



Eyes Over Puget Sound

[Field log](#)[Climate](#)[Water column](#)[Aerial photos](#)[Ferry and Satellite](#)[Moorings](#)

The drought meets the “The Blob” in Puget Sound as warm air temperatures have left little snow to feed the rivers.

An aerial photograph taken from an airplane, showing a vibrant rainbow arching over a coastal town and green fields. The town is densely packed with houses, and the surrounding area is lush with green trees. In the background, the Puget Sound and distant mountains are visible under a blue sky with scattered white clouds. The wing of the airplane is visible on the right side of the frame.

Surface Conditions Report

April 29, 2015

[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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Skip Albertson



*Julia Bos
Suzan Pool*



*Dr. Christopher
Krembs*



Suzan Pool



Please give us feedback

Personal field log [p.4](#)

Marine life in the Rocky Intertidal Zone.

Climate conditions [p.6](#)

Air temperature and ocean conditions remain warm. River flows are lower to the south and higher to the north. It rained only 0.7 inch (15 mm) in the past two weeks.

Water column [p.7](#)

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.

Moorings [p.37](#)

Warmer than normal water temperature. Steady increase in temperature the past week. Temperature and salinity variation may be mostly influenced by winds.

Aerial photography [p.10](#)

Patches of jellyfish are present in finger inlets of South Sound and Sinclair Inlet. Strong red bloom in Sinclair Inlet. Waters show signs of blooms only in confined bays (Henderson Inlet, Port Townsend Bay, Lopez and East Sound, Samish Bay, Quartermaster Harbor). Otherwise, the surface waters appear very clear. High suspended sediment in Port Susan.

Ferry and satellite [p.36](#)

n.a.

Expected Drought Effects and a Warmer Puget Sound



Field log

Climate

Water column

Aerial photos

Ferry and Satellite

Moorings

Extreme low snowpack has triggered a drought emergency

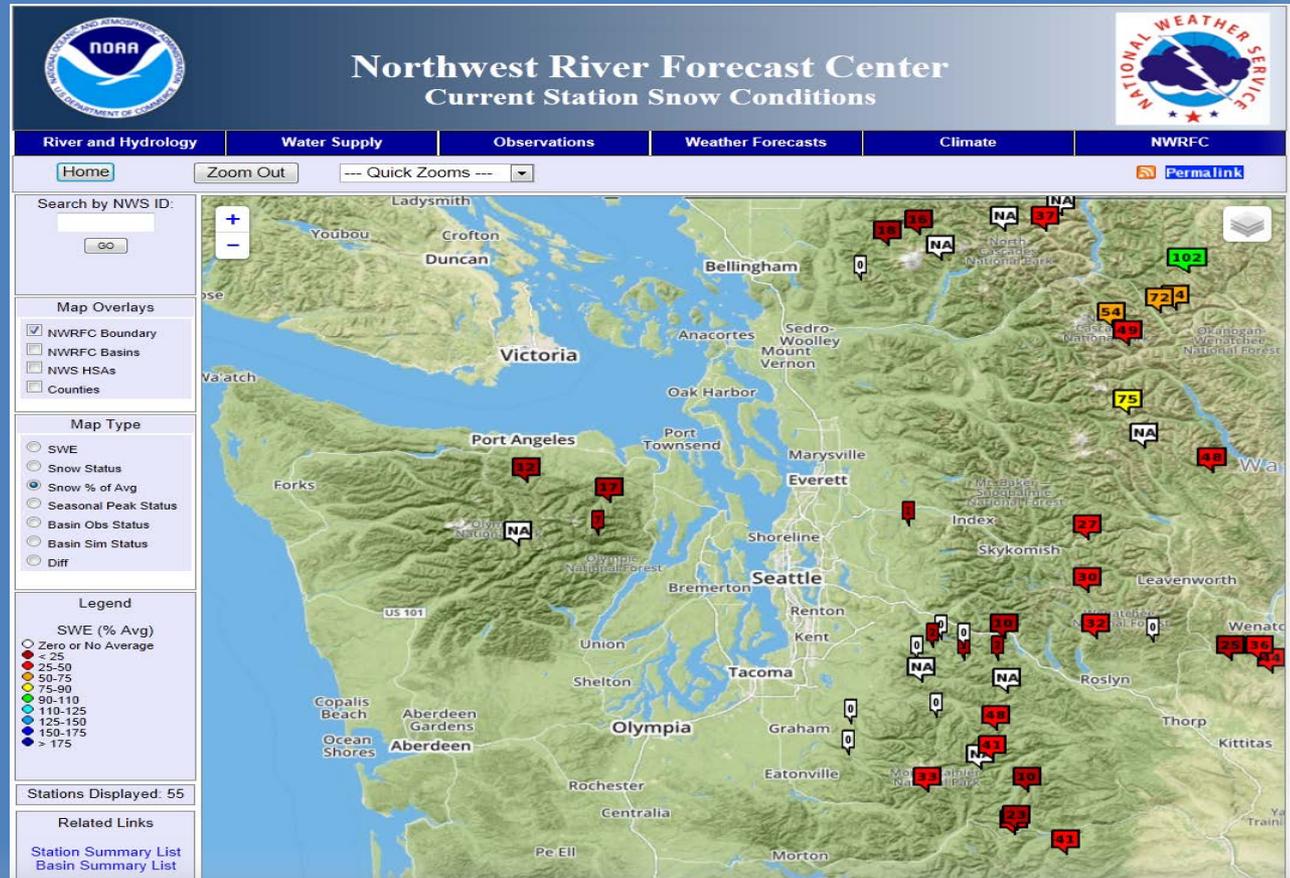
Governor Jay Inslee declared a drought on March 13 in three regions, including the Olympic Peninsula. Low snowpack is threatening a summer of record low flows in many rivers. This can impact Puget Sound in many ways.

A record warm winter has left Puget Sound with extreme low snowpack which will likely result in low summer river flows.

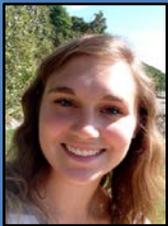
Low flows can both hurt salmon and change the ecosystem of Puget Sound.

Explore the details on how snowpack, salmon, and Puget Sound are expected to be different in 2015.

Go here



The Rocky Intertidal Zone



The coastline in Puget Sound has many rocky intertidal areas. Organisms in this zone are covered with water at high tide and exposed to air at low tide. What kind of organisms can we find in the Puget Sound intertidal zone?

Brooke McIntyre

Sea Lettuce

(*Ulva lactuca*)

- Green algae
- Eaten by sea urchins, mollusks, birds, and other animals



California mussel

(*Mytilus californianus*)

- Can grow up to 8 in. long
- Can live over 20 years
- Edible!



Acorn Barnacle

(*Balanus sp.*)

- Shell made from limestone
- Filter feeder



The Rocky Intertidal Zone

Hairy Hermit Crab

(*Pagurus hirsutiusculus*)

- Live inside shells
- Scavengers that dig for food
- Use right claw, which is larger than the left, for feeding and protection



Plumose anemone

(*Metridium* spp.)

- Predators that eat anything passing by that they can grab with their tentacles!



Ochre Sea Star

(*Pisaster ochraceus*)

- Colored purple, ochre, or brown
- Predator
- Eat mussels, barnacles, snails, and limpets



Photo Credits:

Ochre sea star pic - http://www.seastarsofthepacificnorthwest.info/species/purple_star.html; Ulva - http://www.korseby.net/outer/flora/algae/ulvophyceae/ulva_lactuca.jpeg; Acorn barnacle - <http://www.irelandswildlife.com/acorn-barnacle-semibalanus-balanus-des/>; Mussel - <http://sanctuarysimon.org/species/mytilus/californiana/california-mussel> <http://www.redorbit.com>; Plumose anemone - http://buzzmarinelife.blogspot.com/2013_05_27_archive.html; Hermit crab - <https://www.flickr.com/photos/34486353@N07/galleries/72157622272880387/>



Climate and natural influences, including weather, rivers, and the adjacent ocean, can affect our marine waters. For an explanation of the figure, see:

http://www.ecy.wa.gov/programs/eap/mar_wat/weather.html, page 26.

Summary:

