



Eyes Over Puget Sound

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

Marine Water Condition Index

Surface Conditions Report, August 4, 2015

[Start here](#)

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

Field log

Climate

Water column

Aerial photos

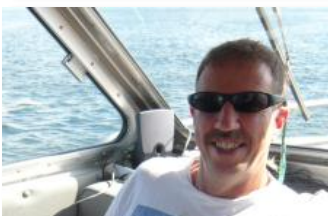
Continuous monitoring

Streams

*Mya Keyzers
Laura Hermanson*



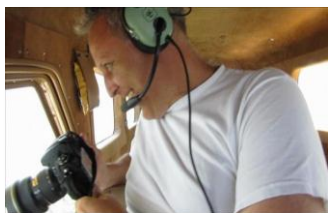
Skip Albertson



*Julia Bos
Suzan Pool*



*Dr. Christopher
Krembs*



*Jessica Payne
Markus von Prause*



Personal field log

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Scientists engage the media to talk about “the Blob”. Ecology and NOAA team up to track jellyfish.

Climate conditions

[p. 6](#)

Air temperature and ocean conditions remain warm. River flows are below normal, especially the Fraser and Skagit rivers. Upwelling off the coast is normal.

Water column

[p. 7](#)

Puget Sound waters are warm because of “the Blob”. Temperatures are the highest on record since 1989 and we keep sitting on the same warm water.

Aerial photography

[p. 11](#)

Impressive jellyfish masses in some finger inlets of South Sound. Large debris islands in Central Sound persist. Phytoplankton blooms in colors of red-brown, green, and brown in South Sound and some bays of Kitsap Peninsula.

Continuous monitoring

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Water is warmer and saltier than the past 5 years.

Streams

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The Deschutes River has very low flows and high nitrogen concentration stemming from groundwater. Does this contribute to the blooms in Budd Inlet?

Scientists Engage the Media to Talk About “the Blob”

On July 30th, Ecology invited local scientists and the media to talk about the warm water “blob” that is affecting the waters of Puget Sound. Warmer water combined with lower than normal river flows, drought conditions, and the resulting lower dissolved oxygen content in the water can lead to many negative environmental repercussions. This media event was an effort to inform the public on the important work agency scientists (local, state, federal, and academic) are doing to monitor and assess these unusual conditions. Visit our blog and links below for details.



Hydrologist Jim Shedd talking to a reporter about drought conditions.



Flight technician Laura Hermanson talking to a KUOW reporter about the CTD.



Oceanographer Christopher Krembs helps set the stage about the unusual conditions.



Special thanks to **Jessica Payne**, our Communications Manager, for setting up the media day.

Some links to media coverage about the warm water Blob:

King 5 video: Warm water “blob” invades Puget Sound

<http://www.king5.com/story/news/local/2015/07/30/blob-in-puget-sound/30916753/>

Ecology's ECOconnect blog: Puget Sound waters left sweltering after double punch from the drought and the Blob

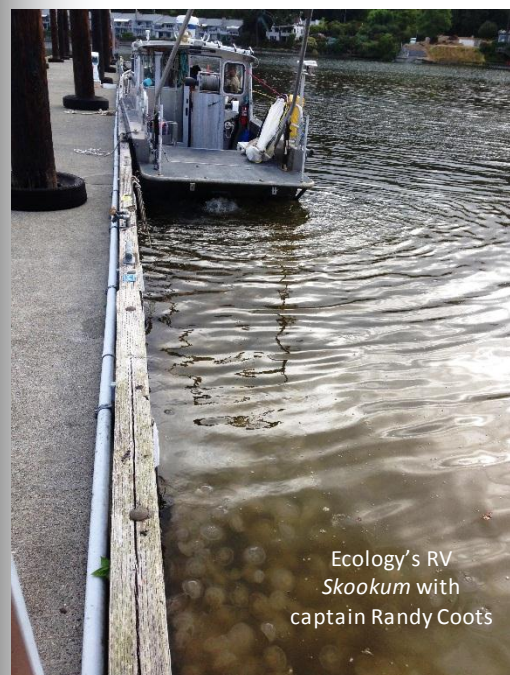
<http://ecology.wa.gov/blog/2015/07/puget-sound-waters-left-sweltering.html?m=1>

KUOW: Puget Sound Salmon Losing, Jellyfish Winning

<http://kuow.org/post/puget-sound-salmon-losing-jellyfish-winning>

Ecology and NOAA team up to track jellyfish in Puget Sound

Can aerial photos of jellyfish smacks be used to track jellyfish populations in Puget Sound? To find out, scientists from NOAA, the Department of Ecology, and Western Washington University are sampling giant patches of jellyfish and comparing the numbers to images of jellyfish aggregations taken on EOPS flights. The goal is to use aerial photos to estimate overall jellyfish abundance and distribution in the inlets of Puget Sound. With the plane in the air and the research vessel *Skookum* on the water, we set out to do some ground-truthing.



Ecology's RV
Skookum with
captain Randy Coots



Excellent coverage by reporter Alison Morrow, King 5 News:

<http://www.king5.com/story/tech/science/environment/2015/08/05/jellyfish-ecology-noaa-puget-sound/31194035/>



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:

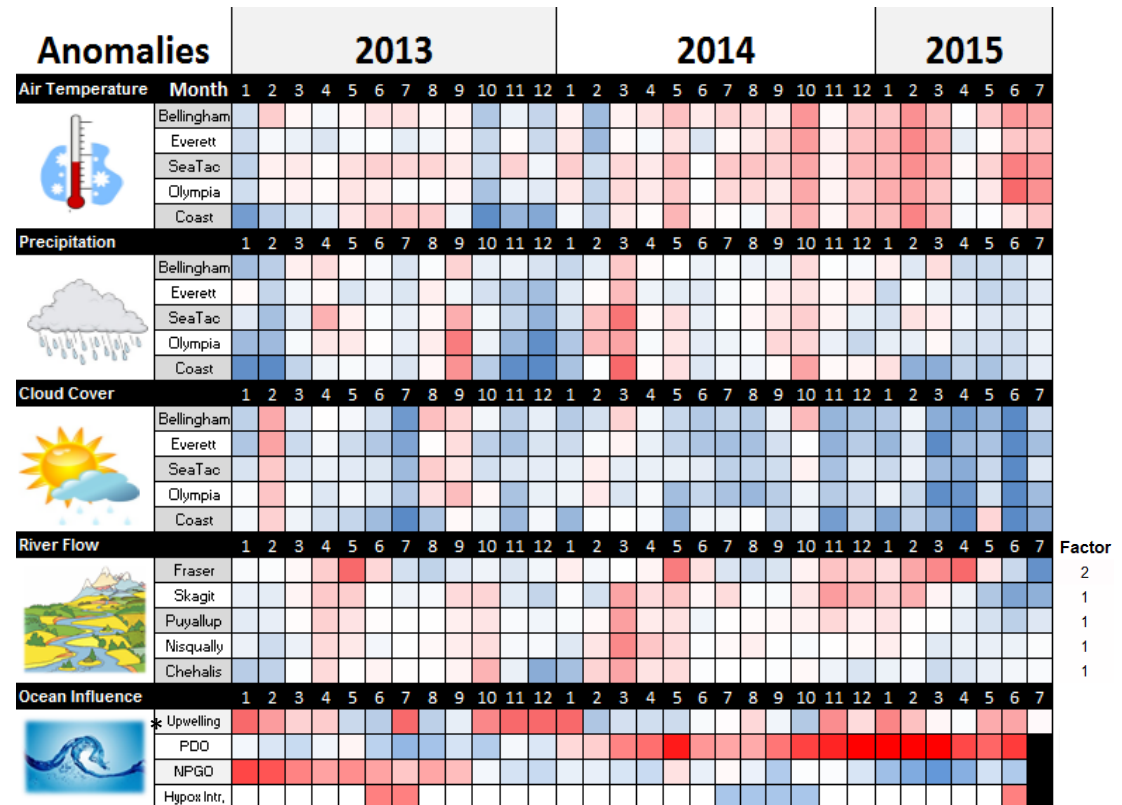
Air temperatures were warmer than normal across western Washington in July.

Precipitation levels have remained below normal in the Puget Sound region.

Sunshine has generally been above normal.

River flows are all below normal, especially the Fraser and Skagit rivers to the north.

Upwelling has returned to normal and the **PDO** remains in the warm phase (July data not yet released).



*Upwelling Anomalies (PFEL)

higher

expected

lower

No data

Our long-term marine monitoring stations in Washington

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- 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

Field log

Weather

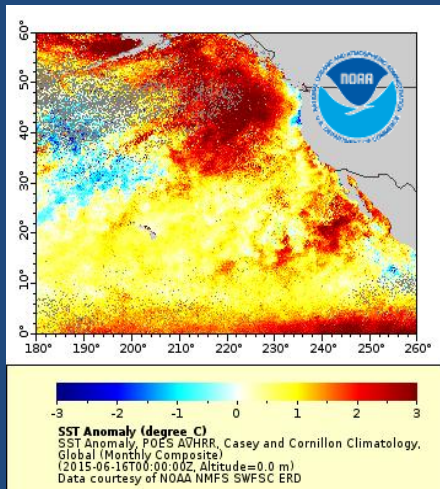
Water column

Aerial photos

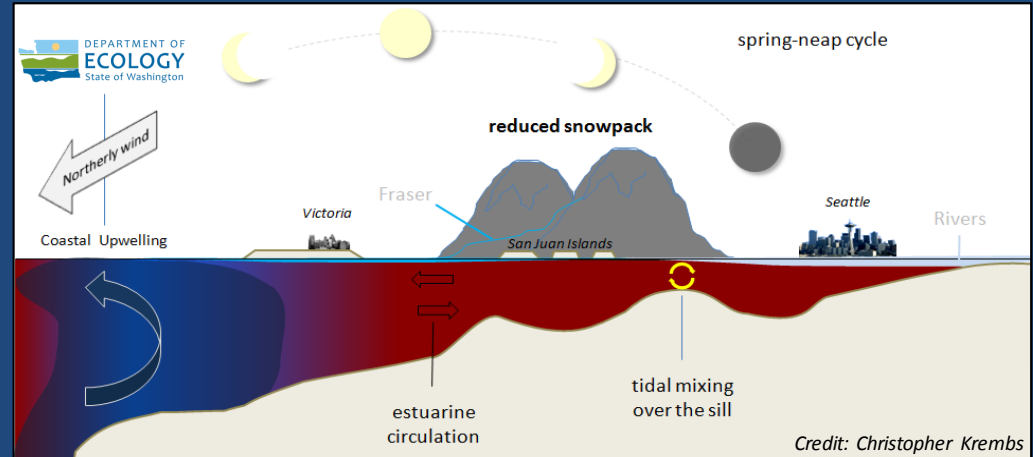
Continuous monitoring

Streams

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.

