



Eyes Over Puget Sound

Field log


Climate

Water column

Aerial photos

Continuous monitoring

Streams

A photograph showing a large number of jellyfish floating in the water near a boat. The boat's hull is dark with the word 'BAY' painted in yellow. Ropes are visible in the foreground.

Surface Conditions Report, September 21, 2015



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



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LONG-TERM MARINE MONITORING UNIT

*Mya Keyzers
Laura Hermanson*



Skip Albertson



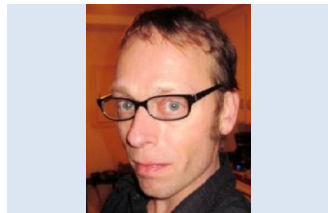
*Julia Bos
Suzan Pool*



*Dr. Christopher
Krembs*



Markus von Prause



Personal field log

[p. 3](#)

Green tides can cause a rotten egg smell on beaches.

Climate conditions

[p. 4](#)

Air temperature and ocean conditions remain warm.

Precipitation has increased, yet river flows remain unusually low. Upwelling has been normal while sea surface temperatures are high.

Water column

[p. 5](#)

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.

Aerial photography

[p. 10](#)

Large jellyfish aggregations are visible in some finger inlets of South Sound, inlets of the Kitsap Peninsula, and East Sound (Orcas Island). Algae blooms present in South Sound and Kilisut Harbor. Nooksack and Stillaguamish river plumes carry soil.

Continuous monitoring

[p. 35](#)

At the Mukilteo mooring, water temperature remains warmer than past five years, salinity is about normal, and dissolved oxygen declines slightly.

Streams

[p. 39](#)

The Skagit River delivers less freshwater to Puget Sound in the summer.

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Algal Mats and Human Health

During the summer, boaters and beachgoers may see large islands of green algae on the water and on the beach. These algal mats may contain a menagerie of seaweed, seagrass, eelgrass, and debris. The “*green tides*” can be a visible sign of **eutrophication** in coastal environments which then negatively effect water quality. The algal mats can also impact human health. When the algae decompose, they give off hydrogen sulfide gas, which is an irritant and a chemical asphyxiant (causing breathing difficulty). It can lead to headaches, fatigue, dizziness, and poor memory. If you smell rotten eggs at the beach, it might be from green tides.



Boaters beware! Floating algal mats can also trap debris such as logs.



Algal mats decomposing on the beach can smell like rotten eggs.

Information on Hydrogen Sulfide from the Washington Department of Health:
<http://www.doh.wa.gov/CommunityandEnvironment/Contaminants/HydrogenSulfide>



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:

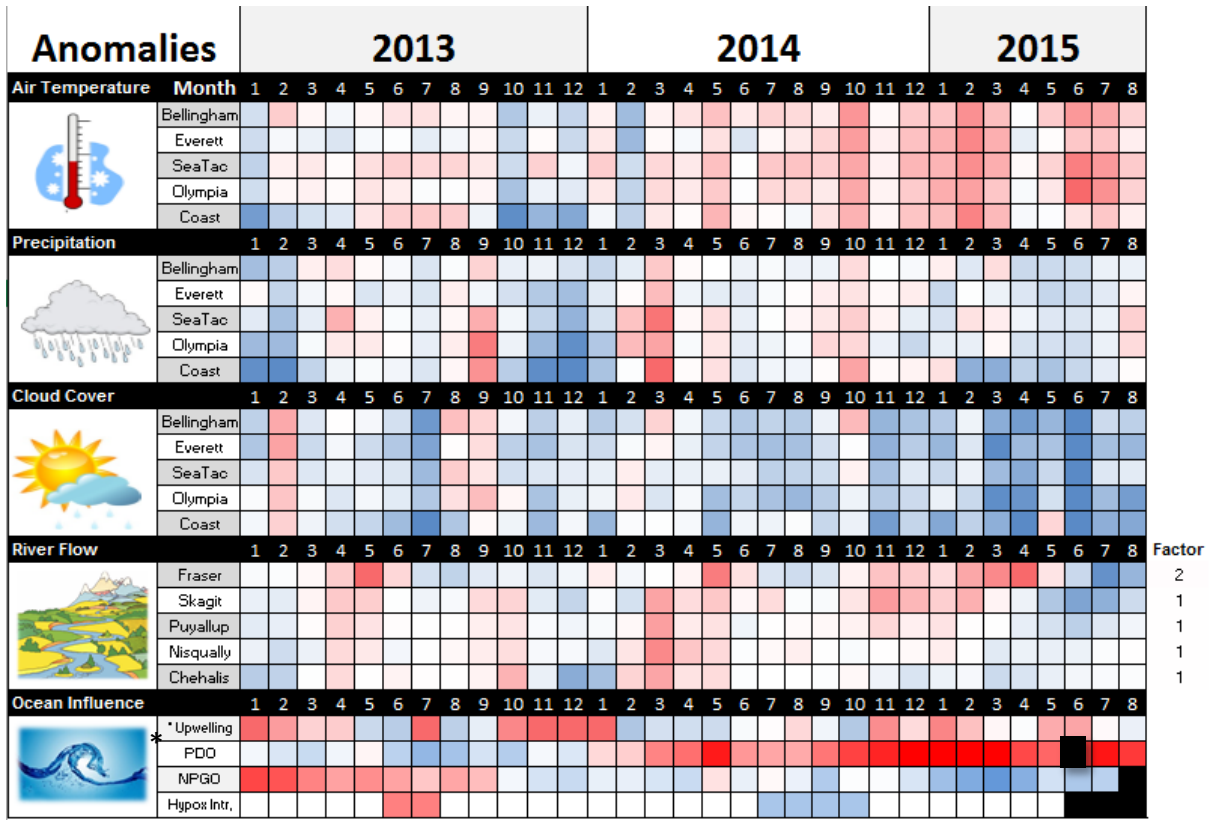
Air temperatures have remained warmer than normal across western Washington since March of 2014.

Precipitation levels were generally above normal in western Washington during August; rain was episodic.

Sunshine has generally been above normal.

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

Upwelling has returned to normal and the **PDO** remains in the warm phase.



*Upwelling Anomalies (PFEL) higher expected lower No data

Our long-term marine monitoring stations in Washington



Field log

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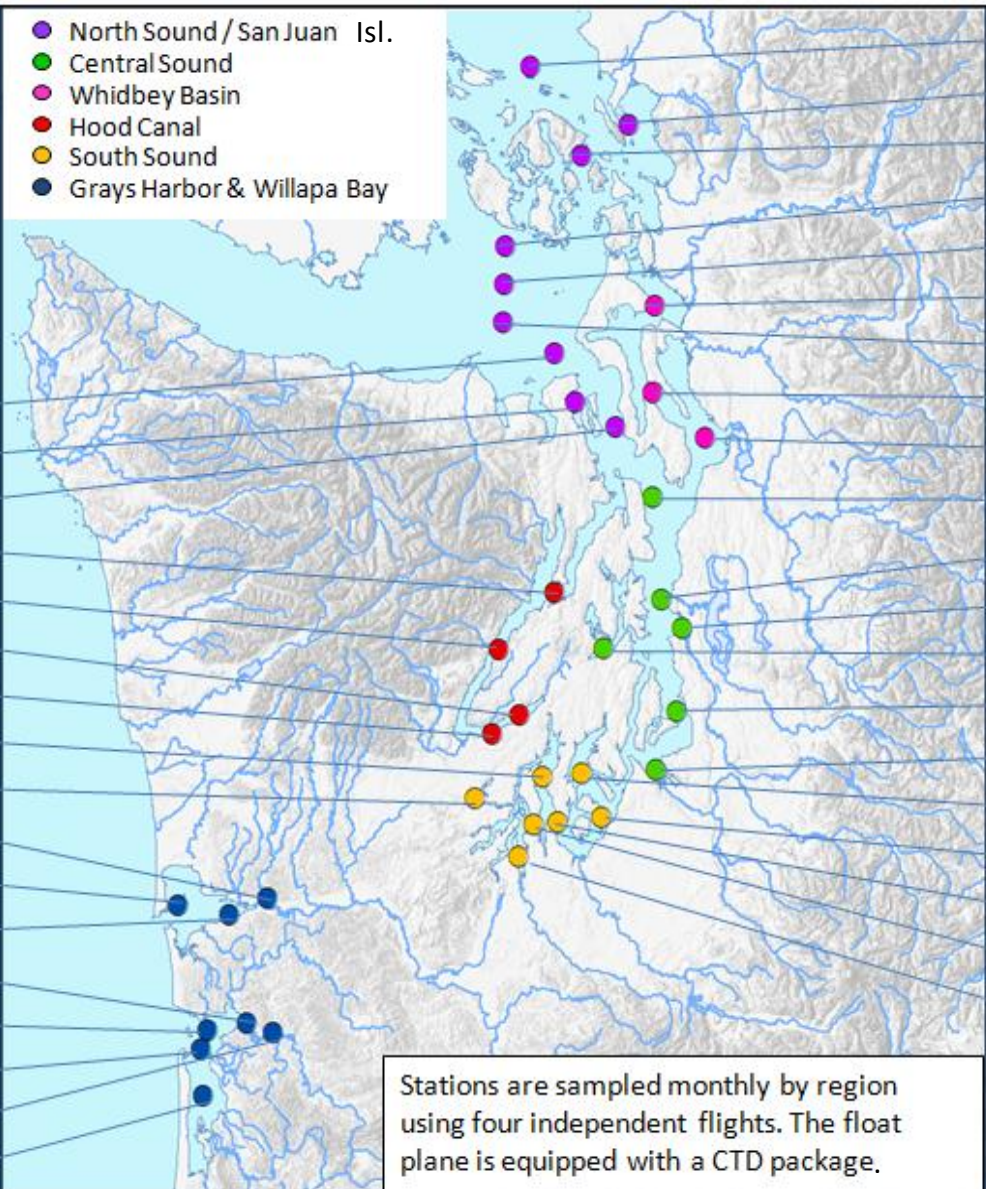
Aerial photos

