

# Eyes Over Puget Sound

[Flight log](#)

[Weather](#)

[Water column](#)

[Aerial photos](#)

[Ferry and Satellite](#)

[Moorings](#)

## Surface Conditions Report

November 21, 2013

[Start here](#)



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings

LONG-TERM MARINE MONITORING UNIT

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*Dr. Brandon  
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## Personal flight log

[p. 3](#)

From Army service to Ecology's marine flights, float plane serial number 710 continues its colorful past and has been around longer than most of us.

## Weather conditions

[p. 5](#)

The weather changed dramatically in the past two days, from warm and cloudy to sunny and colder than normal. River flows peaked briefly on Tuesday and Wednesday in response to Monday's rain, but they were otherwise at or below normal.

## Water column

[p. 6](#)

Fall brings new Puget Sound conditions! The 2011-2012 colder, fresher, higher oxygen conditions are gone. After unusual weather from Aug - Oct, conditions now vary regionally. What will winter 2013-2014 bring?

## Aerial photography

[p. 10](#)

Strong tidal fronts and sediment-rich brackish plumes leave Whidbey Basin and move into Admiralty Reach. Orcas follow the edge of the plume heading north! Red-brown blooms continue in Southern Inlets. Long debris lines are numerous in northern Budd Inlet, Hood Canal, and in Central Sound north of Edmonds.

## Ferry and satellite

[p. 35](#)

True color satellite images confirm large sediment plume leaving Whidbey Basin and heading into Admiralty Inlet.

Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



***Personal Bio of de Havilland Beaver 710** – Writing last month’s edition made me curious about the specific plane we use for our marine flights. I researched serial number 710 and discovered that this plane has quite a colorful past!*



Photo: Robin A. Walker © 22 June 1970

It was delivered to the Army’s 56<sup>th</sup> Artillery Group on October 19<sup>th</sup>, 1954, with a \$72,000 price tag. The tail number 53-7902 tells us that it was the 7,902<sup>nd</sup> plane delivered to the Army, in then West Germany.



Photo: Kenneth I. Swartz © 15 October 1978

In the late 1970’s it retired from the Army and was taken to Kenmore Air in Seattle to be refurbished for civilian use.



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings

The plane may have had a nice quiet civilian life for a while, but on September 2, 1995, all that changed. A sudden headwind switch during takeoff caused 710 to crash into the shoreline. The pilot and passenger weren't injured but 710 was ...



Photo: Joe Leatherman 2013



Photo: Neil Aird © 13 September 1995

20 years after their first meeting, Kenmore put the plane back to together again. Not long after, 710 became part of the Kenmore Air fleet. With our sampling, 710 has returned to its roots as the ultimate utility plane. I think it is so fantastic that Ecology is now a part of its storied history.

*Special thanks to DHC-2.com for collecting the stories of these amazing planes, Hal Bryan for his insights into that history, and Kenmore Air for filling in the gaps.*



**Meteorological conditions typically explain up to half of the variance in observed marine variables** (Moore et al. 2008), particularly in shallower waters like those of south Puget Sound. I summarized the specific conditions prevalent during the past two weeks, from north to south. Source: [http://www-k12.atmos.washington.edu/k12/grayskies/nw\\_weather.html](http://www-k12.atmos.washington.edu/k12/grayskies/nw_weather.html)

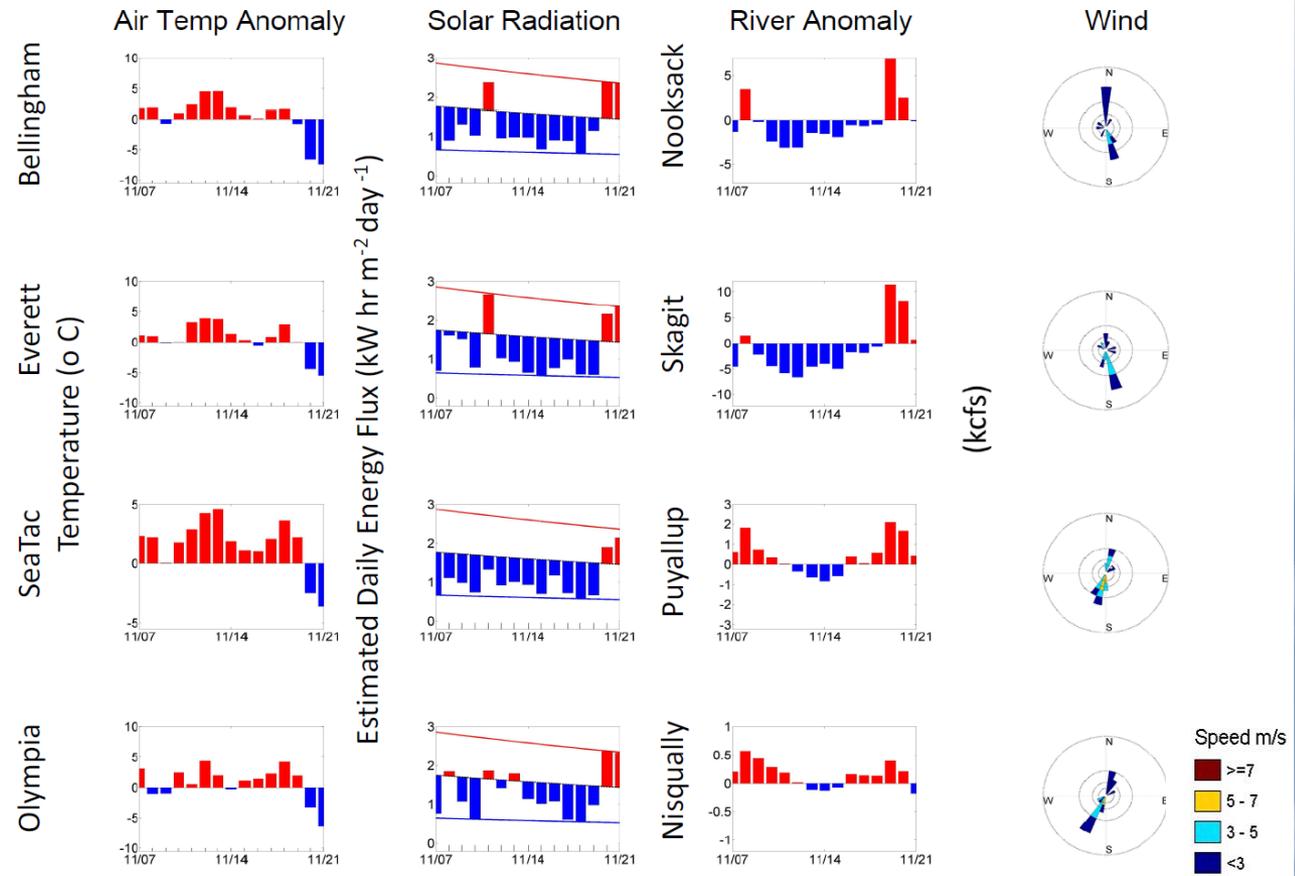
## Two week summary:

**Air temperatures.** Daily average air temperatures had been above normal, but the past two days have been cold!

**Sunshine** levels had been below normal, but the past two days have been sunny.

**River flows** had been low, but peaked two days ago after heavy rain on 11/18.

**Winds** have been weak from the north for the past two days, otherwise stronger and from the south.



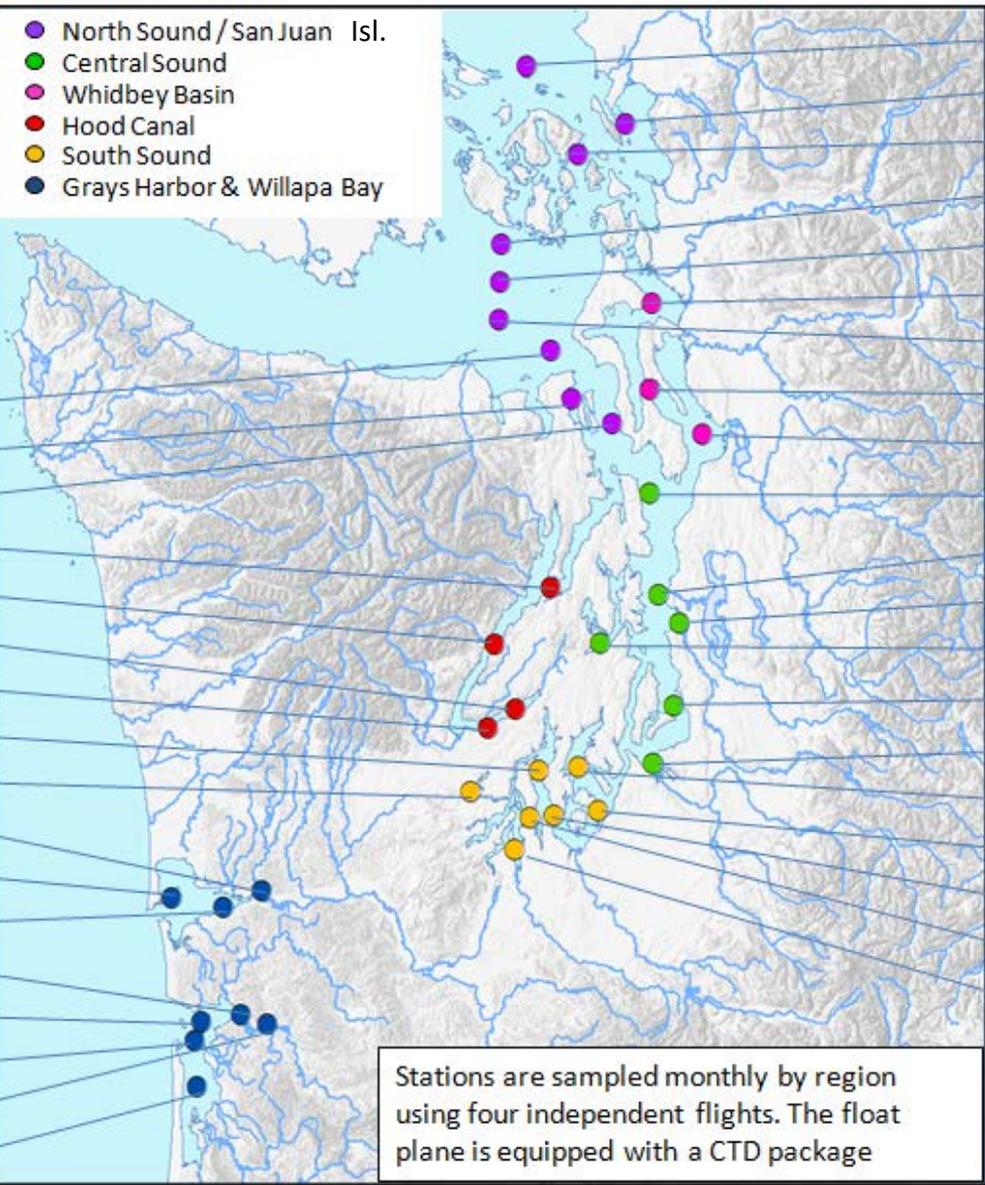
# Our long-term marine monitoring stations in Washington



