



Eyes Over Puget Sound

[Field log](#)[Climate](#)[Water column](#)[Aerial photos](#)[Continuous monitoring](#)[Streams](#)

Marine Water Condition Index



Surface Conditions Report, July 6, 2015

Guest: *Gabriela Hannach, King County Environmental Lab*

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

Field log

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LONG-TERM MARINE MONITORING UNIT

*Mya Keyzers
Laura Hermanson
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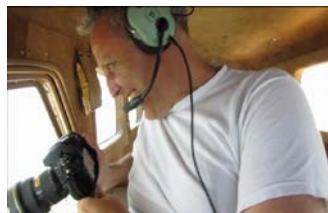
Skip Albertson



*Julia Bos
Suzan Pool*



*Dr. Christopher
Krembs*



*Gabriela Hannach
Markus von Prause*



Personal field log

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Experience as a Washington Conservation Corps Intern at Ecology.

Climate conditions

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Unusually warm temperatures and sunshine continue around the region. River systems connected to the Puget Sound are experiencing lower than normal summer flows.

Water column

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Warm water in Puget Sound because of “the Blob”. Temperatures are the highest on record since 1989. Oxygen is exhibiting new historical minima, an unusual condition given the time of year.

Aerial photography

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Very large debris islands in South and Central Sound, Port Susan, and Padilla Bay. Numerous patches of jellyfish in finger inlets of South Sound and Sinclair Inlet. Phytoplankton blooms in South Sound, smaller bays of Kitsap Peninsula, and around the San Juan Islands.

Continuous monitoring

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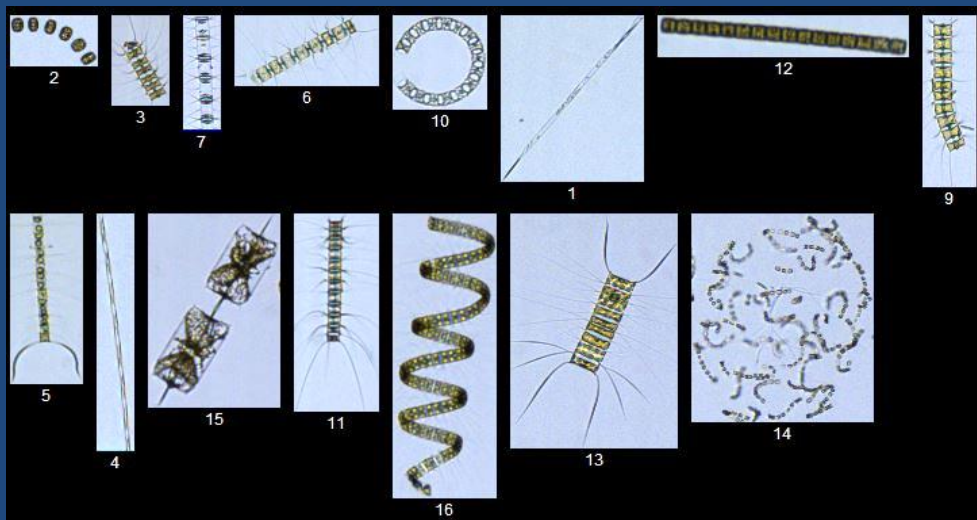
Water is warmer and saltier than the past 5 years. Oxygen is near normal.

Streams

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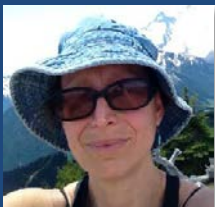
The Nooksack River has the highest nitrogen yield of all Puget Sound Rivers!

A. Diatoms continue to bloom in Puget Sound



A sample of images collected with a FlowCAM shows various chain-forming diatoms, including several species of the common genus *Chaetoceros*.

Noctiluca are 0.5 mm across, with an active tentacle that helps in the movement of food particles.



Gabriela Hannach
King County
Environmental Lab

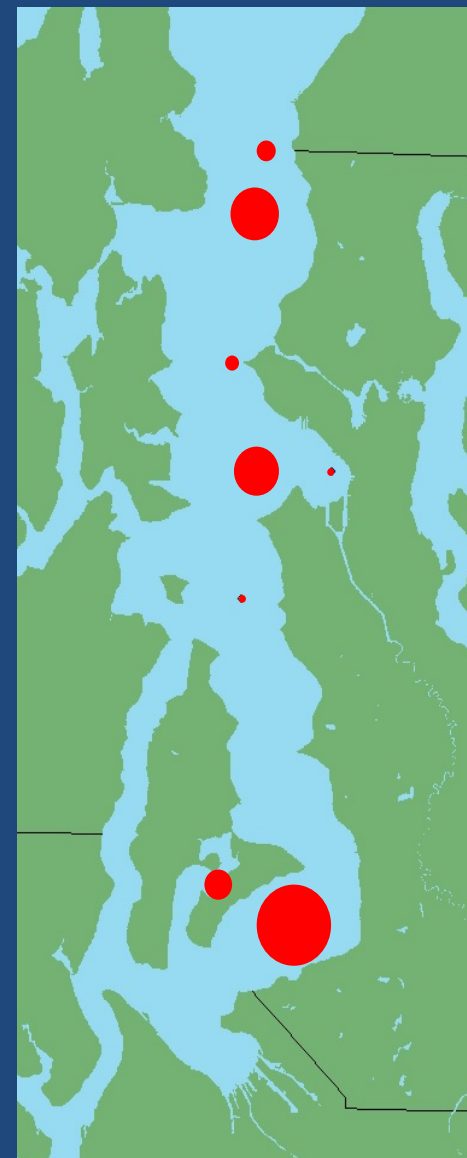


B. *Noctiluca* blooms

Noctiluca is a large dinoflagellate that often causes conspicuous blooms in Puget Sound.

Carotenoid pigments from ingested algae give *Noctiluca* blooms their characteristic bright orange color: **“tomato-soup red”**

Circles show concentrations ranging from 5 to 1400 cells per liter (June 15-17, 2015).



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Experience as a Washington Conservation Corps (WCC) Intern at Ecology

For Brooke McIntyre, work in the Marine Monitoring Unit at Ecology is dynamic and fun. I divide my time between water and sediment monitoring, and the BEACH program. Here's a peek into my experience...



I operate a CTD and collect water samples on marine flights.



I service moorings. The sensor at the bottom gets covered in barnacles! I help clean these off so it can function properly again.



I run chlorophyll and dissolved oxygen lab samples.

← Mt. Rainier sunrise



I collect sediment samples in the field. Look at this huge polychaete we caught in the grab! →

Advice for young scientists:

- Be curious and always ask questions.
- Be a volunteer. Make connections and discover what gets you excited.
- Be engaged. Give every task 100%.



I volunteered on a NOAA tow-netting cruise. We caught a variety of fish and lots of fried egg jellyfish like this one!



I sort samples for benthic invertebrates under the scope.





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.

Summary from June:
(Skip is on vacation)

Air temperatures were warmer than normal across Western Washington.

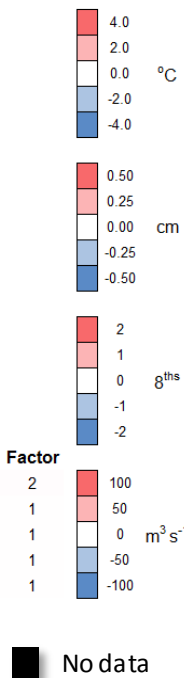
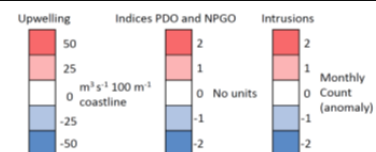
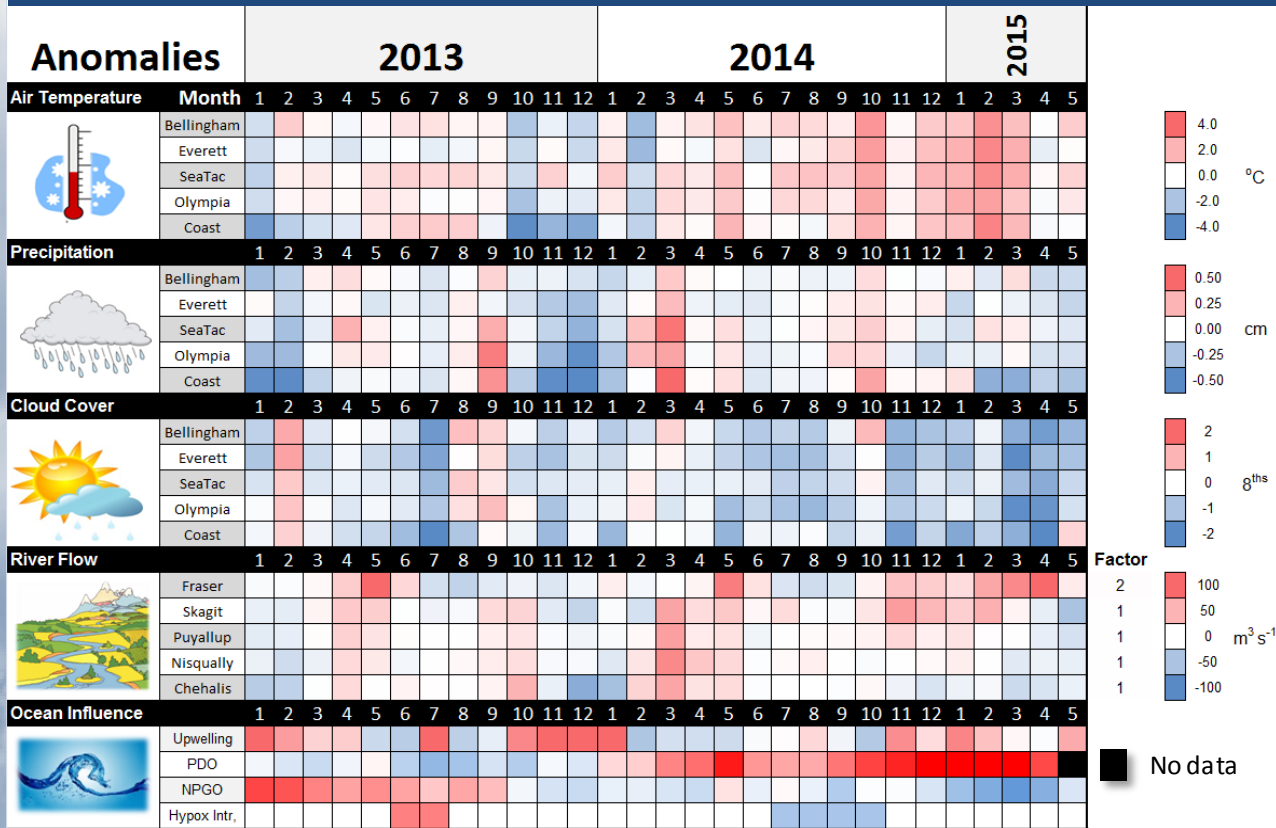
Precipitation was below normal in the Puget Sound region.