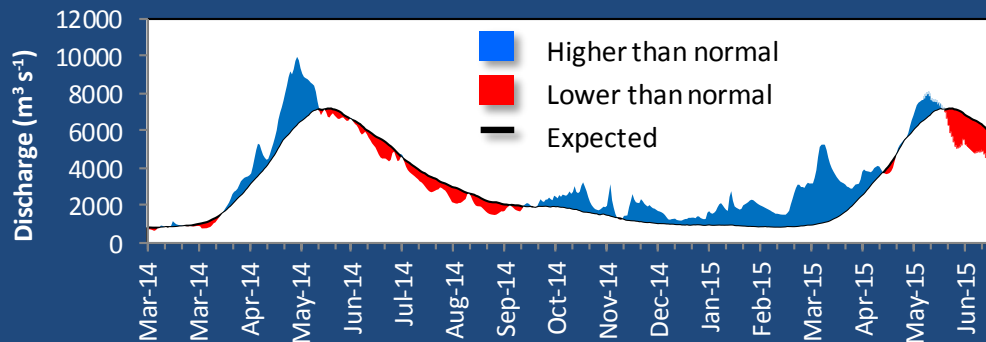


As of June 2015 (left), the Blob is sitting offshore, separated from the coast by a thin band of cooler, upwelled water, like in summer of 2014.



Estuarine circulation is now weak since the snowpack-starved rivers have record low flows. This reduces chances to bring cool, upwelled ocean water into Puget Sound.

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



The freshet of the Fraser River and other rivers flowing into Puget Sound came much earlier due to the mild winter, resulting in below normal flows. Water that is in Puget Sound will therefore remain longer. That means more warming and, potentially, an accumulation of pollutants.

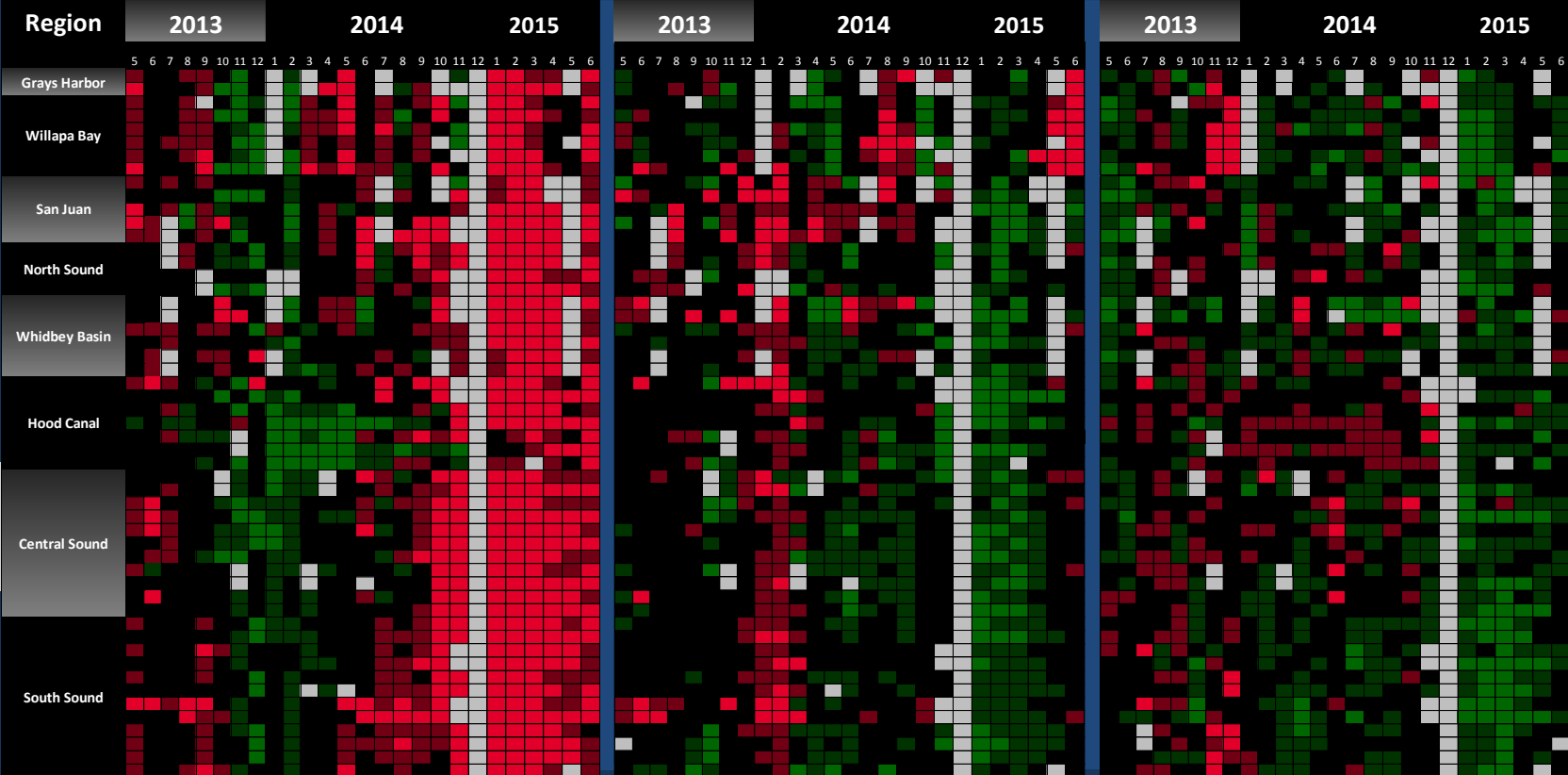


June **temperatures** were still exceptionally **high**, even with the onset of seasonal upwelling. In May, temperatures in some regions suggested a possible return to normal (Willapa Bay, Hood Canal) but residual Pacific Ocean Blob effects continue to dominate our waters. Coastal bays showed saltier waters with lower oxygen, while Puget Sound regions had more expected salinity and oxygen.

Higher Temperature!

Expected Salinity

Expected Oxygen



Coastal stations warmer and saltier.

Black boxes show expected temperatures based on historical data

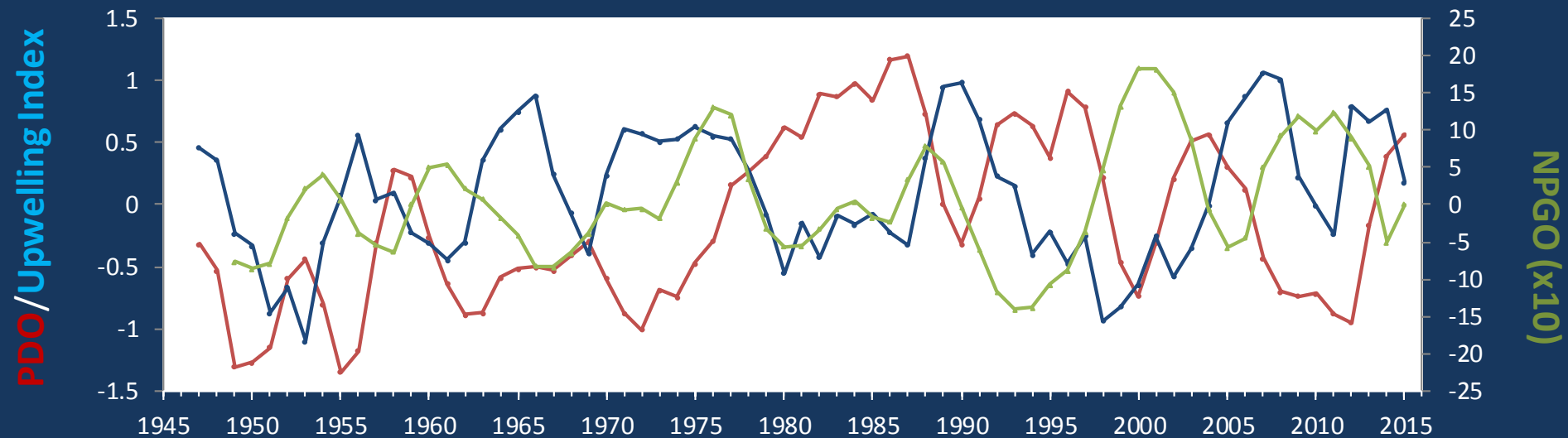
[Explore profiles at all stations](#)

The ocean affects water quality: Ocean Climate Indices

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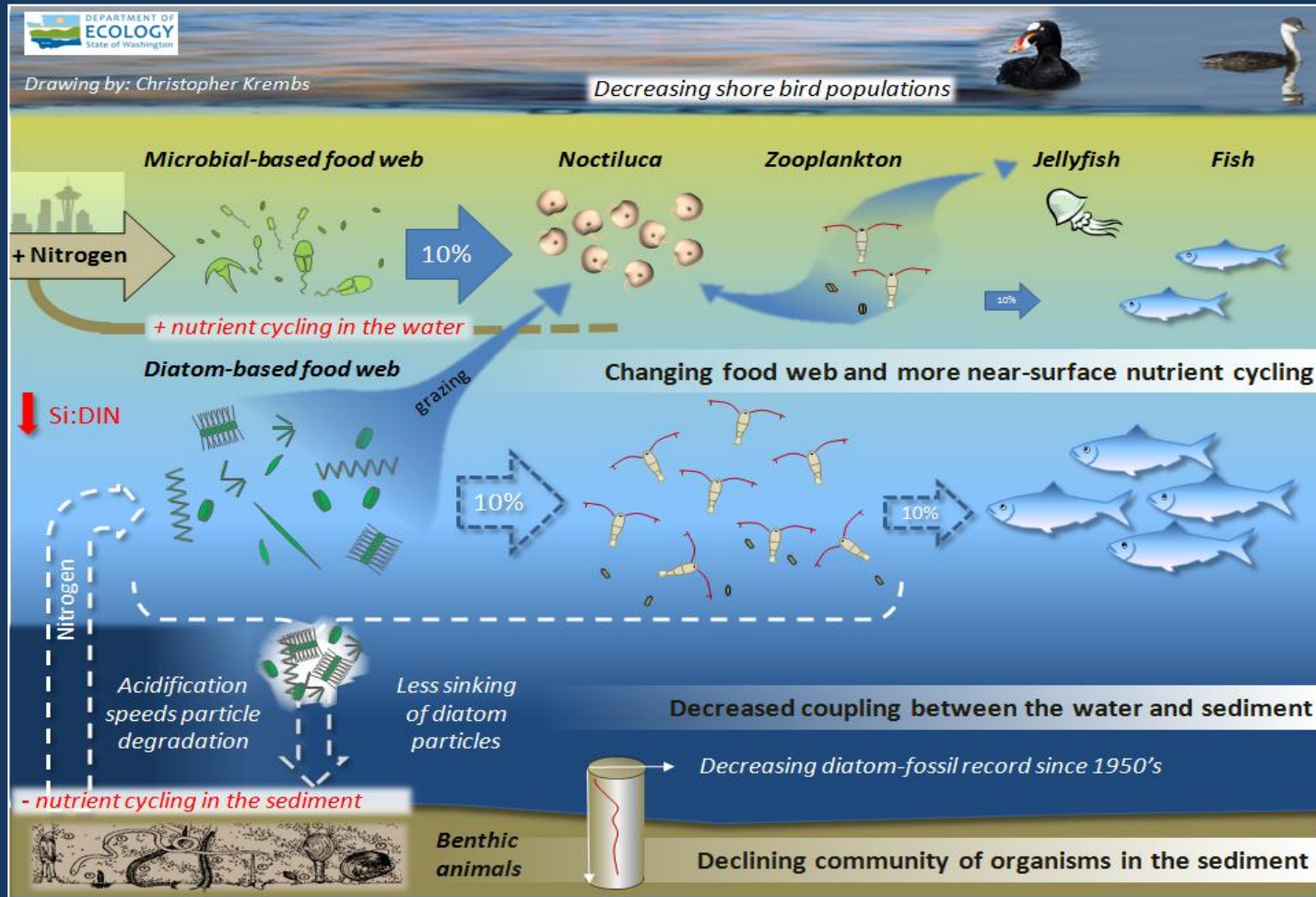
- a) Pacific Decadal Oscillation Index (**PDO, temperature**) [\(explanation\)](#)
- b) Upwelling Index (anomalies) (**Upwelling, low oxygen**) [\(explanation\)](#)
- c) North Pacific Gyre Oscillation Index (**NPGO, productivity**) [\(explanation\)](#)