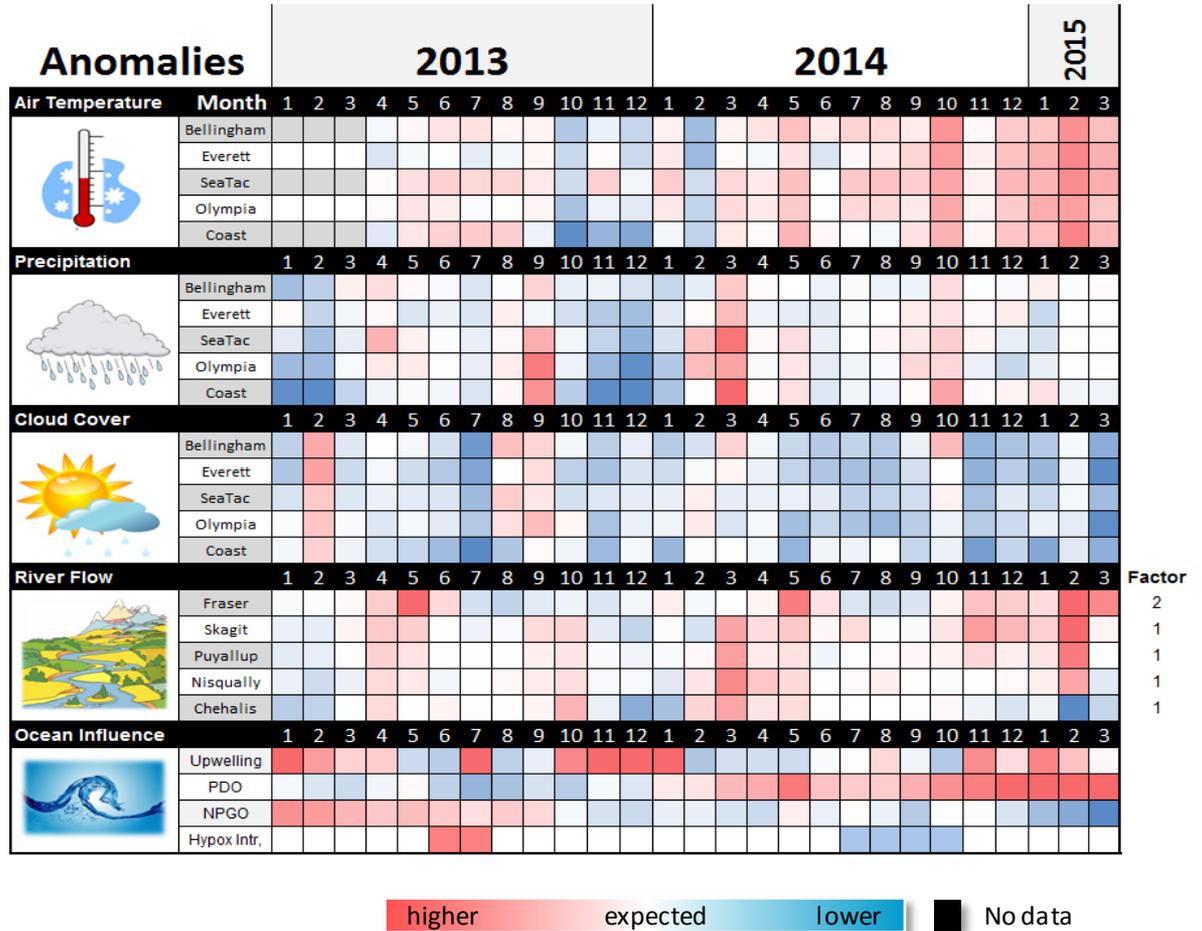
Air temperatures remain above normal which continue a year-long trend.

Precipitation levels are normal, but the Puget Sound lowlands saw little rain in late April, only 15 mm.

Sunshine has generally been above average with less cloud cover than normal.

River flows are lower overall, especially in the last 2 weeks. The Fraser is higher, reflecting early snow-melt in response to warm conditions.

PDO remains in the warm phase, **upwelling** is normal, but the lower **NPGO** suggests low productivity along the coast.



Our long-term marine monitoring stations in Washington



Field log

Weather

Water column

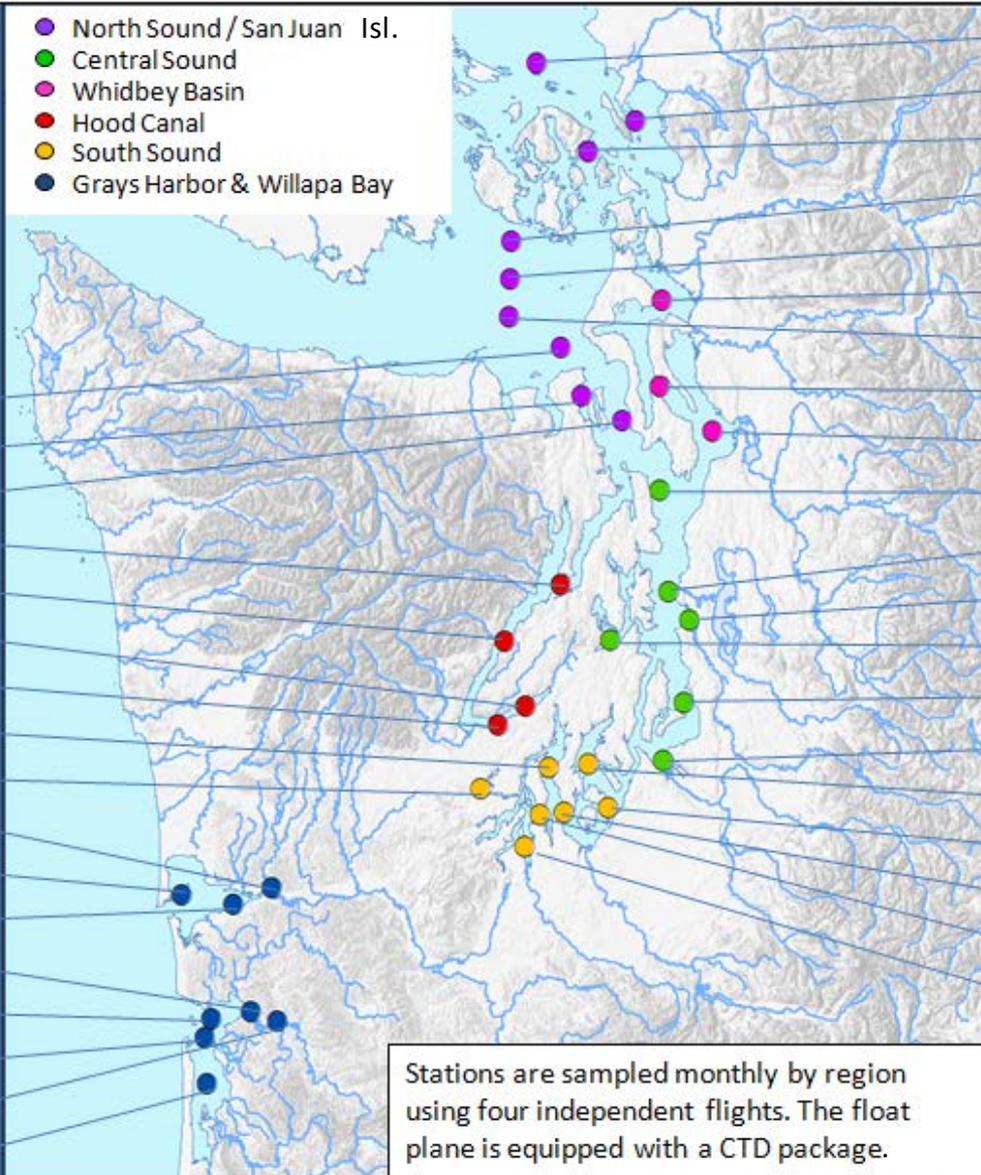
Aerial photos

Ferry and Satellite

Moorings



- 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 statistically historic context



Field log

Weather

Water column

Aerial photos

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Moorings



Conditions were dominated by warm water associated with the warm NE Pacific Ocean surface anomaly (“The Blob”). Starting in October, temperatures are the highest on record since 1989. Salinities are lower and oxygen is exhibiting new historical minima throughout the water column, an unusual spring condition.

Higher Temperature!

Lower Salinity

Lower Oxygen

March, 2015:



Red boxes show that the water measured is warmer than any of our measurements since 1989.

[Explore profiles at all stations](#)

