

Eyes Over Puget Sound

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

Surface Conditions Report

September 11,
2013

Ozone sensors on board: Donovan Rafferty, Ecology Air Quality Program ([here](#))

[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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*Dr. Brandon
Sackmann*



Personal flight log

[p. 4](#)

Flying for Ecology's marine program attracts experienced and engaged float-plane pilots. Joe Leatherman fits the bill like no other. A little visitor sweetened our day ([see more](#)).

Weather conditions

[p. 6](#)

New record temperature of 91 deg F on EOPS flight day. Overall: warm air temperatures, more sunshine in the south, and decreasing river flows during the past week.

Water column and mooring

[p. 7](#), [p. 38](#)

After 2 years of colder temperatures and higher oxygen, Puget Sound waters are taking a turn towards lower dissolved oxygen. Or are they?

Aerial photography

[p. 11](#)

Red-brown blooms in South Sound inlets and San Juans. Large amounts of floating organic material in Hood Canal and Puget Sound inlets. Flows from glacier-fed rivers are visible by the turquoise-colored water. Many fronts seen at the surface in the San Juans.

Ferry and satellite

[p. 36](#)

Satellite imagery reveals widespread phytoplankton blooms in Whidbey Basin, Hood Canal, and South Puget Sound. Fraser River plume extends across Strait of Georgia!

North Sound Flight with Kenmore Air pilot Joe Leatherman

Want to fly a float plane like Joe?
Get a commercial pilot certificate,
add 100 hours of flight time, pass
written & oral flight tests, add
10 hours of in-plane instructor
training, and pass a ride
check with an FAA
pilot examiner.



Joe was hand-picked by Kenmore Air's director of operations, Chuck Perry, for our work. Joe is dedicated to our safety and our success. He got the float plane bug after flying to Alaska. EOPS flights include friendship, science, flying skills, environmental curiosity, and knowledge. To learn more: <http://www.ecology.com/2013/08/28/healthy-puget-sound/>

Flight log

Weather

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Ferry and Satellite

Moorings



JOE ON THE GO:

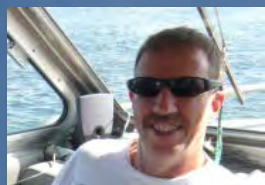
- A. Loading CTD sensors
- B. Installing CTD winch
- C. Flying to stations
- D. Helping with samples
- E. Unloading plane

Flight log	Weather	Water column	Aerial photos	Ferry and Satellite	Moorings
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Elevated ozone concentrations can occur when sunlight and air temperatures are high.

The [Air Indicator Report for Public Awareness and Community Tracking](#) (AIRPACT) is a computerized system for predicting air quality that might impact public and environmental health. With high ozone concentrations predicted on Sept. 11, GPS-referenced ozone monitoring equipment joined the flight to compare predicted (AIRPACT) and measured concentrations.





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

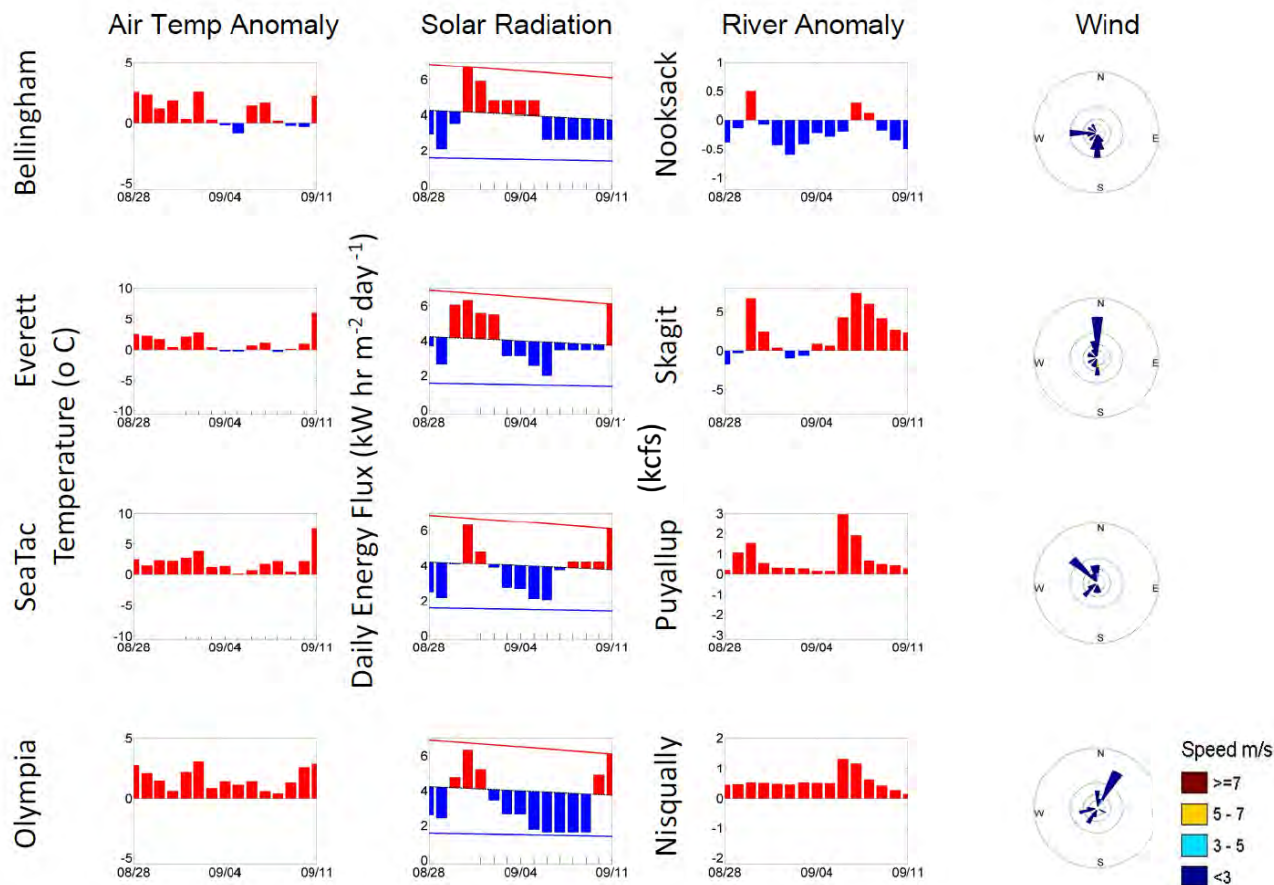
Two week summary:

Air temperatures: Daily average air temperatures have increased to mostly above-normal levels.

Sunshine: Daily averages frequently have been below normal during the past week as the result of a marine layer.

River flows have decreased to near-normal from higher levels after the heavy rain last week. Below normal flow levels exist for the Nooksack.

