



Eyes Over Puget Sound

Field log

Climate

Water column

Aerial photos

Continuous monitoring

Streams

National Award for Innovation!



Marine Water Condition Index

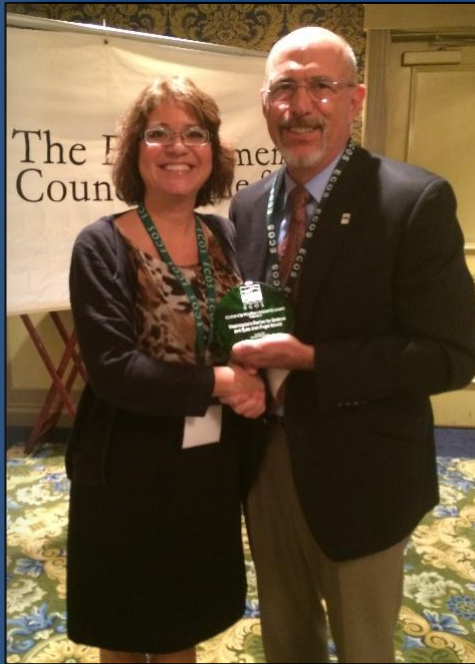
Surface Conditions Report, October 6, 2015

[Start here](#)

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

Ecology Receives National Award for Innovation!

Winning programs: Ferries for Science and Eyes Over Puget Sound



“This national award and recognition are exciting. I’m proud of this team for their hard work and the innovative program they run. They find cost-effective ways to conduct our science, engage the public, and protect Puget Sound. Congratulations, team!”
 – Director Maia Bellon



Each year, the Environmental Council of the States (ECOS) honors outstanding state initiatives with Innovation Awards. Ecology Director, Maia Bellon, accepts the 2015 Award at the annual meeting in Rhode Island (left) and presents it to the Ecology team (right).

Pictured: Back row: Christopher Krembs, Skip Albertson.
Front row: Brooke MacIntyre, Laura Hermanson, Maia Bellon, Julia Bos, Carol Maloy.
Not pictured: Mya Keyzers, Suzan Pool, Brandon Sackmann (Integral Consulting), Jim Thomson (UW Applied Physics Lab).



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LONG-TERM MARINE MONITORING UNIT

*Suzan Pool
Ardi Kveven (ORCA)*



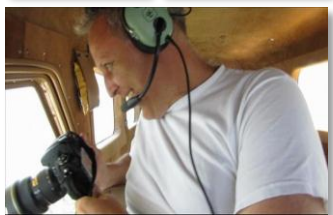
Skip Albertson



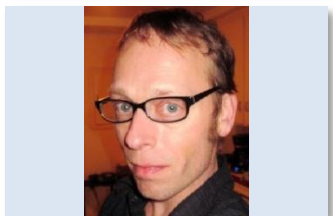
*Julia Bos
Suzan Pool*



*Dr. Christopher
Krembs*



Markus von Prause



Personal field log

[p. 4](#)

Moored sensors, a late summer barnacle bonanza!

Climate conditions

[p. 5](#)

Ocean conditions remain warm with expected upwelling on the coast. Precipitation is higher, temperatures have cooled, and river flows are finally recovering to normal.

Water column

[p. 6](#)

Puget Sound waters continue to have record high temperatures. Ongoing drought effects (lower freshwater inputs) shift salinity to higher than normal levels. Coastal Bays, Hood Canal, and South Sound exhibit lower oxygen. Will the rain change it?

Aerial photography

[p. 10](#)

Jellyfish still going strong, drifting among red-brown blooms in some finger inlets of South Sound. Numerous oil sheens in Lake Washington Ship Canal and Lake Union.

Continuous monitoring

[p. 25](#)

Phytoplankton blooms are generally fading away. Higher phytoplankton concentration still present south of Whidbey Island.

Streams

[p. 26](#)

The Nisqually River was less affected by the drought than other rivers and water quality has been improving.

Moored sensors become home to marine animals

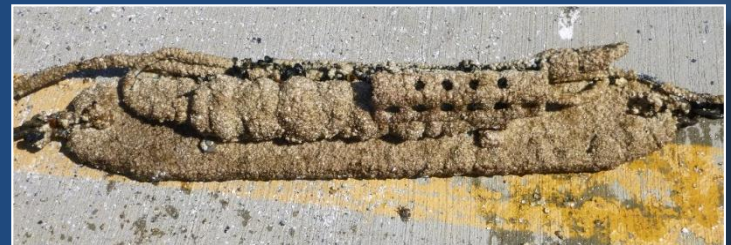
On our moorings, marine animals such as barnacles, mussels, and crabs, find homes amongst the sensors. The most active settling is during summer months when population and growth are highest. To maintain the sensors, we remove this “biofouling”. The prolific growth is why we service our moorings every four to six weeks.



A clean, near-bottom sensor package (left) becomes heavily biofouled with mostly barnacles (right).

See the bare spot on the left side of the fouled package? It has a copper tape which acts as an anti-foulant. Because of the copper effectiveness, we added more copper tape to the clean package.

A near-surface sensor is heavily covered with mostly barnacles after being in the water for two summer months.



After scraping and scrubbing, we also remove barnacles, mussels, etc. from underneath the conductivity cell guard.





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.

Putting the puzzle pieces of influencing factors together...

Summary:

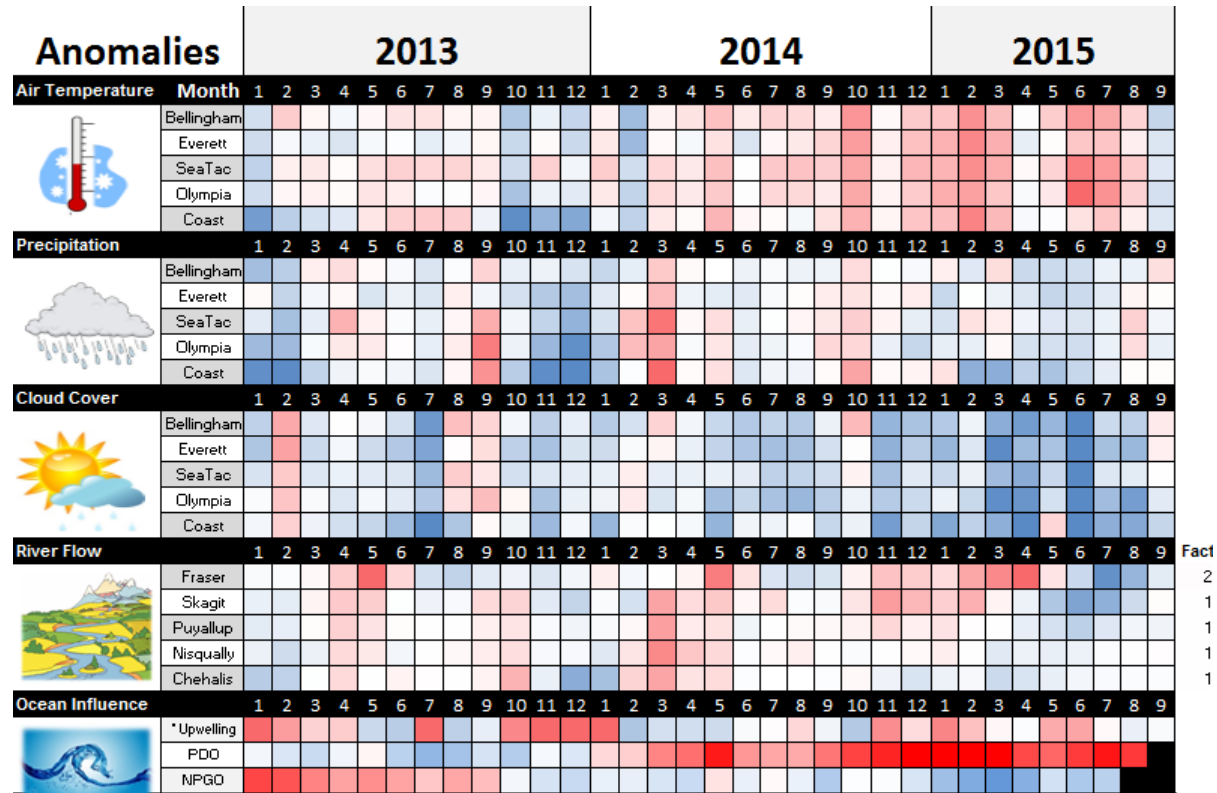
Air temperatures are cooler than normal again after a long hot summer.

