


Eyes Over Puget Sound

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

Surface Conditions Report April 8, 2013

We have a new website (http://www.ecy.wa.gov/programs/eap/mar_wat/)

[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



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*Dr. Christopher
Krembs*



*Guest: Dr. Brandon
Sackmann*



Personal flight log

[p. 3](#)

The connection between beer and chlorophyll *a*.

Weather conditions

[p.5](#)

For the last week, sunshine has been below normal and rivers have been running above normal in response to heavy rain. Air temperatures have been mostly above normal.

Water column and mooring

[p.6](#), [p.31](#)

Are conditions leading to better water quality disappearing? Currently, spring conditions lead to increasing oxygen levels and heavy rain over the last days affects salinity.

Aerial photography

[p. 10](#)

Long foam lines marking sediment-rich river water leaving South Sound and Hood Canal appear in response to heavy rain. Jellyfish patches persist through the winter in some bays.

Ferry and satellite

[p. 30](#)

Victoria Clipper IV is back in the water after its annual maintenance and data will be available in May.

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North Sound Flight

I always look forward to sampling the North Sound stations. You never know when you may spot some whales. Alas, we saw a whale watching boat but no whales. We did have one unique sighting in the Strait of Georgia. A Canadian search and rescue plane! It was an impressive sight. I have never seen another aircraft like it.



Panoramic view of Hood Canal
courtesy of Joe Leatherman.

We were busy in 2012:

- 66 L water filtered (for chlorophyll a)
- 60 km of line spooled (36 miles)
- 400,784 CTD sensor data points collected

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North Sound Flight



Our monitoring isn't all tulips and float planes. We collect data year round. It is a constant flow of samples and data to manage. In 2012 we **filtered 66,300 milliliters of chlorophyll *a*** samples, which translates to **140 pints. That's a lot of beer!** We put out ~**60,000 meters of line, which is 37 miles.** That would be a nice scenic drive from our offices in Lacey to Union in Hood Canal. We also collected **400,784 data points** with our CTD package! If that were miles you could almost get to the moon and back.



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

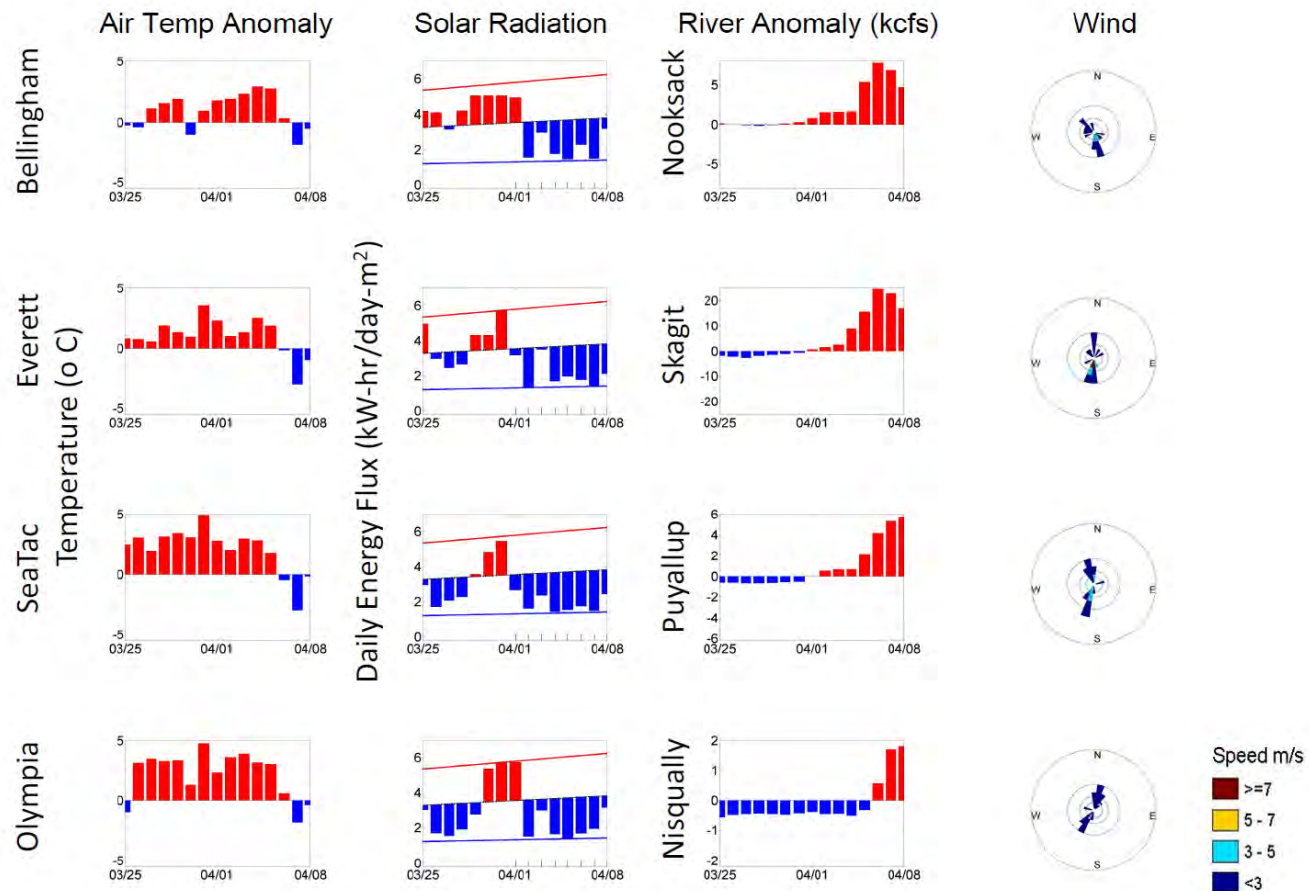
Summary:

Air temperatures have been above normal over Puget Sound except for the past few days.

Sunshine levels have been below normal for the last week.

Rivers have been running above normal in response to rain.

Winds have mostly been from the south.