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



Field log

Climate

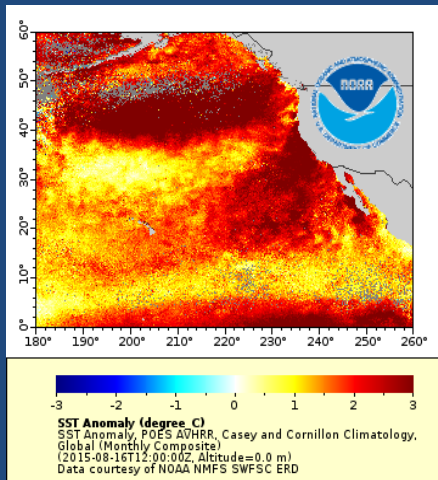
Water column

Aerial photos

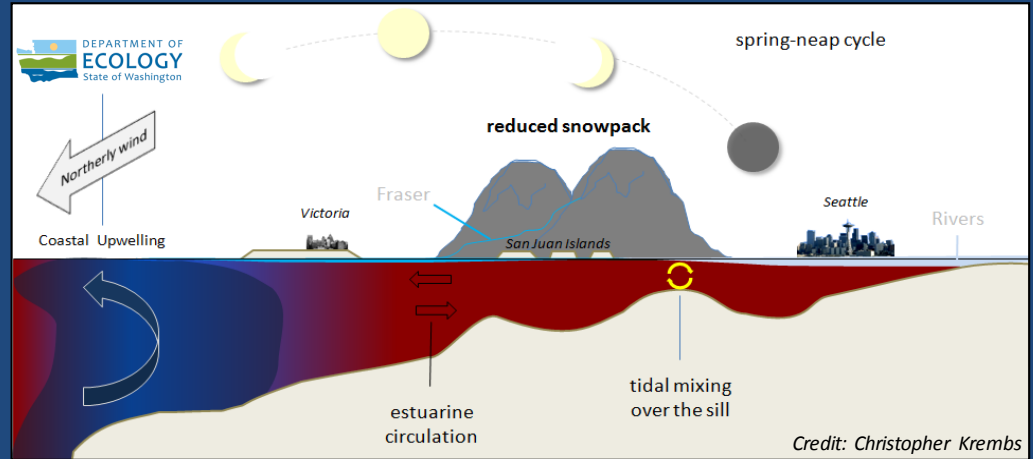
Continuous monitoring

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.

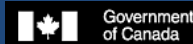
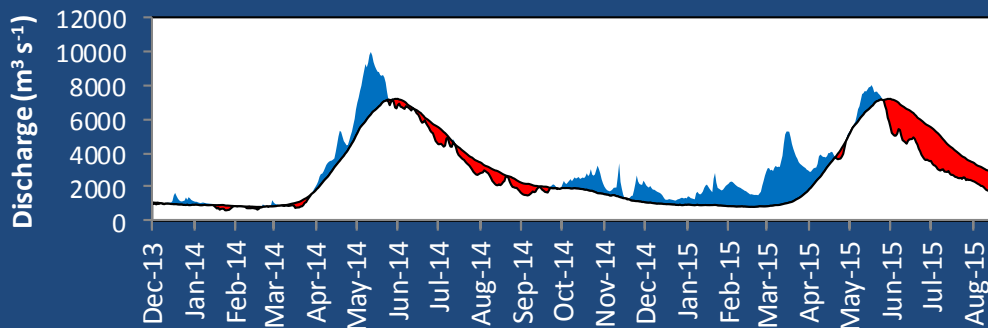


As of Aug 2015 (left), the Blob is sitting offshore, separated from the coast by a thin band of cooler, upwelled water, like in summer of 2014.



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.

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



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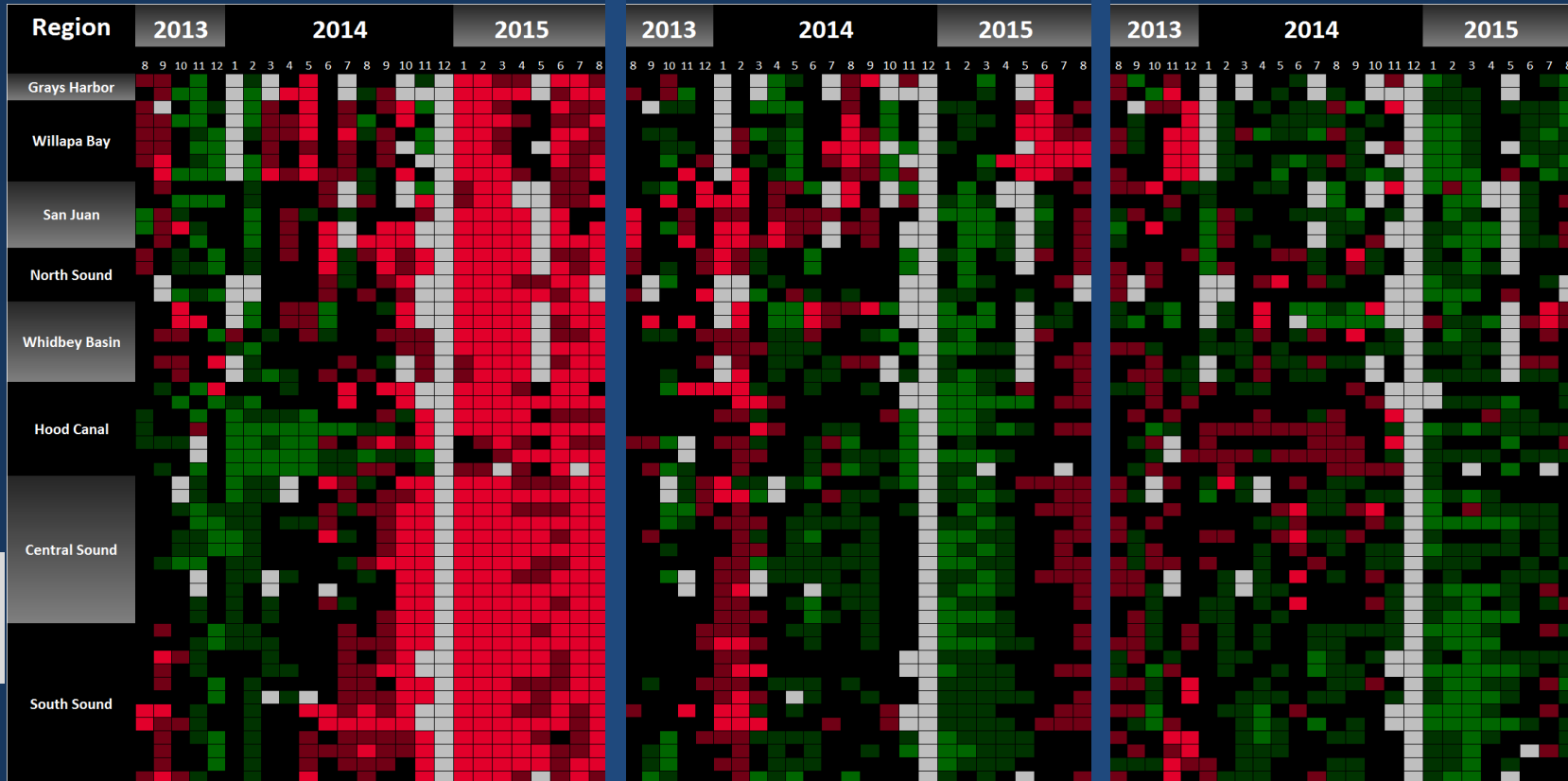


August **temperatures** are still at record-breaking **highs**. Ongoing drought effects (lower freshwater inputs) shift salinity to higher than normal levels. Coastal Bays, Hood Canal, and South Sound exhibit lower oxygen.

Higher Temperature!

Higher Salinity

Expected Oxygen



Is lower oxygen in Hood Canal and South Sound due to lack of water exchange?

[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

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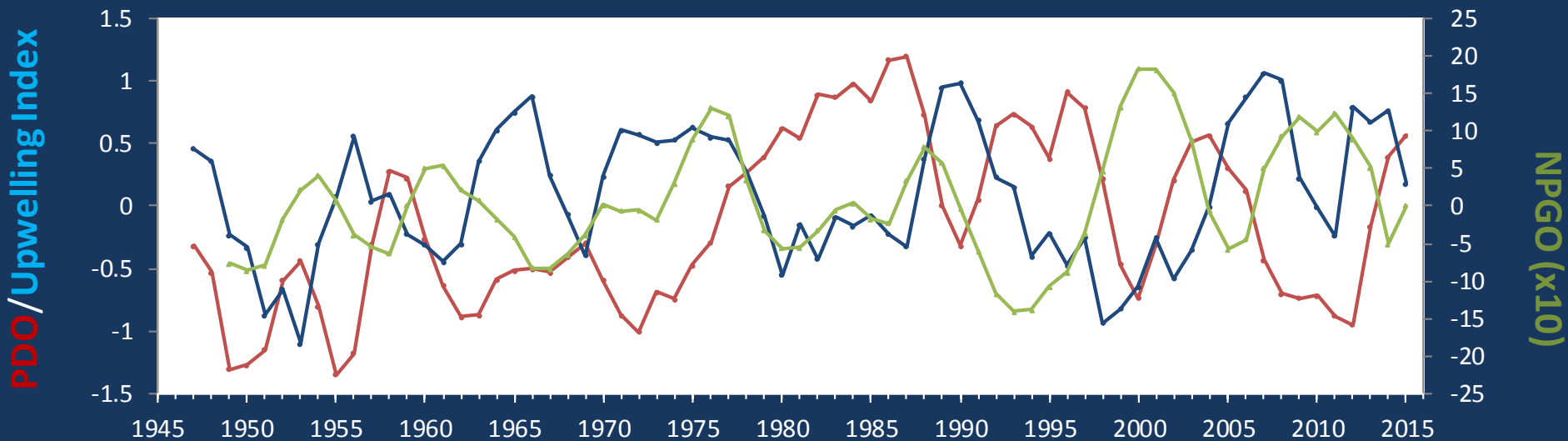
Aerial photos

