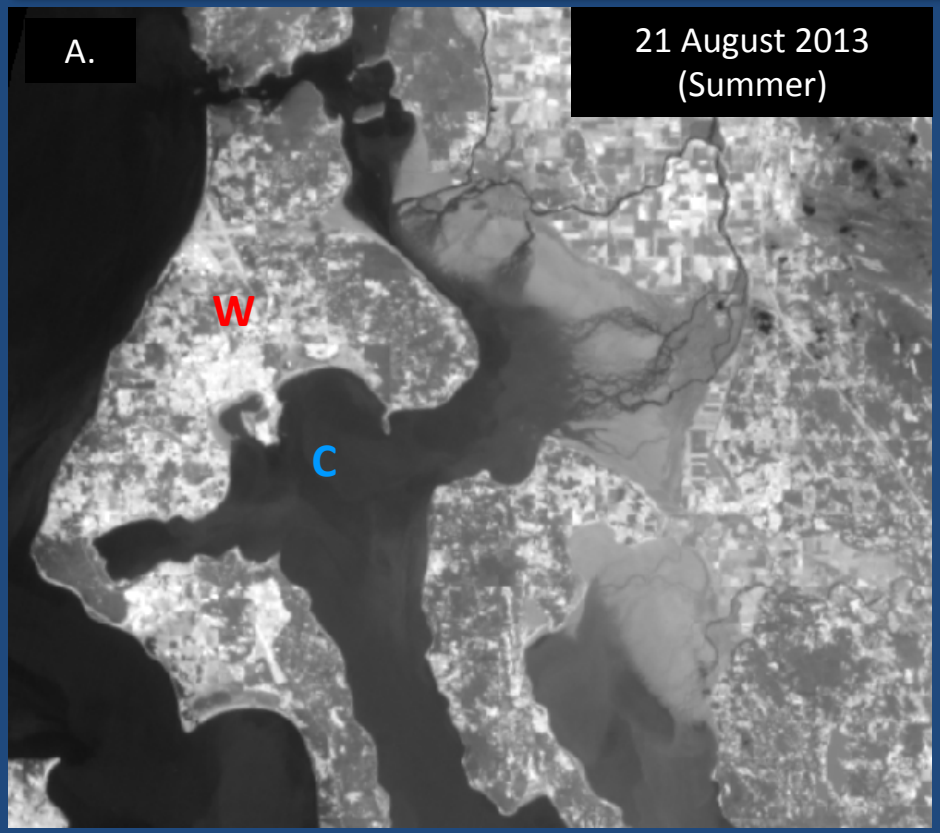


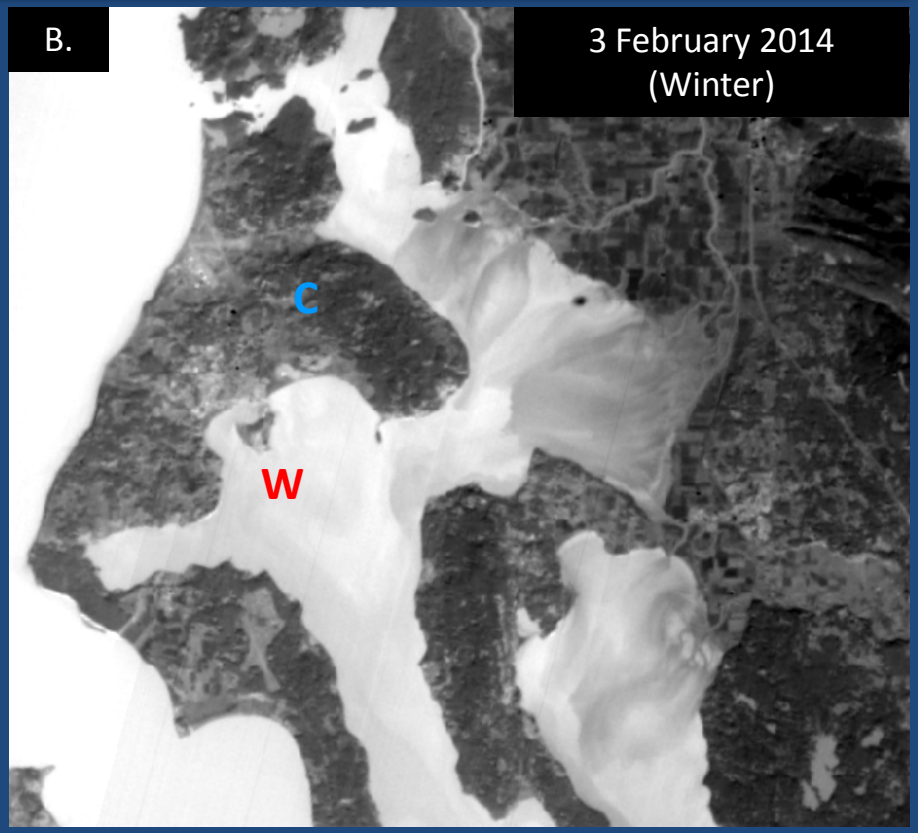
Victoria Clipper IV leaving Elliott Bay

No Victoria Clipper data available – Hardware upgrades in progress!!!

Guest: Ferry and satellite observations 2-4-2014

Thermal Infrared Imagery (Landsat 8) Reveals Seasonal Temperature Differences in Puget Sound (Whidbey Basin)



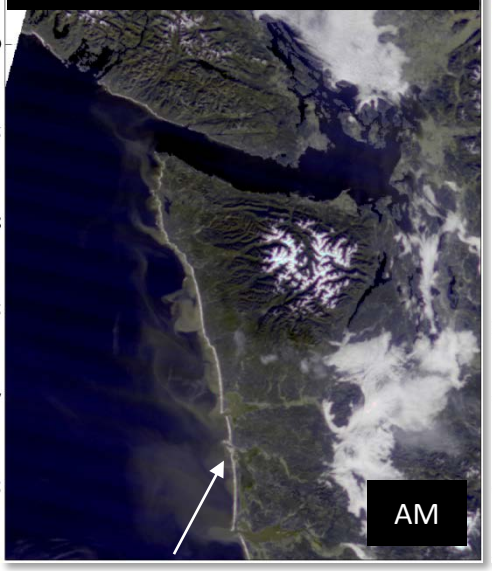


Seasonal temperature fluctuations on land are more dramatic than what is observed over the open