Publication No. 15-03-079

DEPARTMENT OF ECOLOGY State of Washington

Eyes Over Puget Sound

Surface Conditions Report, December 14, 2015

MWCI

Marine Water Condition Index

Start here

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

Marine conditions from 12-14-2015 at a glance

LONG-TERM MARINE MONITORING UNIT

Mya Keyzers
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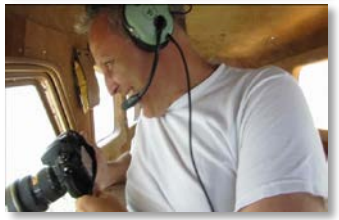
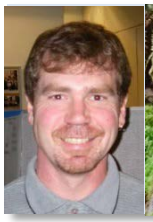


Jim Shedd



Editorial assistance provided by: Suzan Pool, Julianne Ruffner, Carol Maloy

Personal Field Impression 12-14-2015

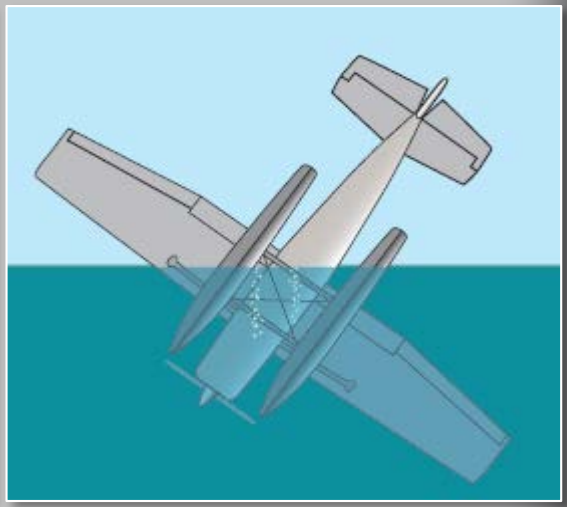
There is no harm in hoping for the best as long as you're prepared for the worst.
(Stephen King)

The Marine Flight program used 2015 to reassess flights through the lens of safety.

I found myself strapped into a floating cockpit, upside down with only one big breath of air, water flooding my sinuses, no sight, and the eerie silence of underwater. The core flight team, Laura, Joe, and I (Mya) attended Egress Training with Bryan Webster from Aviation Egress Training Systems in Victoria, B.C. This training involved pool time with crash simulators.

Mya practicing 1,2,3,4 out the door on dry land.

Students practicing egress in the small fuselage in the foreground and large cabin in the background.



Float plane capsized, read more at: (Source: AvStop.com)

After the training, we felt empowered that if we find ourselves having, in Bryan's words, "a very bad day," we would have a fighting chance at survival. We experienced firsthand how disorienting it is to be upside down in the water. We learned it is important to maintain a point of reference and how to exit the plane. I love flying and always feel safe during flights, but when it comes to survival, preparedness is a must.

http://dunkyou.com

Natural Influences leading to 12-14-2015

Climate and natural influences, including weather, rivers, and the adjacent ocean, can affect our marine waters. Graphics are based on provisional data and are subject to change. http://www.ecy.wa.gov/programs/eap/mar_wat/weather.html, page 26.

Summary:

Air temperatures were below normal for November, which is a big change from October.

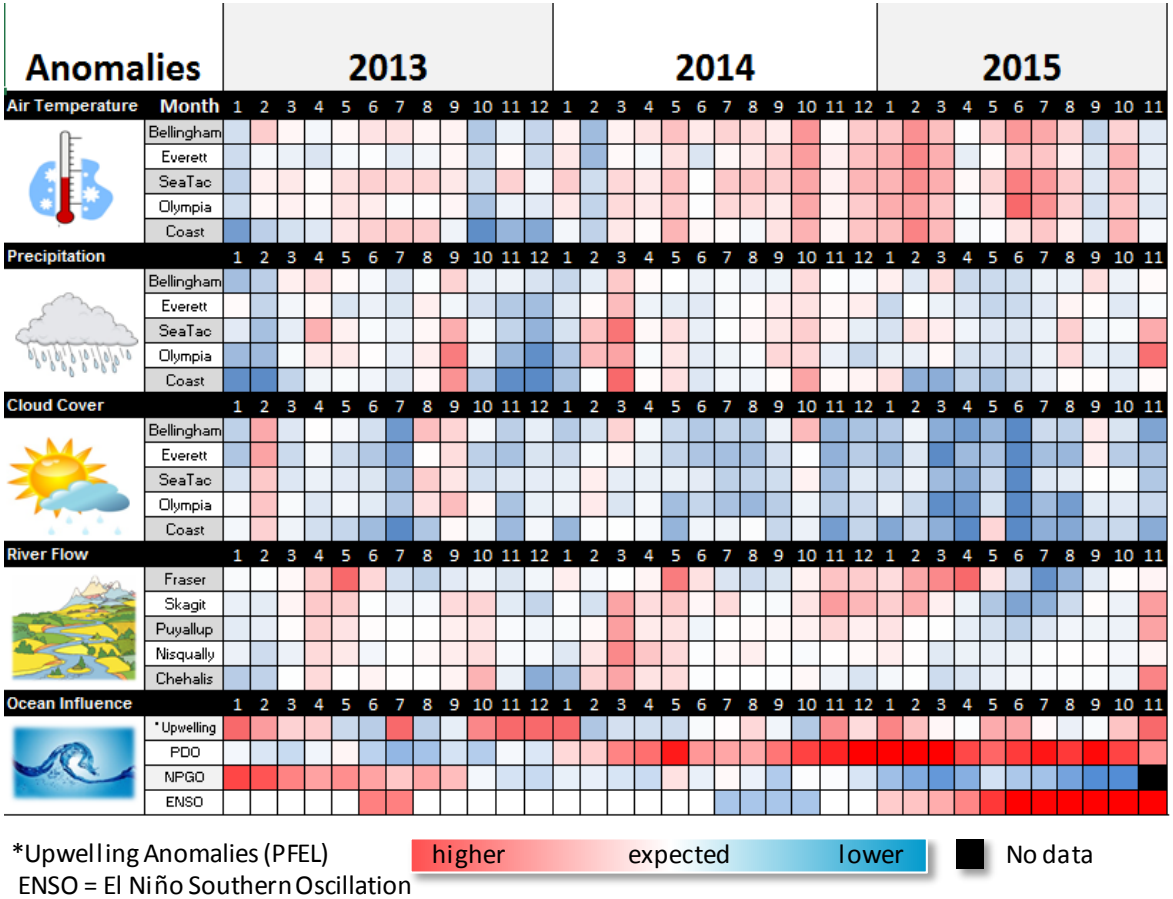
Precipitation levels were slightly above normal, particularly for South Sound. One wet period occurred at the beginning of November, and the other mid-month.

Sunshine was above normal in the Puget Sound lowlands.

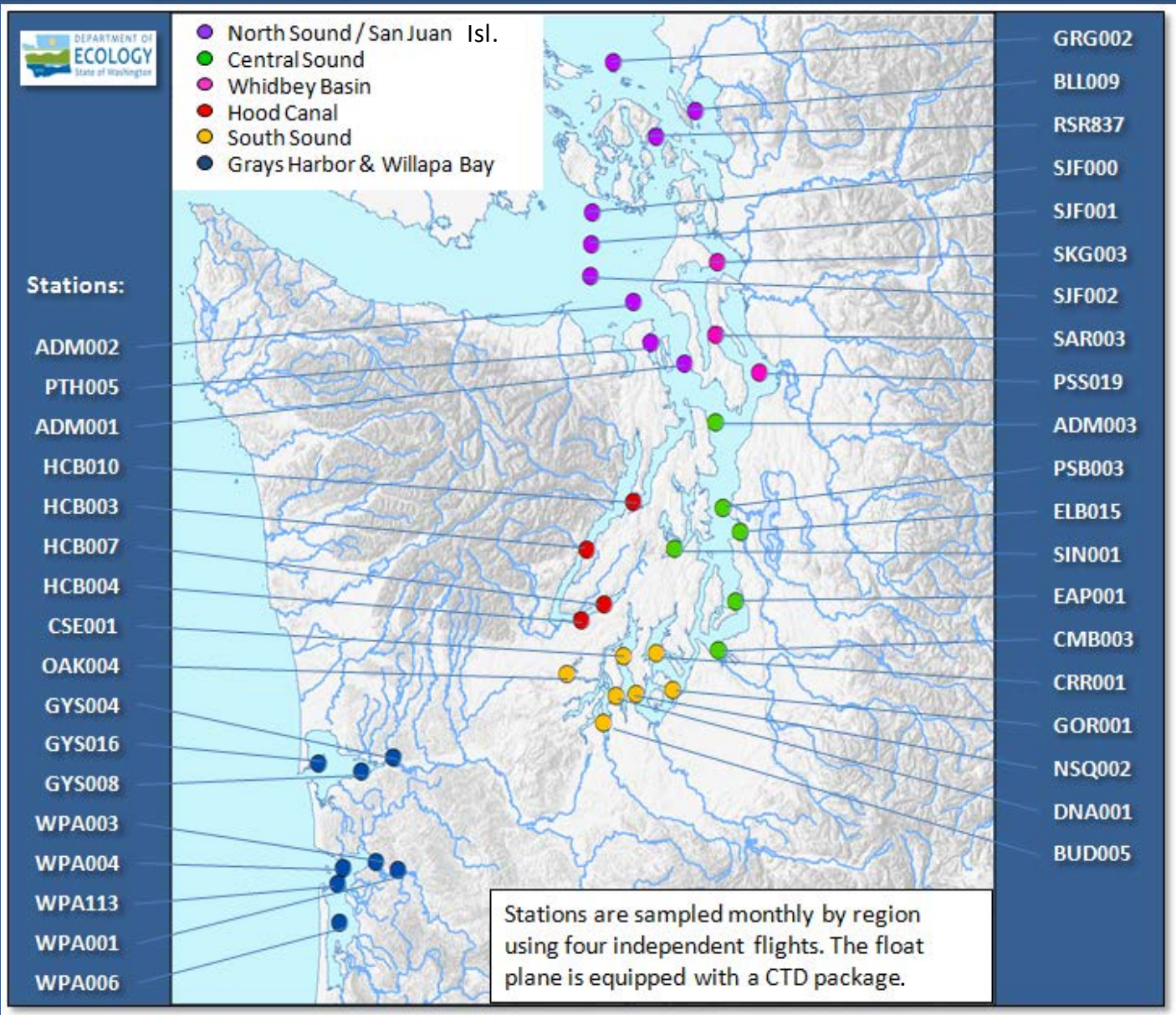
River flows were mostly above normal.