Precipitation levels are again normal and higher to the north.

Cloud Cover is back so **sunlight** was lower in the north, and normal in the south.

River flows are recovering to normal levels (large rivers flowing into Puget Sound).

Upwelling is seasonally normal but **PDO** (Pacific Decadal Oscillation) remains in the warm phase.



*Upwelling Anomalies (PFEL) ■ higher ■ expected ■ lower ■ No data

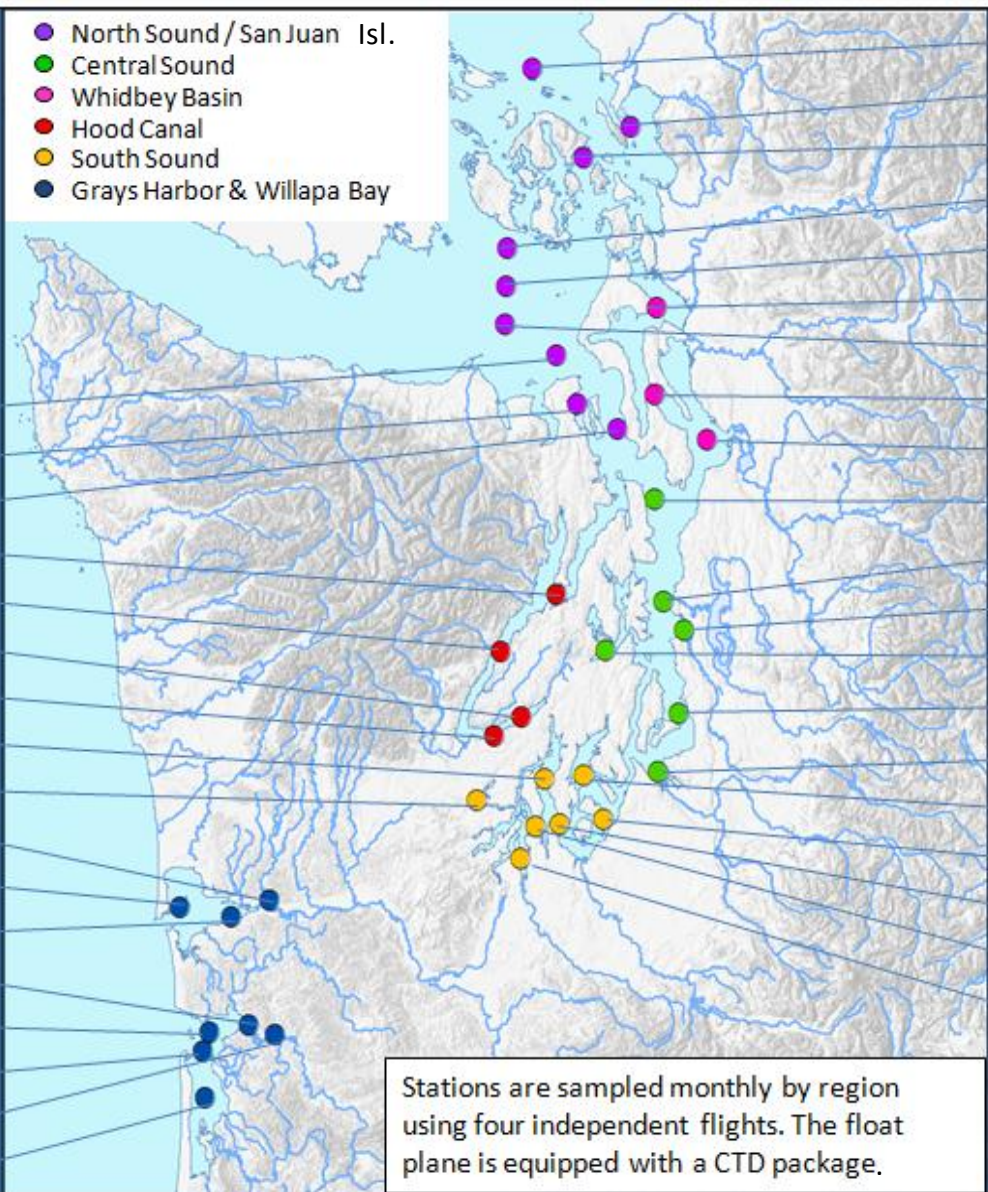
Our long-term marine monitoring stations in Washington



- Field log
- Climate
- 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.

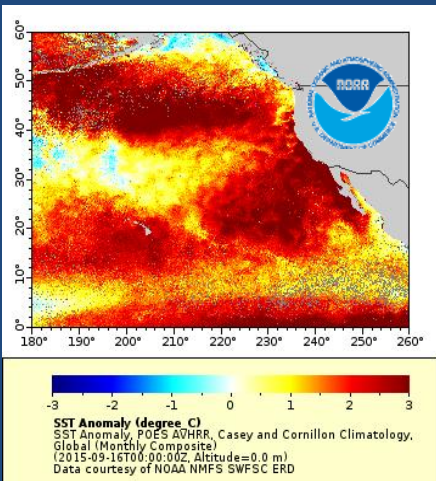
Start here

We communicate data and environmental marine conditions using:

- Marine Water Condition Index (MWCI)**
- Eyes Over Puget Sound (EOPS)**
- Anomalies and source data**

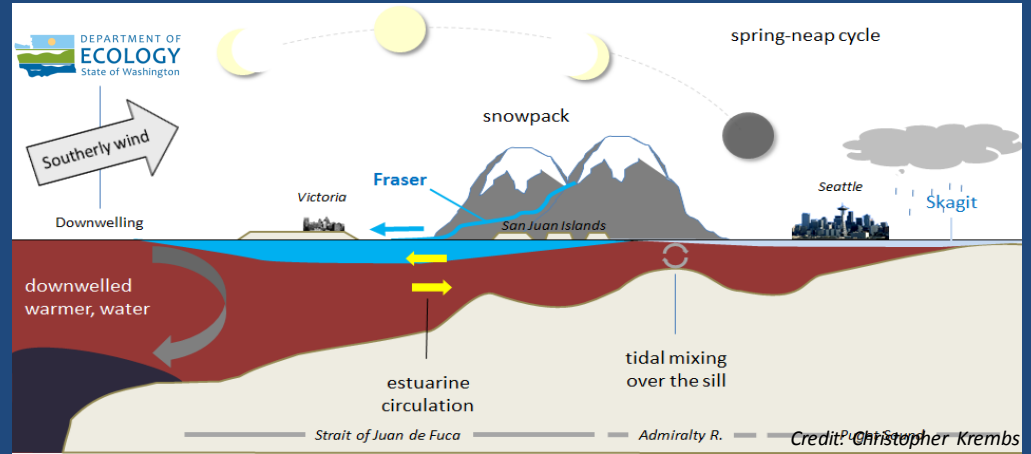


In 2014, a massive pool of warm water developed in the NE Pacific (the Blob). During the summer of 2014, Blob waters were held offshore by the process of upwelling, as northerly winds moved surface waters offshore to be replaced by cooler upwelled water. This buffered the coast. In the fall of 2014, northerly winds subsided and the Blob moved onshore, entering Puget Sound on a massive scale.