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

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

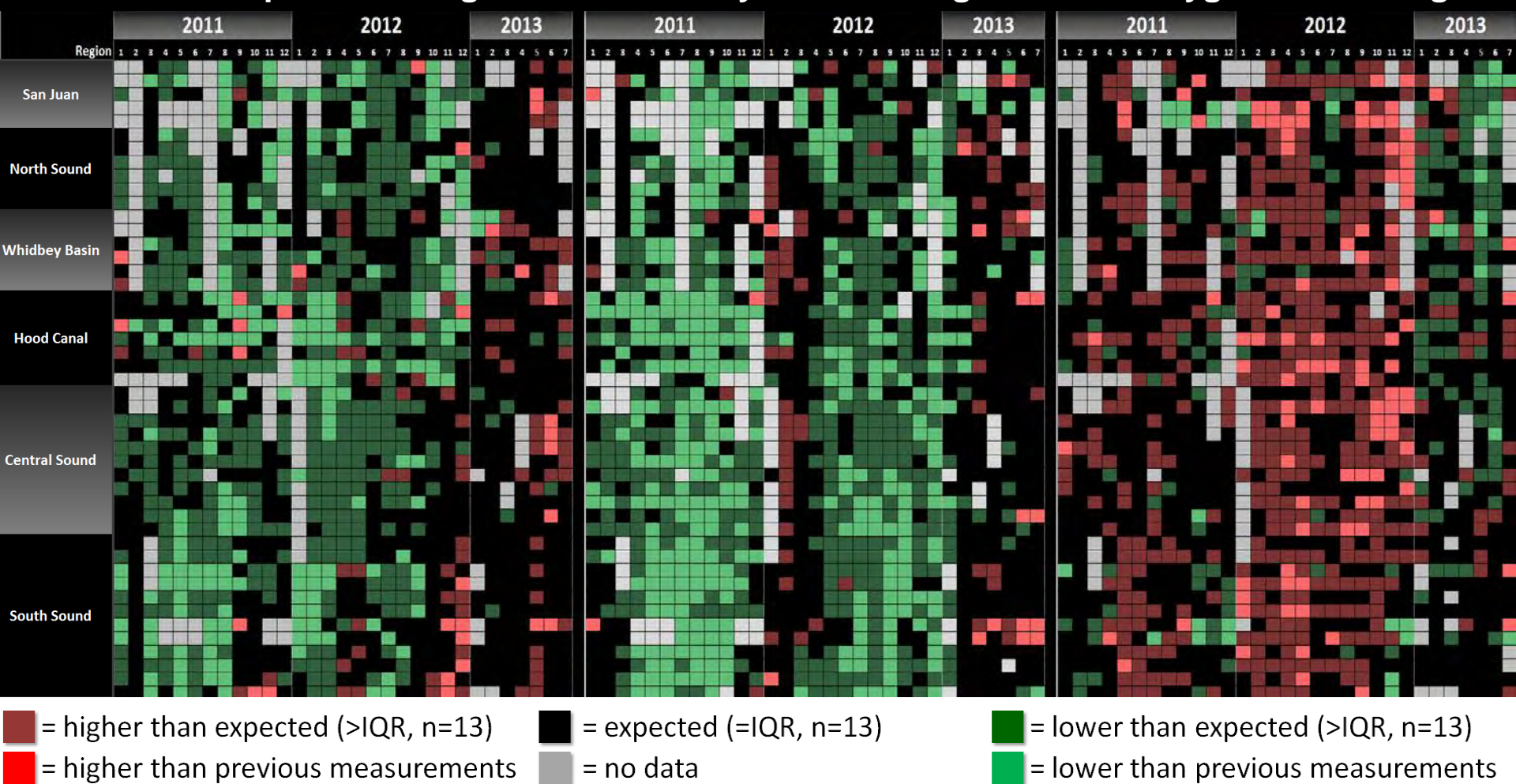
Ferry and Satellite

Moorings

In 2013: Temp. is warming!

Salinity is increasing!

Is Oxygen decreasing?



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

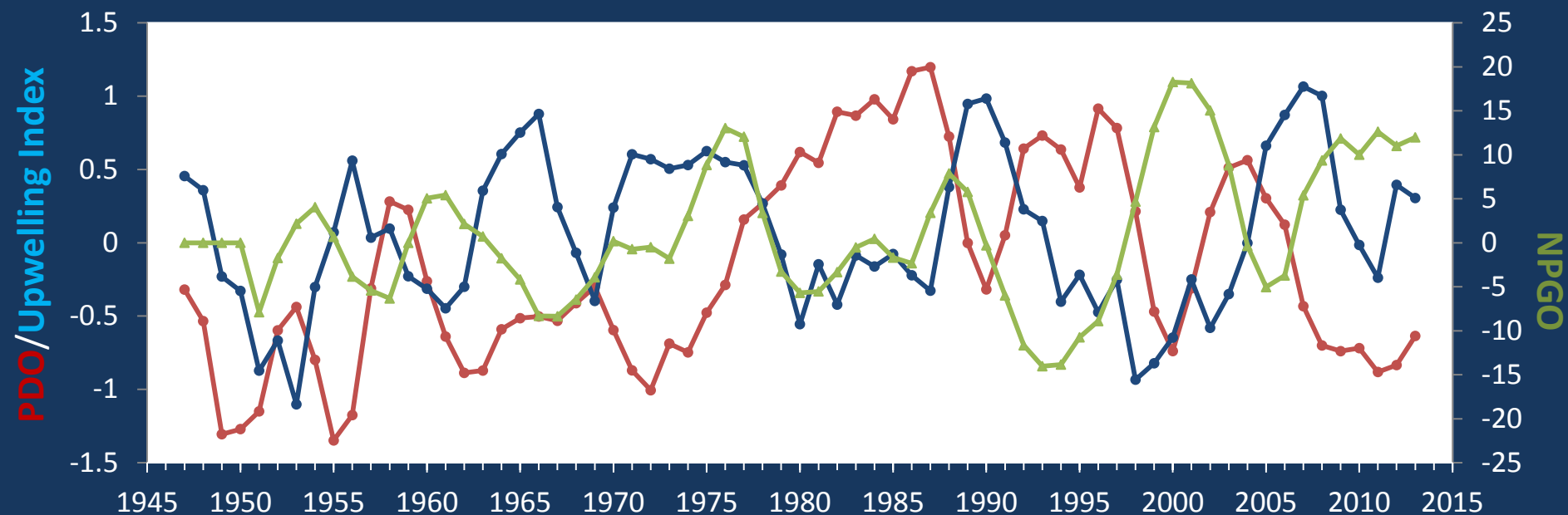


The ocean affects water quality: Ocean Climate Indices

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



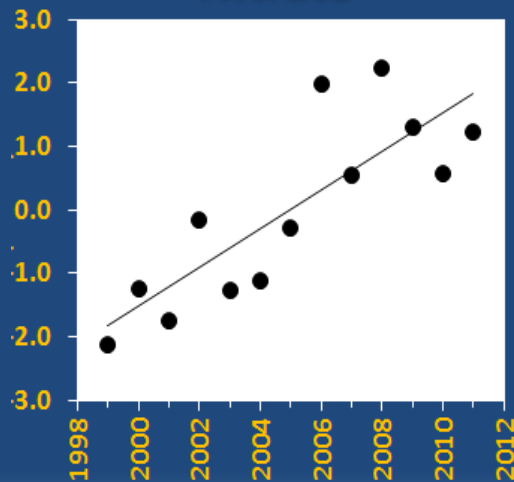
Phosphate



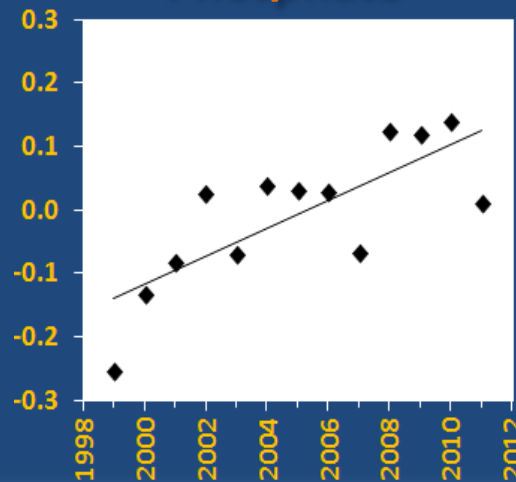
**Changing
Nutrient Balance**

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

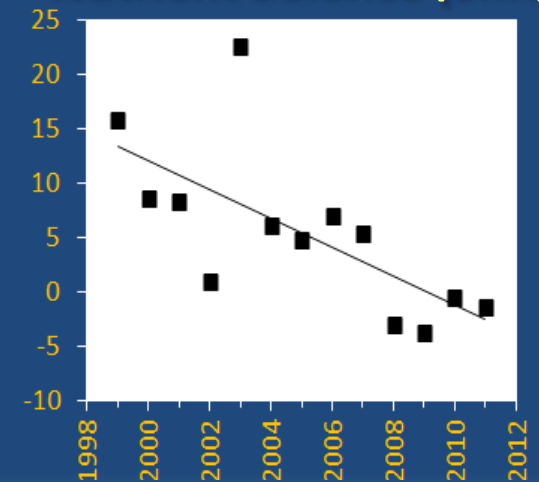
Nitrate



Phosphate



Nutrient Balance (Si:N)



