

Eyes Over Puget Sound

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

Surface Conditions Report, August 21, 2013

Featured Report: The Marine Waters 2012 Overview Report, ([go here](#))

[Start here](#)

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

Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings

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Skip Albertson



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Suzan Pool
David Mora*



*Dr. Christopher
Krembs*



*Dr. Brandon
Sackmann*



Personal flight log

[p. 4](#)

Yesterday's flight encapsulates all the lovely things about summer.

Weather conditions

[p.6](#)

Warm air temperatures, less sunshine in the north, and increasing river flows in the past week.

Water column and mooring

[p.7](#), [p.39](#)

After 2 years of favorable conditions with colder temperatures and higher oxygen, Puget Sound waters are turning lower in dissolved oxygen.

Aerial photography

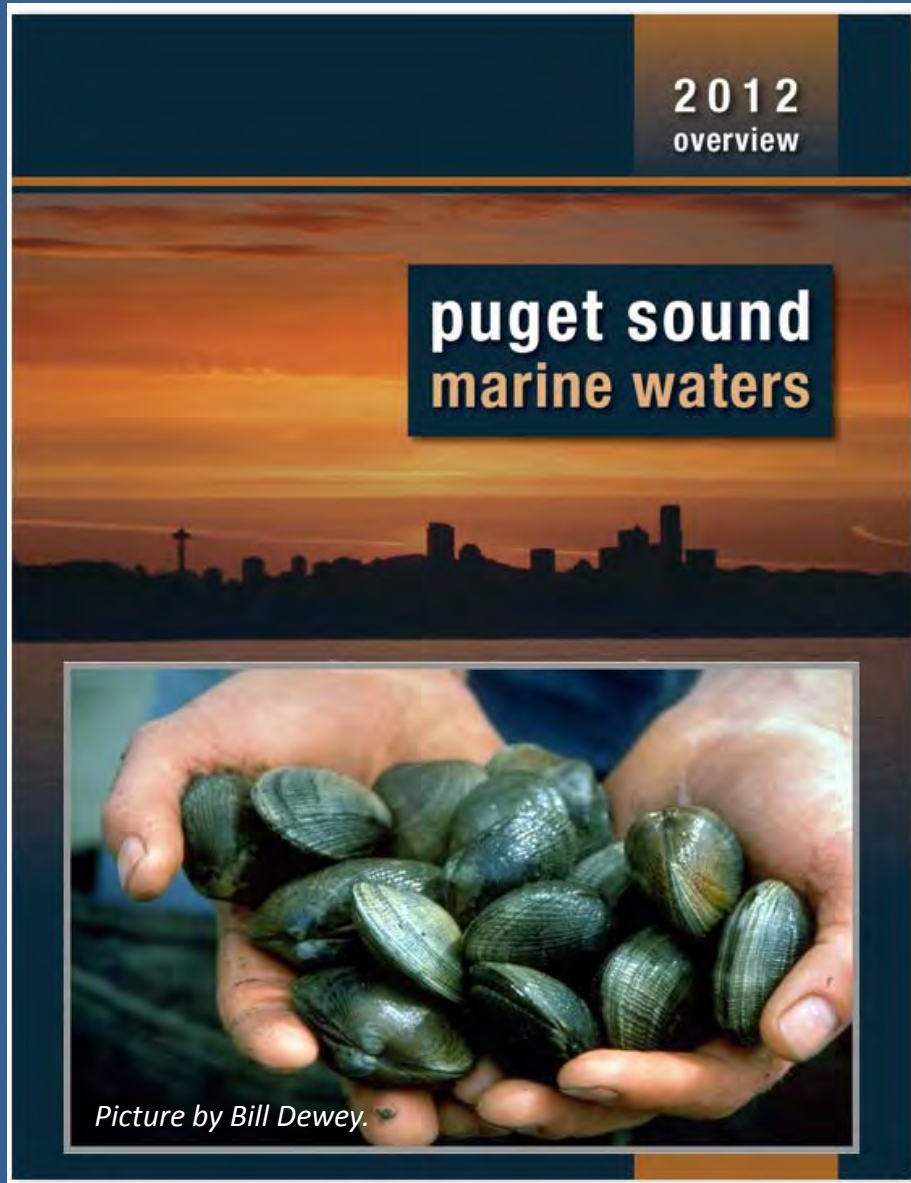
[p. 11](#)

Red-brown blooms abundant in inlets of South Sound and the Kitsap Peninsula. Large algal mats in Hood Canal, Central Sound, Sinclair Inlet, and Padilla Bay. Effects of glacier fed rivers strong.

Ferry and satellite

[p. 36](#)

Near-surface temperatures warm in South Sound. Low-tide imagery provides rare glimpse of beautiful braided channels criss-crossing Whidbey Basin river deltas!



The Puget Sound Marine Waters: 2012 Overview

informs on the marine water conditions and associated biota in Puget Sound. It compiles the physical, chemical, and biological information obtained from diverse marine monitoring and observing programs.

- The report represents a collaboration among agencies and scientists forming a collective view of marine water conditions to enhance the ecological understanding of Puget Sound as an economic lifeline for Western Washington.
- Highlights include intense blooms of Noctiluca and unprecedented shellfish harvesting closures in Hood Canal due to contamination with biotoxins from harmful algae.

http://www.psp.wa.gov/downloads/psemp/PSmarinewaters_2012_overview.pdf



Flight log	Weather	Water column	Aerial photos	Ferry and Satellite	Moorings
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North Sound Flight



Mya and
Christopher

Yesterday's flight seemed to encapsulate all the lovely things about this summer. I was having a lovefest with the northwest. Flying on a beautiful summer day will do that. Allow me to capture this moment so in a few months when we are bemoaning the short days and grey skies I can revisit my ode to these memorable summer days...

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

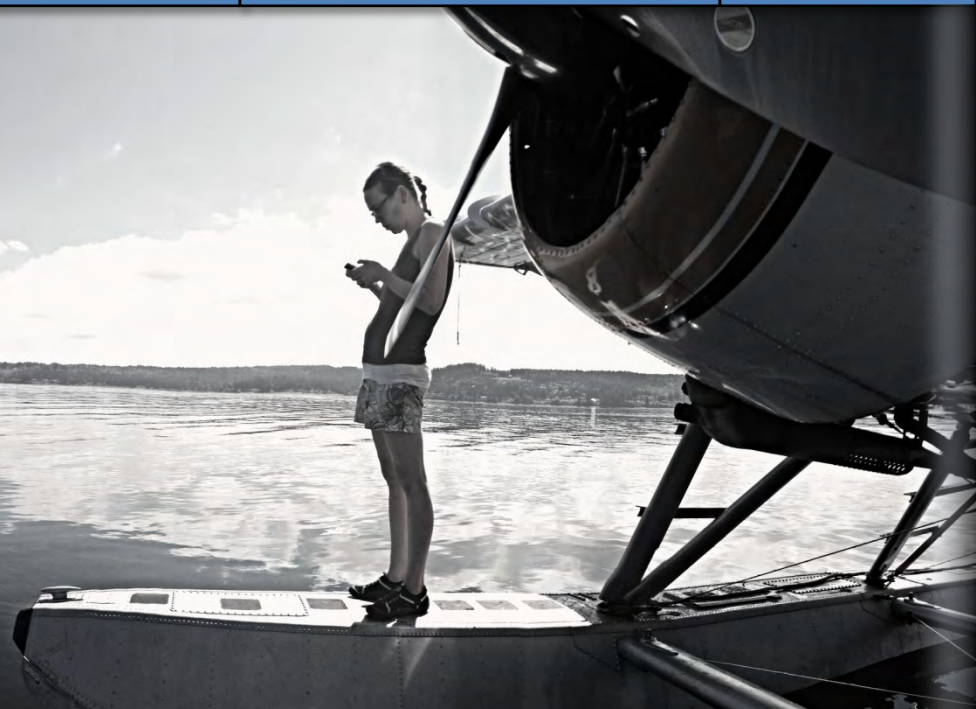
Summer we love thee,

Blue skies and cool water and salt air abound.

The people on ships come wave and shake us,
the kids looking up with faces of glee.

**When iced tea and lab work blend and befriend us
and ideas are born from the wind and the sea.**

**Please join us and take a minute to wonder
at the Puget Sound summer of 2013!**



Plane parked ashore

Boaters everywhere!



Thatcher Pass



When water meets water





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

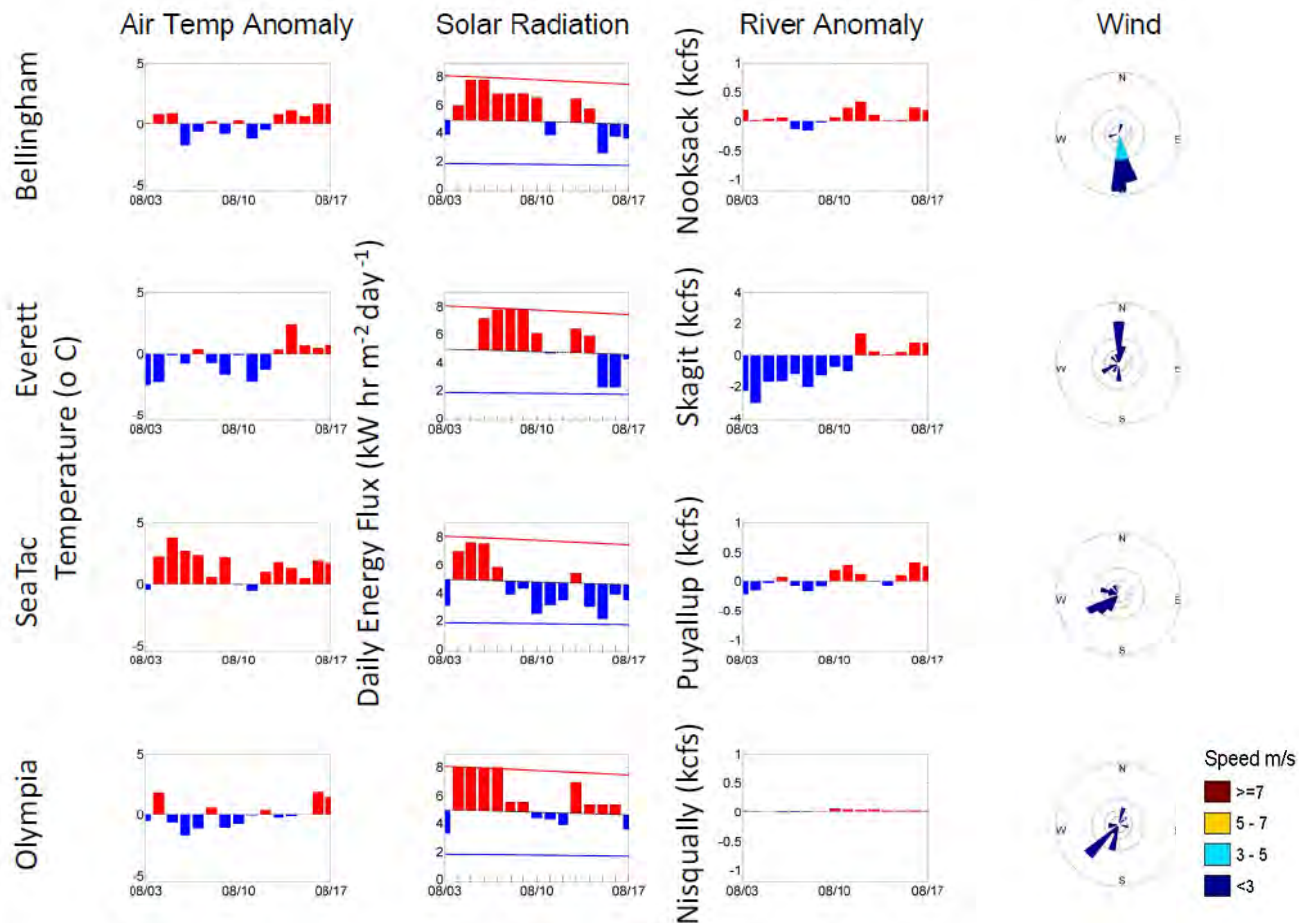
Summary:

Air temperatures. Daily average air temperatures have increased to above-normal levels for the past several days.

Sunshine levels have been higher than normal in early August but lower for the past several days except in South Puget Sound.

River flows transitioned from below to slightly above normal levels.

Winds have been weak and variable throughout the region.





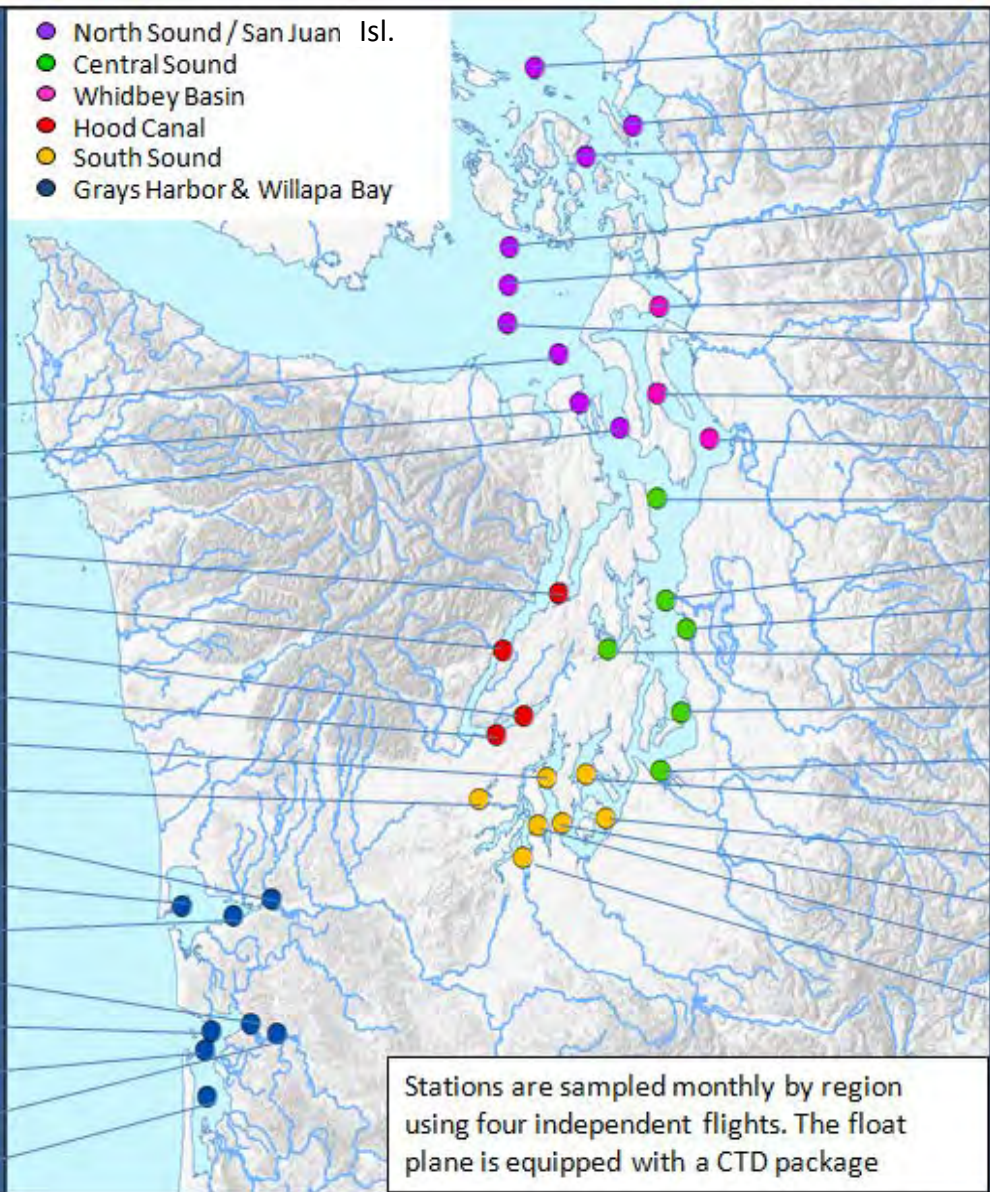
Our long-term marine monitoring stations in Washington



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

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

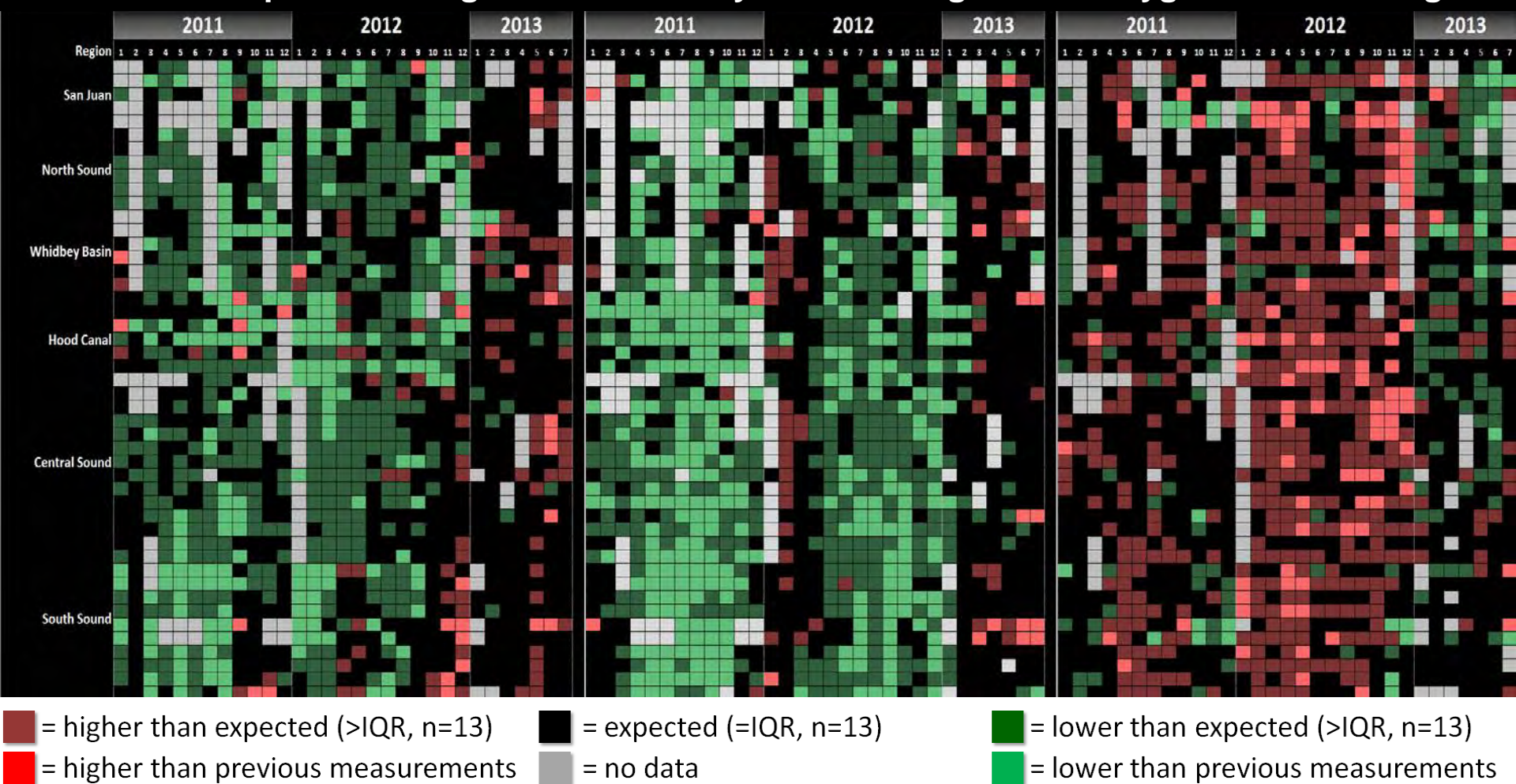
Ferry and Satellite

Moorings

In 2013: Temp. is warming

Salinity is increasing?

Oxygen is decreasing!!!



Puget Sound water conditions are changing again! Compared to 2011-2012, when waters were colder and fresher with higher oxygen, values are beginning to show signs of warmer temperatures and decreasing oxygen. Each pixel is a monthly survey at a single station.