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

The ocean affects water quality: Ocean Climate Indices



Field log

Weather

Water column

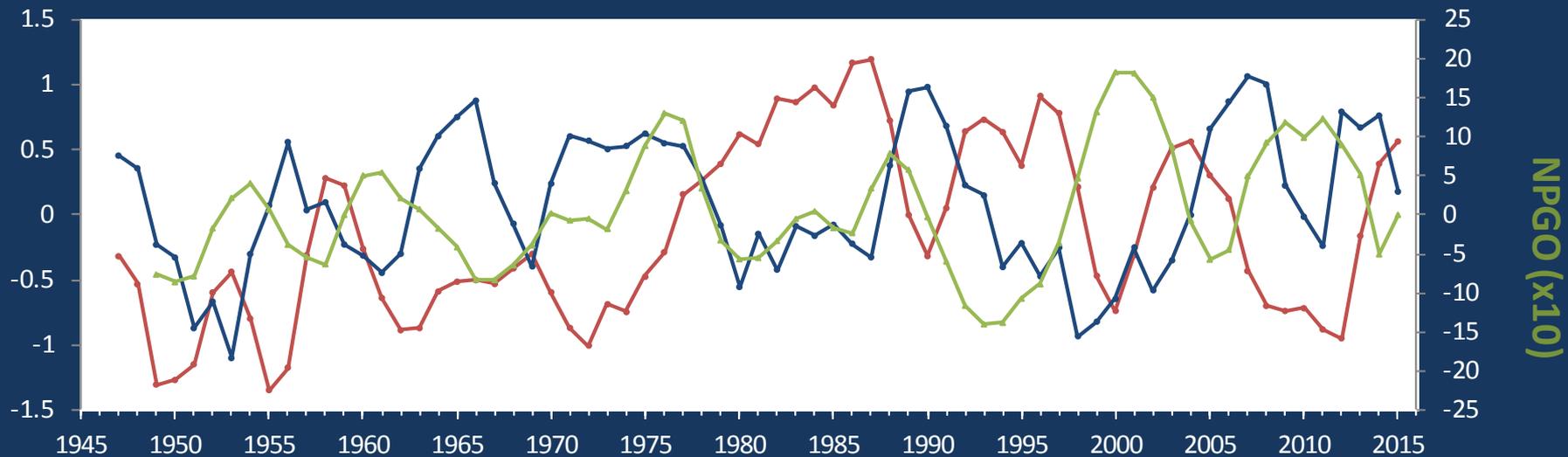
Aerial photos

Ferry and Satellite

Moorings

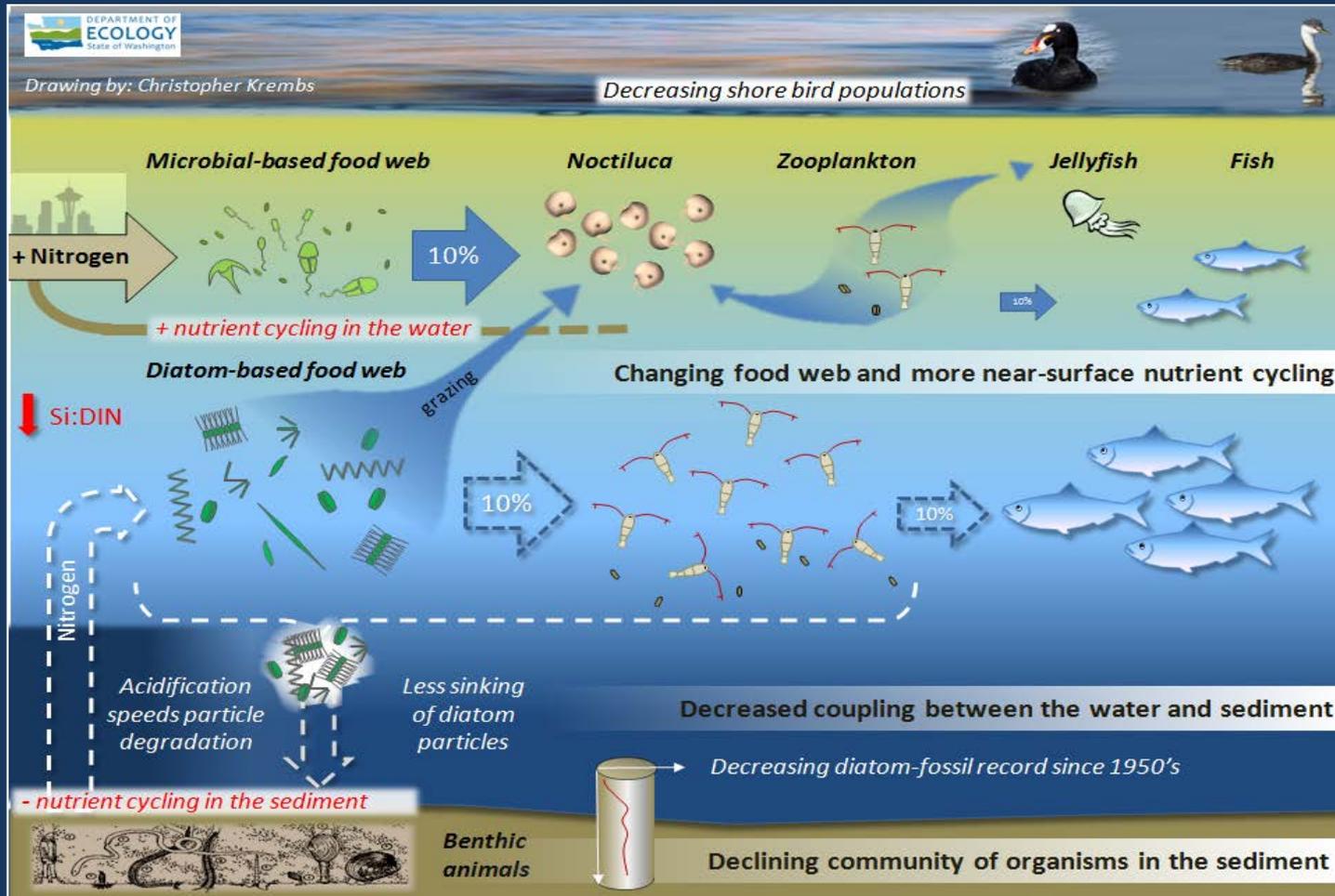
- a) Pacific Decadal Oscillation Index (**PDO, temperature**) [\(explanation\)](#)
- b) Upwelling Index (anomalies) (**Upwelling, low oxygen**) [\(explanation\)](#)
- c) North Pacific Gyre Oscillation Index (**NPGO, productivity**) [\(explanation\)](#)

Three-year running average of PDO, Upwelling, and NPGO indices scores



Ocean boundary conditions are no longer favorable for water quality in Puget Sound: (a) water is warming (PDO), (b) upwelling of low oxygen and high nutrient ocean water is again increasing (Upwelling Index), and (c) higher surface productivity along the coast (NPGO) is falling. 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 low food web?

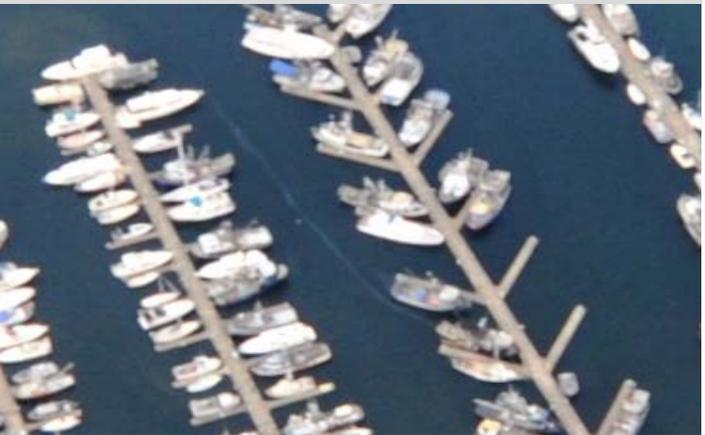
[Follow the experts](#)
[WebEx](#)

Field log	Weather	Water column	Aerial photos	Ferry and Satellite	Moorings
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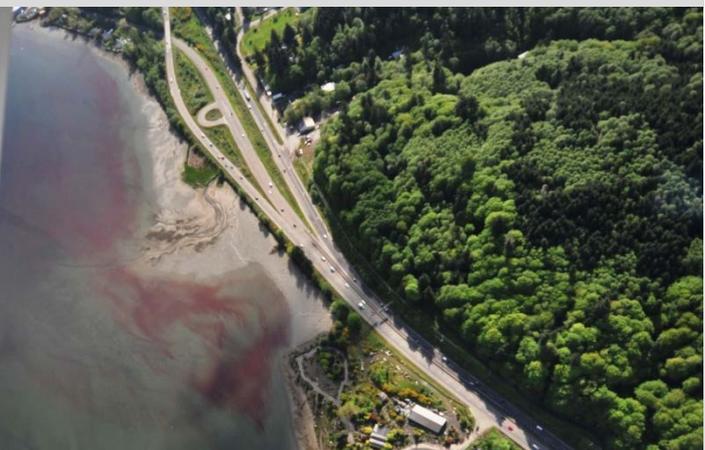


Patches of jellyfish are present in finger inlets of South Sound and Sinclair Inlet. Strong red bloom in Sinclair Inlet. Waters show signs of blooms only in confined bays (Henderson Inlet, Port Townsend Bay, Lopez and East Sound, Samish Bay, and Quartermaster Harbor). Otherwise, the surface waters appear very clear. High suspended sediment in Port Susan.

Oil sheen and boats, Salmon Bay, Seattle



Red bloom in Sinclair Inlet, Bremerton



Click on numbers

Start here



Mixing and Fronts: [1](#) [5](#) [6](#) [7](#) [12](#) [18](#) [19](#)

Distinct tidal fronts in Admiralty Reach, entrance to Hood Canal and north of the San Juan Islands. Tidal eddy in Lopez Sound. Tidal wedge in Quartermaster Harbor.



Jellyfish: [3](#) [4](#) [20](#)

Sizable jellyfish patches present in southern inlets of South Sound (Budd Inlet) and in Sinclair Inlet.



Suspended sediment: [4](#) [5](#) [6](#) [7](#) [8](#) [9](#) [10](#) [11](#) [12](#) [13](#) [14](#)

Large suspended sediment patches in Kensington Bay, Port Susan. Suspended sediment originating from Magnolia Bluffs in Seattle and high concentrations at entrance to Lummi Bay.



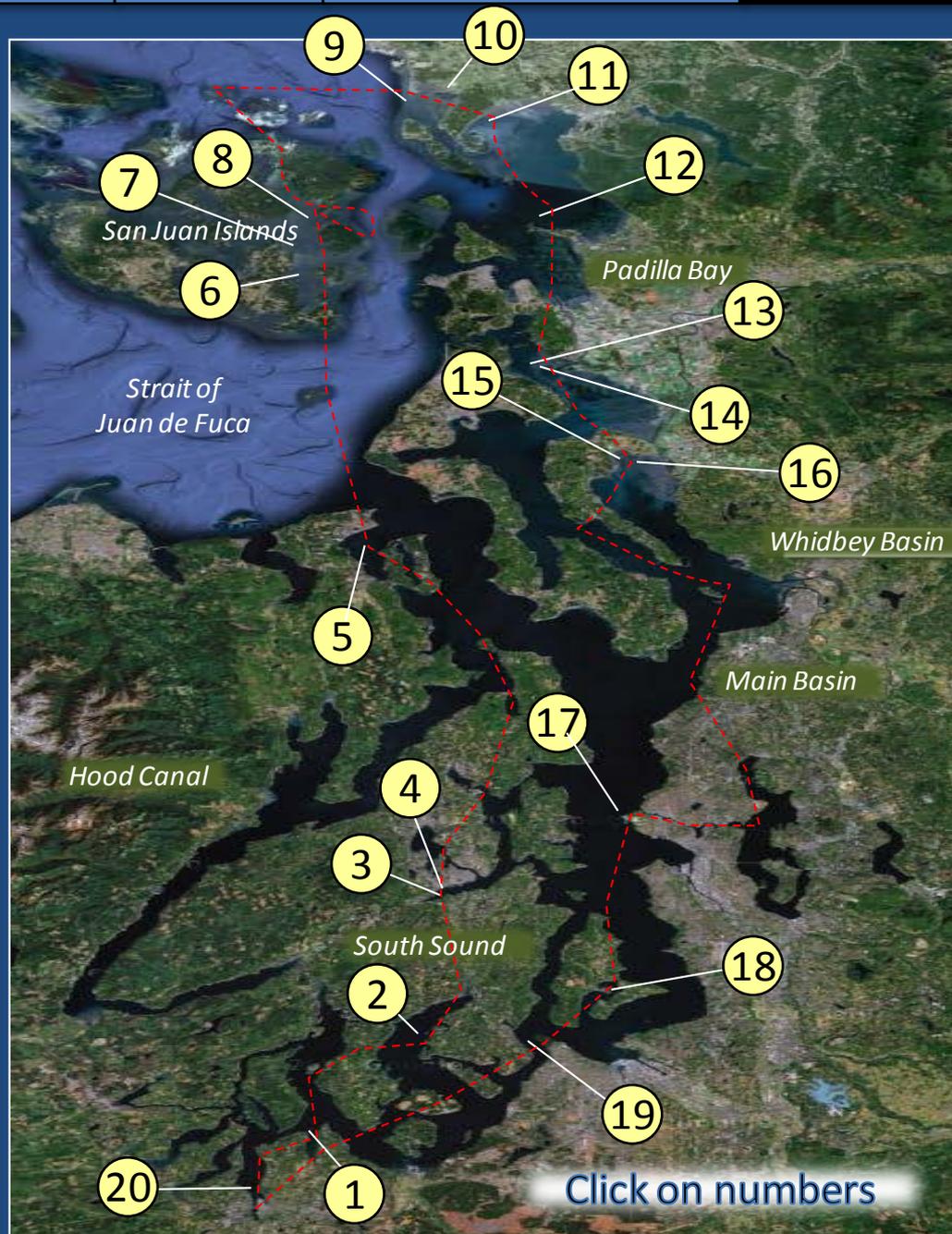
Visible blooms: [1](#) [3](#) [4](#) [5](#) [6](#) [7](#) [8](#) [12](#)