Flight log	Weather	Water column	Aerial photos	Ferry and Satellite	Moorings
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Red-brown blooms in South Sound inlets and San Juans. Large amounts of floating organic material in Hood Canal and Puget Sound inlets. Flows from glacier-fed rivers are visible by the turquoise-colored water containing glacial flour. Many fronts seen at the surface in the San Juans.

Bloom in Swantown Marina, Olympia



Bloom in Cap Sante Marina, Anacortes



Start here

Front

Mixing and Fronts:

Pronounced fronts due to suspended sediment in Rosario Strait, Skagit Bay, the San Juan Islands, and Dana Passage.

[2](#) [4](#) [5](#) [6](#) [7](#) [8](#) [9](#) [10](#) [11](#) [12](#) [15](#) [16](#) [19](#)



Jellyfish: Only a few patches seen in Budd Inlet.

Plume

Suspended sediment:

Glacier-fed rivers bring glacial flour to north Puget Sound.

[2](#) [4](#) [5](#) [6](#) [7](#) [12](#) [13](#) [14](#) [15](#) [16](#)

Bloom

Visible blooms:

Red brown: Anacortes marina, West Sound, and Budd, Eld, and Totten inlets.

Green : Sinclair Inlet, Port Susan, Port Angeles, Olympia marina.

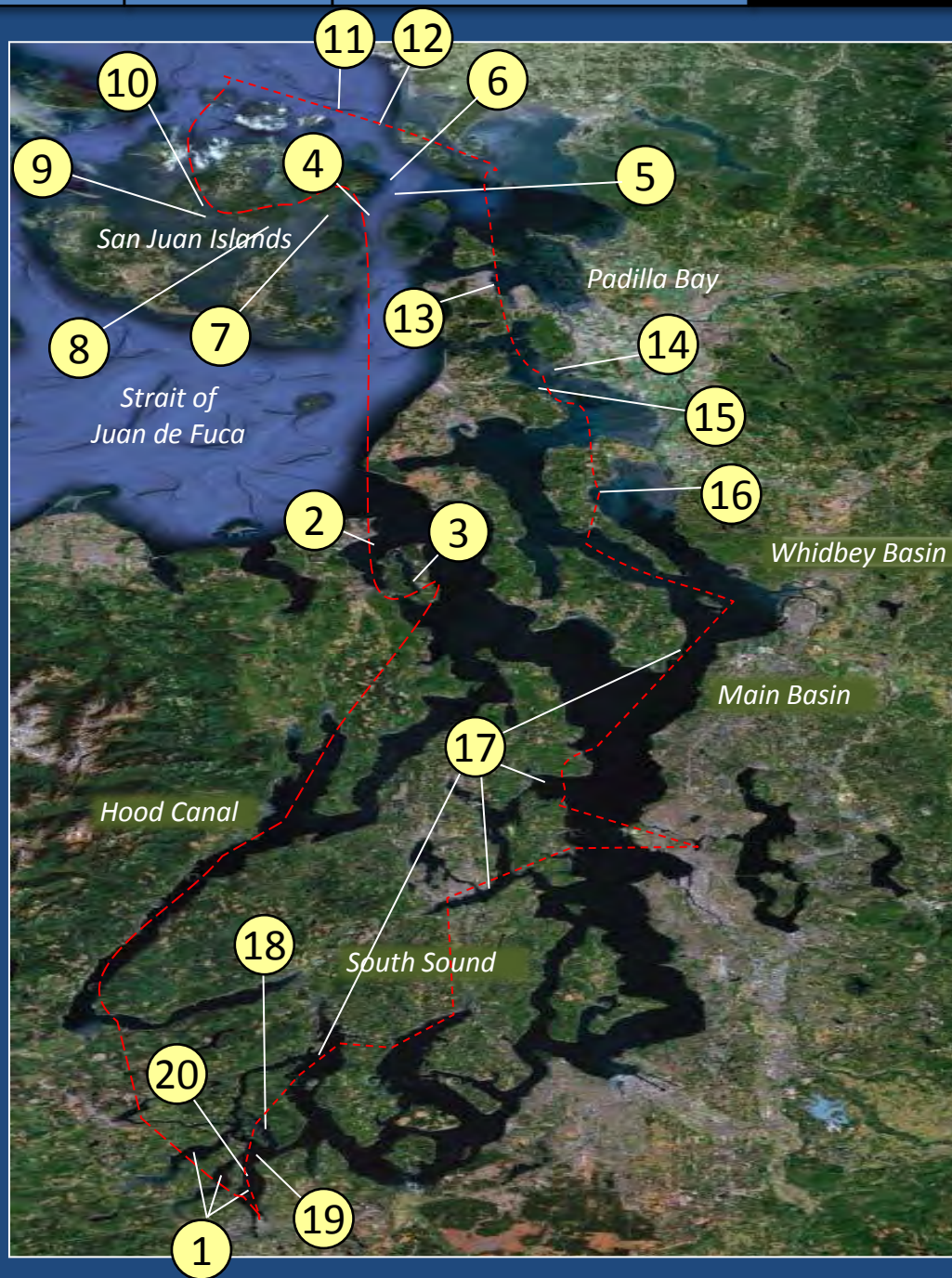
[1](#) [2](#) [3](#) [9](#) [10](#) [12](#) [13](#) [16](#) [18](#) [19](#) [20](#)

Debris

Debris:

Abundant in Case, Budd, and Totten inlets, Dana Passage, Hood Canal, Port Susan, Port Madison, Mukilteo, and Sinclair Inlet.

[1](#) [2](#) [5](#) [8](#) [9](#) [10](#) [11](#) [16](#) [17](#) [18](#) [19](#) [20](#)



Seattle: H. tide: 10:17 AM, 9:23 PM, L. tide: 3:30 AM, 3:44 PM

Aerial photography & navigation guide



Date: 9-11-2013

Click on numbers

Flight Information:

Morning flight, photos 1-7:

Good visibility, calm

Afternoon flight, photos 8-20:

Good visibility, calm, hot.

Observation Maps:

Central Sound & North Sound

Hood Canal & South Sound

Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings

A.

Internal waves

Bloom

B.

Bloom

boats

Debris

C.

Bloom

boats

D.

Bloom

Red-brown blooms, wave structures and organic debris in southern inlets.
Location: A. Budd Inlet. B. Eld Inlet. C-D. Totten Inlet. (South Sound) 9:19 AM.