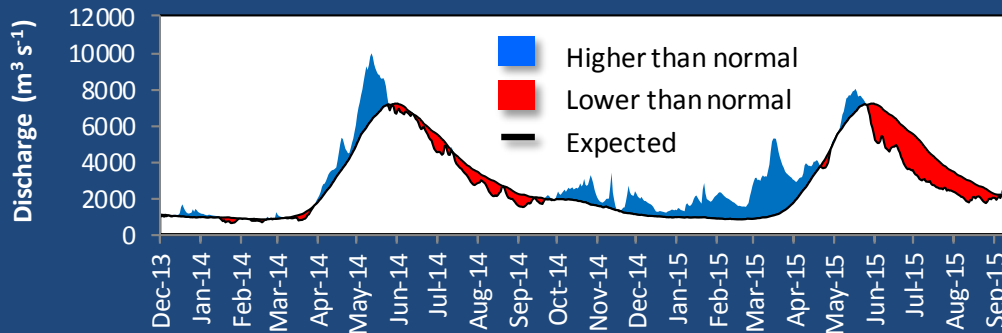
As of Sept 2015 (left), the Blob is sitting offshore.

A second warm water feature off California is growing.



Estuarine circulation had been weak since the rivers had record low flows. Rivers now normalize, increasing estuarine circulation and exchange of water, likely bringing warm surface water into Puget Sound.

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



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 due to rain and estuarine circulation should rebound.

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



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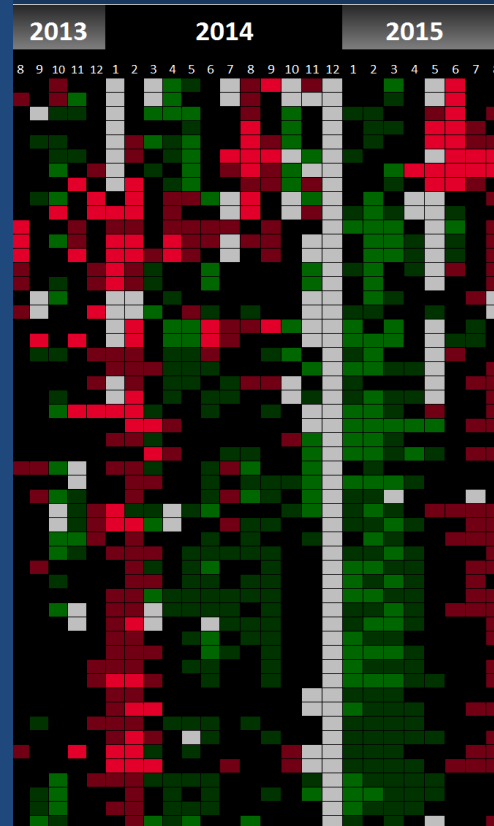


August **temperatures** were still at record-breaking **highs**. Drought effects (lower freshwater inputs) shift salinity to higher than normal levels. With recent rain in October (data not shown) salinity patterns should soon change.

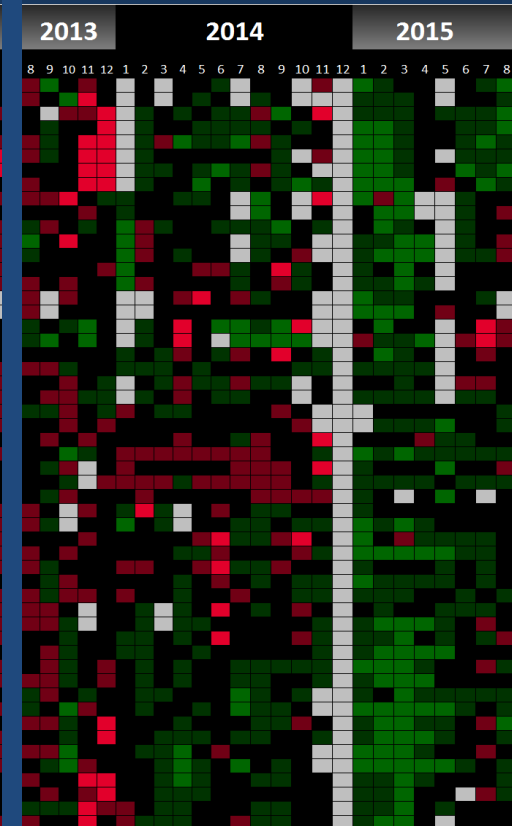
Higher Temperature!



Higher Salinity



Expected Oxygen



[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



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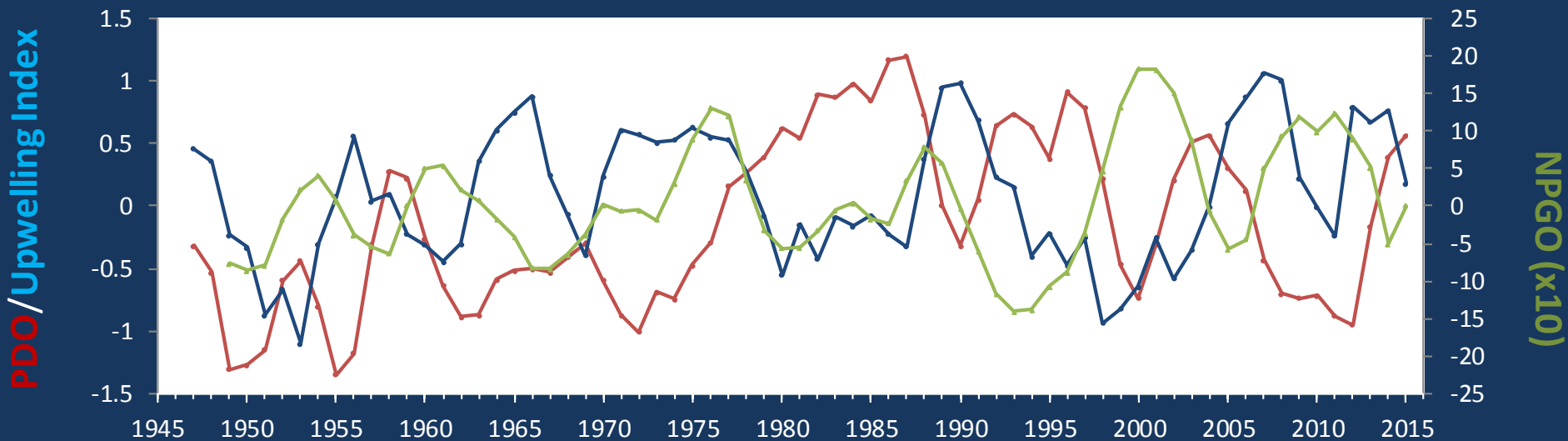
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- a) Pacific Decadal Oscillation Index (**PDO, temperature**) [\(explanation\)](#)
- b) Upwelling Index (anomalies) (**Upwelling, low oxygen**) [\(explanation\)](#)
- c) North Pacific Gyre Oscillation Index (**NPGO, productivity**) [\(explanation\)](#)

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?

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Large jellyfish aggregations still going strong in some finger inlets of South Sound surrounded by red-brown phytoplankton blooms. Suspended sediments from rivers and shorelines. Several oil sheens in Lake Washington Ship Canal and Lake Union.

Start here

Jellyfish still going strong in Budd Inlet



Oil sheen off Fairview Park, Lake Union



Mixing and Fronts:

Fronts visible around river plumes.



Jellyfish:

Numerous jellyfish patches observed in southern inlets of South Sound (Budd and Henderson) and reported in Sinclair Inlet and Quartermaster Harbor.



Suspended sediment:

Suspended sediments occurring as expected near rivers and eroding shores.



Visible blooms:

Red-brown: Eld, Budd, and Henderson Inlets.