Downwelling was much weaker than normal. ENSO and PDO remain in the warm phase.

Putting the puzzle pieces of influencing factors together…



Our long-term marine monitoring stations in Washington



We use a chartered float plane and boat to access our monthly monitoring stations.

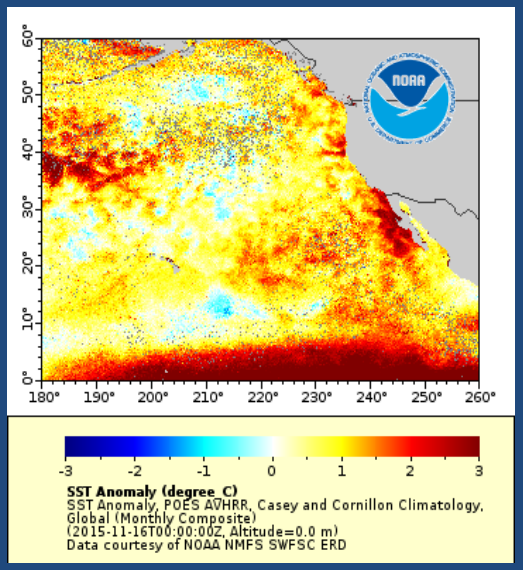
Start here

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**

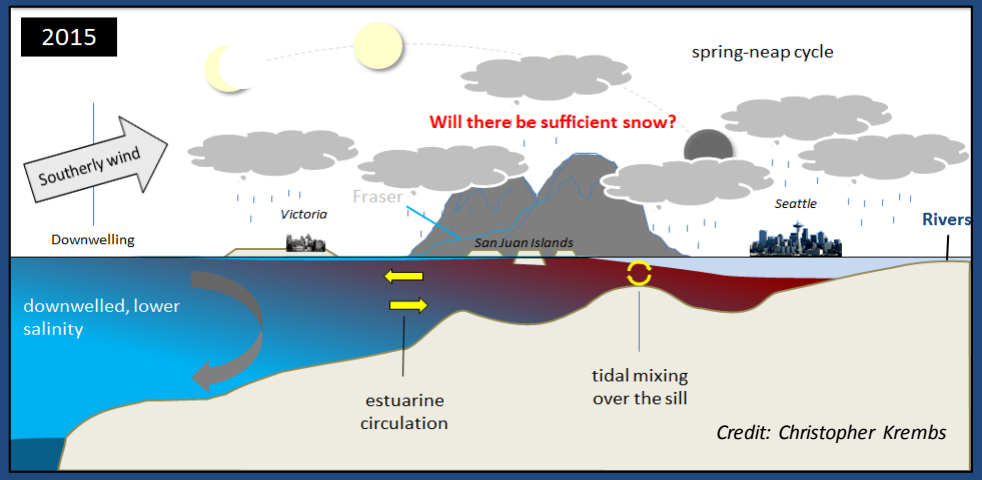
Are Puget Sound conditions are normalizing?

Year 2015 was a record breaker for water temperature in Puget Sound and for global temperatures. Premature melting of the snowpack in early summer caused initially fresh conditions. In July, unusually high salinities started in response to drought and generally very low river flows. Fortunately, November brought rain and, as a result, estuarine circulation has increased to renew the water within Puget Sound.



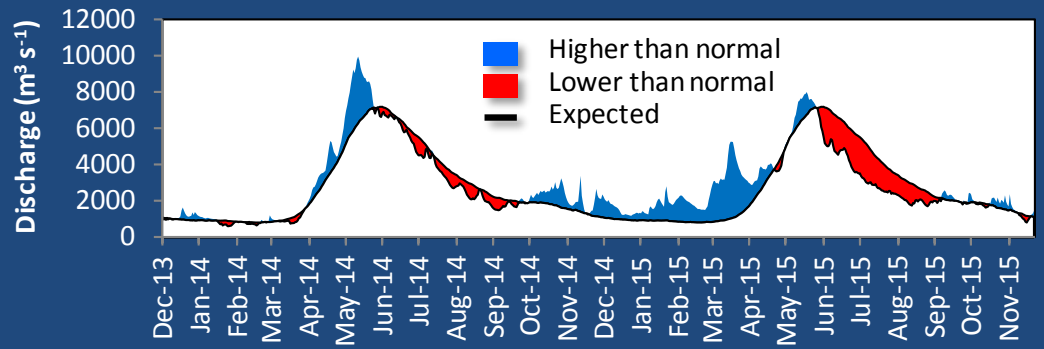
As of November 2015 (left), the Blob has eroded away.

El Niño is growing very strong along the equator.



Rivers are flowing higher and increasing water exchange. This is an opportunity to bring cooler ocean water into Puget Sound.

The Fraser River is the largest freshwater source for the Salish Sea, significantly affecting estuarine circulation.



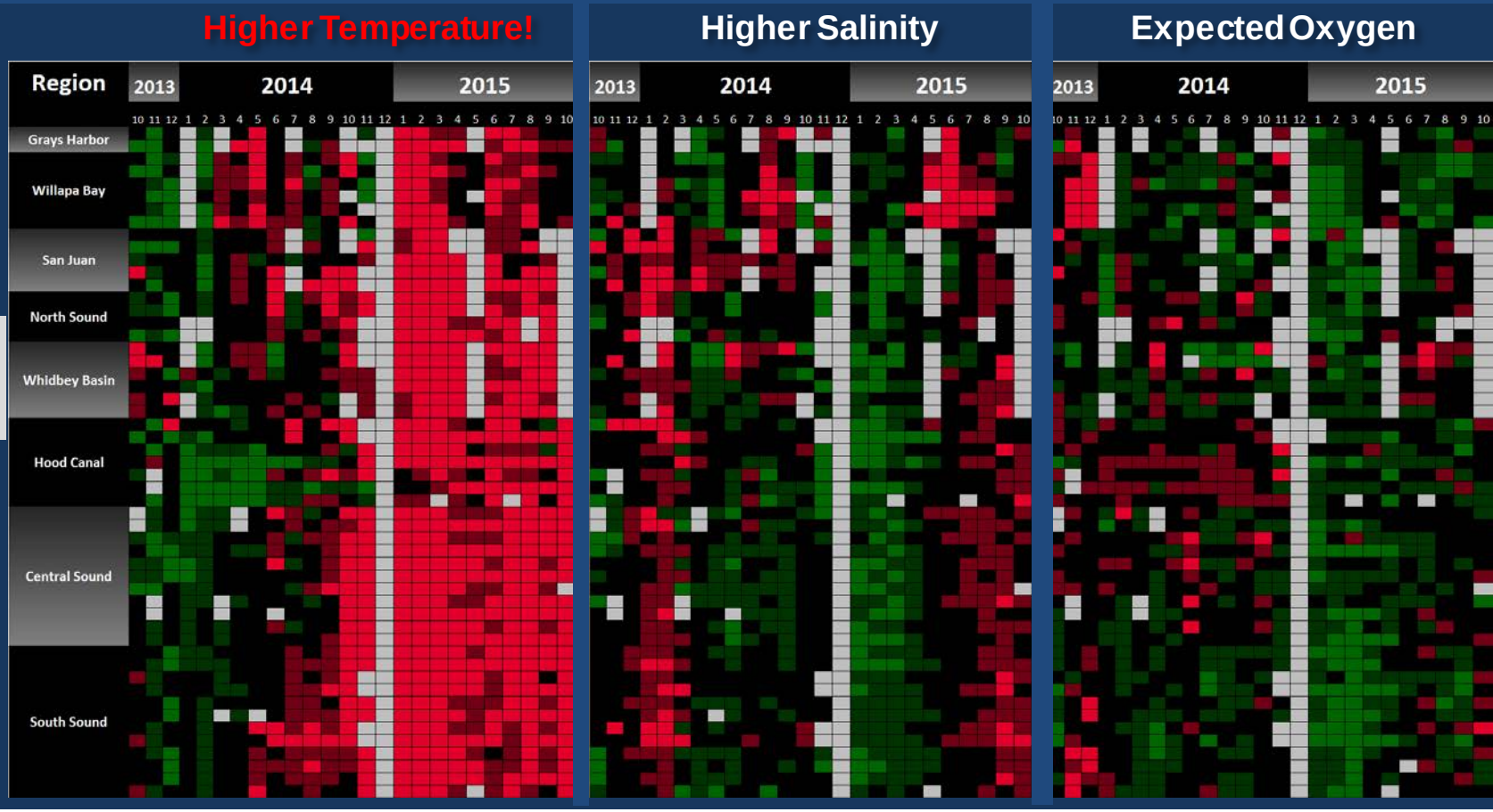
Government of Canada

In winter and spring 2015, the Fraser River and other rivers discharged prematurely. Very low summer flows followed and inhibited the renewal of water in Puget Sound. Rivers are now normalizing from recent rain. Estuarine circulation is expected to rebound.