- Flight 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 to access our monthly monitoring stations most cost effectively.

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

# Conditions of the last two years change at our stations

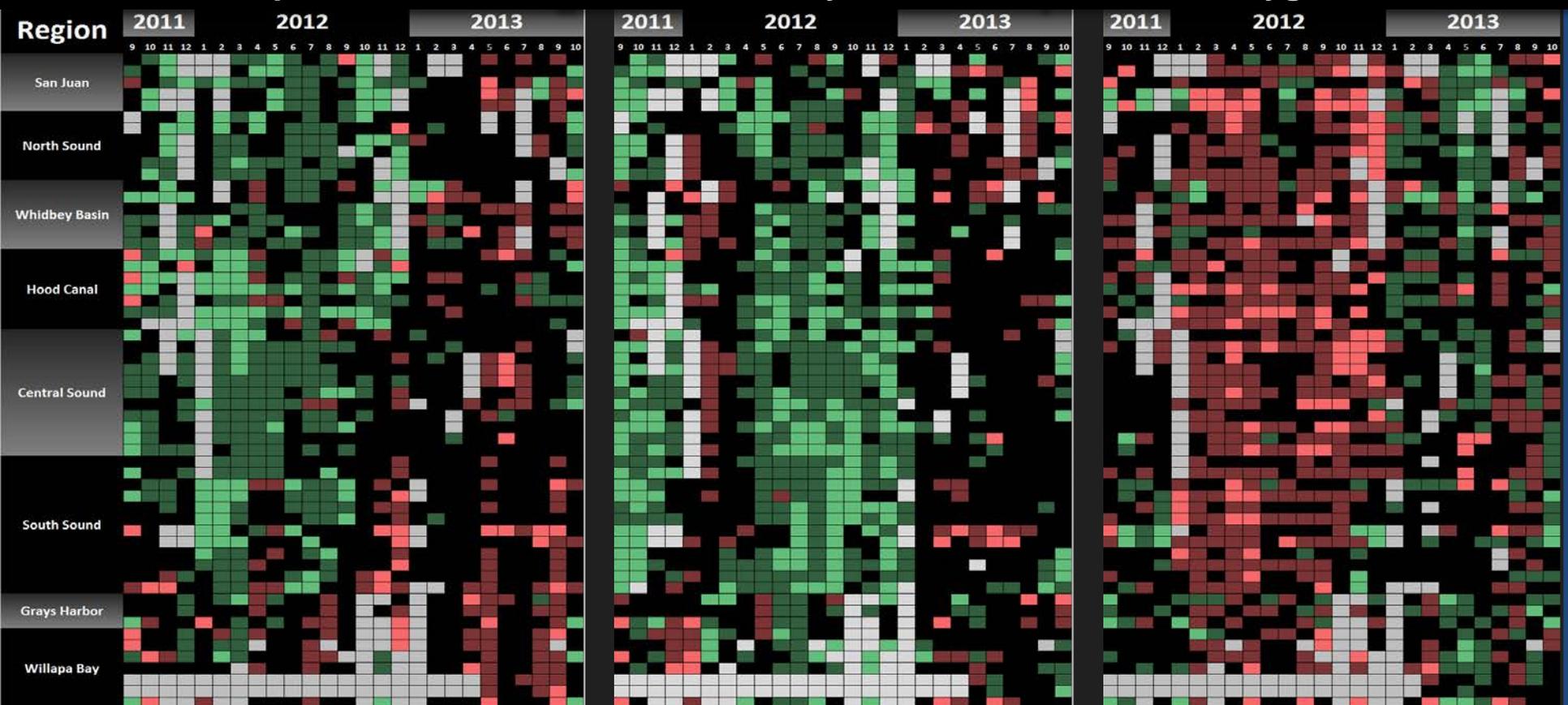


- Flight log
- Weather
- Water column
- Aerial photos
- Ferry and Satellite
- Moorings

## In 2013: Temperature varies

## Salinity varies

## Oxygen varies



■ = 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

Fall brings new Puget Sound conditions! The 2011-2012 colder, fresher, higher oxygen conditions are gone. So far in 2013, there were warmer temperatures at the Coast, and a lower oxygen in the northern parts of Puget Sound and Hood Canal. After unusual weather from Aug - Oct, conditions now vary regionally. What will winter 2013-2014 bring?

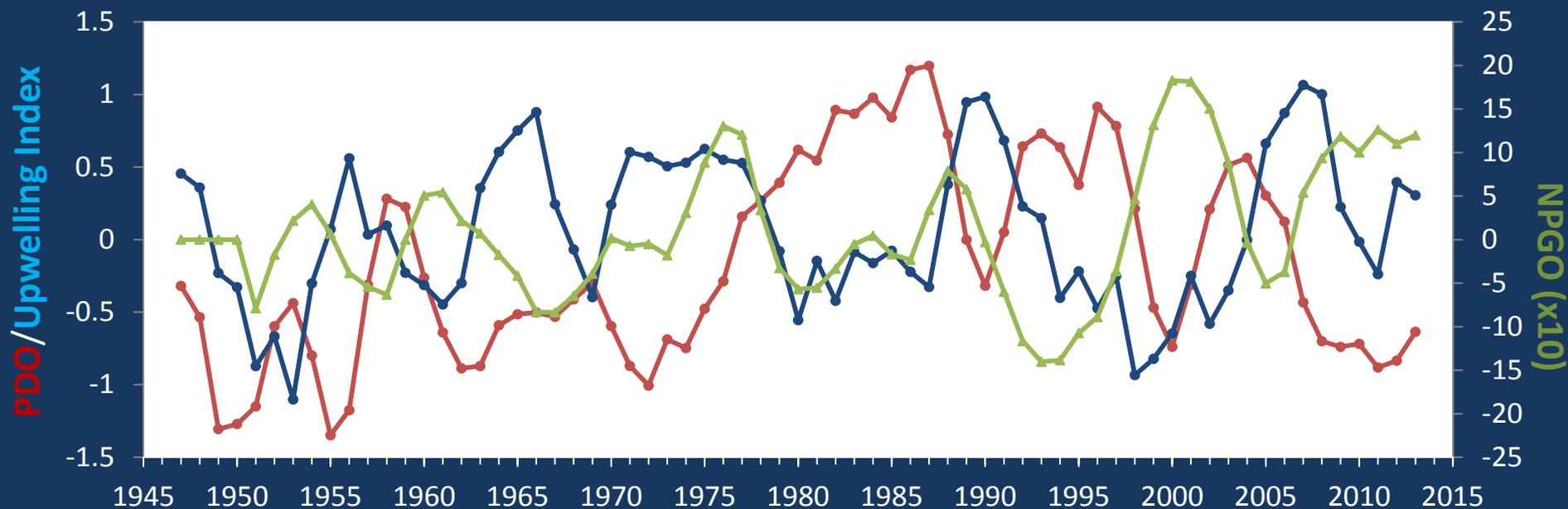
# The ocean affects water quality: Ocean Climate Indices



Flight 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 have been favorable for water quality in Puget Sound: (a) colder water (PDO), (b) less upwelled low oxygen and high nutrient ocean water reaching Puget Sound (Upwelling Index), and (c) higher surface productivity along the coast (NPGO). Where are we heading next?