Sunshine has generally been above normal.

River flows have all dropped, especially the Skagit and Puyallup Rivers. Fraser River is the only river running still (slightly) above normal.

PDO remains in the warm phase, and **upwelling** is now above normal.

Putting the puzzle pieces of influencing factors together...



Our long-term marine monitoring stations in Washington



Field log

Weather

Water column

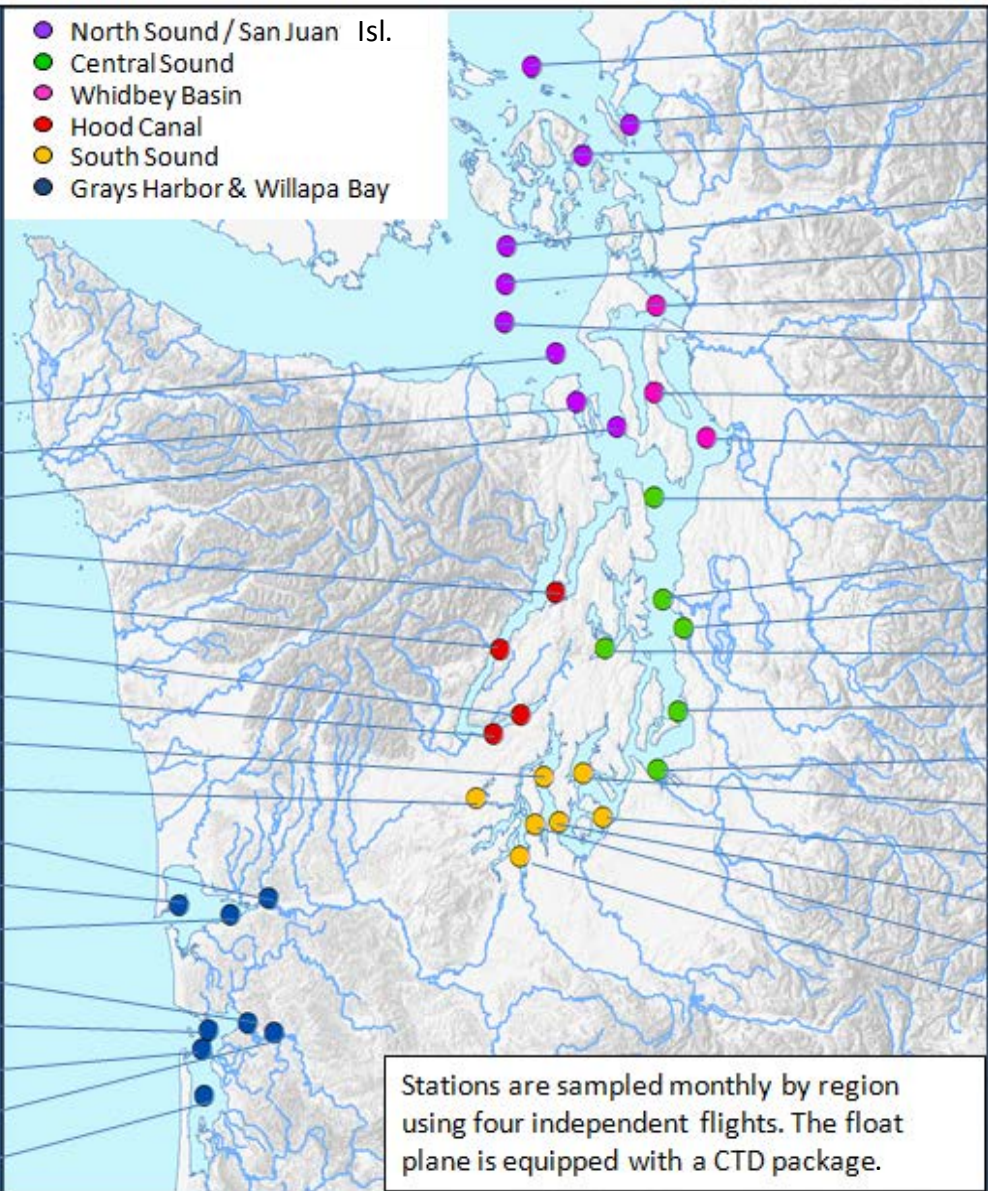
Aerial photos

Continuous monitoring

Streams



- North Sound / San Juan Isl.
- Central Sound
- Whidbey Basin
- Hood Canal
- South Sound
- Grays Harbor & Willapa Bay



Stations:

- ADM002
- PTH005
- ADM001
- HCB010
- HCB003
- HCB007
- HCB004
- CSE001
- OAK004
- GYS004
- GYS016
- GYS008
- WPA003
- WPA004
- WPA113
- WPA001
- WPA006

- GRG002
- BLL009
- RSR837
- SJF000
- SJF001
- SKG003
- SJF002
- SAR003
- PSS019
- ADM003
- PSB003
- ELB015
- SIN001
- EAP001
- CMB003
- CRR001
- GOR001
- NSQ002
- DNA001
- BUD005

Stations are sampled monthly by region using four independent flights. The float plane is equipped with a CTD package.

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

Physical conditions tracked in a statistical & historical context

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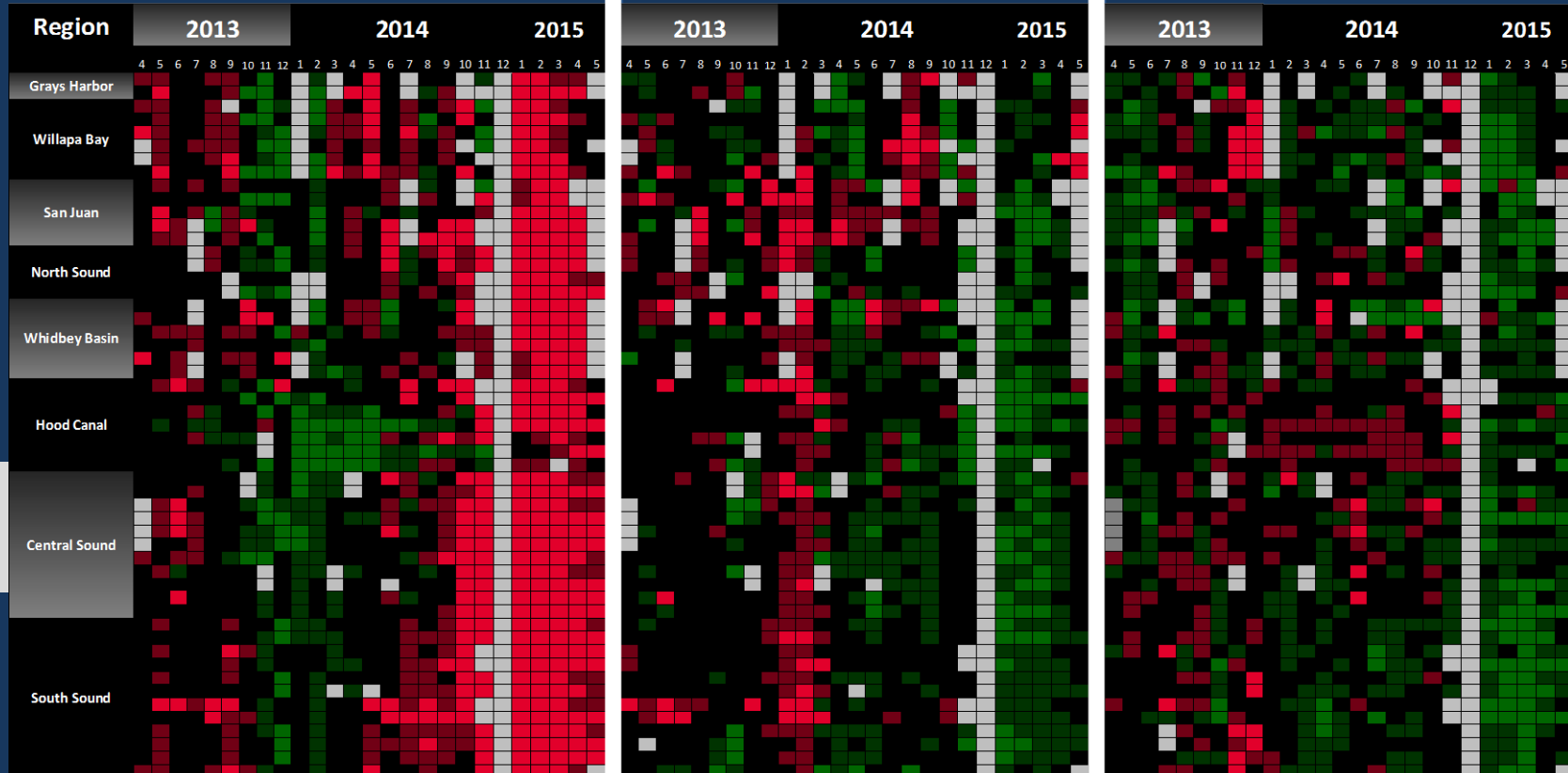


Conditions are still dominated by **warm water** overall, yet some places (Willapa Bay, Hood Canal surface) show seasonally normal temperatures. Salinity has increased to expected levels and oxygen shows a mix of expected and lower levels in Puget Sound.

Higher Temperature!

Expected Salinity

Lower Oxygen



Is Willapa Bay returning to normal?

Black boxes show expected temperatures based on historical data

[Explore profiles at all stations](#)

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

The ocean affects water quality: Ocean Climate Indices



Field log

Weather

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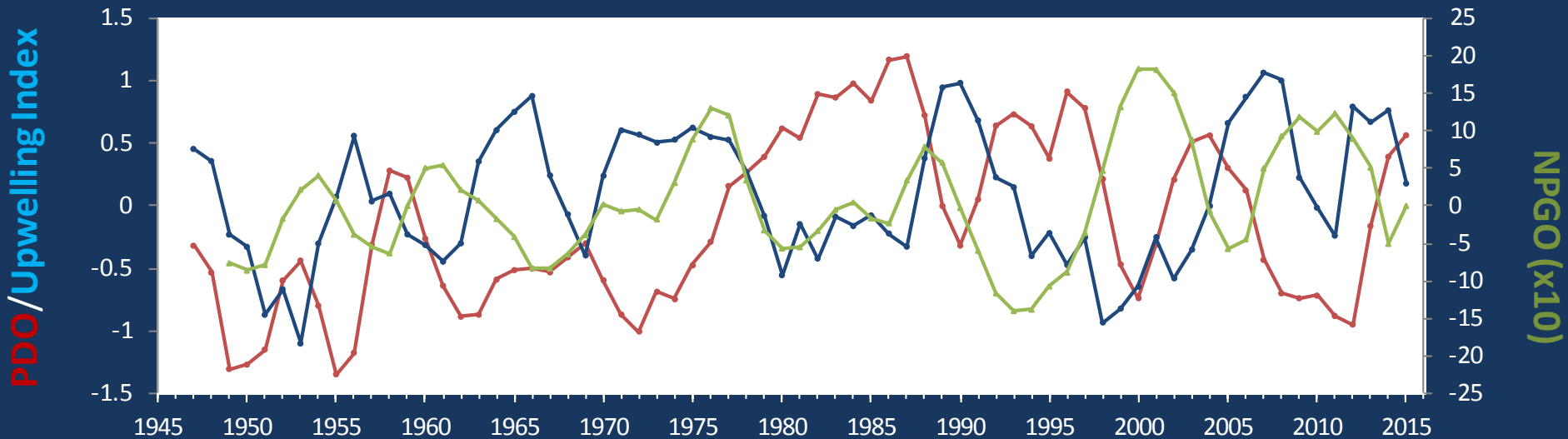
Aerial photos

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- 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 is expected (Upwelling Index), and (c) higher surface productivity along the coast (NPGO) is expected. Where are we heading next?