Green-brown: Port Townsend Bay (Admiralty Reach)
Red-brown: Lopez and East Sound (San Juan Island)
Red: Sinclair Inlet
Green: Quartermaster Harbor



Debris: [1](#) [11](#)

A few patches of macro-algae in Carr Inlet, Sinclair and Dyes Inlets and Bellingham Bay. Foam along tidal fronts.



Aerial photography and navigation guide

Date: 4-29-2015

Tides (Seattle)	Feet	Stage
2:52 AM	10.51	H
9:35 AM	3.03	L
3:24 PM	8.46	H
9:00 PM	3.67	L

Flight Information:

Morning flight, photos 1-8

Sunny, mild, high visibility, clouds

Afternoon flight, photos 9-20

Broken ceiling, good visibility, locally windy and cloudy

--- Flight route and fueling stop

Observation Maps:

Central and North Sound

South Sound



Field log

Climate

Water column

Aerial photos

Ferry and Satellite

Moorings



old pier

jellyfish

boat

A. Debris line and front at entrance to inlet. B. Early red-brown bloom, jellyfish patches, and organic debris. Location: A. Woodland Bay; B. Dickenson Point; Henderson Inlet (South Sound), 9:35 AM.



Field log

Climate

Water column

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Ferry and Satellite

Moorings



*Internal waves near Rafts Island across entire Inlet. Water very clear.
Location: Cutts Island (South Sound), 9:44 AM.*



Field log

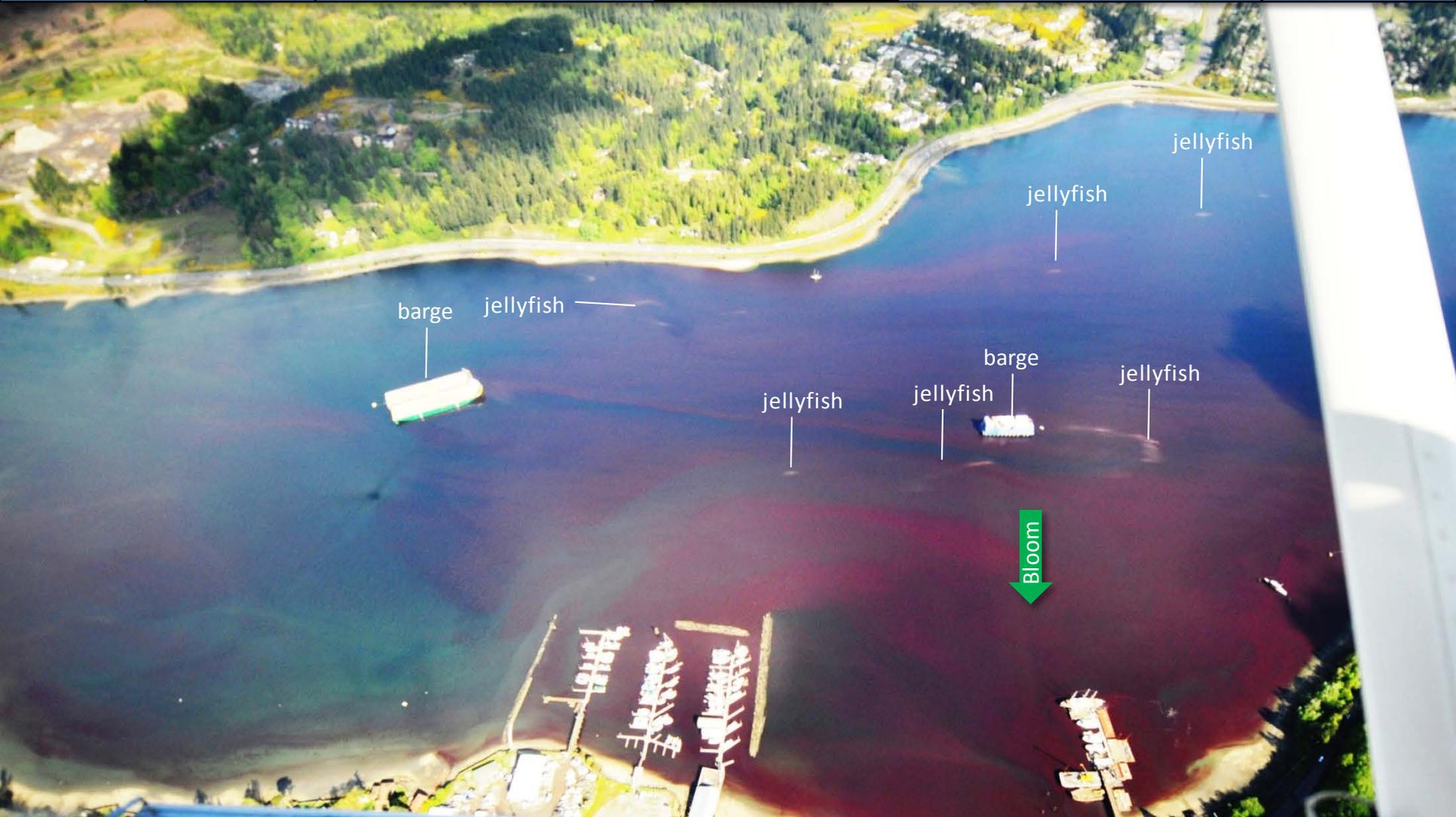
Climate

Water column

Aerial photos

Ferry and Satellite

Moorings



Red bloom and patches of jellyfish.

Location: Kitsap Marina, Sinclair Inlet (Bremerton), 9:52 AM.



Field log

Climate

Water column

Aerial photos

Ferry and Satellite

Moorings



Red bloom and patches of jellyfish.

Location: Ross Point, Sinclair Inlet (Bremerton), 9:52 AM.



Field log

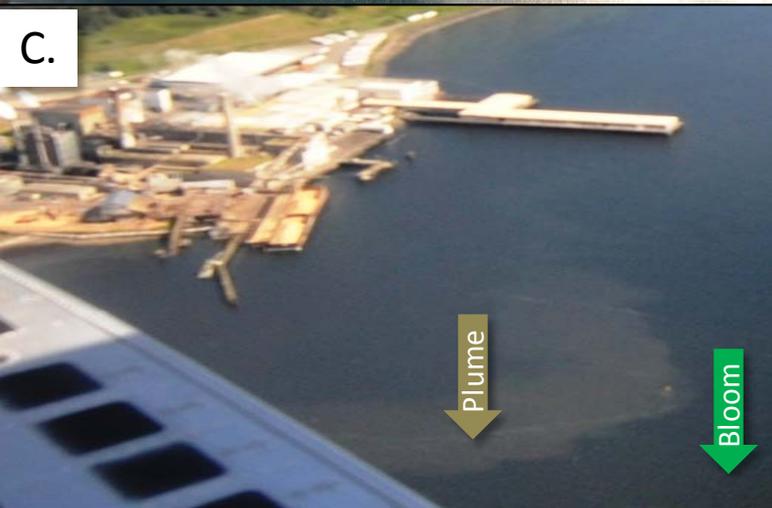
Climate

Water column

Aerial photos

Ferry and Satellite

Moorings



A. Brown bloom and front. B. Bloom along west side of Bay. C. Discolored water next to plant.
 Location: A. Entrance to Bay; B. Port Townsend Bay; C. Glenn Cove (Admiralty Reach), 10:18 AM.



Field log

Climate

Water column

Aerial photos

Ferry and Satellite

Moorings



Bloom developing in water with glacial flour.

Location: Center Island, Lopez Sound (San Juan Islands), 12:08 PM.



Field log

Climate

Water column

Aerial photos

Ferry and Satellite

Moorings



Bloom developing in water with glacial flour. Small tidal eddy.
Location: Frost Island, Lopez Sound (San Juan Islands), 11:07 AM.