# Get the data and trends from us!

We observe increasing nutrients and changing patterns of algal biomass in Puget Sound

*Algae bloom, Budd Inlet 2010*



**Nitrate**



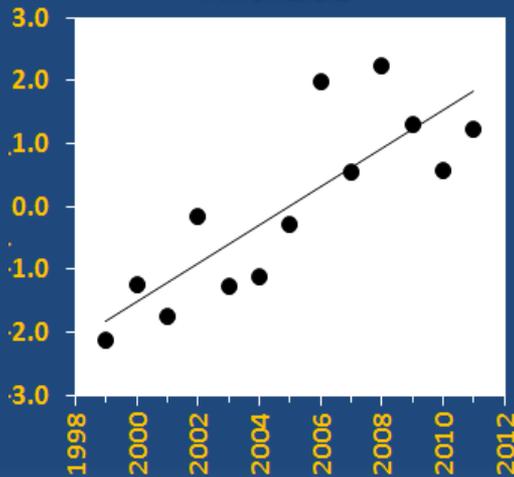
**Phosphate**



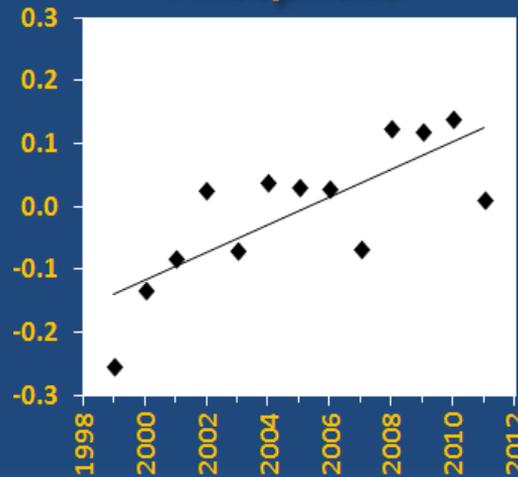
**Changing  
Nutrient Balance**

Nutrients in Puget Sound are increasing, read [http://www.ecy.wa.gov/programs/eap/mar\\_wat/trends.html](http://www.ecy.wa.gov/programs/eap/mar_wat/trends.html)

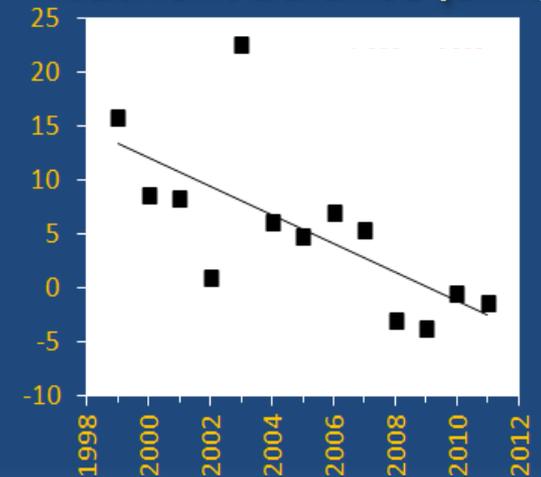
**Nitrate**



**Phosphate**



**Nutrient Balance (Si:N)**



Flight log	Weather	Water column	<b>Aerial photos</b>	Ferry and Satellite	Moorings
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Strong tidal fronts and sediment-rich brackish plumes leave Whidbey Basin and move into Admiralty Reach. Orcas follow the edge of the plume heading north! Red-brown blooms continue in Southern Inlets. Long debris lines are numerous in northern Budd Inlet, Hood Canal, and in Central Sound north of Edmonds.

[Start here](#)

Views of clouds in Hood Canal near Union



Seattle and the rest are bright and clear



**Mixing and Fronts:**

Many tidal and salinity fronts seen in Admiralty Inlet.

[3](#) [8](#) [10](#) [11](#) [12](#) [15](#) [16](#) [17](#) [Click on numbers](#)



**Jellyfish:** Infrequent small patches seen in Budd Inlet



**Suspended sediment:**

Abundant in Admiralty Inlet originating in Whidbey Basin. Sediment rich river plumes seen in Hood Canal Main stem.

[1](#) [2](#) [7](#) [11](#) [13](#) [15](#) [16](#) [17](#) [18](#) [20](#) [Click on numbers](#)



**Visible blooms:**

**Red brown:** Budd, Eld, Totten and Henderson inlets.

[1](#) [2](#) [3](#) [19](#) [20](#) [Click on numbers](#)

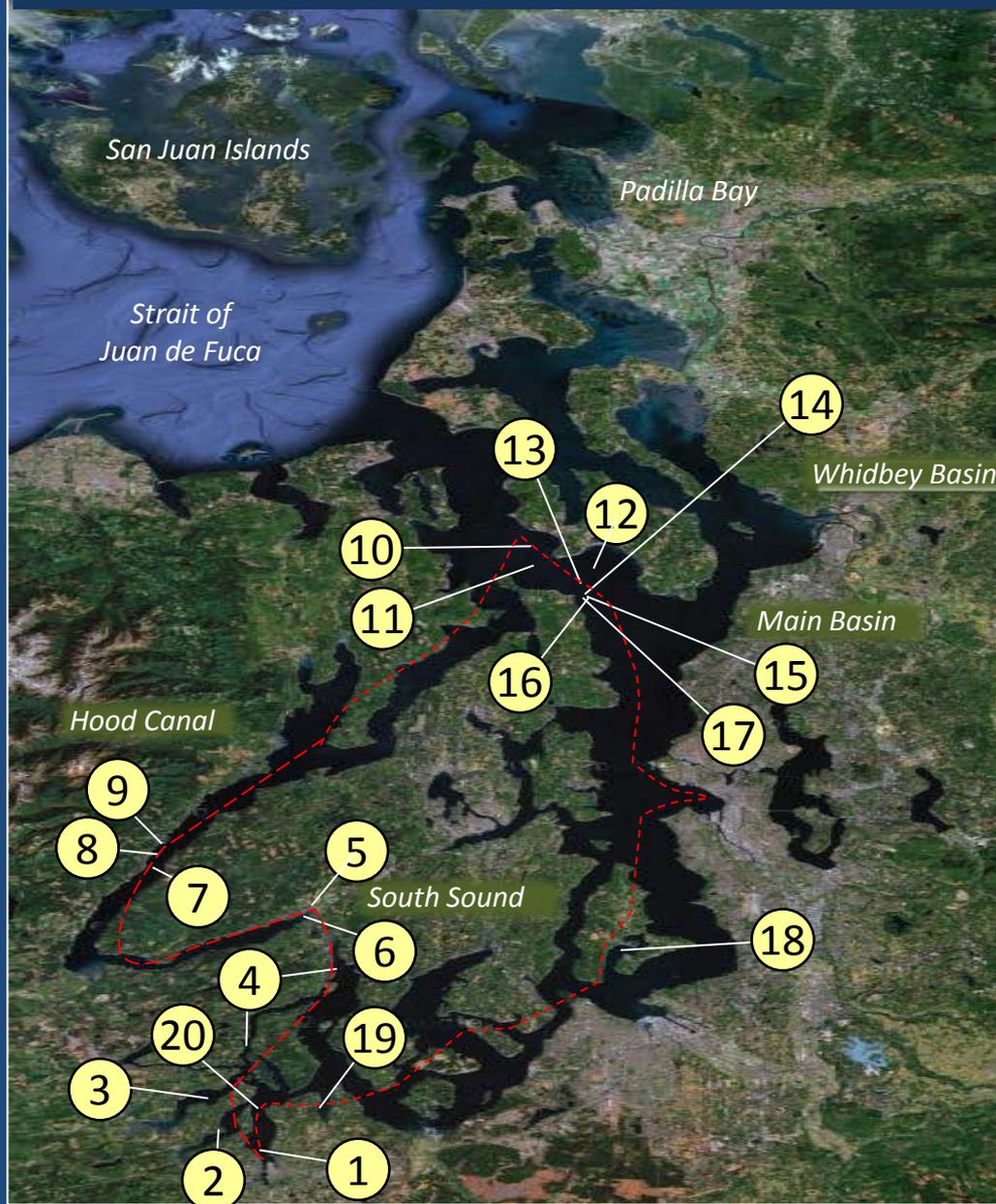


**Debris:**

Abundant in Hood Canal and Admiralty Inlet.

[2](#) [3](#) [4](#) [5](#) [6](#) [7](#) [8](#) [9](#) [10](#) [11](#) [13](#) [14](#) [15](#) [16](#) [17](#) [20](#)

Seattle: H. tide: 7:46 AM, 6:13 PM, L. tide: 12:22 AM, 1:40 PM



## Aerial photography & navigation guide

**Date: 11-21-2013**

**Click on numbers**

### Flight Information:

#### **Morning flight, photos 1-9:**

Good visibility, calm, glare on water.

#### **Afternoon flight, photos 10-20:**

Good visibility, wind and waves.

### Observation Maps:

Central Sound & Hood Canal

South Sound



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



*Suspended sediments, internal waves, and red-brown algal bloom.*  
Location: Budd Inlet (South Sound) 10:28 AM.