Conditions of the last two years change at our stations



Flight log

Weather

Water column

Aerial photos

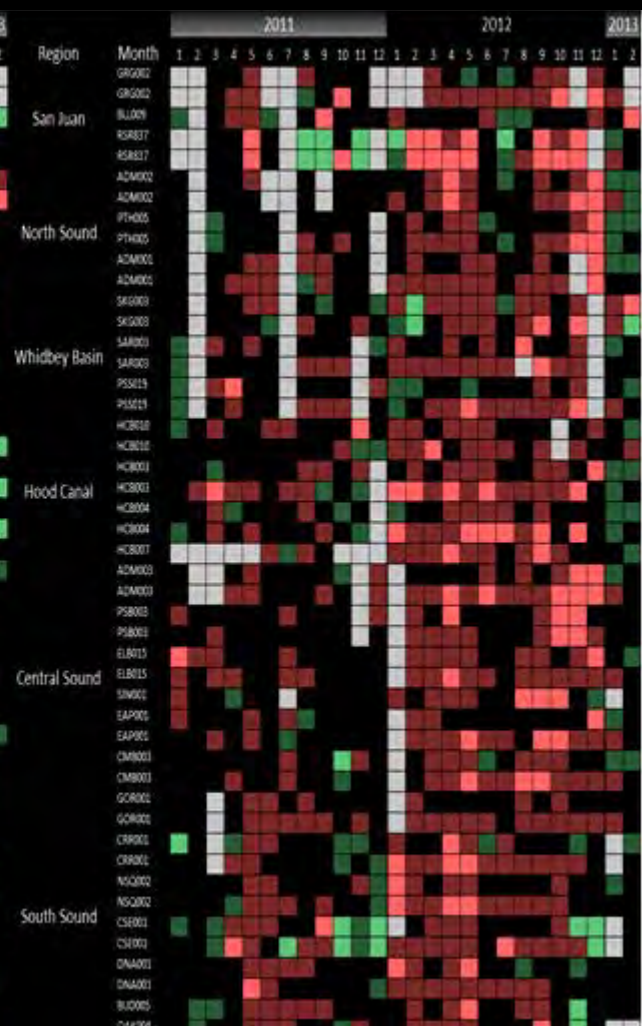
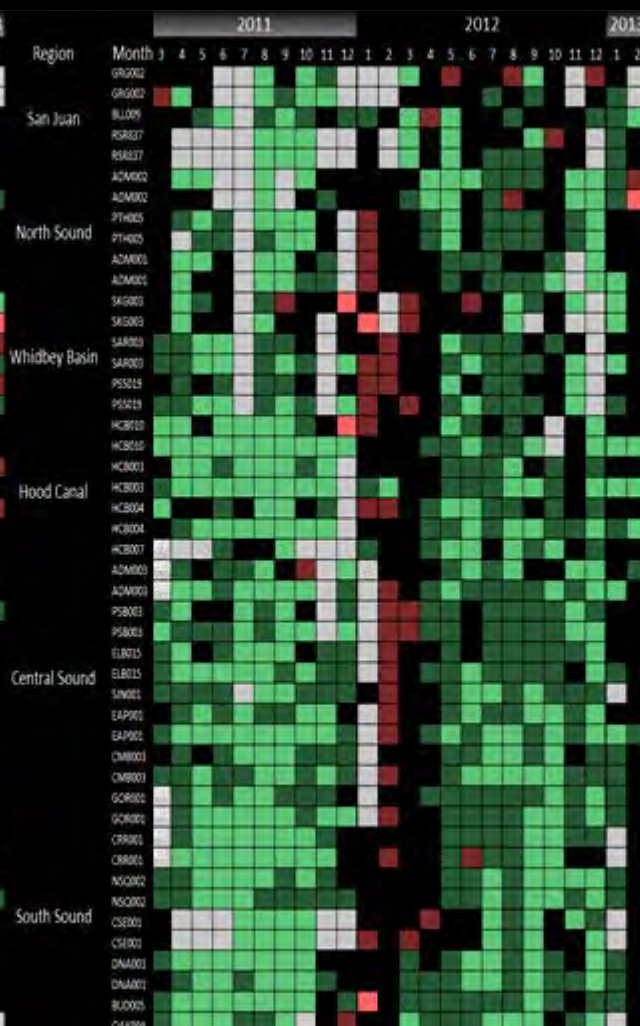
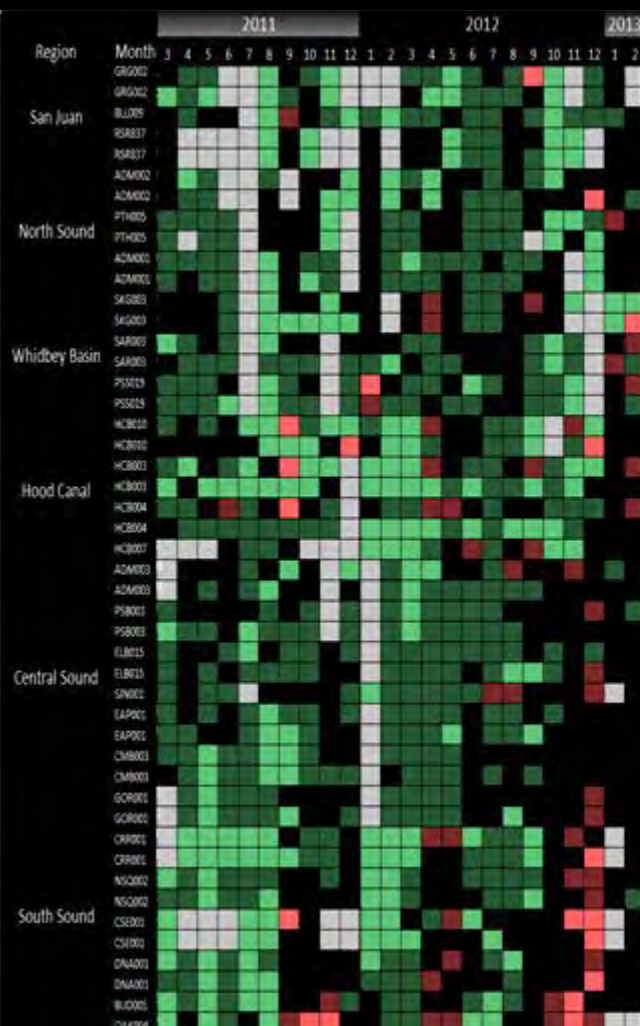
Ferry and Satellite

Moorings

Temp: No longer colder!

Salinity: No longer fresher?

Oxygen: No longer higher!



Red = higher than expected (>IQR, n=13)
 Red = higher than previous measurements

Black = expected (=IQR, n=13)
 Grey = no data

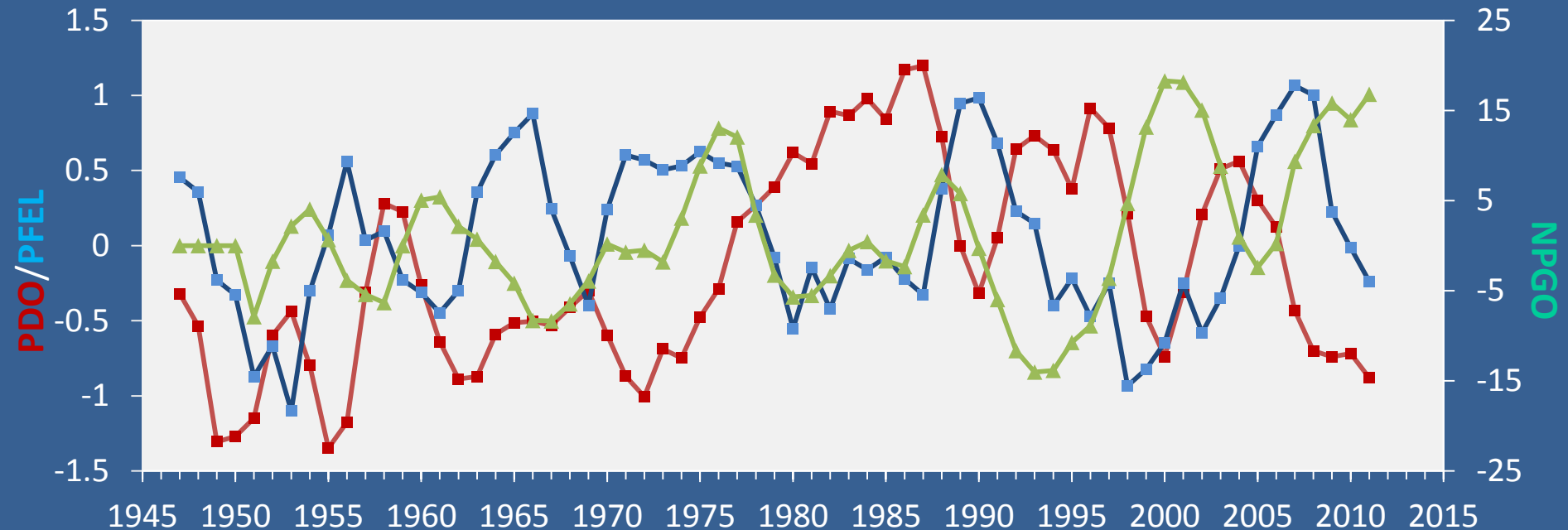
Green = lower than expected (>IQR, n=13)
 Green = lower than previous measurements

Ocean boundary conditions likely change: Ocean Climate Indices

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- Pacific Decadal Oscillation Index (**PDO**) [...\(explanation\)](#)
- Upwelling Index (**PFEL**) [...\(explanation\)](#)
- North Pacific Gyre Oscillation Index (**NPGO**) [...\(explanation\)](#)

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



Our long-term marine monitoring stations in Puget Sound region

Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



- North Sound / San Juan S.
- 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.

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

Get the data and trends from us?

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

Algae bloom Budd Inlet 2010



Nitrate



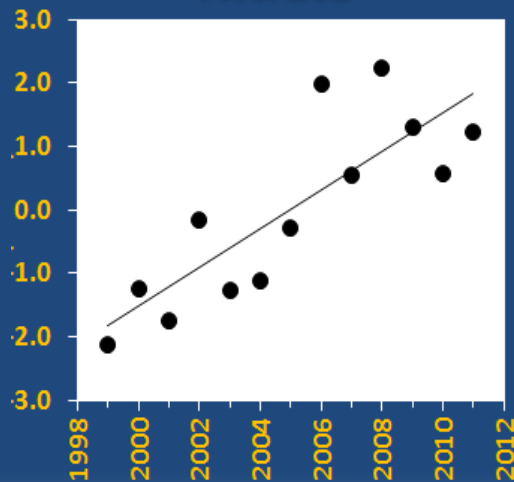
Phosphate



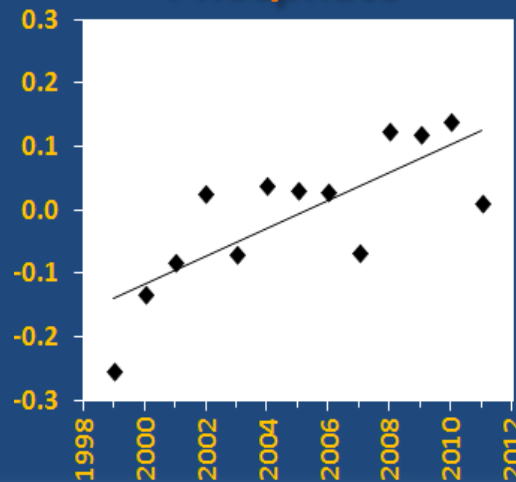
**Changing
Nutrient Balance**

Nutrients in Puget Sound are increasing, read http://www.ecy.wa.gov/programs/eap/mar_wat/trends.html

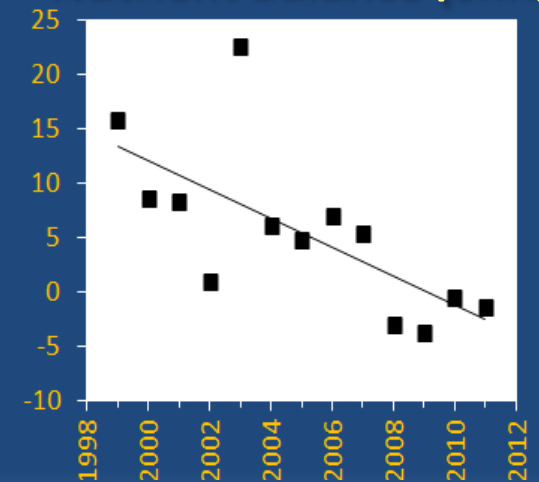
Nitrate



Phosphate



Nutrient Balance (Si:N)



Flight log

Weather

Water column

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Ferry and Satellite

Moorings



Long foam lines delineating sediment-rich river water leaving South Sound in response to heavy rain. Jellyfish patches still persist through the winter in some bays.