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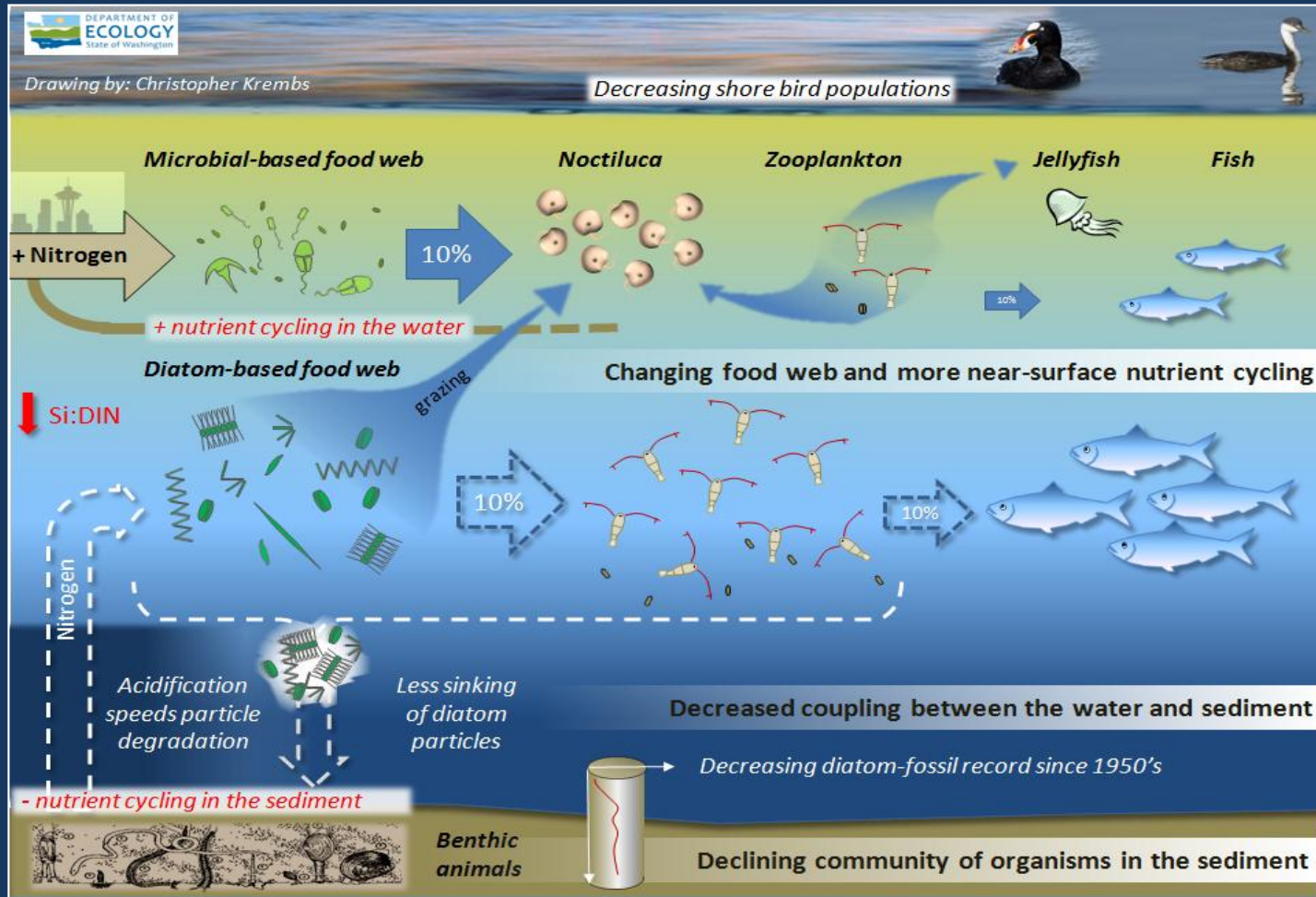
- a) Pacific Decadal Oscillation Index (**PDO, temperature**) [\(explanation\)](#)
- b) Upwelling Index (anomalies) (**Upwelling, low oxygen**) [\(explanation\)](#)
- c) North Pacific Gyre Oscillation Index (**NPGO, productivity**) [\(explanation\)](#)

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?

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](#)

| | | | | | |
|-----------|---------|--------------|----------------------|-----------------------|---------|
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|-----------|---------|--------------|----------------------|-----------------------|---------|



Large jellyfish aggregations are in some finger inlets of South Sound and present in inlets of the Kitsap Peninsula and East Sound (Orcas Island). Phytoplankton blooms in colors of red-brown in South Sound. Brown bloom was in Kilisut Bay. Occasional algal mats drift in Central Sound and Samish Bay. Nooksack and Stillaguamish river plumes carry sediment.

[Start here](#)

Greeted in the morning by moon jellyfish



Mixing and Fronts:
Fronts visible around river plumes.



Jellyfish:
Very abundant and large jellyfish patches in southern inlets of South Sound (Budd and Eld Inlets), Sinclair Inlet, and East Sound (Orcas Island).



Suspended sediment:
Suspended sediments with brownish color suggest soil in Nooksack and Stillaguamish River plumes. Skagit River with glacial flour.



Visible blooms:
Green-brown: Quatermaster Harbor.
Red-brown: Eld, Budd, and Henderson Inlets.
Brown: Kilisut Harbor, Marrowstone Island.



Debris:
Occasional mats in Central Sound and Samish Bay.

Algal bloom in Quatermaster Harbor





Aerial photography and navigation guide

Date: 9-21-2015

Tide data (Seattle):

| Time | Pred | High/Low |
|----------|------|----------|
| 04:59 AM | 0.96 | L |
| 12:13 PM | 9.51 | H |
| 05:50 PM | 6.82 | L |
| 11:02 PM | 8.86 | H |

Flight Information:

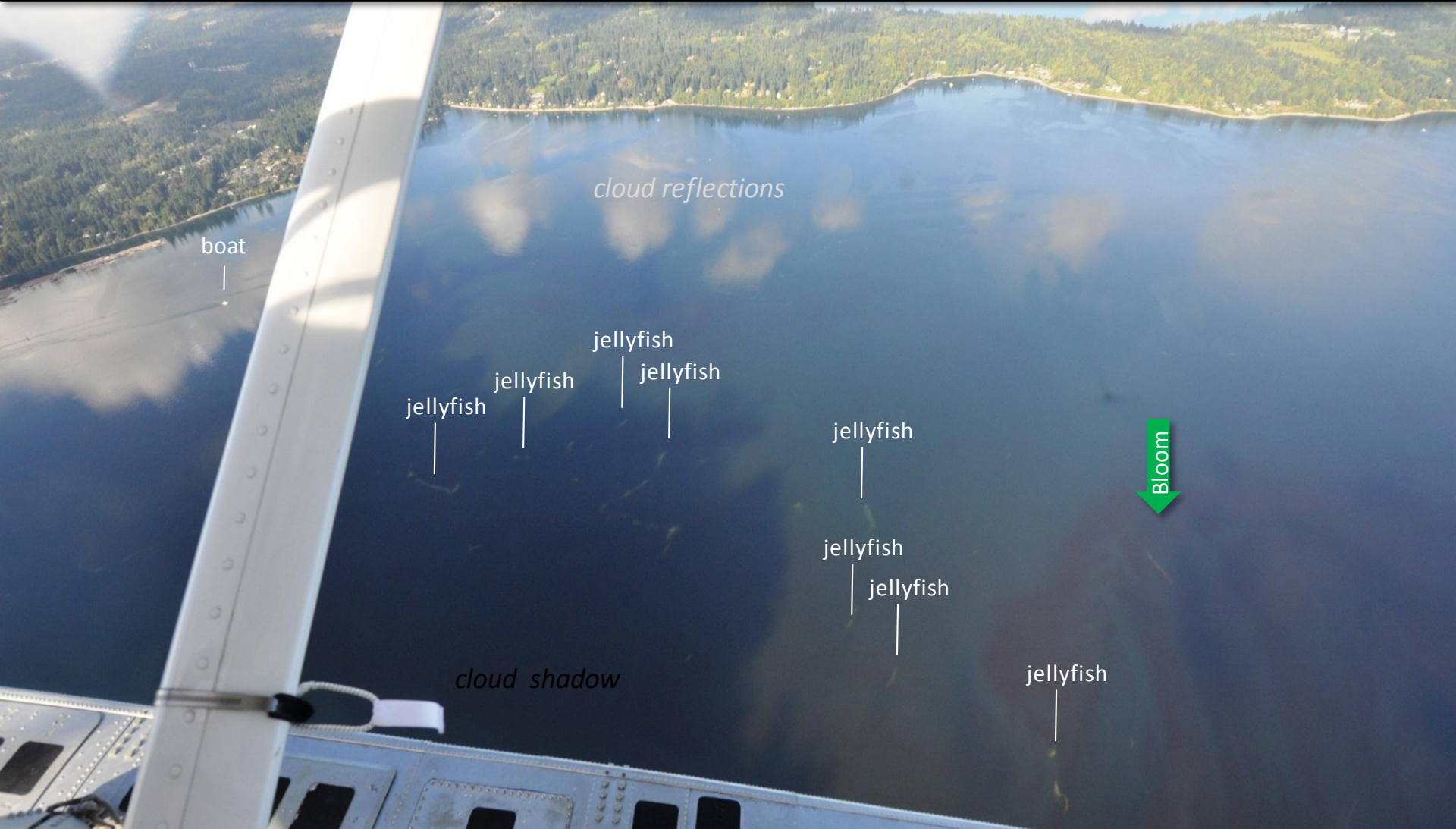
Good visibility in North Sound, broken clouds in South Sound.