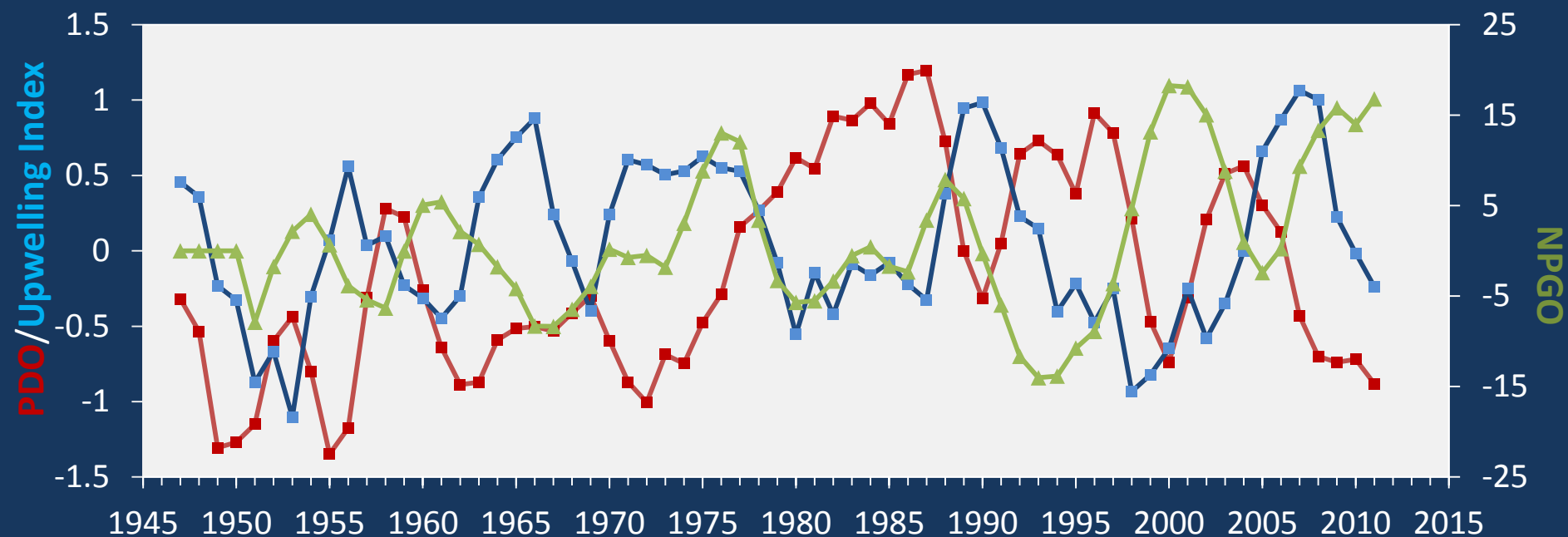


The ocean affects water quality: Ocean Climate Indices

Flight log Weather Water column Aerial photos Ferry and Satellite Moorings

- a) Pacific Decadal Oscillation Index (**PDO**) [...\(explanation\)](#)
- b) Upwelling Index (*anomalies*) (**Upwelling**) [...\(explanation\)](#)
- c) North Pacific Gyre Oscillation Index (**NPGO**) [...\(explanation\)](#)

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 algal biomass patterns in Puget Sound

Algae bloom, Budd Inlet 2010



Nitrate



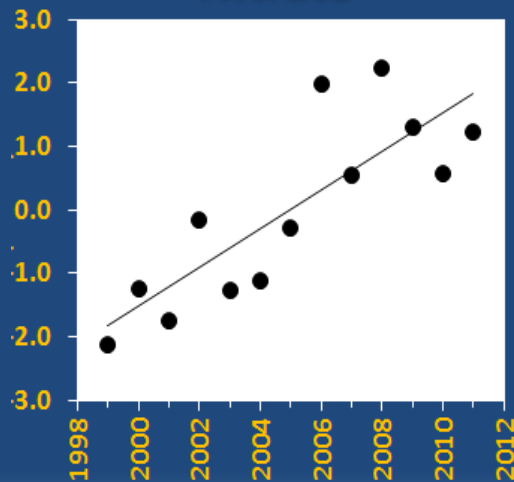
Phosphate



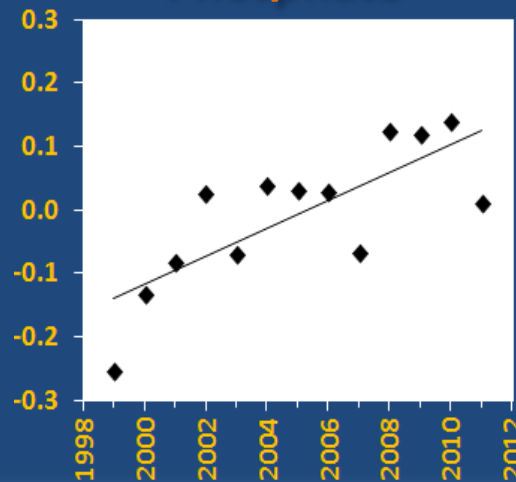
**Changing
Nutrient Balance**

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

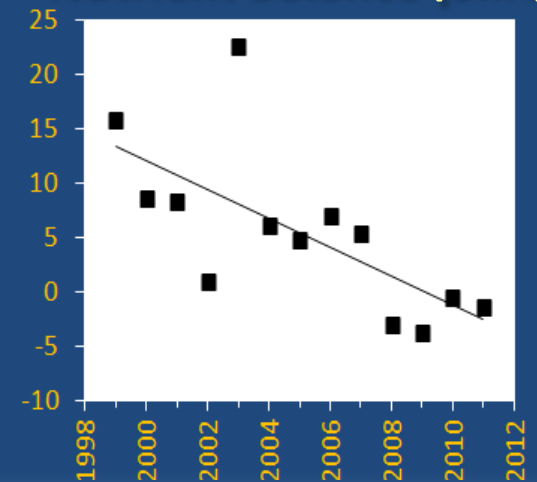
Nitrate



Phosphate



Nutrient Balance (Si:N)



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



Red-brown blooms abundant in all inlets of South Sound and the Kitsap Peninsula. Large algal mats and floating organic material persists in Hood Canal, Central Sound, Sinclair Inlet and Padilla Bay. Jellyfish less abundant. Effects of glacier fed rivers are strong.

[Start here](#)

Small red-brown bloom, Bainbridge



Small red-brown bloom, Sinclair Inlet



Front

Mixing and Fronts:

Pronounced fronts due to suspended sediment in Skagit Bay, and the San Juan Islands, and into the Straits. Tidal eddies large. [2](#) [6](#) [7](#) [8](#) [9](#) [10](#) [11](#) [13](#) [14](#) [17](#) [18](#)



Jellyfish: Low numbers in Budd Inlet.

Plume

Suspended sediment:

Glacier fed rivers and re-suspension due to strong tides.

[2](#) [6](#) [7](#) [8](#) [9](#) [10](#) [11](#) [12](#) [13](#) [14](#) [15](#) [16](#) [17](#)

Bloom

Visible blooms:

Red brown: All inlets of South Sound and Kitsap Peninsula.

Green yellow: Scow Bay (Kilisut Harbor) and Echo Bay.

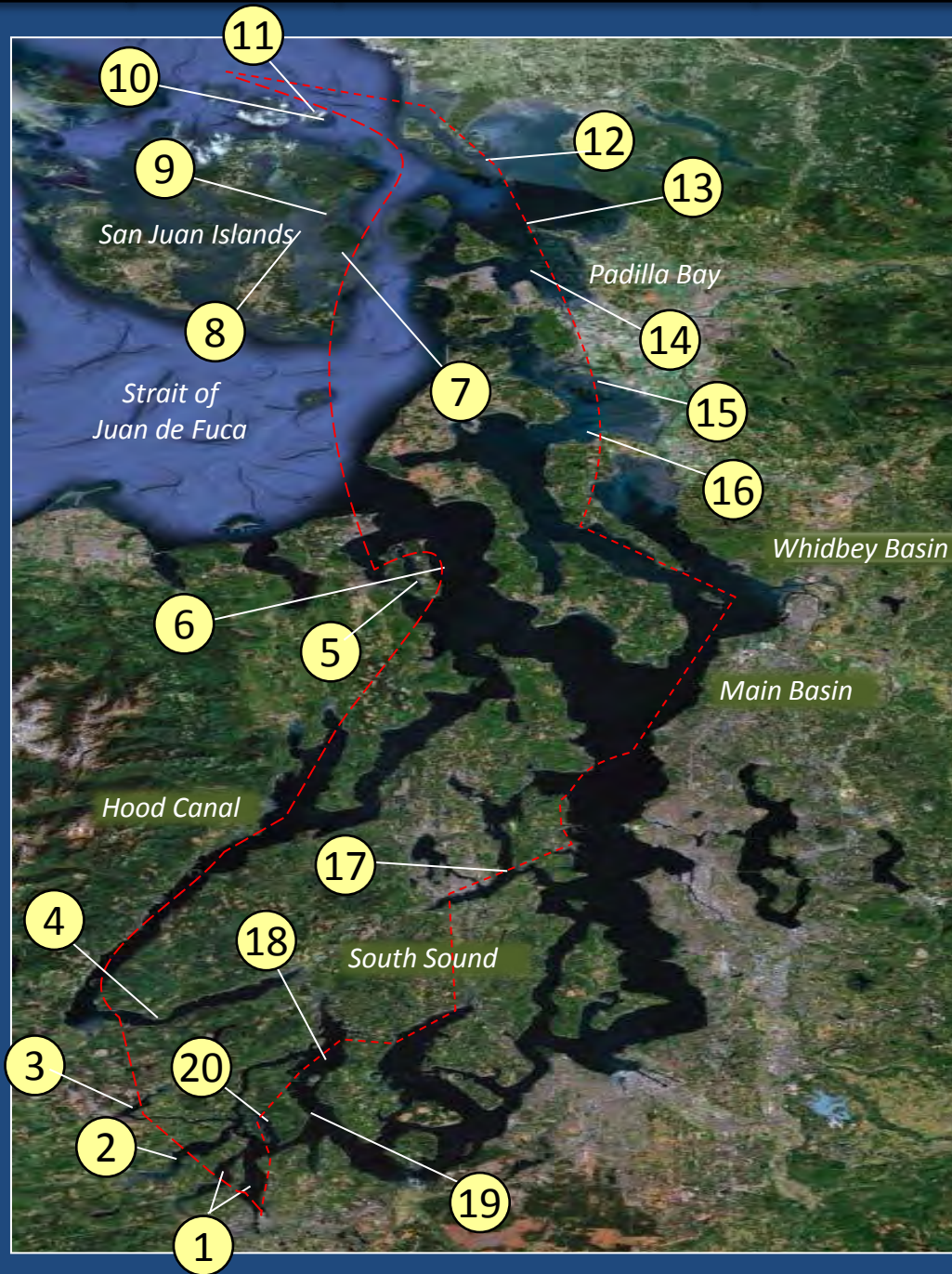
[1](#) [2](#) [3](#) [11](#) [15](#) [18](#) [19](#) [20](#)

Debris

Debris:

Abundant in Oakland Bay and Case, Budd, Eld, Totten inlets
Abundant in northern Central Basin. Abundant in Padilla Bay.