Track repair, Carkeek Park, Seattle



suspended
sediment

A cloudy morning flight, McNeil Island



Start here



Mixing and Fronts: [1](#) [2](#) [3](#) [4](#) [8](#) [9](#) [10](#) [11](#)

Strong fronts in many places in response to recent rain.



Jellyfish:

Present in Budd and Sinclair Inlets.



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

High sediment loads in response to recent rain.



Visible blooms: [1](#) [2](#) [9](#) [11](#) [12](#) [13](#) [14](#) [15](#)

Red bloom in Sinclair Inlet.

Red-brown bloom in Hood Canal washing away due to Skokomish river effluent.

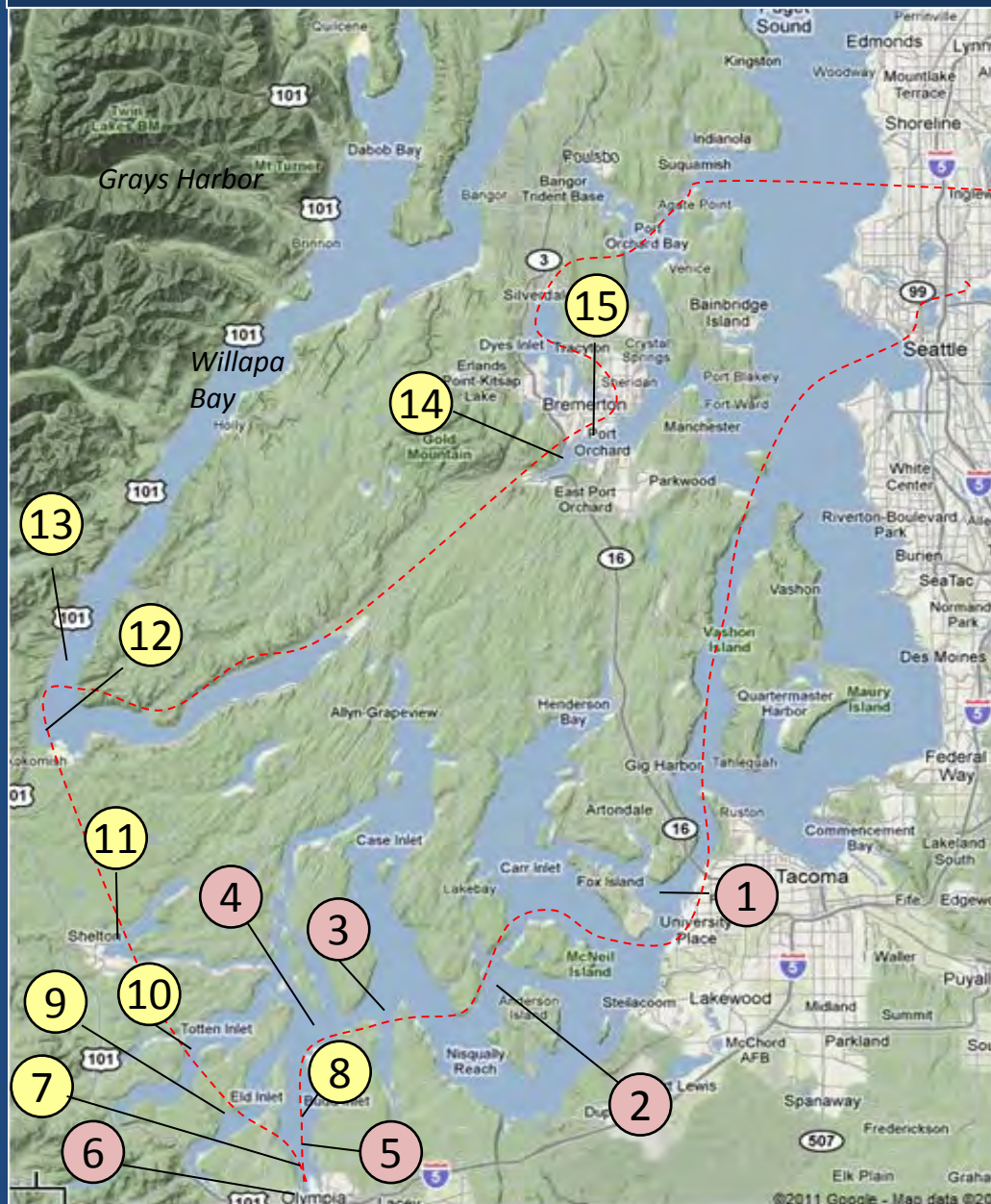


Debris: [1](#) [2](#) [3](#) [4](#) [9](#) [10](#) [11](#)

Very pronounced, long foam lines from Oakland Bay to Tacoma Narrows outlining fronts.

High tides: 4:18 AM, 4:55 PM

Low tides: 10:45 AM, 10:42 PM





Aerial photography navigation guide, 4-8-2013



Click on numbers

Flight Information:

-  **Morning flight:** -----
Low visibility, clouds forced altered route
-  **Evening flight:** -----
Variable visibility, some cloud reflections on water, calm

Observation Maps:

Central Sound

South Sound



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



Surface debris (foam bands) delineating adjacent water masses.

Location: Tacoma Narrows (South Sound), 8:57 AM

Flight log

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Water column

Aerial photos

Ferry and Satellite

Moorings



Surface debris (foam bands) delineating adjacent water masses.

Location: Anderson Island (South Sound), 9:03 AM



Flight log

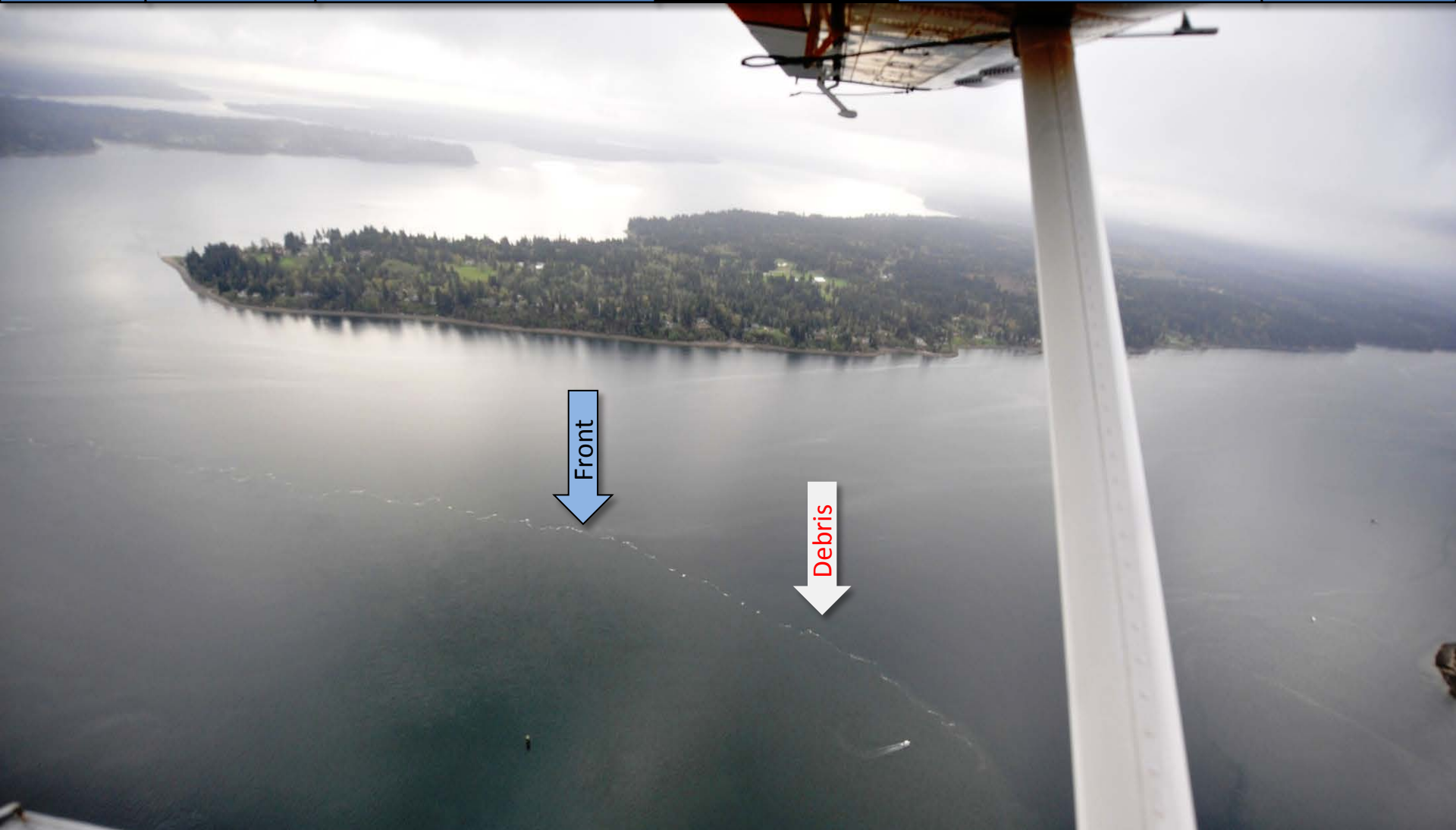
Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