Flight log

Weather

Water column

Aerial photos

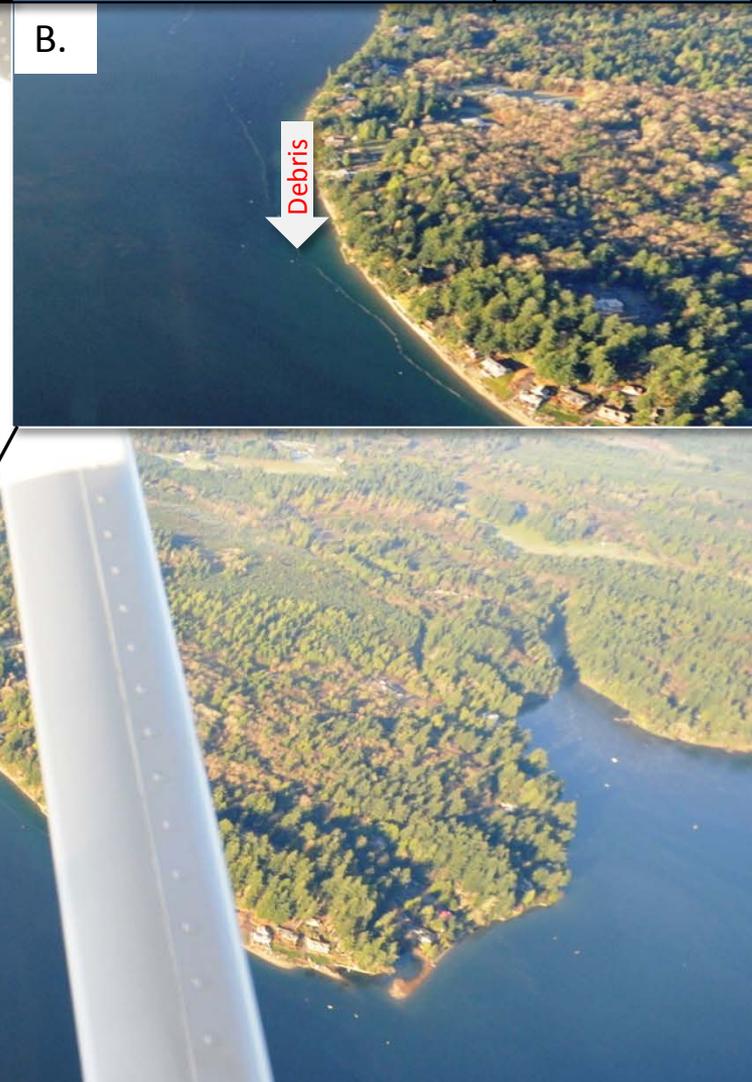
Ferry and Satellite

Moorings

A.



B.



*Red-brown bloom, and debris line.*

Location: Eld Inlet, A. Looking south, B. Close up (South Sound), 10:30 AM.



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



*Red-brown algal bloom, fronts, and debris lines.* Location: Totten Inlet (South Sound), 10:32 AM.



Flight log

Weather

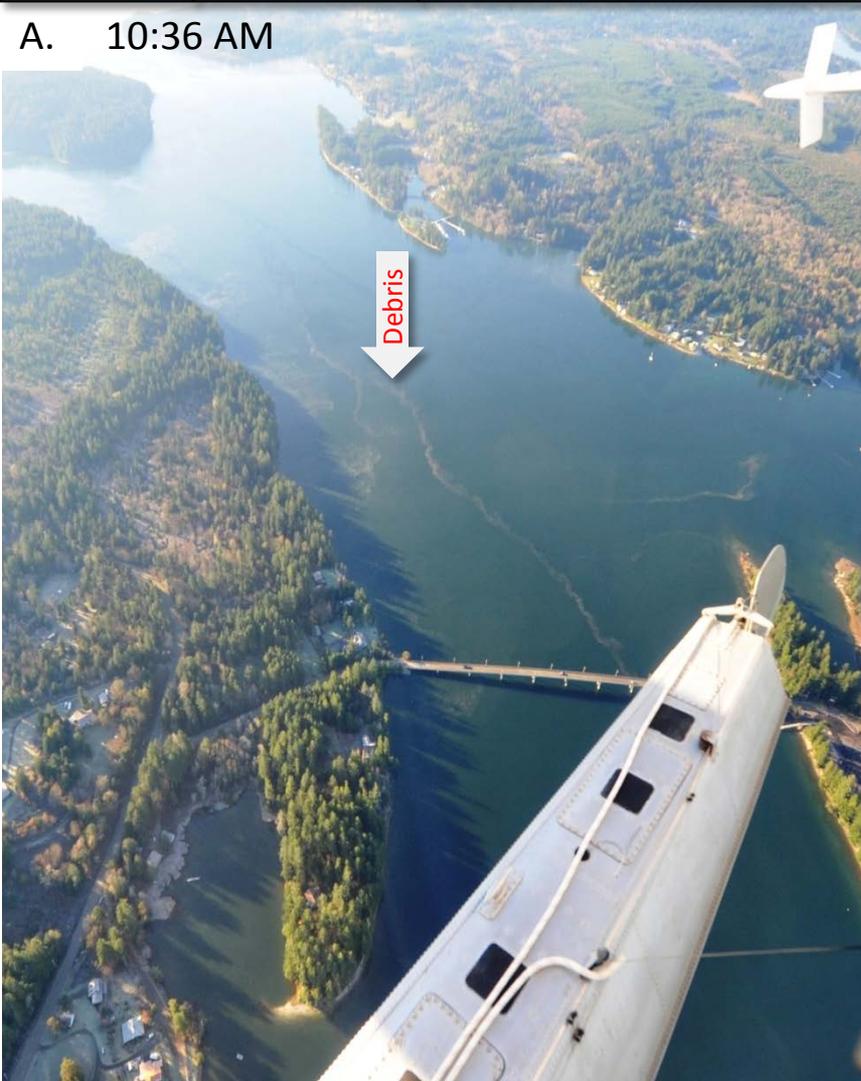
Water column

Aerial photos

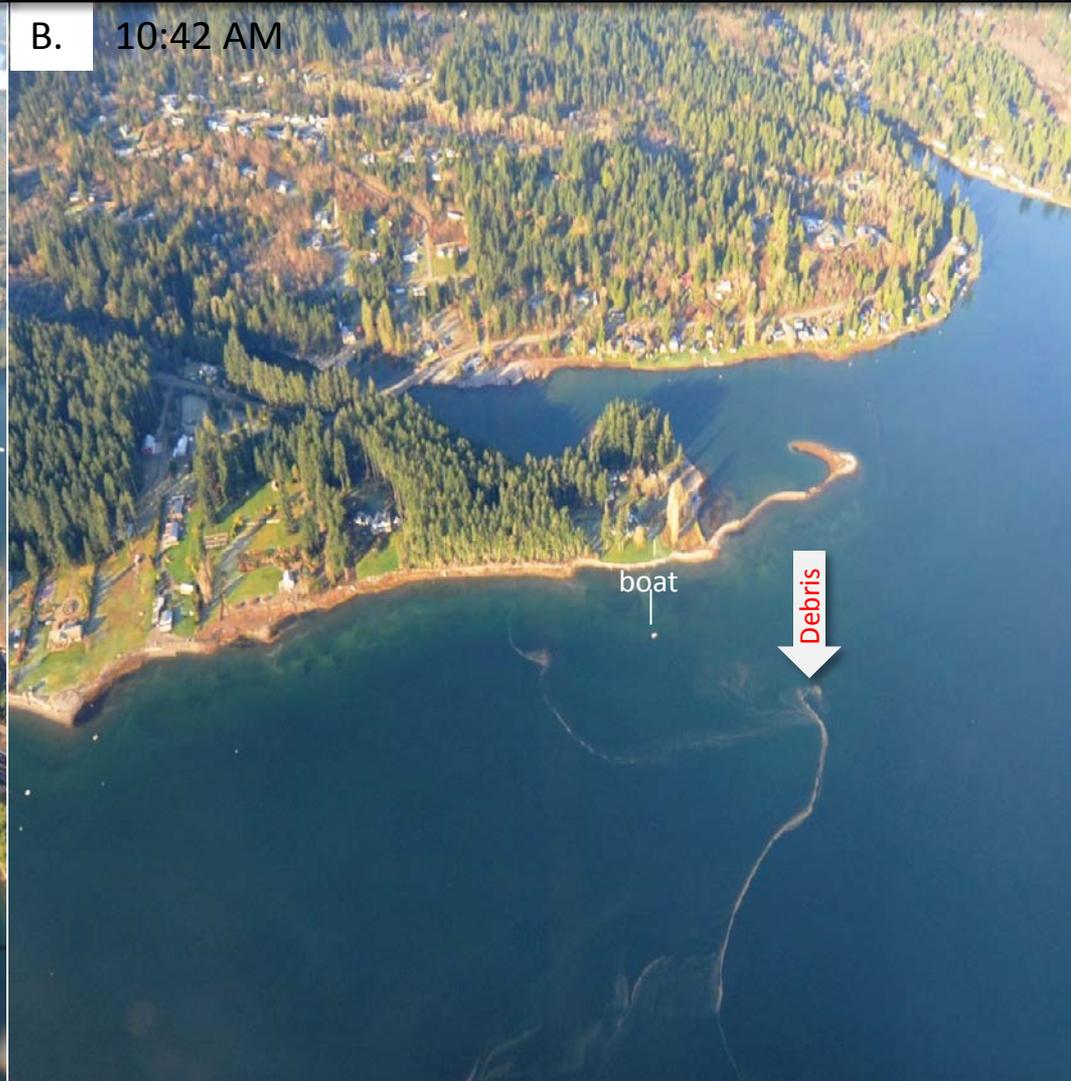
Ferry and Satellite

Moorings

A. 10:36 AM



B. 10:42 AM



*Long debris lines outlining tidal flow.*

Location: A. Pickering Passage, B. Reach Island, Case Inlet (South Sound).