[1](#) [2](#) [3](#) [4](#) [6](#) [10](#) [12](#) [13](#) [14](#) [16](#) [17](#) [18](#) [19](#)



Seattle: H. tide: 5:02 AM, 6:18 PM, L. tide: 11:34 AM

Aerial photography navigation guide, 8-21-2013



Click on numbers

Flight Information:

Morning flight, photos 1-9:

Good visibility, calm

Afternoon flight, photos 10-20:

Good visibility, wind increasing from the north.

Observation Maps:

Central Sound & North Sound

Hood Canal & South Sound



Flight log

Weather

Water column

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Ferry and Satellite

Moorings



Red-brown bloom and organic debris in southern inlets.

Location: A-B. Budd Inlet, C-D. Totten Inlet (South Sound) 9:12 AM.

Flight log

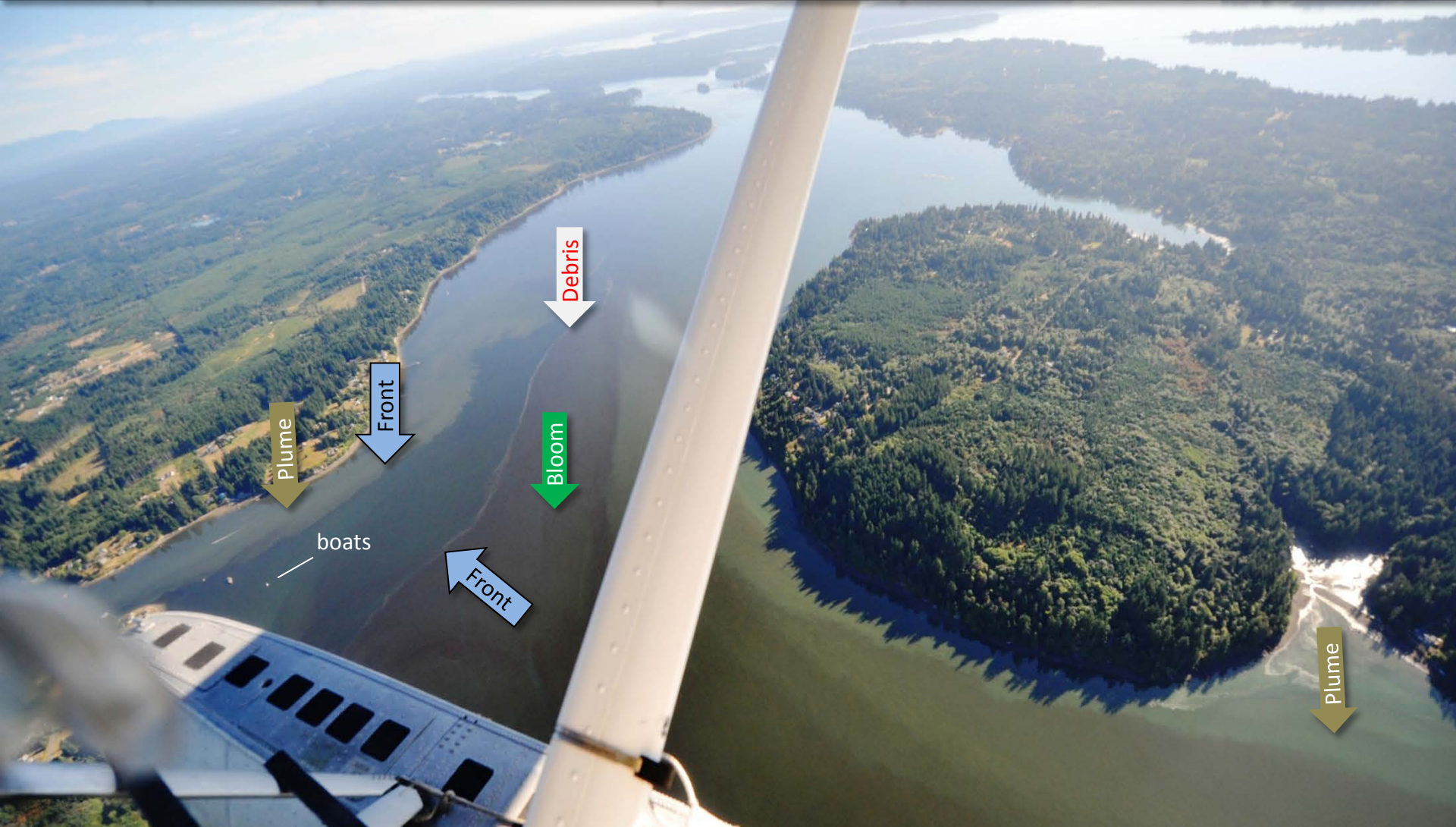
Weather

Water column

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Moorings



Different surface water with red-brown bloom, high sediment load, and clearly delineated by a long line of organic debris. Location: Eld Inlet (South Sound), 9:14 AM.



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Sediment rich water, red-brown bloom, and lines of organic surface debris.
Location: Oakland Bay (South Sound), 9:18 AM.



Flight log

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Moorings



Large drifting mats of organic material at surface.
Location: Near Tahuya River (Hood Canal), 9:26 AM.

Flight log

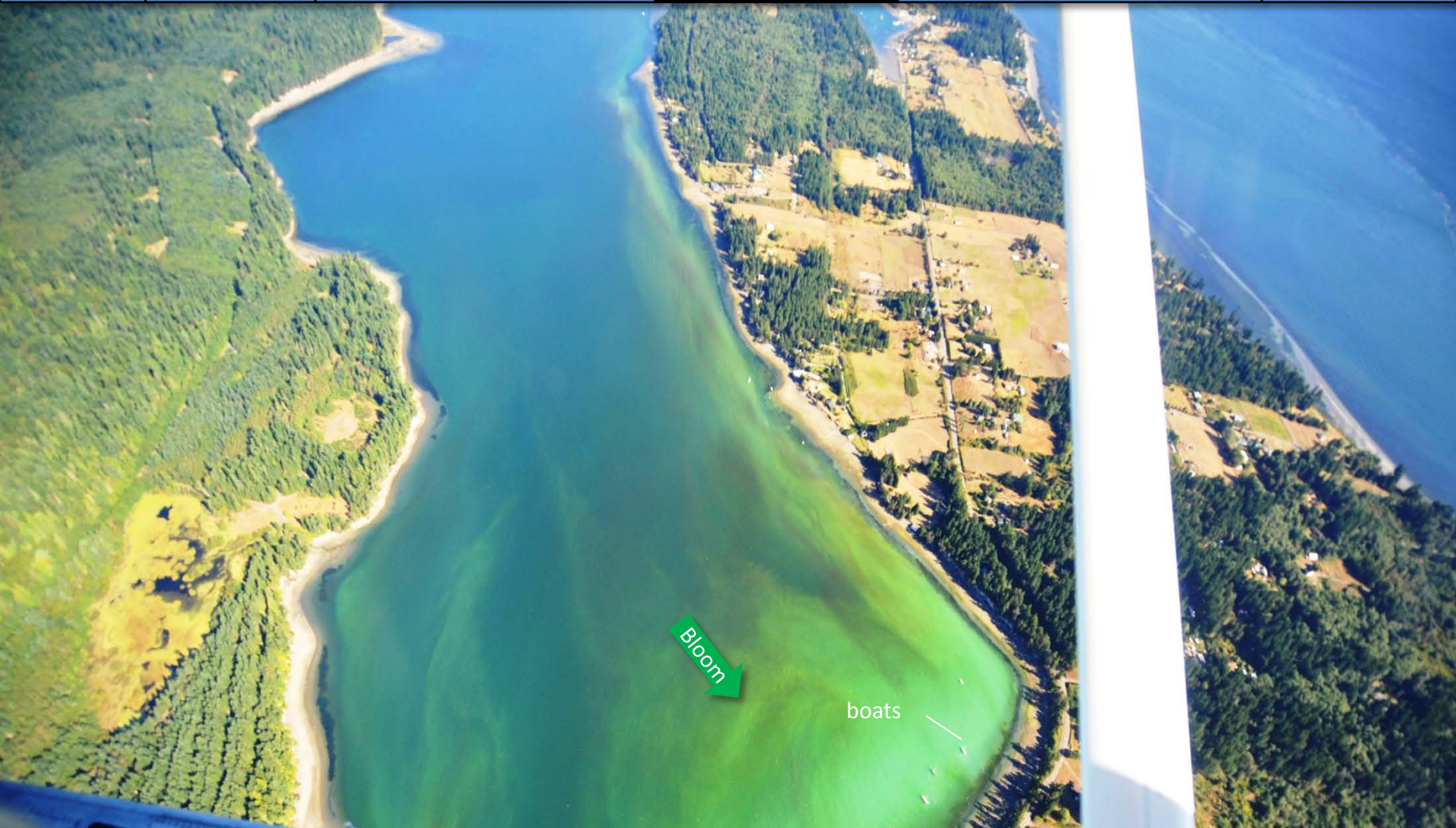
Weather

Water column

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Moorings



Intense green yellow and red-brown phytoplankton bloom.

Location: Scow Bay in Kilisut Harbor (Indian Island near Port Townsend), 10:00 AM.

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Surface debris (algal mats) and strong front with distinctly different water.
Location: Off Marrowstone Island (Central Sound), 10:02 AM.



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Fraser River sediment traversing and mixing dramatically with water in the San Juan Islands.
Location: Blakely Island (San Juan Islands), 11:45 AM.

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Fraser River sediment traversing and mixing dramatically with water in the San Juan Islands.
Location: Near Lopez Sound (San Juan Islands), 11:48 AM.



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Fraser River sediment traversing and mixing dramatically with water in the San Juan Islands.
Location: Near Obstruction Island (San Juan Islands), 11:49 AM.



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Moorings



Subsurface Fraser River plume re-surfacing in response to tidal currents.

Location: Echo Bay, Sucia Island (San Juan Islands), 12:24 PM.



