

Eyes Over Puget Sound

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

Surface Conditions Report

October 28, 2013

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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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Krembs*



*Dr. Brandon
Sackmann*



Personal flight log

[p. 3](#)

A historic glimpse into the life of our chartered plane: the de Havilland Beaver float plane.

Weather conditions

[p. 5](#)

Cool, foggy mornings have been alternating with warm sunny afternoons. Overall air temperatures were low, increasing only in the last days. River flows are gradually decreasing. Winds have been light and from the north.

Water column

[p. 6](#)

Oxygen in Puget Sound waters are normalizing again after 7 months of a lower oxygen phase that followed a 2-year period of colder temperatures and higher oxygen (2011 to 2012).

Aerial photography

[p. 10](#)

Red-brown blooms and jellyfish in south Puget Sound. Grays Harbor has abundant surface debris with green algae in North Bay. Some rivers in Willapa Bay with red-brown blooming algae. Many unexplained patches of suspended sediment in shallow waters in Grays Harbor and Willapa Bay. Who knows the answer?

Ferry and satellite

[p. 34](#)

Victoria Clipper IV – an unique sampling platform for monitoring water quality in Puget Sound – is getting upgraded. Foggy conditions for October limit availability of satellite data.

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History of the de Havilland Beaver - Before I started this job, I had never ridden in a small plane of any kind. Over the years I have come to appreciate the special abilities of the de Havilland Beaver DHC-2 float planes we fly in. These are fixed wing single engine planes, **also called bush planes.**

De Havilland named all their planes after animals and so this hard working plane was named the "Beaver."



Beavers lined up at Kenmore Air's dock in Seattle

Developed by de Havilland Canada, 1,657 Beavers were produced from 1947 to 1967, helped by demands of the Korean War.

Photo: Joe Leatherman 2013

The combination of the large engine and long wing give it superb short landing and takeoff for its size, making it well suited for remote areas. A Beaver can easily be fitted with floats, skis, or wheels and the doors on both sides make it easy for loading passengers and cargo. It has a hatch that was used for crop dusting and other aerial applications.

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The belly hatch was used for crop dusting and other aerial applications. The designers would probably be thrilled to learn that the hatch allows us to deploy our CTD. We can add one more application to the Beaver's resume: **oceanographic sampling platform**.

Capacity: 6 passengers or 2,100 lb payload, Cruise speed: 143 mph, Range: 455 miles

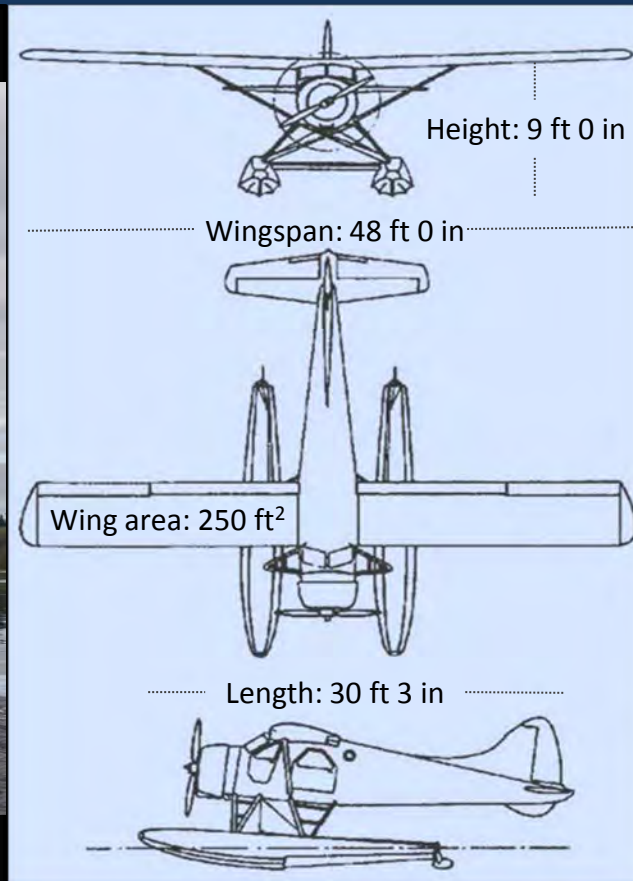
Photo: Clint Ferrara 2013



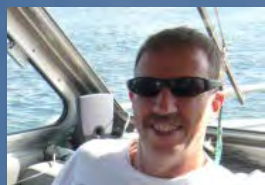
Loading the Beaver with sampling gear in Olympia

Service ceiling: 18,000 ft, Rate of climb: 1,020 ft/min (More details here)

[more](#)



Despite their age, hundreds of Beavers are still flying, thanks in part to Kenmore Air. These planes have been heavily modified and updated and are now known as "Kenmore Beavers." Changes include the quieter 3-blade propeller and, my personal favorite, a bubble window for the back seat passengers.