Flight log

Weather

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Aerial photos

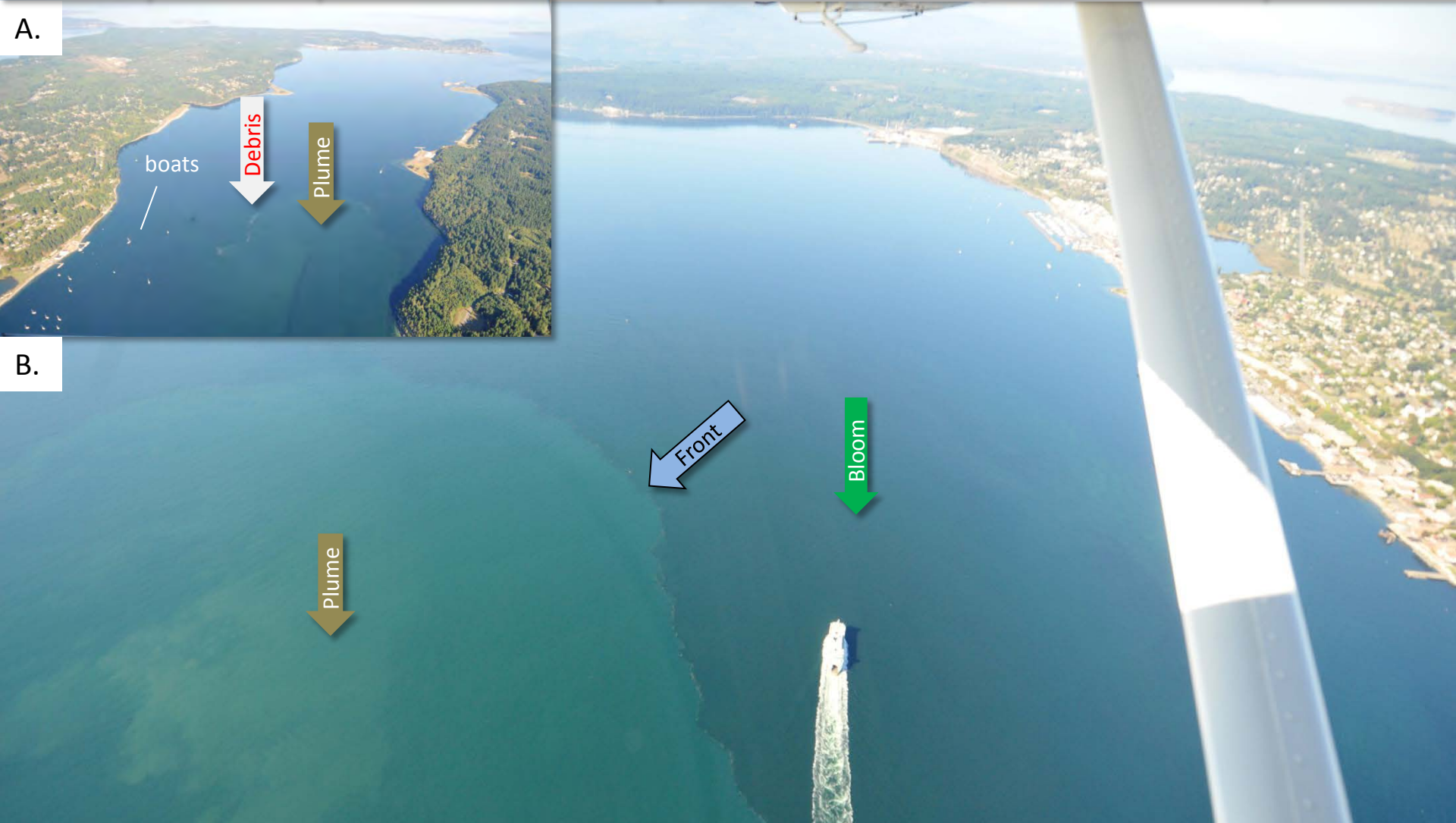
Ferry and Satellite

Moorings

A.



B.



Water with high silt content entering into Port Townsend Bay from two sides.
Location: A. Near Port Townsend Canal, B. Port Townsend (Central Sound), 10:01 AM.

Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings

A.



B.



A. Surface debris (algal mats). B. Green-yellow and red-brown phytoplankton bloom.
Location: Scow Bay in Kilisnoe Harbor (Indian Island near Port Townsend), 10:00 AM.



Flight log

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Large front delineating sediment-rich water from other water.

Location: Rosario Strait (San Juan Islands), 11:38 AM.

Flight log

Weather

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Moorings



Large-scale mosaic of water masses with different sediment content.
Location: Rosario Strait (San Juan Islands), 11:40 AM.

Flight log

Weather

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Aerial photos

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Mooring



Strong front and bordering surface water with different sediment content.
Location: Rosario Strait (San Juan Islands), 11:41 AM.

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

Fraser River sediment traversing and mixing dramatically with water in the San Juan Islands.
Location: Near Obstruction Island (San Juan Islands), 12:15 PM.

Flight log

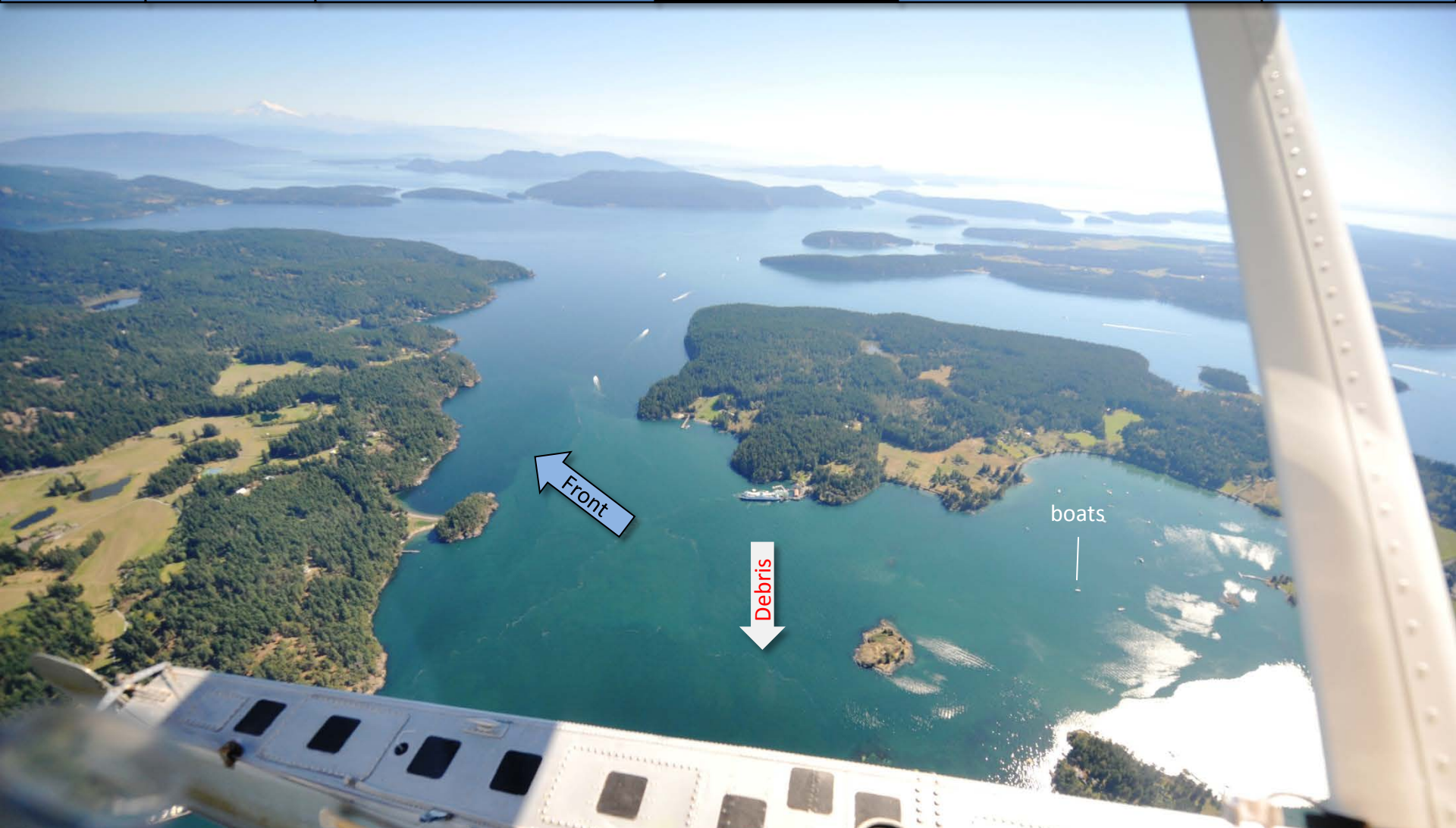
Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