marine waters of Puget Sound. In summer (A), land is noticeably warmer, whereas in winter (B), the opposite is true. On 3 February 2014 measured air temperatures at West Point were ~38°F; surface water temperatures in Port Susan (Whidbey Basin) were ~46°F. Darker tones = cooler (C), lighter tones = warmer (W).

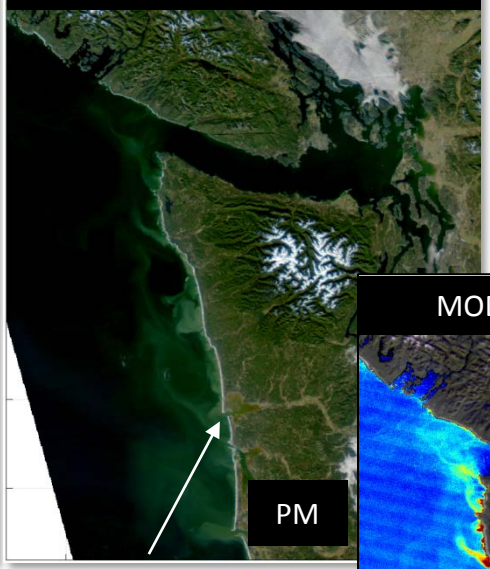
Guest: Ferry and satellite observations 2-4-2014

MODIS-Aqua and MODIS-Terra for January 24, 2014
-- Hi-resolution (250-m) Turbidity Product --