Source: http://wateroffice.ec.gc.ca/index_e.html

Physical conditions tracked in historical context

Fall **temperatures** are still at record-breaking **highs in Puget Sound**. Drought effects (lower freshwater inputs) shifted salinity to higher than normal levels. With recent rains the past few months (data not shown) salinity patterns are changing. At the Coast, temperature and salinity are back to expected conditions. Oxygen is mostly expected, with local variability.



[Explore profiles at all stations]

= 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

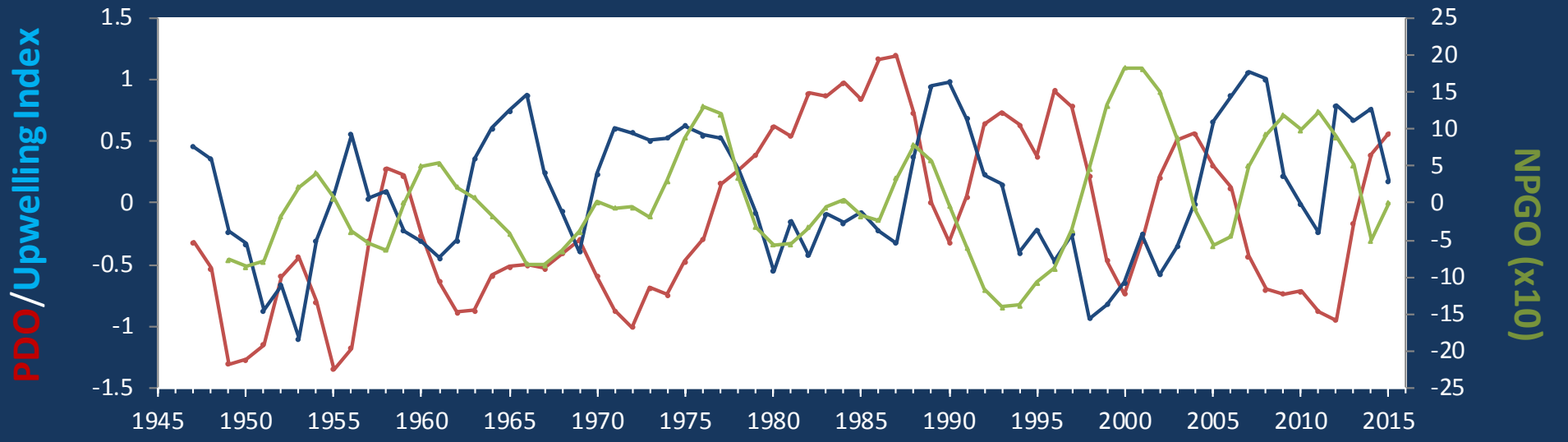
The ocean affects water quality: Ocean Climate Indices

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 are in transition: (a) water is warm (PDO), (b) upwelling of low oxygen and high nutrient ocean water are expected (Upwelling Index), and (c) higher surface productivity along the coast (NPGO) is expected. Where are we heading next? What will El Niño bring?

Summary: Aerial photography 12-14-2015

Rivers transport large amounts of suspended sediments into Puget Sound.
Again, oil sheens in Salmon Bay near the Ballard bridge.

Start here

Washington Conservation Core Intern

Oil sheen near the Ballard bridge

Front

Mixing and Fronts:
Tidal fronts visible in Drayton Passage, off Blake Island and Shilshole Bay.

Jellyfish:
Murky water from the recent rain makes spotting jellyfish difficult. In Budd Inlet, we spotted patches.

Plume

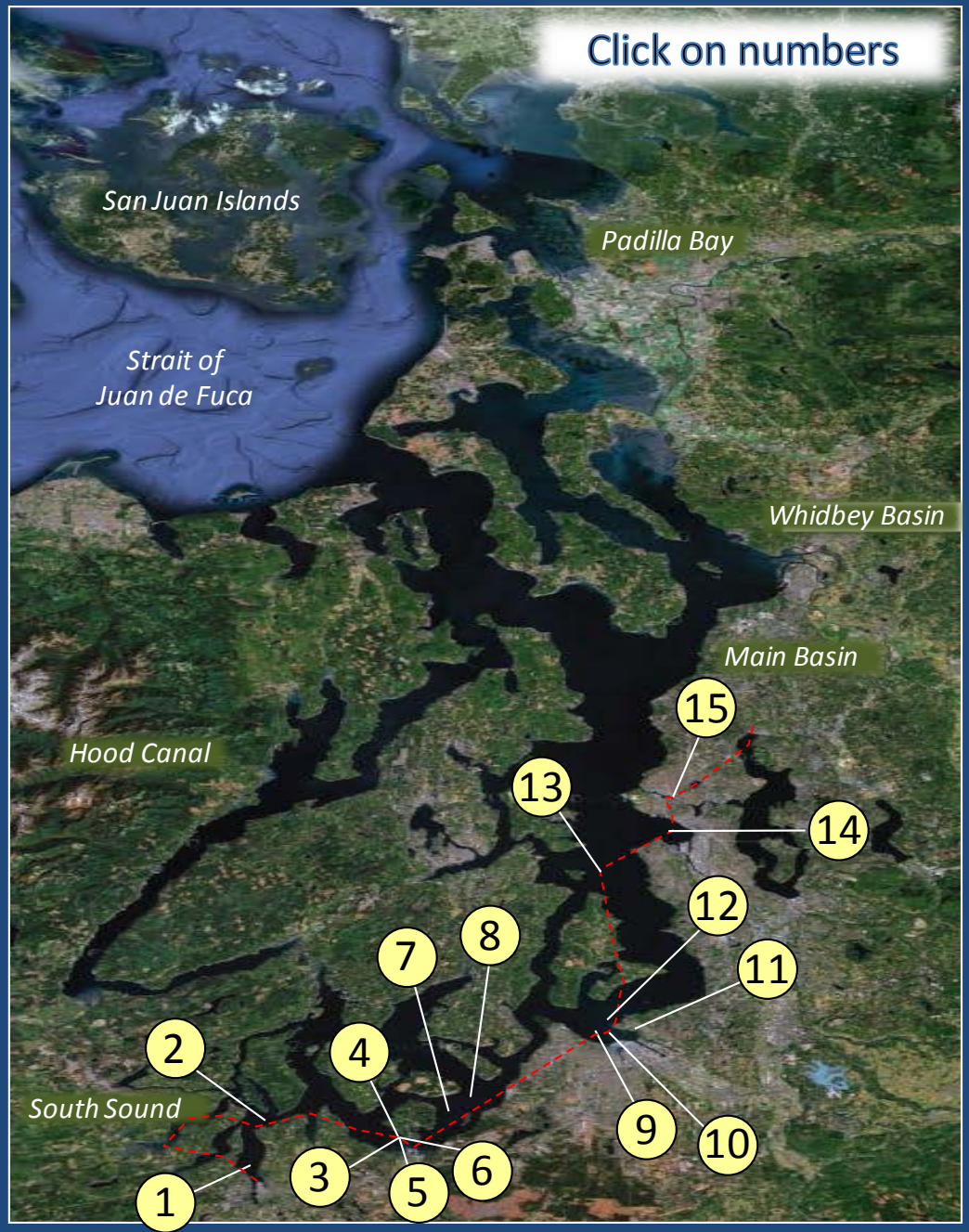
Suspended sediment:
Very high sediment loads from all major rivers and stormwater flows. Suspended sediment plumes extend far into the basins. Brown color suggests bank erosion and soil as part of the suspended sediment.

Bloom

Visible blooms:
Murky water precludes detection of blooms.

Debris

Debris:
Occasional floating organic debris near Vashon Island.



Aerial photography and navigation guide

Date: 12-14-2015

Tide data (Seattle):

	Pred	High/Low
12:08 AM	-1.72	L
07:22 AM	12.42	H
01:06 PM	6.77	L
05:53 PM	10.01	H

Flight Information:

Good visibility in South and Central Sound.

Flight route

Observation Maps:

Central Sound

South Sound

Patches of moon jellyfish appear faint in water with suspended sediment and internal waves.

Location: Budd Inlet (South Sound), 2:10 PM.

Calm conditions in Dana Passage showing no signs of phytoplankton bloom.