Field log

Climate

Water column

Aerial photos

Ferry and Satellite

Moorings



*Sediment-rich water and a red-brown bloom meet at Obstruction Pass.
Location: West of Obstruction Island (San Juan Islands), 11:09 AM.*



Field log

Climate

Water column

Aerial photos

Ferry and Satellite

Moorings



Water with suspended sediment leaving Lummi Bay.
Location: Sandy Point, Lummi Bay (North Sound), 12:03 PM.



Field log

Climate

Water column

Aerial photos

Ferry and Satellite

Moorings



macro algae

Lummi River delta with light green macro-algae in the shallows along shoreline.
Location: Lummi Bay (North Sound), 12:03 PM.

[Field log](#)[Climate](#)[Water column](#)[Aerial photos](#)[Ferry and Satellite](#)[Moorings](#)

brown material

The Nooksack River appears to run low and clear. Line of unidentified brown material.
Location: Nooksack River delta (Bellingham Bay), 12:06 PM.



Field log

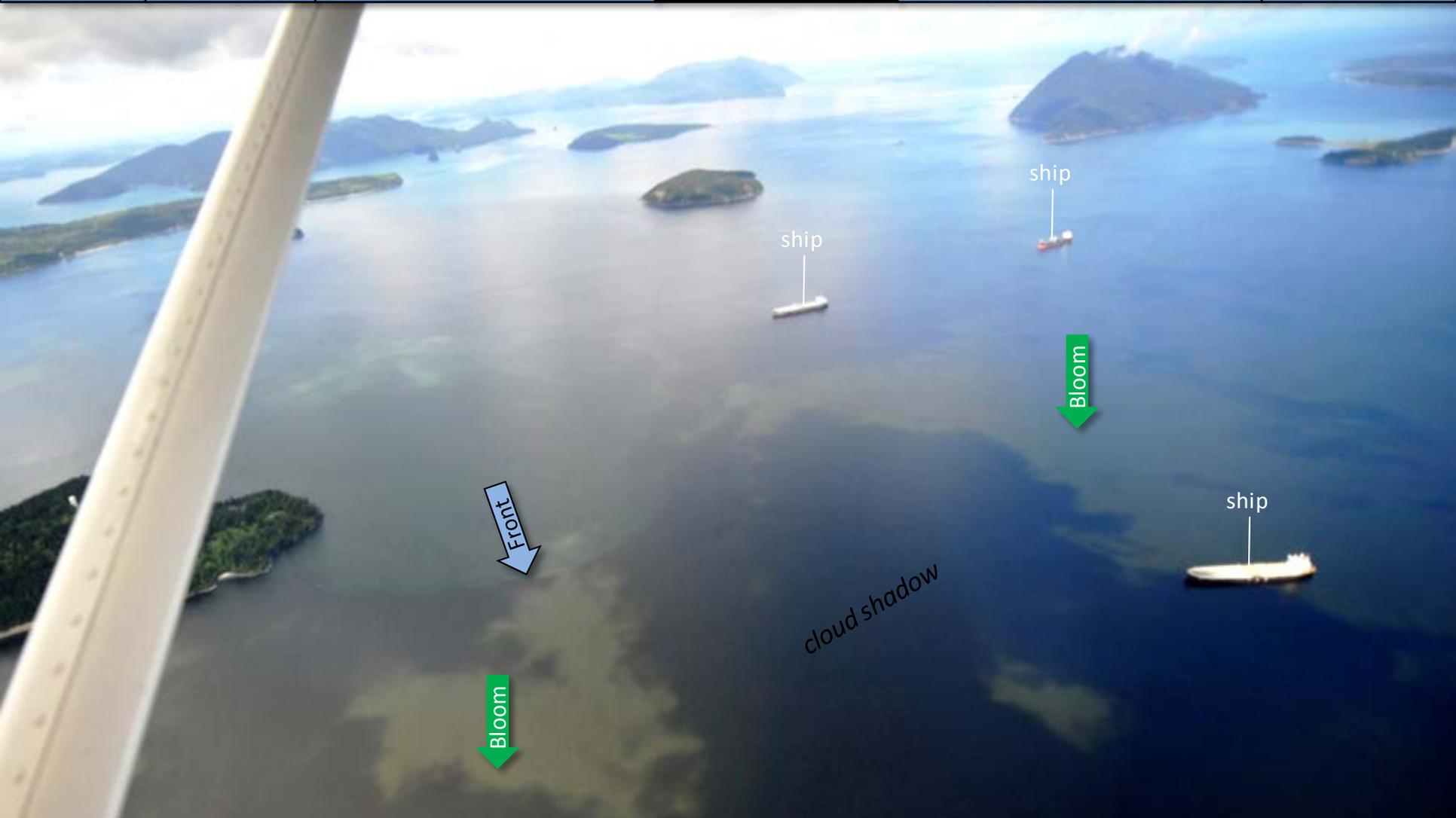
Climate

Water column

Aerial photos

Ferry and Satellite

Moorings



*Murky water in Samish Bay, likely from bloom. Front near Samish Island.
Location: Bellingham Bay (Bellingham Bay), 12:36 PM.*

[Field log](#)[Climate](#)[Water column](#)[Aerial photos](#)[Ferry and Satellite](#)[Moorings](#)

*North Fork Skagit River carrying no suspended sediment or glacial flour. Exposed mudflats.
Location: Near La Conner, Skagit Bay (Whidbey Basin), 12:46 PM.*

[Field log](#)[Climate](#)[Water column](#)[Aerial photos](#)[Ferry and Satellite](#)[Moorings](#)

cloud shadow

Water in Skagit Bay is very clear.

Location: Goat Island, Skagit Bay (Whidbey Basin), 12:46 PM.



Field log

Climate

Water column

Aerial photos

Ferry and Satellite

Moorings



Patches of very murky water with suspended sediments near mudflats.
Location: Livingston Bay, Port Susan (Whidbey Basin), 1:21 PM.



Field log

Climate

Water column

Aerial photos

Ferry and Satellite

Moorings



Patches of very murky water with suspended sediments near mudflats.
Location: Livingston Bay, Port Susan (Whidbey Basin), 1:21 PM.

[Field log](#)[Climate](#)[Water column](#)[Aerial photos](#)[Ferry and Satellite](#)[Moorings](#)

*Flying inside a rainbow looking at suspended sediment originating from Magnolia Bluffs.
Location: West Point Light House (Central Sound), 3:50 PM.*



Field log

Climate

Water column

Aerial photos

Ferry and Satellite

Moorings



*Green bloom in inner bay meeting clearer water flowing in with tide at two locations.
Location: A. Inner bay; B. Middle of Quartermaster Harbor (Vashon Island), 4:03 PM.*



Field log

Climate

Water column

Aerial photos

Ferry and Satellite

Moorings



*Differently colored water in Tacoma Narrows. Very little suspended sediment from the Puyallup River.
Location: Point Defiance (Central Sound), 4:07 PM.*