Field log	Weather	Water column	Aerial photos	Continuous monitoring	Streams
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Massive debris islands in South and Central Sound, Dyes Inlet, Liberty Bay, Port Susan, and Padilla Bay. Numerous patches of jellyfish in finger inlets of South Sound and Sinclair Inlet. Phytoplankton blooms in South Sound, smaller bays of Kitsap Peninsula, and San Juan Islands. Remnants of *Noctiluca* bloom near Mukilteo and East Passage.

[Start here](#)

Skagit River flows are noticeably low!



View of the CTD into the water from plane



Mixing and Fronts:

Tidal eddy off Blake Island. Tidal fronts are nicely visible by different coloration of the water in response to blooms.



Jellyfish:

Sizable jellyfish patches present in southern inlets of South Sound (Budd and Eld Inlets), Sinclair Inlet, and Liberty Bay.



Suspended sediment:

Reduced suspended sediments from river plumes found in expected locations near rivers.



Visible blooms:

Green-brown: Totten Inlet, Dyes Inlet, Port Townsend, eastern Central Basin, Case Inlet.

Red-brown: Eld, Budd, and Henderson Inlets; East Sound.

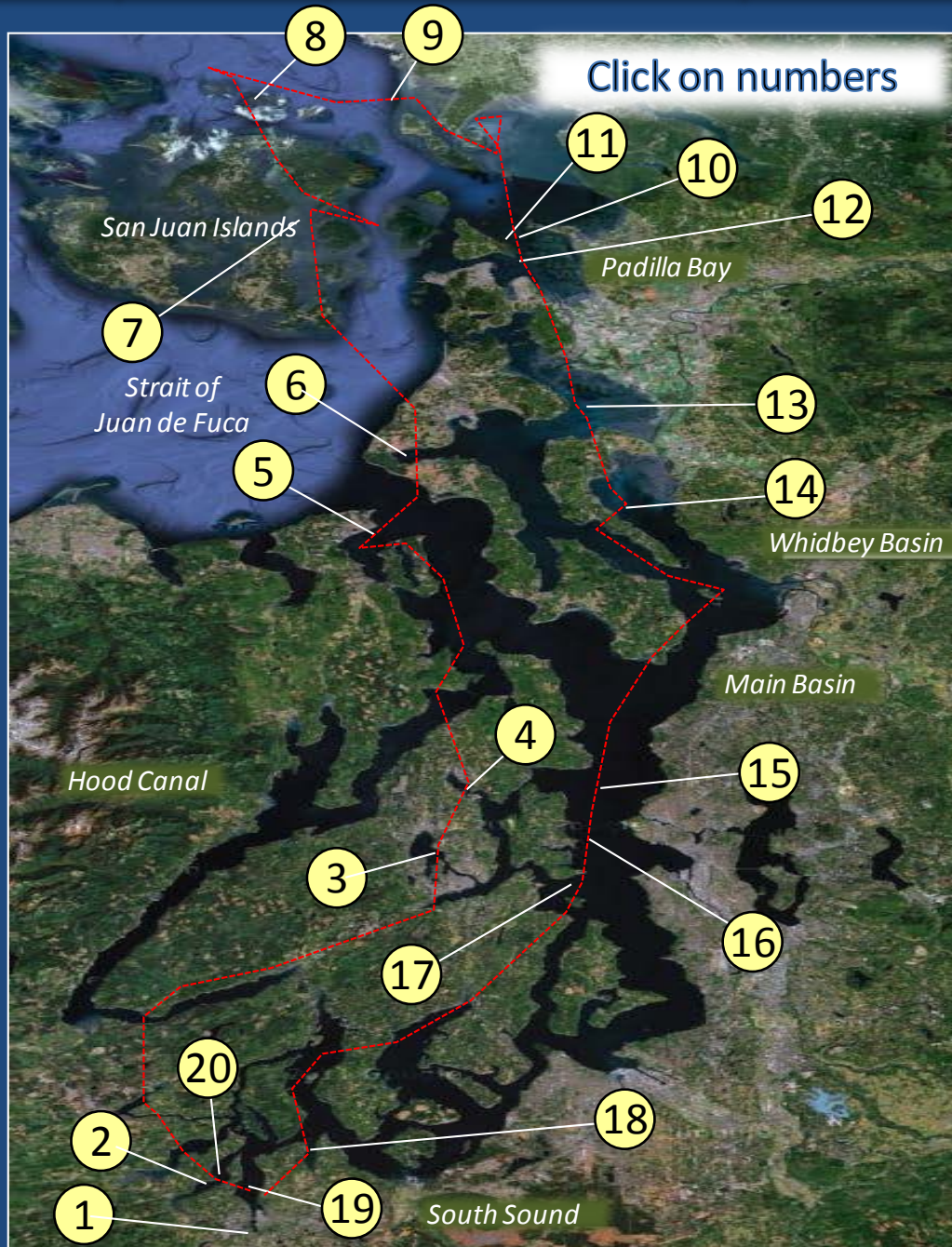
Green: Port Susan.

Noctiluca: Mukilteo and East Passage.



Debris:

Massive occurrences in South and Central Basin, Dyes Inlet, and Padilla Bay.



Aerial photography

July 6, 2015, NASA Earth Observatory



<http://earthobservatory.nasa.gov/IOTD/view.php?id=86190>

Flight Information:

Limited visibility, due to smoke from Canadian forest fires that increased haziness towards the north.

--- Flight route

Observation Maps:

Central and North Sound

South Sound



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*Large patches of algae at the surface of Capitol Lake.
Location: Olympia (South Sound), 9:34 AM.*



Field log

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Numerous patches of jellyfish in water containing red-brown algal bloom.

Location: Eld Inlet (South Sound), 9:37 AM.



Field log

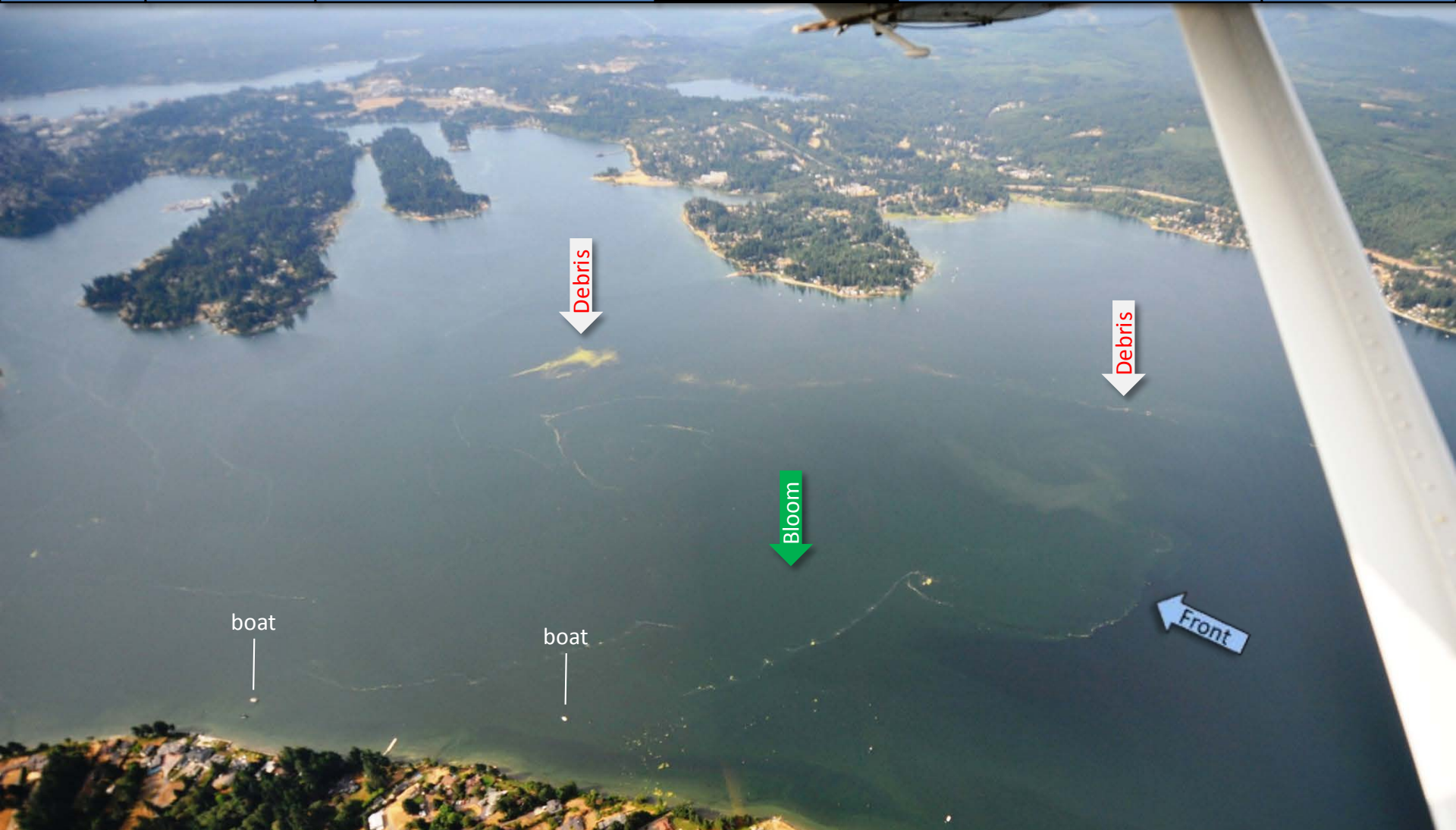
Climate

Water column

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*Large islands of organic material and a front with red-brown algal bloom.
Location: Dyes Inlet (Central Sound), 9:59 AM.*



Field log

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*Large islands of organic material and patches of jellyfish.
Location: Liberty Bay (Central Sound), 10:03 AM.*