--- Flight route

Observation Maps:

Central and North Sound

South Sound



*Large patches of moon jellyfish mixed in with red-brown bloom. Reflections and shadow of cloud.
Location: Budd Inlet (South Sound), 10:21 AM.*



Field log

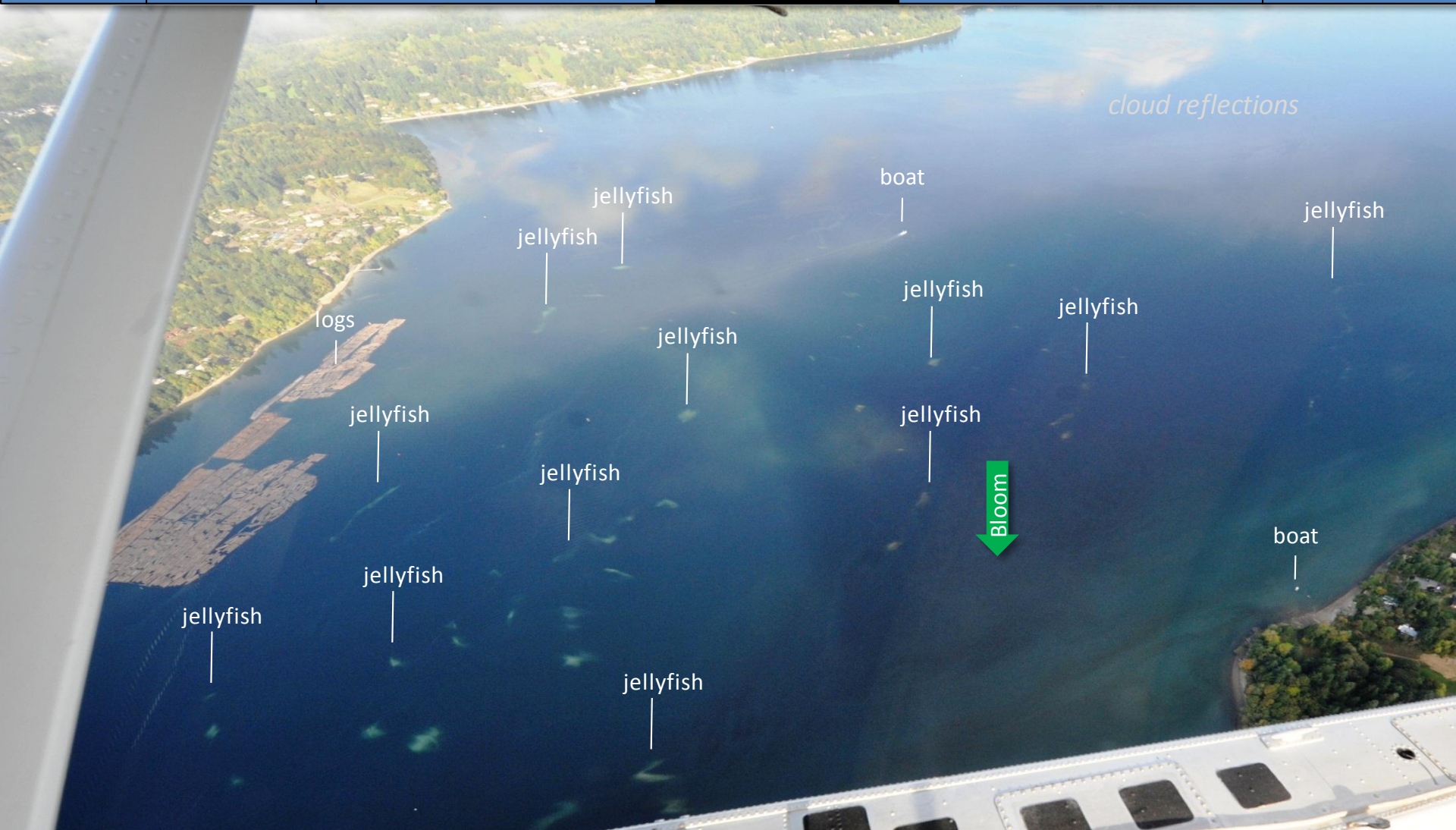
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Numerous patches of jellyfish in water containing red-brown algal bloom.
Location: Priest Point Park, Budd Inlet (South Sound), 10:22 AM.



Field log

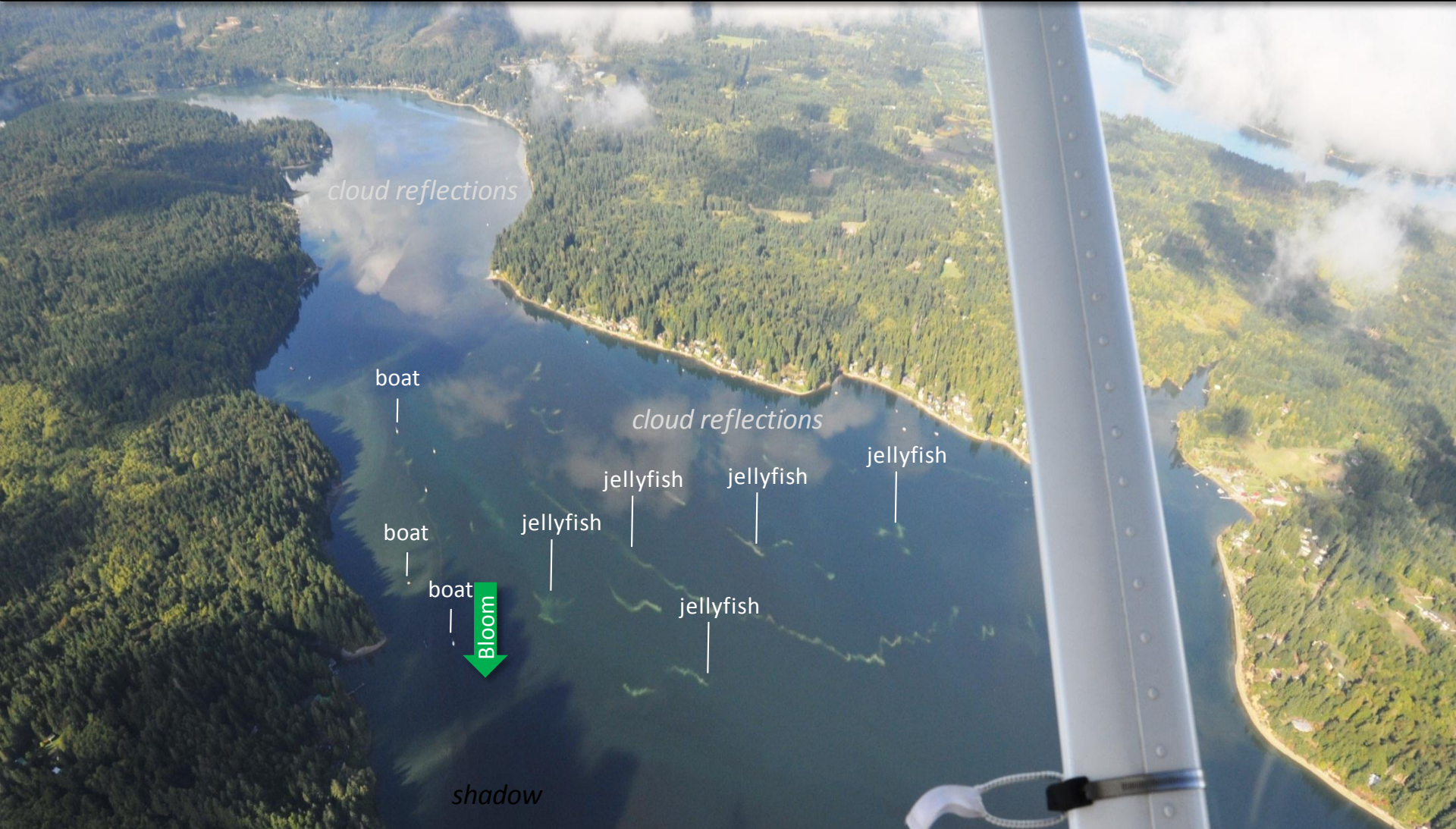
Climate

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

Location: Eld Inlet (South Sound), 10:24 AM.



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Numerous large patches of jellyfish in water of turquoise color.
Location: Sinclair Inlet (Central Sound), 10:46 AM.



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*cloud shadow*

Bloom

boat

cloud shadow

Mixing of water containing different colors due to algae bloom.
Location: Off Illahee State Park, Port Orchard (Central Sound), 10:50 AM.



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Greenish algae bloom and fish pen.

Location: Port Gamble (Central Sound), 11:00 AM.



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*Northern end of brown algal bloom bordering clearer water with a view to bottom.
Location: Kilisut Harbor, Marrowstone Island (Central Sound), 11:09 AM.*

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Greenish algal bloom in western portion of Penn Cove.

Location: Off Fort Ebey State Park, Penn Cove (South Sound), 11:50 AM.