Surface debris (foam bands) delineating adjacent water masses, boat wake.
Location: Henderson Inlet (South Sound), 9:07 AM



Flight log

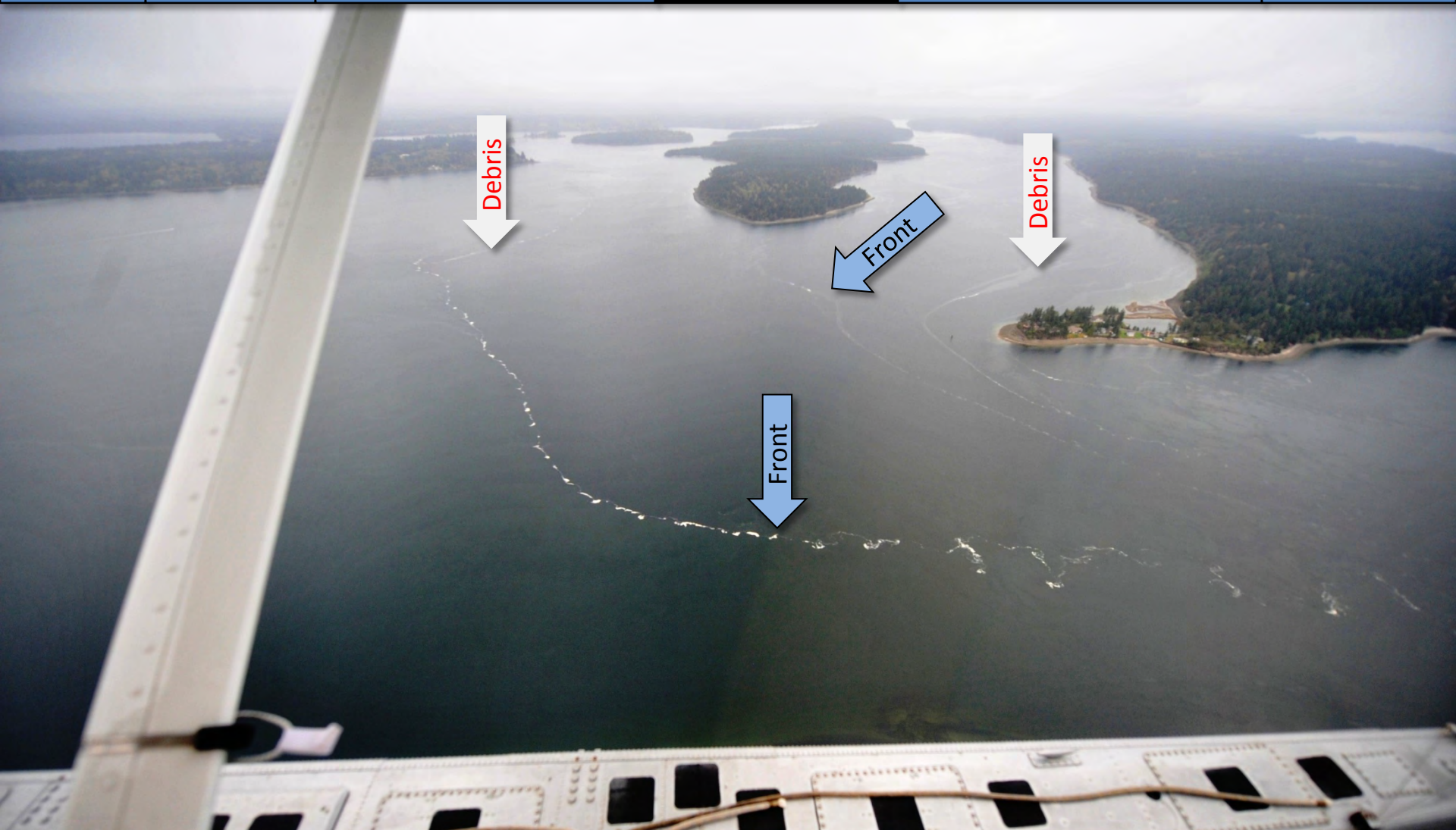
Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



Intense surface debris (foam bands) delineating adjacent water masses.

Location: Dana Passage (South Sound), 9:08 AM

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Deschutes River plume with suspended sediment filling the estuary at surface.

Location: Budd Inlet (South Sound), 9:12 AM



Flight log

Weather

Water column

Aerial photos

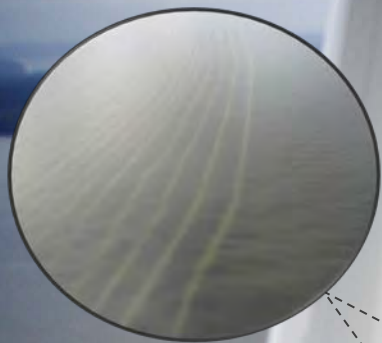
Ferry and Satellite

Moorings



Deschutes River with brown suspended sediment filling Capitol Lake.

Location: Olympia (South Sound), 9:13 AM

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Internal
waves

Plume

Deschutes River plume layers marked by sediment bands, showing internal waves during mixing.
Location: Budd Inlet (South Sound), 9:14 AM