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?

Hypothesis for combining a series of recent observations affecting energy and material transfer to higher trophic levels



Hypothesis!

Increases in nitrate concentrations could be caused by a top-down control on phytoplankton biomass.

Is *Noctiluca* a visible harbinger of a food web change?

Are changes in higher trophic levels part of a story of the lower food web?

[Follow the experts](#)
[WebEx](#)

Field log Weather Water column **Aerial photos** Continuous monitoring Streams



Impressive jellyfish masses in some finger inlets of South Sound and, to a lesser extent, present in inlets of the Kitsap Peninsula. Large debris islands in Central Sound. Phytoplankton blooms in colors of red-brown, green, and brown in South Sound and some bays of the Kitsap Peninsula.

Greeted in the morning by moon jellyfish



Casimir Rice (NOAA)...no words needed.



Start here



Mixing and Fronts:

Well developed tidal fronts exiting from Pickering Passage and Central Sound.



Jellyfish:

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



Suspended sediment:

Suspended sediments found in expected locations near rivers.



Visible blooms:

Green-brown: Totten Inlet

Red-brown on a large scale: Eld, Budd, Henderson, and Case Inlets; Liberty Bay.

Green: Henderson Bay



Debris:

High occurrences in Port Madison, Central Sound.



Click on numbers



Aerial photography and navigation guide

Date: 8-4-2015

Tide data (Seattle):

02:32 AM	2.84	L
08:14 AM	9.97	H
02:28 PM	0.68	L
09:03 PM	12.37	H

Flight Information:

Good visibility in South Sound,
cloudy in Central Sound with limited
visibility.

--- Flight route

Observation Maps:

Central and North Sound

South Sound

Field log

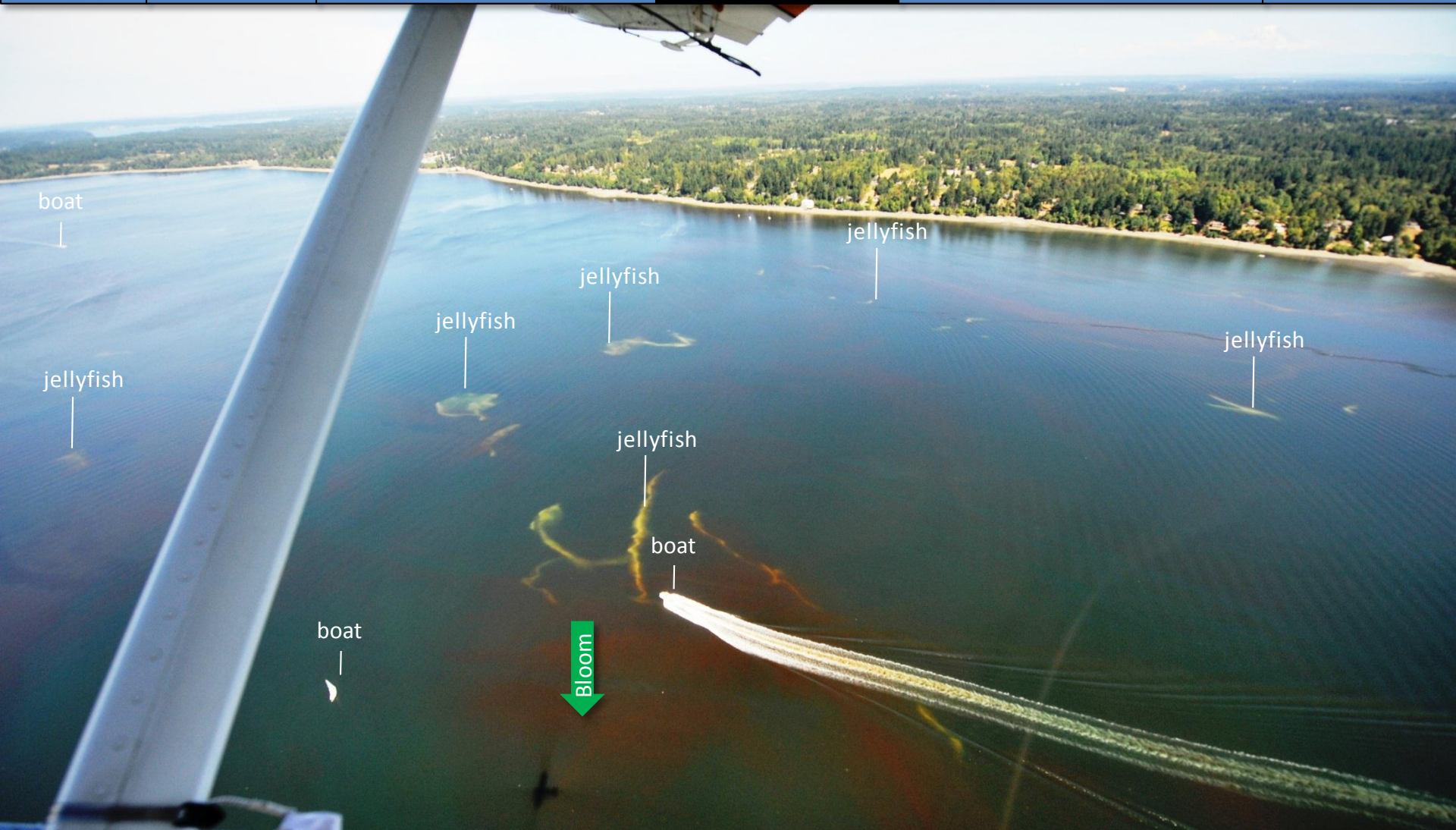
Climate

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Large patches of moon jellyfish mixed in with red-brown bloom.
Location: Budd Inlet (South Sound), 2:56 PM.



Field log

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Numerous patches of jellyfish in water containing bright red-brown algal bloom.
Location: Priest Point Park, Budd Inlet (South Sound), 2:59 PM.



Field log

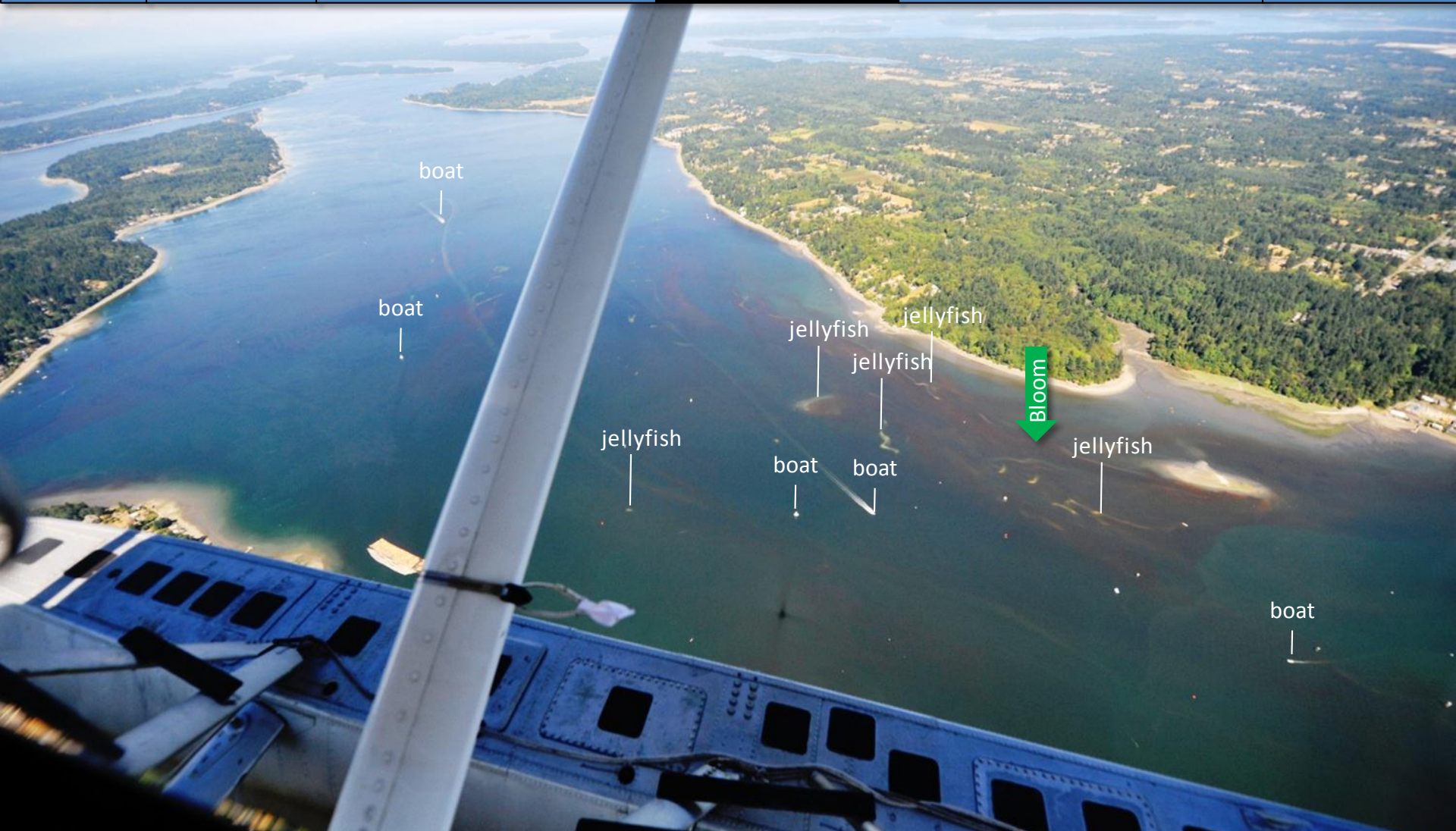
Climate

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Large jellyfish patches in water containing red-brown algal bloom.