Field log

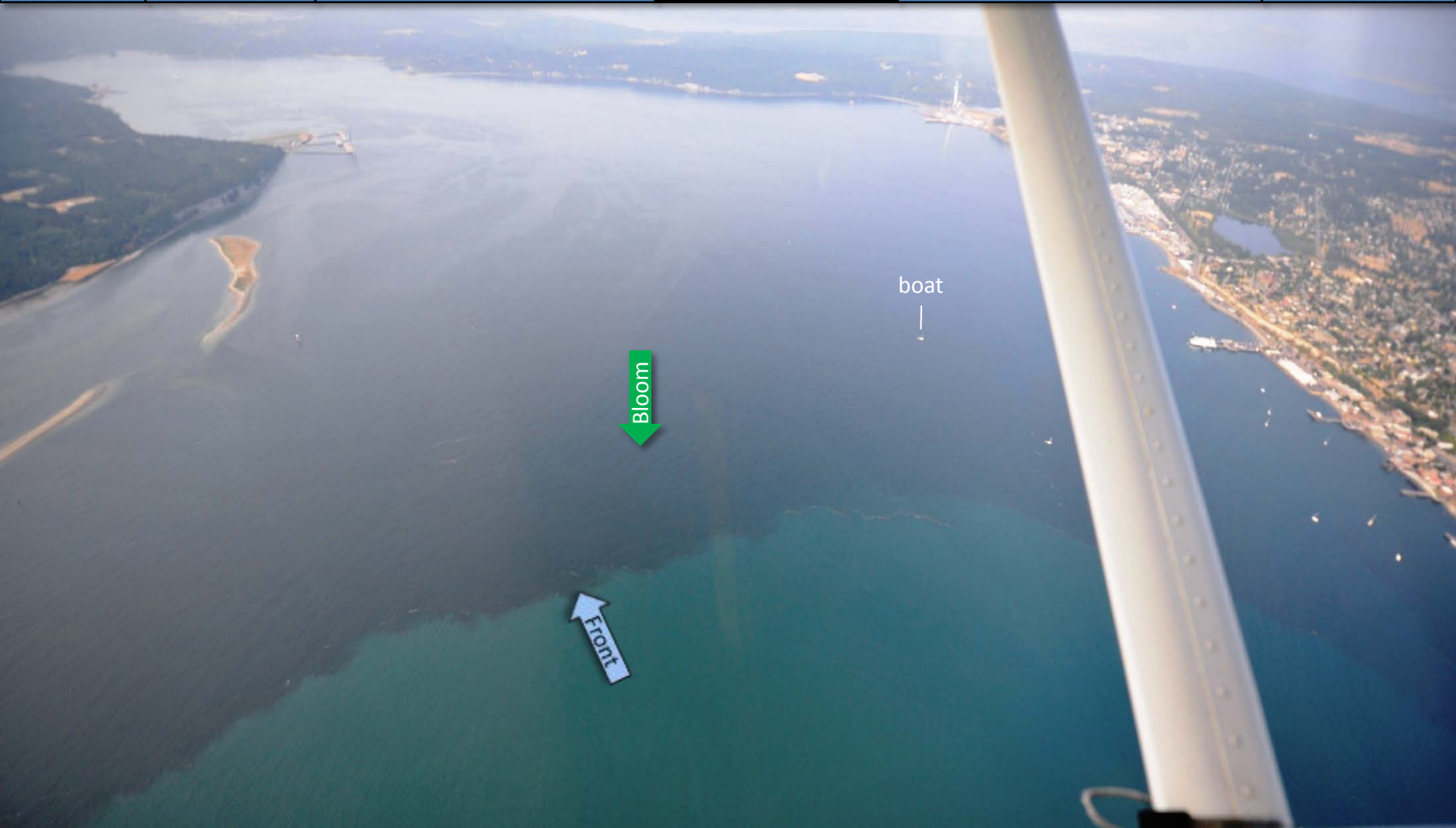
Climate

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Red-brown bloom separated by front from water in Admiralty Reach.

Location: Port Townsend (North Sound), 10:16 AM.



Field log

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Bloom at surface near aquaculture pens.
Location: Penn Cove (Whidbey Basin), 10:58 AM.



Field log

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Water rich in glacial flour from Fraser River meet red-brown bloom and reveal patterns of mixing.
Location: West of Blakely Island, San Juan Islands (North Sound), 11:10 AM.



Field log

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*Reflection of reddish sunlight in bays due to smoke of Canadian forest fires in BC and northerly winds.
Location: Sucia Island (San Juan Islands), 11:44 PM.*



Field log

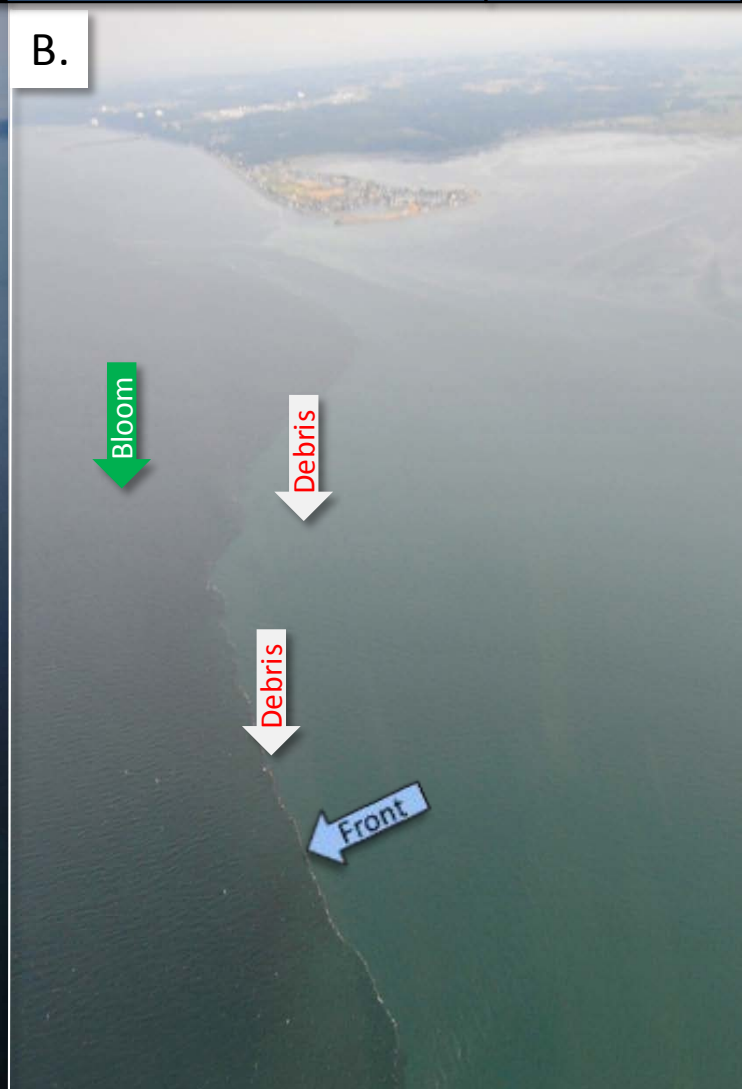
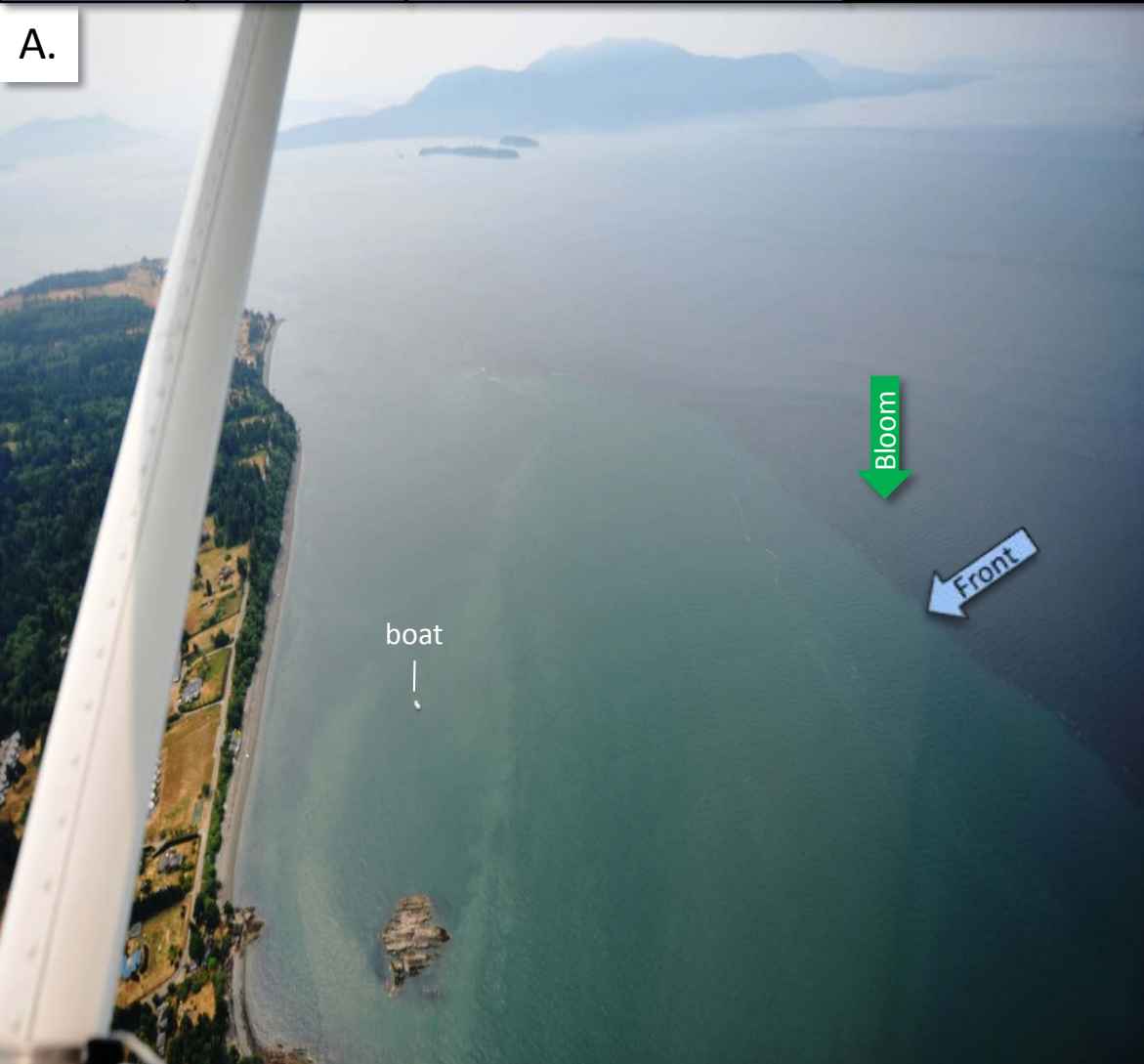
Climate

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*Water contain Nooksack River plume adjacent to a front with a brown bloom from Georgia Basin.
Location: A. West of Lummi Island, B. Lummi Bay (North Sound), 12:34 PM.*



Field log

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Large islands of organic material drifting at the surface off Samish Island.