Field log

Climate

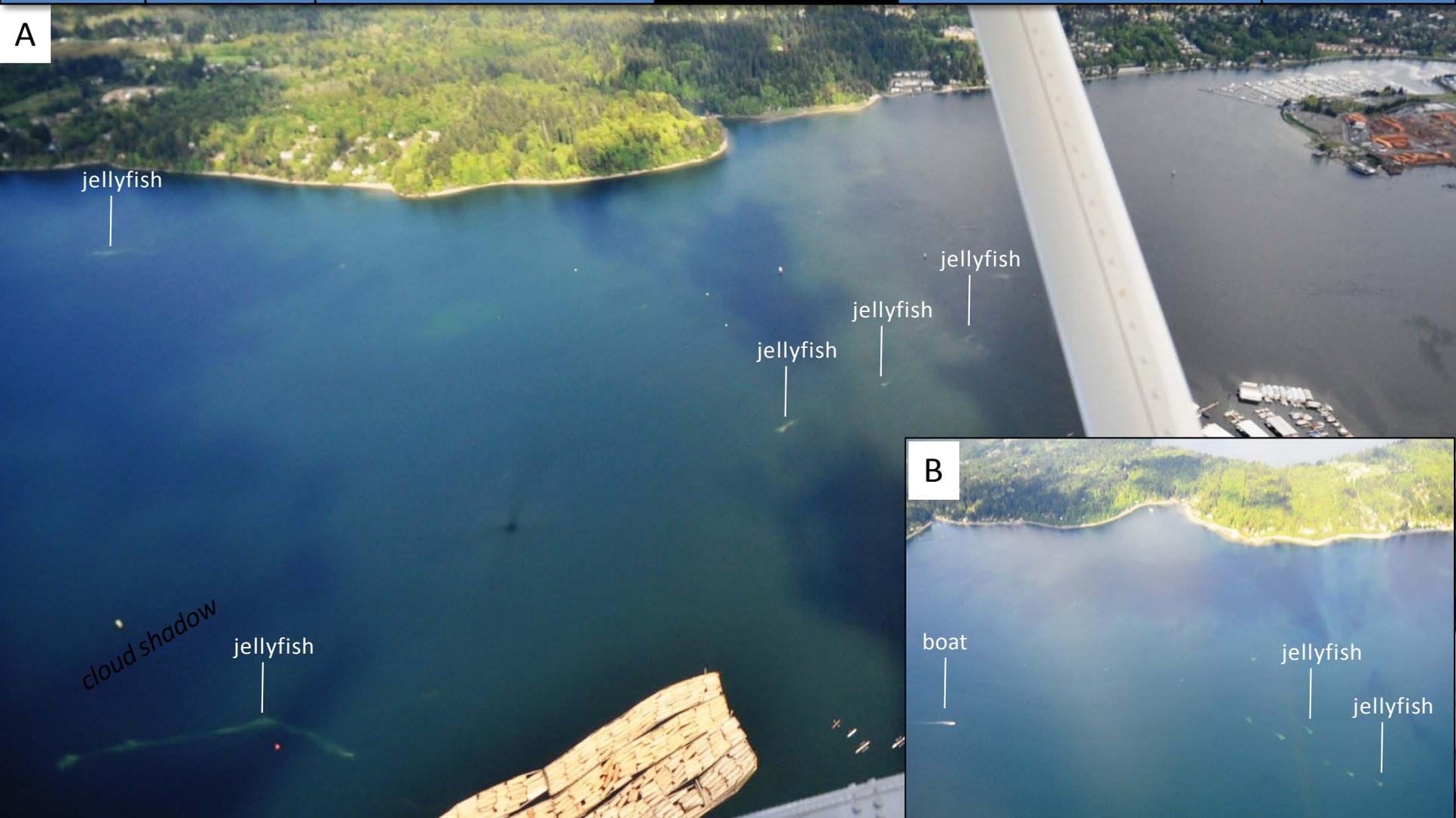
Water column

Aerial photos

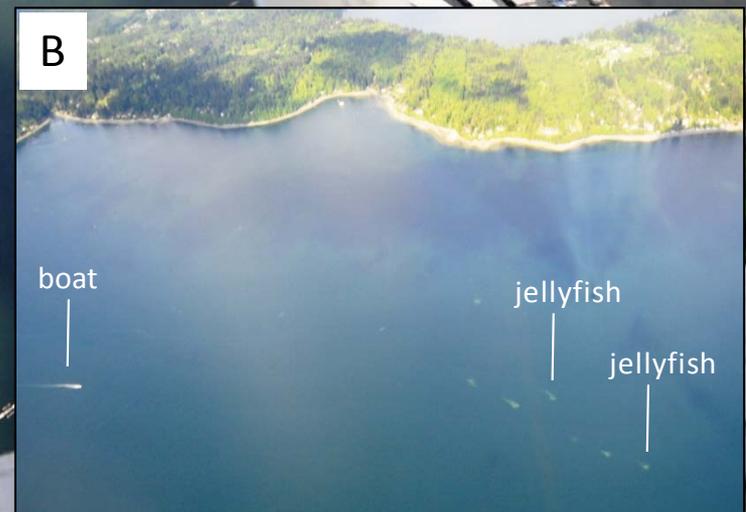
Ferry and Satellite

Moorings

A



B



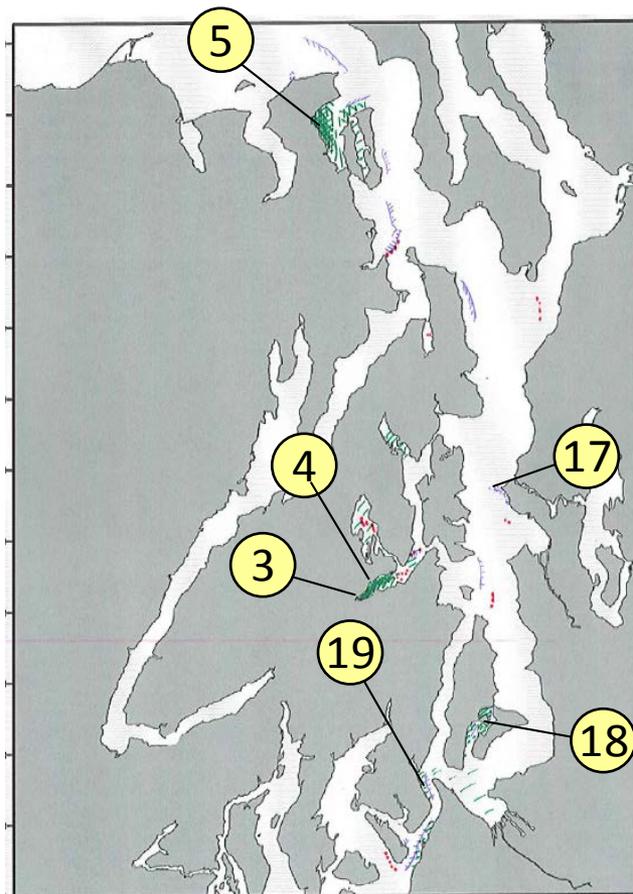
Patches of jellyfish.

Location: A. Across Priest Point; B. Big Tykle Cove, Budd Inlet (South Sound), 4:22 PM.

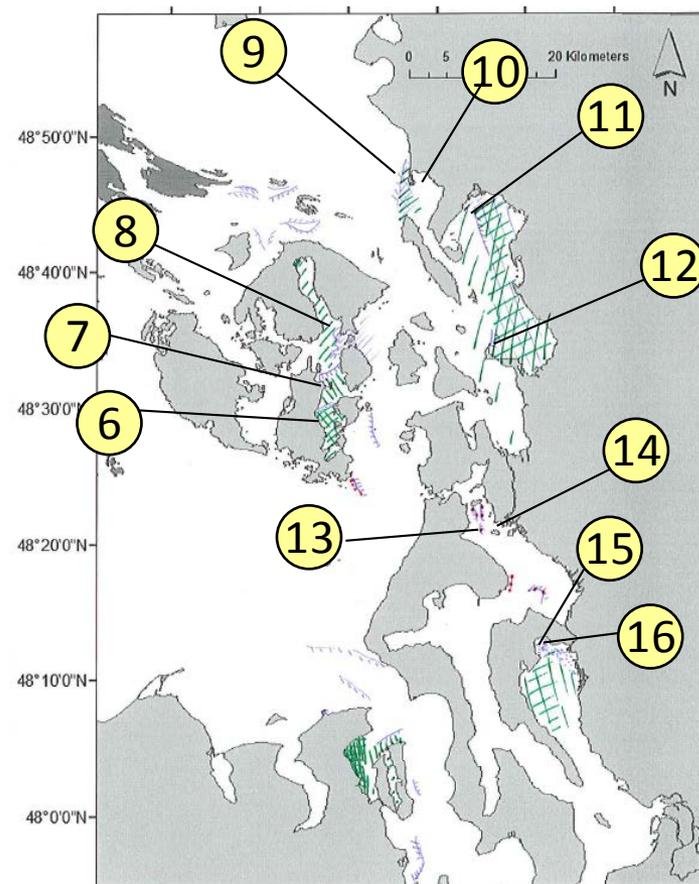


Date: 4-29-2015

Central Sound



North Sound/San Juan Islands

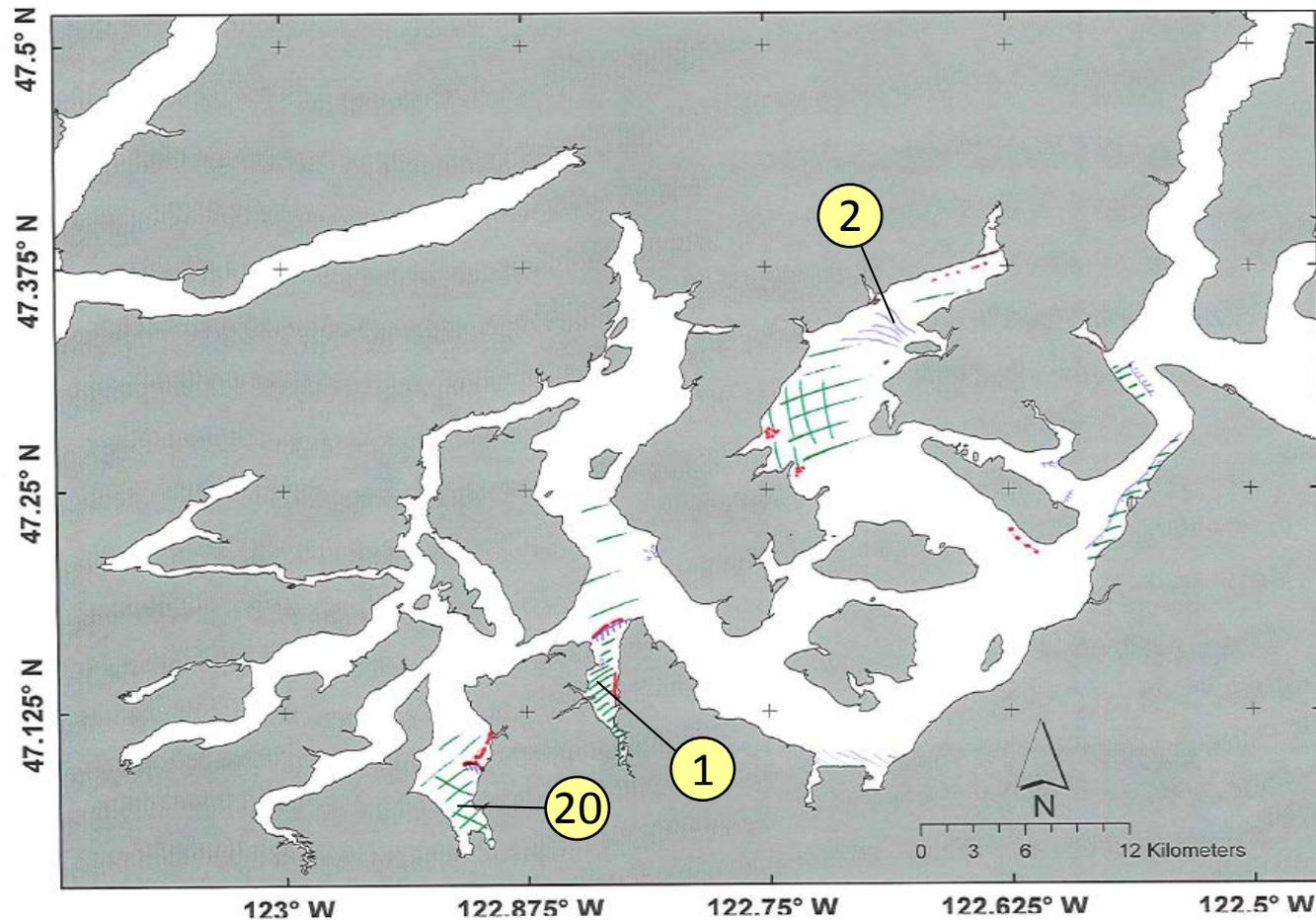


Numbers on map refer to picture numbers for spatial reference



Date: 4-29-2015

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.

