Publication No. 14-03-072

DEPARTMENT OF ECOLOGY State of Washington

Eyes Over Puget Sound

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

Surface Conditions Report

April 21, 2014

Start here

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

Marine conditions from 4-21-2014 at a glance

LONG-TERM MARINE MONITORING UNIT

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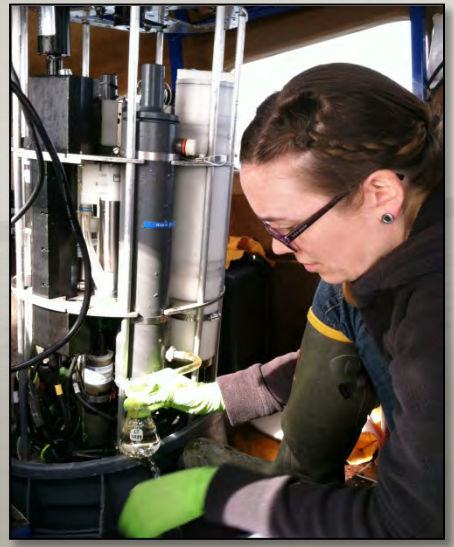
Guest: Dr. Brandon Sackmann, Integral

Previous Eyes Over Puget Sound reports: www.ecy.wa.gov/programs/eap/mar_wat/eops/

The Life of a Dissolved Oxygen Sample

In addition to sensor data from our CTD, we also collect water samples from several depths for laboratory analysis. One type of sample collected is for measuring dissolved oxygen (DO), used to verify the readings obtained from the DO sensor.



Sample Collection

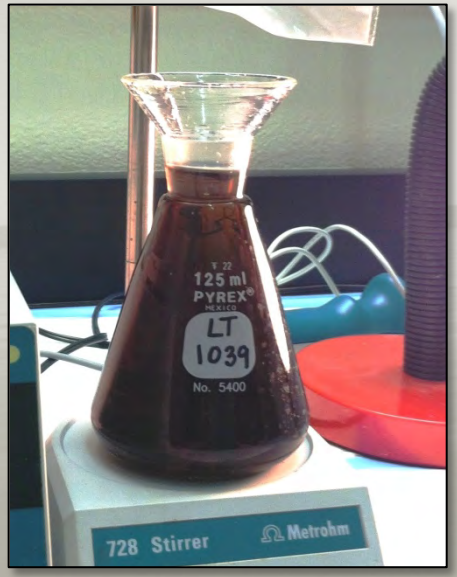
Adding Chemicals

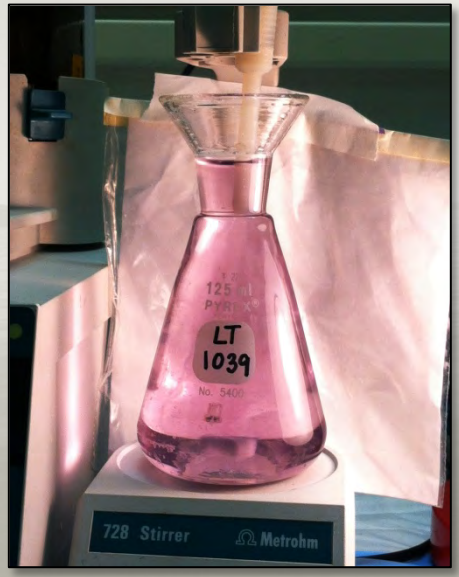
Sample Ready for Analysis

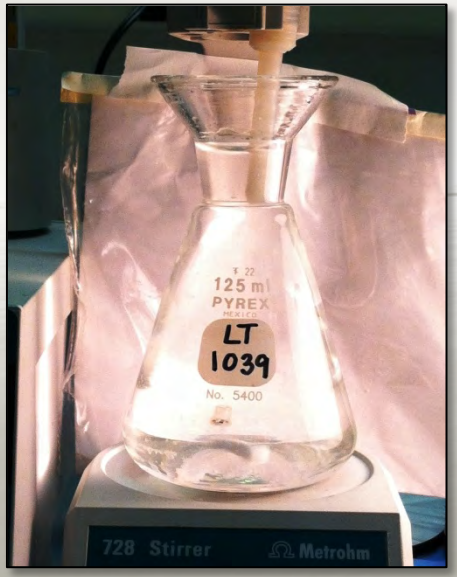
The water is collected into a flask from the Niskin bottle, being careful not to introduce bubbles. Two different chemicals are added to the water sample to bind the dissolved oxygen with manganese. A pale solid material forms and will eventually settle to the bottom of the flask. The sample is brought back to the lab for analysis.

The Life of a Dissolved Oxygen Sample

Back at the lab, we use a titration method to determine the oxygen content of the water. Iodine is produced through a controlled chemical reaction that equals the amount of oxygen in the sample. We can then measure the iodine using a colored indicator to find out how much dissolved oxygen was in the water.







First, acid dissolves the solid. Then, starch binds to iodine which turns the sample a deep blue so we can easily see the color change.

A neutralizing chemical is slowly added that makes the deep blue color disappear.

When the sample is “crystal clear” we can calculate how much iodine and thus, dissolved oxygen was in the sample.

Weather of the past two weeks before 4-21-2014

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:

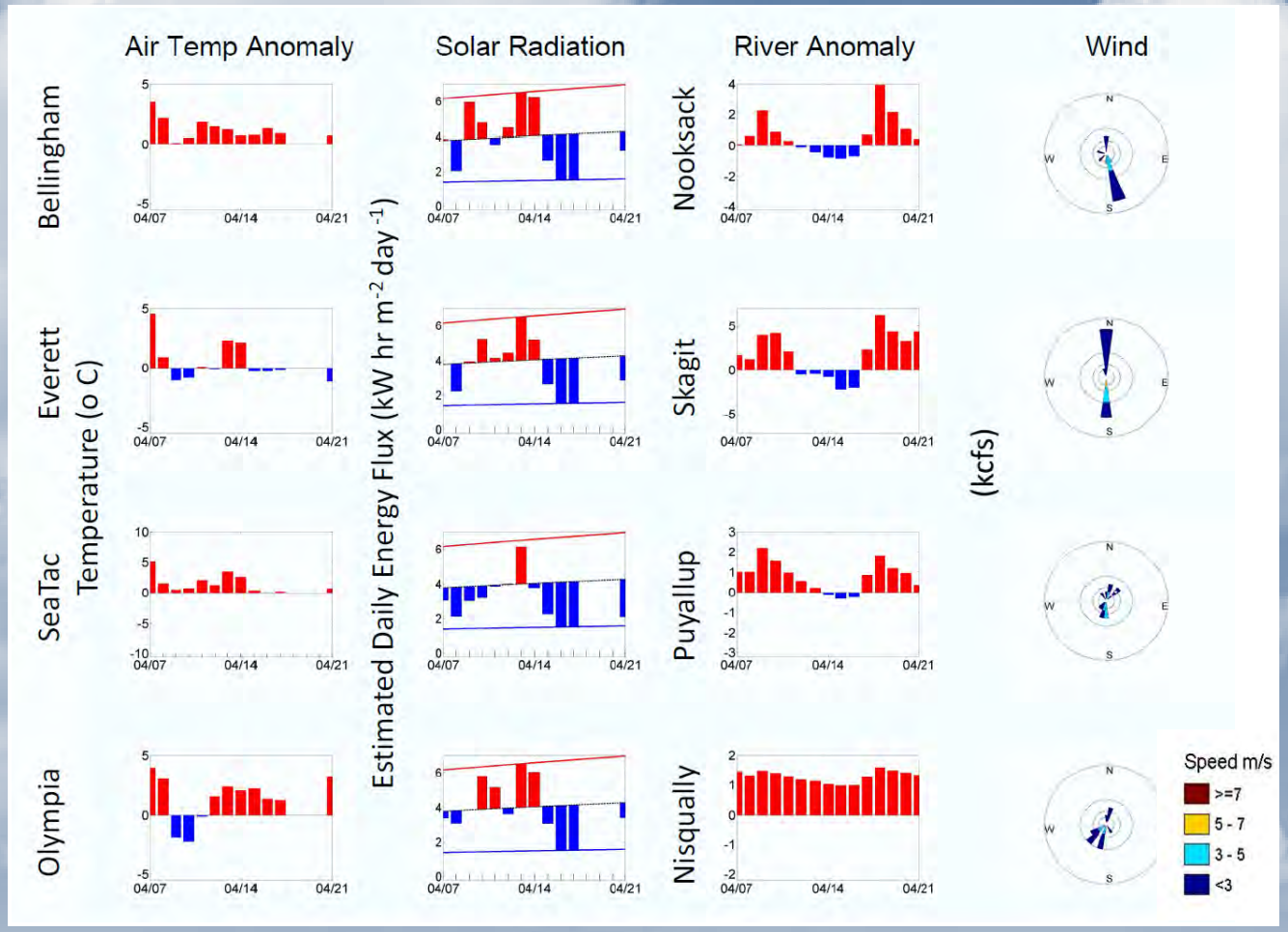
Air temperatures. Daily air temperatures have been slightly above normal.