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

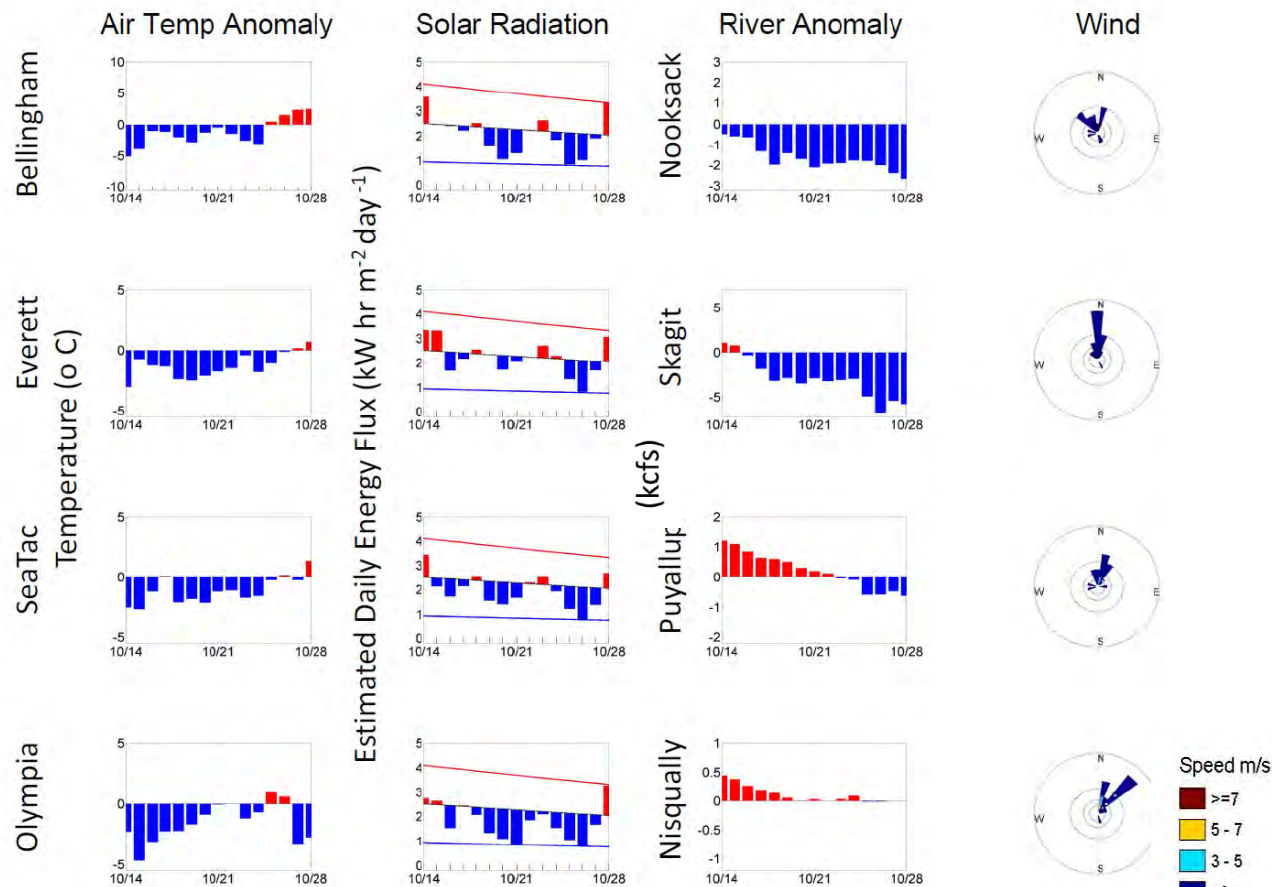
Two week summary:

Air temperatures were mostly below normal, with cool foggy nights. In the last days warm sunny afternoons contributed to increased temperatures.

Sunshine levels have been high to the north, but lower to the south where the marine layer has not burned off.

River flows have fallen below normal levels following a wet September.

Winds have been weak but generally from the north.



Our long-term marine monitoring stations in Washington

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- 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

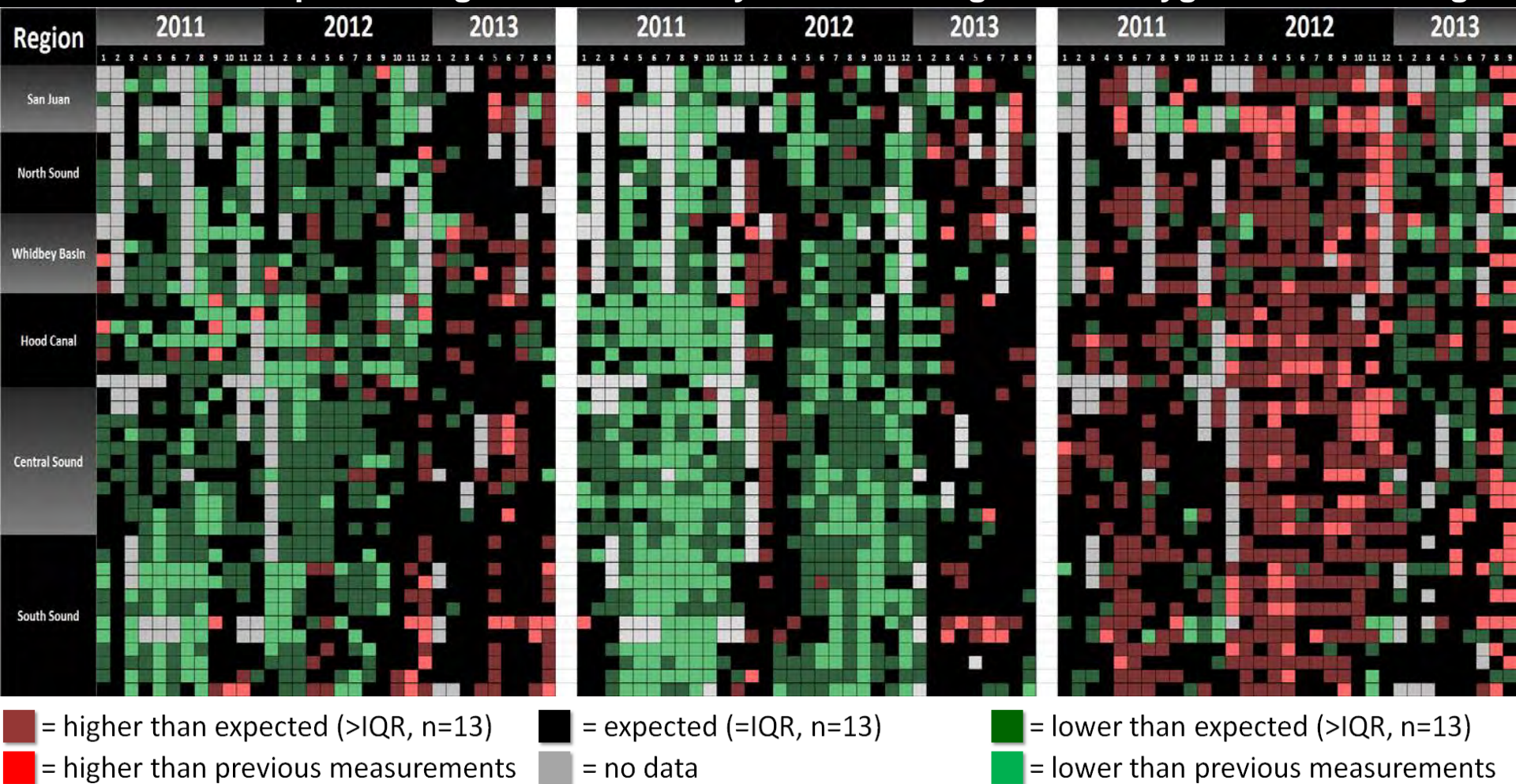


Flight log Weather Water column Aerial photos Ferry and Satellite Moorings

In 2013: Is temp. warming?

Salinity is normalizing

Oxygen is rebounding



Puget Sound water conditions are normalizing after a 7-month reduced oxygen phase from Jan. to July, 2013. This follows two years (2011, 2012) of higher oxygen. Anomalies are calculated in reference to a time-averaged seasonal cycle using the years 1999 to 2008. Each pixel is a monthly survey at a single station.