*Fraser River sediment traversing and mixing with water in the San Juan Islands.
Location: Orcas Island (San Juan Islands), 12:23 PM.*



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Mooring



Red-brown bloom in West Sound and sediment-rich water.

Location: Orcas Island (San Juan Islands), 12:24 PM.



Flight log

Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



Red-brown bloom in West Sound and Massacre Bay.
Location: Orcas Island (San Juan Islands), 12:24 PM.



Flight log

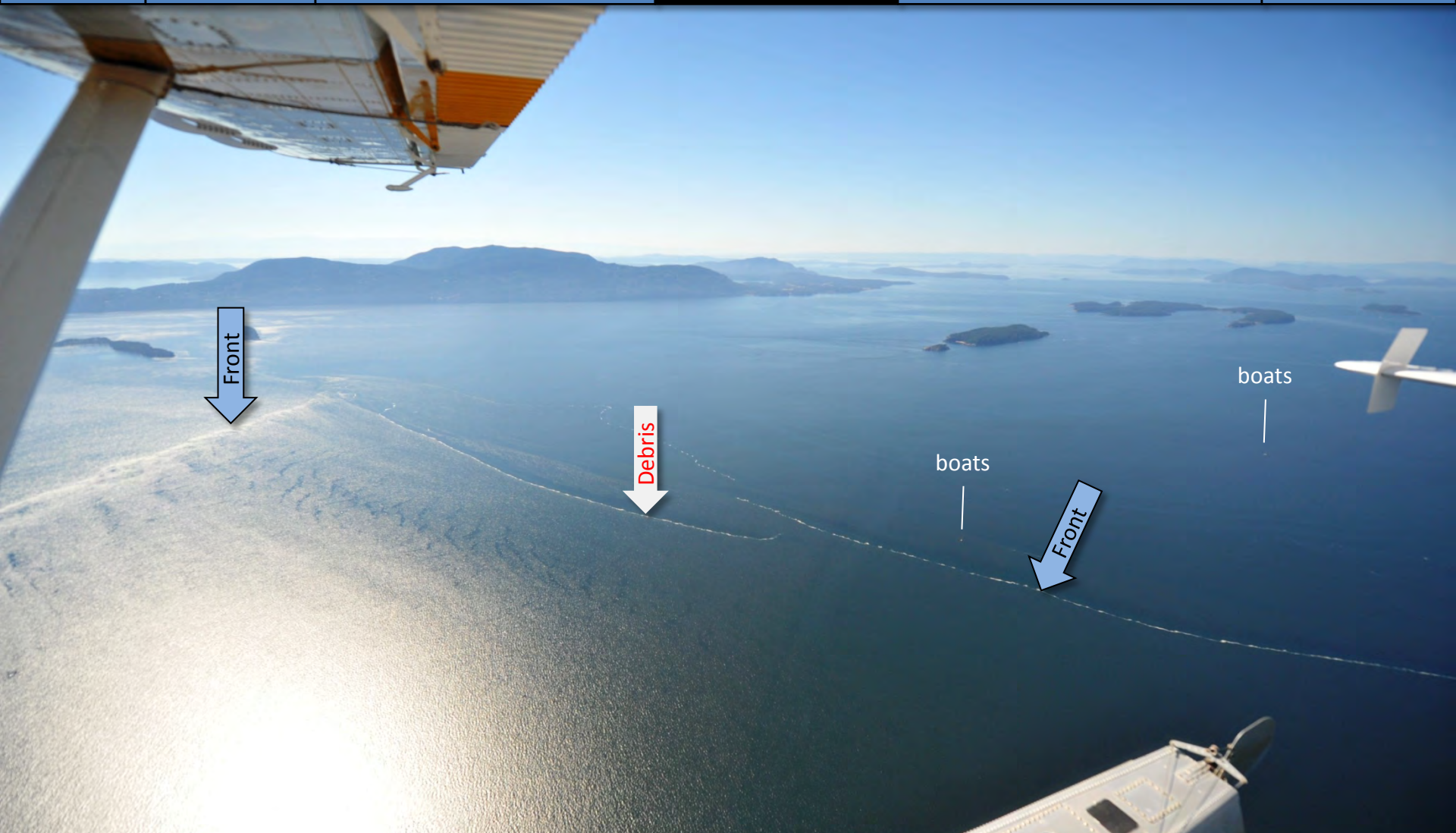
Weather

Water column

Aerial photos

Ferry and Satellite

Moorings



*Fraser River plume and front with debris originating out of Rosario Strait.
Location: North of Rosario Strait (Georgia Basin), 1:35 PM.*



Flight log

Weather

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Ferry and Satellite

Moorings



Large-scale eddies with different sediment and algal content.
Location: Northwest of Lummi Island (San Juan Islands), 1:36 PM.



Flight log

Weather

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Moorings



*Intense red-brown bloom in Cap Sante Marina and sediment in water near barge.
Location: Anacortes Harbor (Anacortes), 2:19 PM.*



Flight log

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Moorings



Distinctly different water separated by dike: Swinomish Channel and Skagit glacier-fed water
Location: Near La Conner (Skagit Bay), 2:26 PM.

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Narrow band of Skagit river plume rich in glacial silt hugging the western shore of Skagit Bay.
Location: Skagit River estuary near Dugualla Bay (Skagit Bay), 2:27 PM.