Location: Padilla Bay (North Sound), 1:05 PM.



Field log

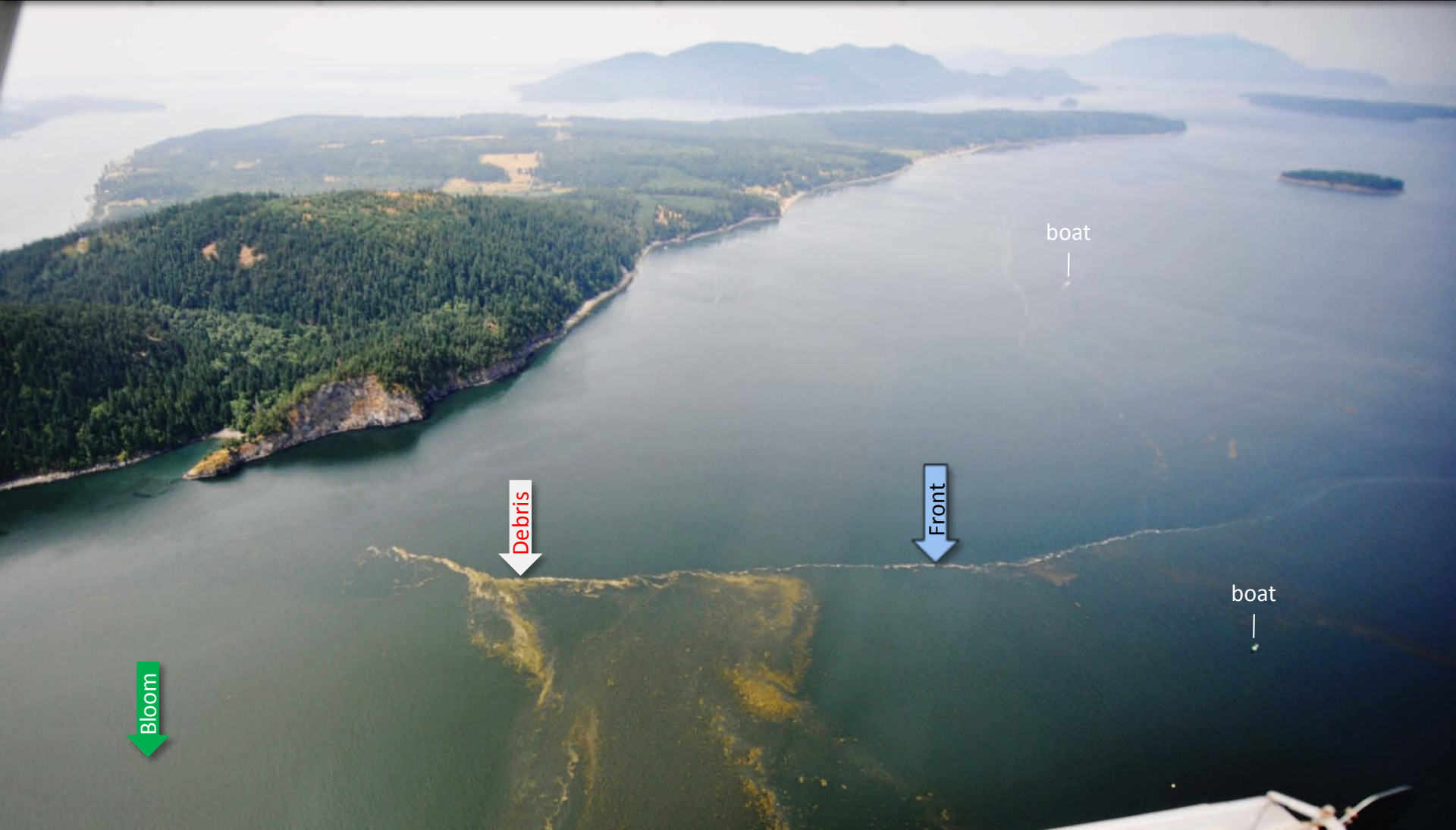
Climate

Water column

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*Large islands of organic material drifting at the surface off Guemes Island.
Location: Padilla Bay (North Sound), 1:05 PM.*



Field log

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*Tidal fronts separating sediment-rich water from water with organic debris islands at Huckleberry Island.
Location: Guemes Island, Padilla Bay (North Sound), 1:06 PM.*



Field log

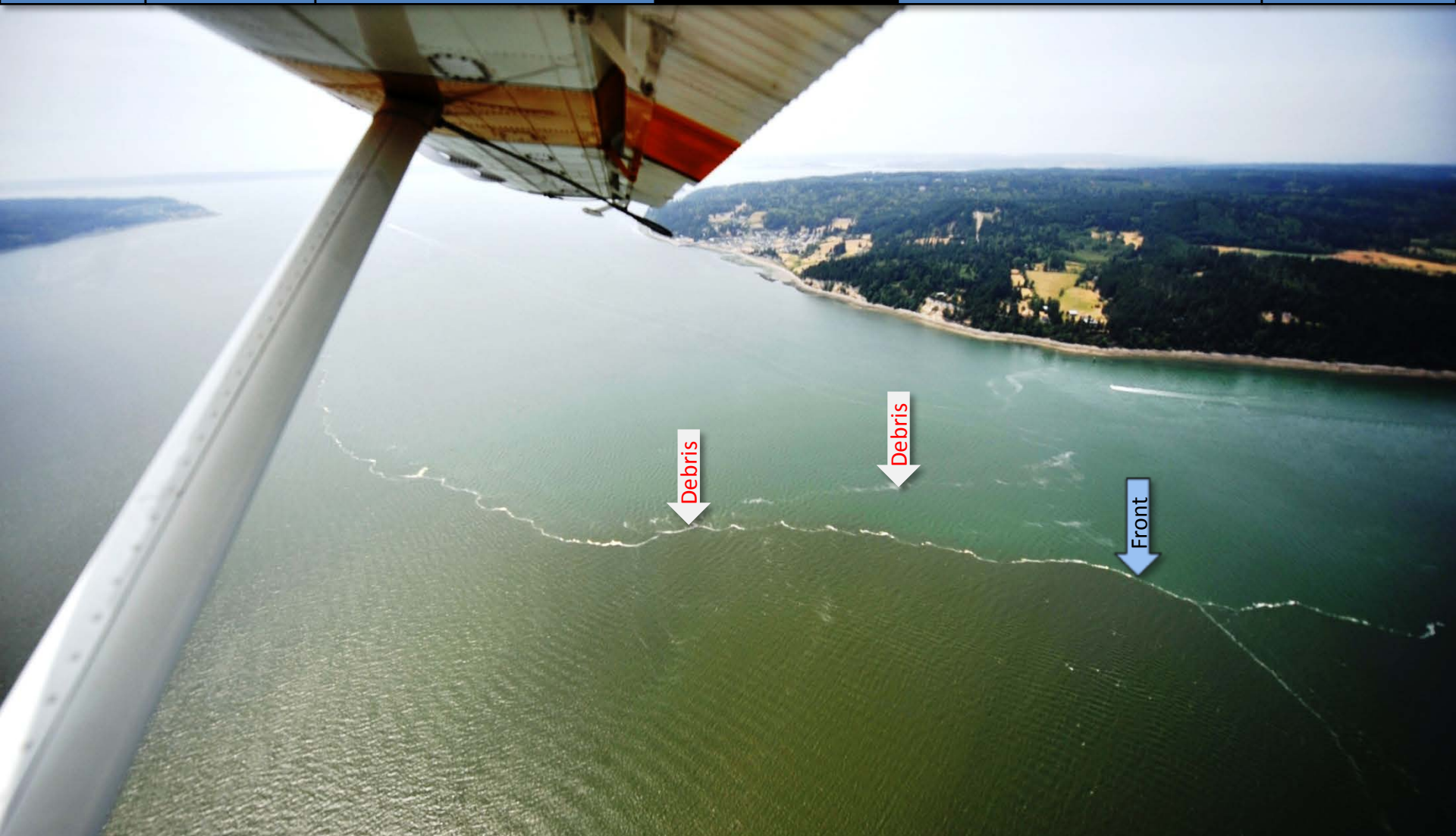
Climate

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*Long debris line along tidal front separating sediment-rich water from water with glacial flour.
Location: Skagit Bay (Whidbey Basin), 1:39 PM.*



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Organic debris islands, green algal bloom, and sediment-rich water show complexity of surface water.
Location: Off Beach Drive, Camano Island, Port Susan (Whidbey Basin), 1:44 PM.



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Extensive accumulations of organic debris along fronts spanning across Central Sound. Brown bloom.
Location: Between Port Madison and Shilshole (Central Sound), 3:03 PM.



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*Extensive accumulations of organic debris, a brown algal bloom, and a large oil sheen.
Location: Between Port Madison and Shilshole (Central Sound), 3:05 PM.*



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Tidal front lined with organic debris separating phytoplankton-rich water entering Central Sound.
Location: Between Fort Worden and Blake Island (Central Sound), 3:09 PM.



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Diffusely structured red-brown bloom in water and macro-algae on the beach.
Location: Henderson Inlet (South Sound), 3:30 PM.



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Strong red-brown bloom dwarfing sailboat.
Location: Big Tykle Cove, Budd Inlet (South Sound), 3:33 PM.