Sunshine levels were higher the previous week and then lower this week.

River flows have been above normal.

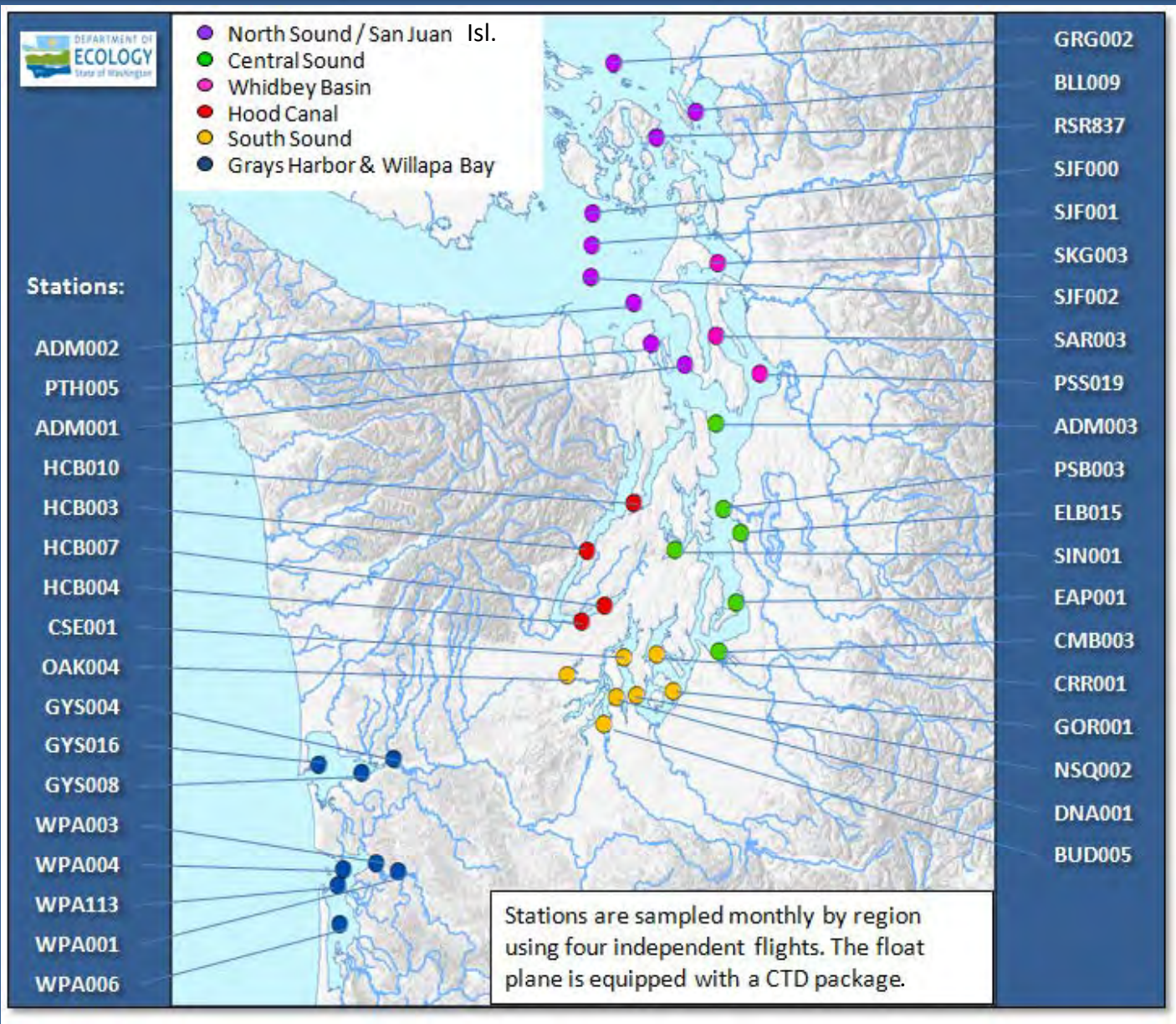
Winds have alternated between northerlies and southerlies. Marine air diverges north of Everett, resulting in north wind at Everett and south wind at Bellingham.

- Higher than expected
- Lower than expected



Moore et al. 2008. Local and large-scale climate forcing of Puget Sound oceanographic properties on seasonal to interdecadal timescales. Limnol. Oceanogr., 53(5), 1746–1758

Our long-term marine monitoring stations in Washington



We use a chartered float plane to access our monthly monitoring stations most cost effectively.

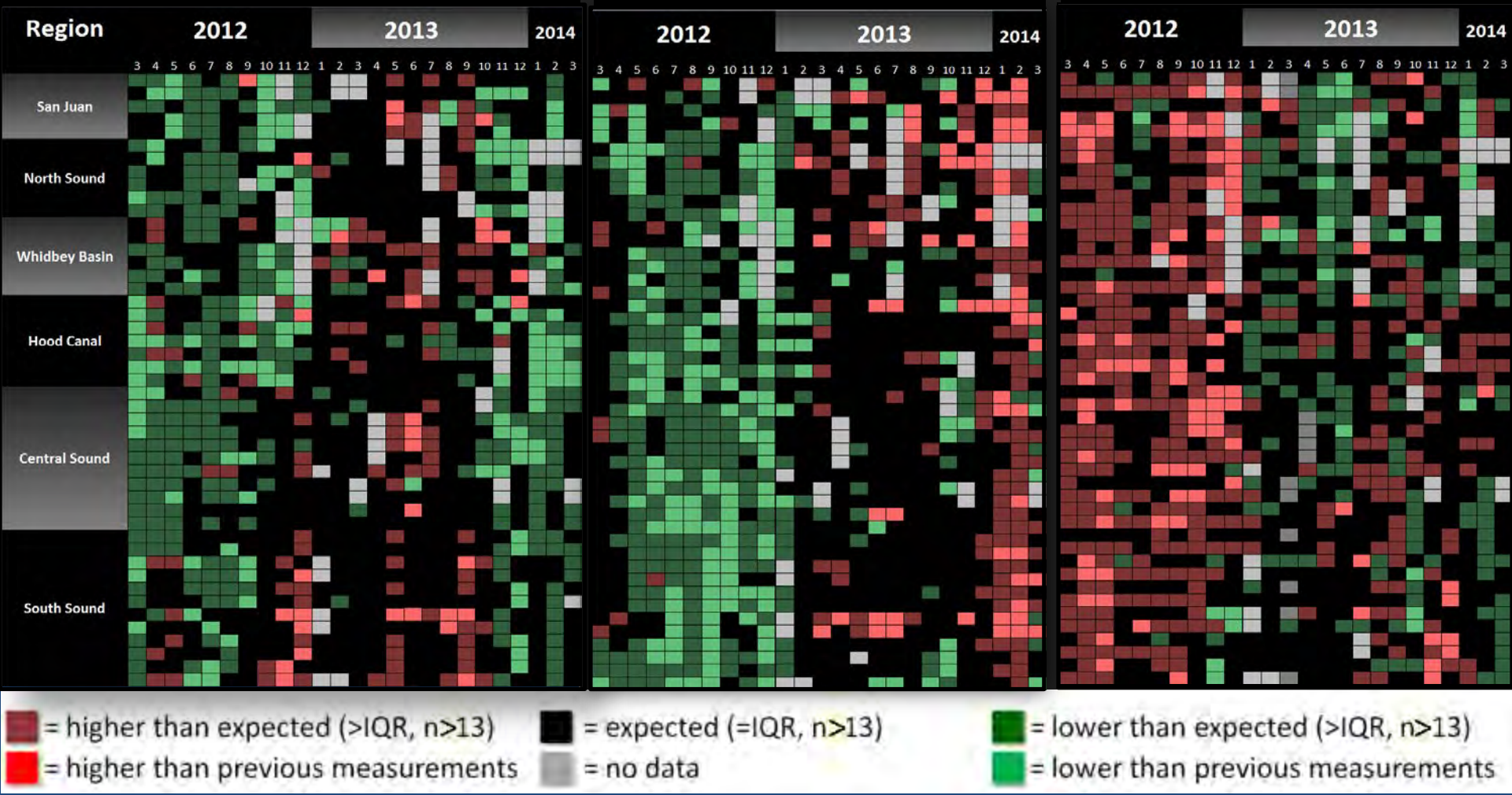
Start here

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**

Physical conditions tracked in statistically historic context

March 2014: Temperature lower Salinity higher Oxygen lower



The 2012 colder, fresher, higher oxygen conditions are gone. In 2013 Puget Sound was warmer, with normal salinity. Lower oxygen conditions appeared in the northern areas early in the year. In 2014, colder, saltier conditions are developing throughout Puget Sound. Oxygen is lower primarily in Whidbey Basin, Central and South Sound.