Location: Dana Passage (South Sound), 2:18 PM.

Large input of sediment from the Nisqually River extending into Nisqually Reach.
Location: Anderson Island (South Sound), 2:23 PM.

Brown-colored Nisqually River plume suggests bank erosion and soil input from the river.

Location: Anderson Island (South Sound), 2:23 PM.

Large input of sediment from the Nisqually River extending into Nisqually Reach.

Location: Anderson Island (South Sound), 2:23 PM.

Distinct edge of the Nisqually River plume.

Location: South of Anderson Island (South Sound), 2:23 PM.

Edge of the Nisqually River plume.

Location: Balch Passage, Anderson Island (South Sound), 2:27 PM.

The wake of a barge shows the thin nature of the edge of the Nisqually River plume.

Location: Steilacoom (South Sound), 2:27 PM.

Aerial photography 12-14-2015

Flying across Tacoma into Commencement Bay to explore Puyallup River plume.

Location: Commencement Bay, Tacoma (Central Sound), 2:32 PM.

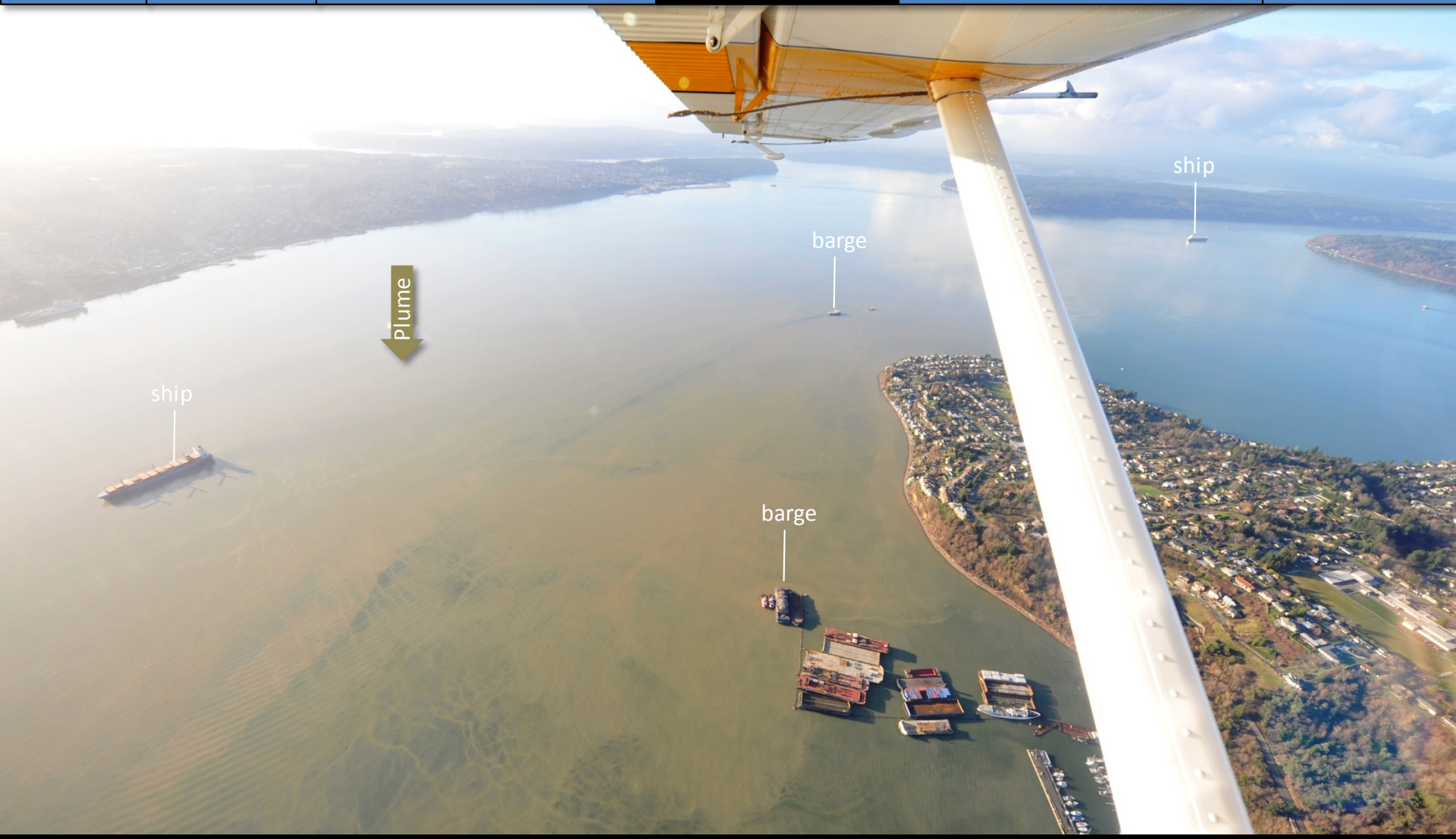
Brown-colored Puyallup River plume suggests bank erosion and soil input from the river.

Location: Commencement Bay, Tacoma (Central Sound), 2:32 PM.

Aerial photography 12-14-2015

Suspended sediments of the Puyallup River reach partially into Blair Waterway of the Port of Tacoma.

Location: Commencement Bay, Tacoma (Central Sound), 2:32 PM.



Large sediment inputs of the Puyallup River into Commencement Bay and Puget Sound.

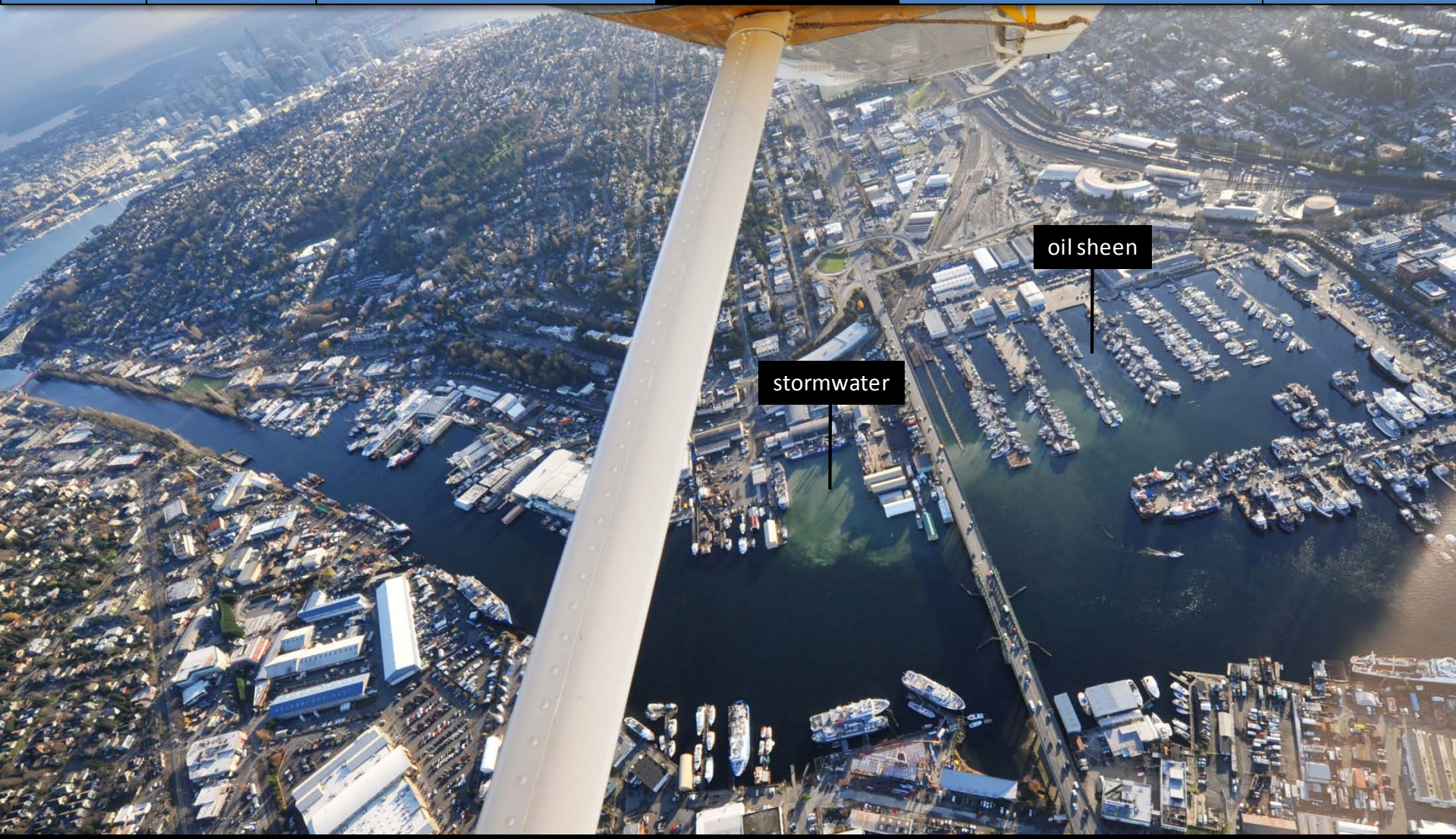
Location: Commencement Bay, Tacoma (Central Sound), 2:34 PM.