Field log

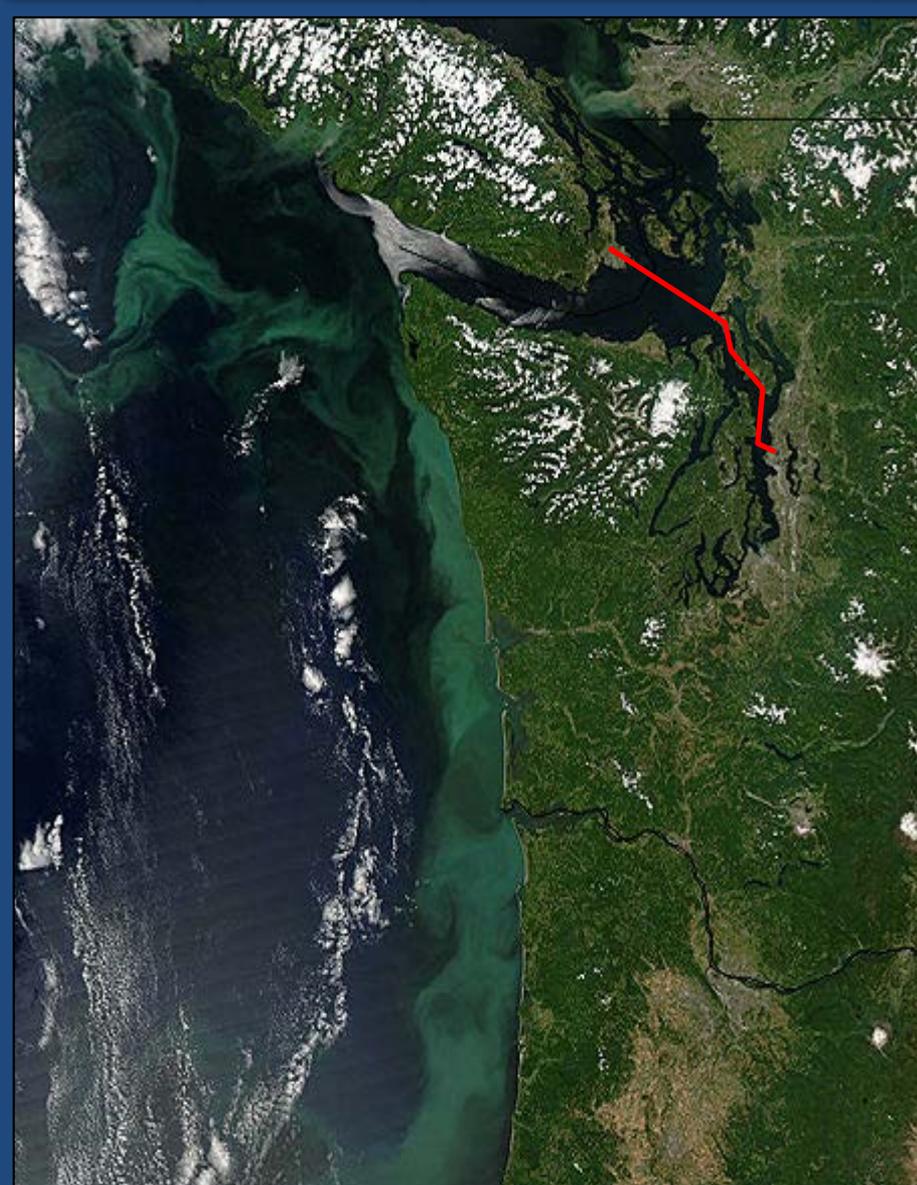
Climate

Water column

Aerial photos

Ferry and Satellite

Moorings



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.

Current Conditions:

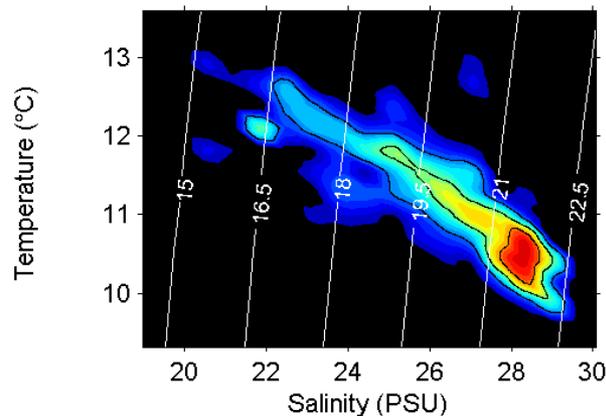
n.a



At the Mukilteo mooring, we continue to observe warmer than normal water temperature. In the past week, temperature has steadily increased. In the near-bottom mooring, we are starting to observe two water masses. Temporal variation in temperature and salinity seem to be mostly influenced by shifting winds.

Density (kg/m^3)

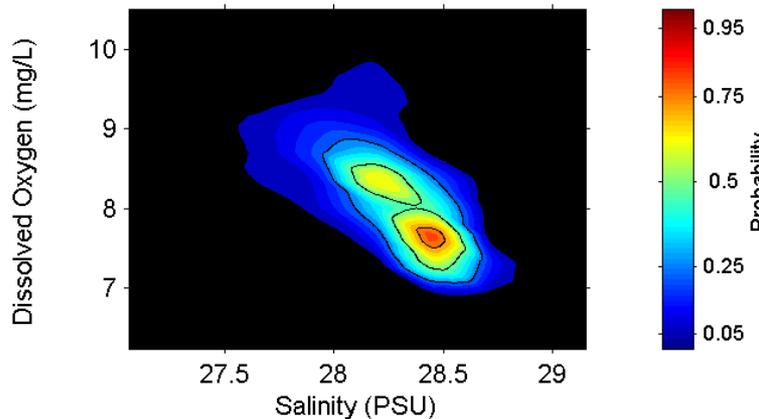
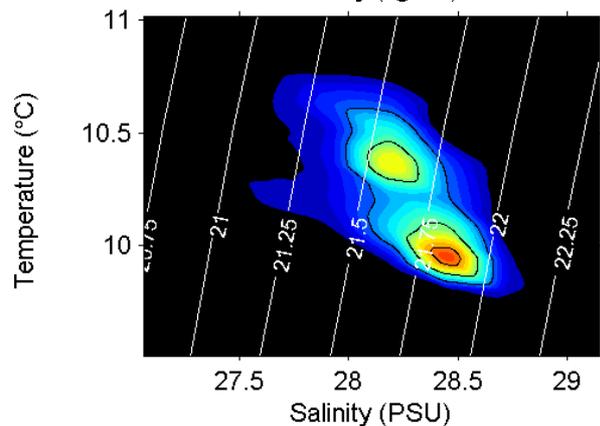
2-6 m depth



No oxygen sensor on the shallow instrument package.

Density (kg/m^3)

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.

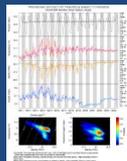
Right Panel: Dissolved oxygen concentration in relation to salinity.

Our mooring station at Mukilteo is located in Whidbey Basin near Everett. It is 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.

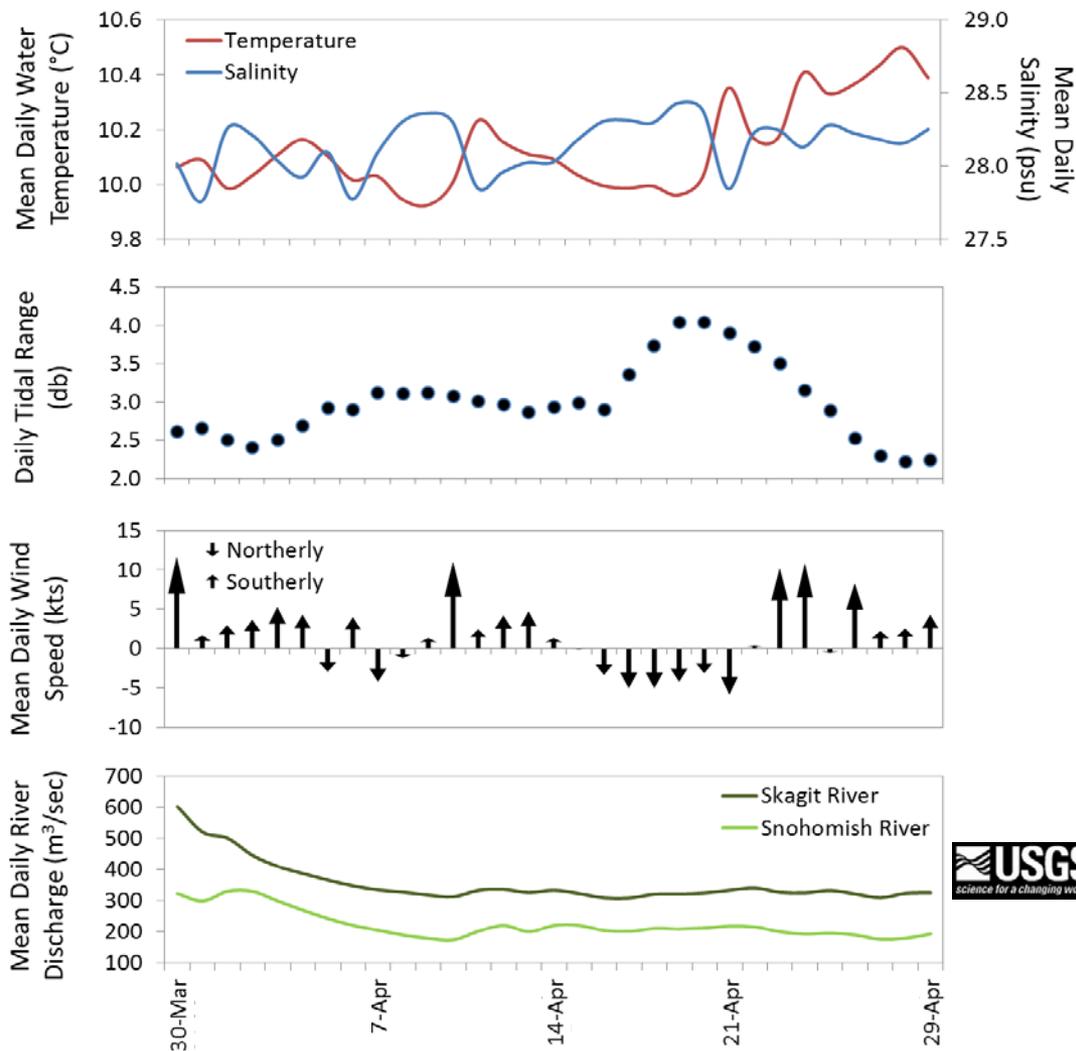
As the largest regional contributor of freshwater to Puget Sound, understanding the timing and magnitude of the Skagit River flow is important.