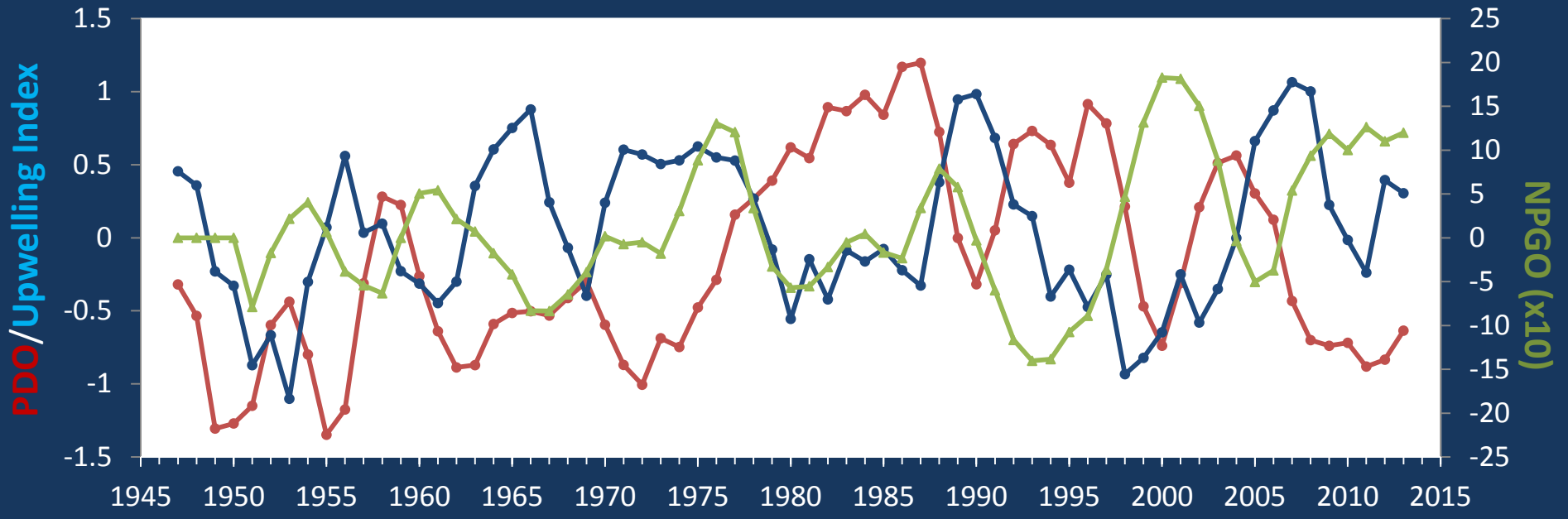
The ocean affects water quality: Ocean Climate Indices

a) *Pacific Decadal Oscillation Index (**PDO, temperature**)* *(explanation)*

b) *Upwelling Index (anomalies) (**Upwelling, low oxygen**)* *(explanation)*

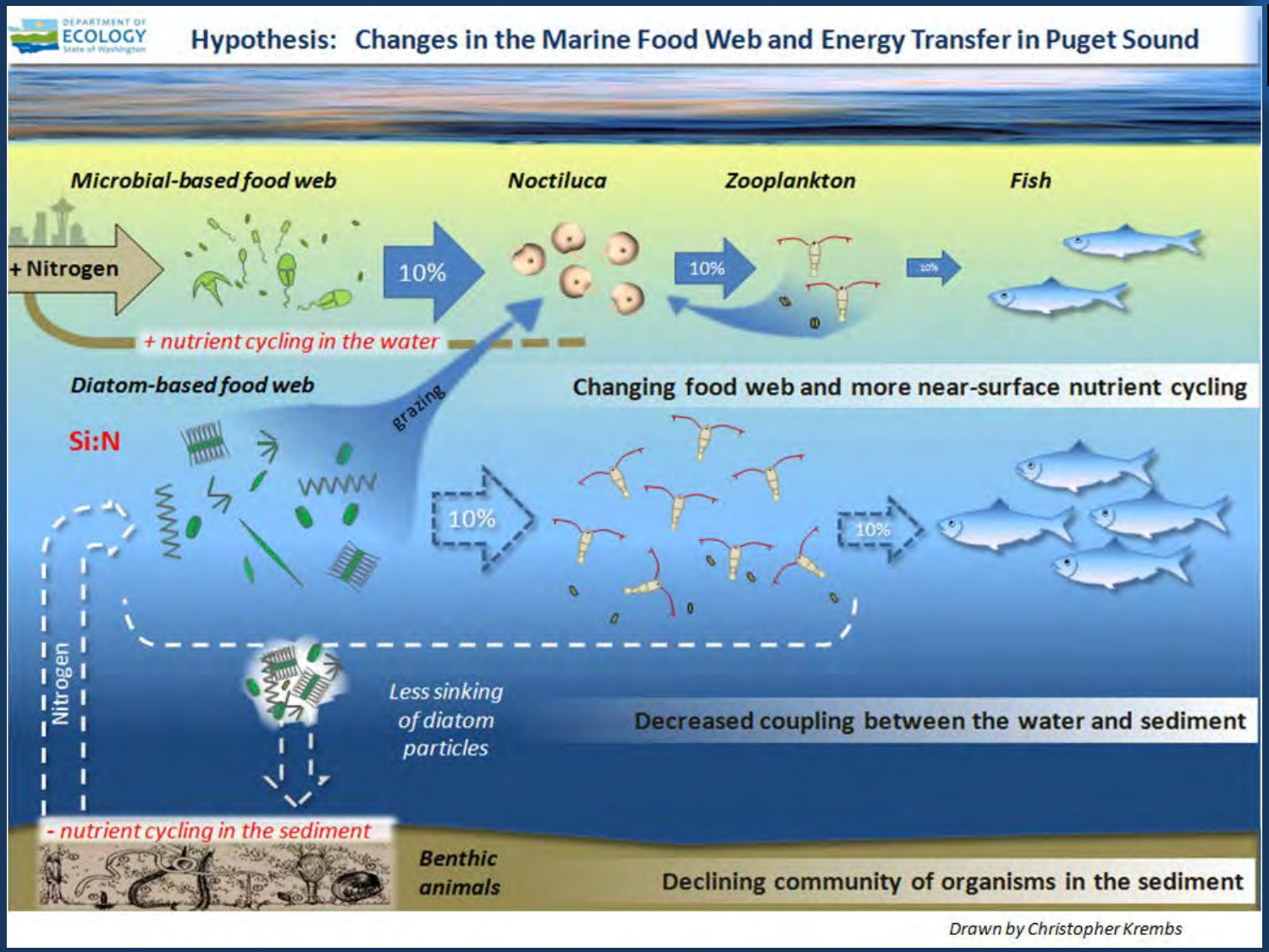
c) *North Pacific Gyre Oscillation Index (**NPGO, productivity**)* *(explanation)*

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?

Is the food web changing in Puget Sound?



Hypothesis!

Should we pay greater attention to nutrient ratios, energy transfer, and material cycling in Puget Sound?

Noctiluca blooms are a visible harbinger of a changing microbial food web in Puget Sound's waters.

[The story in 5 min]

[Explore the data]

[Follow the experts]

Summary: Aerial photography 4-21-2014

Blooms present in Whidbey Basin and isolated bays, otherwise very clear water. Sediment-rich water entering from Stillaguamish River after the Oso mudslide. Debris lines in Hood Canal and North Sound. Multiple oil sheens in Lake Washington Ship Canal. Many fronts.