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



*Organic surface debris over mudflats at high tide. Location: Lynch Cove (Hood Canal), 10:48 AM.*



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



*Organic surface debris over mudflats at high tide. Location: Lynch Cove (Hood Canal), 10:48 AM.*



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

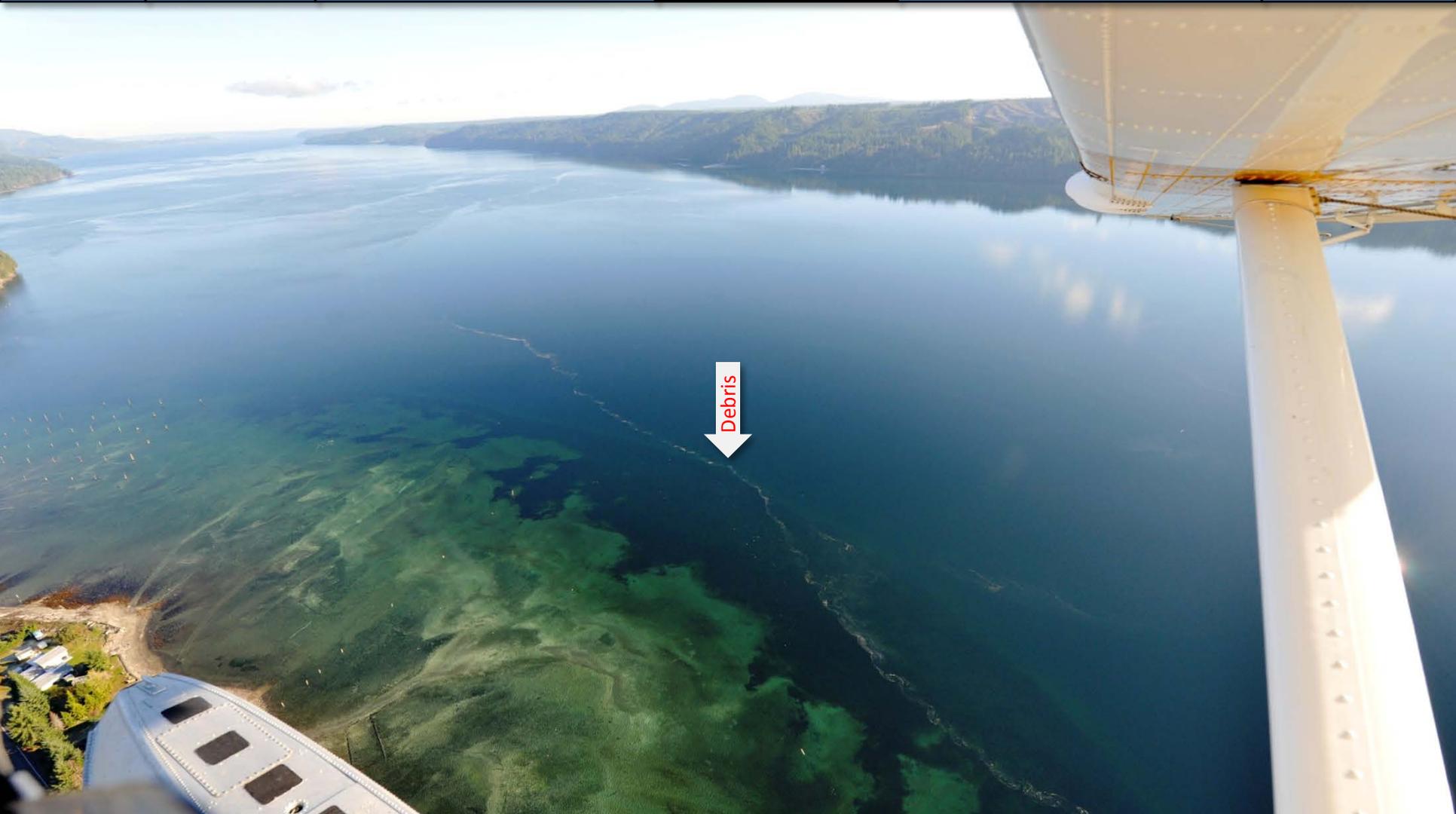
Moorings



*Sediment laden river plume with internal wave feature hugging eastern shore.*  
Location: Across Ayock Beach Drive (Hood Canal), 11:25 AM.

[Flight log](#)[Weather](#)[Water column](#)[Aerial photos](#)[Ferry and Satellite](#)[Moorings](#)

*Long debris line.* Location: Off Hama Hama Ridge Drive (Hood Canal), 11:26 AM.

[Flight log](#)[Weather](#)[Water column](#)[Aerial photos](#)[Ferry and Satellite](#)[Moorings](#)

*Long debris line parallel to western shore.*  
Location: Near Jorsted Creek (Hood Canal), 11:27 AM.

Flight log	Weather	Water column	Aerial photos	Ferry and Satellite	Moorings
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*Lines of organic debris and large tidal front. Location: Off Mutiny Bay (Admiralty Inlet), 1:02 PM.*



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



*Lines of organic debris and large tidal front.* Location: Off Mutiny Bay (Admiralty Inlet), 1:03 PM.



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings

A. 1:45 PM



B. 1:46 PM



*Tidal front separating clear and sediment laden water. Location: Useless Bay (Admiralty Inlet).*



Flight log

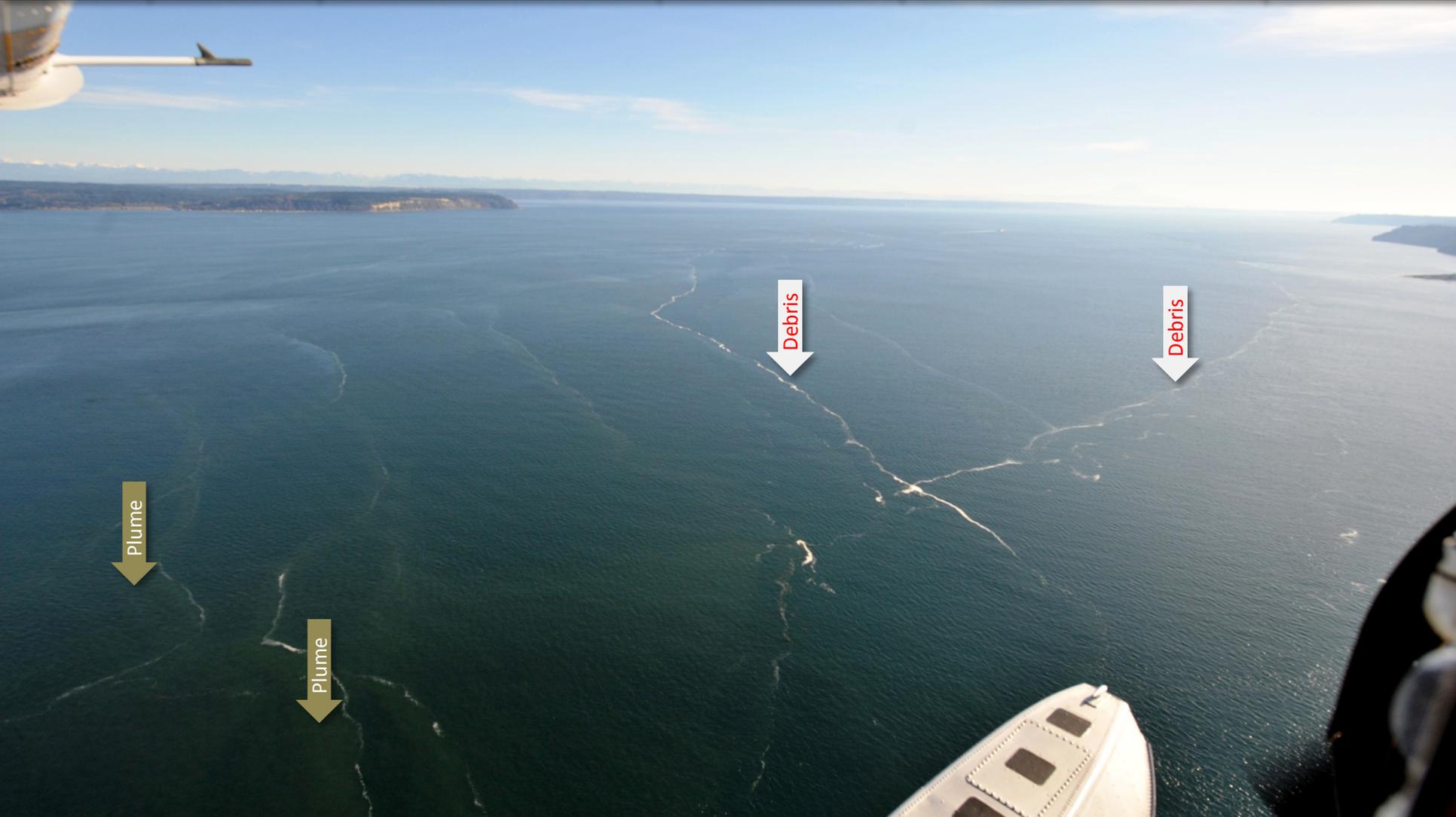
Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



*Many organic debris lines and layers of sediment laden water originating from Whidbey Basin.  
Location: Off Skunk Bay (Admiralty Inlet), 1:48 PM*



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



*Many organic debris lines and sediment laden water originating from Whidbey Basin.  
Location: Off Point No Point (Central Sound), 1:48 PM.*



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



*Many organic debris lines and sediment laden water originating from Whidbey Basin. Orcas swimming along front. Location: Point No Point (Central Sound), 1:50 PM.*