Flight log

Weather

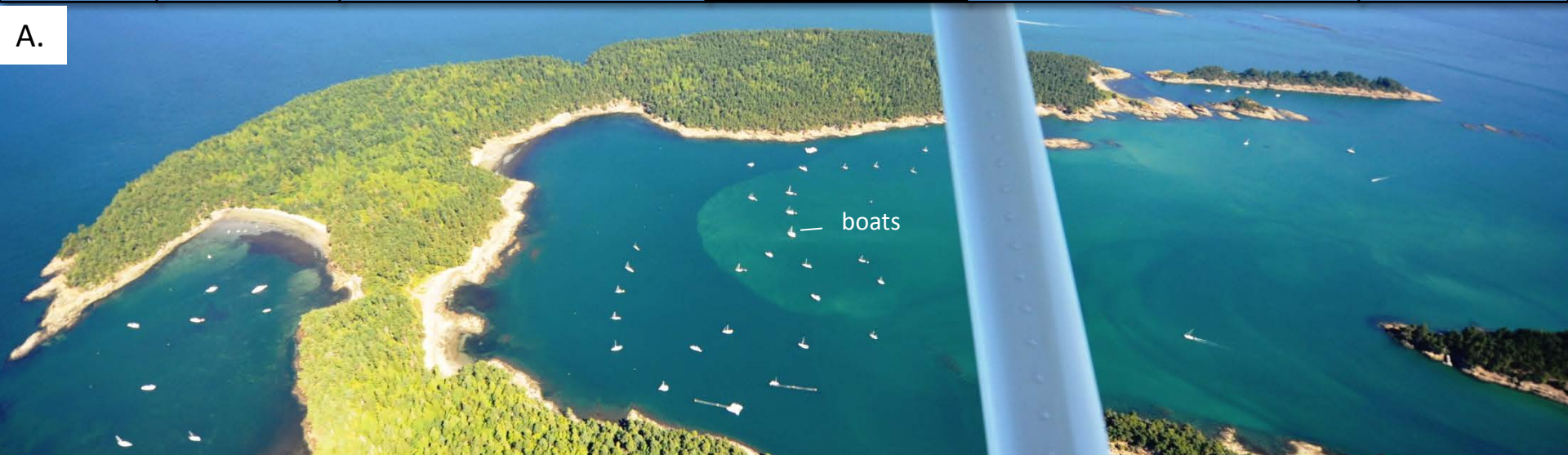
Water column

Aerial photos

Ferry and Satellite

Moorings

A.



B.



A. Sub-surface Fraser River plume entering Echo Bay. B. Yellow-green bloom in Fossil Bay.
Location: Echo Bay, Sucia Island (San Juan Islands), 12:24 PM.

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Interplay of water, sediment, and waves form striking surface patterns.

Location: East of Lummi Island (Bellingham Bay), 1:29 PM.



Flight log

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Mooring



Interplay of water, sediment, and waves form striking surface patterns.

Location: Samish Island (Samish Bay), 1:58 PM.



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



Large algal mats and organic debris.

Location: Near Saddlebag Island (Padilla Bay), 2:00 PM.

Flight log

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Moorings



Green phytoplankton bloom forms a fringe along a sediment plume in shallow water.
Location: Skagit River estuary (Skagit Bay), 2:07 PM.

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Red brown phytoplankton bloom mixed in with Skagit River sediment.

Location: North of Camano Island (Skagit Bay), 2:54 PM.



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Large tidal eddy with sediment rich water and surface debris.
Location: Southern Bainbridge Island (Sinclair Inlet), 5:10 PM.



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Red-brown algae bloom, sediment stained water, and surface debris.

Location: Case Inlet (South Sound), 5:24 PM.



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Red-brown algae bloom and abundant surface debris.

Location: McMicken Island (Case Inlet), 5:24 PM.

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Red-brown bloom between Harstine Island and Squaxin Island

Location: Squaxin Island (South Sound), 5:28 PM.

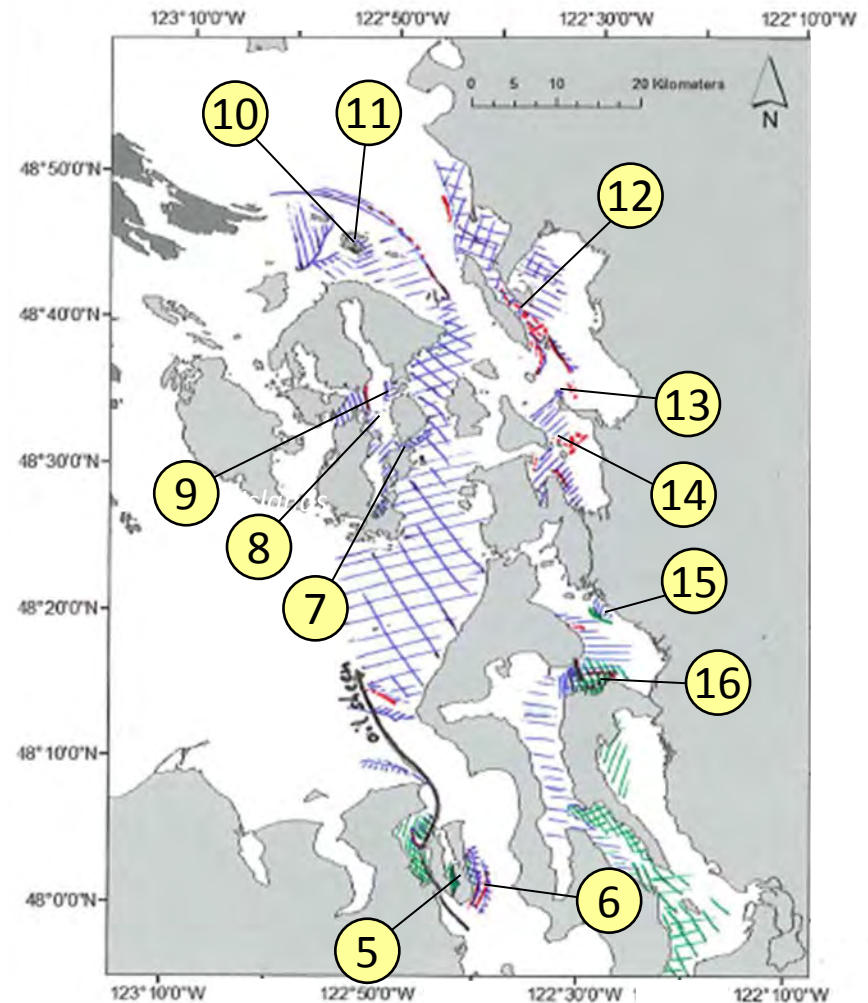
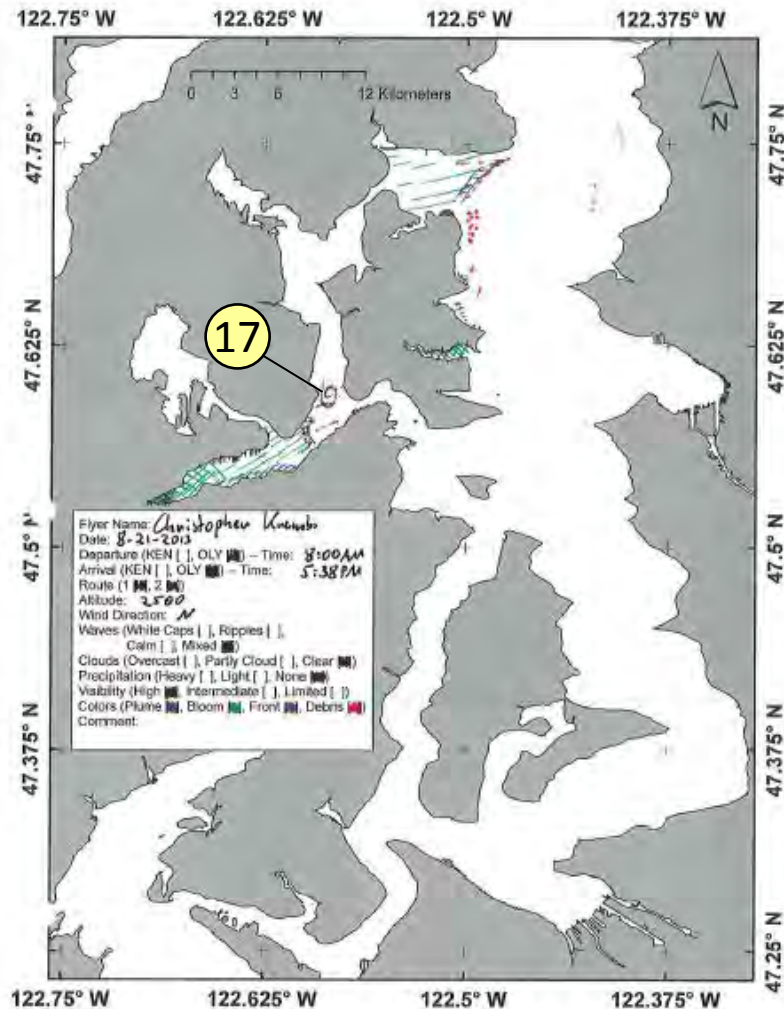
Aerial photography observations in Central Sound

[Navigate](#)