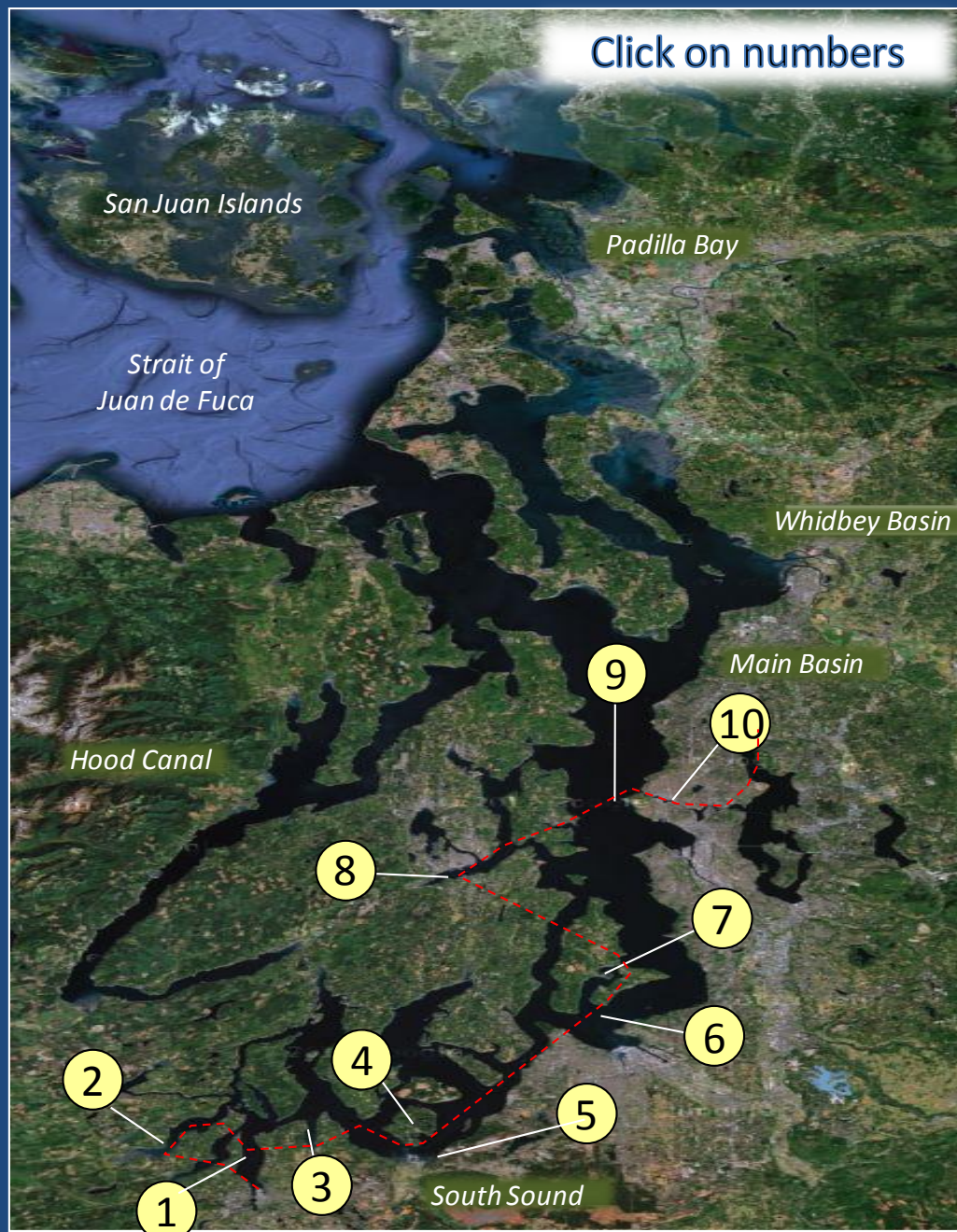


Debris:

Very little floating organic debris, confined to fronts.



Click on numbers



Aerial photography and navigation guide

Date: 10-6-2015

Tide data (Seattle):

Time	Predicted High/Low	
6:20 AM	1.34	L
2:04 PM	10.57	H
8:18 PM	5.16	L

Flight Information:

Poor visibility in South and Central Sound, increasing wind.

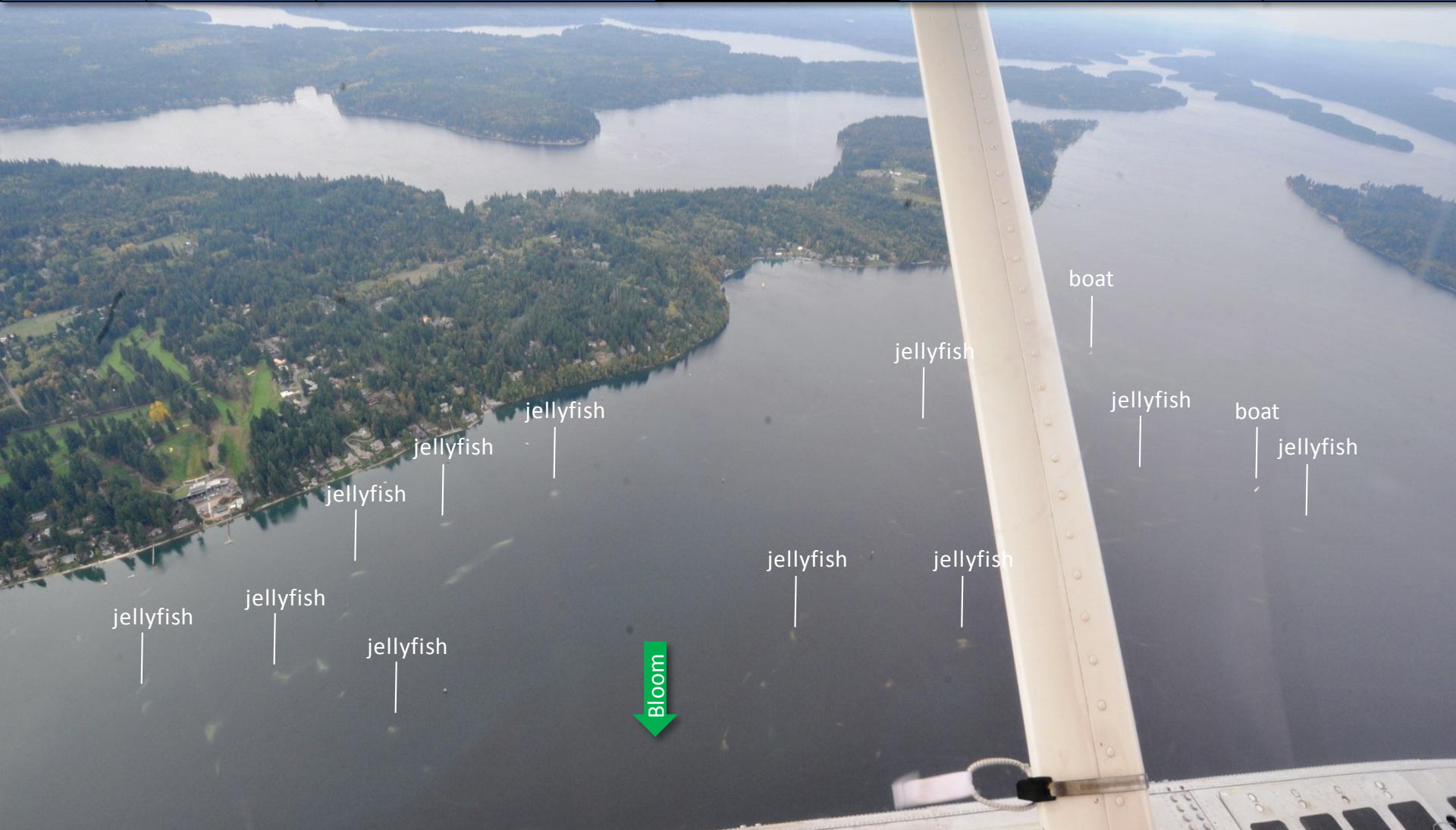
--- Flight route

Observation Maps:

Central and North Sound

South Sound

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Numerous patches of moon jellyfish mixed in with red-brown blooms.
 Location: Budd Inlet (South Sound), 1:45 PM.