Aerial photography 12-14-2015

Distinct front between water located north and south of Blake Island show difference in sediment content.

Location: Blake Island (Central Sound), 2:43 PM.

Brown-colored Duwamish River plume with ferry tracks reveal the thin layer of suspended sediment across Elliott Bay. Location: Elliott Bay, Seattle (Central Sound), 2:46 PM.



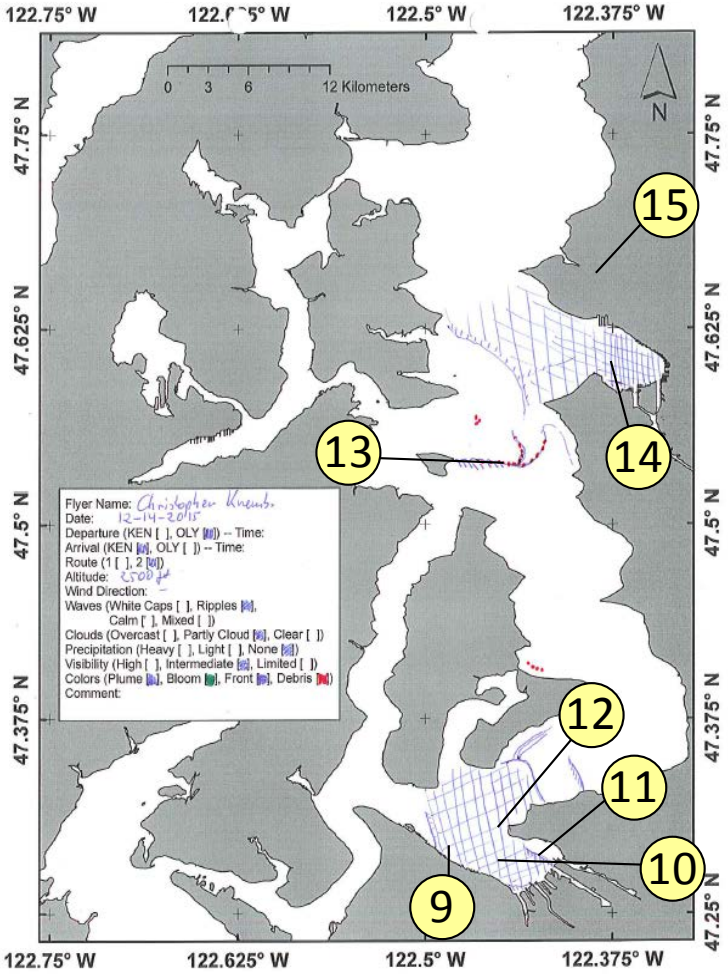
Oil sheens between docks and sediment-rich plume in Salmon Bay.

Location: Lake Washington Ship Canal and Salmon Bay, Seattle (Central Sound), 2:48 PM.

Qualitative aerial observer map during transit

Date: 12-14-2015

Central Sound



North Sound/San Juan Islands

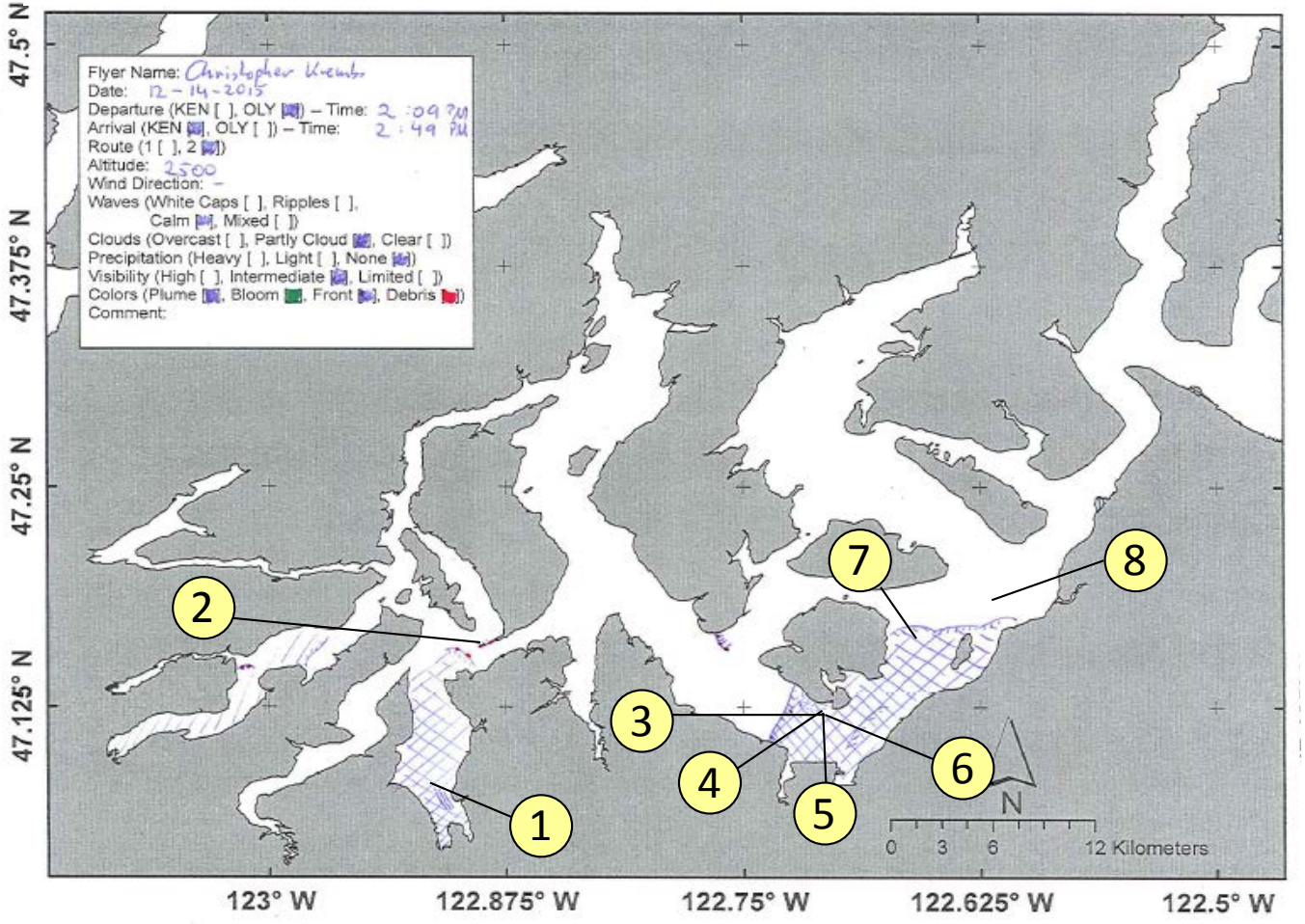
n.a.

Numbers on map refer to picture numbers for spatial reference

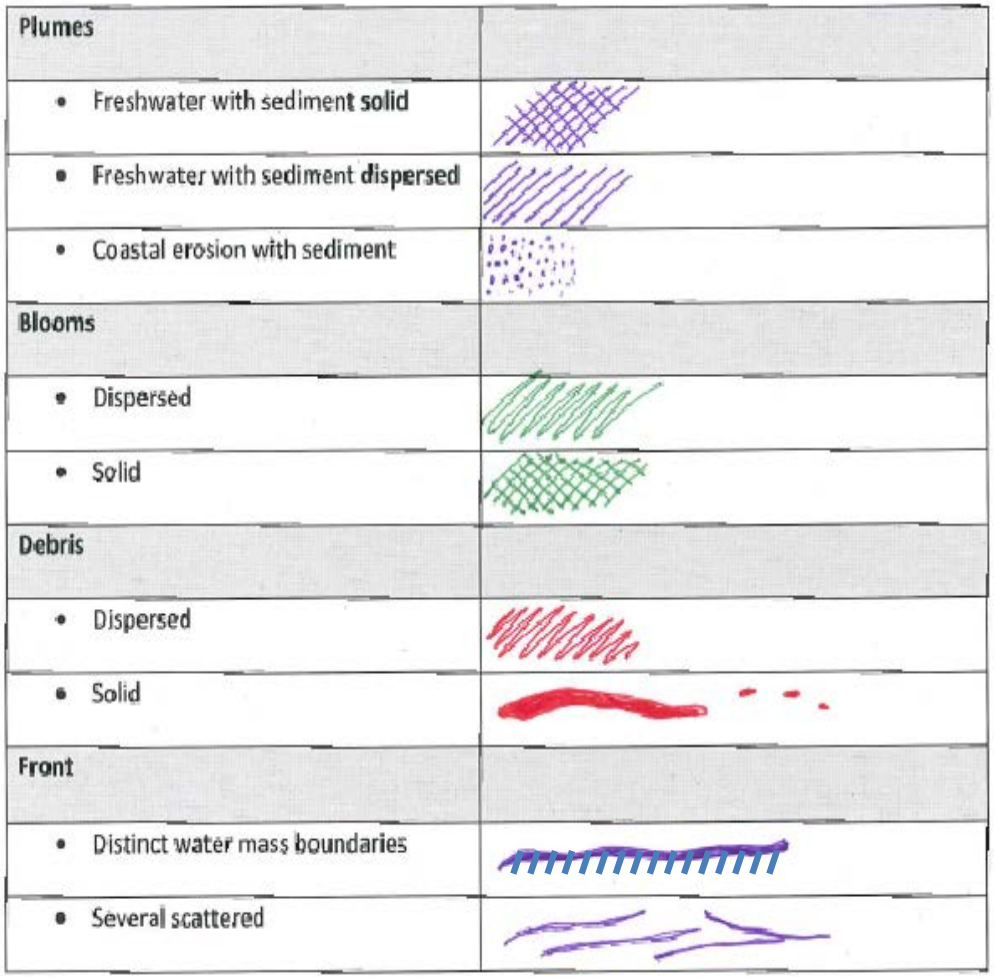
Qualitative aerial observer map during transit