Flight log

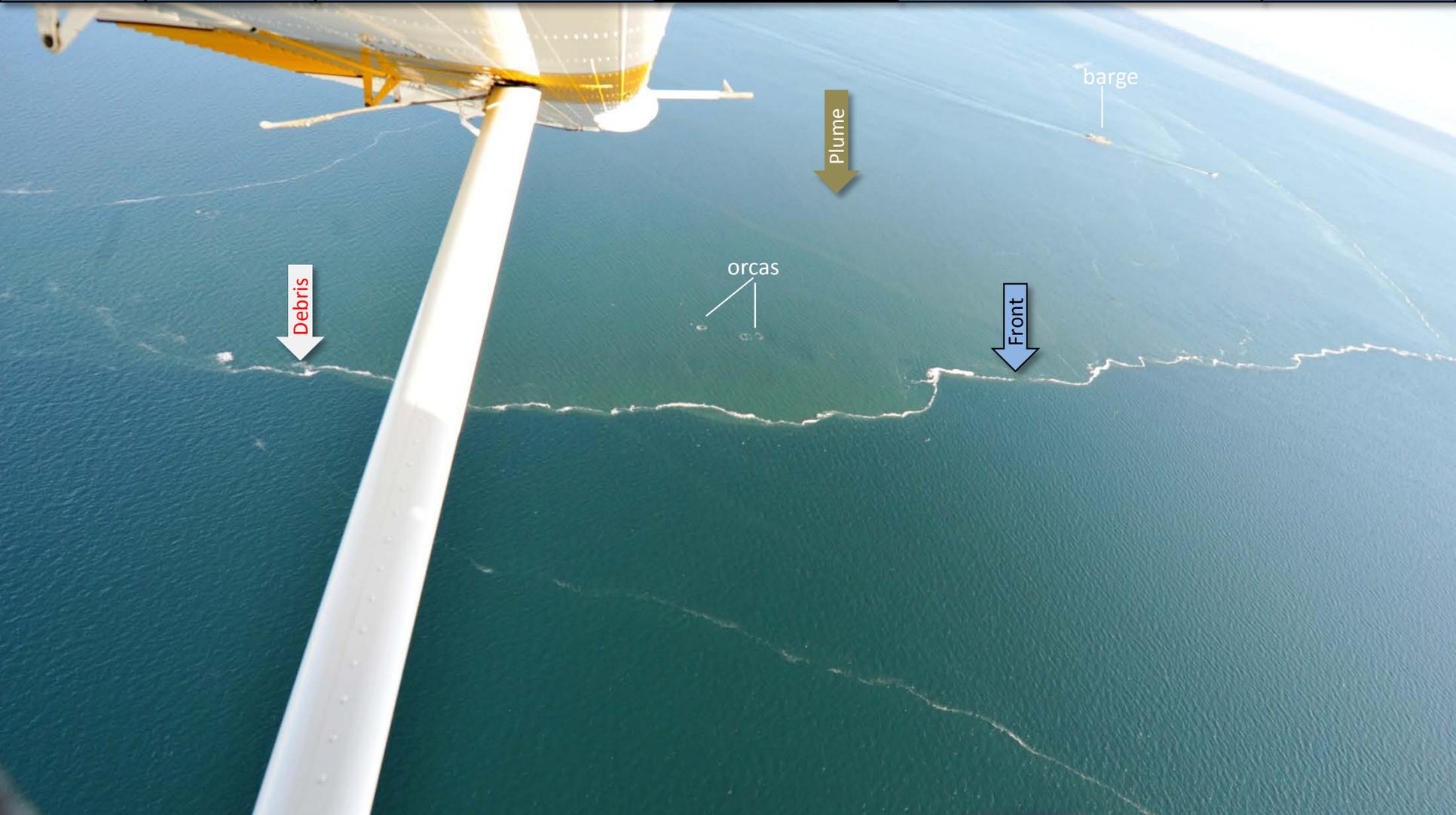
Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



*Many organic debris lines and sediment laden water originating from Whidbey Basin. Orcas swimming along front towards the north. Location: Point No Point (Central Sound), 1:50 PM.*



Flight log

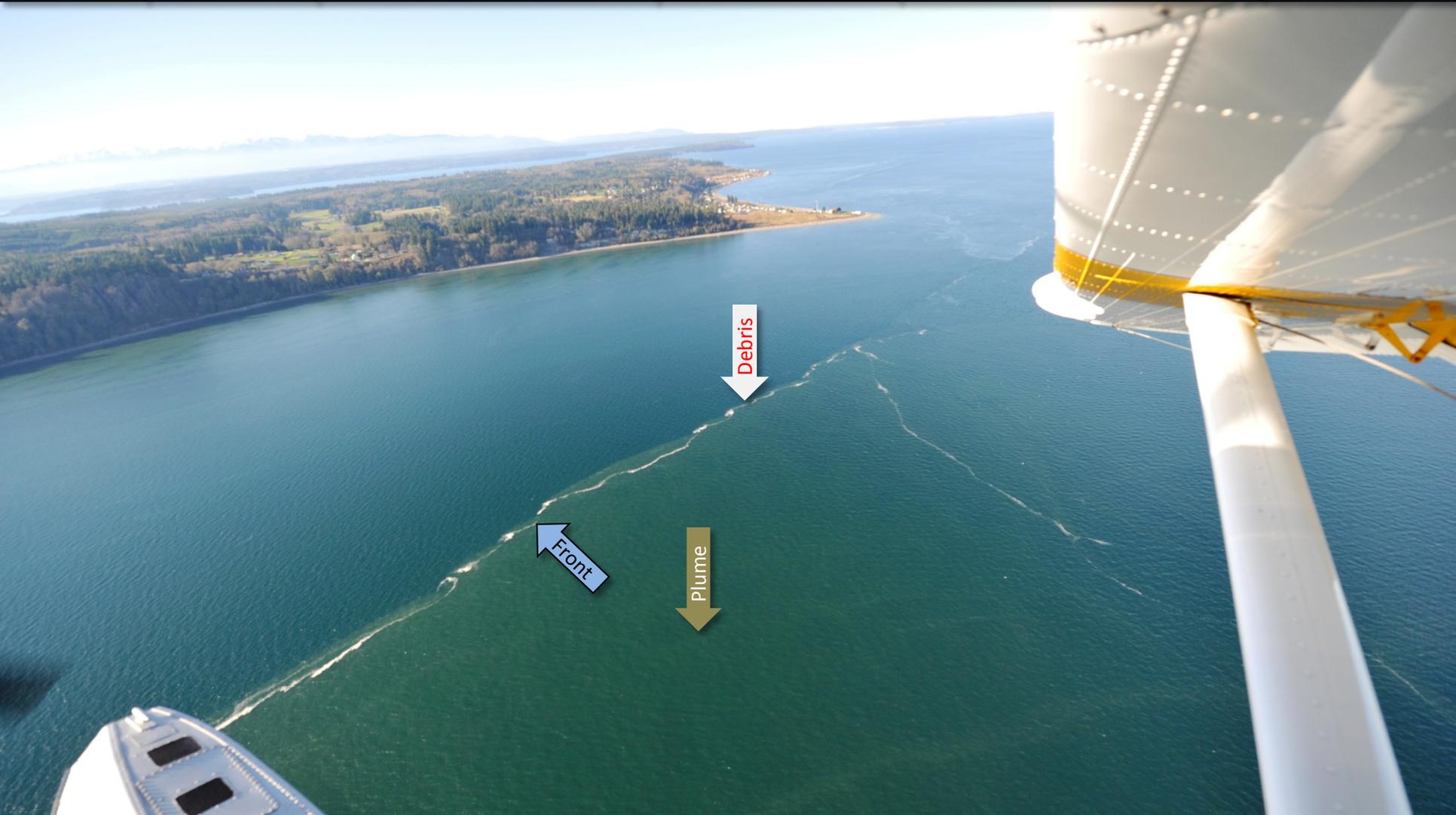
Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



*Many organic debris lines and sediment laden water originating from Whidbey Basin.  
Location: Point No Point (Central Sound), 1:57PM.*



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



*Water from the Puyallup River containing sediment entering Quartermaster Harbor.  
Location: Quartermaster Harbor (Vashon Island), 3:58PM.*