Location: Budd Inlet (South Sound), 3:00 PM.



Field log

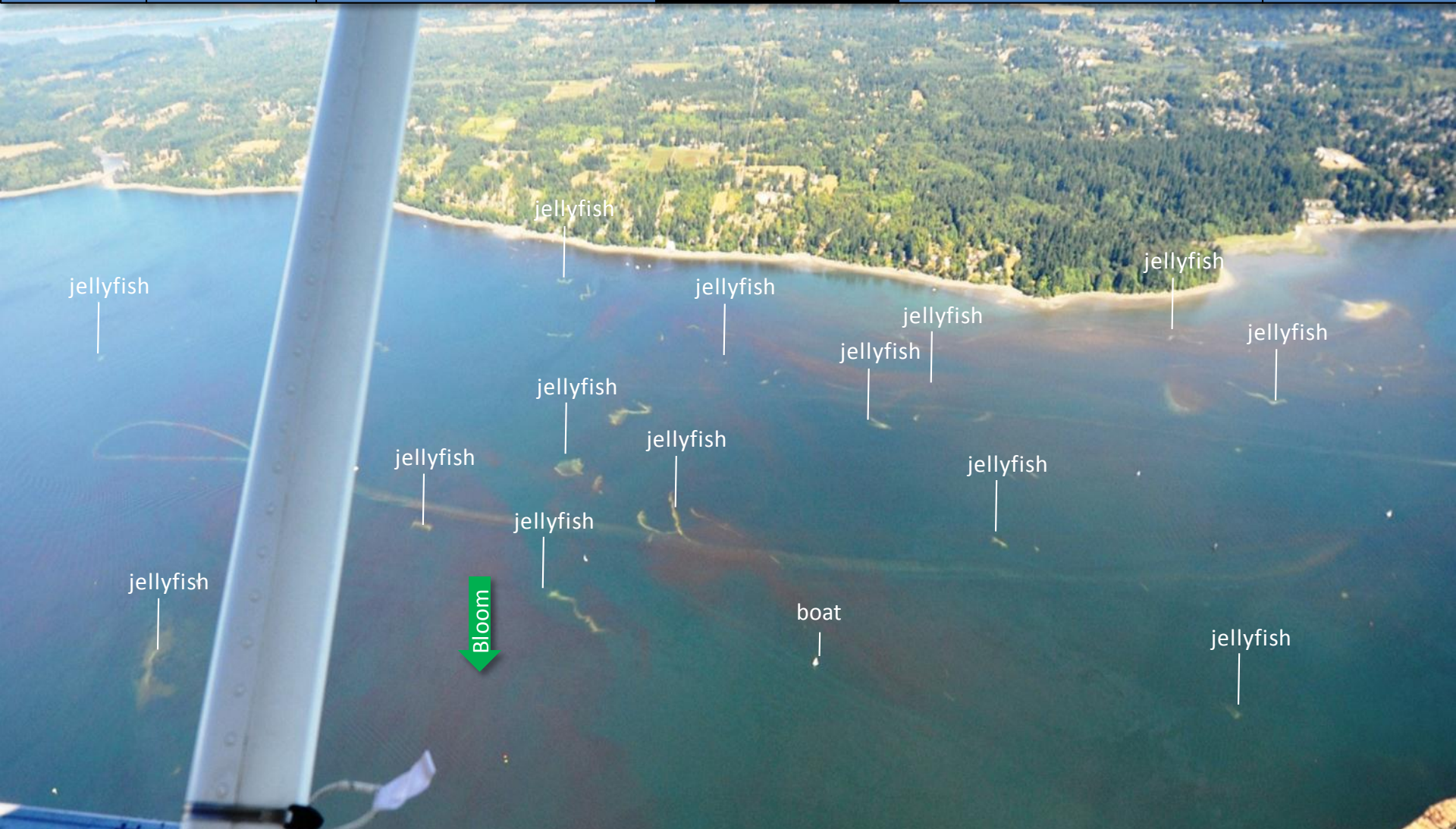
Climate

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Numerous large patches of jellyfish in water containing red-brown algal bloom.
Location: Budd Inlet (South Sound), 3:12 PM.



Field log

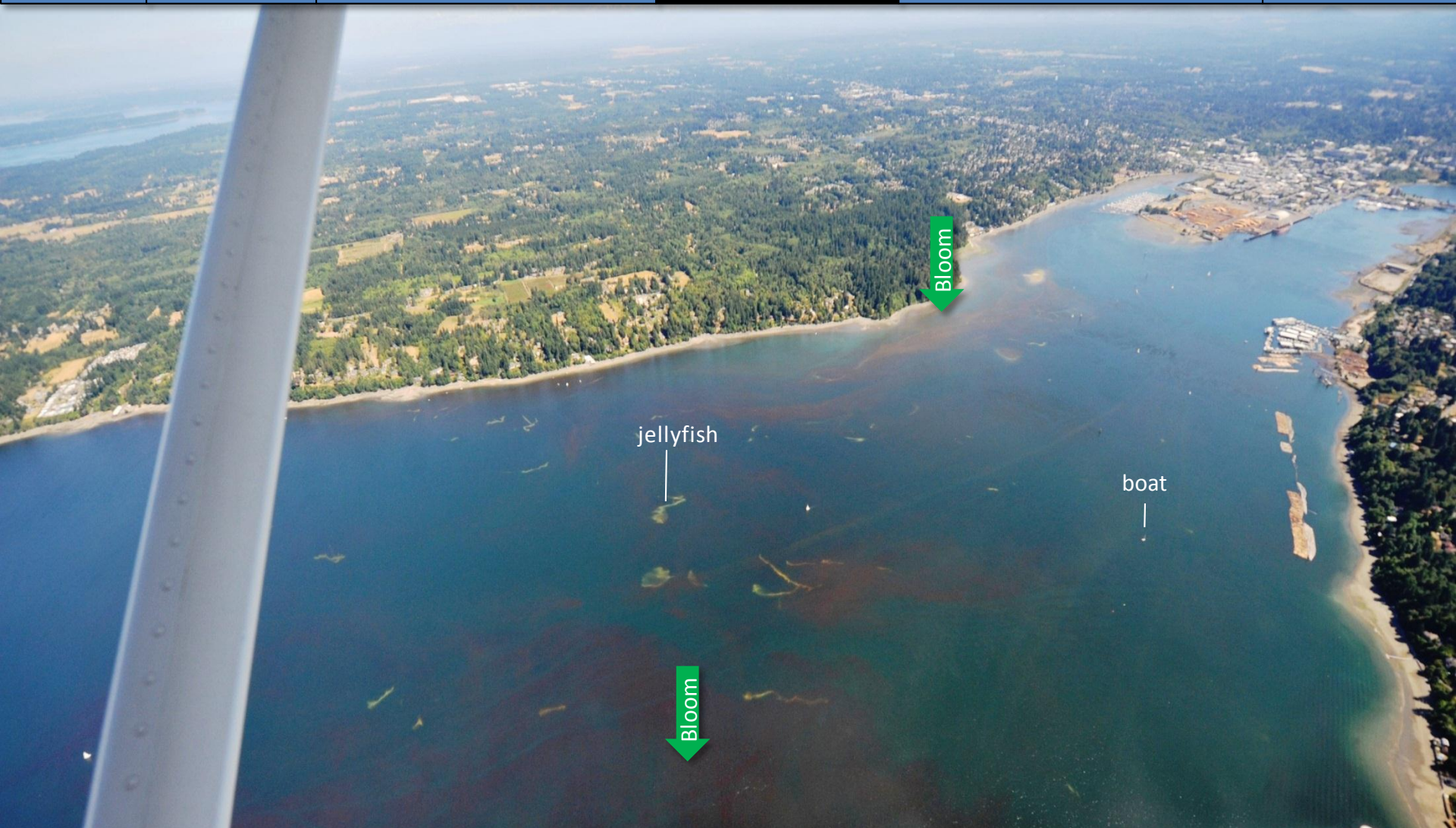
Climate

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Long and curvy patches of jellyfish in water containing red-brown algal bloom in the inner inlet.
Location: Budd Inlet (South Sound), 3:12 PM.