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



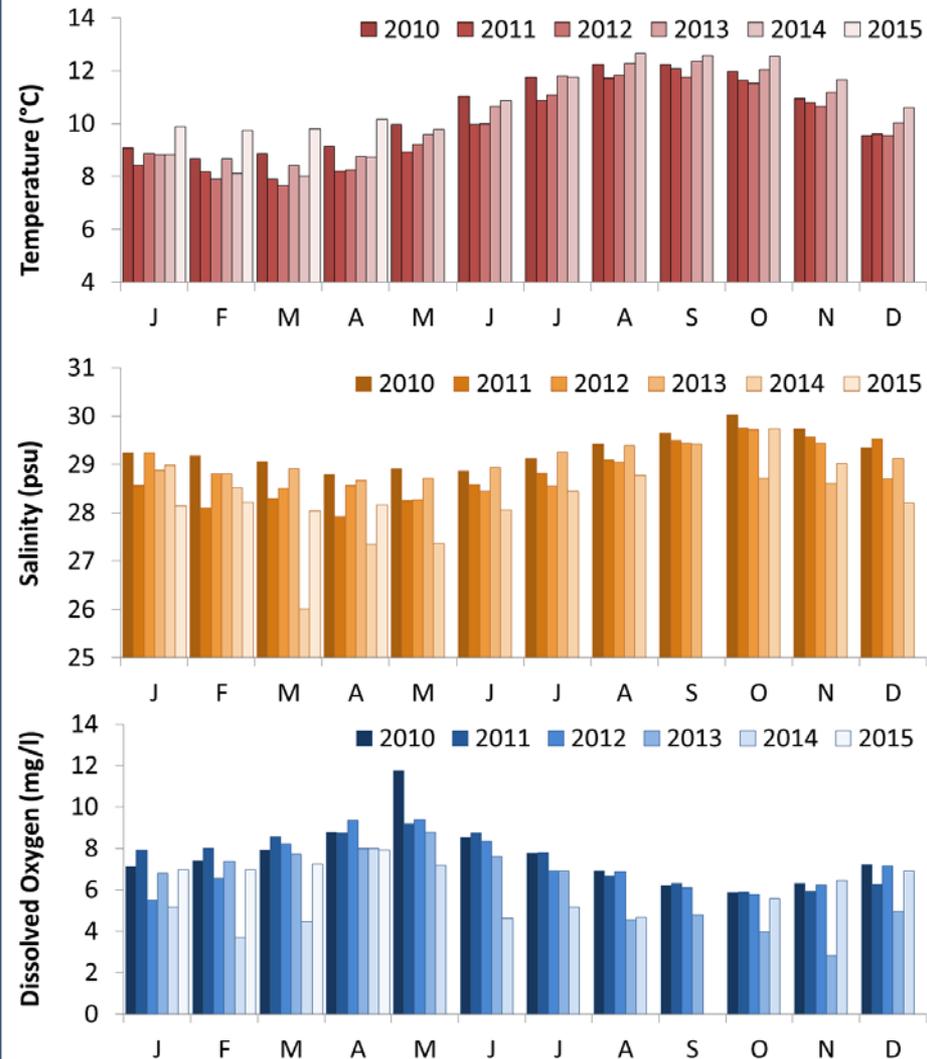
At the Mukilteo mooring, we use the near-bottom sensor (12-16 m deep) to measure significant inter-annual variability in temperature, salinity, and dissolved oxygen.

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

In April, water continues to be warmer than the past several years. Salinity is higher than 2011 and 2014. The amount of dissolved oxygen is roughly similar to 2013 and 2014.

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

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



Get data from Ecology's Marine Monitoring Programs



Field log

Climate

Water column

Aerial photos

Ferry and Satellite

Moorings

Long-Term Monitoring Network

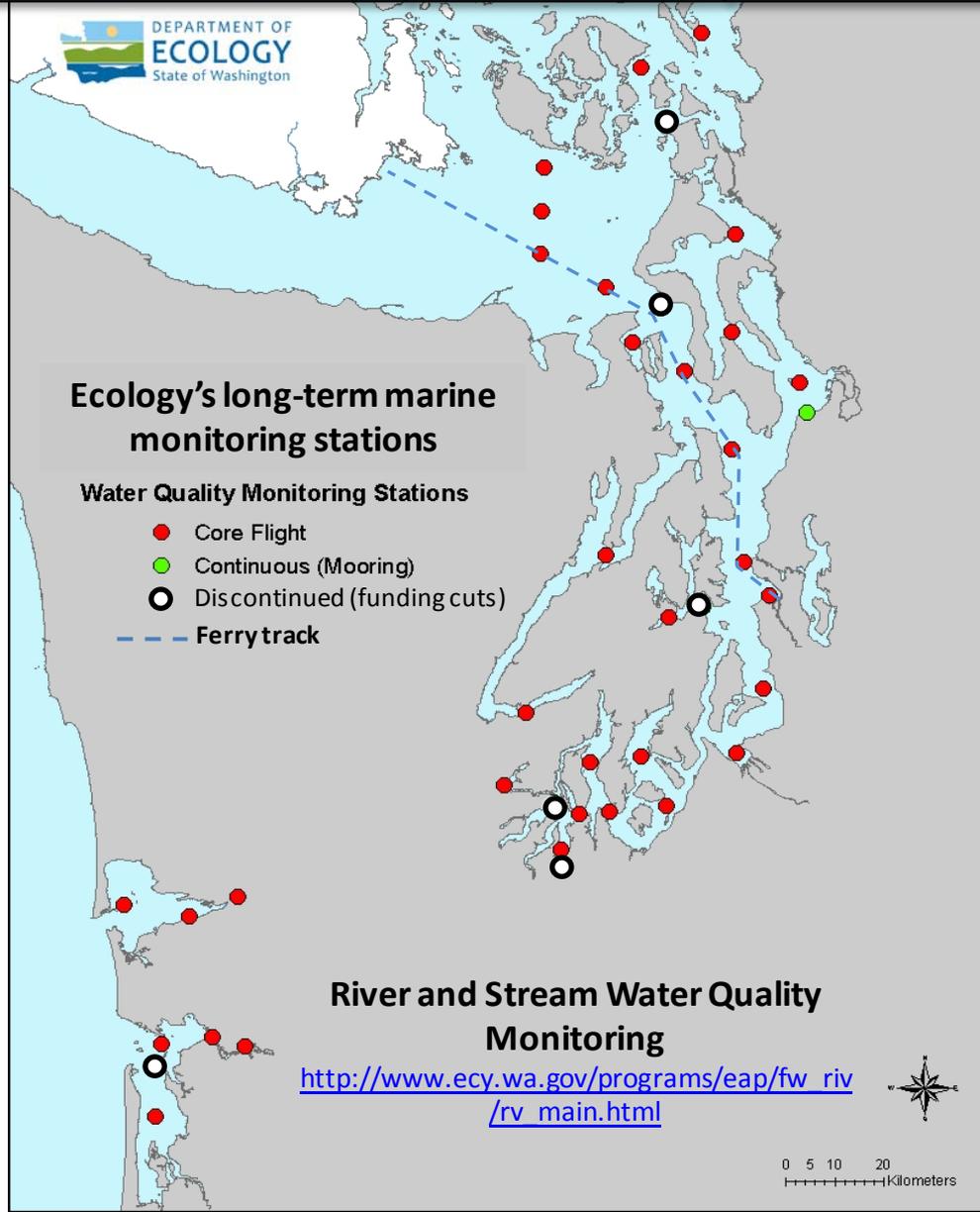


christopher.krems@ecy.wa.gov



Access core monitoring data:

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



Real-Time Sensor Network



Suzan.Pool@ecy.wa.gov



Access mooring data:

ftp://www.ecy.wa.gov/eap/Mooring_Raw/Puget_Sound/

You may subscribe or unsubscribe to the Eyes Over Puget Sound email listserv by going to:

<http://listserv.wa.gov/cgi-bin/wa?A0=ECOLOGY-EYES-OVER-PUGET-SOUND>



Field log

Climate

Water column

Aerial photos

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Moorings

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