Field log

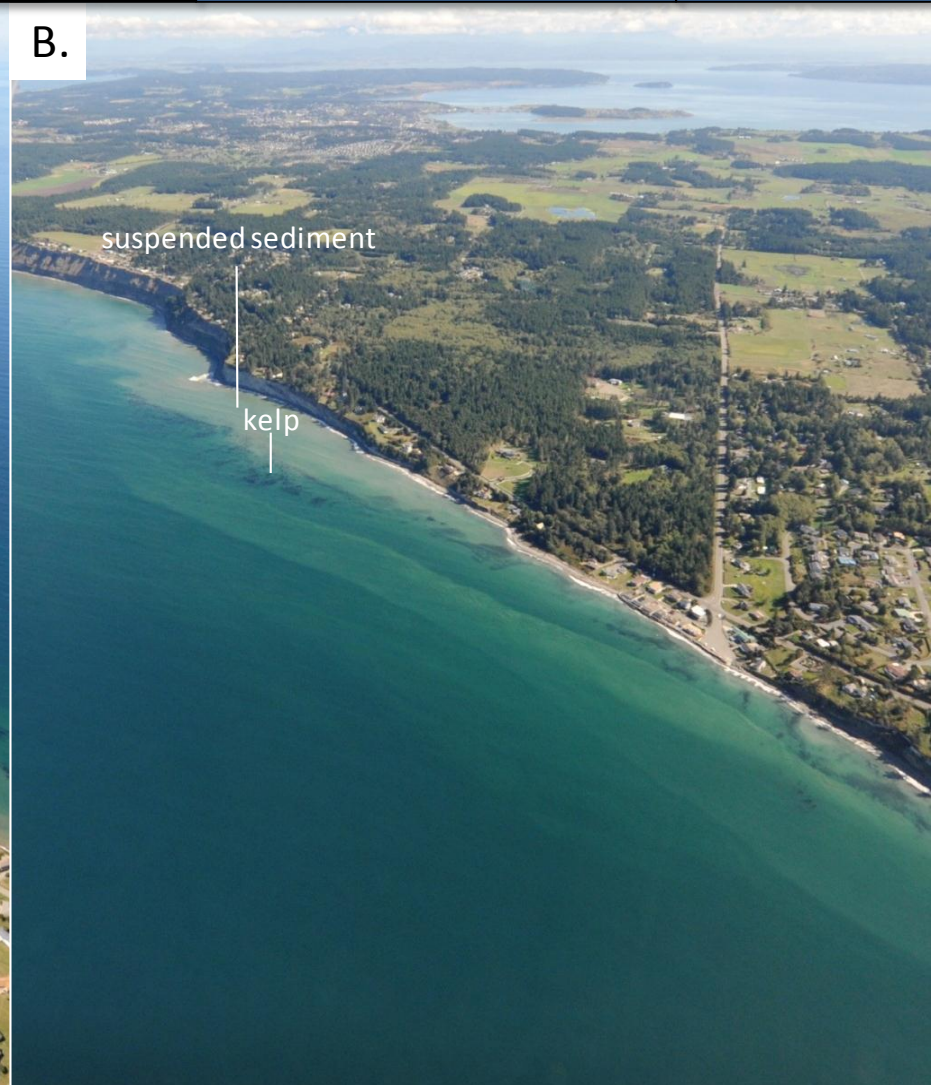
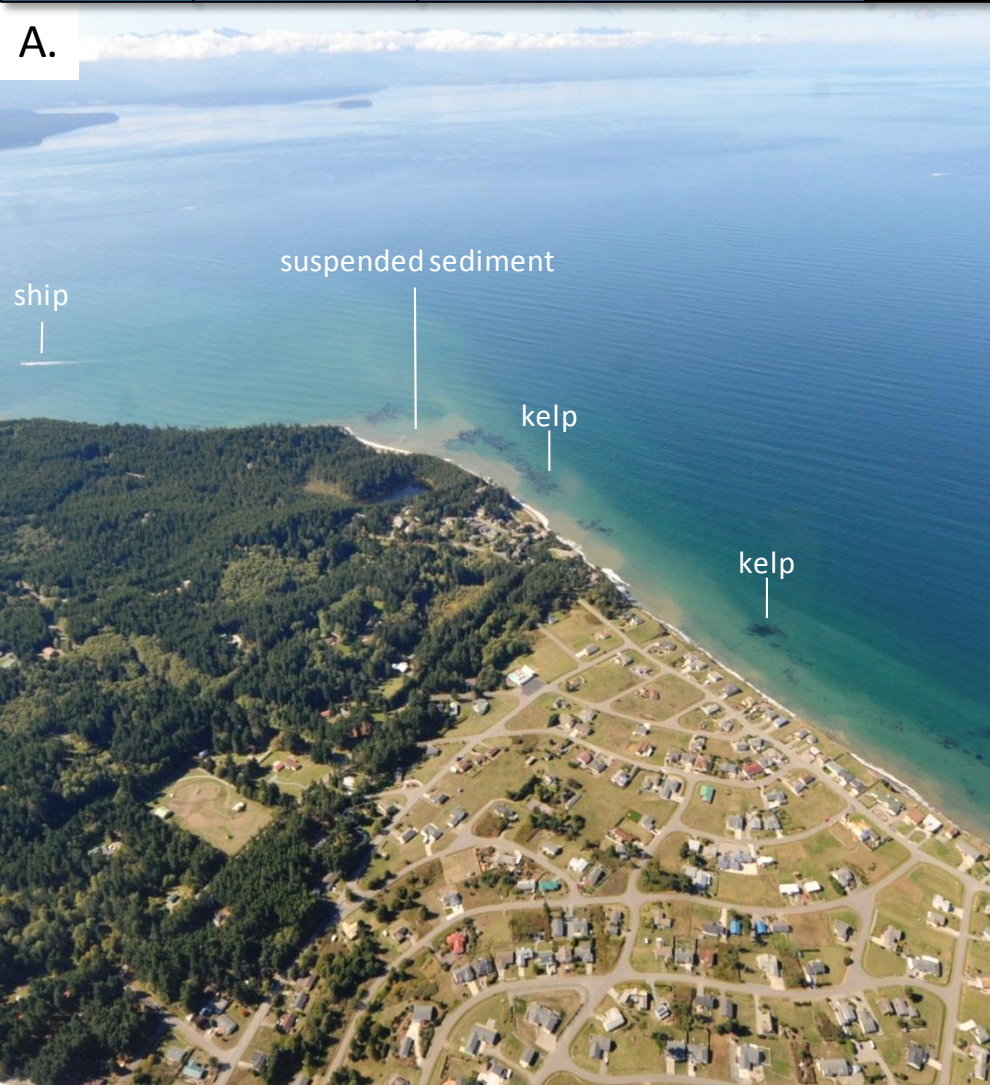
Climate

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Coastal erosion and suspended sediment near cliffs along shoreline.

Location: A. Off Fort Ebey State Park, B. West Hastie Lake Road, Whidbey Island (North Sound), 11:52 AM.



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Signs of a red-brown bloom mixed with a greenish bloom.
Location: Mud Bay, Lopez Sound (North Sound), 11:59 AM.



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*Sediment-rich water of the Nooksack River flowing across "the Portage" during high tide.
Location: Portage Bay, Bellingham Bay (North Sound), 12:57 PM.*



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Sediment-rich plume of the Nooksack River with a brown hue discharging into Bellingham Bay.
Location: Portage Bay, Bellingham Bay (North Sound), 12:57 PM.



Boat wake shows thin sediment-rich layer at surface. Front and water carrying glacial flour off Lummi Island. Location: Off Portage Island, Bellingham Bay (North Sound), 12:58 PM.



Field log

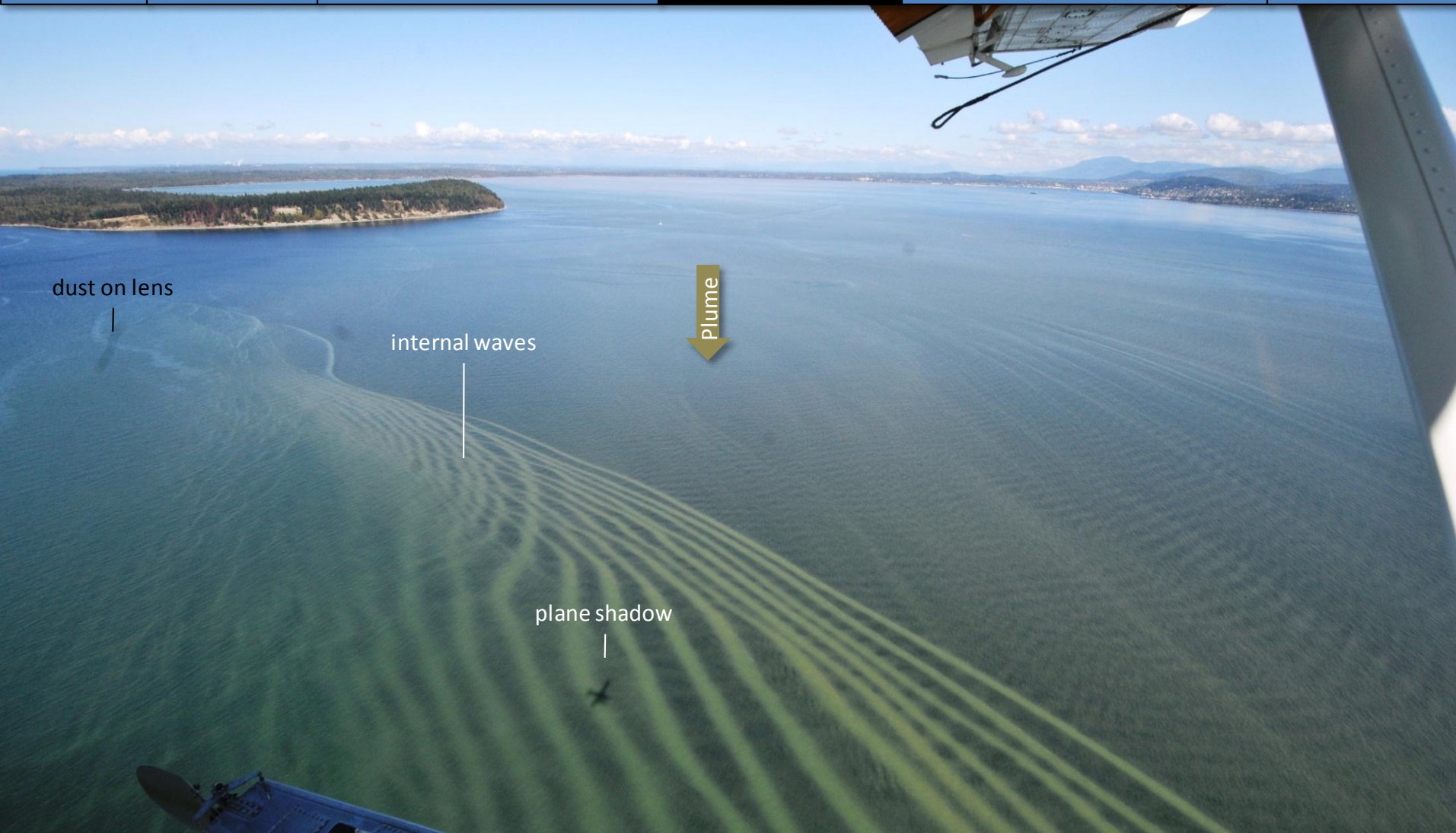
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Bands of internal waves form near surface of thin sediment-rich surface layer.
Location: Bellingham Bay (North Sound), 1:21 PM.