Start here

Blooms of a different kind, tulips in Skagit

Green macro-algae mats, Saratoga Passage

Front

Mixing and Fronts: Click on numbers

Tidal fronts in Admiralty Reach and complex fronts in area between Bellingham Bay and Fidalgo Bay.

1 2 3 4 5 7 8 10 11 13 14 15 16 17

Jellyfish: Small patch seen only in East Sound.

Plume

Suspended sediment:

Subsurface suspended sediment around San Juan Islands. Port Susan and Stillaguamish River estuary have very high sediment loads. 7 8 15 17

Bloom

Visible blooms: 3 6 15 16

Clear water in many places, atypical for April!

Green-brown: Port Susan, Saratoga Passage, Possession Sound, Bellingham Bay

Red-brown: Kilisut Harbor, East Sound

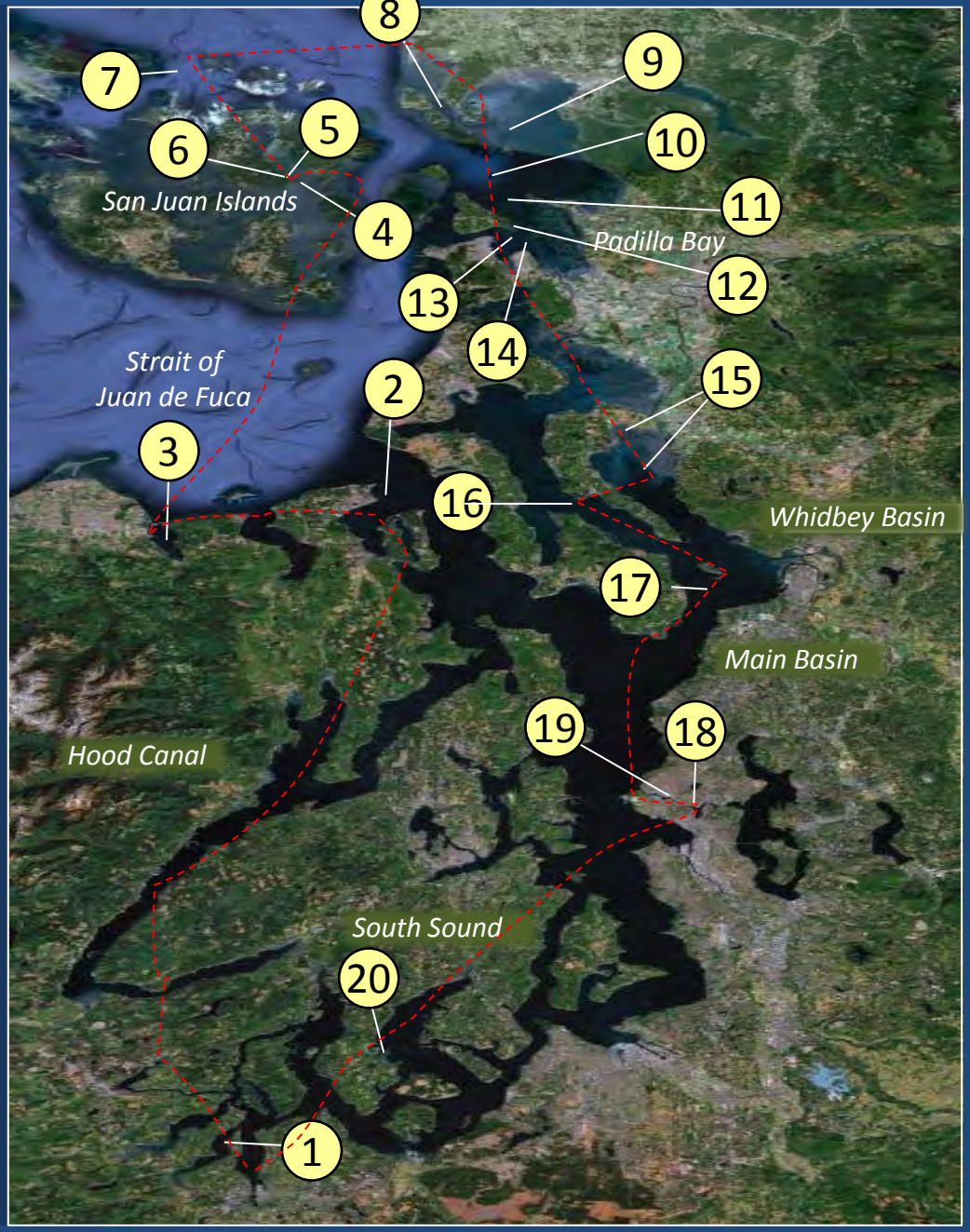
Near-shore green macro-algae abundant and increasing

Debris

Debris: 1 2 3 5 6 7 8 9 11 12 13 14 15

Abundant in Hood Canal, Sequim Bay, and Bellingham Bay to Padilla Bay. 16 17 20

Seattle Tides: H. tide: 9:30 AM 11:45 PM, , L. tide: 4:28 AM,4:27 PM



Aerial photography and navigation guide

Date: 4-21-2014

Click on numbers

Flight Information:

Morning flight, photos 1-6
Reduced visibility, haze

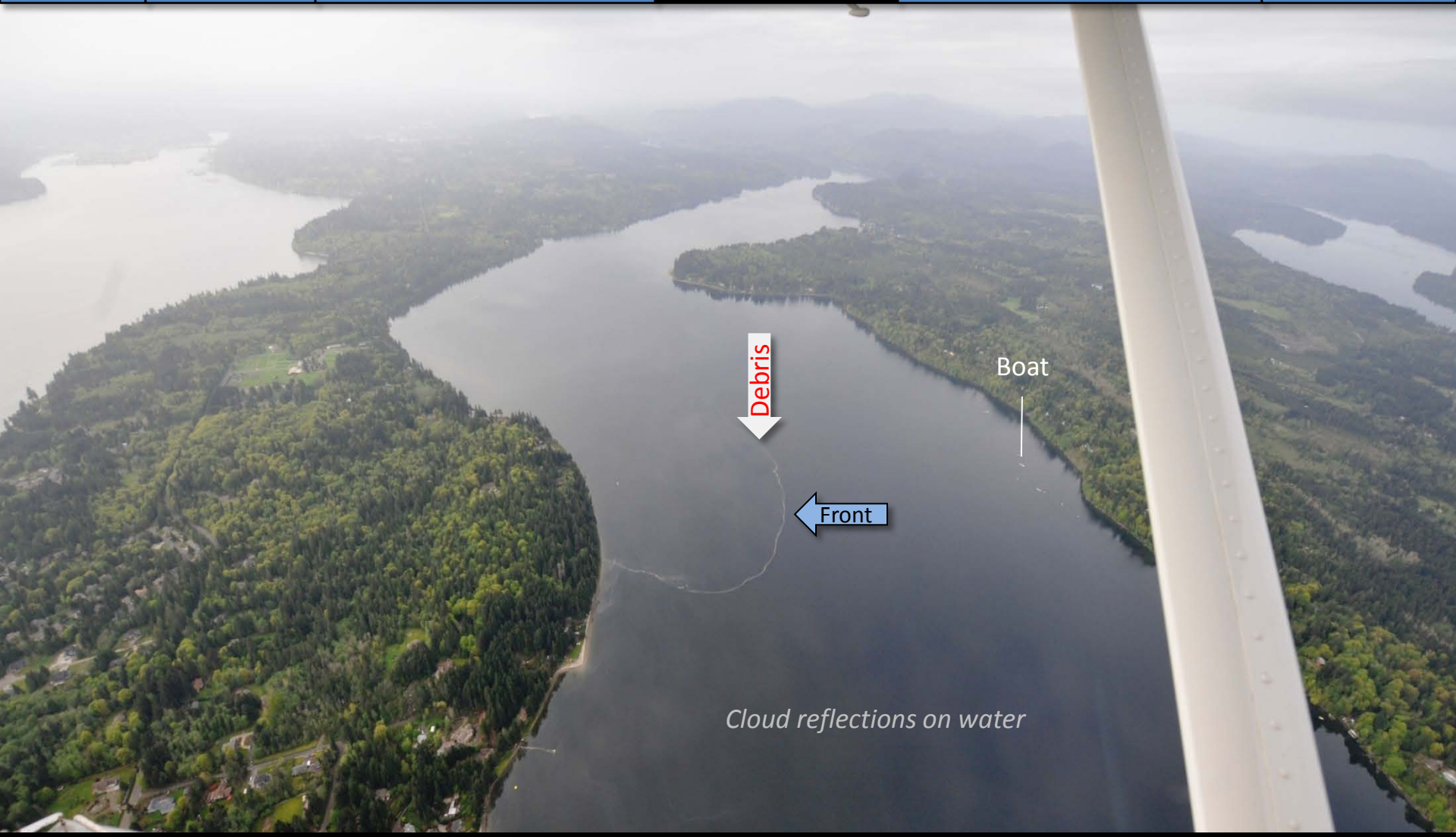
Afternoon flight, photos 7-20:
Reduced visibility, haze, and wind