Date: 12-14-2015

South Sound



Numbers on map refer to picture numbers for spatial reference



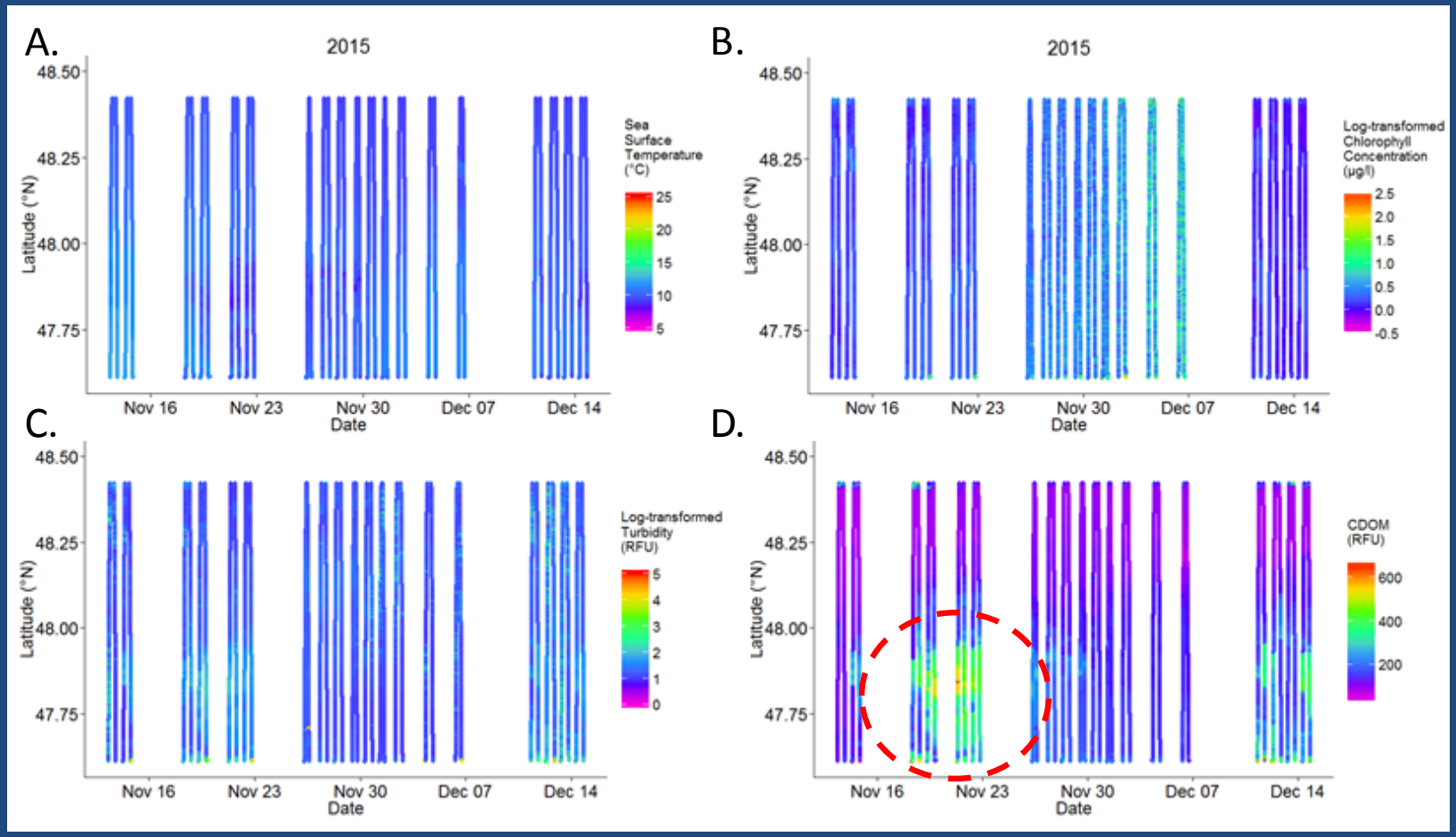
Comments:
Maps are produced by observers during and after flights. They are intended to give an approximate reconstruction of the surface conditions on scales that connect to and overlap with satellite images in the section that follows.

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 and 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.

Continuous monitoring 12-14-2015

Summary of *Victoria Clipper IV* data:
Near-surface water on the *Victoria Clipper IV* ferry route has become cooler and phytoplankton declined. Turbidity between Nov 18 and Nov 23 is elevated in response to increased suspended sediment from Whidbey Basin that extend deep into Central Basin.

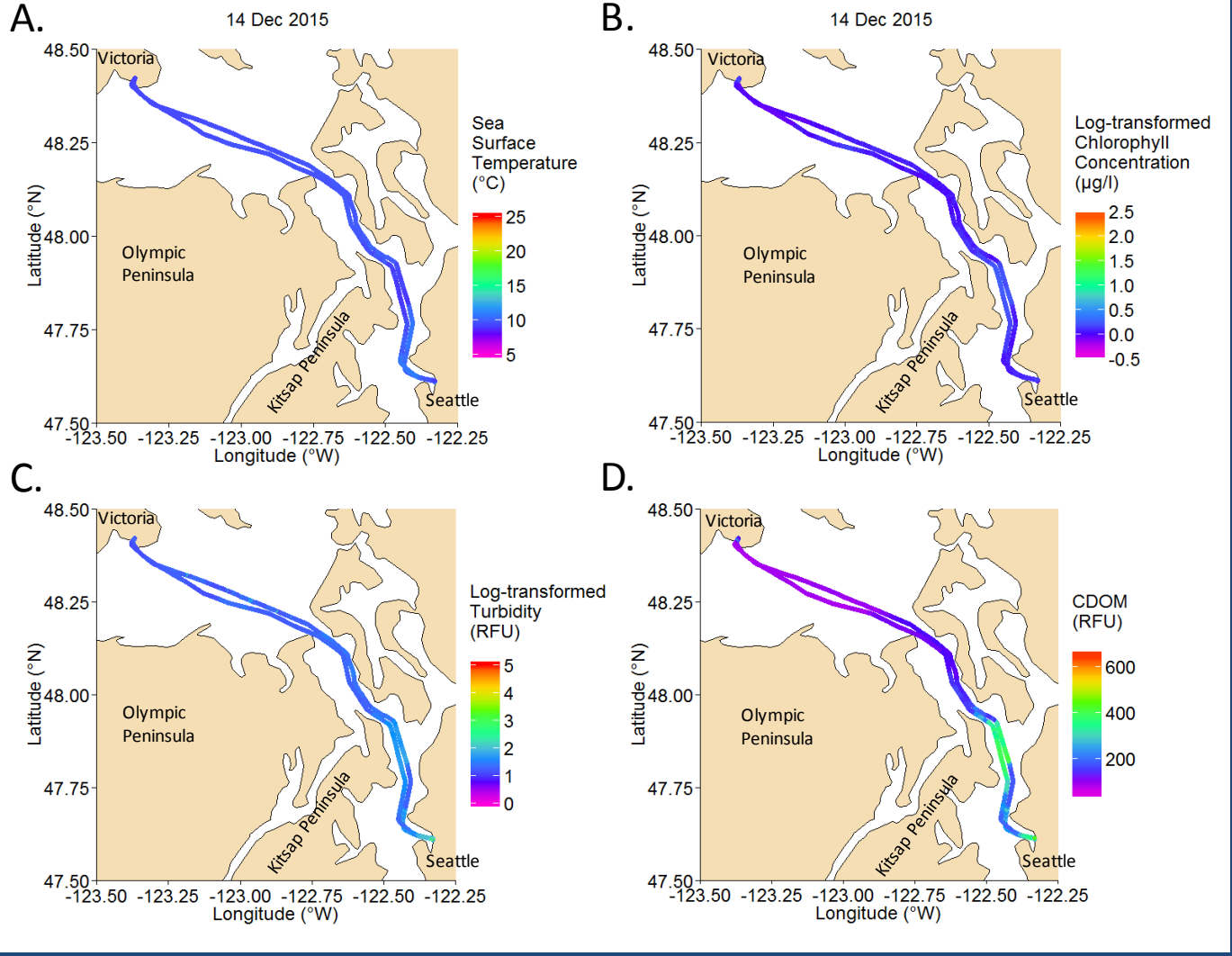


The *Victoria Clipper IV* carries sensors in its sea chest. The sensors allow us to plot over time transects of:

A. Temperature
B. Chlorophyll
C. Turbidity
D. CDOM

Over time, we see the dynamic of these variables in surface water between Seattle and Victoria, BC.