MODIS-Terra True Color

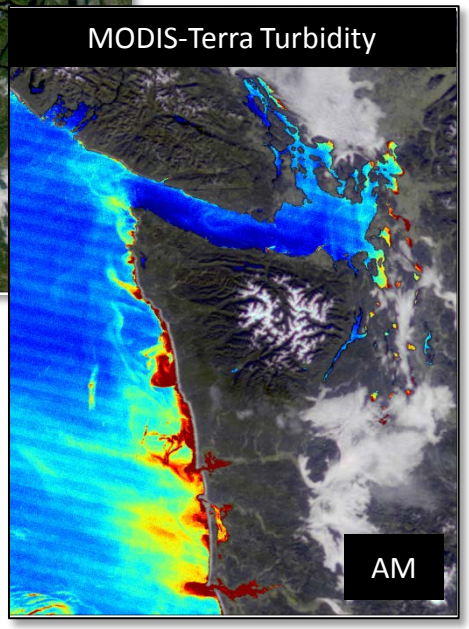


MODIS-Aqua True Color

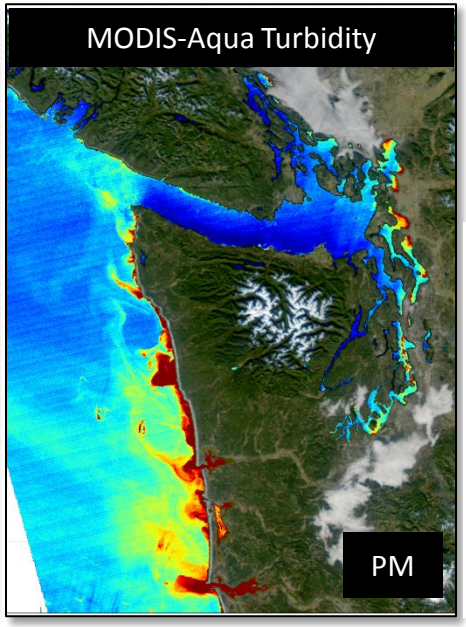


MODIS-Terra (left) and MODIS-Aqua (right) provide synoptic coverage (2x per day) of key water quality variables (e.g., turbidity) that allows us to visualize dynamic processes, such as sediment transport, taking place off our coast.

MODIS-Terra Turbidity

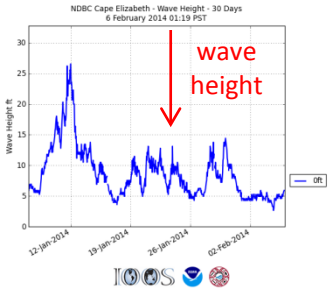


MODIS-Aqua Turbidity



Bright white lines along the coast suggest breaking waves…

Wave heights off Cape Elizabeth were >10 ft. on 24 January!!!



Future Focus of Mooring Operations

Note: Due to state and federal budget reductions, our mooring program is being downscaled.

Strength through collaboration across agencies, academic institutions and companies. We have plans to continue to collect data at our Admiralty Reach (UW Applied Physics Lab) and Mukilteo (ORCA College) moorings into the future. Operations at all other mooring locations have been suspended in order to reallocate existing resources.

We are now focusing on measuring ocean intrusions!

Why? The importance of the ocean on water quality in Puget Sound is being emphasized by Ecology's mooring at Admiralty Reach, long term monitoring data, modeling studies, and academic publications. Admiralty Reach is a challenge - it requires a team effort!

Upwelling along the coast can bring **high nutrient**, **low oxygen** and **low pH** ocean water into Puget Sound. Such intrusions explain much of the year to year variability in **water quality**.

For intrusions to enter Puget Sound, several conditions have to align:

- **Prolonged upwelling** along the Washington coast. *Driver: Northerly winds*
- **Estuarine circulation moving dense water from the coast** into the Strait of Juan de Fuca. *Driver: High Fraser River flow during summer*
- **Neap-Spring tide phase and character** favorable to intrusions along the 30 km length of Admiralty Reach. *Drivers: Neap tides and tidal harmonics*