– – – Flight route

Observation Maps:

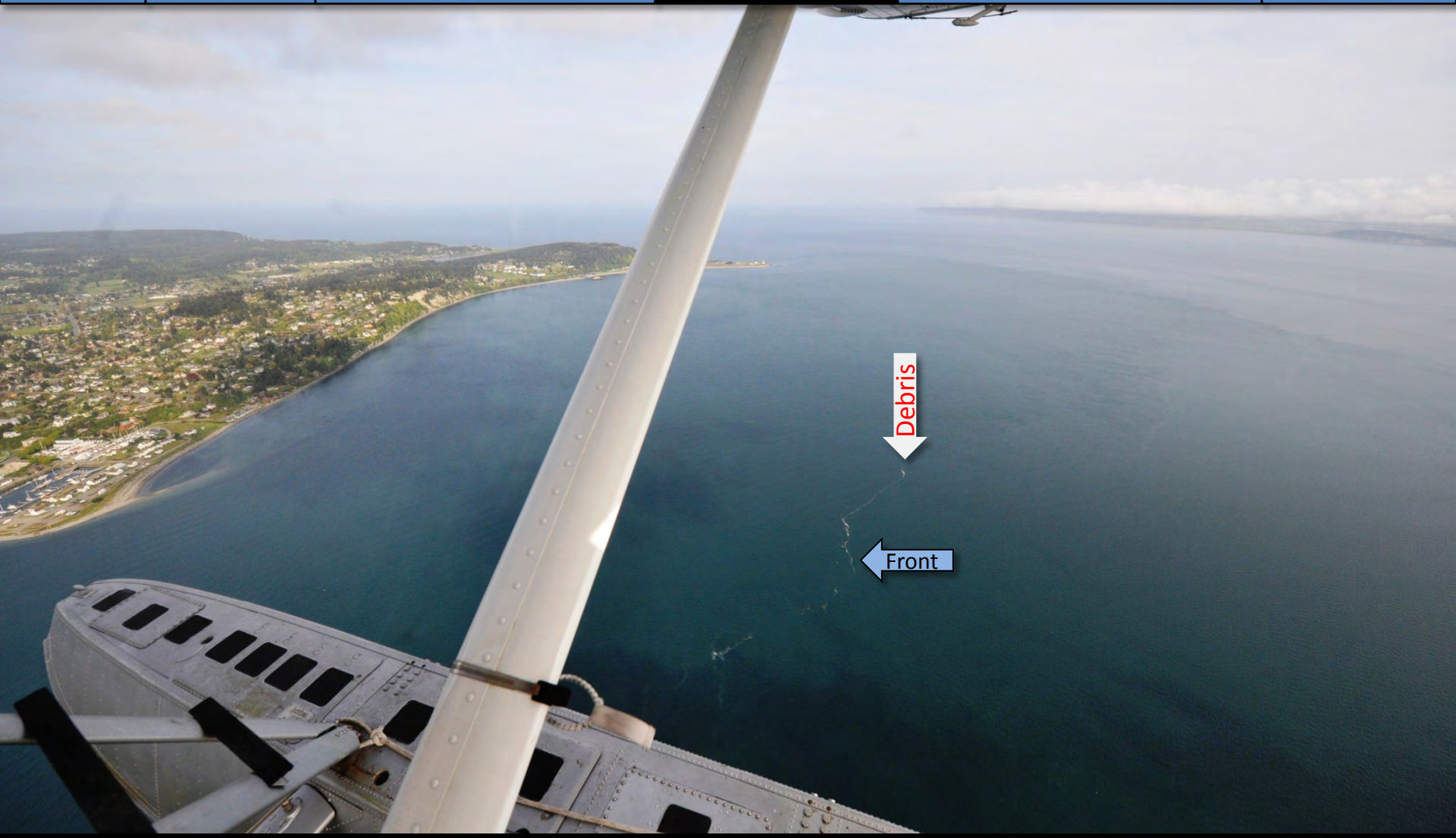
Central and North Sound

Hood Canal and South Sound



Debris line outlining surface flow on the eastern side of the bay during an outgoing tide.

Location: Eld Inlet (South Sound), 9:32 AM.



Debris line highlighting the separation of surface water from Admiralty Reach.

Location: Port Townsend, 10:09 AM.

Debris lines of organic material and a green-brown phytoplankton bloom.

Location: Sequim Bay (Strait of Juan de Fuca), 10:49 AM.

Subsurface mixing bringing turquoise water rich in silt towards the surface.
Location: North of Lopez Island, (San Juan Islands), 11:33 AM.

Suspended sediment

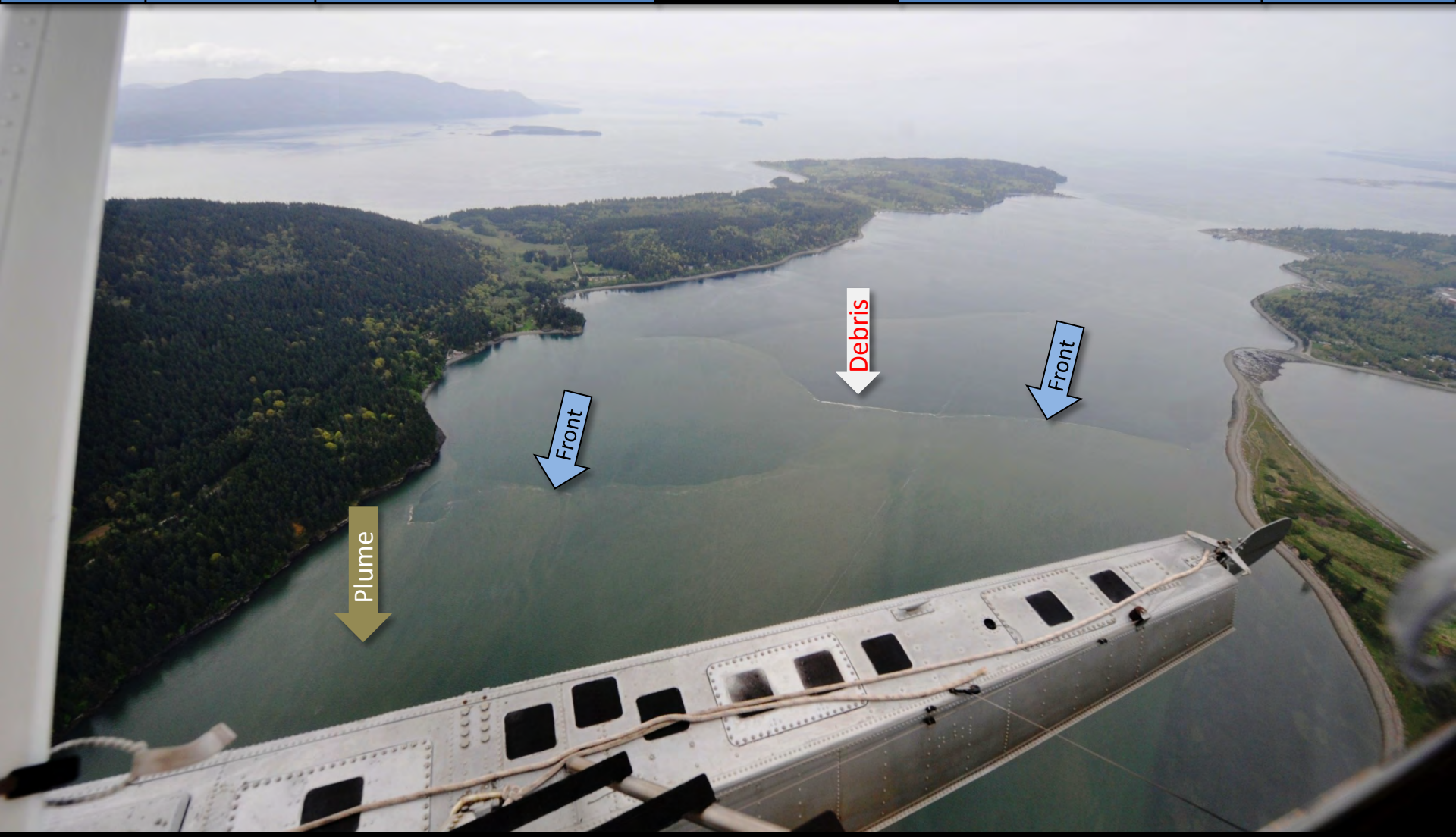
Red-brown bloom leaving East Sound on the southwestern side. Sun reflection in small bay.