Field log

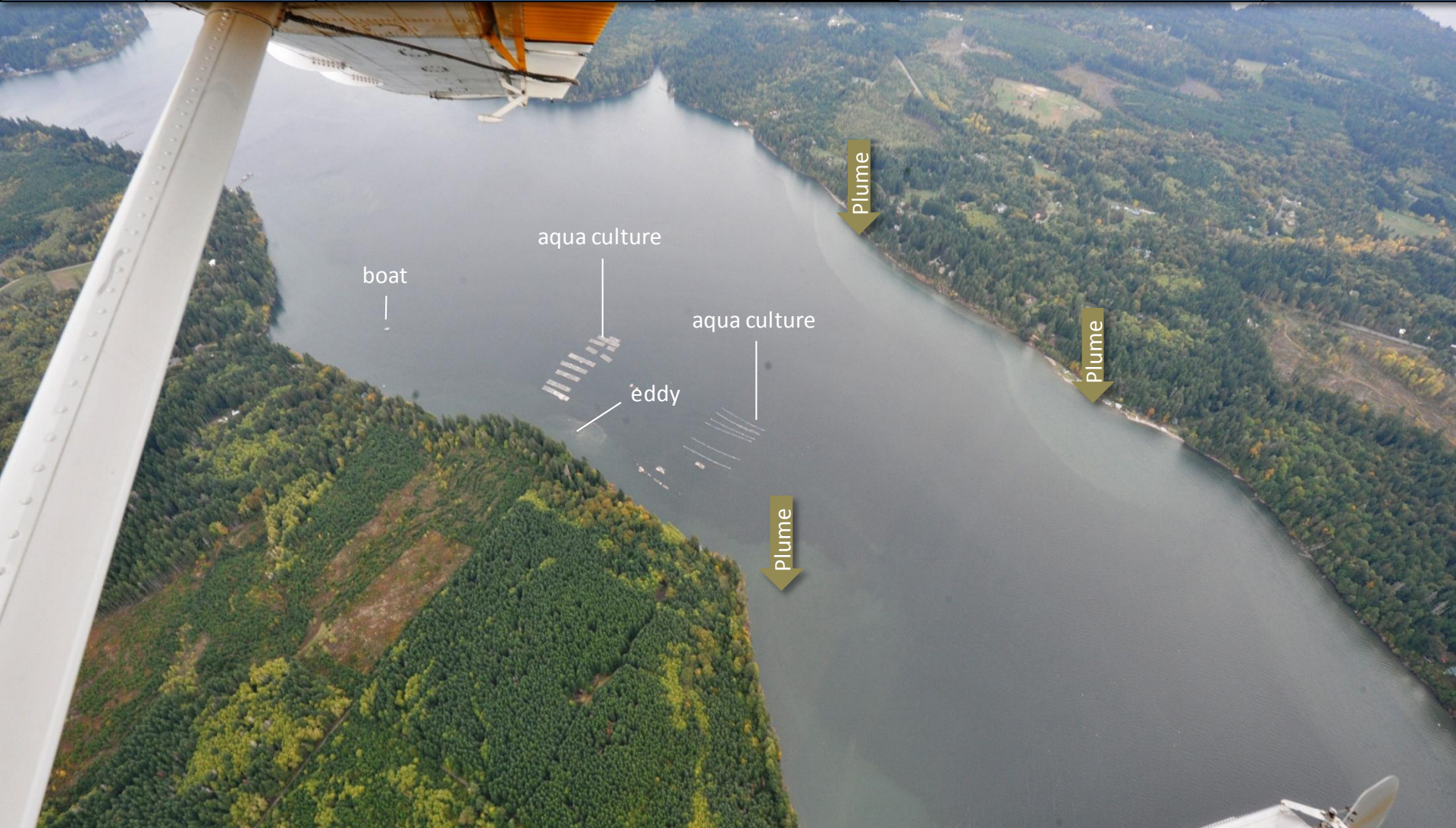
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Freshwater plumes with sediment hugging both shores. Small eddy.
Location: Big Cove, Totten Inlet (South Sound), 1:51 PM.



Field log

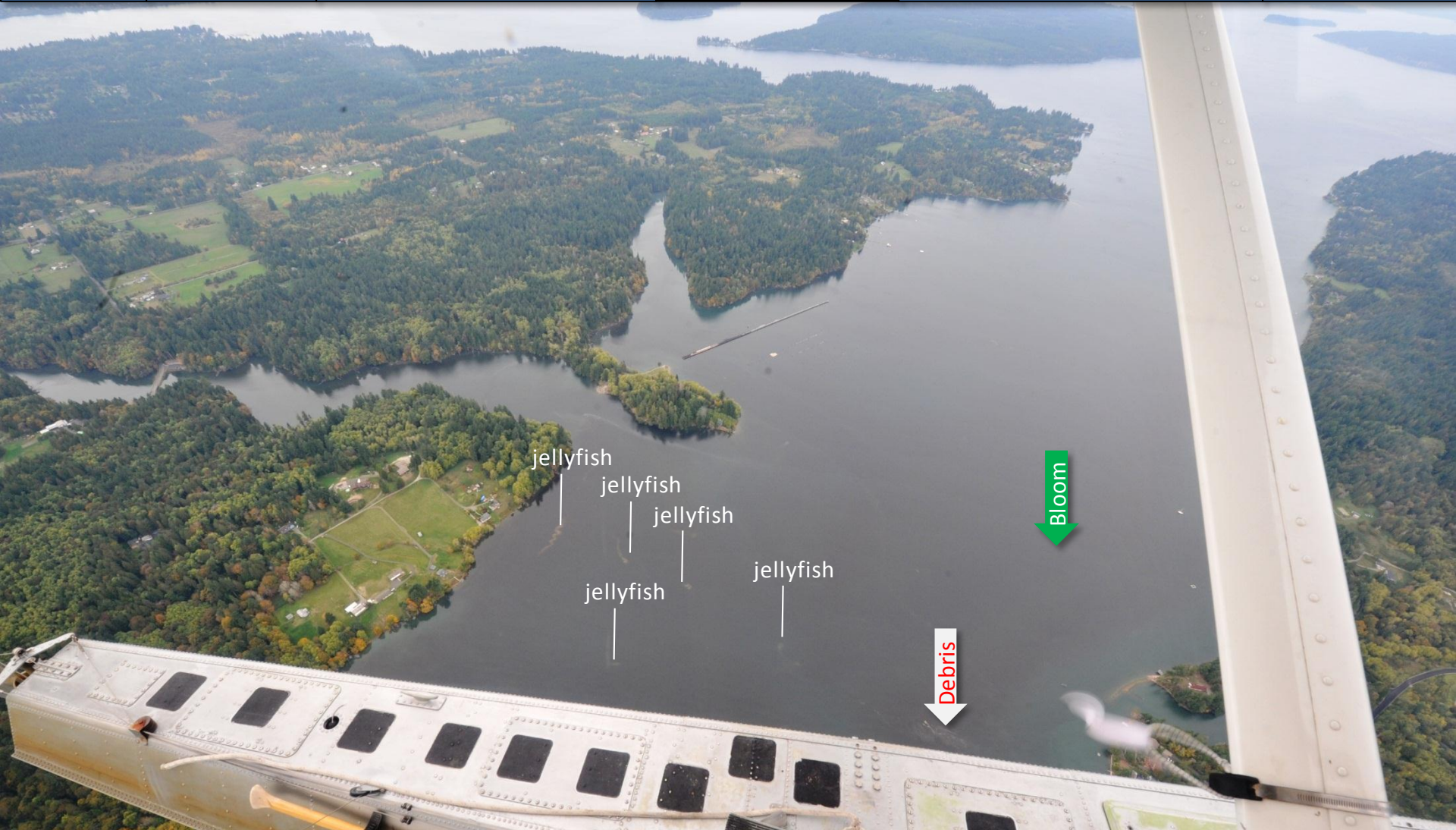
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Jellyfish patches in water containing red-brown algal bloom.