Continuous monitoring 12-14-2015



Figures show daily sensor data installed on the ferry which measures near-surface water at 5-sec intervals while the *Victoria Clipper IV* transits between Victoria, BC and Seattle.

A. Sea Surface Temperature: Water is isothermal in Puget Sound and the Strait of Juan de Fuca.

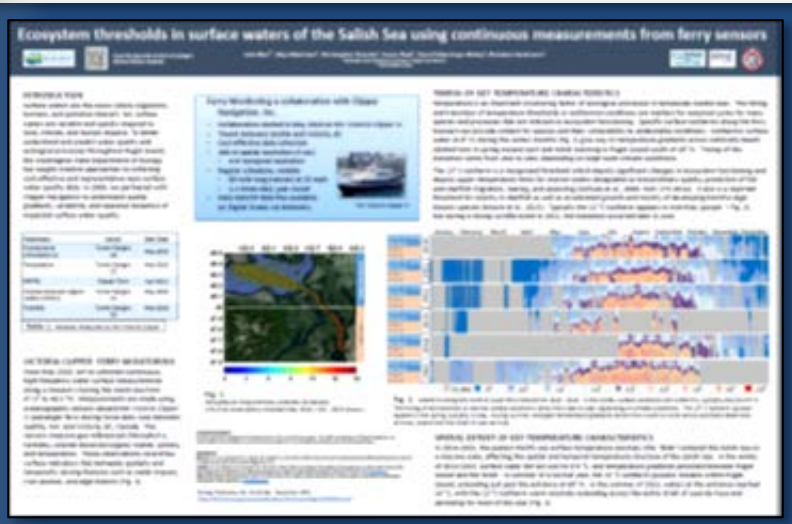
B. Chlorophyll: Concentrations are low, particularly in the Strait.

C. Turbidity: Central Basin was slightly turbid on Dec 14.

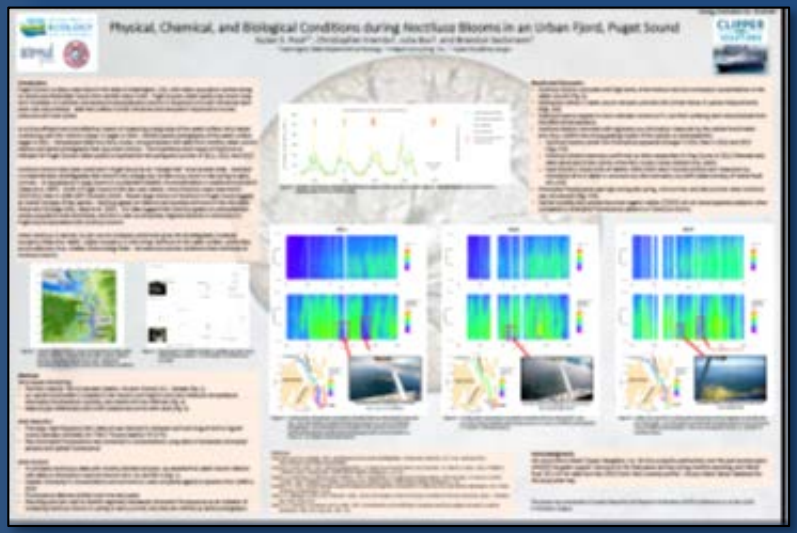
D. Colored Dissolved Organic Matter (CDOM): Particulates in the water were abundant in Central Basin and nearly absent in the Strait.

Continuous monitoring 12-14-2015

Check out our posters that we presented at the Coastal and Estuarine Research Federation conference in Portland, Oregon during November 2015.

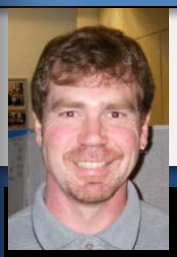


Bos, J., S. Albertson, C. Krembs, S. Pool, C. Falkenhayn Maloy, and B. Sackmann. 2015. **Ecosystem Thresholds in Surface Waters of the Salish Sea using Continuous Measurements from Ferry Sensors**. Poster presented at Coastal Estuarine and Research Federation 2015 Conference, Portland, Oregon. Washington State Department of Ecology Publication No. 15-03-041. https://fortress.wa.gov/ecy/publications/documents/1503041.pdf



Pool, S.S., C. Krembs, J. Bos, and B. Sackmann. 2015. Physical, Chemical, and Biological Conditions during *Noctiluca* Blooms in an Urban Fjord, Puget Sound. Poster presented at Coastal Estuarine and Research Federation 2015 Conference, Portland, Oregon. Washington State Department of Ecology Publication No. 15-03-040. https://fortress.wa.gov/ecy/publications/documents/1503040.pdf

Snoqualmie River goes through extremes



Jim Shedd, Ecology

In contrast to drought conditions in summer 2015, late autumn brought heavy rains and high stream flows to the Puget Sound Basin.

Snoqualmie during minimum flows

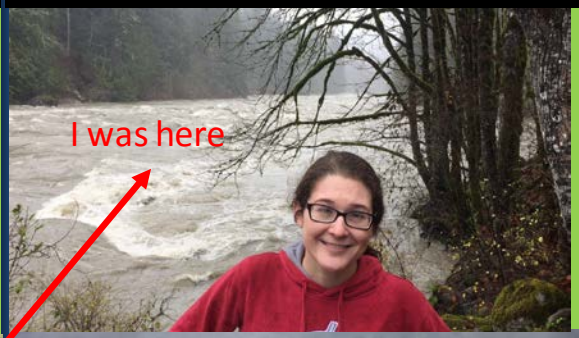
Snoqualmie River Falls on Aug. 26, 2015, a paltry **250 cubic feet per second** (cfs). The historic median flow for August 26 is **563 cfs**.

Ecology's Sarah Oxford indicates on the staff gage the normal water level in contrast to the existing water level on August 26.

Watch the video

PLAY

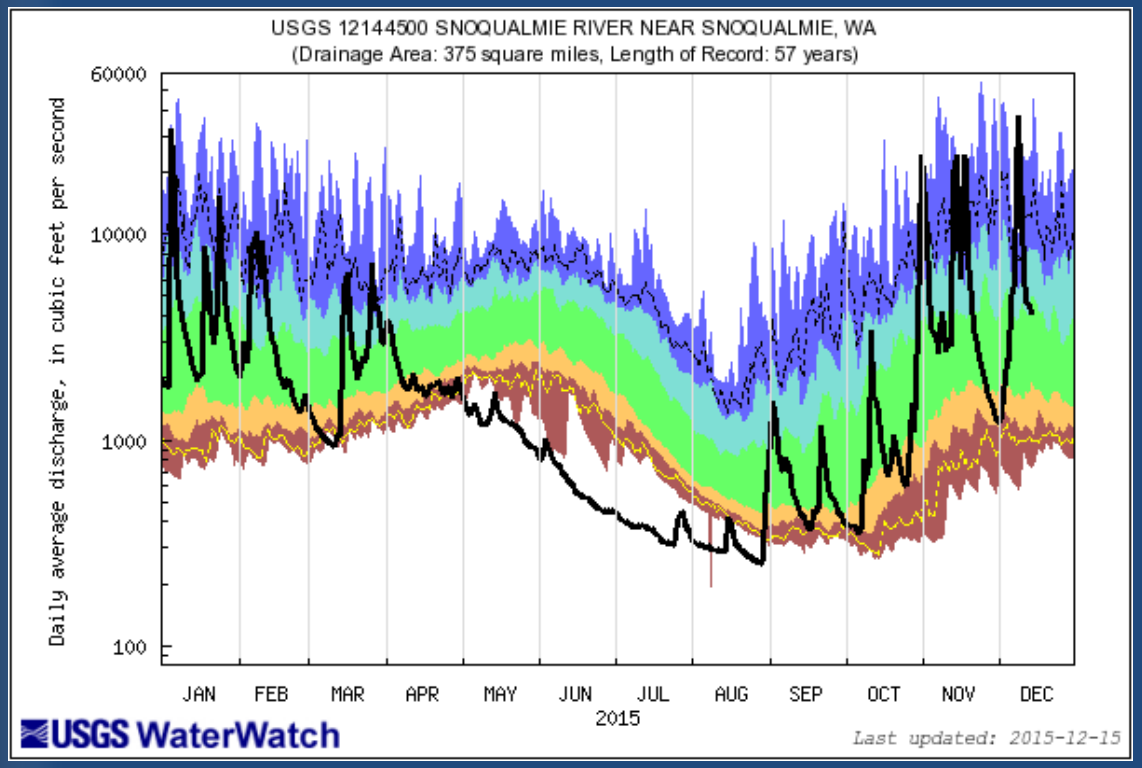
Snoqualmie flows now

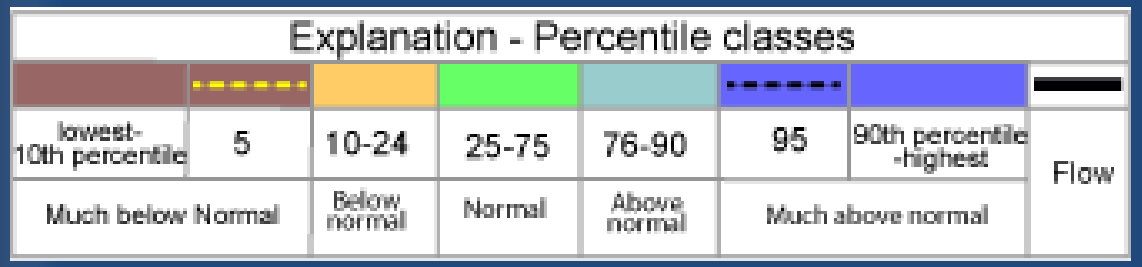


Ecology's Kellie Gillingham explaining the details of the high flow event of November 13.