Location: East Sound, Orcas Island (San Juan Islands), 11:34 AM.

Red-brown bloom leaving East Sound on the southwestern side. Debris line or organic material?

Location: East Sound, Orcas Island (San Juan Islands), 11:35 AM.

Sediment-rich water billowing through very clear water to the surface during outgoing tide. (Secchi depth 15m) Location: Haro Strait (San Juan Islands, Georgia Basin), 12:25 PM.



Sediment-rich water from Bellingham Bay with several front lines .

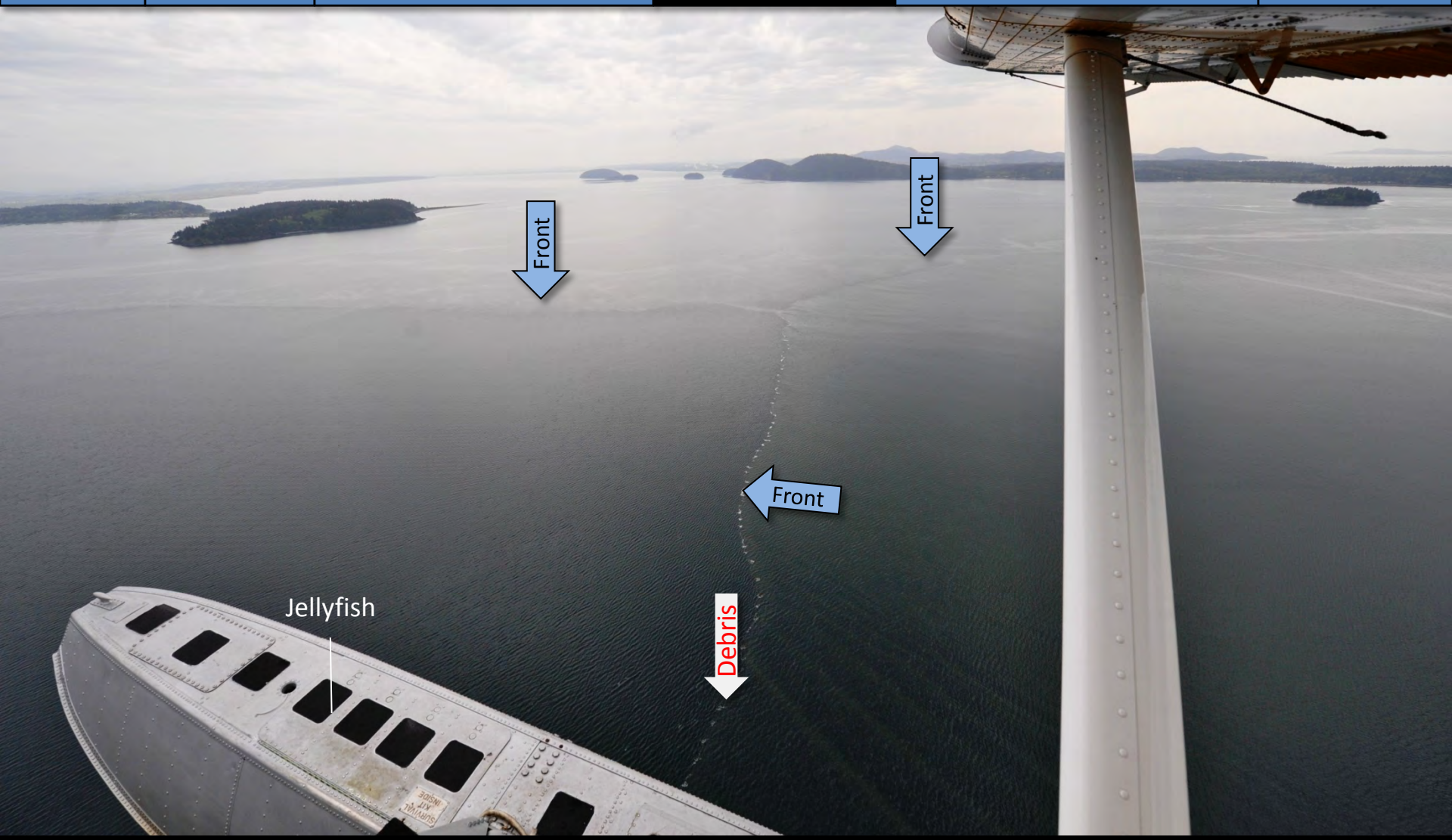
Location: Between Lummi Island and Portage Bay (North Sound), 12:34 PM.

Long lines of organic surface debris and sediment-rich water.
Location: Bellingham Bay (North Sound), 1:33 PM.

Front with multiple fine lines bordering clearer water.

Location: Vendovi Island (Samish Bay), 2:05 PM.

Aerial photography 4-21-2014



Multiple fronts converging, illustrating the regionally complex structure of surface water.

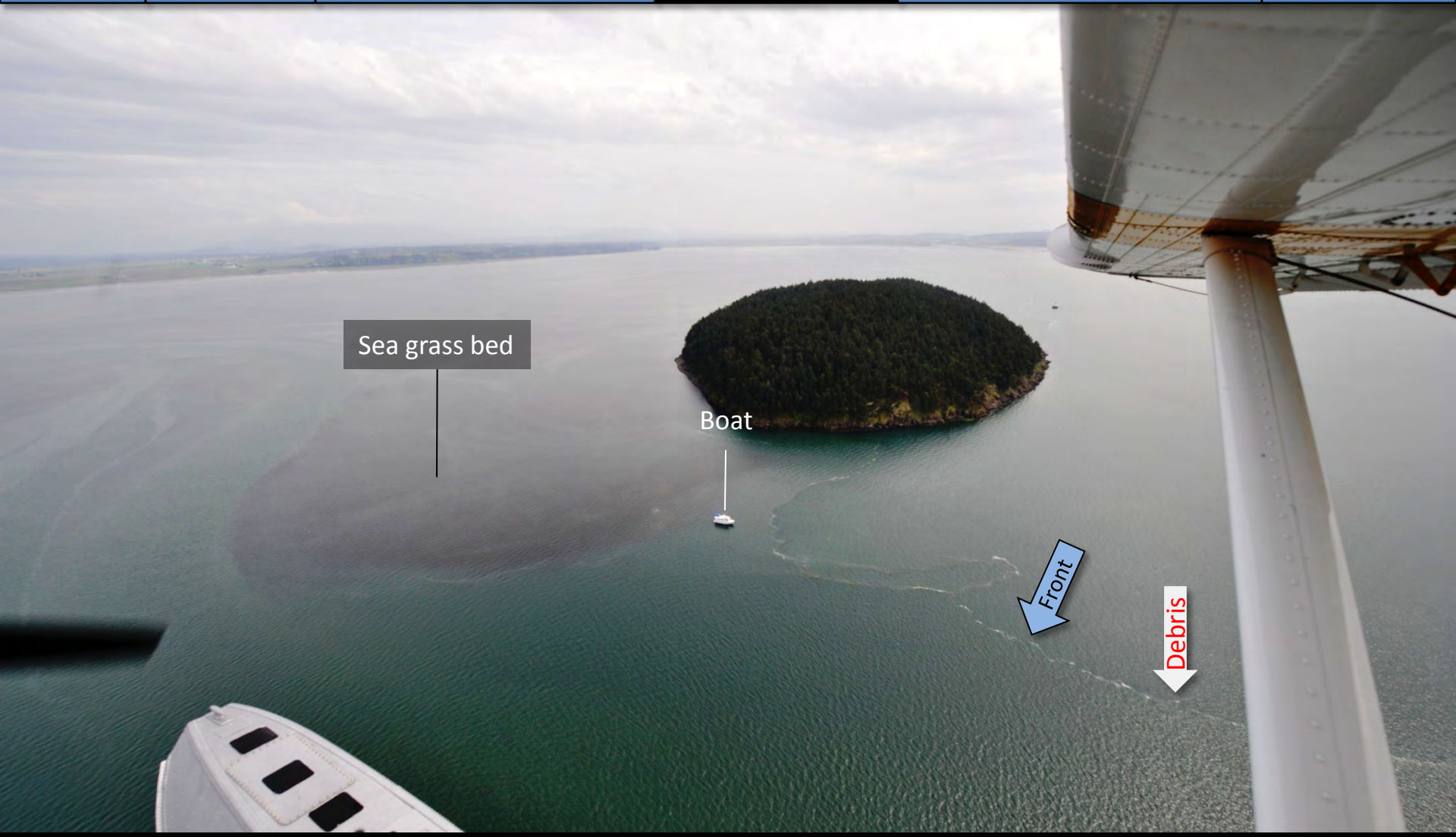
Location: Between Samish and Guemes Island (North Sound), 2:06 PM

Aerial photography 4-21-2014

Sediment-rich water mixed to the surface by tidal currents, large organic debris patches.