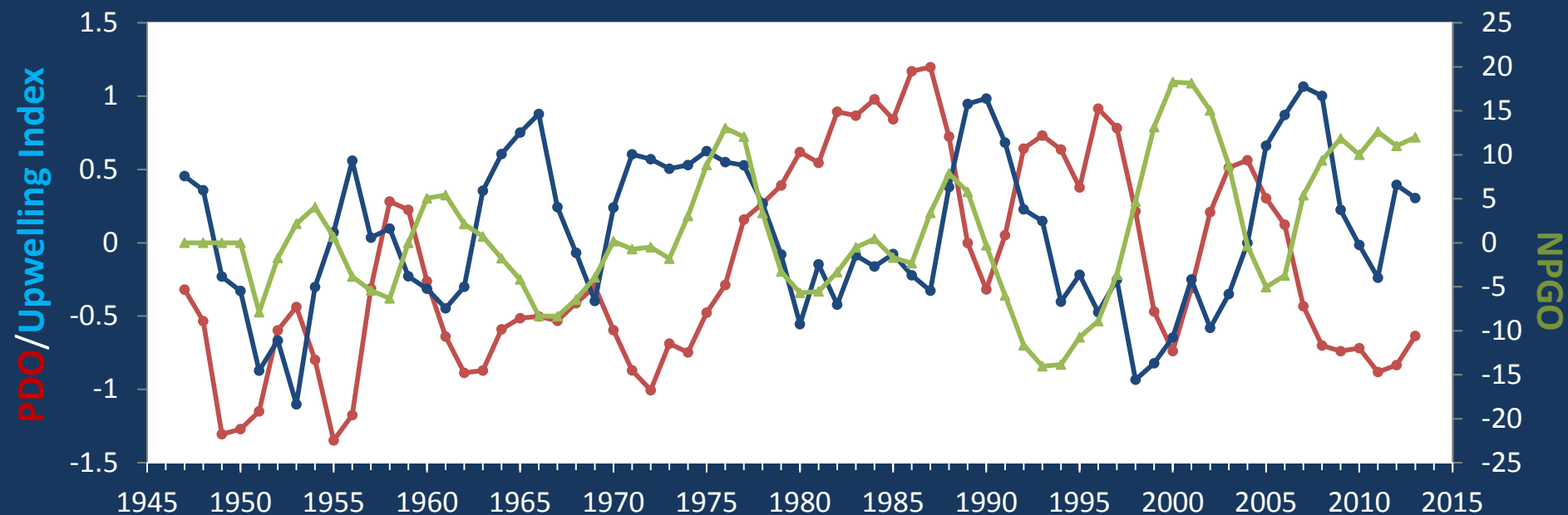
The ocean affects water quality: Ocean Climate Indices



Flight log Weather Water column Aerial photos Ferry and Satellite Moorings

- a) Pacific Decadal Oscillation Index (**PDO, 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 algal biomass patterns in Puget Sound

Algae bloom, Budd Inlet 2010



Nitrate



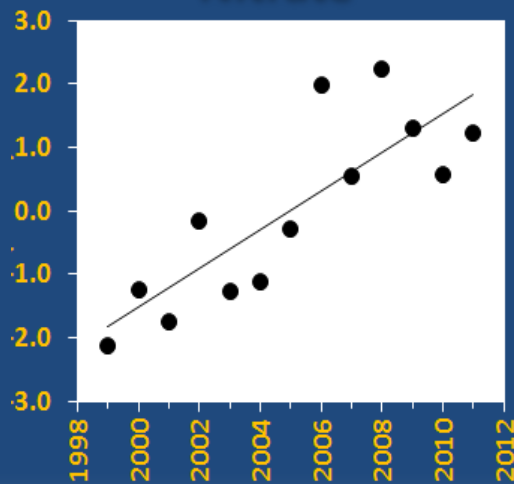
Phosphate



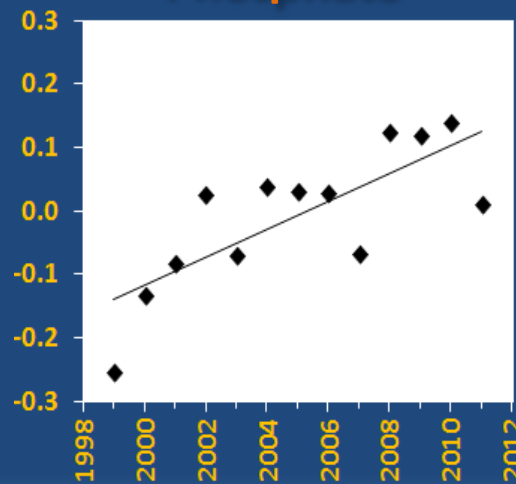
**Changing
Nutrient Balance**

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

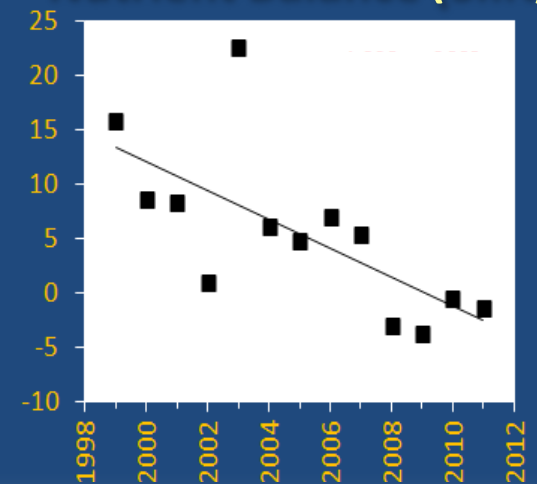
Nitrate



Phosphate



Nutrient Balance (Si:N)



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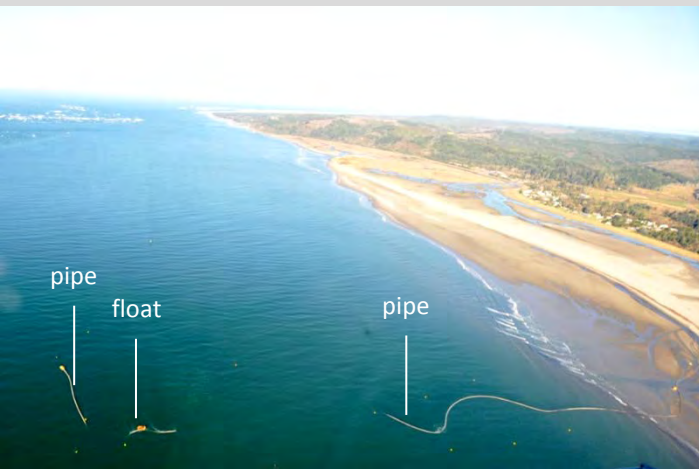
Red-brown blooms and jellyfish in south Puget Sound. Grays Harbor has abundant surface debris with green algae in North Bay. Some rivers in Willapa Bay with red-brown blooming algae. Many unexplained patches of suspended sediment in shallow waters in Grays Harbor and Willapa Bay.