Flight log

Weather

Water column

Aerial photos

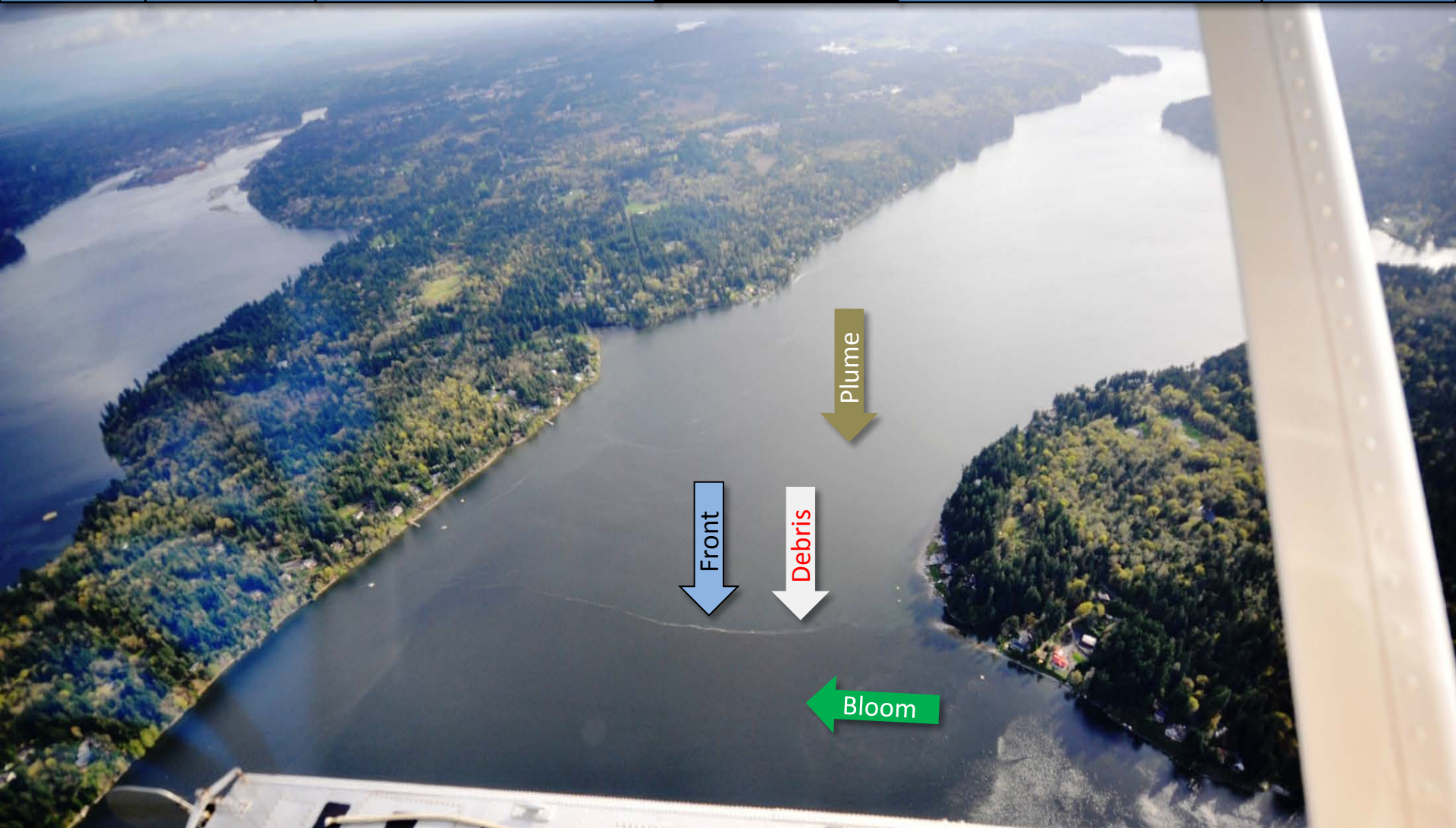
Ferry and Satellite

Moorings



Deschutes River plume with suspended sediment filling the eastern side of the estuary.

Location: Budd Inlet (South Sound), 5:12 PM

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Red-brown bloom and debris-rich front and river plume to the south.

Location: Totten Inlet, 5:14 PM

Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



Sediment-rich river plume hugging southeastern shore.

Location: Eld Inlet, 5:16 PM



Flight log

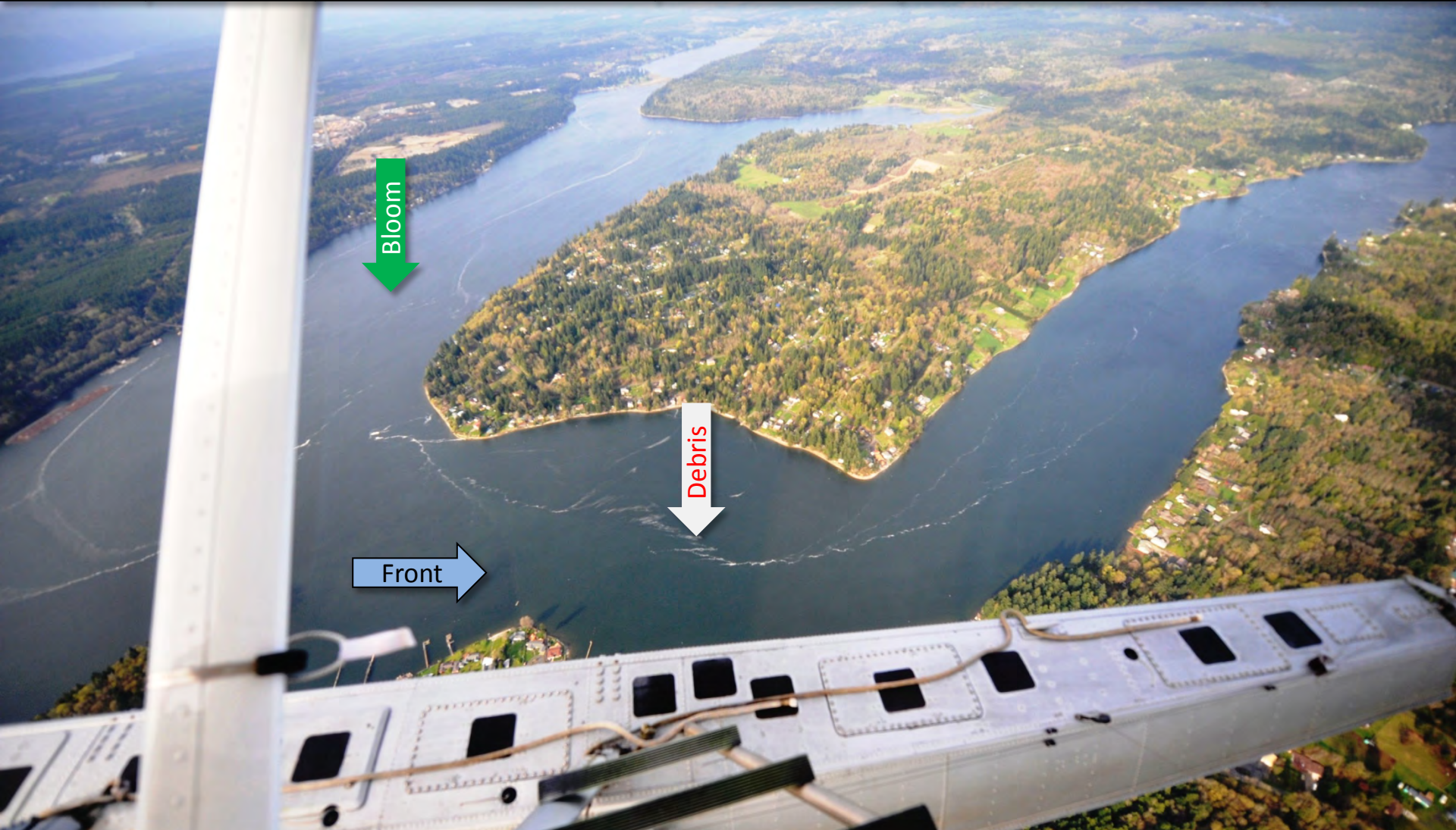
Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



Brown algal bloom, debris lines (foam) and front.

Location: Oakland Bay, 5:13 PM

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Red-brown algal bloom and glacial flour in plume from the Skokomish River.

Location: Southern Hood Canal, 5:25 PM



Flight log

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Moorings



Red-brown algal bloom and glacial flour in plume from the Skokomish River.

Location: Southern Hood Canal, 5:25 PM



Flight log

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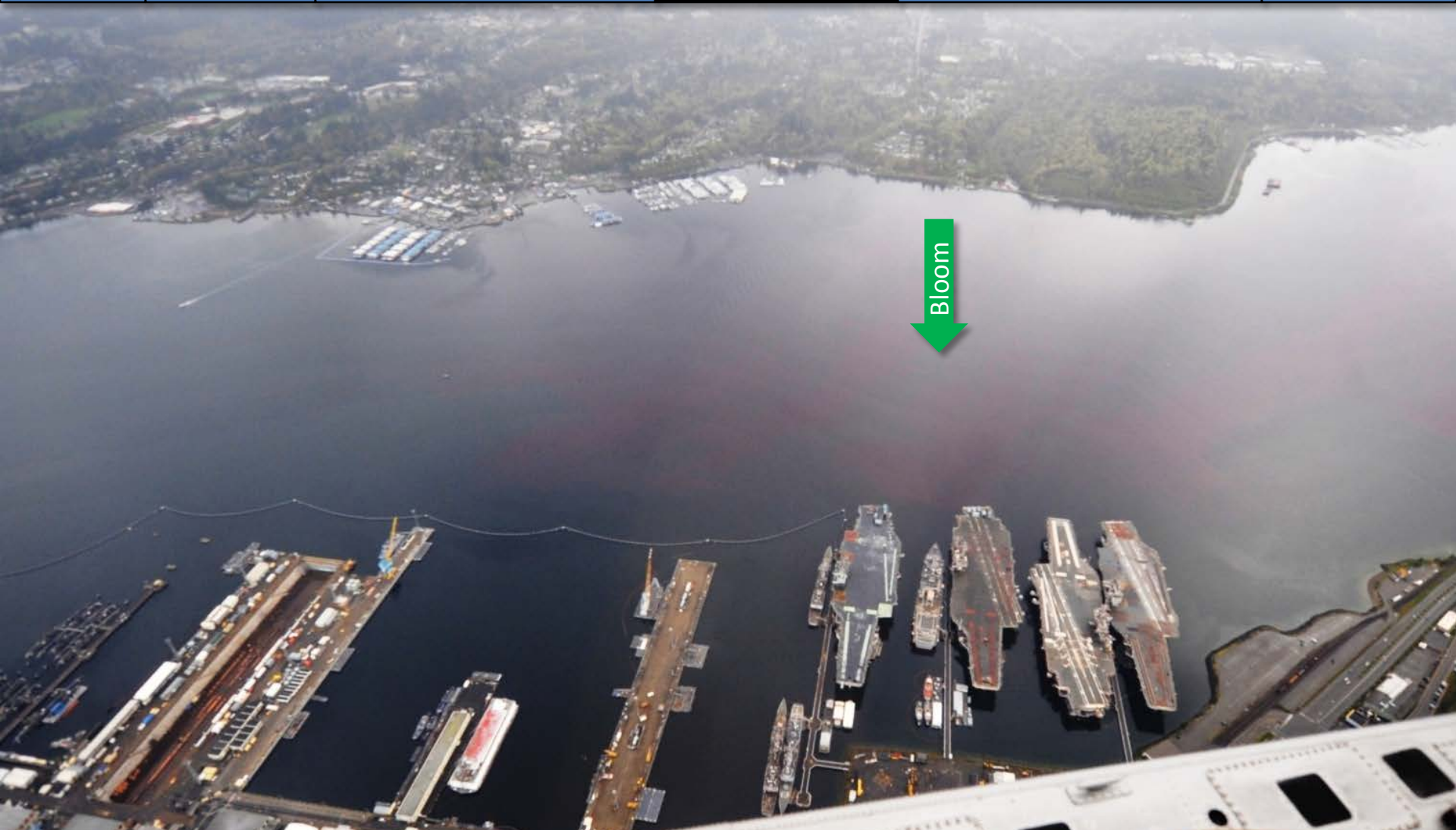
Ferry and Satellite

Moorings



Red plankton bloom, surface debris and jellyfish.