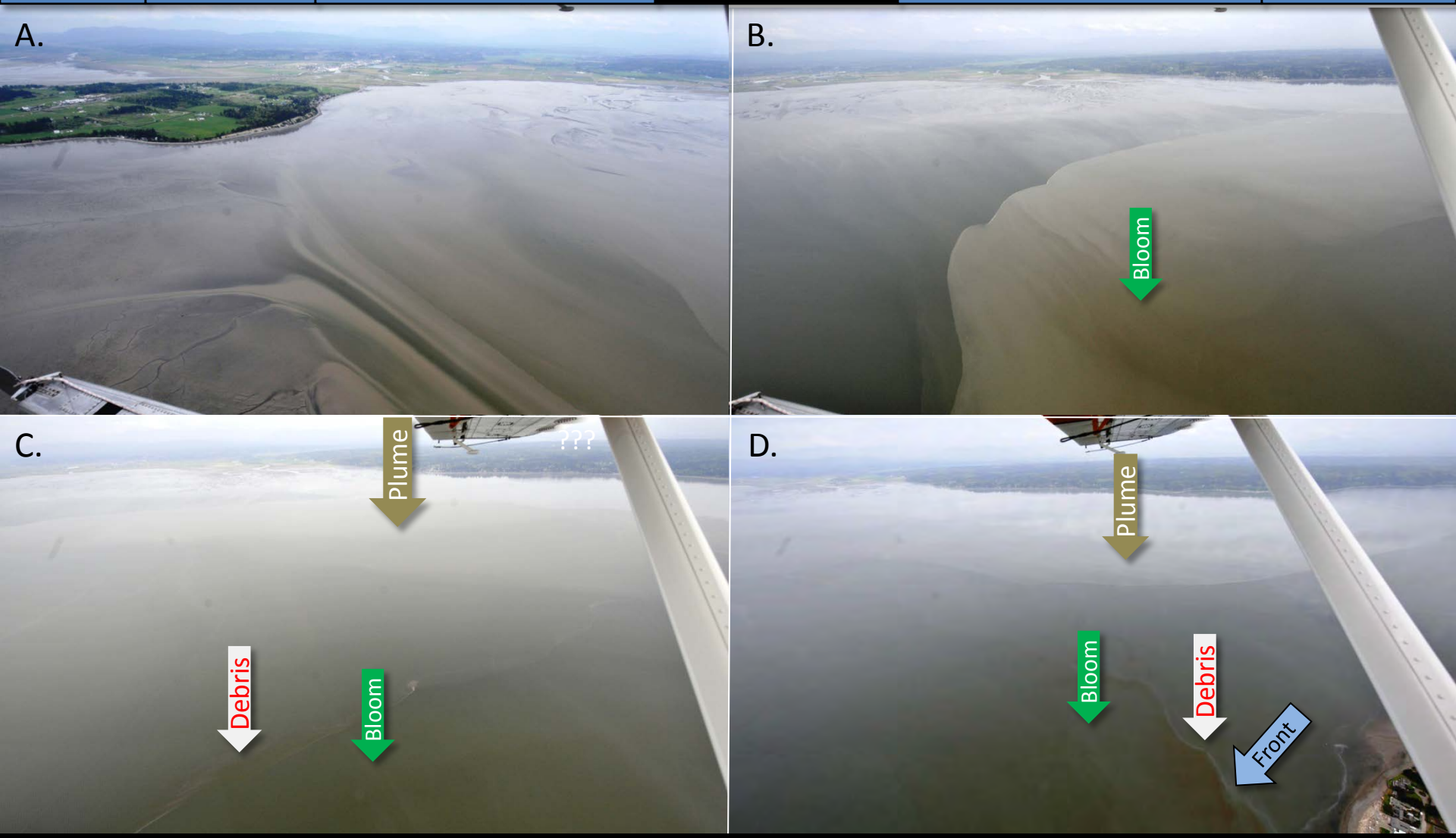
Location: Northeastern tip of Guemes Island (North Sound), 2:09 PM

Multiple fronts converging and illustrating the regionally complex structure of surface water.
Location: Between Fidalgo Bay, Padilla Bay and Guemes Channel (North Sound), 2:10 PM.



Shallow beds of sea grass near a structured front with debris lines.

Location: Hat Island, Padilla Bay (North Sound), 2:31PM.

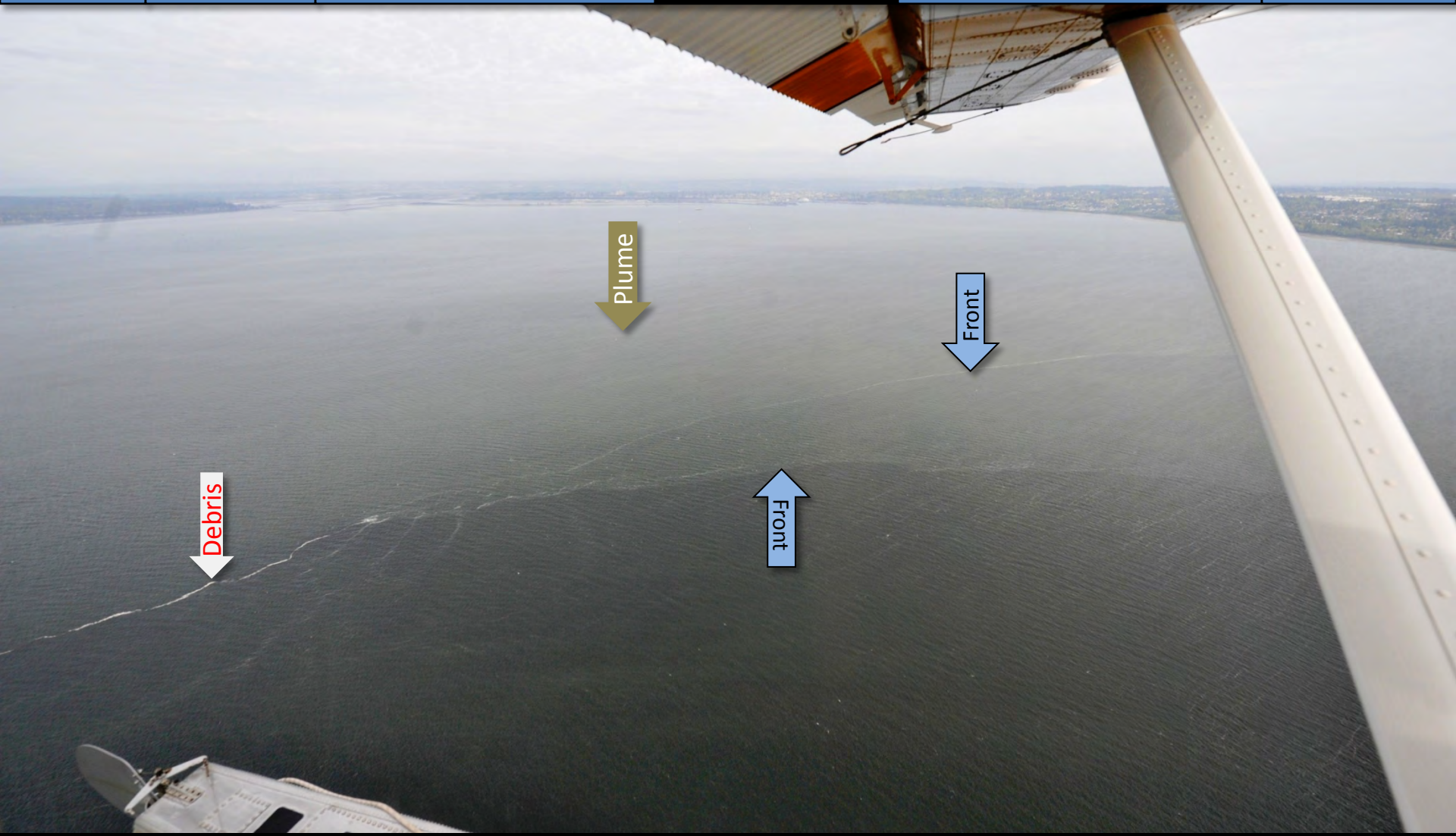


Large amounts of suspended sediment mixed in with phytoplankton bloom and debris.