Field log

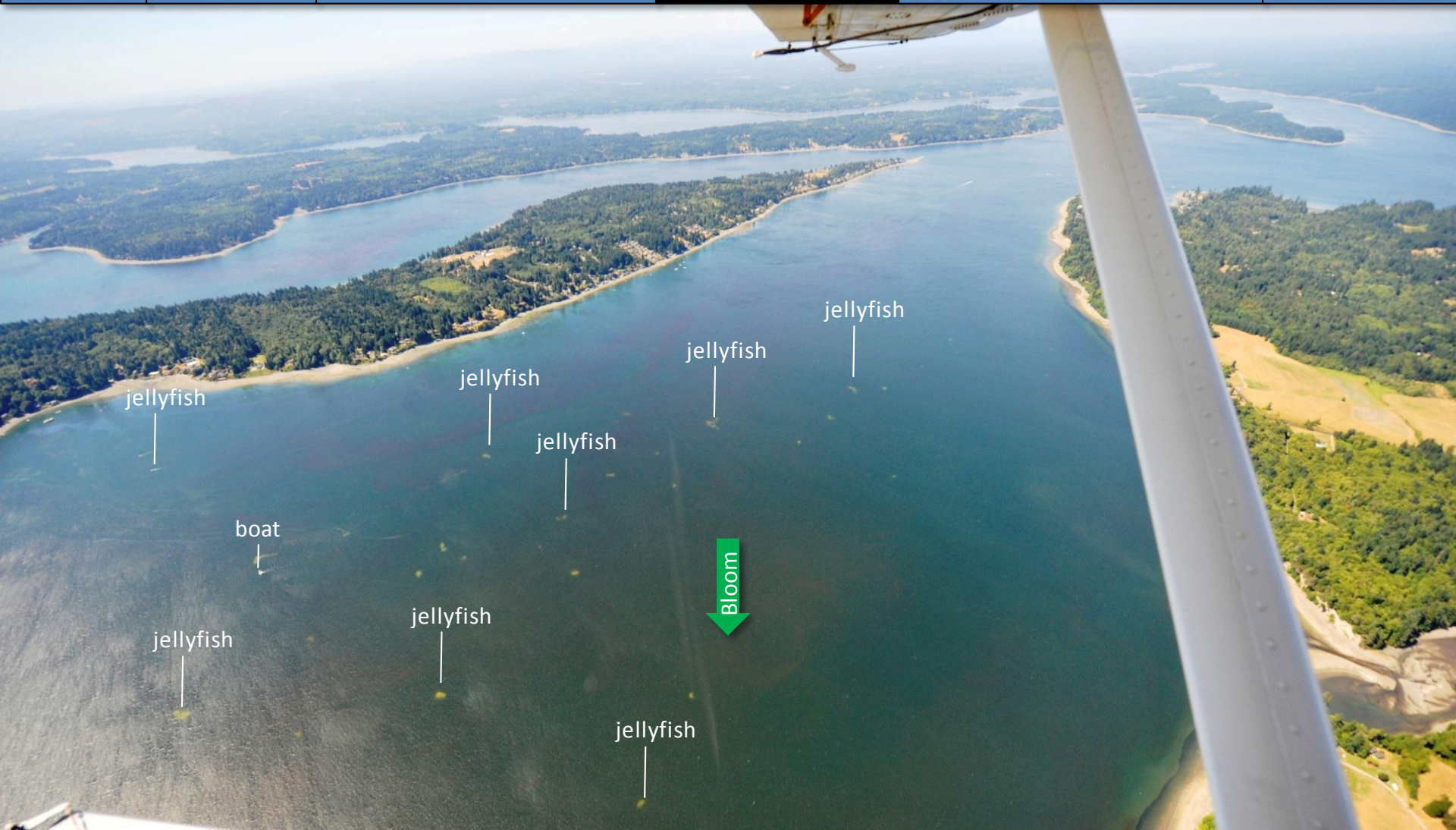
Climate

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Numerous small round patches of jellyfish in the outer part of the inlet.

Location: Budd Inlet (South Sound), 3:13 PM.

Field log

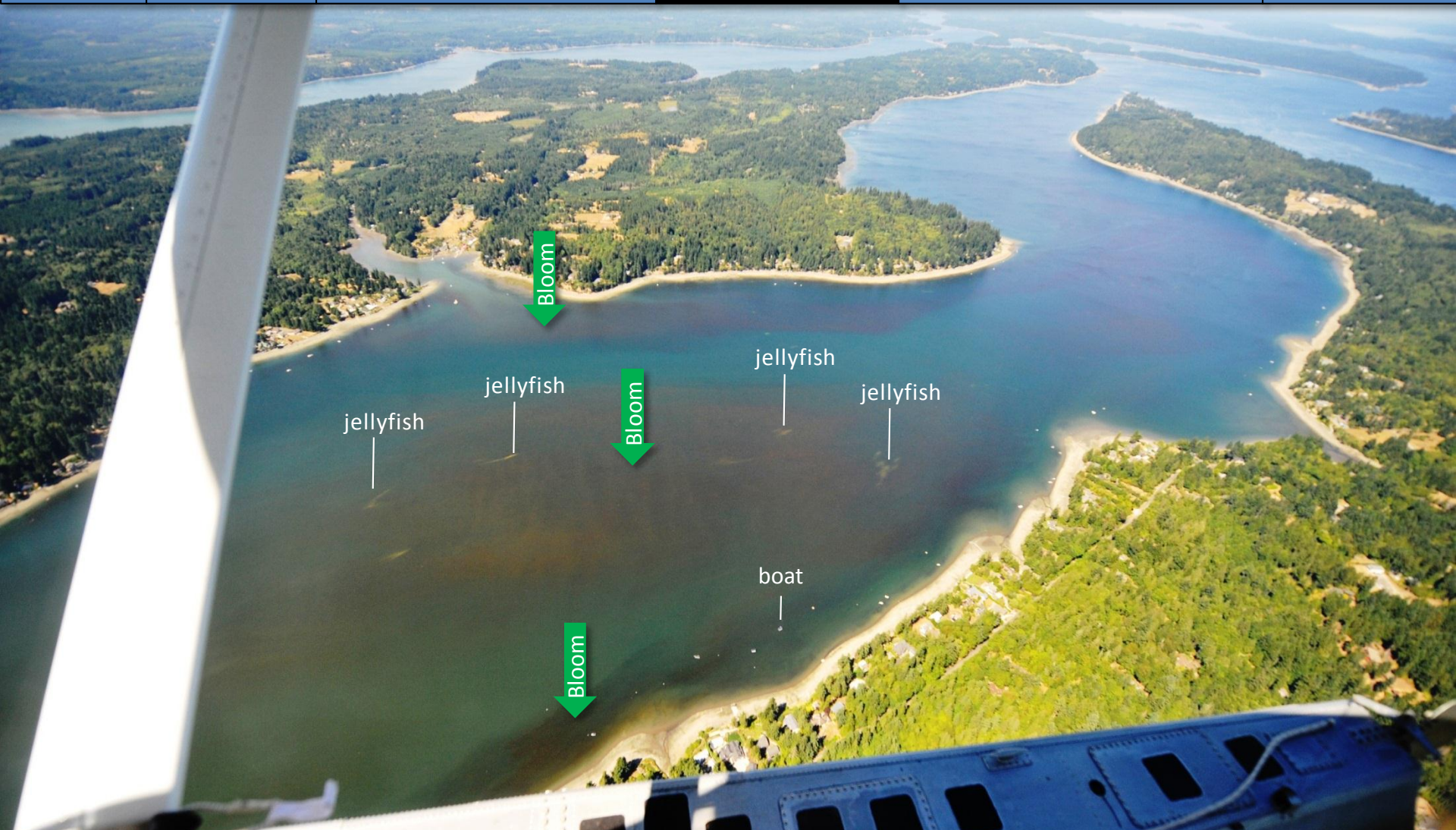
Climate

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Numerous patches of jellyfish in water containing red-brown algal bloom.
Location: Eld Inlet (South Sound), 3:09 PM.



Field log

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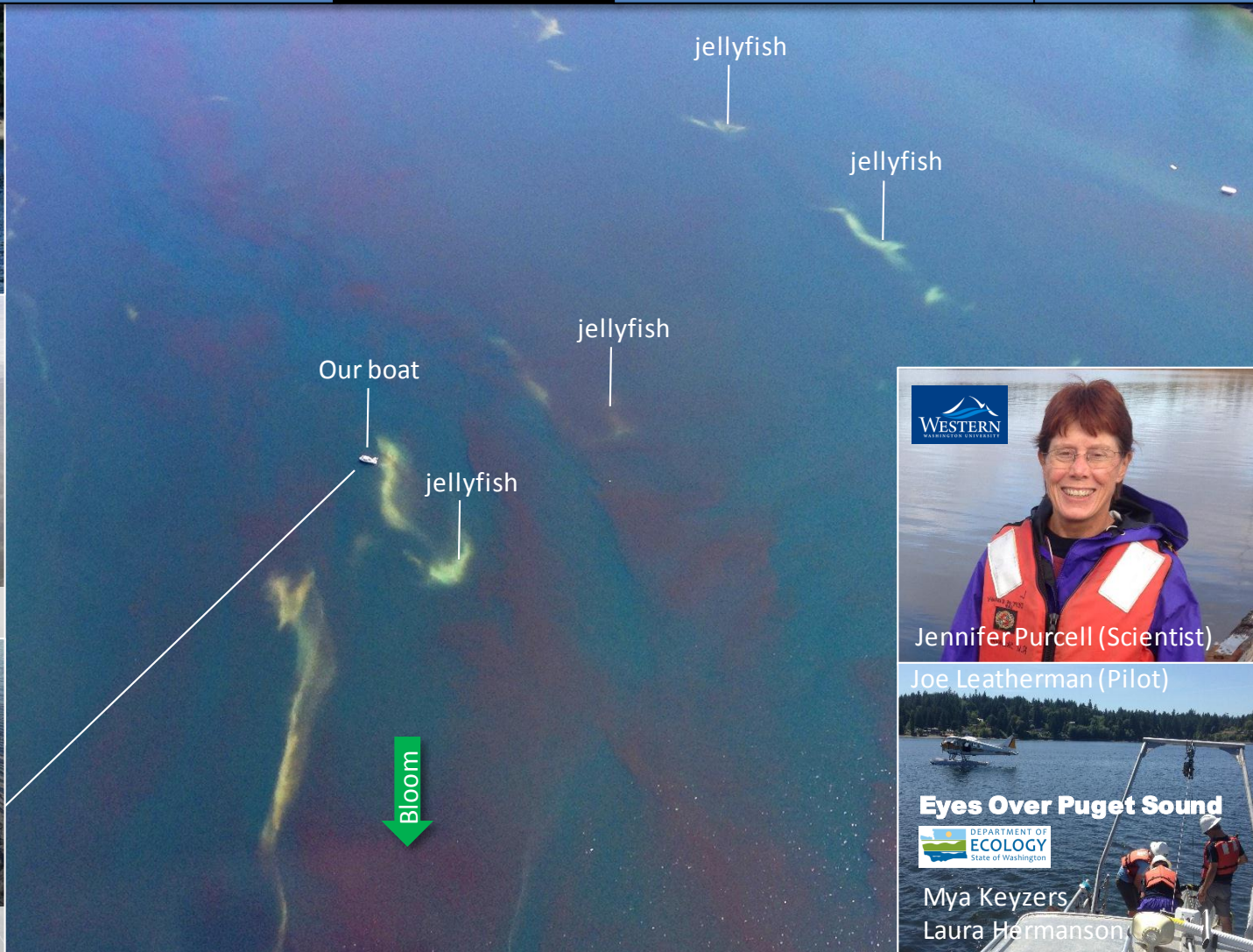
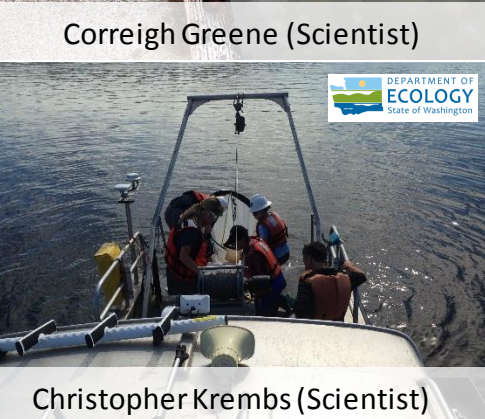
Aerial photos

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*Numerous patches of jellyfish in water containing red-brown algal bloom.
Location: Eld Inlet (South Sound), 3:09 PM.*

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Collaborating on air to ground measurements of jellyfish super smacks (this one is > 2 million individuals)
Location: Eld Inlet (South Sound, 1400 ft), 1:10 PM.