Field log

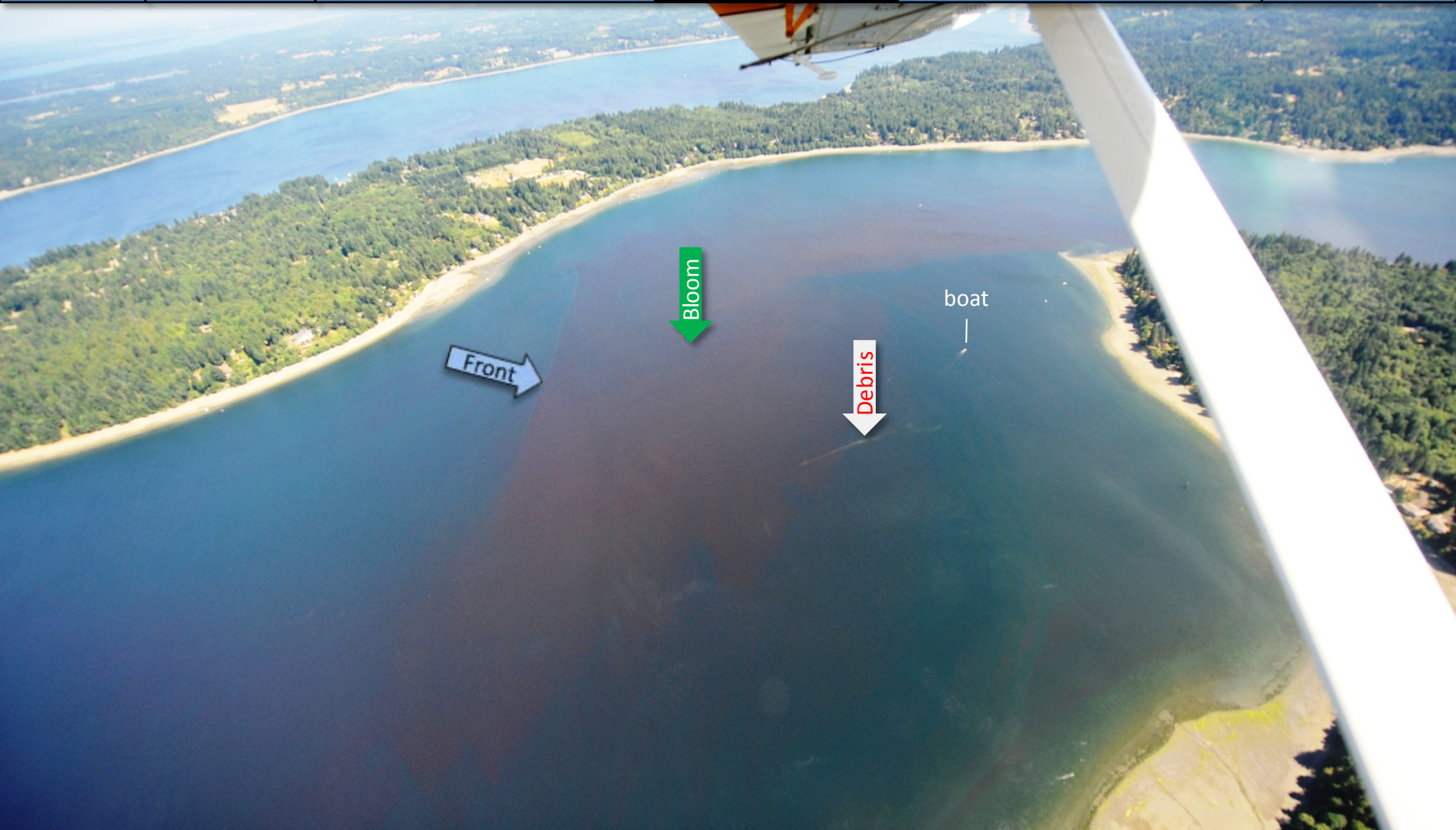
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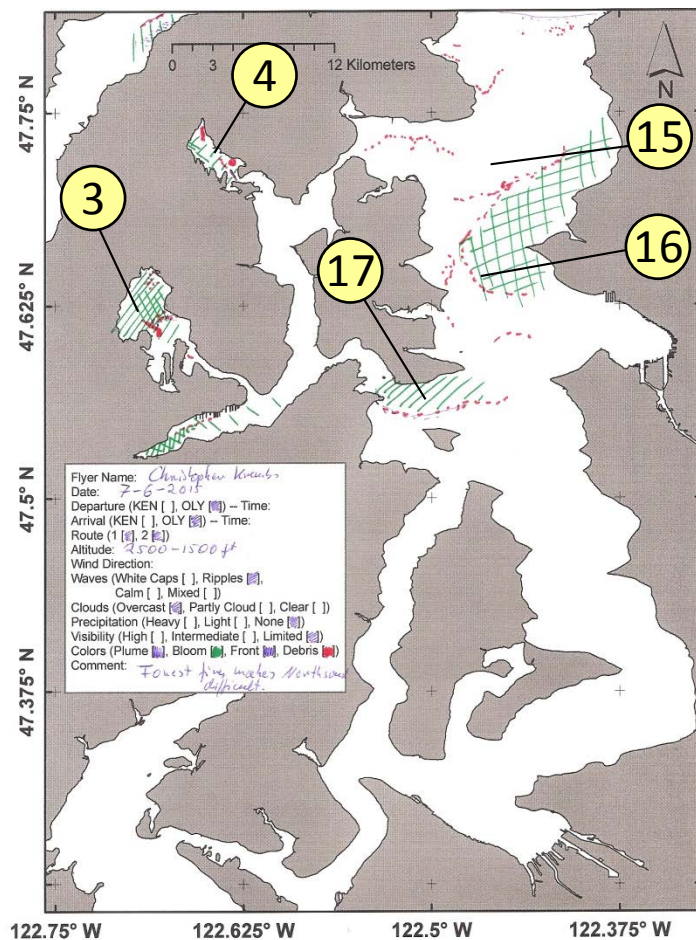


Red-brown bloom and a tidal front.

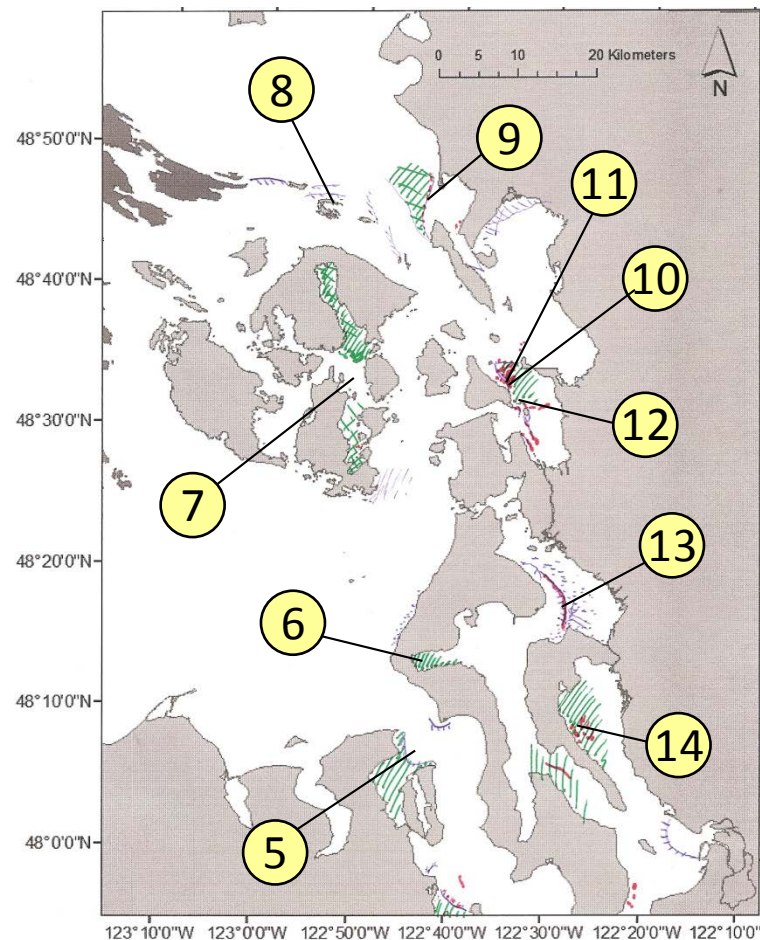
Location: Across Frye Cove County Park, Eld Inlet (South Sound), 3:35 PM.

Date: 7-6-2015

Central Sound



North Sound/San Juan Islands

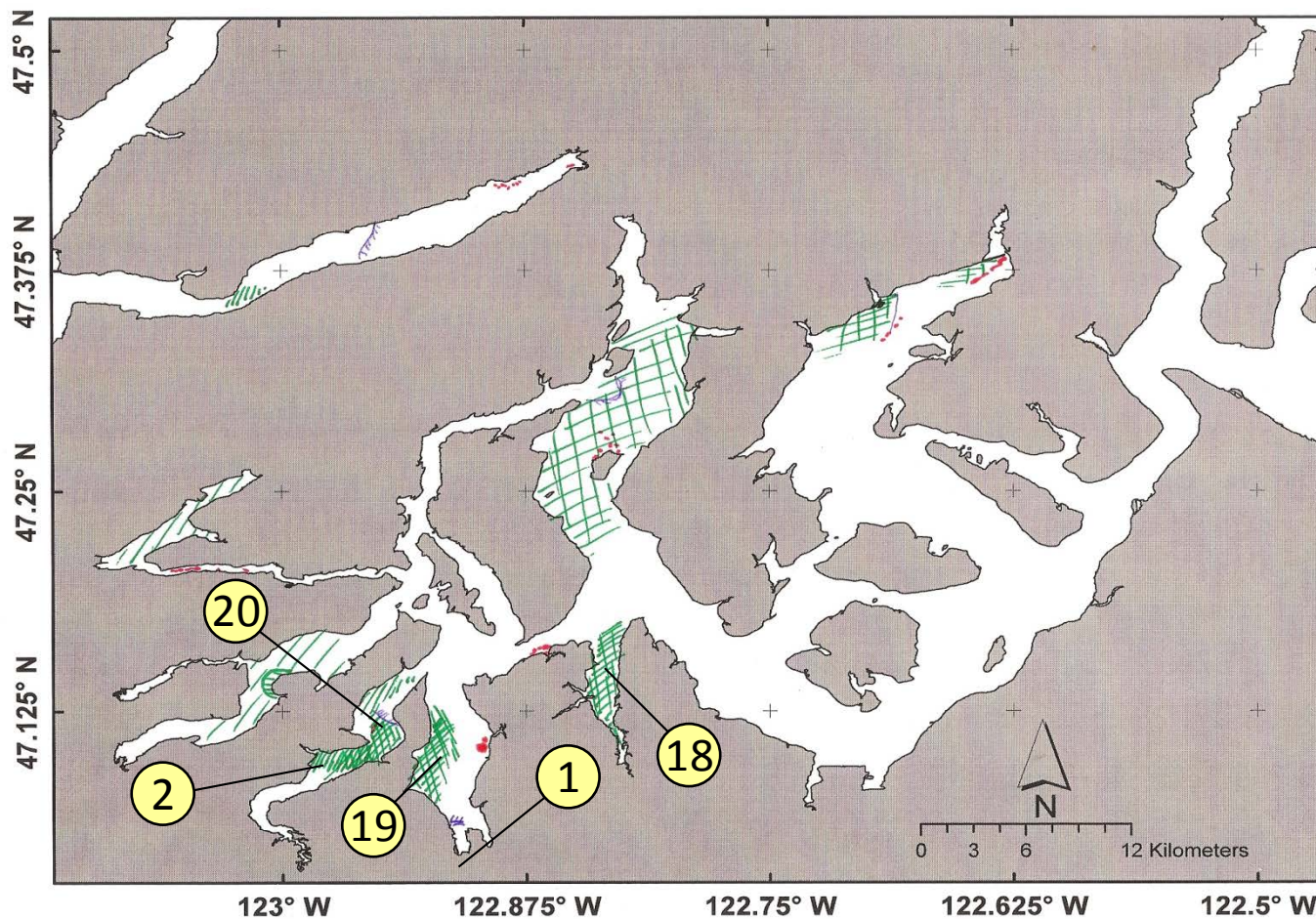


Numbers on map refer to picture numbers for spatial reference












Date: 7-6-2015

South Sound



Numbers on map refer to picture numbers for spatial reference

Plumes	
• Freshwater with sediment solid	
• Freshwater with sediment dispersed	
• Coastal erosion with sediment	
Blooms	
• Dispersed	
• Solid	
Debris	
• Dispersed	
• Solid	
Front	
• Distinct water mass boundaries	
• Several scattered	

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.