Flight log

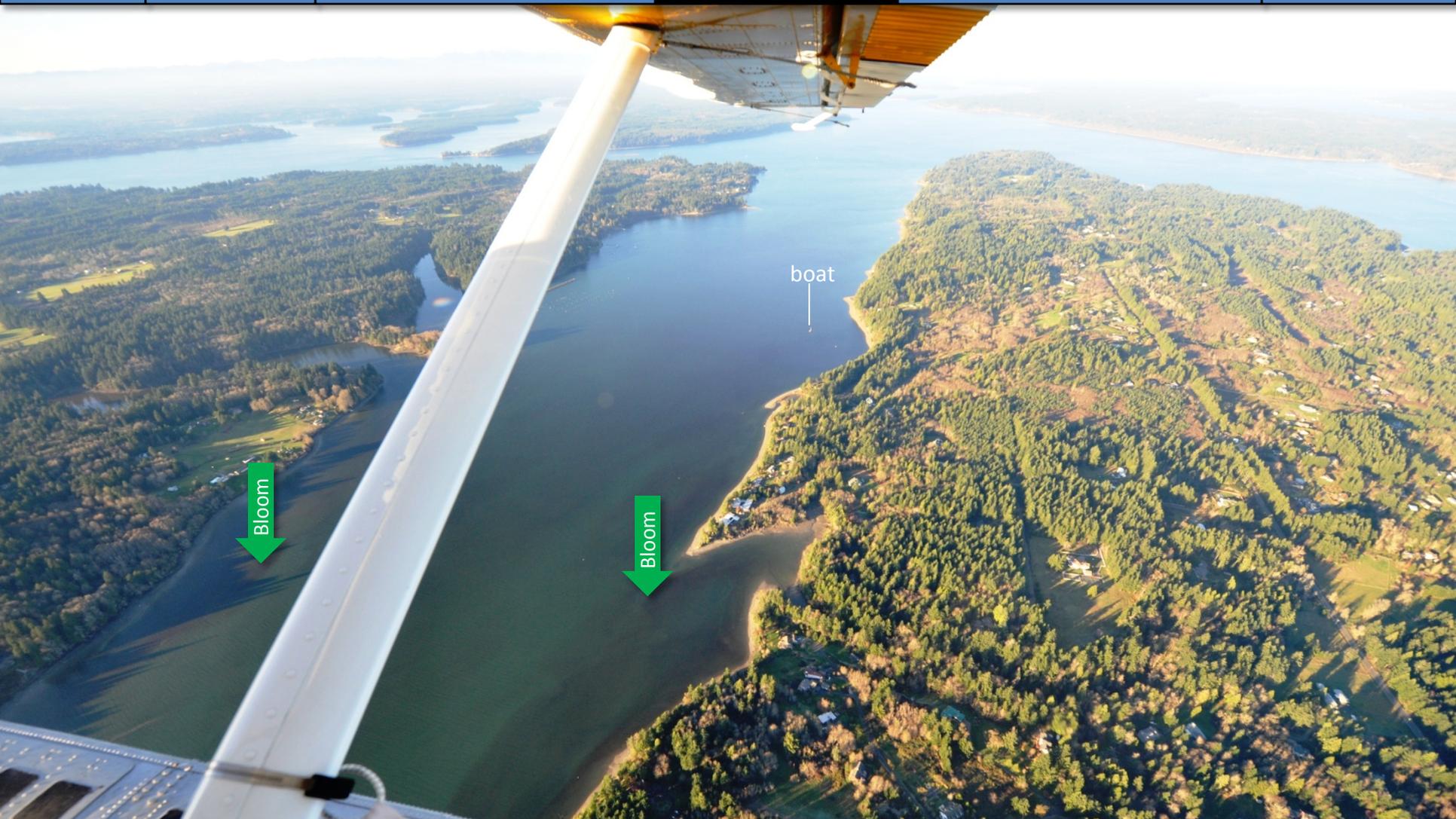
Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



*Red-brown algae bloom and turquoise water.* Location: Henderson Inlet (South Sound), 4:09 PM.



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings

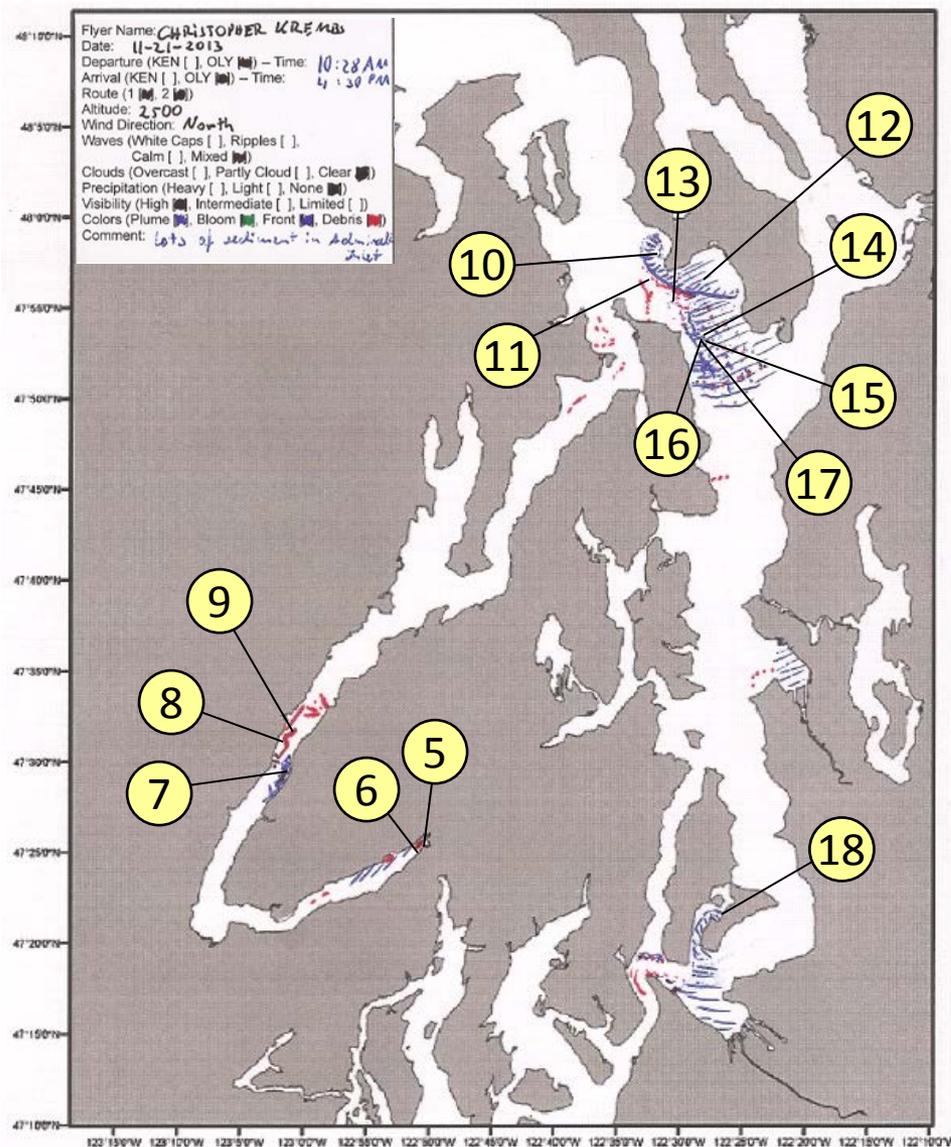


*Red-brown algae bloom, suspended sediment, surface debris and wind driven foam lines. Location: Budd Inlet (South Sound), 4:11 PM.*



**Date: 11-21-2013**

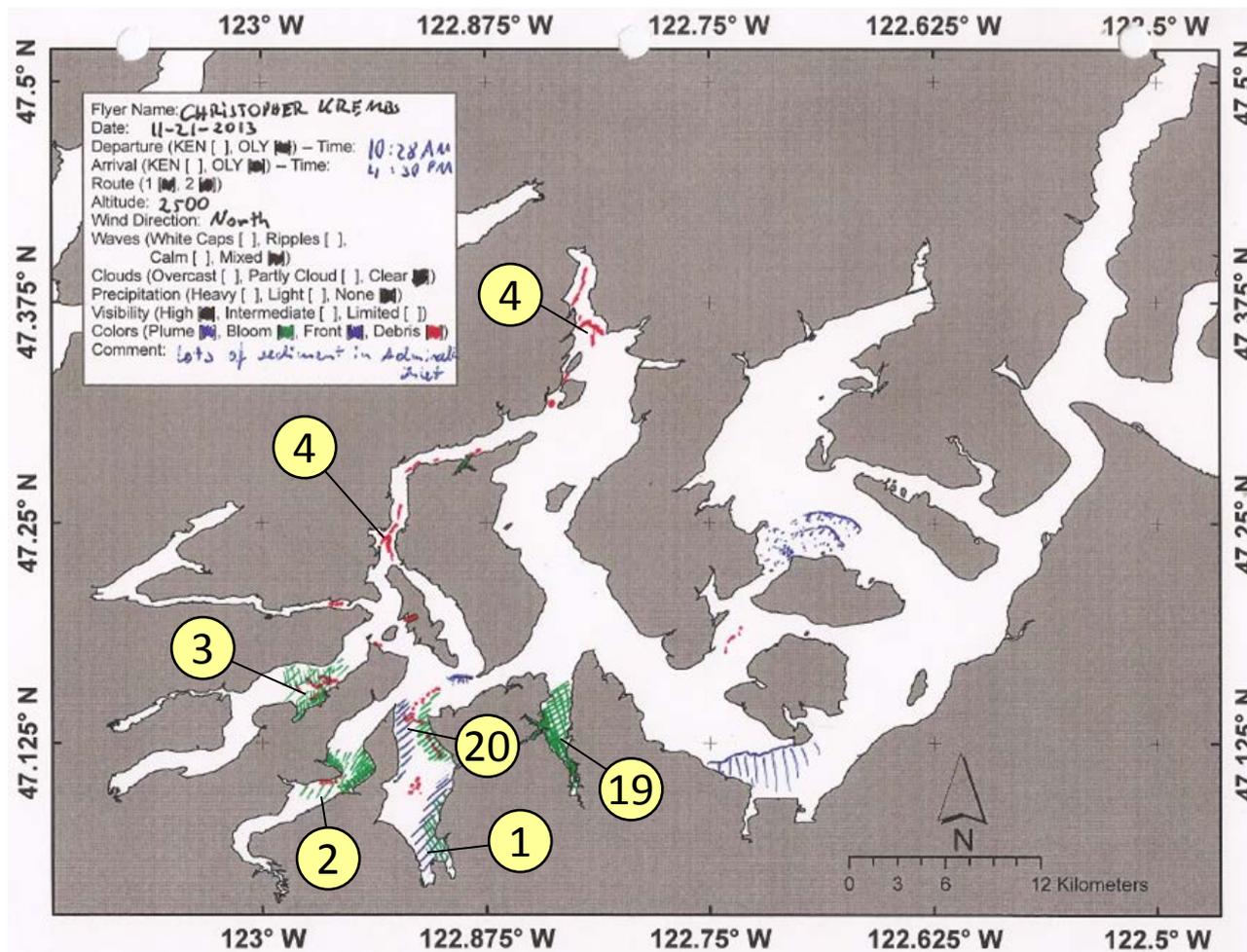
*Numbers on map refer to picture numbers for spatial reference*