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Sediment from river plume and bloom blend (no jellyfish).

Location: Totten Inlet (South Sound), 3:04 PM.

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boat

Patches of red-brown bloom.

Location: Henderson Inlet (South Sound), 3:14 PM.

Field log

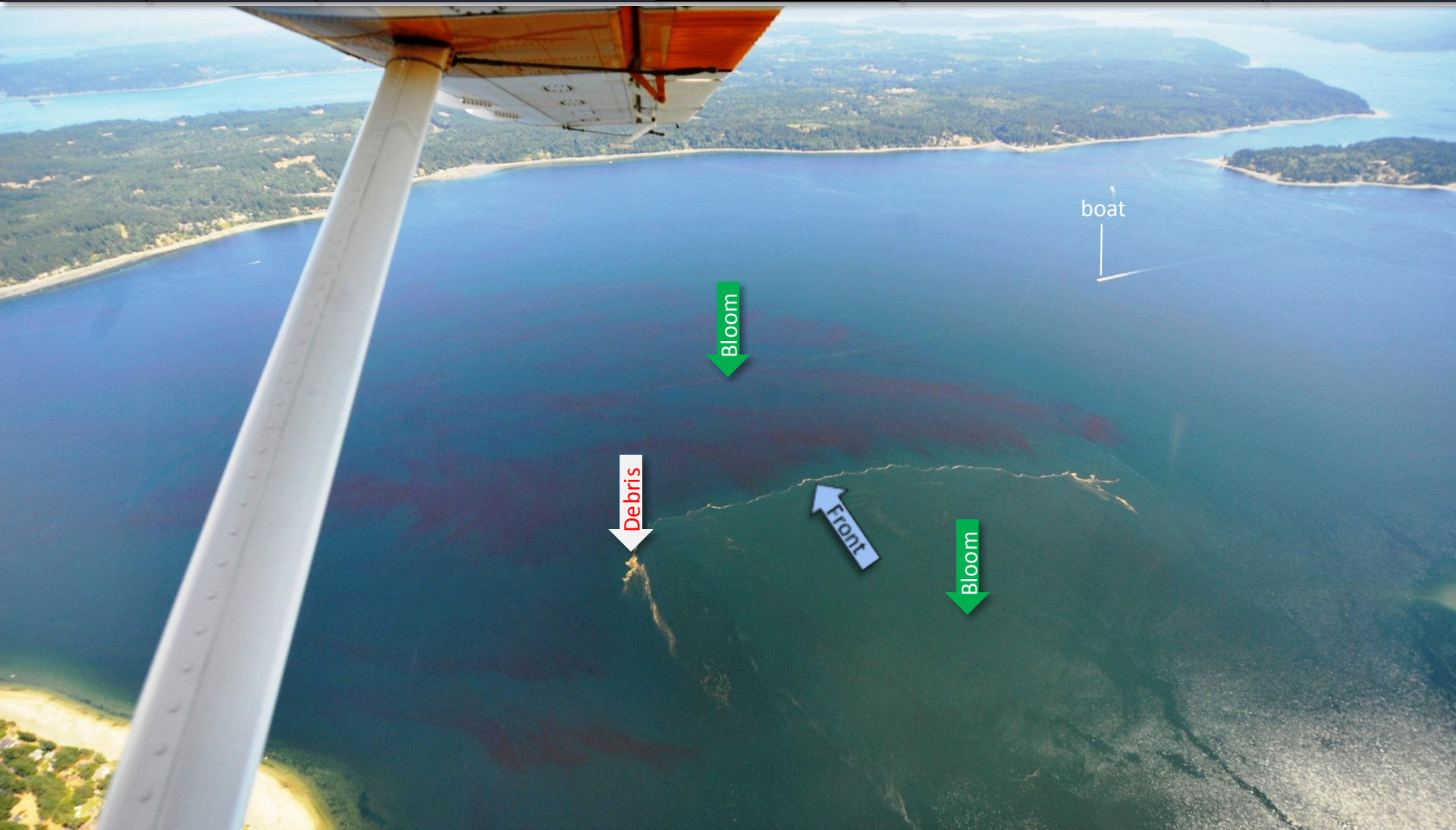
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Tidal front with organic debris separating feather-shaped red-brown bloom from green water originating from Pickering Passage. Location: Stretch Island, Case Inlet (South Sound), 3:20 PM.



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Red-brown bloom and organic debris.

Location: Off Rock Bay, Case Inlet (South Sound), 3:20 PM.



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Bands of red-brown bloom.

Location: Off Vaughn Bay, Case Inlet (South Sound), 3:20 PM.

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Green bloom and organic debris patches

Location: Henderson Bay, Carr Inlet (South Sound), 3:25 PM.



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Extensive and multiple oil sheens (reported).

Location: Port Orchard, Sinclair Inlet (Central Sound), 3:05 PM.

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Patches of red-brown bloom, organic debris, and some jellyfish patches.

Location: Liberty Bay (Central Sound), 3:40 PM.



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Numerous patches of organic debris, some accumulating along front; bloom in background.
Location: Port Madison (Central Sound), 3:43 PM.



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Numerous patches of organic debris, some accumulating along front.
Location: Off Point Jefferson (Central Sound), 3:43 PM.



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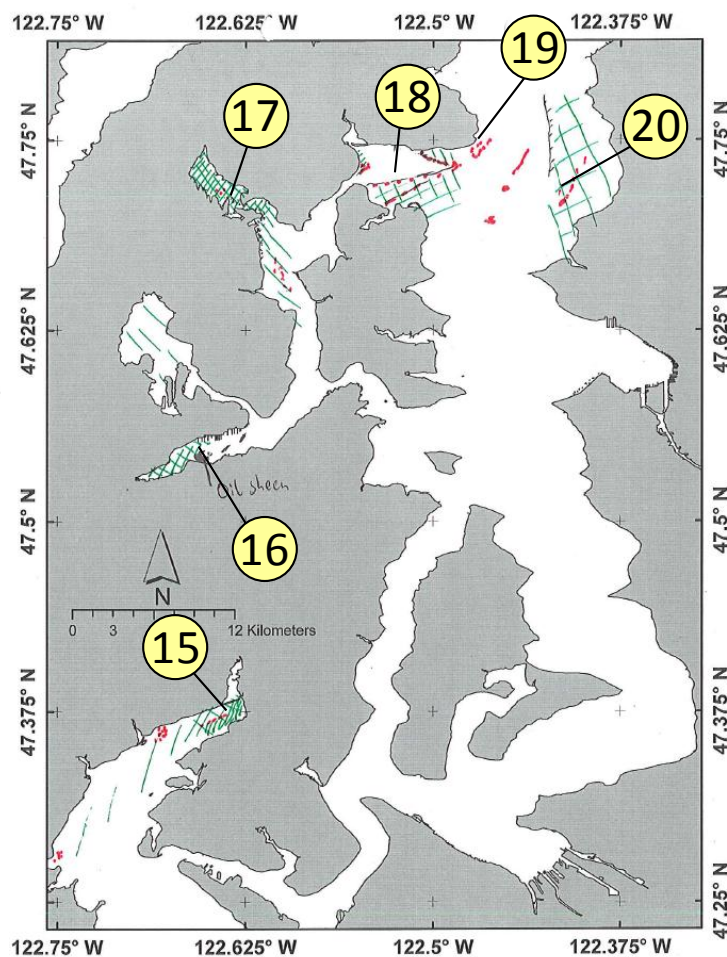
Numerous patches of organic debris (tug and barge provide scale).

Location: Across Port Madison (Central Sound), 3:46 PM.

**Date: 8-4-2015**

Central Sound

North Sound/San Juan Islands



n.a.

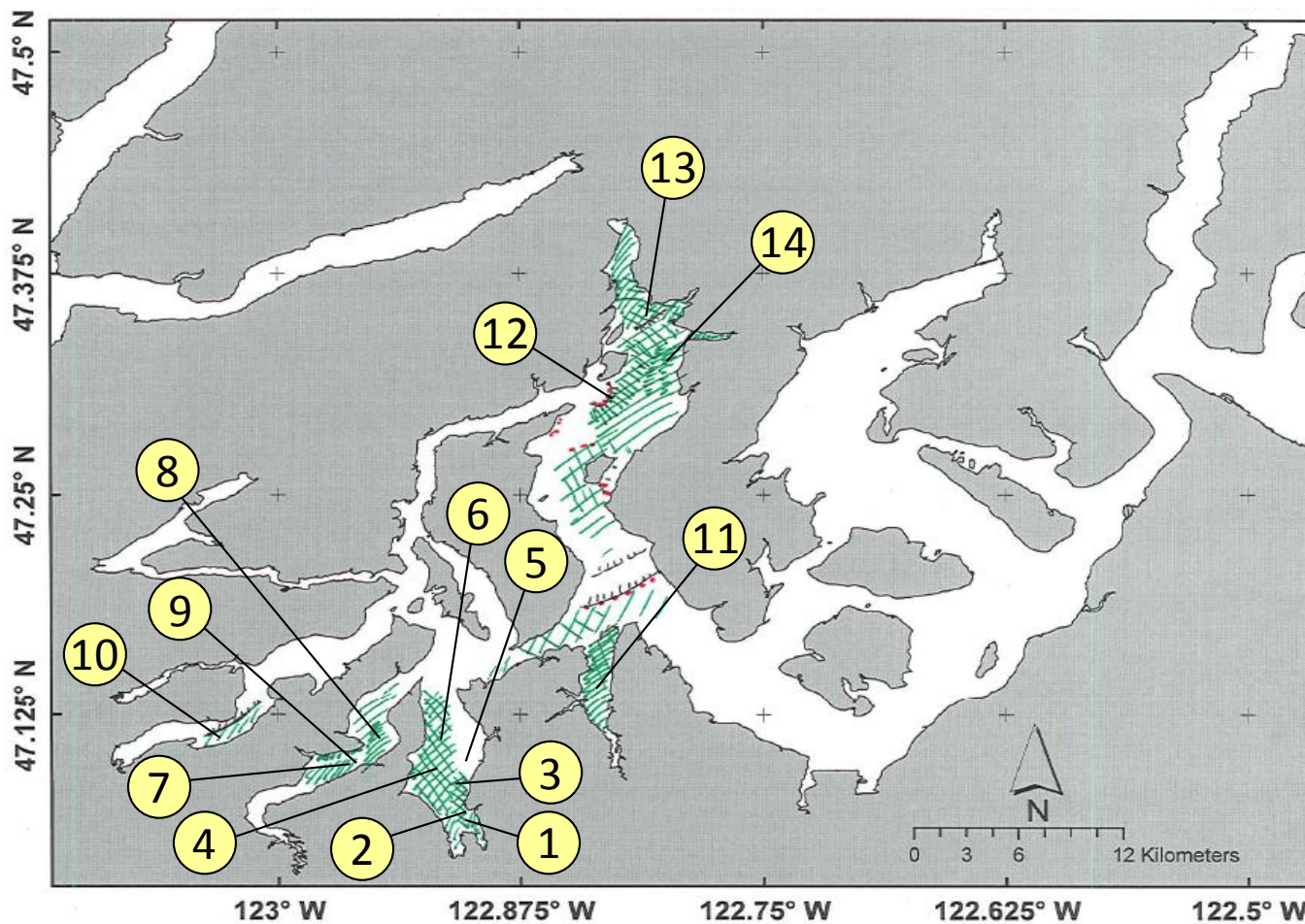
Numbers on map refer to picture numbers for spatial reference