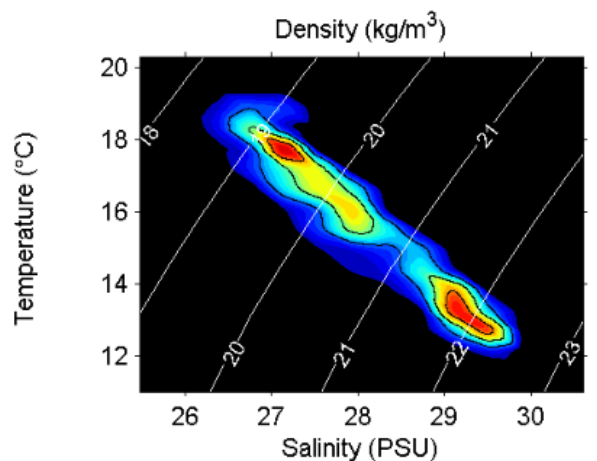
Debris:

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”.

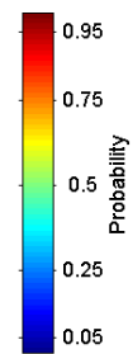
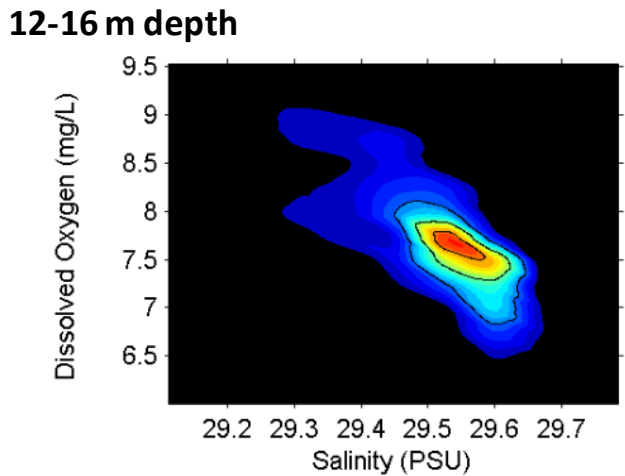
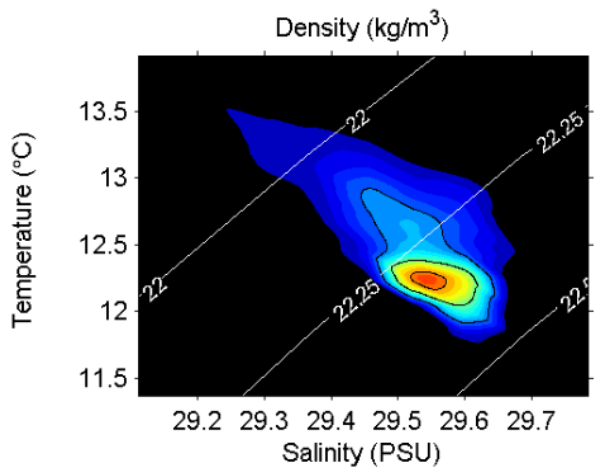
S.L. Moore, M. J. Allen. 2000. Distribution of Anthropogenic and Natural Debris on the Mainland Shelf of the Southern California Bight. Marine Pollution Bulletin, 40(1): 83–88.



At the Mukilteo mooring station, we continue to observe warmer than normal water temperature. Tidal cycle and low river flows influence gradual increase in temperature and salinity for the past month. Dissolved oxygen is decreasing for summer and is near normal levels observed in June. Temporal patterns follow a seasonal trend.



No oxygen sensor on the shallow instrument package.



These plots show the probability of observations over the past two-week period. High probability shown in warm colors.

Left Panels: Density is defined by salinity and temperature.

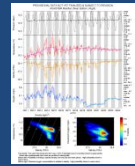
Right Panel: Dissolved oxygen concentration in relation to salinity.

Our mooring station in Mukilteo is located in Whidbey Basin near Everett. It is also located at the transition between Possession and Central Sounds at a depth that is influenced by the Skagit and Snohomish River discharges, prevailing winds, and tidal mixing.

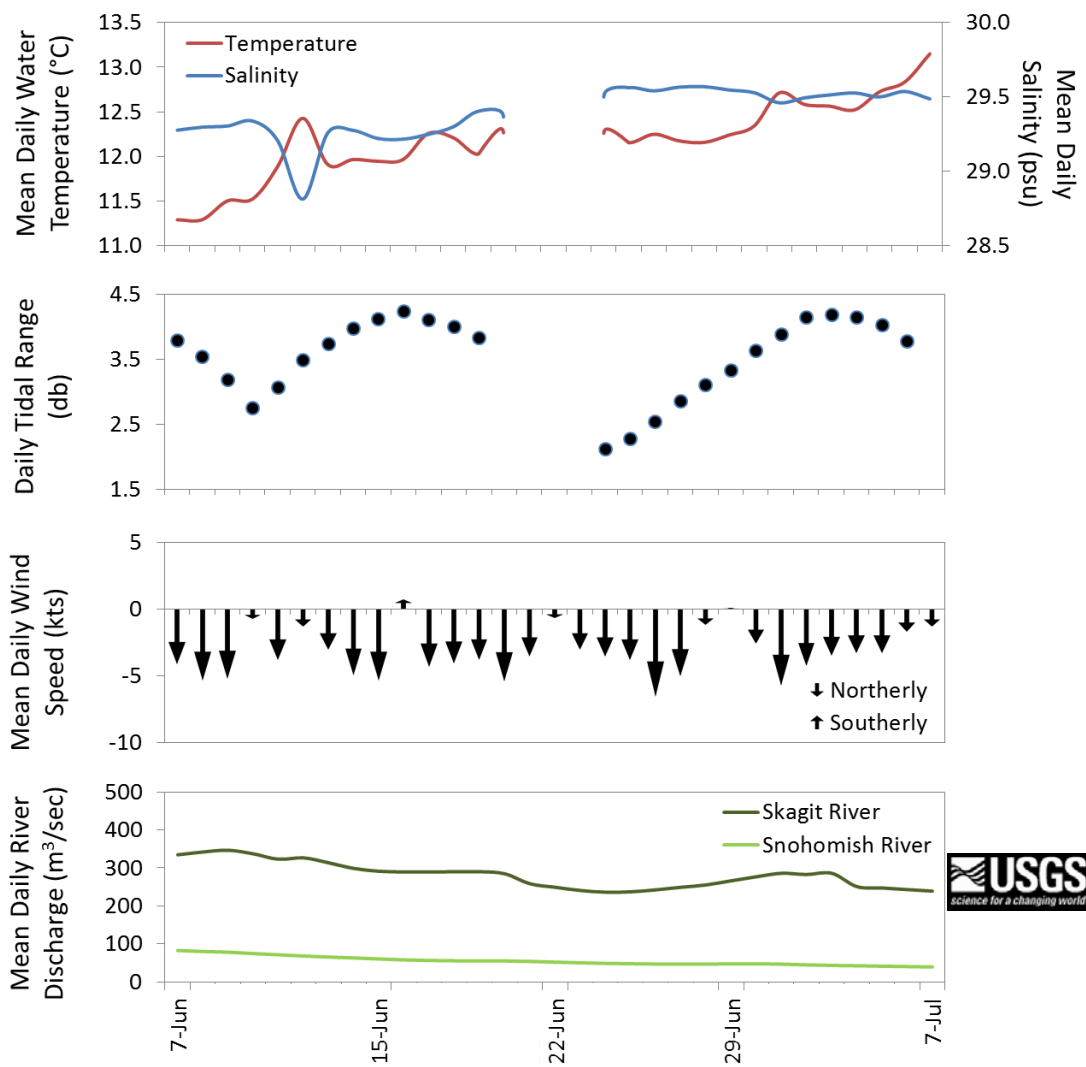
As the largest regional contributor of freshwater to Puget Sound, understanding the timing and magnitude of the Skagit River flow is important.

We present daily means for the past 31 days. Data are plotted in Pacific Standard Time. Wind data are from Paine Field in Everett. River flow data are from USGS.

Click on icon to view real-time data of the moorings



Near-bottom sensor and associated environmental data at Mukilteo

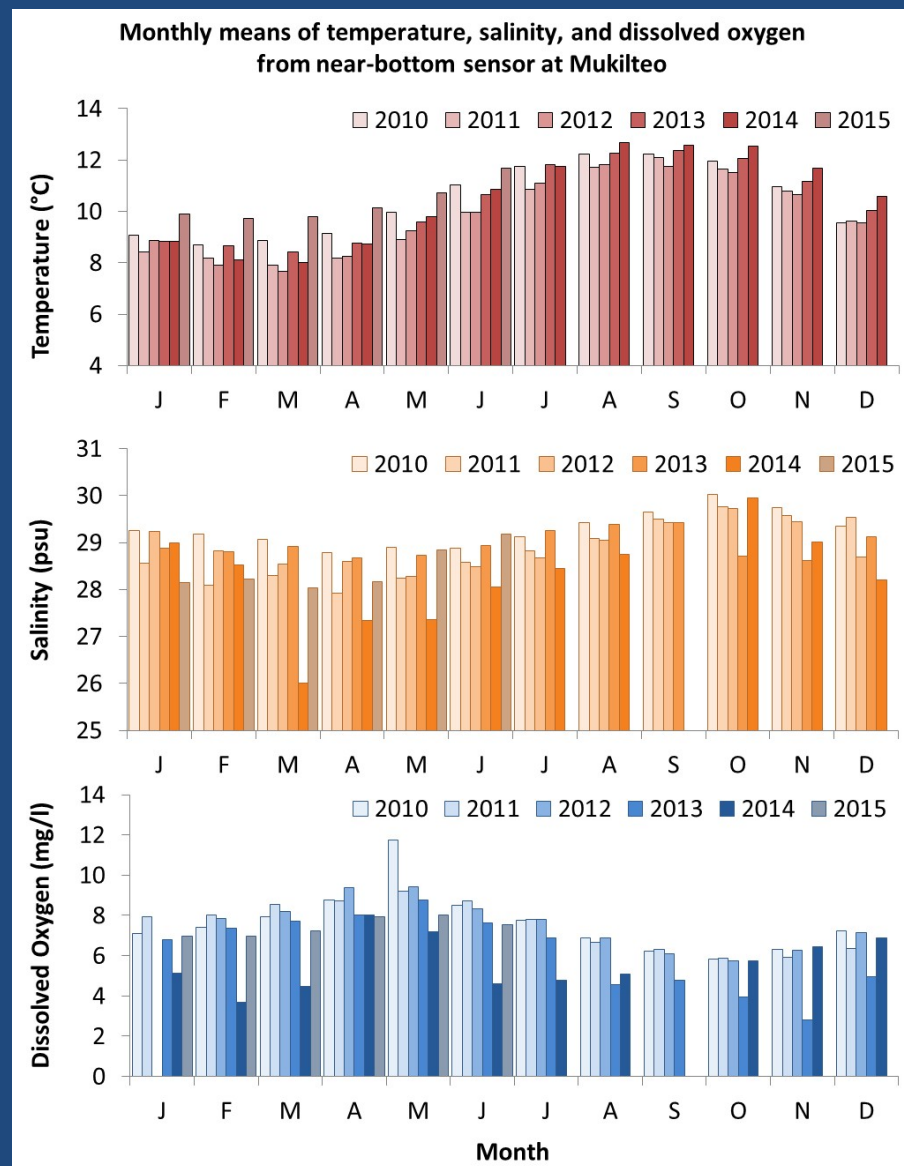


At the Mukilteo mooring, we use the near-bottom sensor (12-16 m deep) to measure significant inter-annual variability in temperature, salinity, and dissolved oxygen.