Location: Henderson Inlet (South Sound), 2:02 PM.

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

Nestled into Nisqually Reach lies Anderson Island with Oro Bay.
Location: Anderson Island (South Sound), 2:06 PM.

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

Nisqually River plume and delta flowing low yet above daily mean values.

Location: Nisqually (South Sound), 2:06 PM.



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Puyallup River plume flowing past Commencement Bay. Several faint fronts.

Location: Dash Point, Commencement Bay (Central Sound), 2:14 PM.

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A picture from Bill & Peggy Fox, Oct. 5, 2015..."We spent the night in Quartermaster Harbor and were visited by these friends"...



Moon jellies reported for Quartermaster Harbor for the day prior to flight. Visibility too low.
Location: Quartermaster Harbor (Central Sound), 2:16 PM.



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Turquoise plume hugging southern shore.
Location: Sinclair Inlet (Central Sound), 2:23 PM.



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*Coastal erosion with suspended sediment from Magnolia Bluff flowing past West Point Lighthouse.
Location: West Point Lighthouse, Seattle (Central Sound), 2:29 PM.*



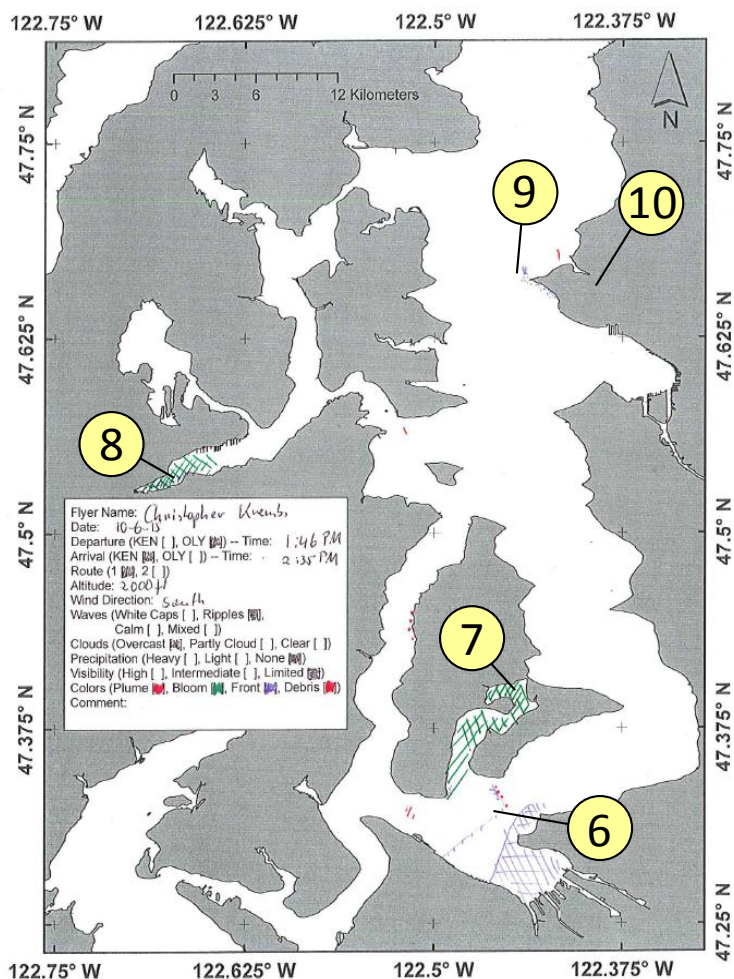
*Extensive oil sheens from dock 4 & 5 spreading with southerly winds across Lake Washington Ship Canal.
Location: Lake Washington Ship Canal, Seattle (Central Sound), 2:31 PM.*



Date: 10-6-2015

Central Sound

North Sound/San Juan Islands

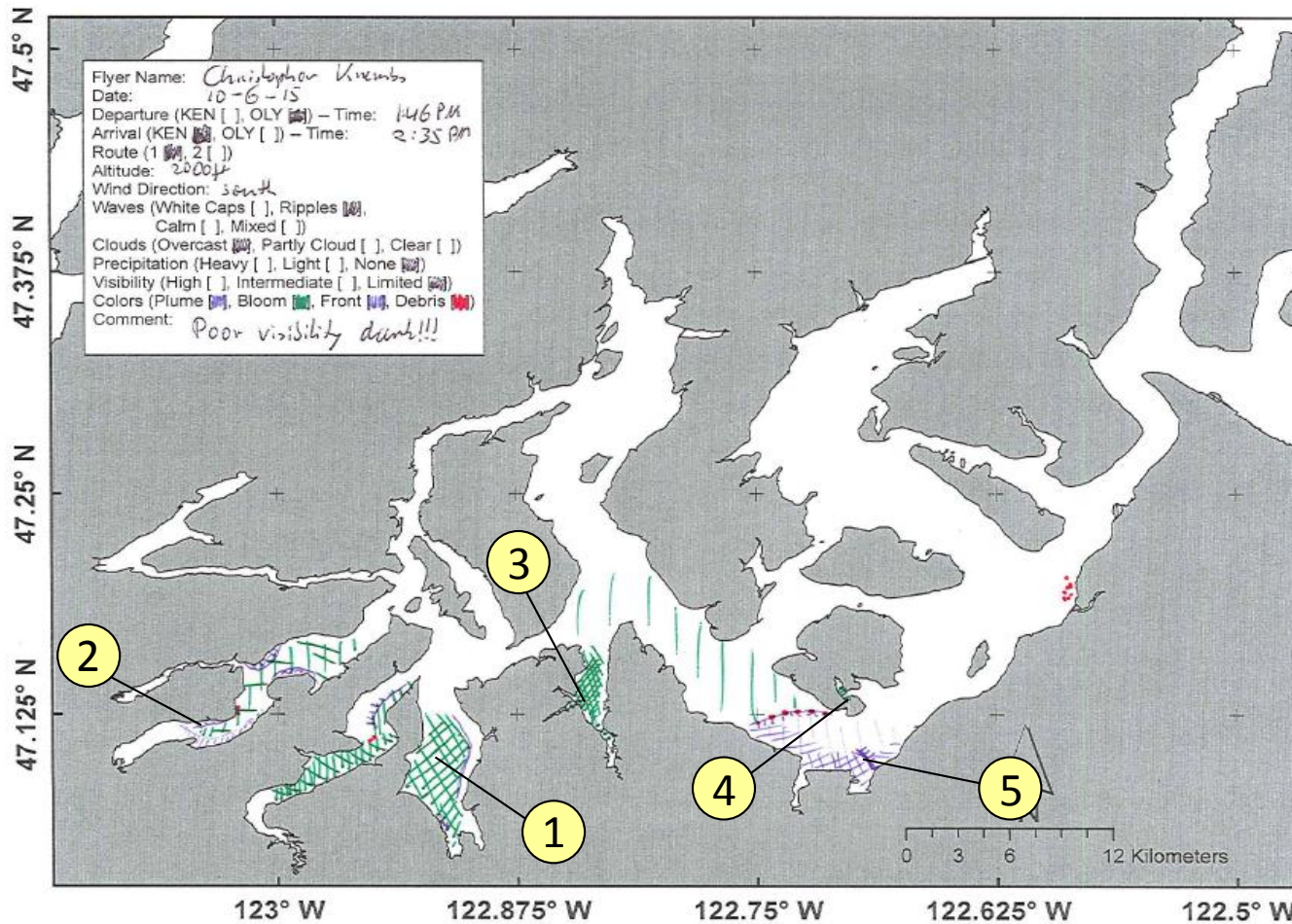


n.a










Numbers on map refer to picture numbers for spatial reference

Date: 10-6-2015

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:

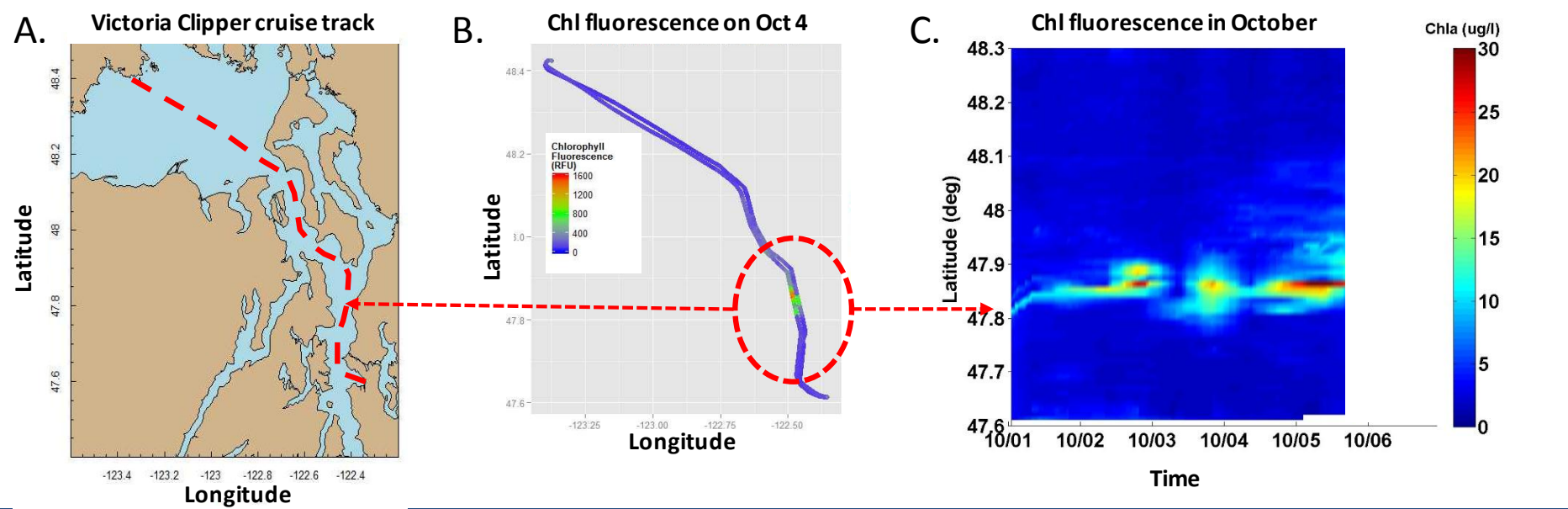
Debris can be distinguished into natural and anthropogenic debris floating at the surface *sensu* Moore and Allen (2000). The majority of organic debris in Puget Sound is natural and mixed with discarded man-made pieces of plastic, wood, etc. From the plane, we cannot differentiate the quality of debris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



Summary of Victoria Clipper data:

In early October, moderate phytoplankton concentrations persist near Edmonds, indicated by chlorophyll fluorescence (A, B, and C). Near Edmonds and south, we see warmer surface water of 14°C, while north of Edmonds, extending into Admiralty Reach, water is 2 °C cooler (data not shown).



The *Victoria Clipper IV* carries sensors in its sea chest. The sensors allow us to get surface transects of temperature, chlorophyll, salinity, and other bio-optical measurements between Seattle and Victoria, BC twice per day.



The Nisqually River was less affected by the drought than other rivers

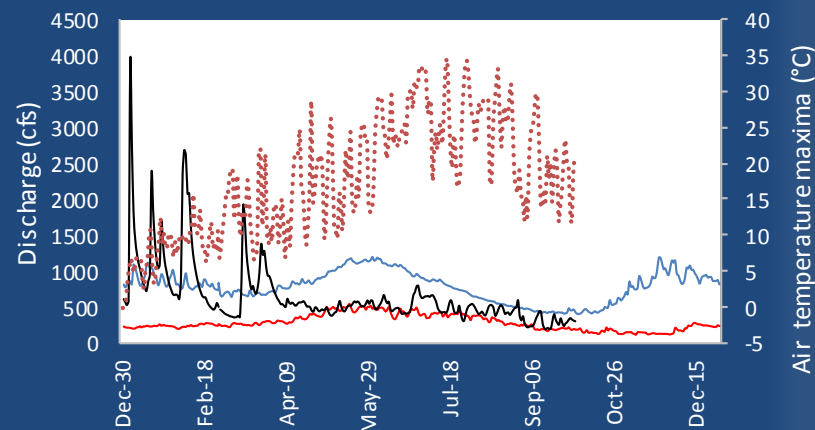
Ecology's River and Stream Monitoring Program has measured Nisqually River water quality at two long term sites since the 1960s . [\(11A080\)](#) [\(11A070\)](#).



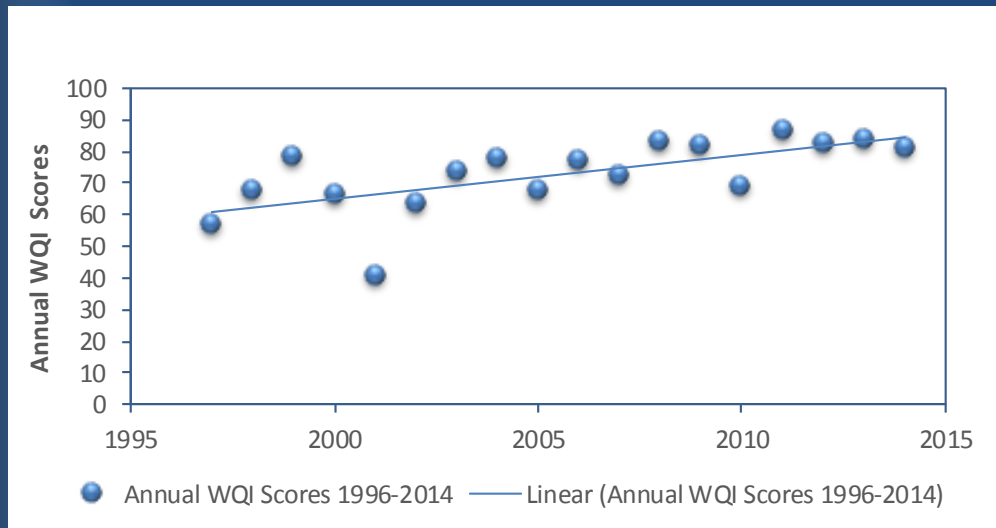
The hydrological cycles in the Nisqually Watershed are shifting. Several best management practices have been implemented and overall water quality has been improving.

Originally fed by glaciers, the Nisqually River provides half the total freshwater to southern Puget Sound.

- Last winter, river flows (black line) were much above historical mean daily values (blue line).
- Starting in April 2015, daily mean flows (black line) stayed just above the historical minimum (red line).