[Start here](#)

Long pipes running across beach, Tokeland



Pipes end mid-channel, Willapa Bay



Front

Mixing and Fronts: [1](#) [8](#)

Many fronts along river plumes and bay water flowing into the ocean.



Jellyfish: Many patches seen in Budd, Eld, and Totten Inlets. Fish schools in Willapa Bay. [1](#) [2](#)

Plume

Suspended sediment: [1](#) [2](#) [3](#) [8](#) [9](#)

Numerous unexplained patches in shallow water without hydrodynamic cause, yet many birds in Grays Harbor and Willapa Bay fly around them.

Bloom

Visible blooms: [1](#) [2](#) [6](#) [7](#) [18](#) [19](#) [20](#)

Red brown: Eld & Totten inlets; Willapa River and tidal slough.

Green: Grays Harbor, Ocean Shores.

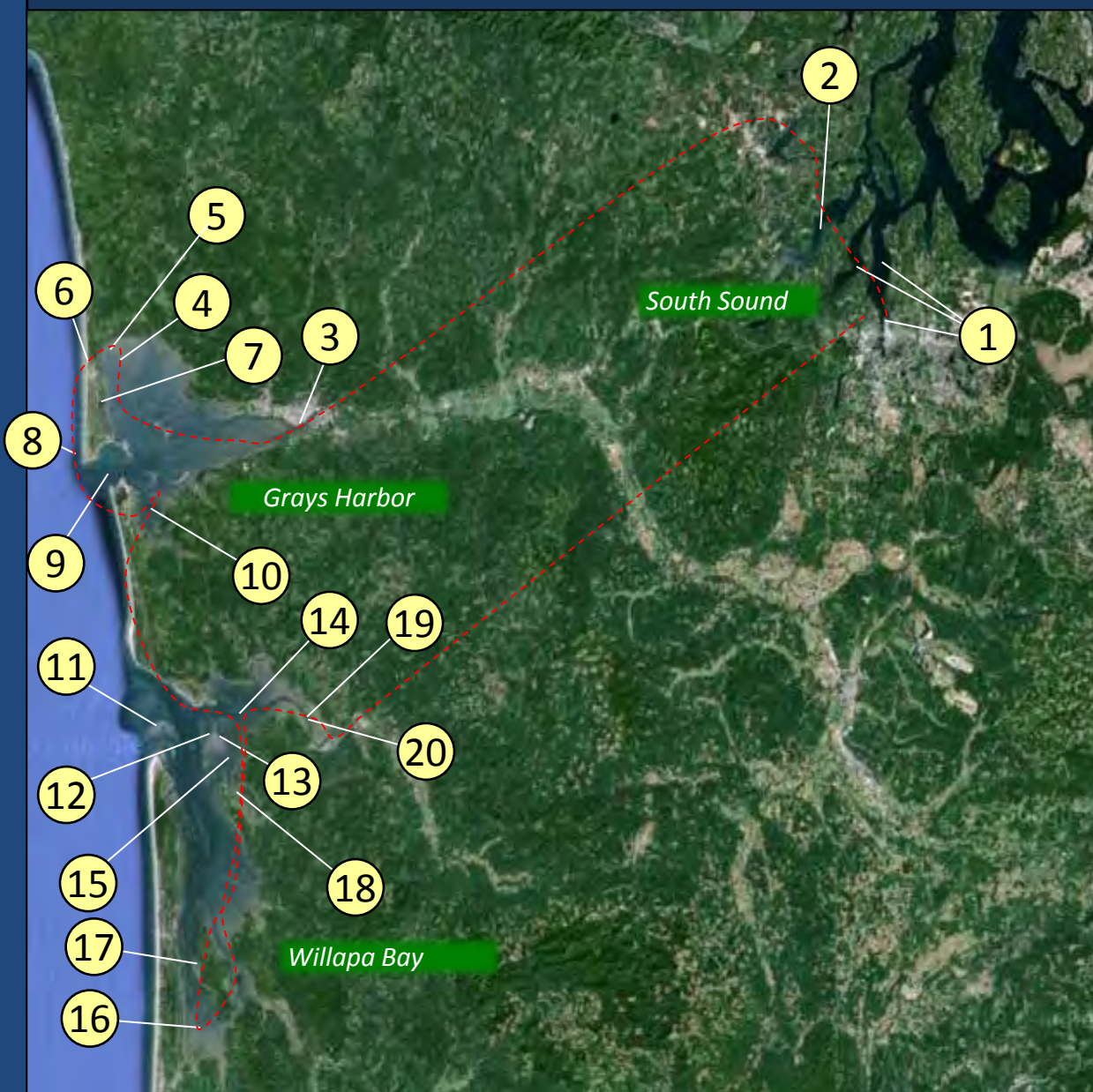
Brown: Along ocean shore.

Debris

Debris: [1](#) [4](#) [5](#) [7](#) [8](#) [9](#) [10](#) [11](#) [14](#) [15](#) [16](#) [17](#)

Abundant in North Bay of Grays Harbor.

Toke Point: H. tide: 9:16 AM, 9:04 PM, L. tide: 2:30 AM, 3:17 PM



Aerial photography & navigation guide

Date: 10-28-2013



Click on numbers

Flight Information:

Morning flight, photos 1-14:

Good visibility, calm

Afternoon flight, photos 15-20:

Good visibility, calm.

Observation Maps:

Coast & South Sound

Flight log

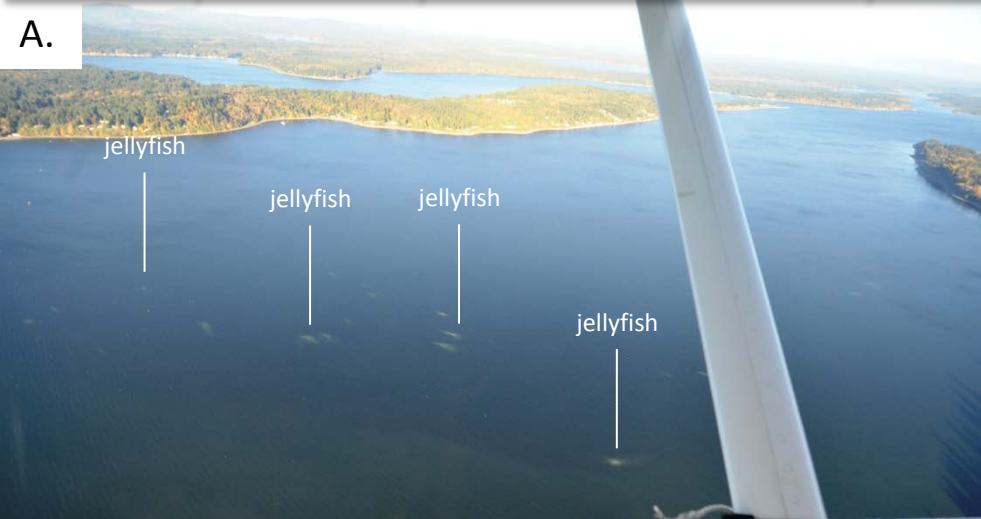
Weather

Water column

Aerial photos

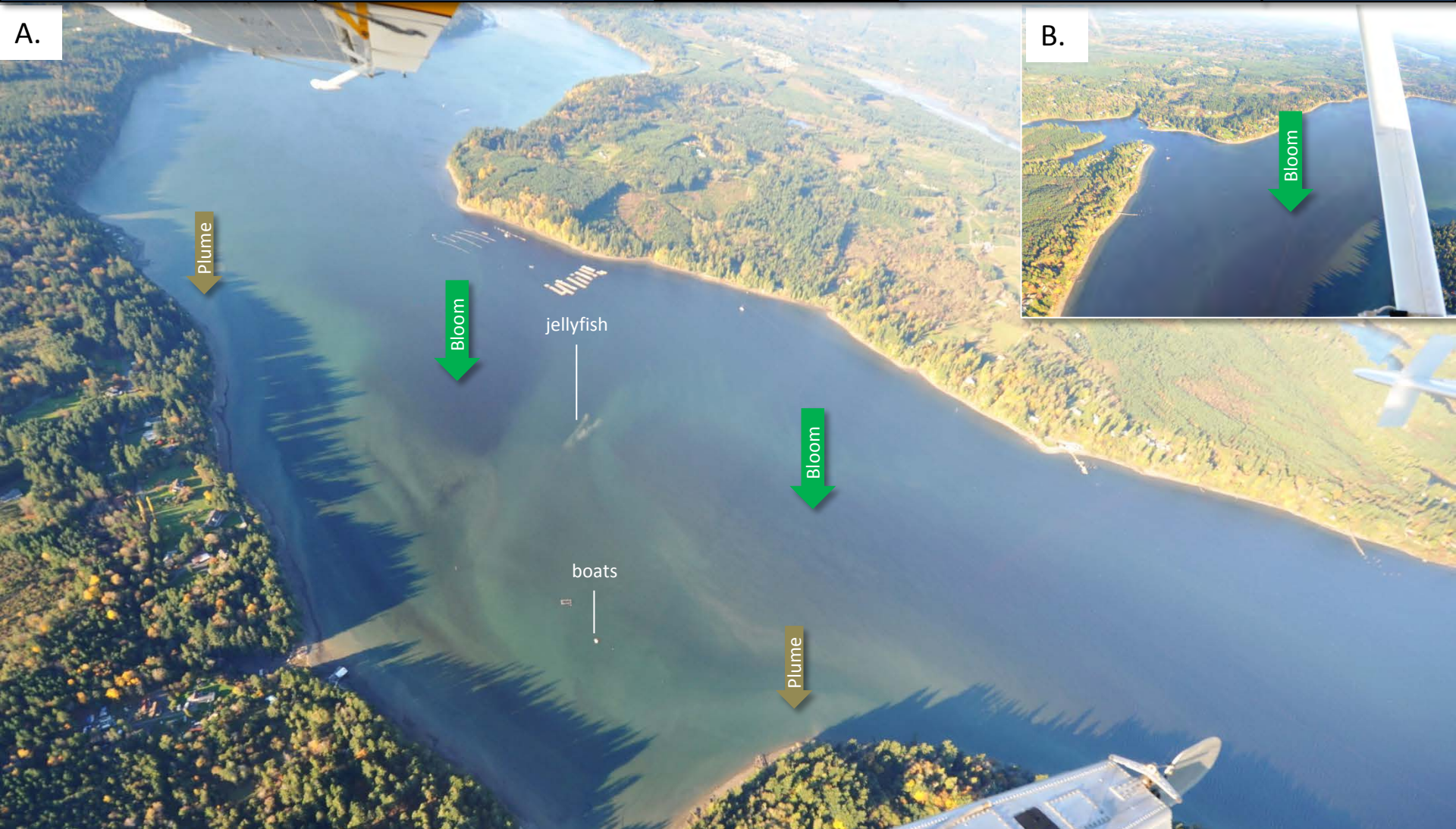
Ferry and Satellite

Moorings



Jellyfish patches, front, suspended sediments, and red-brown algal bloom.
Location: A-B. Budd Inlet. C-D. Eld Inlet. (South Sound) 9:30 AM.

A.



B.

Red-brown bloom, jellyfish, and suspended sediment.

Location: Totten Inlet, A. Looking south, B. Looking north (South Sound), 9:40 AM.



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A. Cloud banks follow river plume with much suspended sediment. B. Low lying clouds follow Chehalis River into estuary. Location: Aberdeen (Grays Harbor), 10:06 AM.

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*Organic surface debris and suspended sediment near exposed mudflat.
Location: North Bay (Grays Harbor), 11:13 AM.*

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Organic surface debris in tidal channels near exposed mudflat.

Location: North Bay (Grays Harbor), 11:14 AM.

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Suspended sediment from waves and diatom bloom at beach.

Location: Ocean Shores (Grays Harbor), 11:17 AM.

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Mooring



Brown, fresh water with bright green algal blooms. Green bay water from bloom.
Location: Duck Lake and North Bay (Grays Harbor), 11:18 AM.



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Grays Harbor water flowing into ocean past Ocean Shores sewage treatment plant. Location: North Jetty (Grays Harbor), 11:19 AM.

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Moorings



Waters with different sediment content and debris flowing out of bay on outgoing tide.
Location: Westhaven State Park (Grays Harbor), 11:19 AM.