Qualitative aerial observer map during transit

[Navigate](#)

Date: 8-4-2015

South Sound



Numbers on map refer to picture numbers for spatial reference

Field log

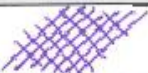








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Plumes	
• Freshwater with sediment solid	
• Freshwater with sediment dispersed	
• Coastal erosion with sediment	
Blooms	
• Dispersed	
• Solid	
Debris	
• Dispersed	
• Solid	
Front	
• Distinct water mass boundaries	
• Several scattered	

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:

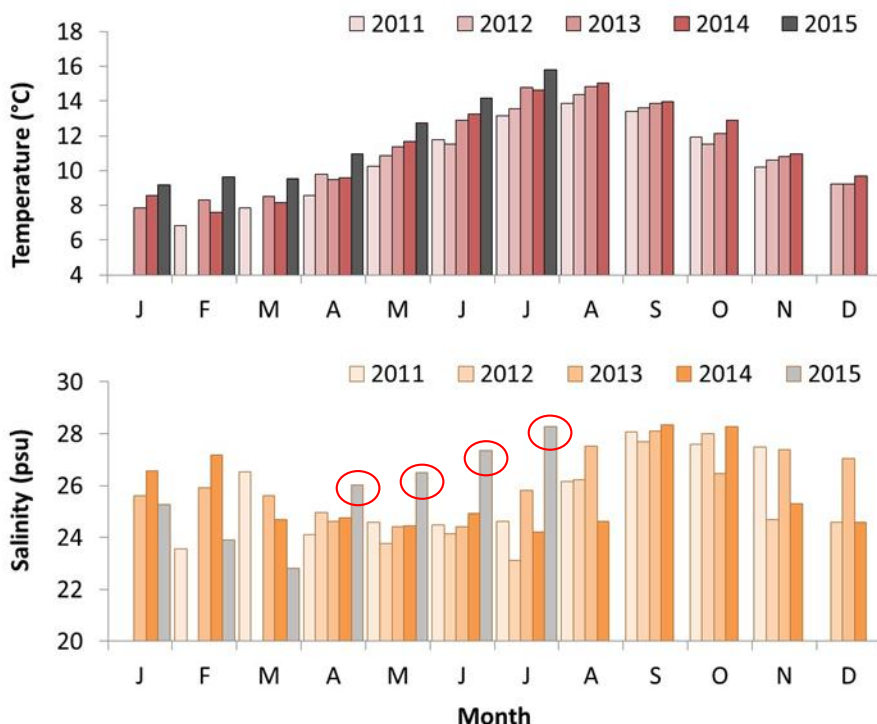
Debris can be distinguished into natural and anthropogenic debris floating at the surface *sensu* Moore and Allen (2000). The majority of organic debris in Puget Sound is natural and mixed with discarded man-made pieces of plastic, wood, etc. From the plane, we cannot differentiate the quality of debris 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: The Mukilteo mooring station has been deployed since September 2009. A near-surface sensor is also measuring water that is warmer and saltier than normal. Before July, the near-bottom sensor has recorded a maximum water temperature of 15.7 °C. During July, a new maximum of 16.7 °C was measured; the mean was 13.2 °C. River flows remain low and minimal. Mostly tides are driving changes in water characteristics.

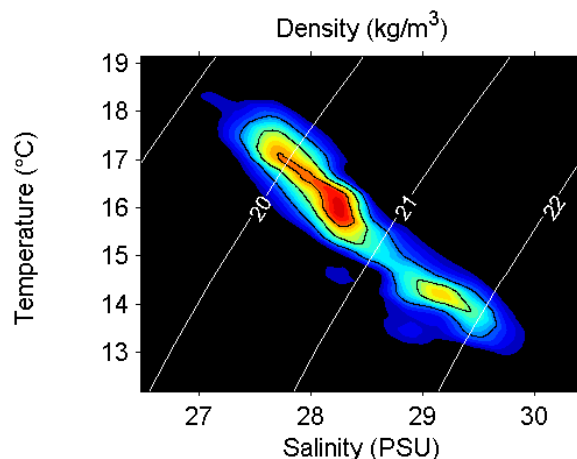


Monthly means of temperature, salinity, and dissolved oxygen from near-surface sensor at Mukilteo



For monthly means of near-bottom data, go to next page.

2-6 m depth



The above plot shows the probability of near-surface observations over the past two-week period. High probability shown in warm colors.

Density is defined by salinity and temperature.

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.

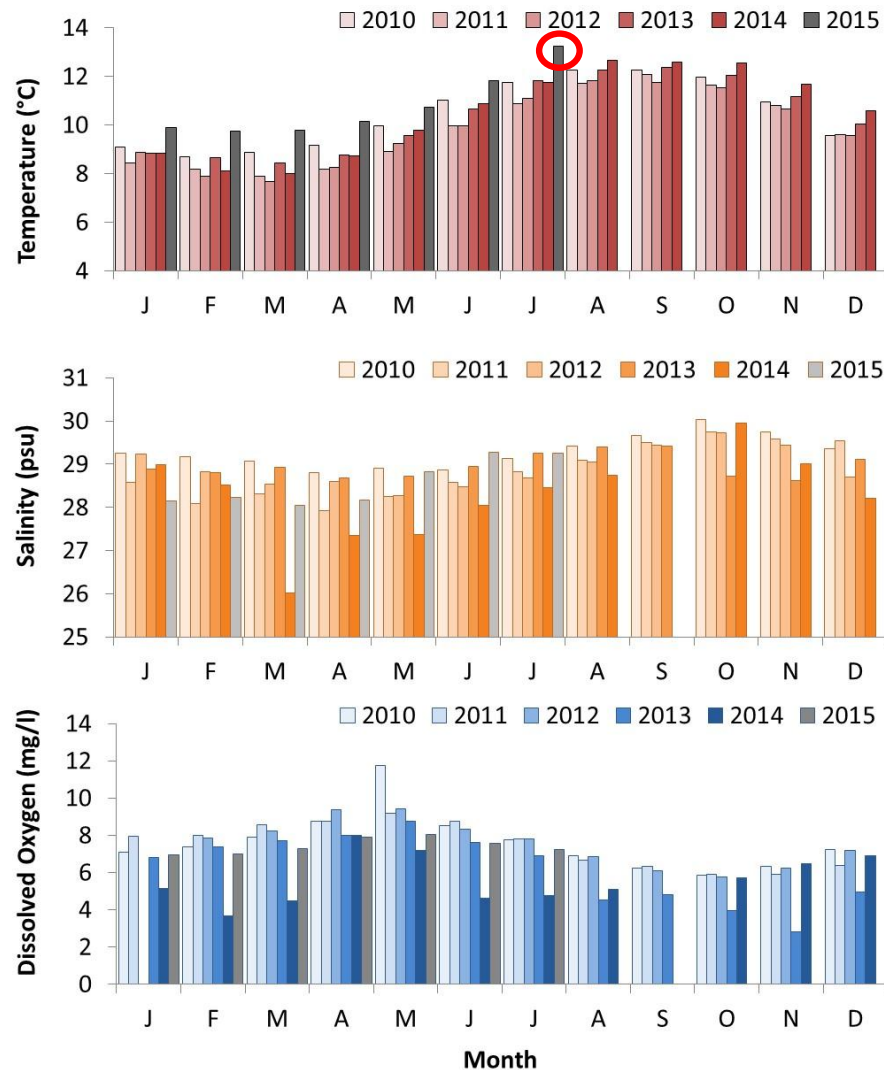
Inter-annual variability is shown over a 5-year period. All three variables show strong seasonality.

In July, the near-bottom sensor recorded the warmest water temperature since late 2009, when the near-bottom mooring began (highlighted by red circle in top plot). Salinity and dissolved oxygen declined slightly from June to July.

Seasonally, variability of each parameter in 2015 remains small from January to July compared to previous years.

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

Monthly means of temperature, salinity, and dissolved oxygen from near-bottom sensor at Mukilteo

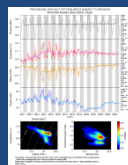


Our mooring station in Mukilteo is located in Whidbey Basin near Everett. It is also located at the transition between Possession and Central Sounds at a depth that is influenced by the Skagit and Snohomish River discharges, prevailing winds, and tidal mixing.