Inter-annual variability is shown over a 5-year period. All three variables show strong seasonality.

In June, water is warmer and saltier than past several years. Dissolved oxygen is near normal levels.

Seasonally, variability of each parameter remains minimal from January to June.



Please note that data are provisional. Data are in GMT.

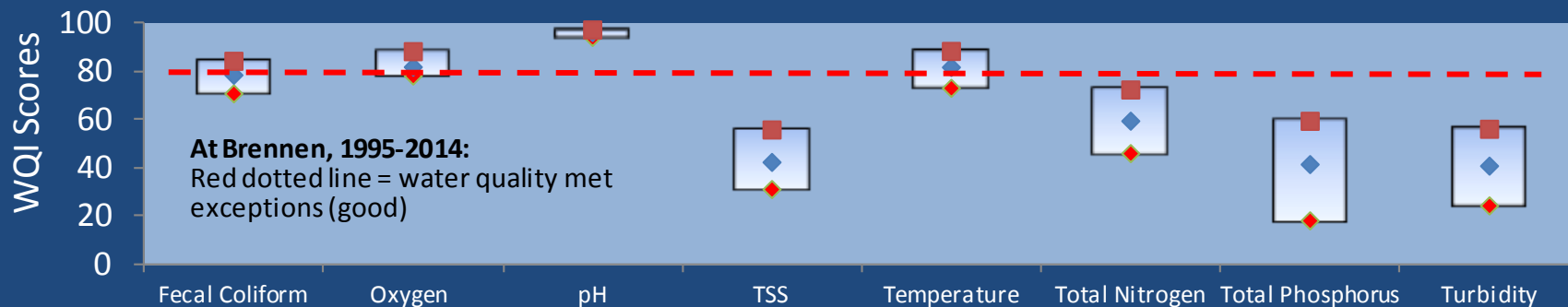
Nooksack River flowing into Bellingham Bay



The **Nooksack River** is listed for exceedances in water quality criteria for temperature and oxygen and has a management plan for bacteria.

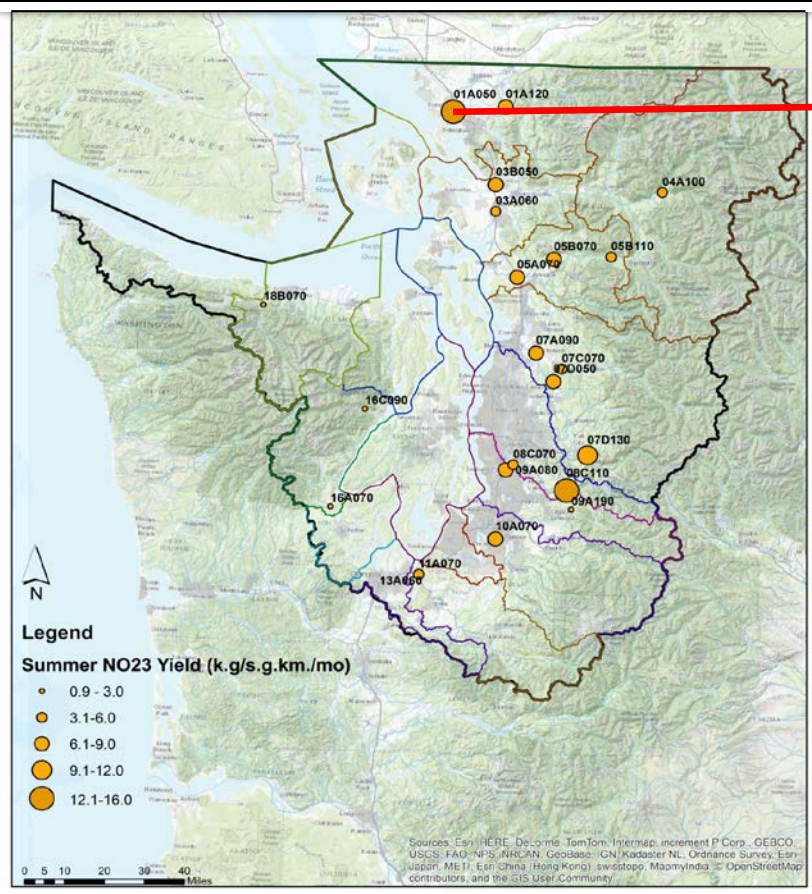
Ecology's River and Stream Monitoring Program has been obtaining water quality information at the confluence of the Nooksack River since 1971.

Annual sediment and nutrient scores are below 80 and range between moderately low to poor. Suspended sediment loading at the confluence of the Nooksack ([USGS Station 12213100](#)) is high, averaging 1070 kilo tons a year since 2011.



Nooksack River represents the largest sources of freshwater nitrogen contribution to Puget Sound. ([Von Prause, 2013](#)).

The Nooksack River has the highest nitrogen yield of all Puget Sound Rivers!



Station	TN (all)	NO _{2,3} (all)
01A050	90.54	64.43
01A120	41.39	32.35
03A060	23.56	15.93
03B050	81.3	64.15
04A100	13.48	9.4
05A070	92.04	49.2
05B070	56.18	44.74
05B110	54.24	41.24
07A090	52.89	41.4
07C070	36.63	28.61
07D050	53.37	41.44
07D130	45.36	37.39
08C070	40.39	53.49
08C110	26.78	23
09A080	52.1	36.17
09A190	21.7	16.81
10A070	36.46	23.47
11A070	29.05	19.19
13A060	49.7	41.22
16A070	34.56	13.03
16C090	9.78	5.01
18B070	10.4	4.23

Nooksack River

Average yields for freshwater nitrogen (kg/sq. km/month). "All" refers to all months.

Data are from WY 1995 through WY 2013.

Darker shading in the table body indicates higher relative yield.

Get data from Ecology's Marine Monitoring Programs



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Long-Term Monitoring Network

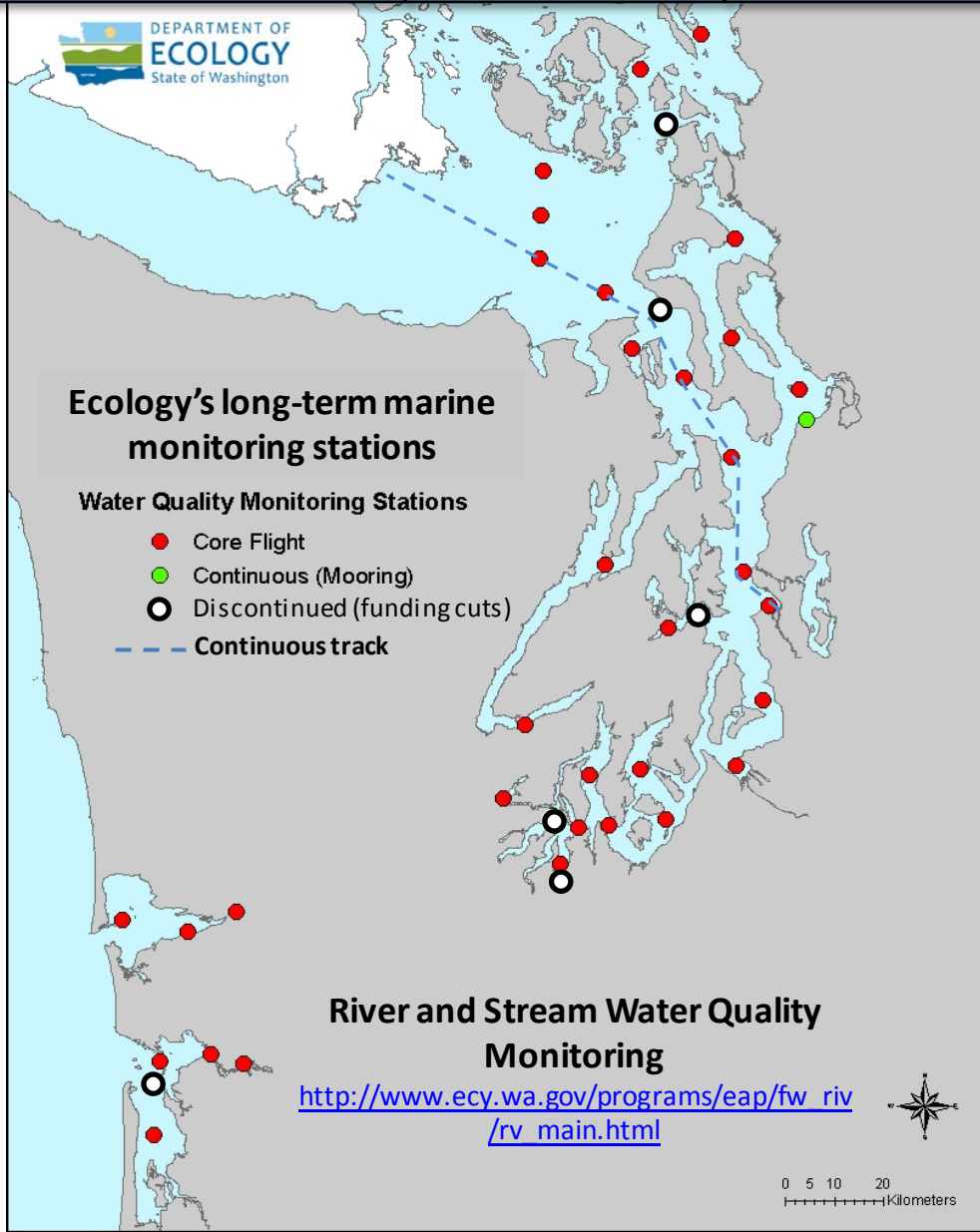


christopher.krems@ecy.wa.gov



Access core monitoring data:

<http://www.ecy.wa.gov/apps/eap/marinewq/mwdataaset.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>



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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