Location: Sinclair Inlet, 3:38 PM

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Red plankton bloom.
Location: Sinclair Inlet, 3:39 PM

Aerial photography observations in Central Sound

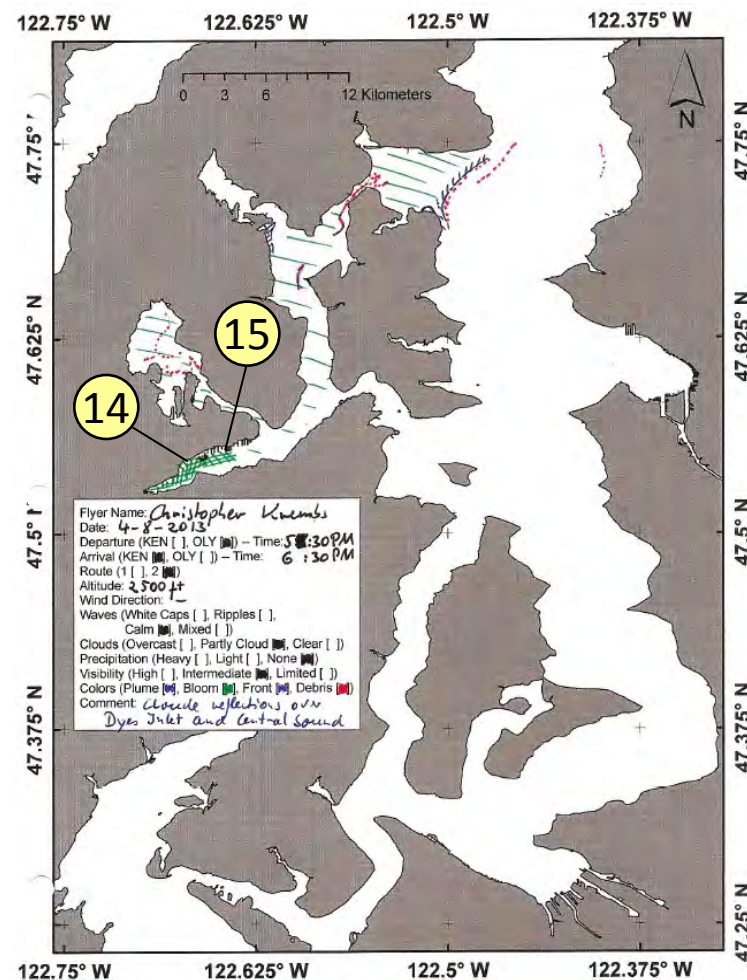
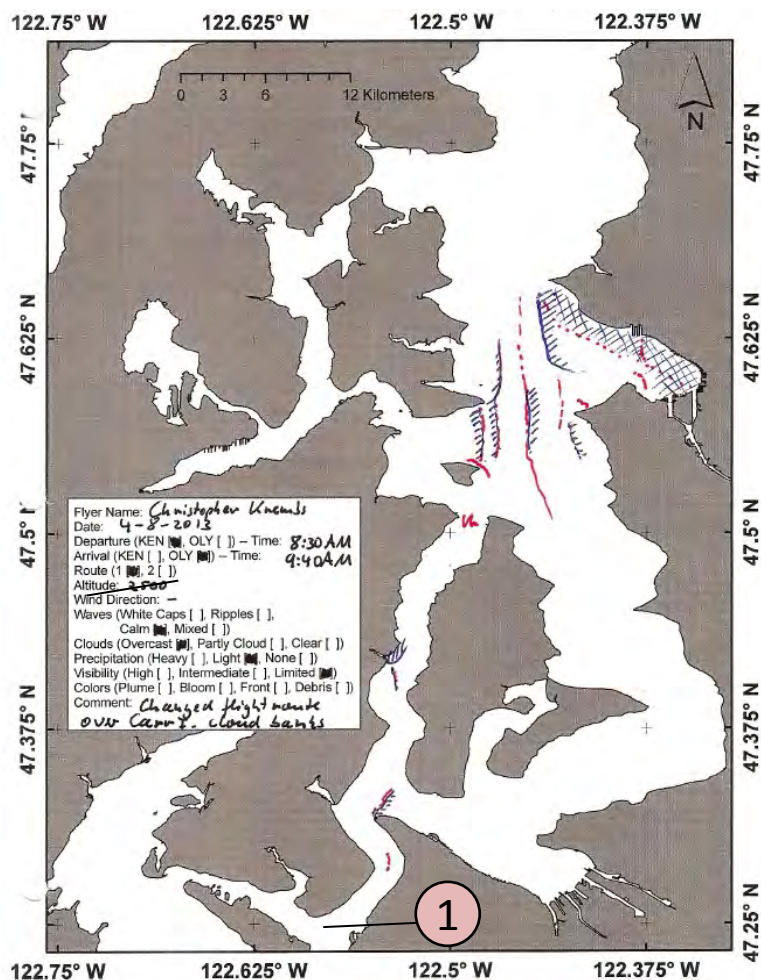
[Navigate](#)