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Water discolored by glacial flour and distinct front that carries organic debris.
Location: Off Carter Point, Lummi Island, Bellingham Bay (North Sound), 1:22 PM.



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*Sediment-rich water and tidal fronts with organic debris mixing with clearer water.
Location: Hat Island, Guemes Channel (North Sound), 1:27 PM.*



dust on lens

boat

Bloom

Bright green algal bloom in a disconnected slough.
 Location: Northern end of Swinomish Channel (North Sound), 1:30 PM.



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*Patches of sediment-rich water with glacial flour of the Skagit River bordered with organic debris.
 Location: Off Goat Island, Skagit Bay (Central Sound), 1:34 PM.*



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*Brownish sediment-rich plume of the Stillaguamish River flowing into Port Susan.
Location: Port Susan, Whidbey Basin (Central Sound), 2:10 PM.*

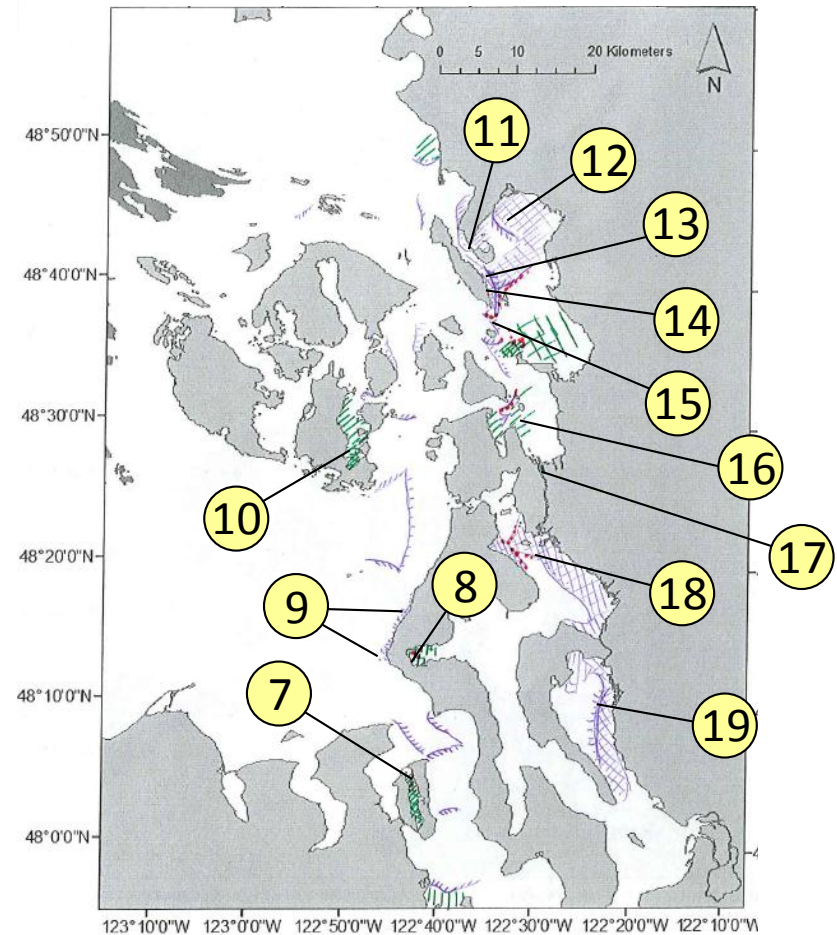
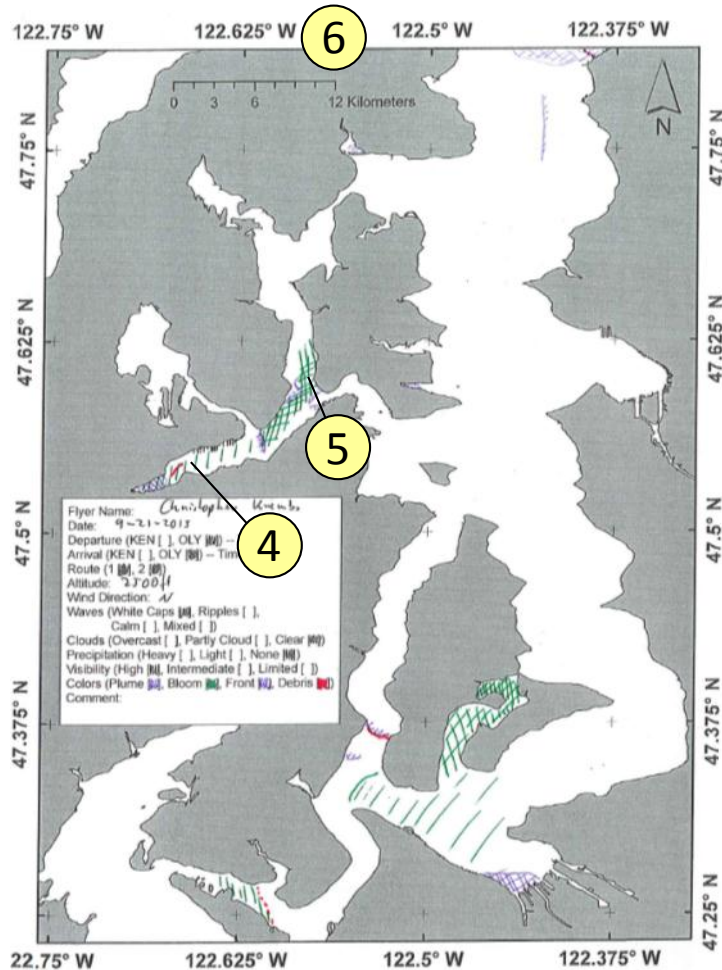


Red-brown algal bloom and jellyfish patches.
 Location: Henderson Inlet, (South Sound), 4:02 PM.

Date: 9-21-2015

Central Sound

North Sound/San Juan Islands



Numbers on map refer to picture numbers for spatial reference

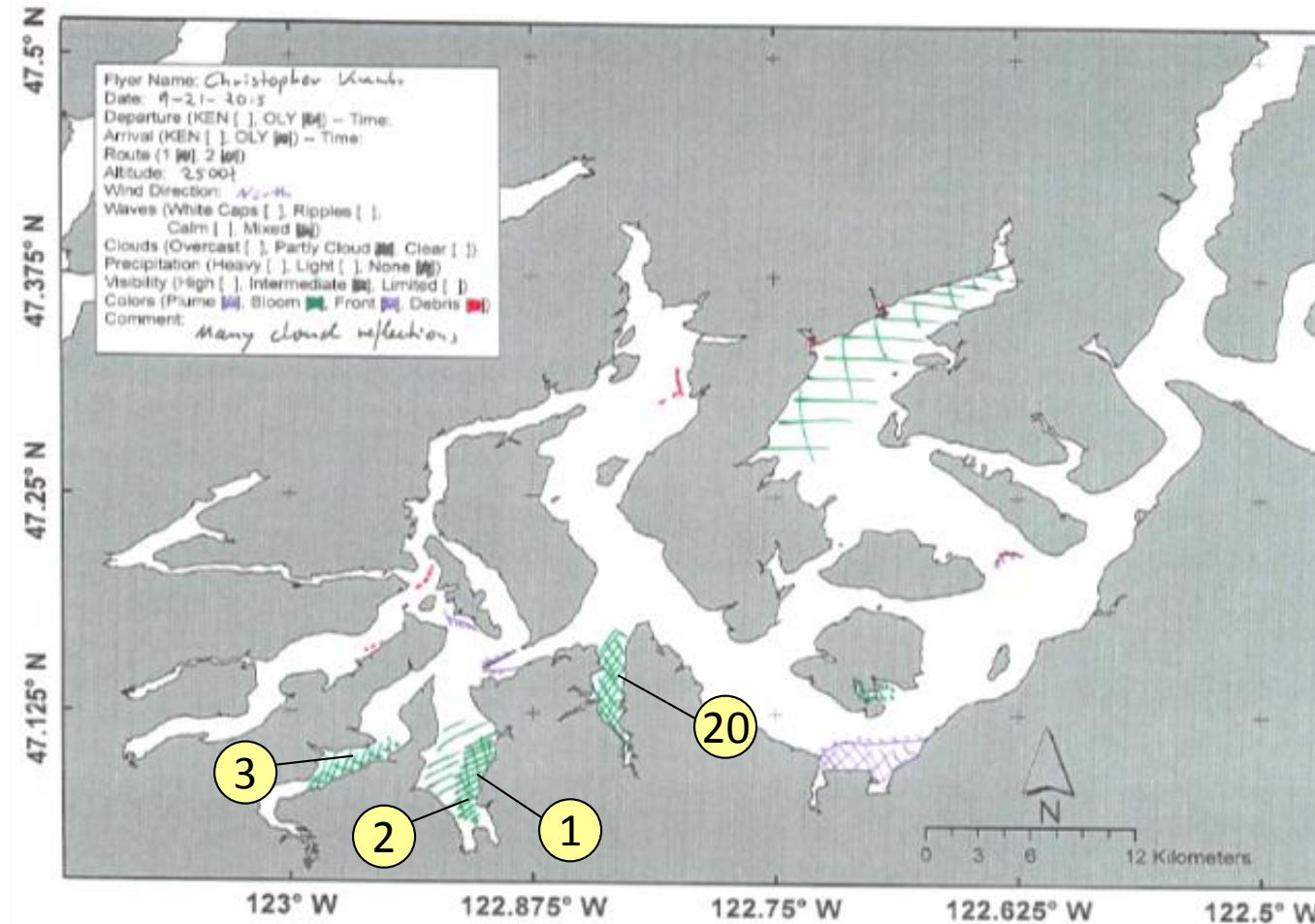
Qualitative aerial observer map during transit

Navigate












Date: 9-21-2015

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.