Flight log

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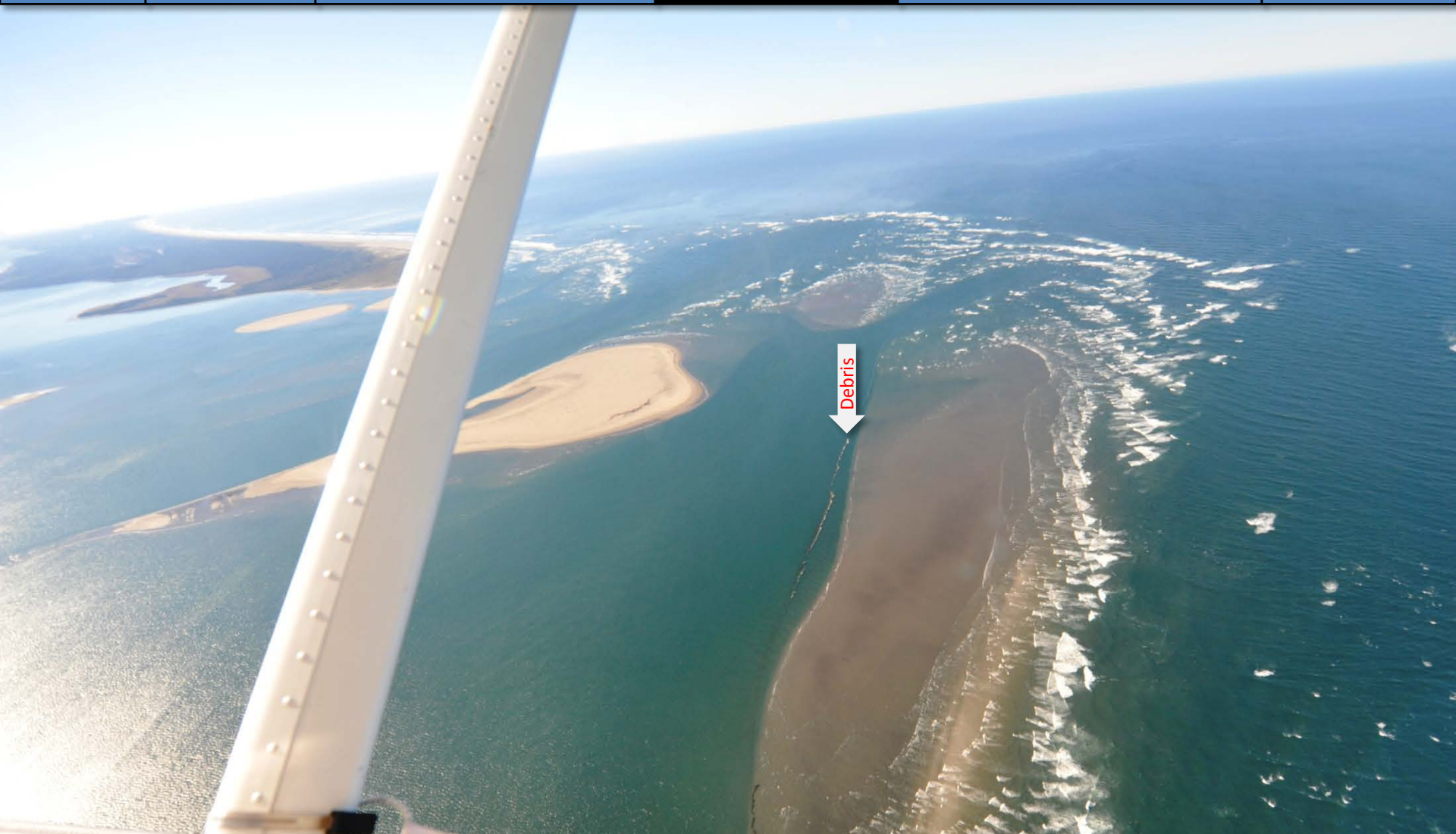
Aerial photos

Ferry and Satellite

Moorings



Lines of organic debris from Sopun, Mallard, and Beardslee Sloughs entering South Bay. Unidentified patches of seagrass or fish? Location: Hwy 105 bridge (Grays Harbor), 11:24 AM.

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Long debris line along sandbar in mouth of Willapa Bay.

Location: North of Leadbetter Point State Park (Willapa Bay), 11:30 AM.

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Schooling fish along shallow sandbar.

Location: South of Tokeland (Willapa Bay), 11:32 AM.

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Schooling fish along shallow sandbars surrounded by seabirds (white little dots, hard to see).
Location: South of Tokeland (Willapa Bay), 11:33 AM.