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*Green phytoplankton bloom meeting plume of Stillaguamish River with debris line .
Location: Triangle Cove (Port Susan), 2:54 PM.*



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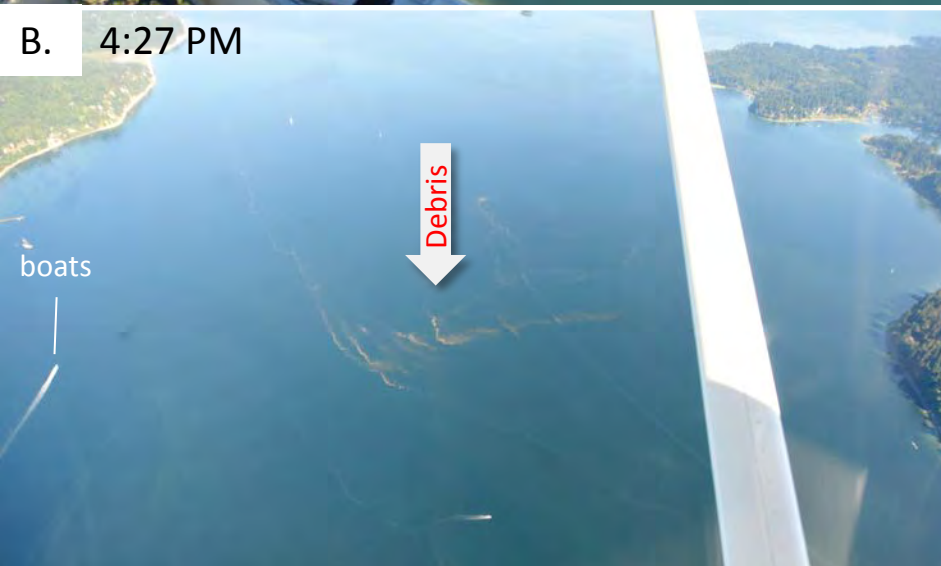
A. 4:17 PM



C. 5:12 PM



B. 4:27 PM



D. 5:25 PM



Large floating debris patches. A. Mukilteo. B. Port Madison. C. Sinclair Inlet. D. Case Inlet.
Location: A-C. Central Sound, D. South Sound, 5:10 PM.

Flight log

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Moorings



A. Red-brown algae bloom and organic surface debris. B. Debris in Pickering Passage.
Location: Between Harstine and Squaxin Island. (South Sound), 5:31PM.



Flight log

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Moorings



Red-brown algae bloom and abundant surface debris outlining front.
Location: Dana Passage (South Sound), 5:32 PM.



Flight log

Weather

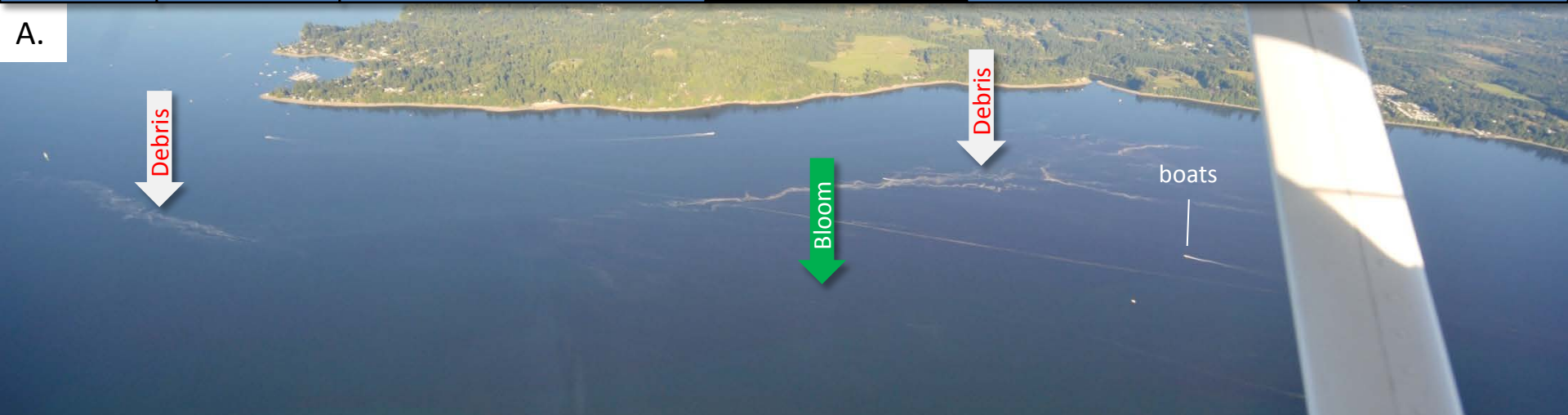
Water column

Aerial photos

Ferry and Satellite

Moorings

A.



B.



Red-brown algae bloom and long organic debris lines.

Location: Budd Inlet (South Sound), 5:35 PM.

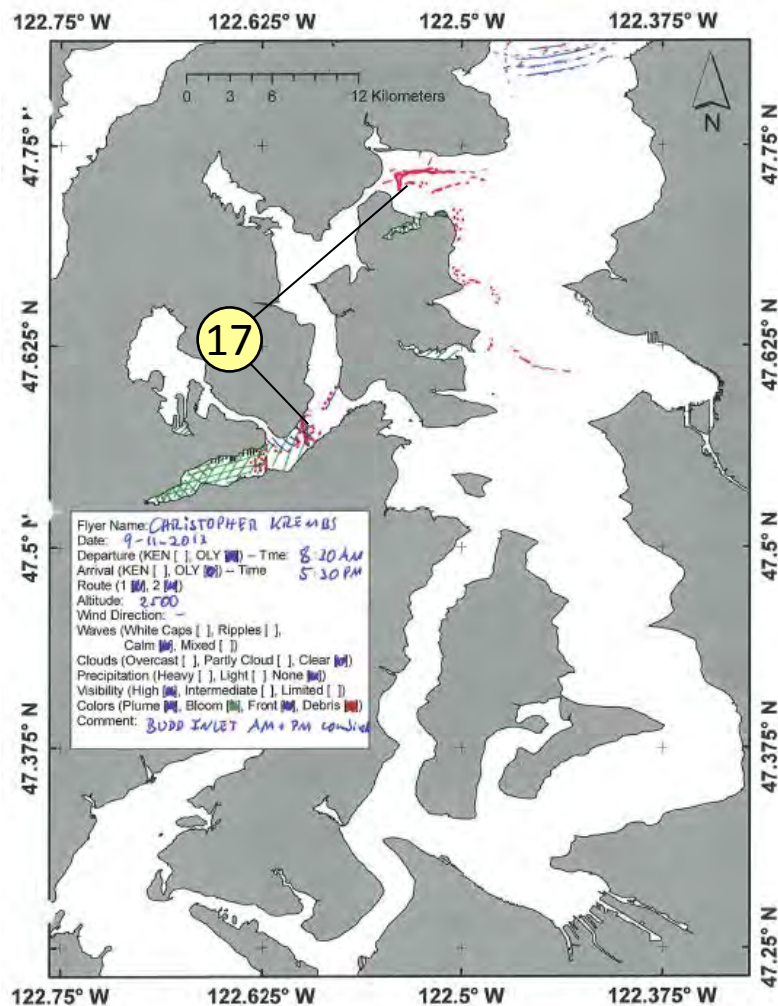
Aerial photography observations in Central Sound

[Navigate](#)