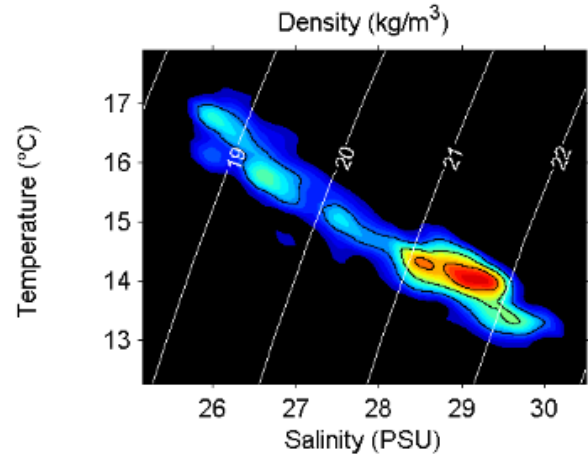
Debris:

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.

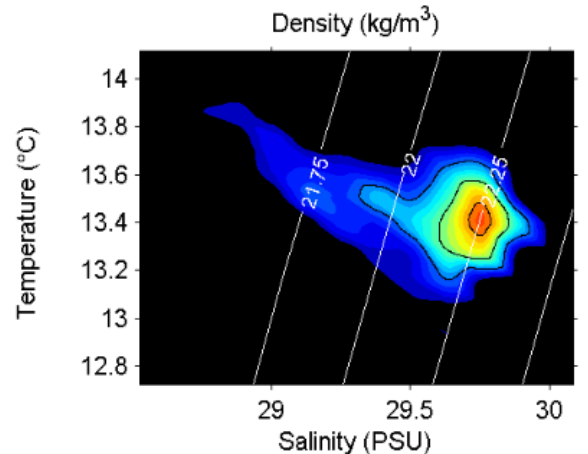


Summary: The Mukilteo mooring station continues to have monthly water temperature that is higher than the past five years. Mean daily temperature and salinity are becoming more variable. River flows remain low and minimal.

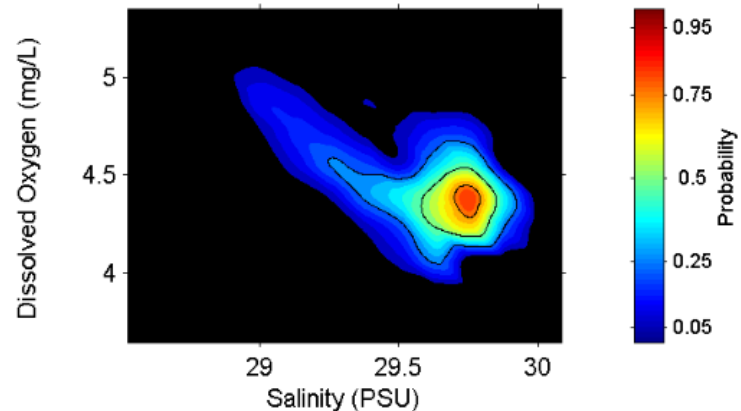


2-6 m depth

No oxygen sensor on the shallow instrument package.



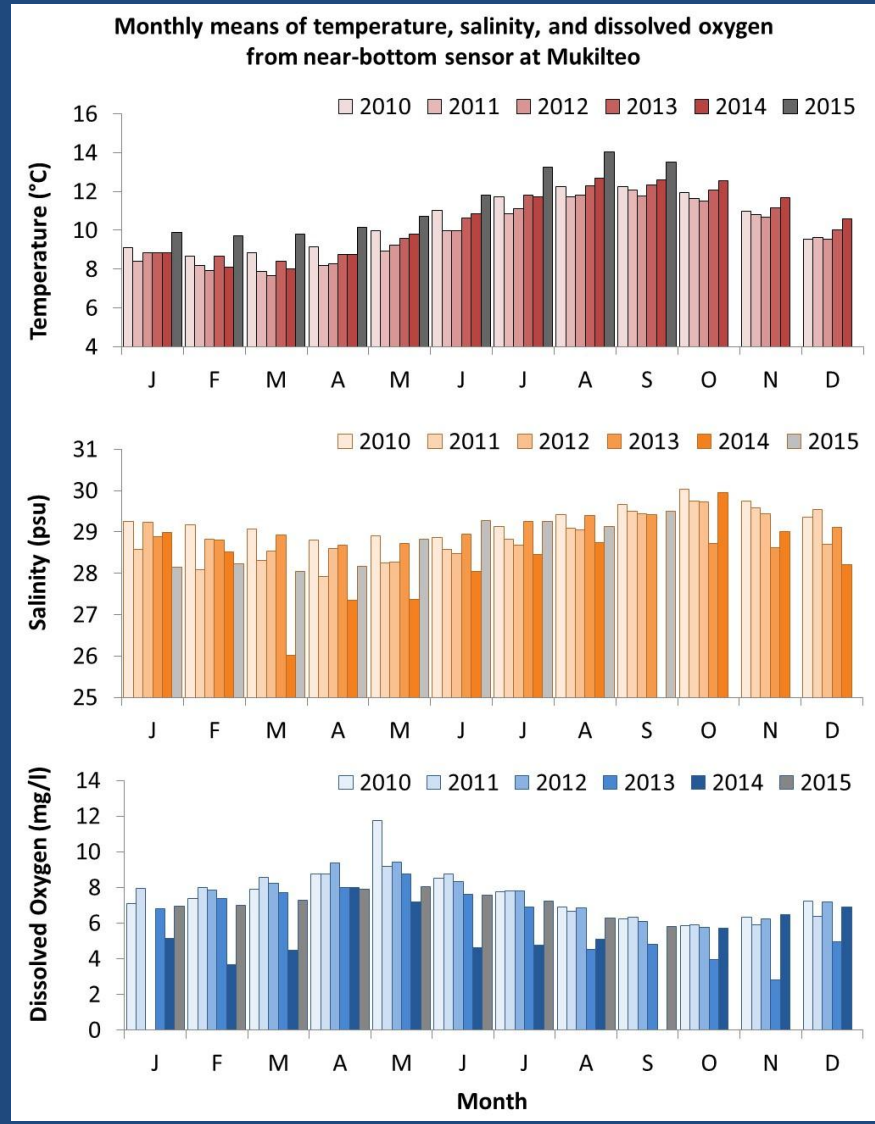
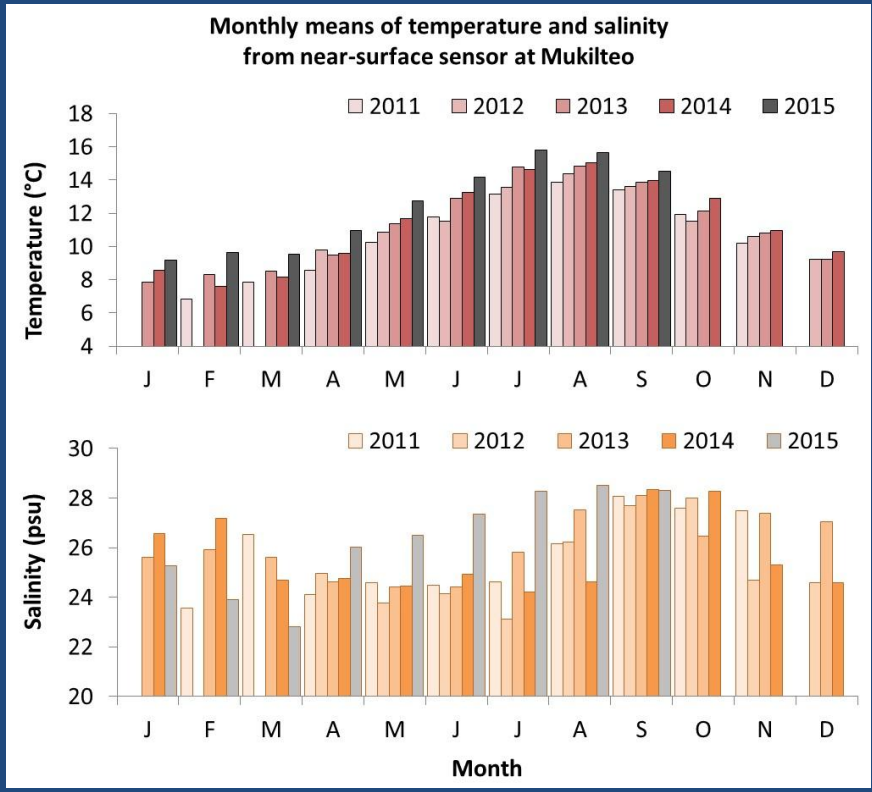
12-16 m depth



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.



In September, water temperature remains warmer than the past five years, salinity is about normal, and dissolved oxygen declines slightly. Seasonality of each parameter remains apparent.

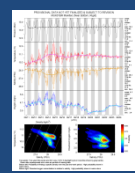
Please note that data are provisional. Data are in GMT.

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.