Date: 8-21-2013

Central Sound

North Sound/San Juans



Numbers on map refer to picture numbers for spatial reference

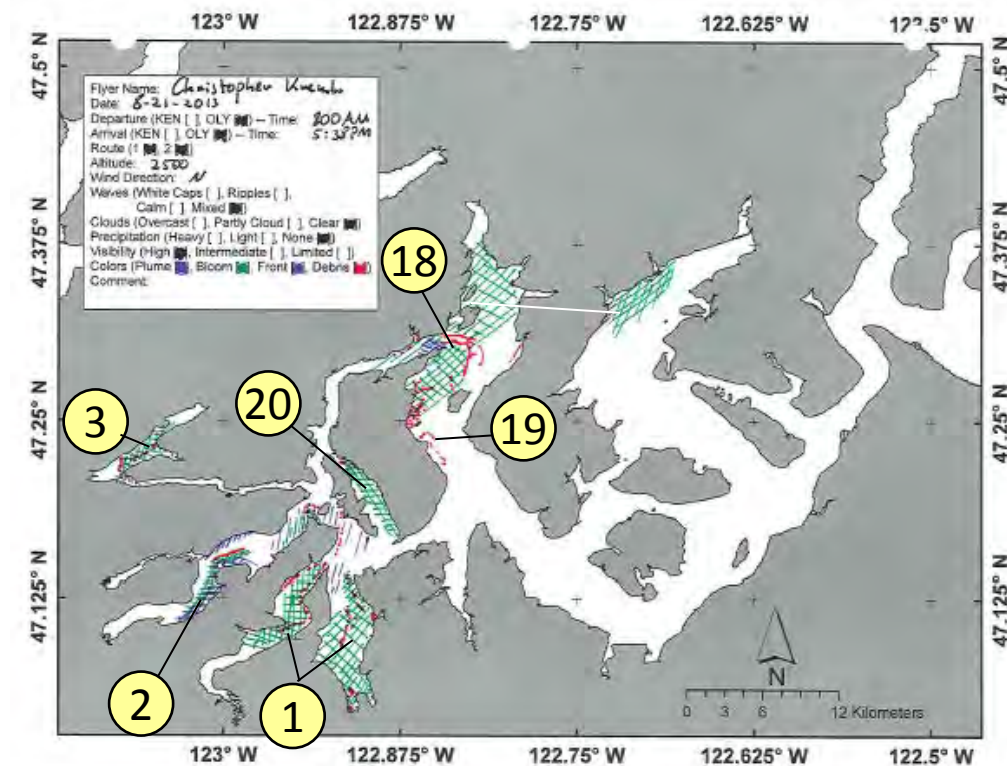
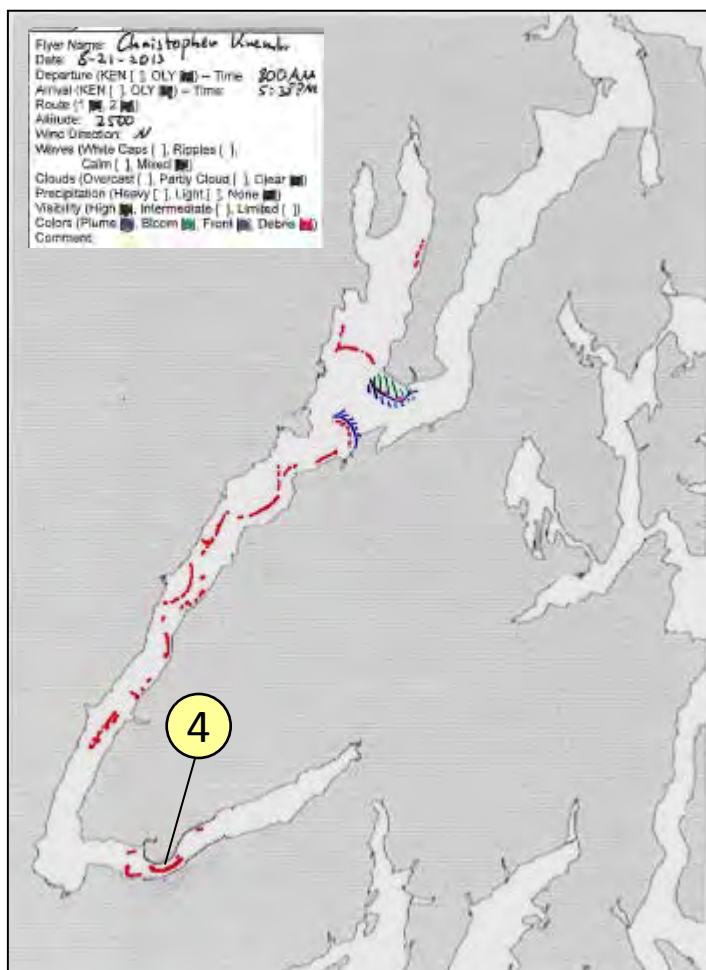
Aerial photography observations in Central Sound








[Navigate](#)

Hood Canal

Date: 8-21-2013

South Sound



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.

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Brandon Sackmann

Contact:

bsackmann@ecy.wa.gov

[Start here](#)



No Victoria Clipper data available –
Hardware upgrades in progress!!!

Current Conditions:

LANDSAT 8 continues to provide valuable near-surface temperature estimates for Puget Sound. Low-tide imagery provides rare glimpse of beautiful braided channels criss-crossing Whidbey Basin river deltas!

Flight log

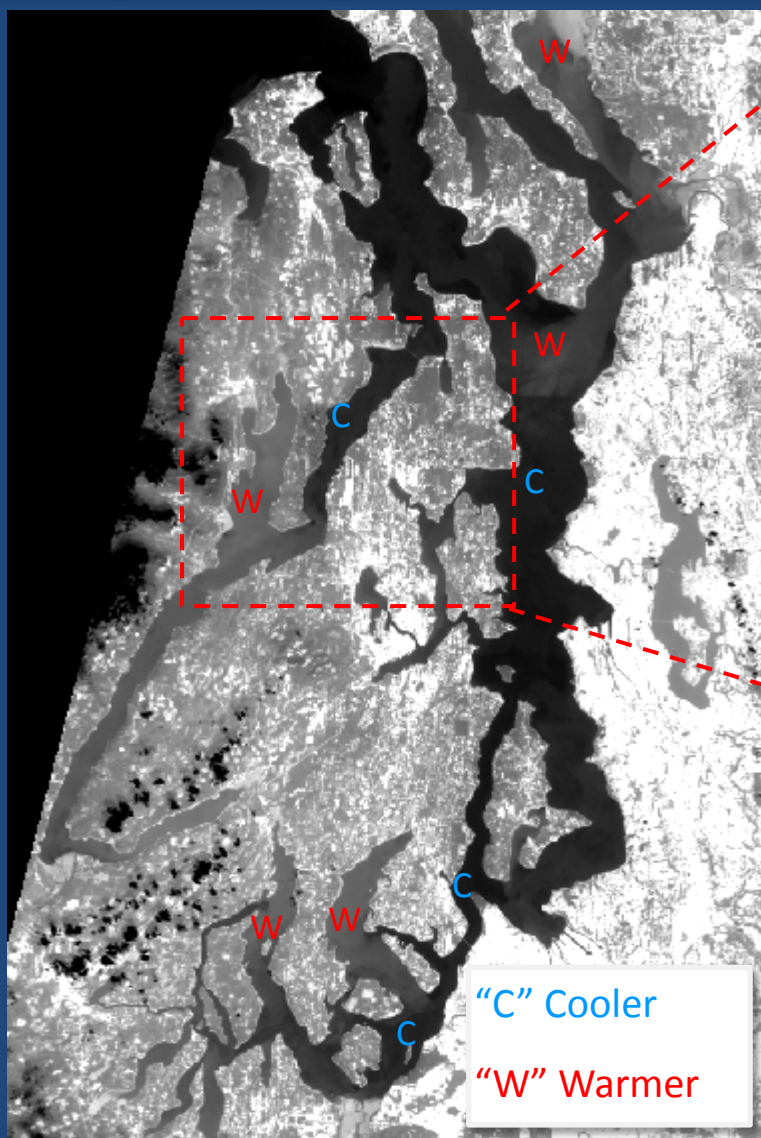
Weather

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100-m Thermal Infrared



Landsat 8 helps visualize dynamic mixing processes in Puget Sound

21 August 2013

Northern arms of Case and Carr Inlet and central/southern Hood Canal are noticeably warmer than other areas in Puget Sound. Local rivers continue to add relatively warm water at the surface.

Flight log

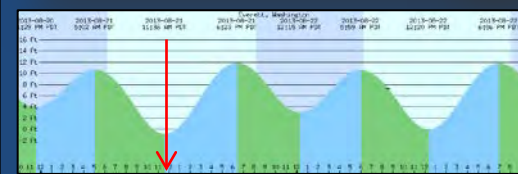
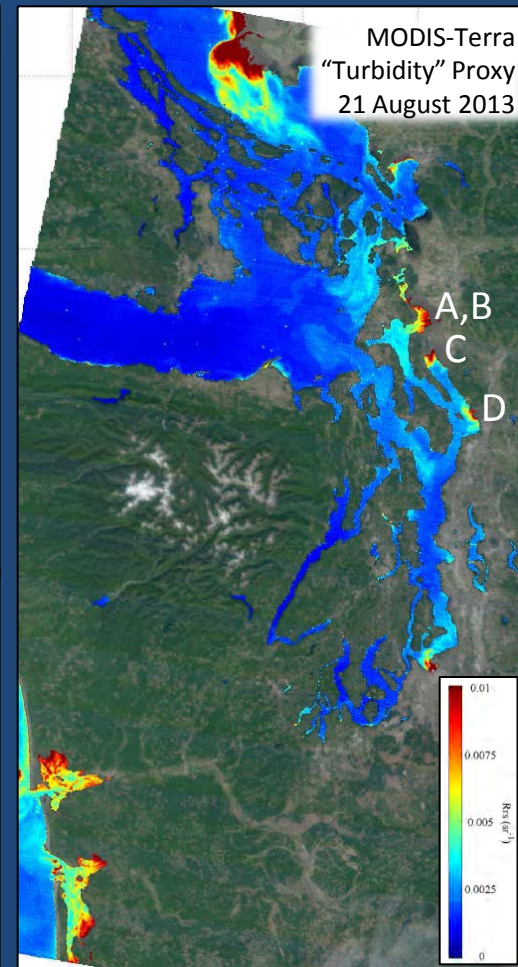
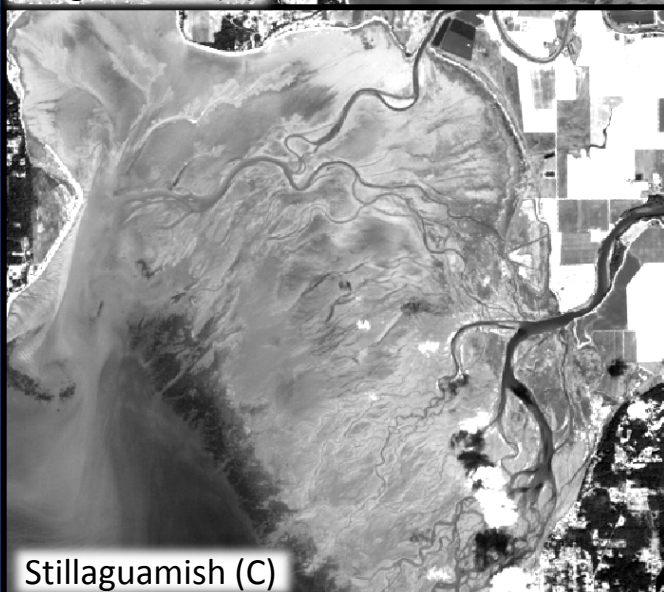
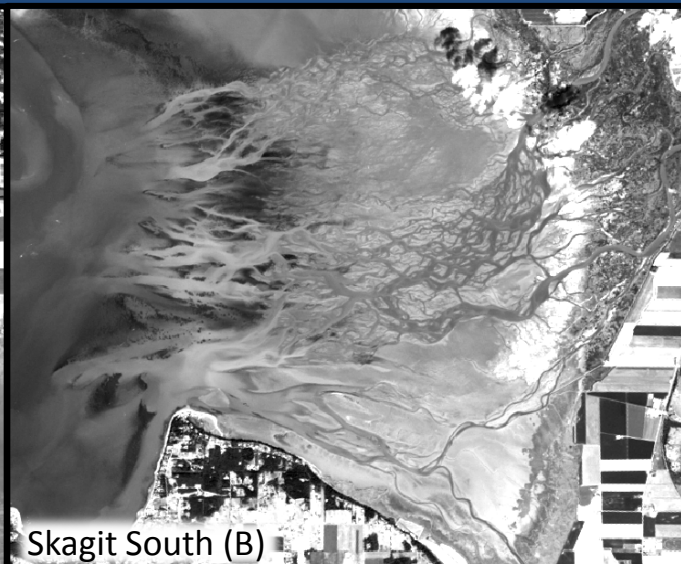
Weather