# Observations in South Sound

[Navigate](#)


Date: 11-21-2013



Numbers on map refer to picture numbers for spatial reference

<b>Plumes</b>	
• Freshwater with sediment <b>solid</b>	
• Freshwater with sediment <b>dispersed</b>	
• Coastal erosion with sediment	
<b>Blooms</b>	
• Dispersed	
• Solid	
<b>Debris</b>	
• Dispersed	
• Solid	
<b>Front</b>	
• 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 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.*



Flight log

Weather

Water column

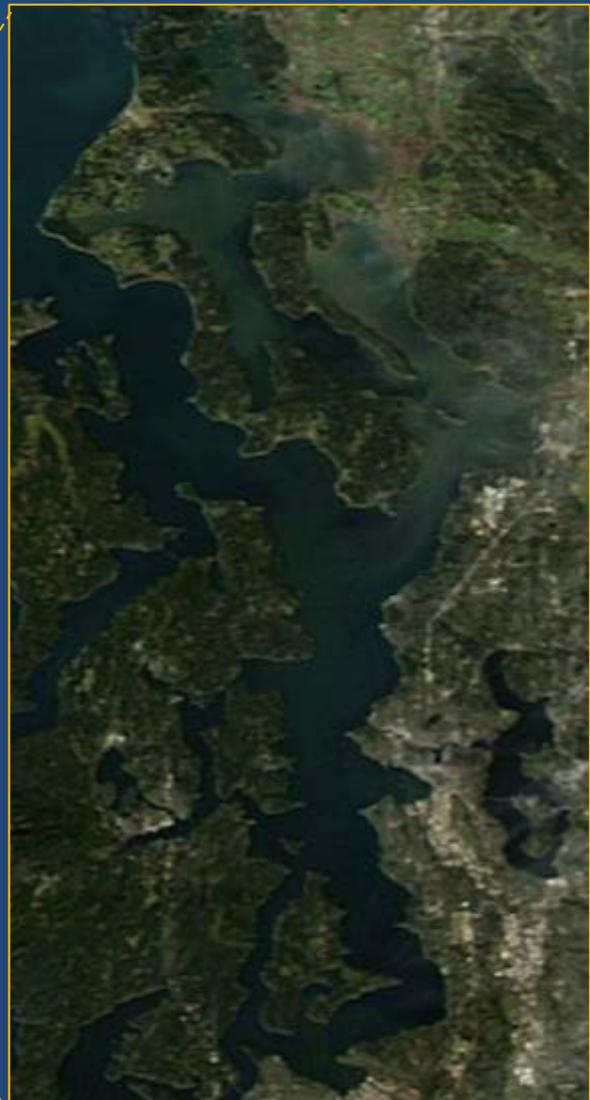
Aerial photos

Ferry and Satellite

Moorings



Brandon Sackmann  
Contact: [bsackmann@ecy.wa.gov](mailto:bsackmann@ecy.wa.gov)  
**High turbidity and sediment concentrations entering Central Sound from Whidbey Basin.**



Note: Due to state and federal budget reductions, our mooring program is being downscaled.



**Strength through collaboration across agencies, academic institutions and companies.** We have plans to continue to collect data at our Admiralty Reach (UW Applied Physics Lab) and Mukilteo (ORCA College) moorings into the future. Operations at all other mooring locations have been suspended in order to reallocate existing resources.



## We are now focusing on measuring ocean intrusions!

**Why?** The importance of the ocean on water quality in Puget Sound is being emphasized by Ecology's mooring at Admiralty Reach, long term monitoring data, modeling studies, and academic publications. Admiralty Reach is a challenge - it requires a team effort!

Upwelling along the coast can bring **high nutrient, low oxygen** and **low pH** ocean water into Puget Sound. Such intrusions explain much of the year to year variability in **water quality**.

For intrusions to enter Puget Sound, several conditions have to align:

- **Prolonged upwelling** along the Washington coast. *Driver: Northerly winds*
- **Estuarine circulation moving dense water from the coast** into the Strait of Juan de Fuca. *Driver: High Fraser River flow during summer*
- **Neap-Spring tide phase and character** favorable to intrusions along the 30 km length of Admiralty Reach. *Drivers: Neap tides and tidal harmonics*



# Get data from Ecology's Monitoring Programs



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings

## Long-Term Monitoring Network

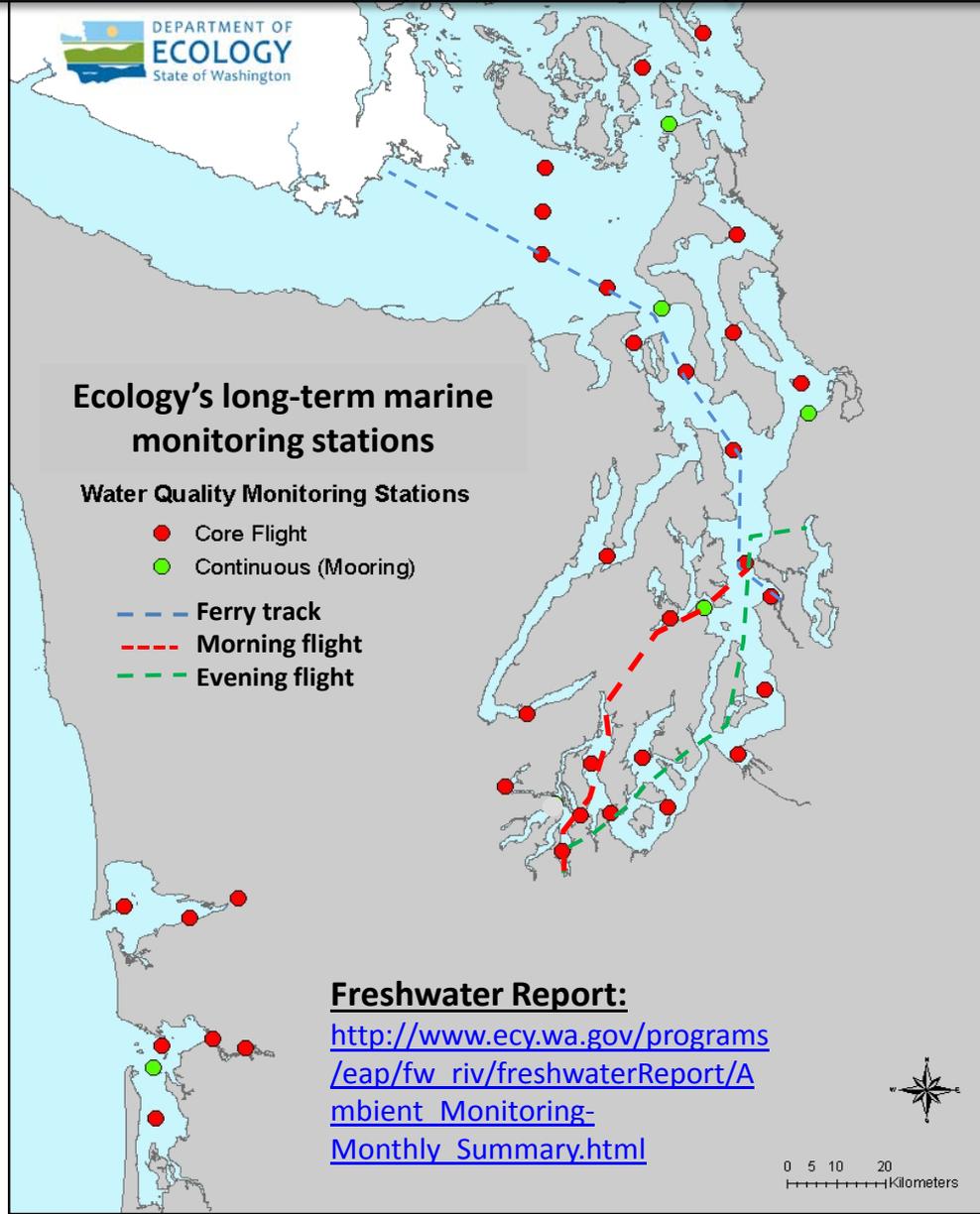


[christopher.krems@ecy.wa.gov](mailto:christopher.krems@ecy.wa.gov)



## Access core monitoring data:

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



## Real-Time Sensor Network



[brandon.sackmann@ecy.wa.gov](mailto:brandon.sackmann@ecy.wa.gov)



## Access mooring data:

[ftp://www.ecy.wa.gov/eap/Mooring\\_Raw/Puget\\_Sound/](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>



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings

We are looking for feedback to improve our products.

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Marine Monitoring Unit  
Environmental Assessment Program  
WA Department of Ecology