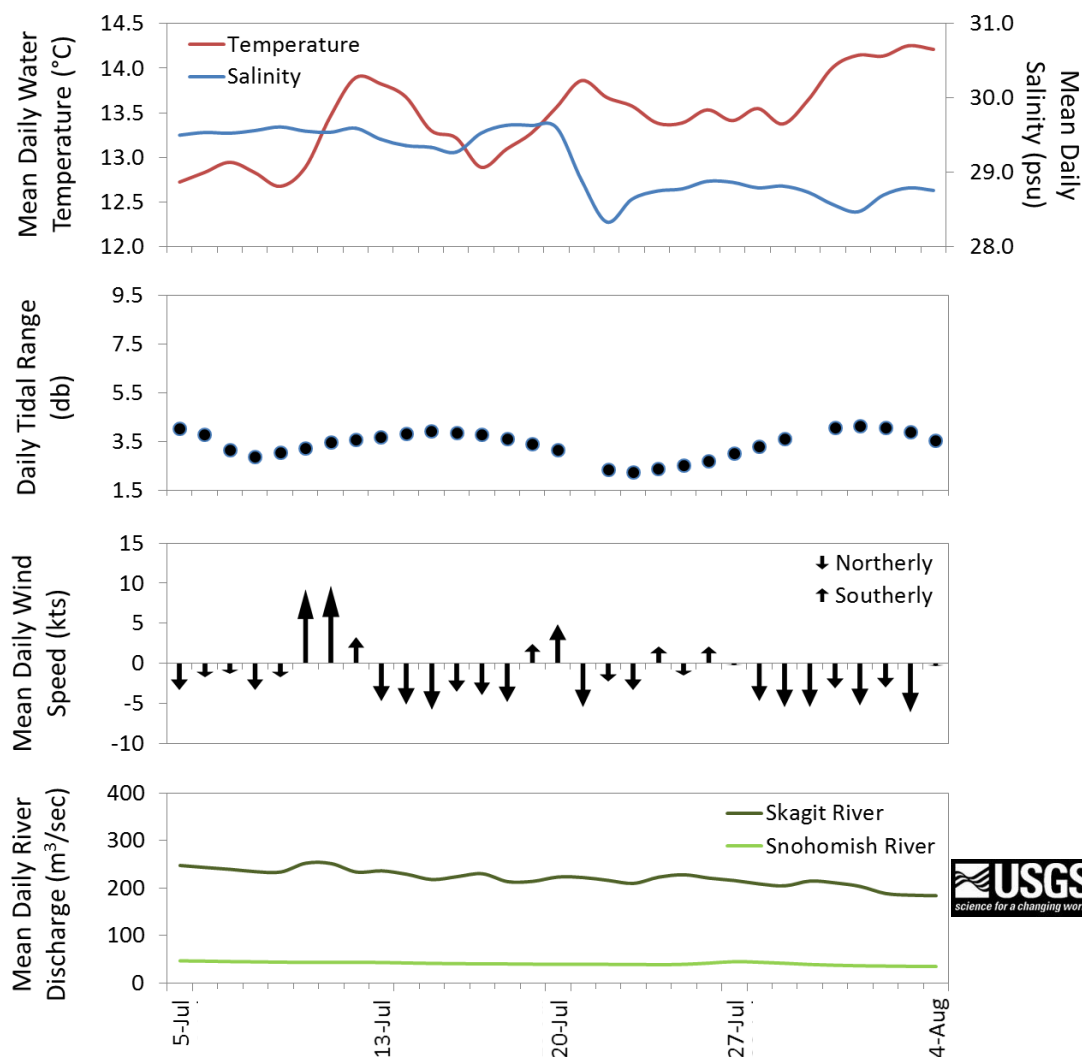
As the largest regional contributor of freshwater to Puget Sound, understanding the timing and magnitude of the Skagit River flow is important.

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

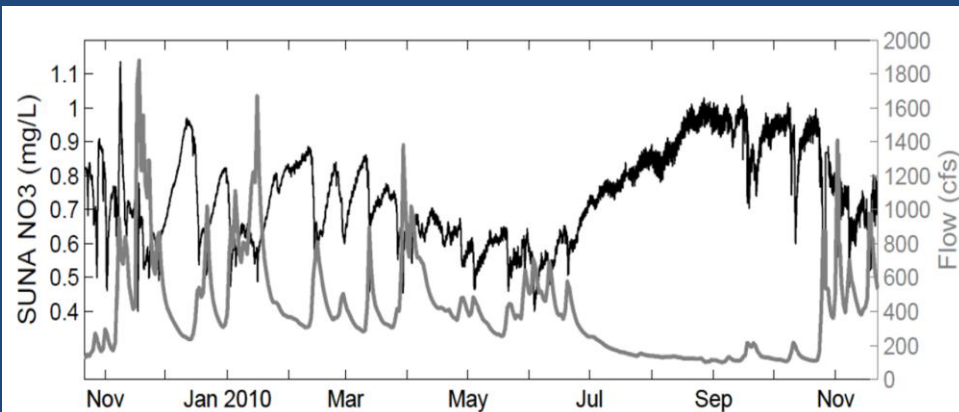


Near-bottom sensor and associated environmental data at Mukilteo



When rivers are flowing low, nutrients become concentrated

[Ecology's River and Stream Monitoring Program](#) measures water quality of the Deschutes River since 1978 ([13A060](#)).

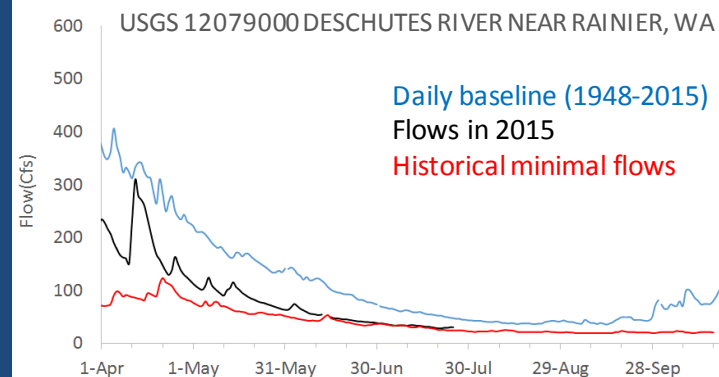


The Deschutes River discharges into Budd Inlet and could fuel the present algal blooms because of low summer flows (below) and elevated nitrate (NO_3) concentrations.

As flows drop, concentrations of nitrogen increase due to increased groundwater influence (left).

Half of the Deschutes River summer flow (55%) comes from water that enters the river from underground. This groundwater carries higher nitrate concentrations with it.

The Deschutes River is the 2nd largest contributor of total nitrogen loads to southern Puget Sound ([Monhamedali et al. 2011](#)). Annual average nitrate loads are estimated to be 678 kg/d ([Sackmann, 2011](#)).



The Deschutes River is now flowing
historical low levels

Flow conditions on the Deschutes River reflect the combined effects of climate and water withdrawals. Stream flows during June and July fell below the normal mean historical (<20%) summer flows. Overall summer base flows have declined since the 1950s.

The Deschutes River is currently on the Clean Water Act 303d list for violating water quality standards for temperature, bacteria, and oxygen.

[Water Quality Index](#) trends show annual nitrogen scores are consistently very low, indicating that nitrogen loading is very high.

Deschutes River nitrate concentrations, observed during summer low flow conditions, continue to show increasing trends since 1995 ([Von Prause, 2013](#)).

Instream flow on the Deschutes River influences stream temperature, dissolved oxygen, and pH while reductions in flow may increase peak temperatures ([Roberts et al, 2012](#)).



Capitol Lake receives Deschutes River water before it enters Budd Inlet. Capitol Lake has had lots of algae growth this summer.

Get data from Ecology's Marine Monitoring Programs



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Long-Term Monitoring Network



christopher.krembs@ecy.wa.gov



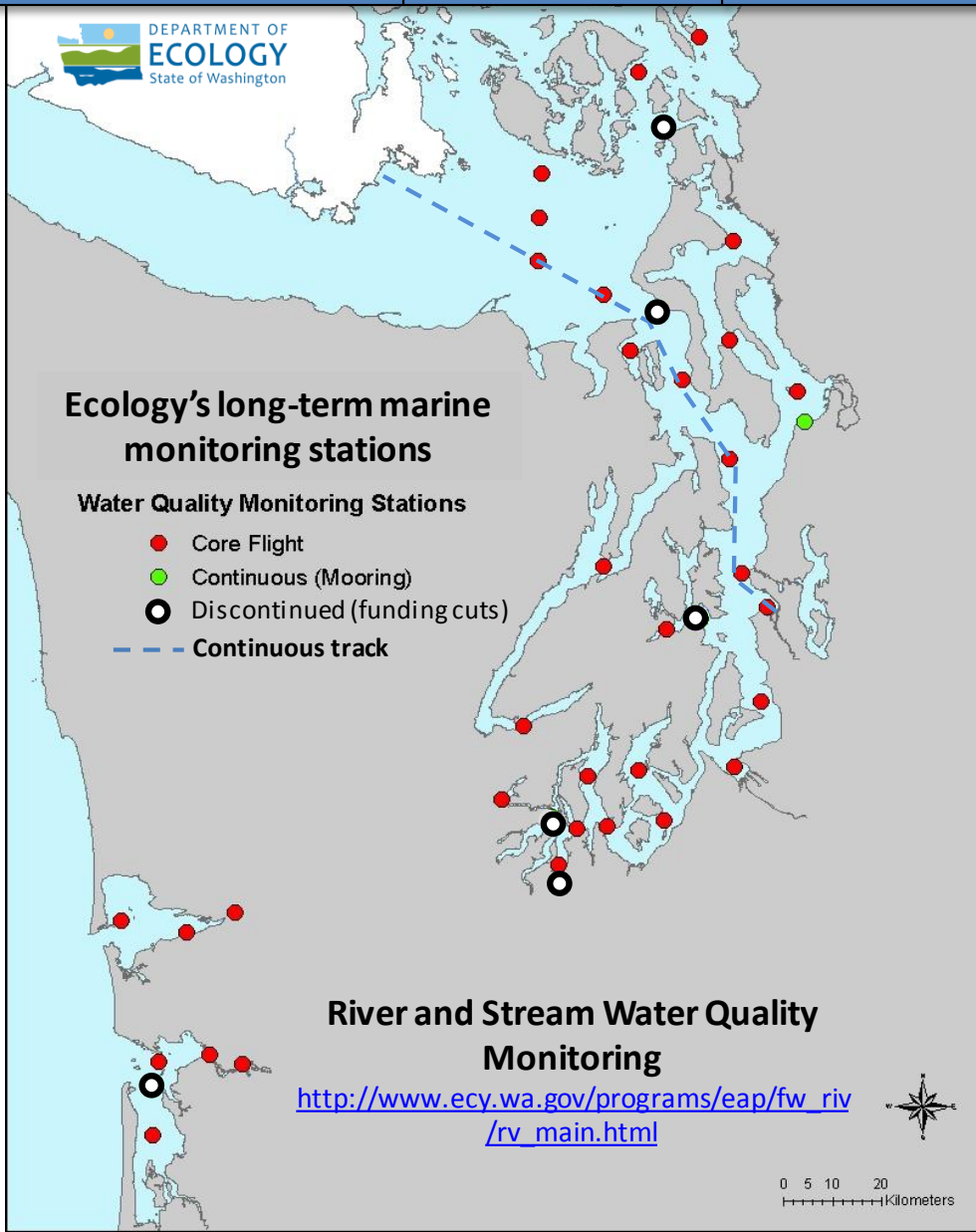
Access core monitoring data:

<http://www.ecy.wa.gov/apps/eap/marinewq/mwdata/taset.asp>

Ecology's long-term marine monitoring stations

Water Quality Monitoring Stations

- Core Flight
- Continuous (Mooring)
- Discontinued (funding cuts)
- Continuous track



River and Stream Water Quality Monitoring

http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html

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**