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21 August 2013 - LANDSAT 8 - 15-m Panchromatic

Tides 8-21-2013

Mooring observations and trends

8-7-2013 to 8-21-2013



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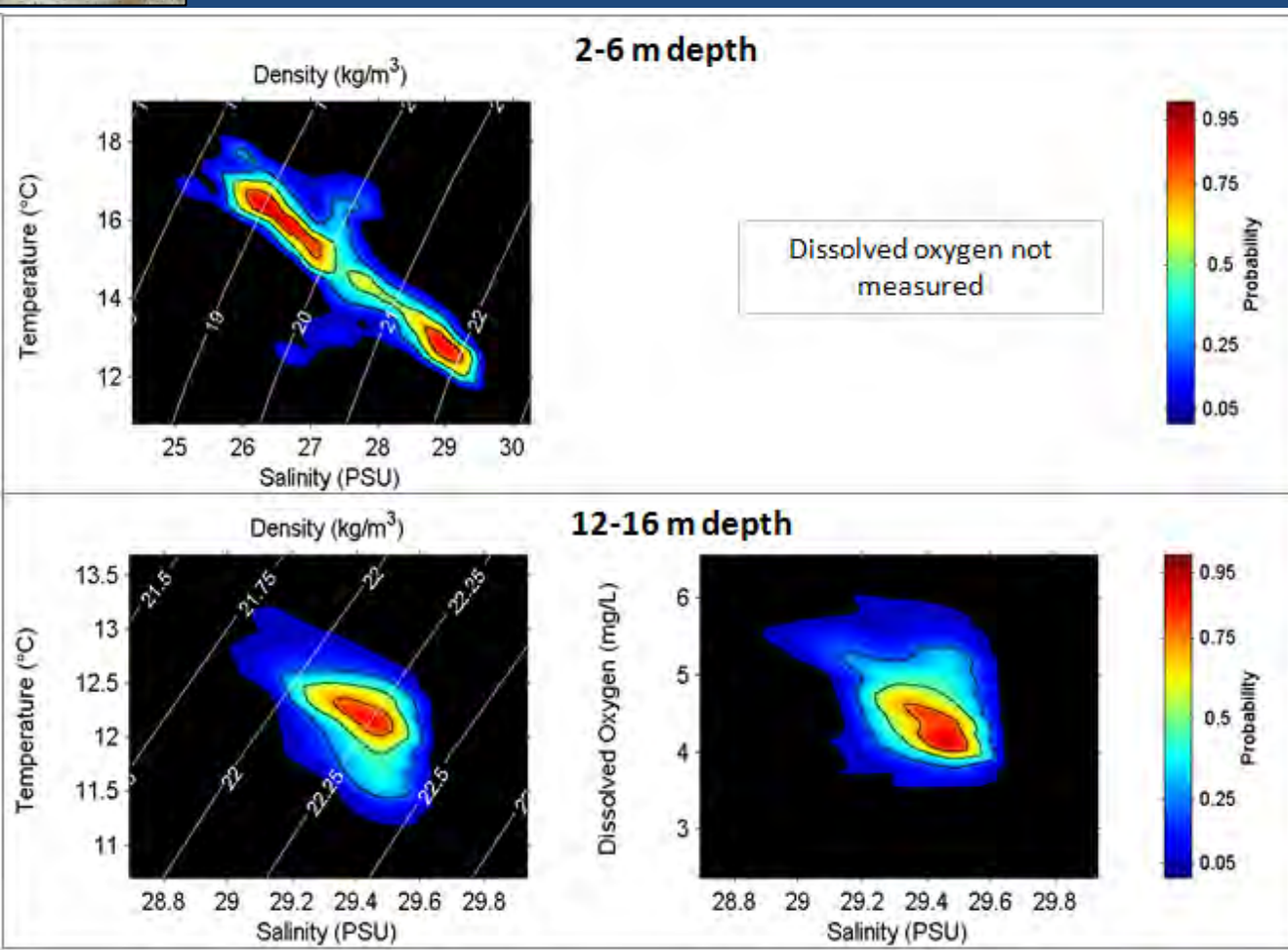
Ferry and Satellite

Moorings



Note: The mooring contribution to EOPS will be significantly downscaled due to budget cuts.

At our Mukilteo moorings, we observed differences in salinity between the surface (26 and 29 PSU) and bottom (29.4 PSU) waters. In the deeper water, dissolved oxygen is lower while salinity is higher.



Left Panels: Density is defined by salinity and temperature. Probability of finding a specific density over the past two-week period can be shown in a T-S plot. 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

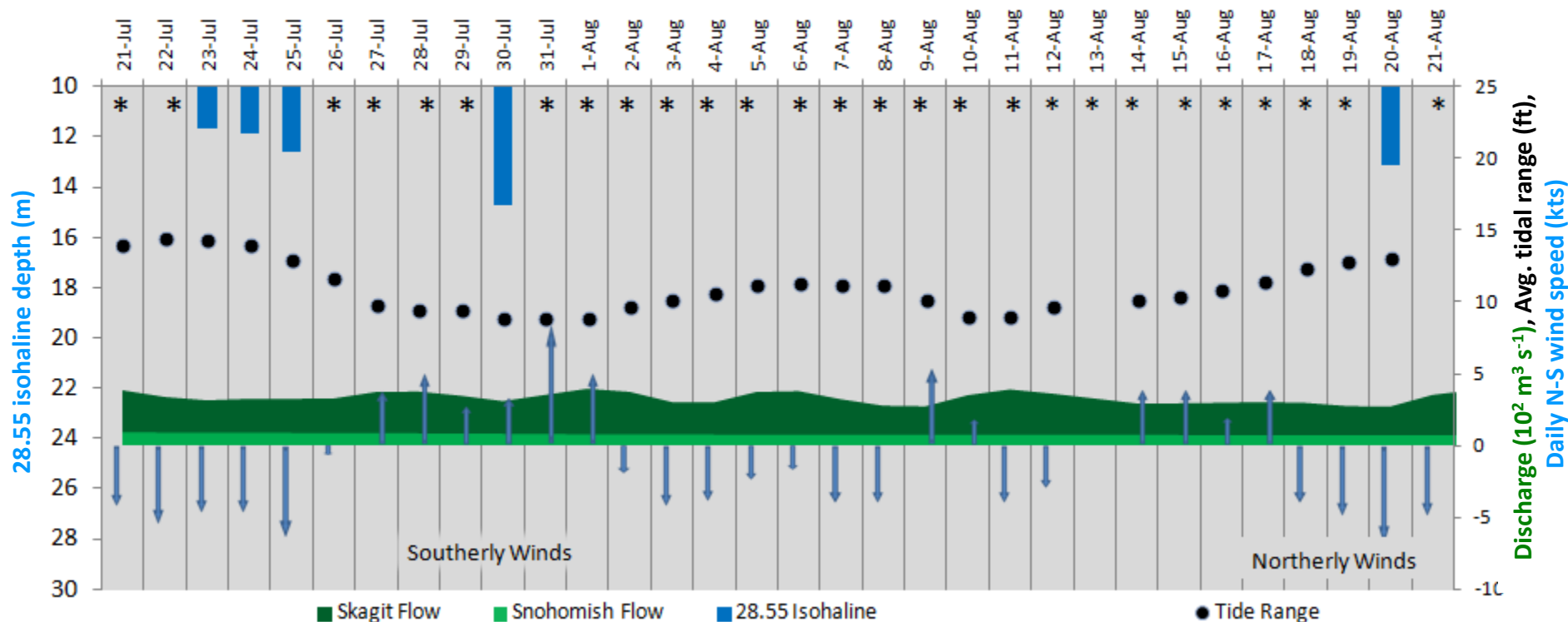
7-21-2013 to 8-21-2013



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

We report on thickness of the fresher surface water layer by monitoring our sensor at 16m. We define its thickness using 28.55 (± 0.05) PSU. At Mukilteo (Whidbey Basin), winds, tidal cycle, and declining river flows influenced the surface water layer thickness, which was rarely detected over the past two weeks. Freshwater input from rivers continues to decline with the Skagit River contributing the largest portion.

Thickness of freshwater layer at Mukilteo and influencing factors



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

River data from



Mooring observations and trends

8-7-2013 to 8-21-2013



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

Note: The mooring contribution to EOPS will be significantly downscaled due to budget cuts.
During the past two weeks, salinity has been increasing and dissolved oxygen decreasing.