Flight log

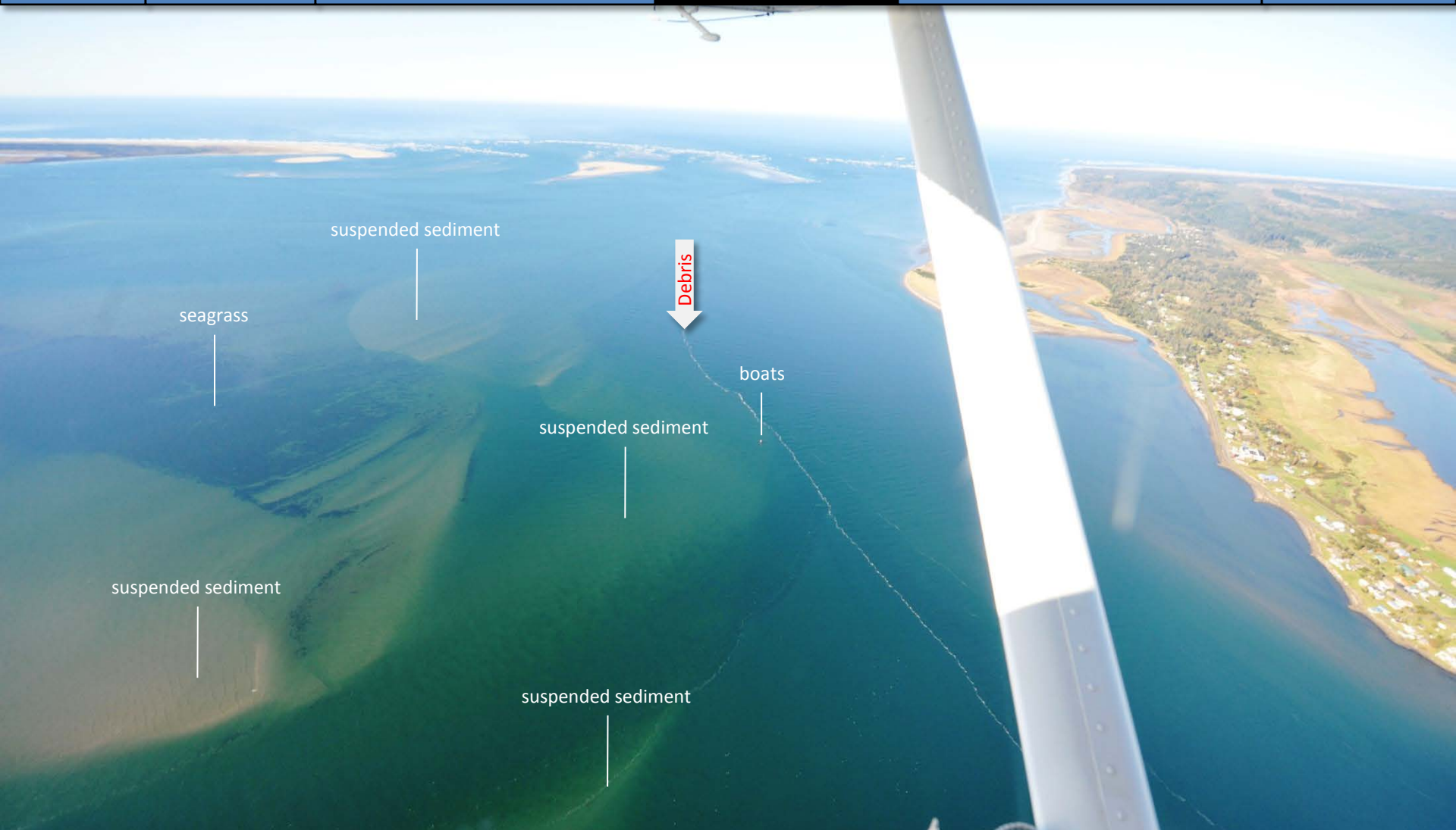
Weather

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Mooring



Long debris line. Green water originating from south and lined by re-suspended sediment flowing past Tokeland. Location: South of Tokeland (Willapa Bay), 11:35 AM.



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Mooring



Pattern of shellfish farming on flooded mud flats. Large suspended sediment cloud and debris lines. Location: Off Bone River (Willapa Bay), 12:04 PM.



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Tidally suspended sediment spilling out of Shoalwater Bay during ebb tide. Location: Willapa National Wildlife Refuge (Willapa Bay), 1:35 PM.



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One of many unexplained large clouds of suspended sediment in shallow water.
Location: Jensen Point, a sand spit on west side of Long Island (Willapa Bay), 1:37 PM.

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Red-brown algae bloom in Palix River near Bay Center.
Location: Palix River, US 101 bridge (Willapa Bay), 1:44 PM..



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Red-brown algae bloom, suspended sediment, vegetation alteration, and red water color on flats across from Willapa Harbor Airport. Location: Willapa River (Willapa Bay), 1:49 PM.



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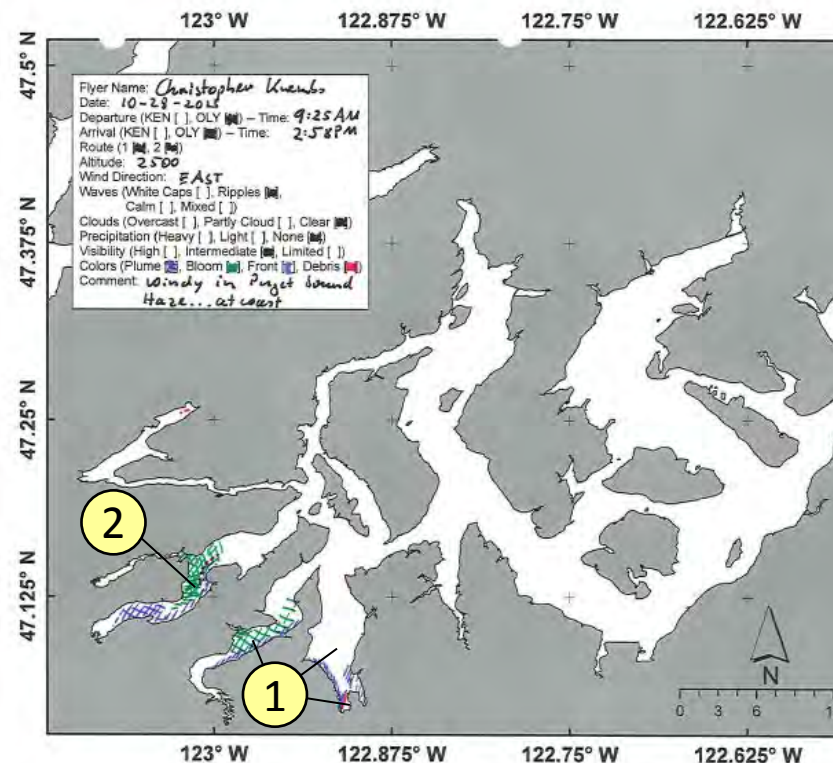
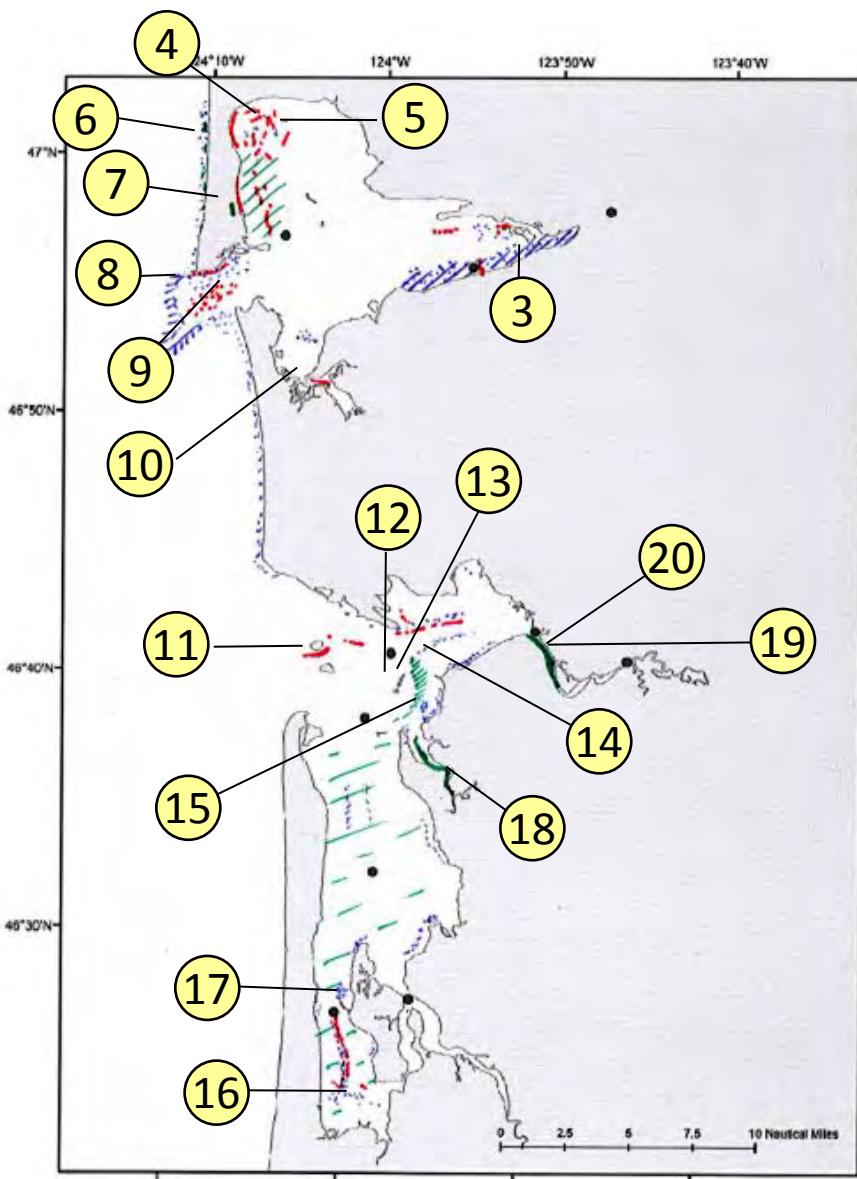