Snoqualmie Falls on December 9 flowing at about **48,000 cfs.**

Snoqualmie River goes through extremes





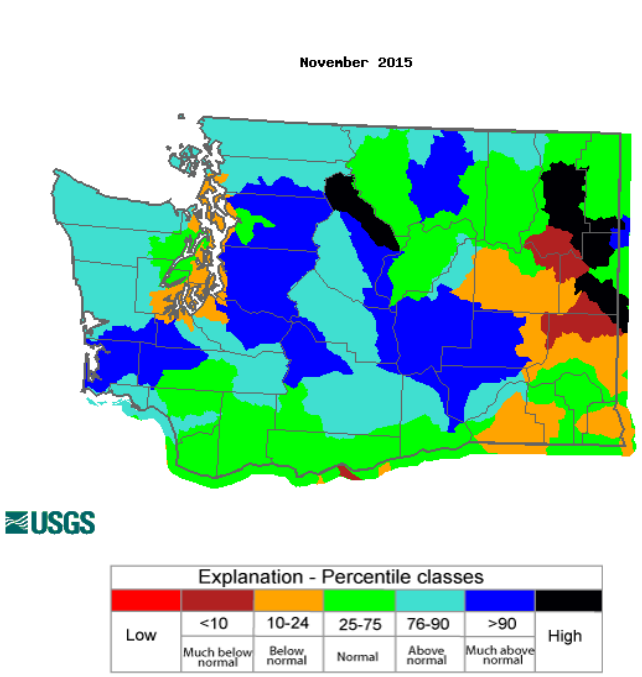
The graphic shows flows this year compared to historic flows at the USGS gage near where the photos on the previous page were taken.

Note from the first of May through the end of August new record low flows were set nearly every day.

In Autumn, flows on the Snoqualmie River began increasing, culminating with near record setting high flows in November and December.

Snoqualmie River goes through extremes

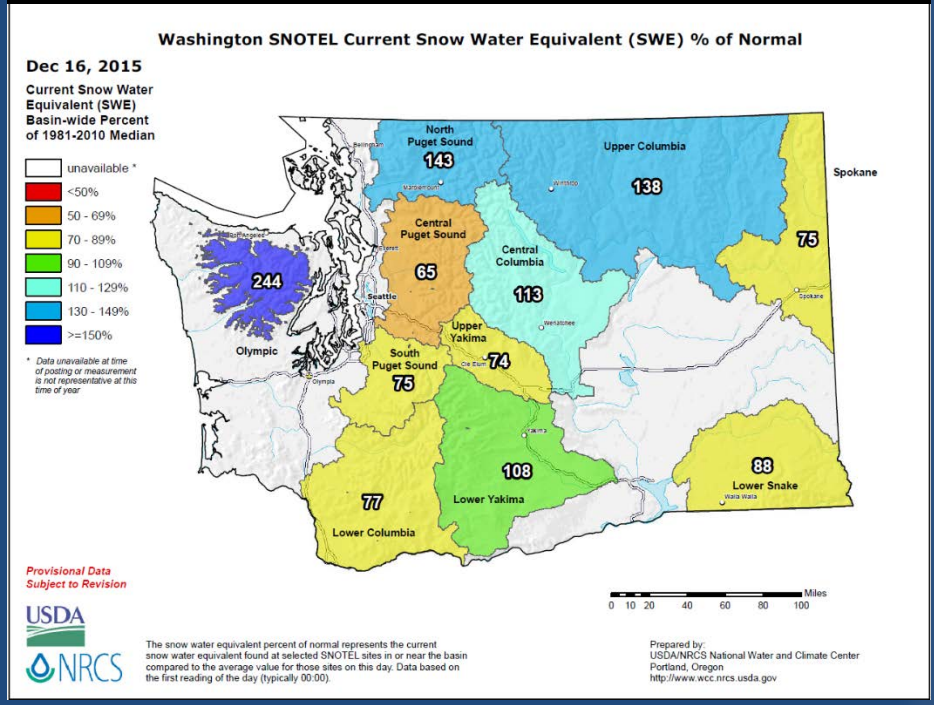
Does it rain?



November monthly mean for rivers and streams in Washington, in water resource regions, compared to historic November flows.

Flows are mostly normal to above normal, even much above normal in western Washington due to higher than normal rainfall in November.

Does it snow?



Central and south Puget Sound basin snow water equivalencies are less than normal while the Olympic region is well above normal.

Snow water equivalencies in central and south Puget Sound Basins have improved over November equivalencies as more snow rather than rain has fallen in these areas recently.

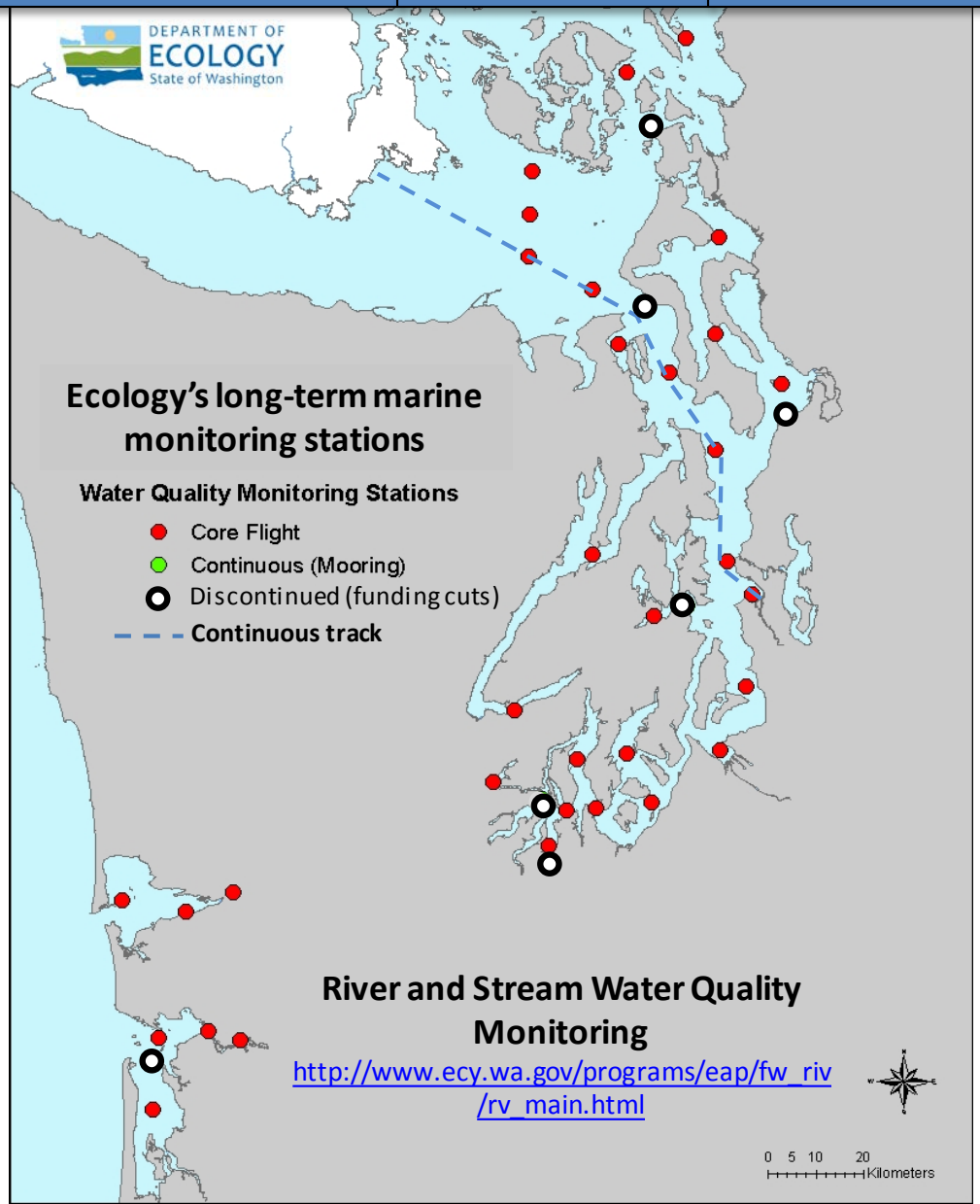
Get data from Ecology's Marine Monitoring Programs

Field log	Climate	Water column	Aerial photos	Continuous monitoring	Streams

Long–Term Monitoring Network

christopher.krembs@ecy.wa.gov

Access core monitoring data:
https://fortress.wa.gov/ecy/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
christopher.krembs@ecy.wa.gov

Marine Monitoring Unit
Environmental Assessment Program
WA Department of Ecology

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