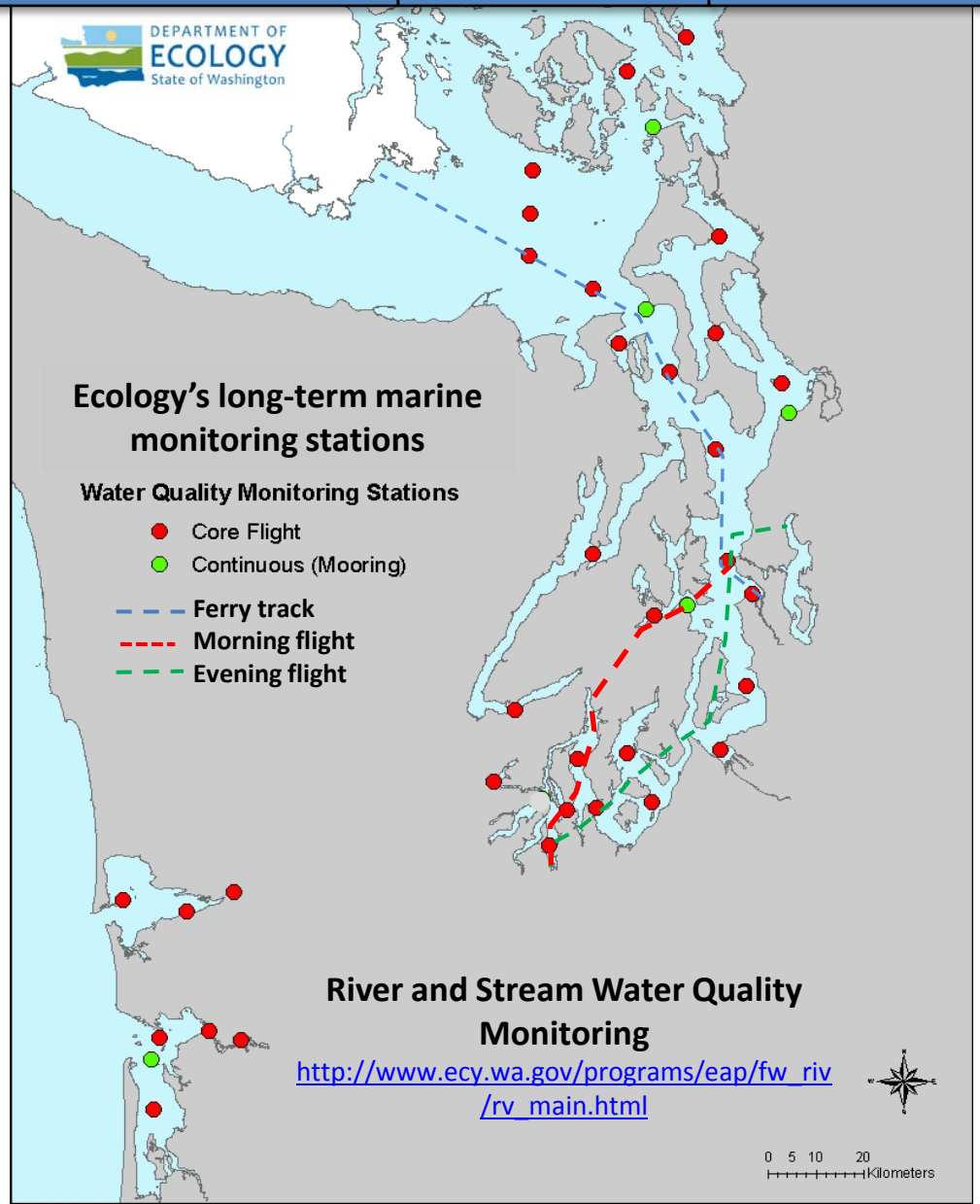
Get data from Ecology's Monitoring Programs

Flight log	Weather	Water column	Aerial photos	Ferry and Satellite	Moorings

Long–Term Monitoring Network

christopher.krembs@ecy.wa.gov

Access core monitoring data:
http://www.ecy.wa.gov/apps/eap/marinewq/mwdataset.asp



Real–Time Sensor Network

Suzan.Pool@ecy.wa.gov

Access mooring data:
ftp://www.ecy.wa.gov/eap/Mooring_Raw/Puget_Sound/

You may subscribe or unsubscribe to the Eyes Over Puget Sound email listserv by going to:
http://listserv.wa.gov/cgi-bin/wa?A0=ECOLOGY-EYES-OVER-PUGET-SOUND

We are looking for feedback to improve our products.

Dr. Christopher Krembs
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Marine Monitoring Unit
Environmental Assessment Program
WA Department of Ecology

Many thanks to our business partners: Clipper Navigation, Swantown Marina, and Kenmore Air.