Red-brown algae bloom, suspended sediment, vegetation alteration, and red water color on flats across from Willapa Harbor Airport. Location: Willapa River (Willapa Bay), 1:49 PM.



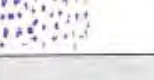






Aerial photography in S. Sound and Coastal Bays

[Navigate](#)


Date: 10-28-2013



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 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.

A cost-effective collaboration with the Victoria Clipper IV has provided an unique insight into surface processes that affect Puget Sound water quality!



Brandon Sackmann

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[Start here](#)

Engine Room



Bridge



Water Quality Sensors

Victoria Clipper IV:

1. 132 feet long, 33.3 feet wide
2. 30 knots top speed (among the fastest passenger vessels in Western Hemisphere!)
3. Water jet propulsion system
4. Seattle-to-Victoria in 2 hrs 45 min; 1-2 trips daily
5. Holds 330 passengers
6. Vessel operates year-round, except for 2 weeks in January (for dry dock operations)
7. Water quality sensor suite installed in May 2010



Victoria Clipper IV



Victoria Clipper IV Leaving Elliott Bay

“A Norwegian boat with German engines, Swedish waterjets, and an American crew going to Canada”
-- Capt. Jason Mihok ([Read more](#))

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

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Satellite Remote Sensing in Puget Sound

-- Some days are easier than others --

2013 was the third worst October period on record for fog!

[Read more](#)

MODIS-Aqua True Color
20 October



finally

MODIS-Aqua True Color
29 October



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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Long-Term Monitoring Network

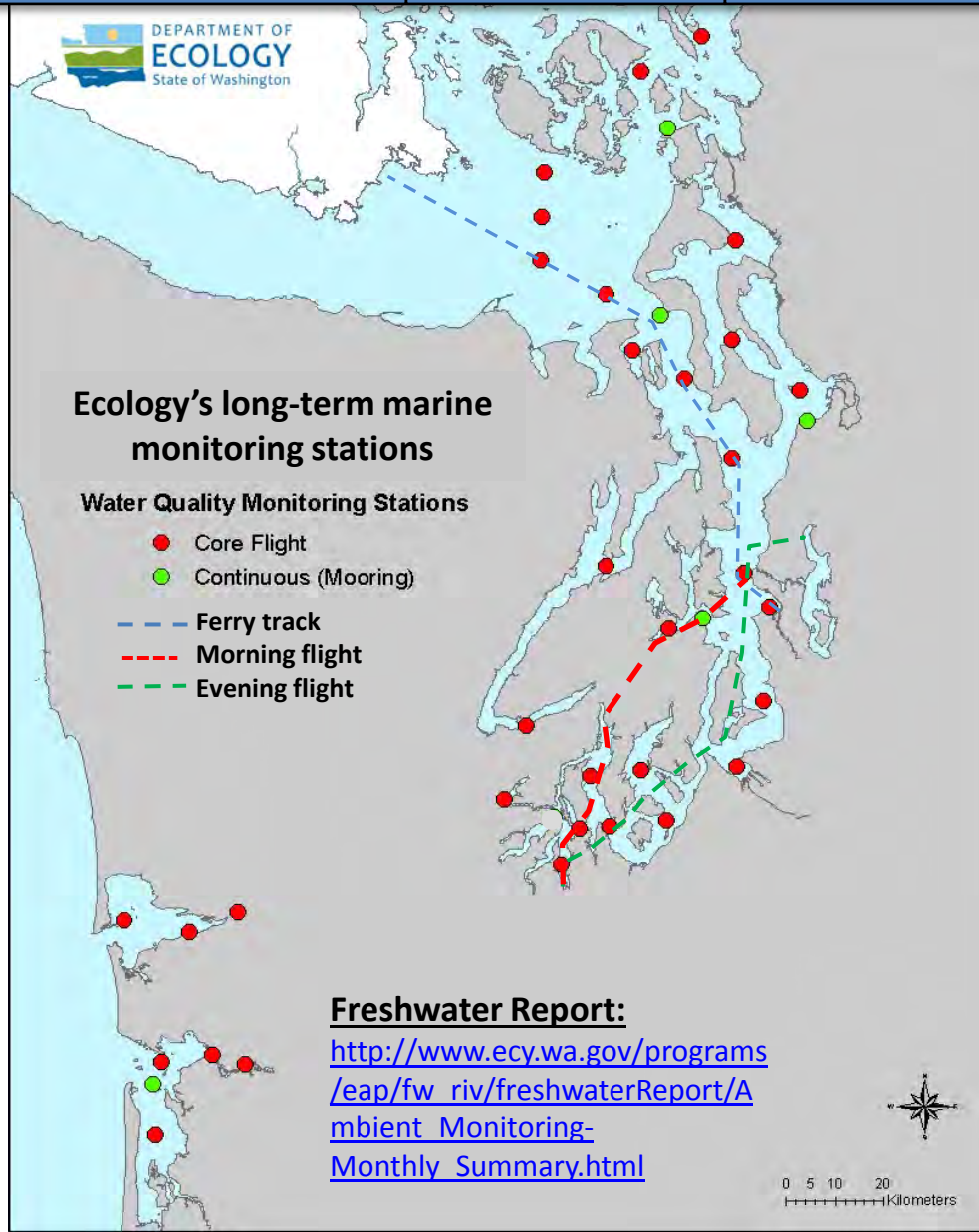


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Access core monitoring data:

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



Freshwater Report:

http://www.ecy.wa.gov/programs/eap/fw_riv/freshwaterReport/Ambient_Monitoring-Monthly_Summary.html

Real-Time Sensor Network



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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>



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We are looking for feedback to improve our products.

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Marine Monitoring Unit
Environmental Assessment Program
WA Department of Ecology