Date: 4-8-2013



Morning

Afternoon



Numbers on map refer to picture numbers for spatial reference



Aerial photography

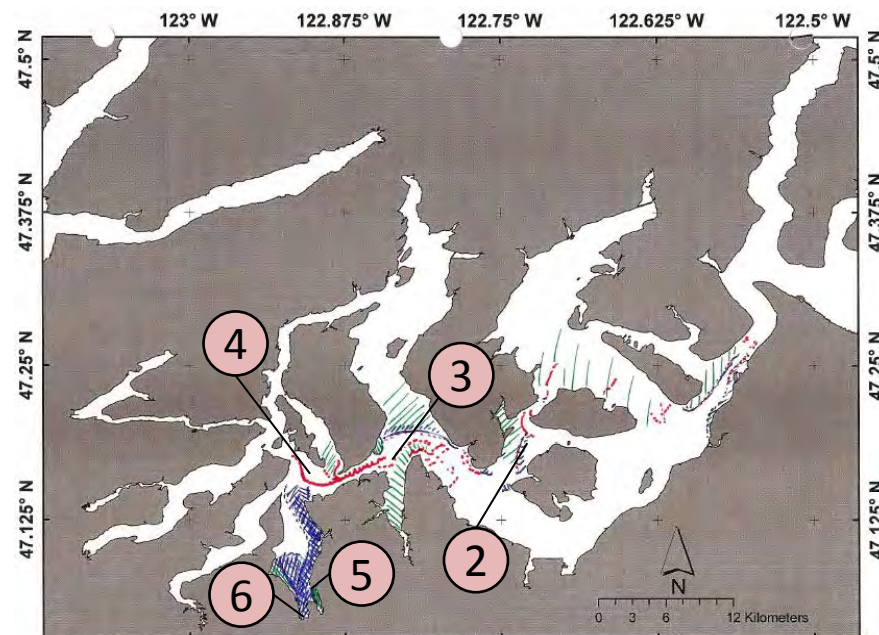
Observations in South Sound: 4-8-2012



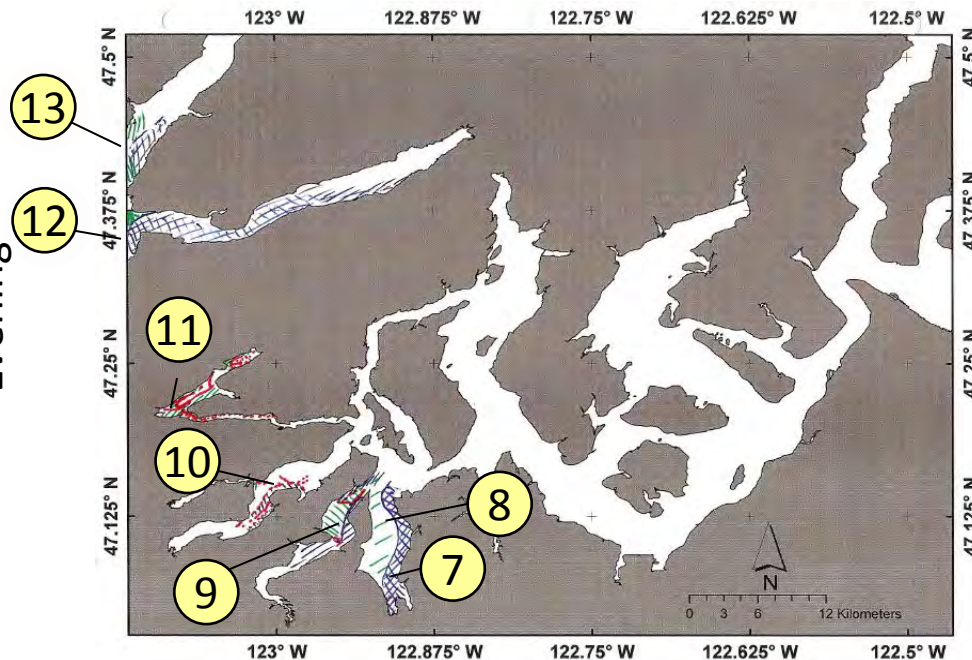
Navigate

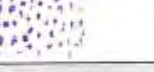




*Numbers on map refer to picture
numbers for spatial reference*

Morning (limited visibility)



Evening



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 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.

Ferry and satellite observations 4-8-2013

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Brandon Sackmann

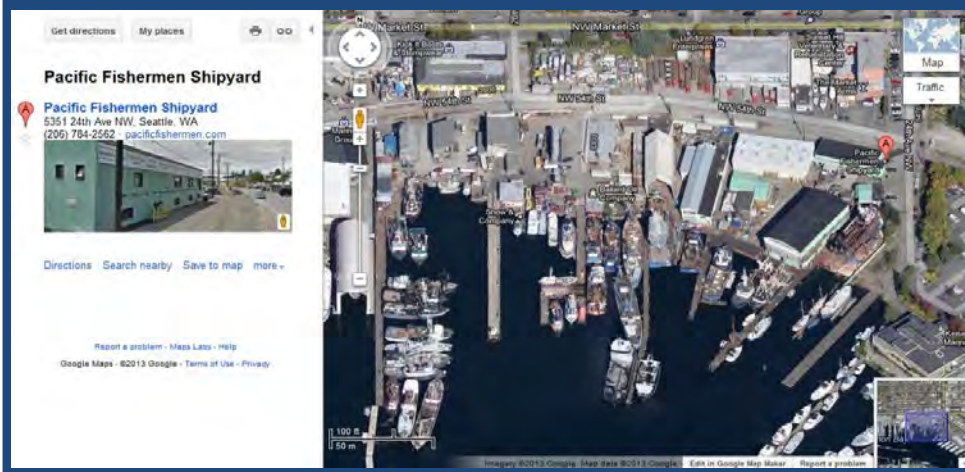
Contact:

bsackmann@integral-corp.com

Current Conditions:

Victoria Clipper IV is back in the water from its annual maintenance. New data will be made available in the next EOPS release in May.

Annual Maintenance. No Data Available.



MERIS True Color image used for spatial context (19 February 2011) of the Victoria Clipper en route monitoring route (red dashes on map).

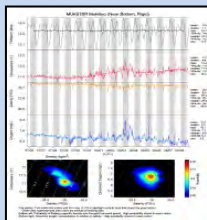


Summary: Dissolved oxygen (DO) is rising in response to seasonal processes such as primary production. Salinity is declining as freshwater levels increase in response to rain and snowmelt. Lower DO is associated with higher salinity.

Mukilteo, Whidbey Basin near Everett:

Mukilteo Dissolved Oxygen Conditions (12-16 m)

DO Max	9.8 mg/L	on 04/03	at 28.4 PSU	8.8 °C	15.6 db
DO Min	7.2 mg/L	on 03/26	at 29.4 PSU	8.4 °C	15.5 db
DO Avg	8.2 mg/L				
DO Trend	1.1 mg/L				
DO-Sal Corr	-0.77				
DO-Temp Corr	0.87				



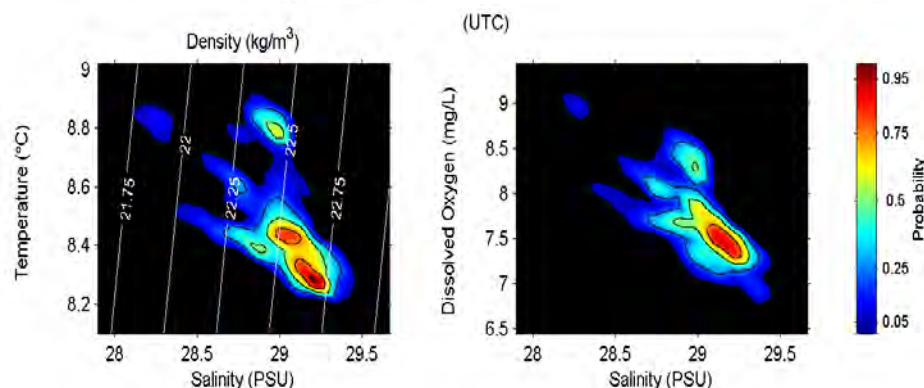
**Real-time
data online
(click)**

Mukilteo Salinity (Sal) Conditions (12-16 m)

Sal Max	29.4 PSU	on 03/28	at 8.3 °C	15.5 db
Sal Min	27.8 PSU	on 04/08	at 8.9 °C	15.1 db
Sal Avg	29 PSU			
Sal Trend	-0.2 PSU			

Mukilteo Temperature (T) Conditions (12-16 m)

T Max	9 °C	on 04/07	at 28.6 PSU	13.1 db
T Min	8.2 °C	on 03/30	at 29.4 PSU	15.2 db
T Avg	8.5 °C			
T Trend	0.4 °C			



Left Panel: Probability of finding a specific density over the past two-week period. High probability shown in warm colors.

Right Panel: Dissolved oxygen concentration in relation to salinity. High probability shown in warm colors.

Mooring observations and trends

3-26-2013 to 4-8-2013



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Moorings

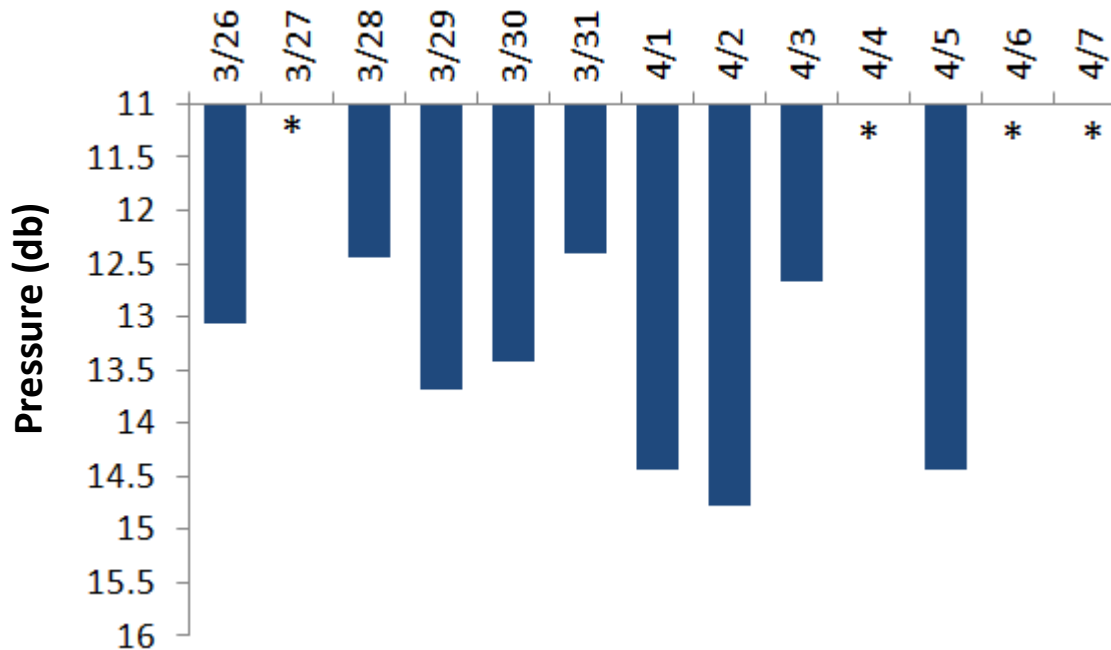
Go to our mooring website at: http://www.ecy.wa.gov/programs/eap/mar_wat/moorings.html



Summary: The strength of freshwater layer can at times be highly variable as indicated by increased depth of the 28.55 isohaline layer at the beginning of April.