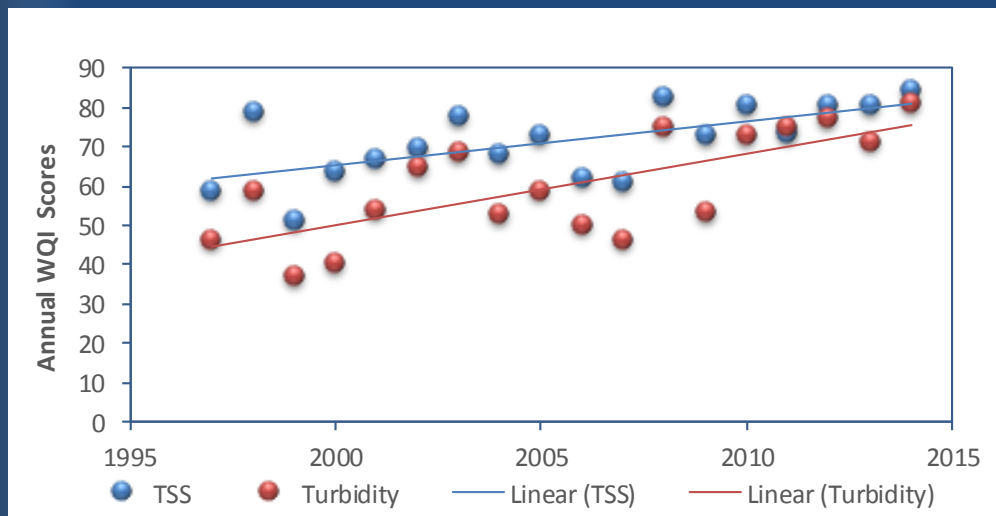
- Historic mean daily discharge 1941-2014
- 2015 mean daily discharge (cfs)
- Historic minimum mean daily 1941-2014
- Daily maximum air temperatures



Flow Adjusted Annual WQI Scores at (11A070)

- Since 1997 the Water Quality Index (WQI) trends have been improving, from scores of 41-70 to scores >80 (good) from 2011-2014.

[Link to: Water Quality Index, \(11A070\)](#)



Annual WQI Scores For Total Sediment Concentration and Turbidity at at (11A070)

- Annual sediment scores (left) have improved substantially in recent years.
- Annual nitrogen, temperature, and phosphorus scores (not shown) have moderate improvement.

Nisqually Watershed Stream Restoration Efforts



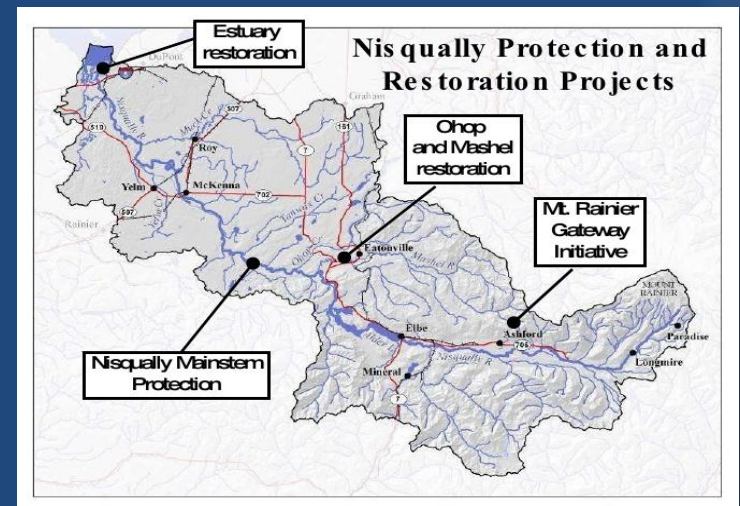
Photo courtesy of the
[South Sound Enhancement Group](#)



Over the past 10 years, best management practices have been taking place to improve water quality and to restore salmon habitat in the Nisqually watershed.

Some projects include riparian restoration to minimize stream bank erosion, stream corridor/culvert improvements and water quality monitoring on tributaries connected to the main stem of the Nisqually River.

Channel reconstruction and restoration efforts on Ohop Creek, a tributary to the Nisqually River.



Get data from Ecology's Marine Monitoring Programs



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Long-Term Monitoring Network

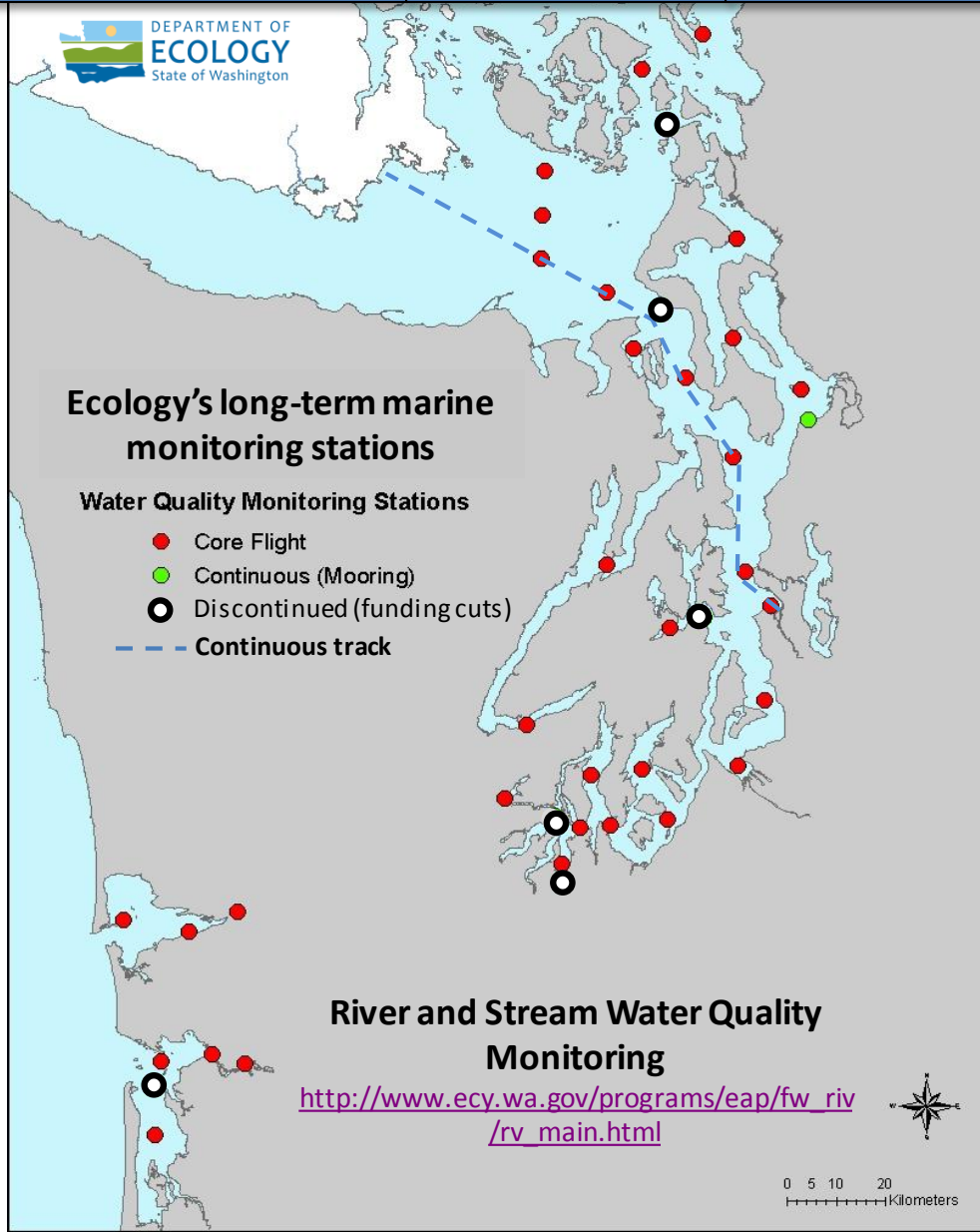


christopher.krems@ecy.wa.gov



Access core monitoring data:

<https://fortress.wa.gov/ecy/eap/marinewq/mwdata set.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
christopher.krembs@ecy.wa.gov

**Marine Monitoring Unit
Environmental Assessment Program
WA Department of Ecology**