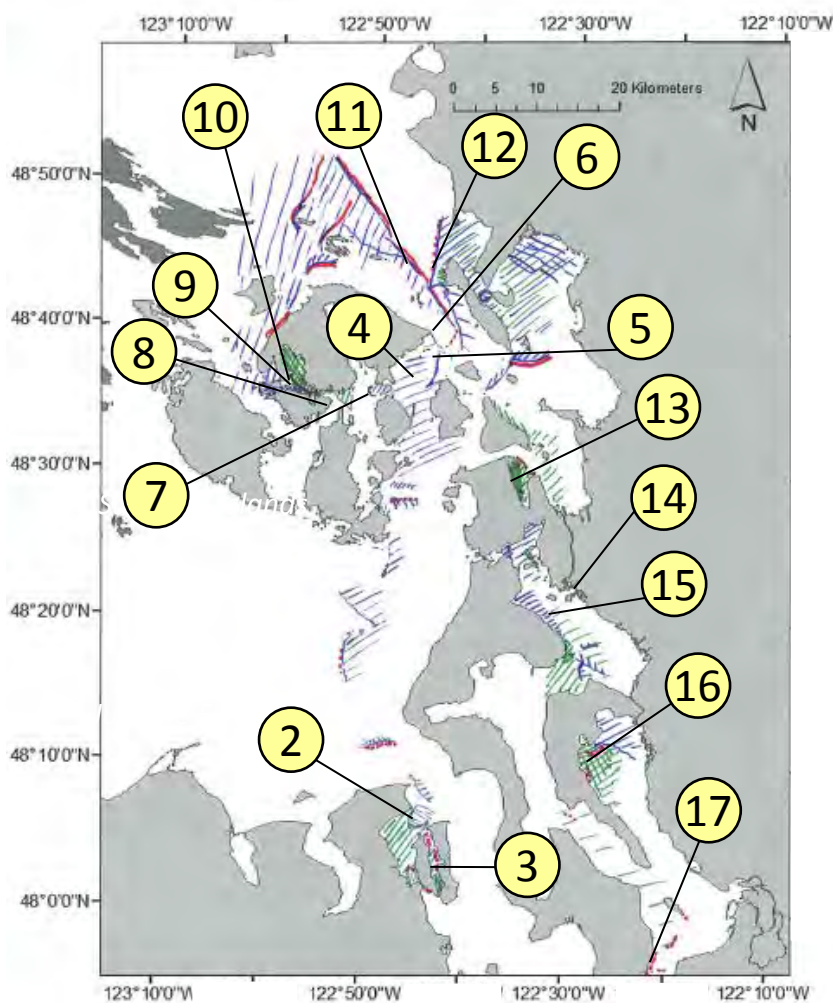
Date: 9-11-2013



Central Sound



North Sound/San Juans



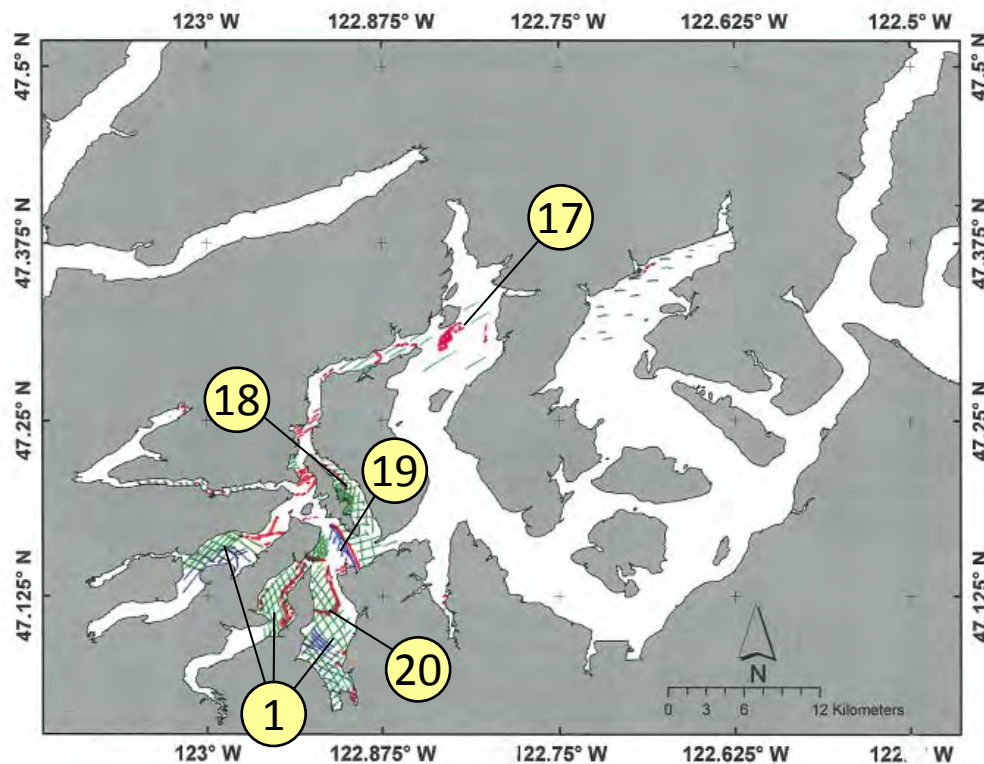
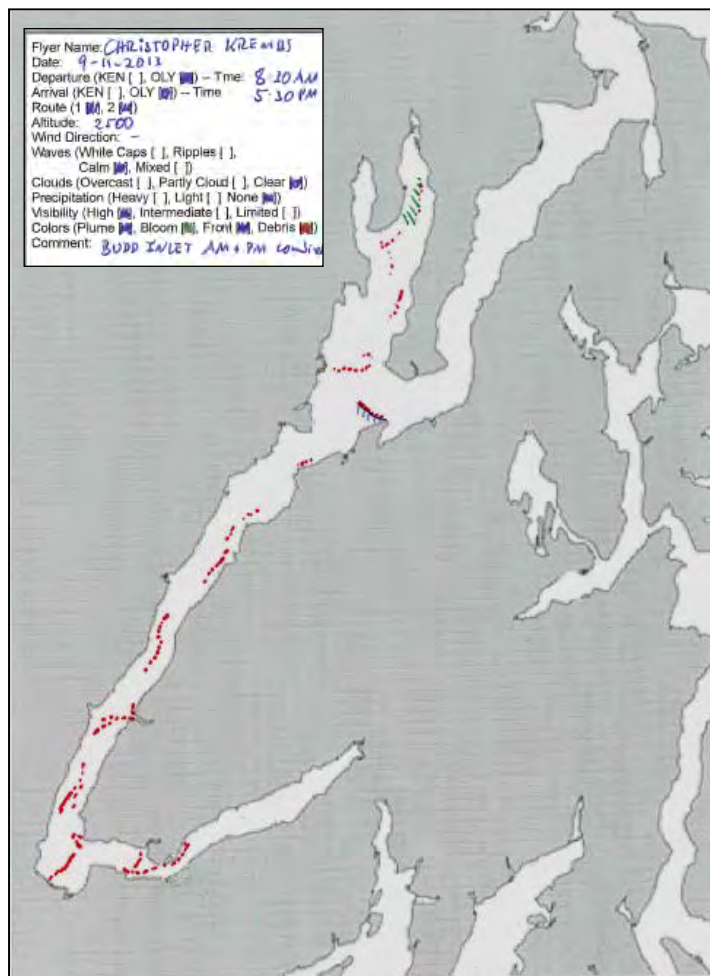
Numbers on map refer to picture numbers for spatial reference












Hood Canal

Date: 9-11-2013

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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bsackmann@ecy.wa.gov