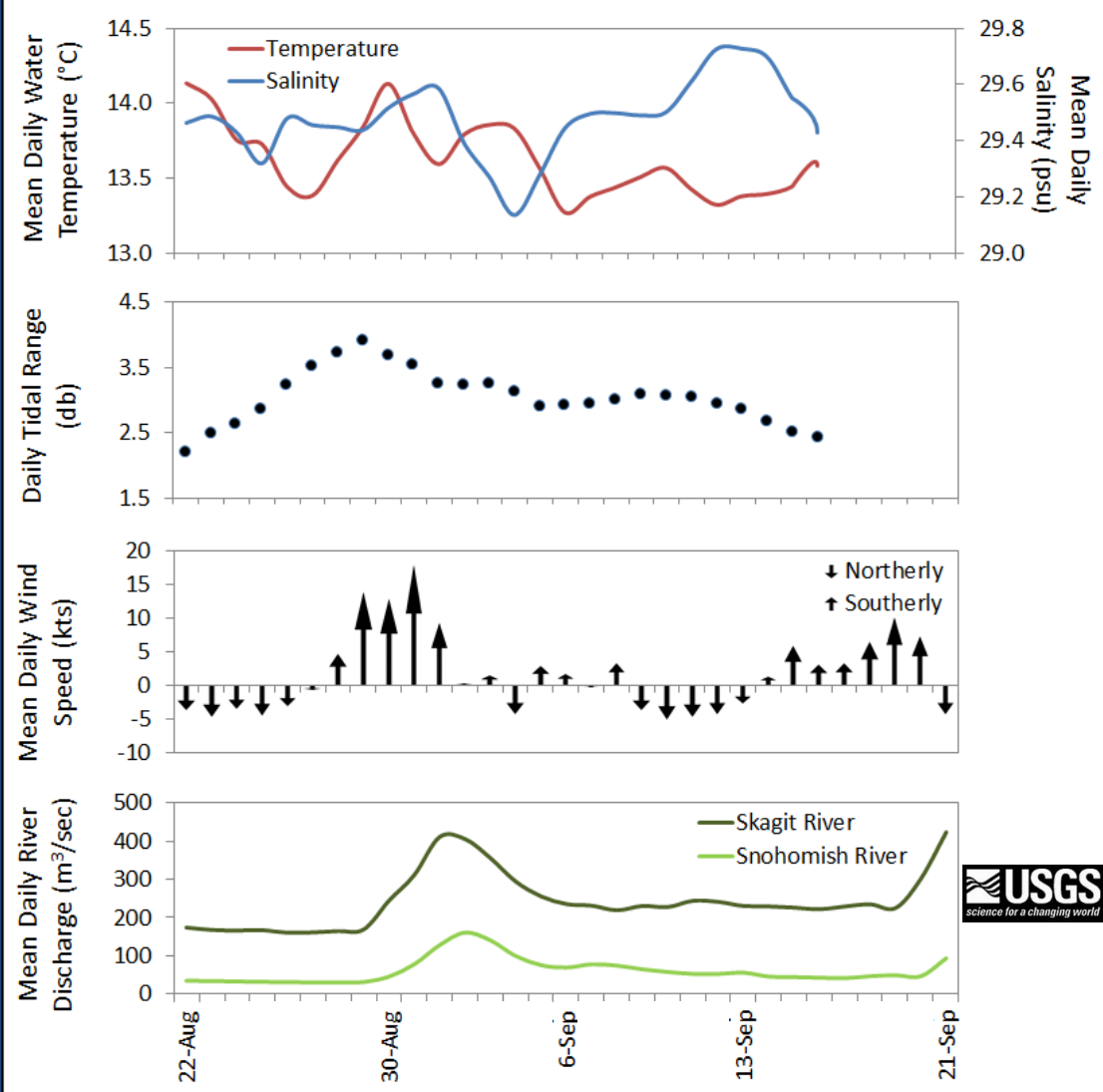
As the largest regional contributor of freshwater to Puget Sound, understanding the timing and magnitude of the Skagit River flow is important. Southerly winds coincided with increased river flows.

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





The Skagit River changes when it delivers its freshwater to Puget Sound

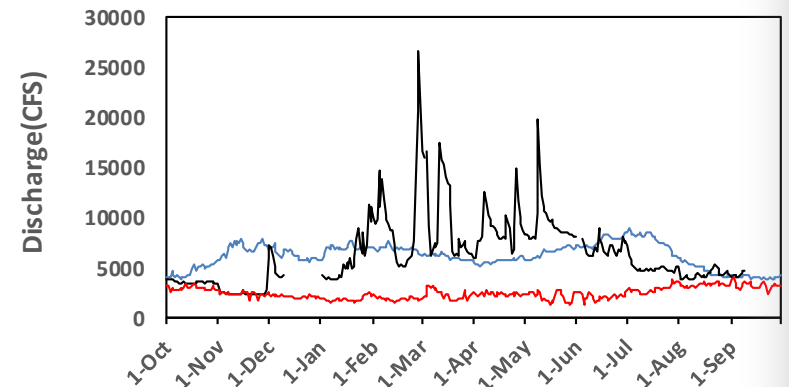
Ecology's River and Stream Monitoring Program measures water quality of the Skagit River since the 1940's at two sites ([03A060](#)) ([04A100](#)).



According to the Skagit Climate Science Consortium, changes in temperature and precipitation will alter the hydrologic behavior of the Skagit River by the late 21st century.

The Skagit River contributes 20% of all the freshwater entering Puget Sound.

- In spring, 2015 river flows (black line) were much above historical mean daily values (blue line).
- Starting in June, flows decreased below historical averages but did not reach record lows (red line).



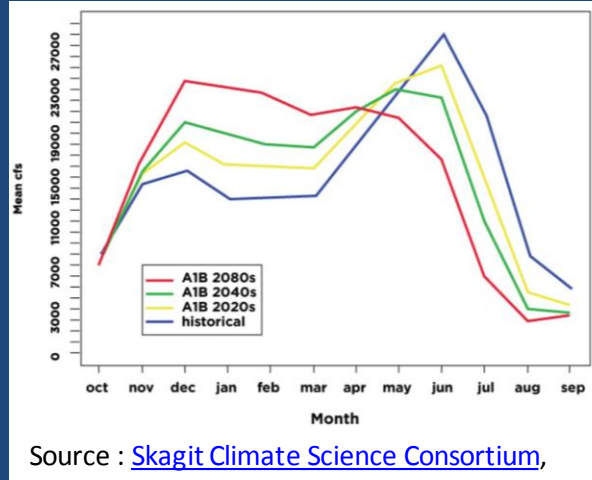
- Mean daily values 1942-2015
- 2015 Water Year discharge (CFS)
- Minimum daily mean value 1942-2015



Easton Glacier photographed in 1912.



Easton Glacier photographed in 2011.



Source : [Skagit Climate Science Consortium](#),

Hydrographs of projected monthly stream flows (CFS) on the Skagit River at Mt. Vernon.

Simulations for the historical (blue), the 2020s (yellow), the 2040s (green) and the 2080s (red).

Warmer temperatures and a higher proportion of winter precipitation falling as rain, rather than stored as snow, will reduce the amount of water stored as snow in the Skagit Basin overall.

The retreat and loss of the glaciers (e.g., Easton Glacier) will continue to effect summertime low flows (400 billion gallons of reduced water supply since 1993) in the Skagit River basin.

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:

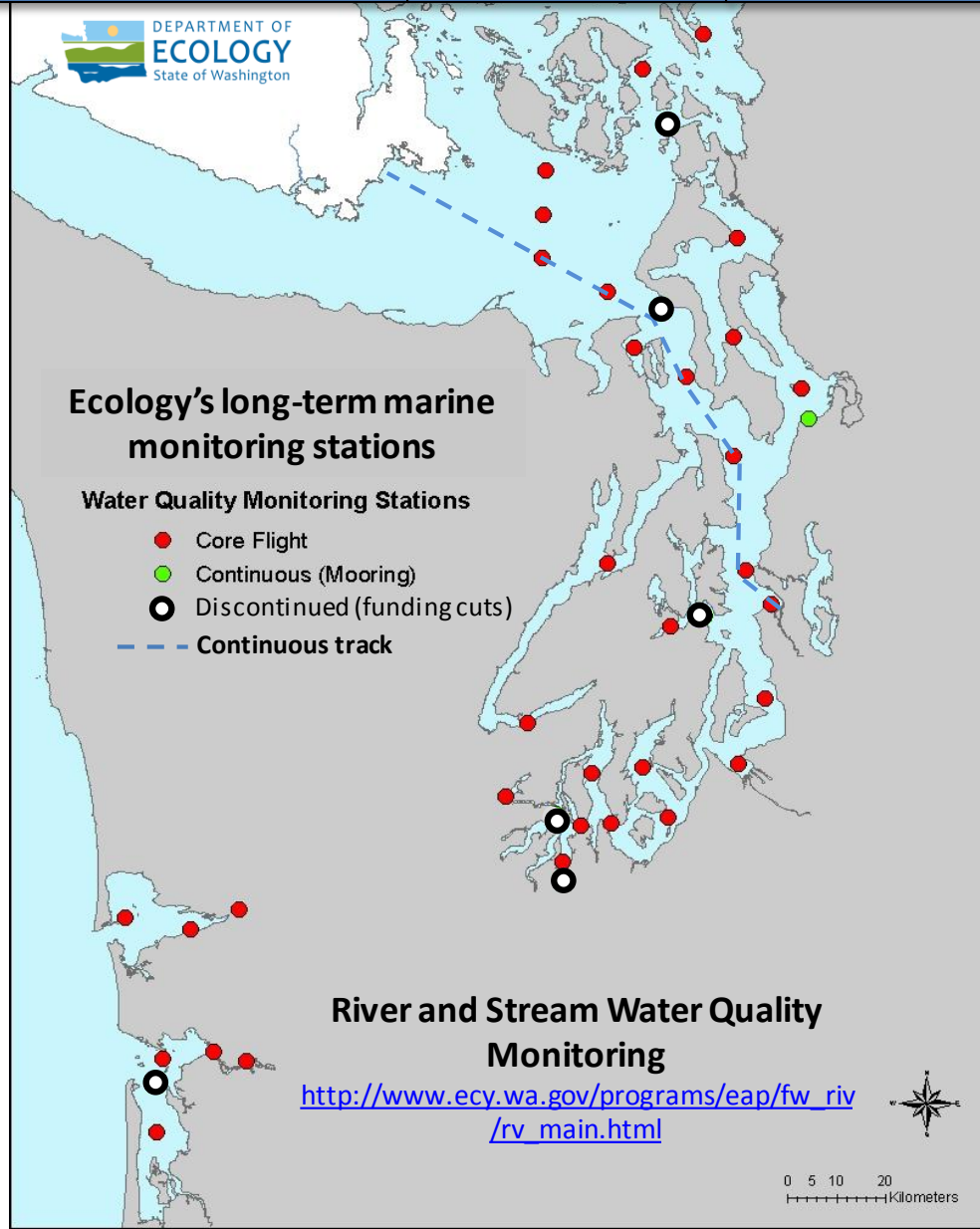
<https://fortress.wa.gov/ecy/eap/marinewq/mwdata/set.asp>



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



0 5 10 20
Kilometers

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**