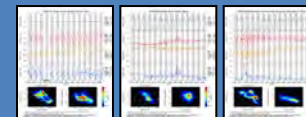
We report on thickness of the freshwater layer by monitoring our near-surface sensor. This is another way to interpret the amount of freshwater entering Puget Sound.

Daily average depth of the 28.55 isohaline at Mukilteo



* The pycnocline is shallower and outside our monitored depth range.

We track the depth of the isohaline where salinity is 28.55 (± 0.05) to measure the thickness of the freshwater layer at our Mukilteo station. The near-surface sensor experienced tidal pressure variations of 11.0 to 16.0 meters (or decibars).



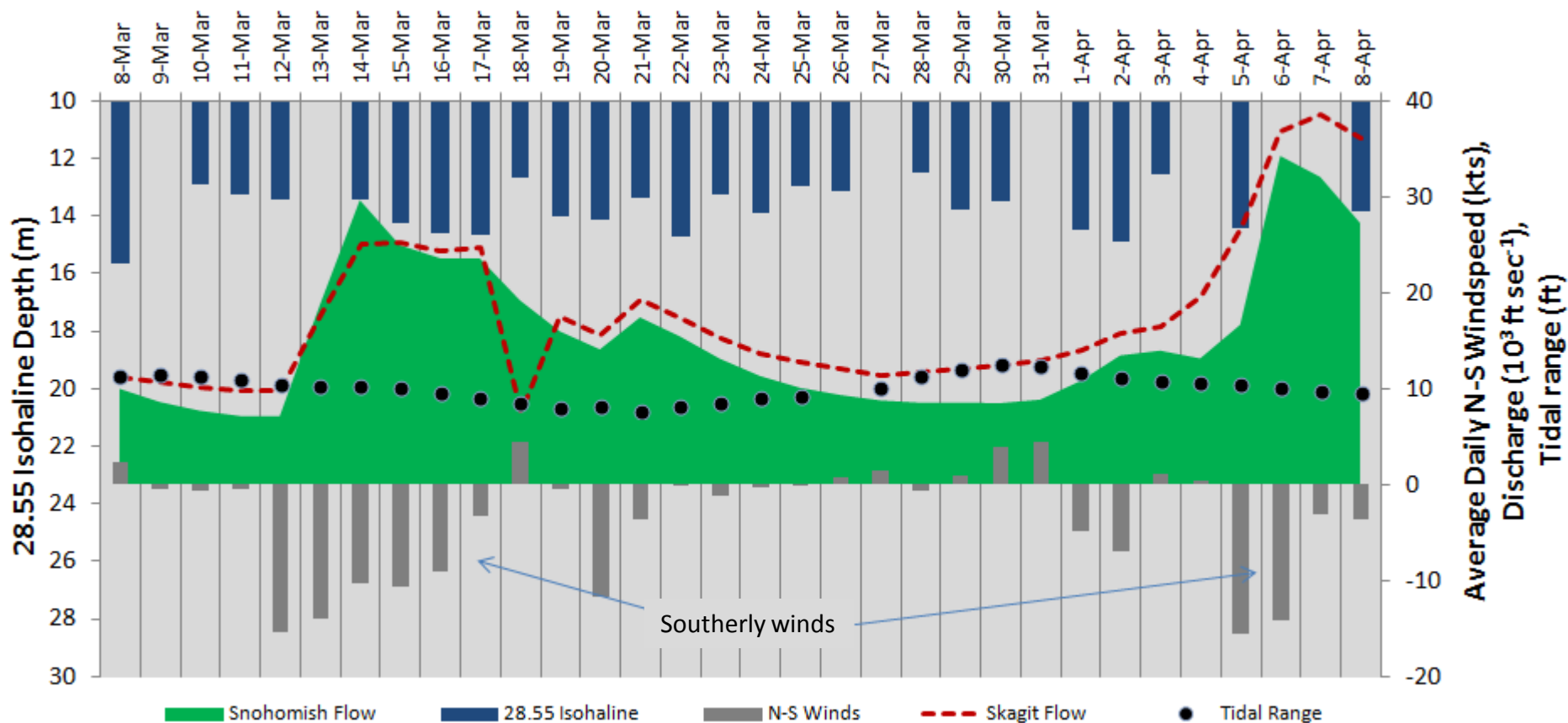
Real-time data online ([click](#))

Mooring observations and trends 3-26-2013 to 4-8-2013



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

During the first week of April, the thickness of the freshwater layer did not immediately respond to increased river flow. Factors influencing the thickness of the freshwater layer, as detected at our Mukilteo station include: mixing with tide changes and wind (speed, duration, and direction) and meandering tidal front. We attempt to capture some of these dynamics in the figure below.



Get data from Ecology's Monitoring Programs



Flight log

Weather

Water column

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Moorings

Long-Term Monitoring Network

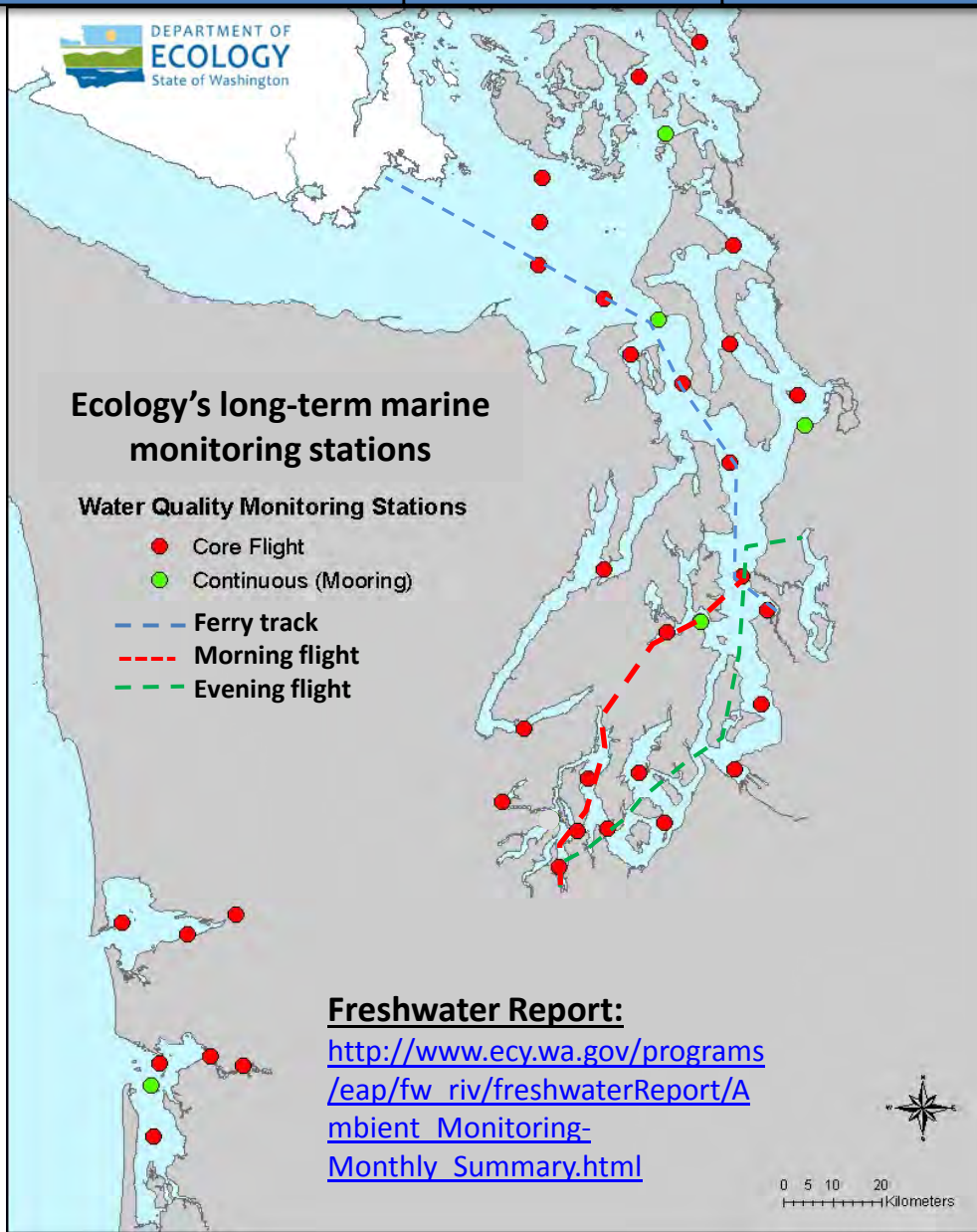


christopher.krembs@ecy.wa.gov



Access core monitoring data:

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



Real-Time Sensor Network



brandon.sackmann@ecy.wa.gov



Access mooring data:

<http://www.ecy.wa.gov/programs/eap/marine/wat/.html>

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

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



Many thanks to our business partners: Clipper Navigation, Swantown Marina, and Kenmore Air.