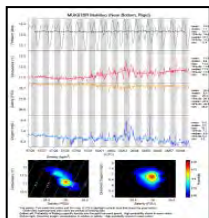
2-6 m depth

Mukilteo Salinity (Sal)

Sal Max	29.9 PSU	on 08/08	at 12 °C	5.8 db
Sal Min	24.7 PSU	on 08/07	at 17.4 °C	4.3 db
Sal Avg	27.3 PSU			
Sal Trend	0.3 PSU			

Mukilteo Temperature (T)

T Max	18.1 °C	on 08/14	at 26 PSU	2.9 db
T Min	11.7 °C	on 08/08	at 29.3 PSU	5.9 db
T Avg	15 °C			
T Trend	-0.3 °C			



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

12-16 m depth

Mukilteo Dissolved Oxygen Conditions

DO Max	6.6 mg/L	on 08/07	at 29.4 PSU	11.3 °C	14.7 db
DO Min	3.9 mg/L	on 08/14	at 29.5 PSU	12 °C	13.4 db
DO Avg	4.8				
DO Trend	-0.6 mg/L				
DO-Sal Corr	-0.68				
DO-Temp Corr	0.3				

Mukilteo Salinity (Sal) Conditions

Sal Max	29.5 PSU	on 08/10	at 11.3 °C	15.7 db
Sal Min	28.8 PSU	on 08/11	at 13 °C	15 db
Sal Avg	29.3 PSU			
Sal Trend	0 PSU			

Mukilteo Temperature (T) Conditions

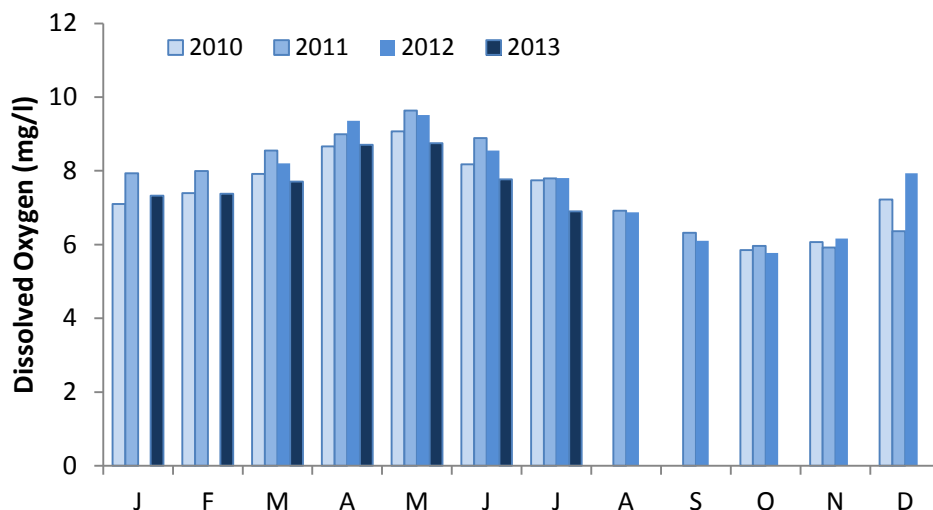
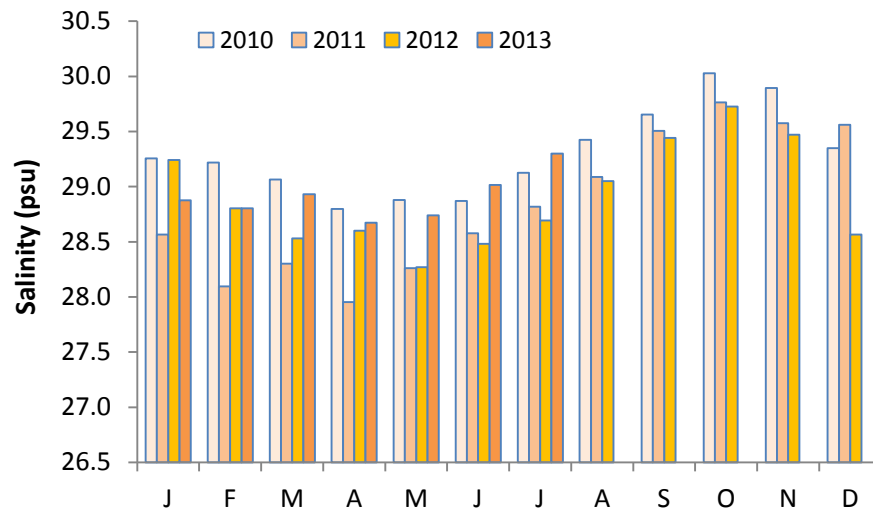
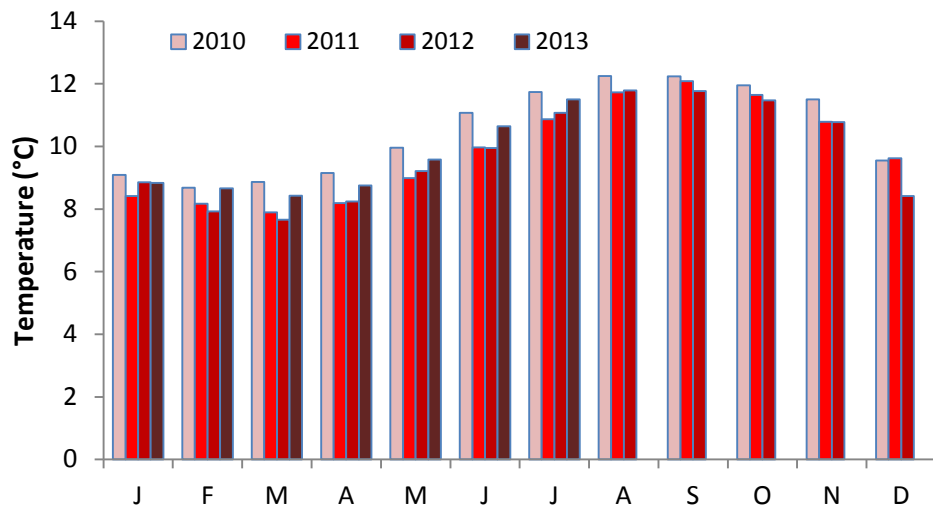
T Max	13.1 °C	on 08/11	at 28.8 PSU	14.9 db
T Min	11 °C	on 08/07	at 29.5 PSU	15.3 db
T Avg	12 °C			
T Trend	0.9 °C			

Mooring observations and trends Mukilteo 2010 to 2013



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

Note: The mooring contribution to EOPS will be significantly downscaled due to budget cuts.



This slide shows data from our Mukilteo mooring capturing water exchange between the Main Basin and Possession Sound at 12-16 m.

Inter-annual variability in temperature, salinity, and dissolved oxygen is shown over a 3.5-year period. All three variables show strong seasonality.

Thus far in 2013, trends are appearing to be similar to 2010 with relatively warmer water temperature, higher salinity, but lower dissolved oxygen.

Get data from Ecology's Monitoring Programs



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Long-Term Monitoring Network

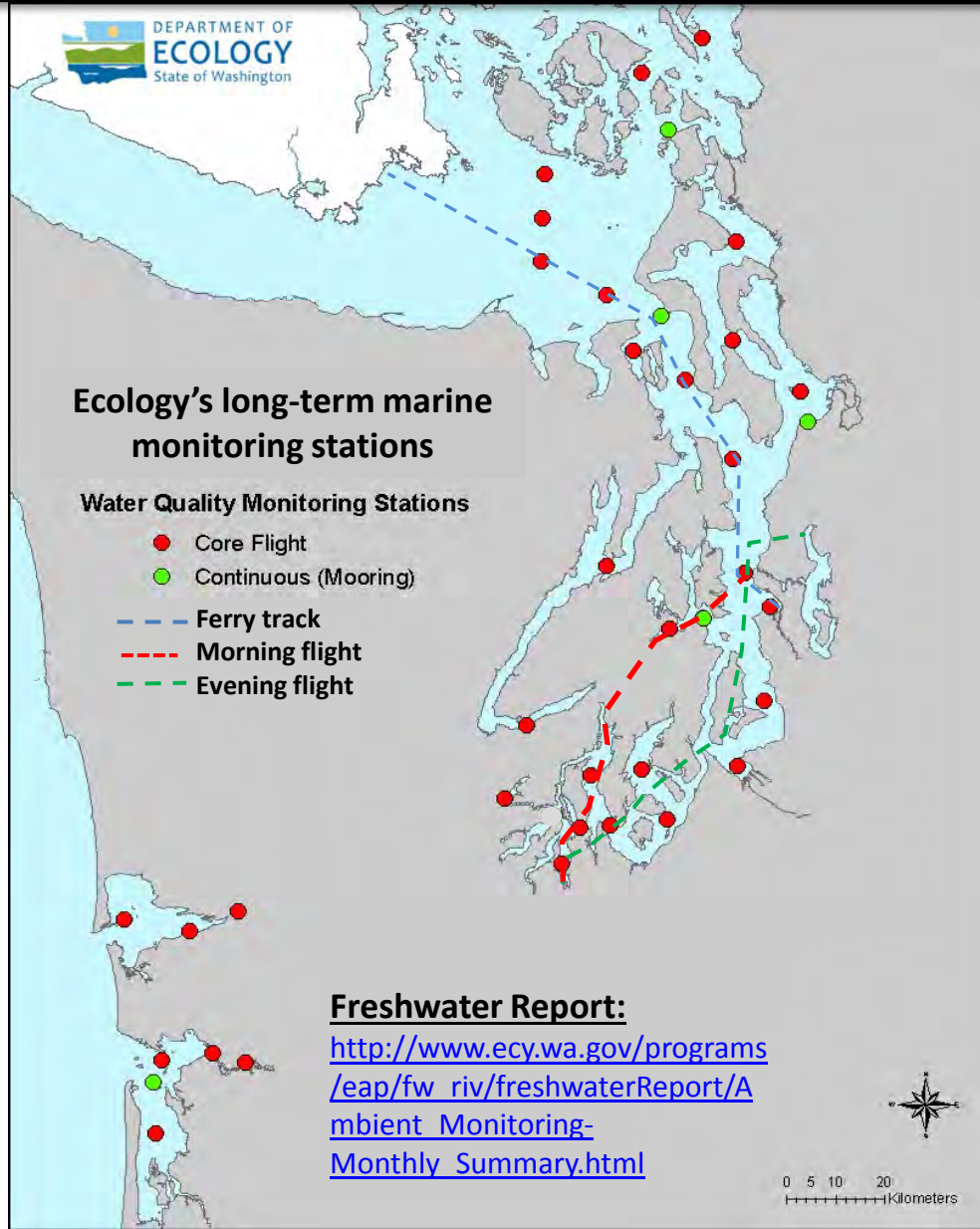


christopher.krembs@ecy.wa.gov



Access core monitoring data:

<http://www.ecy.wa.gov/apps/eap/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
christopher.krembs@ecy.wa.gov

Marine Monitoring Unit
Environmental Assessment Program
WA Department of Ecology



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