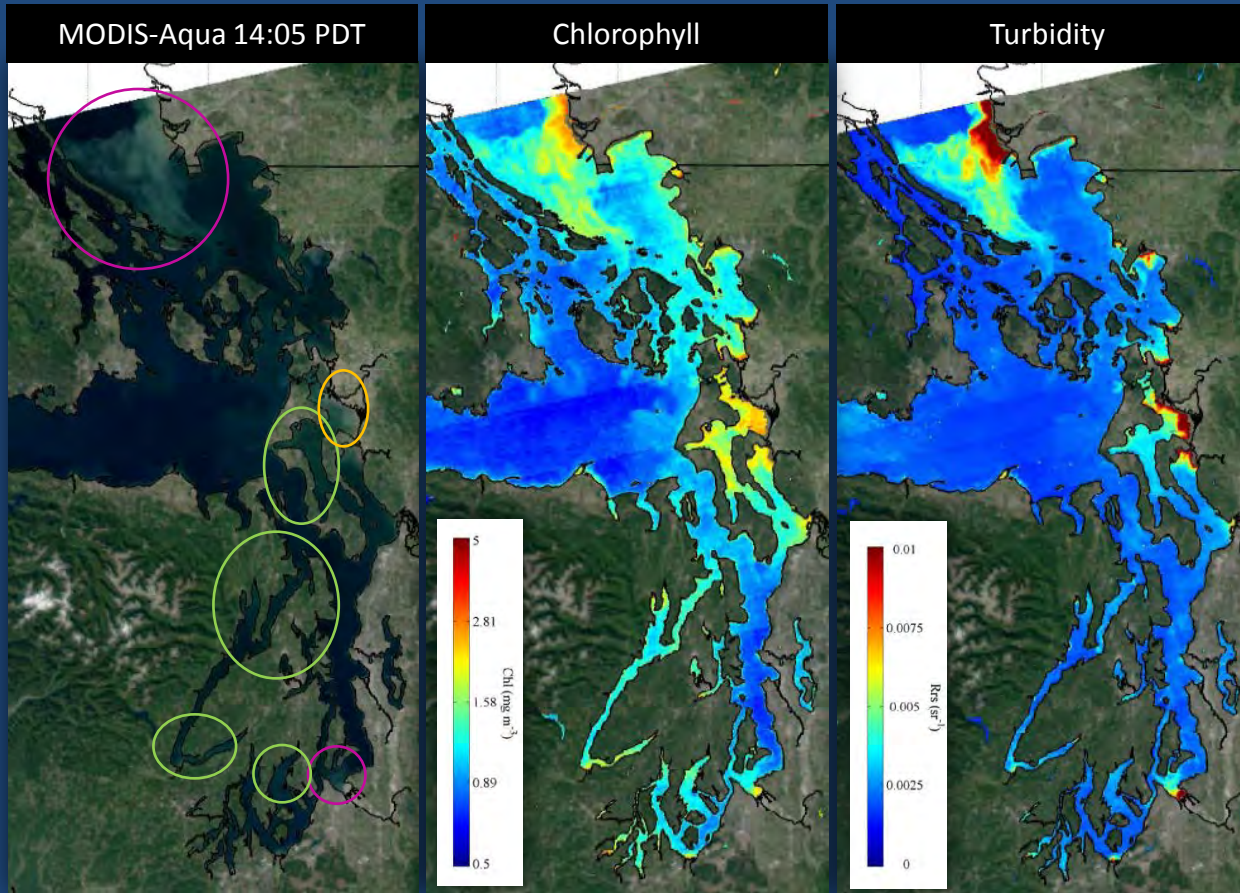
[Start here](#)



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

Current Conditions:

MODIS-Aqua continues to provide valuable near-surface imagery of key water quality parameters throughout greater Puget Sound. Widespread phytoplankton blooms seen in Whidbey Basin, Hood Canal and South Puget Sound. Fraser River plume extends across Strait of Georgia!



Satellite Ocean Color MODIS-Aqua

11 September 2013

Satellite imagery reveals synoptic view of river plumes, phytoplankton blooms, and mud flats!

Widespread phytoplankton blooms observed in Whidbey Basin, Hood Canal, and South Puget Sound. Fraser River plume extends across Strait of Georgia.

- River Plumes
- Phytoplankton Blooms
- Mud Flats

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



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Water column

Aerial photos

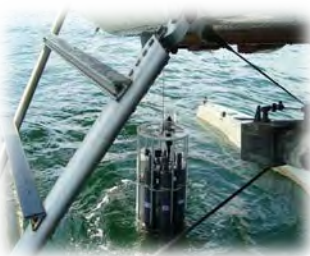
Ferry and Satellite

Moorings

Long-Term Monitoring Network

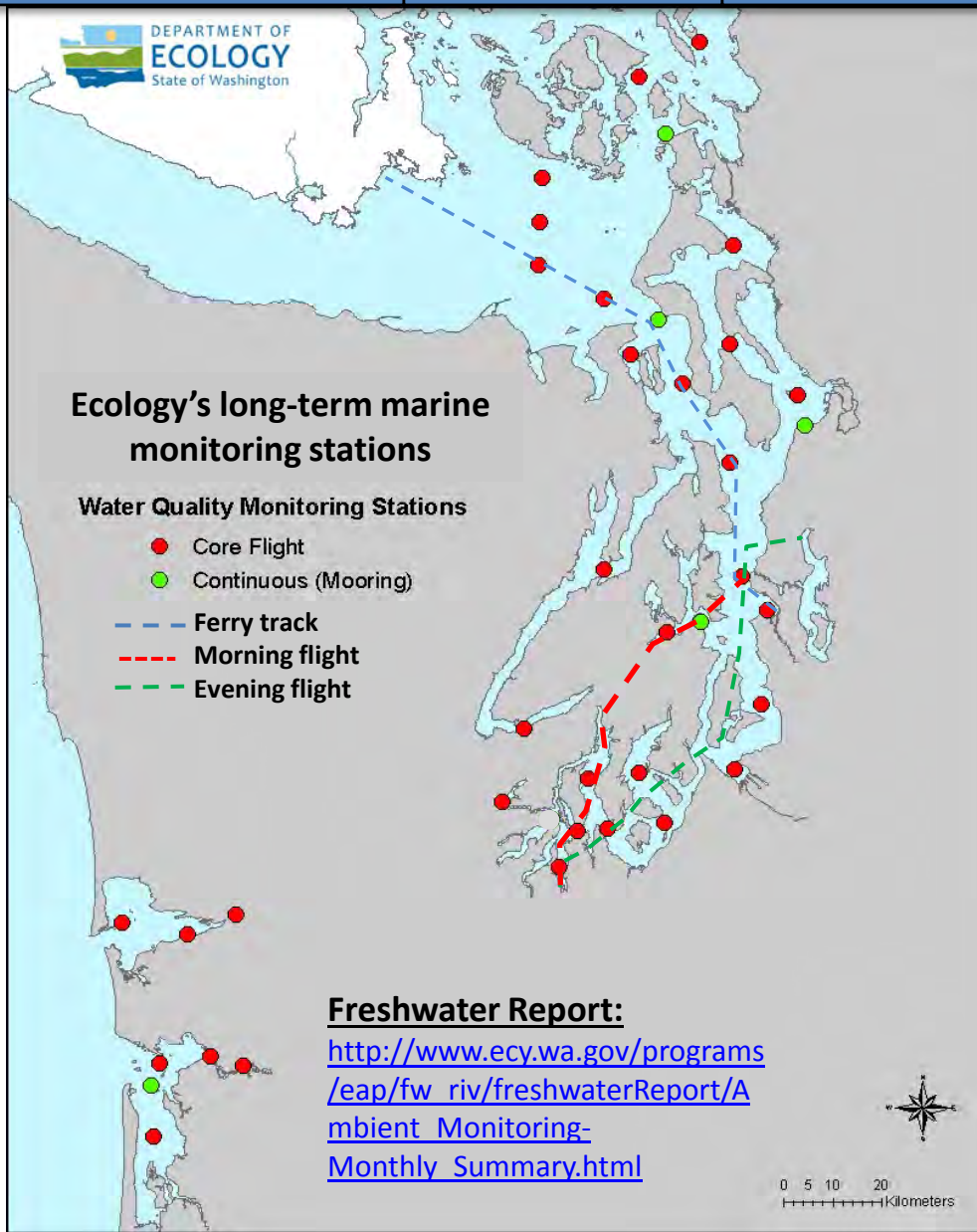


christopher.krembs@ecy.wa.gov



Access core monitoring data:

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



Real-Time Sensor Network



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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.