Location: A. Livingston Bay, B-D. Stillaguamish River sediment plume, Port Susan (Whidbey Basin), 3:10 PM.

Golden brown algal bloom and surface water flowing southward forming a tidal front.

Location: Looking across Elgar Bay, Saratoga Passage (Whidbey Basin), 3:16 PM.



Sediment-laden water and different water mass with golden brown bloom meeting in Possession Sound.
Location: Possession Sound (Whidbey Basin), 4:41 PM.

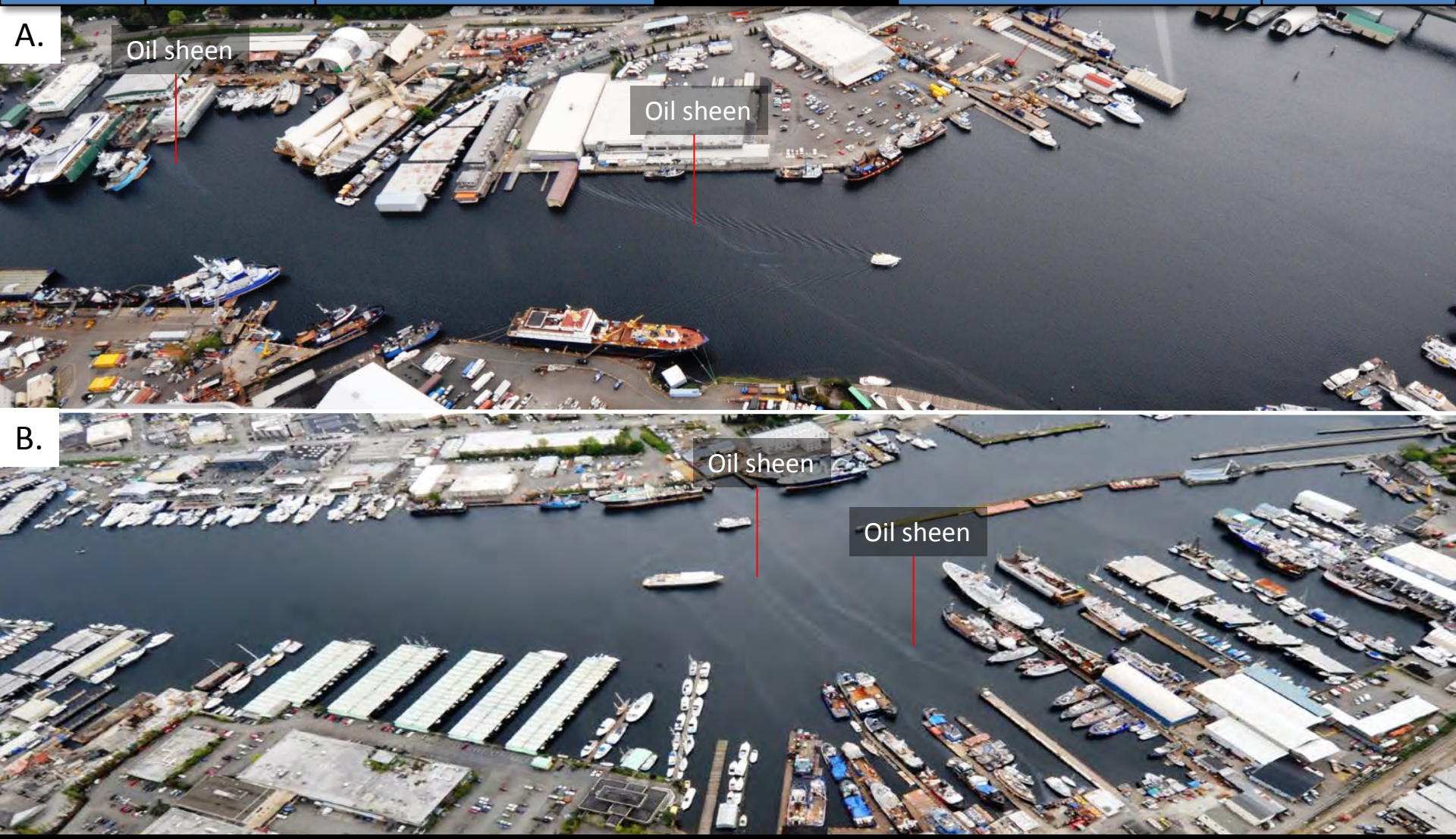
A.

B.

Reported oil sheen between docked boats and ships.

Location: A. West of Gas Works Park, Lake Union; B. Lake Washington Ship Canal (Seattle), 5:16 PM.

Aerial photography 4-21-2014



Reported multiple oil sheens located between docked boats and ships.

Location: A. Lower Queen Anne Ship Canal; B. Salmon Bay (Seattle), 5:17 PM.

Aerial photography 4-21-2014

Green macro-algae developing into large mats on nearby beaches.

Location: Mayo Cove and South Head (Carr Inlet), 5:35 PM.

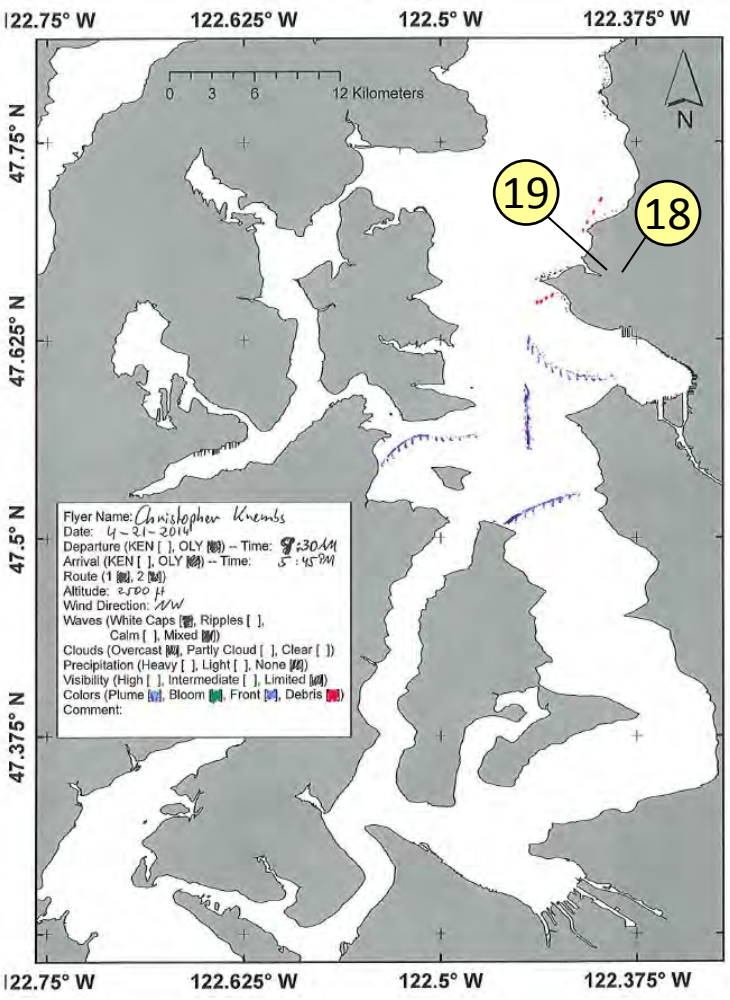
DEPARTMENT OF ECOLOGY State of Washington

Observations in Central and North Sound

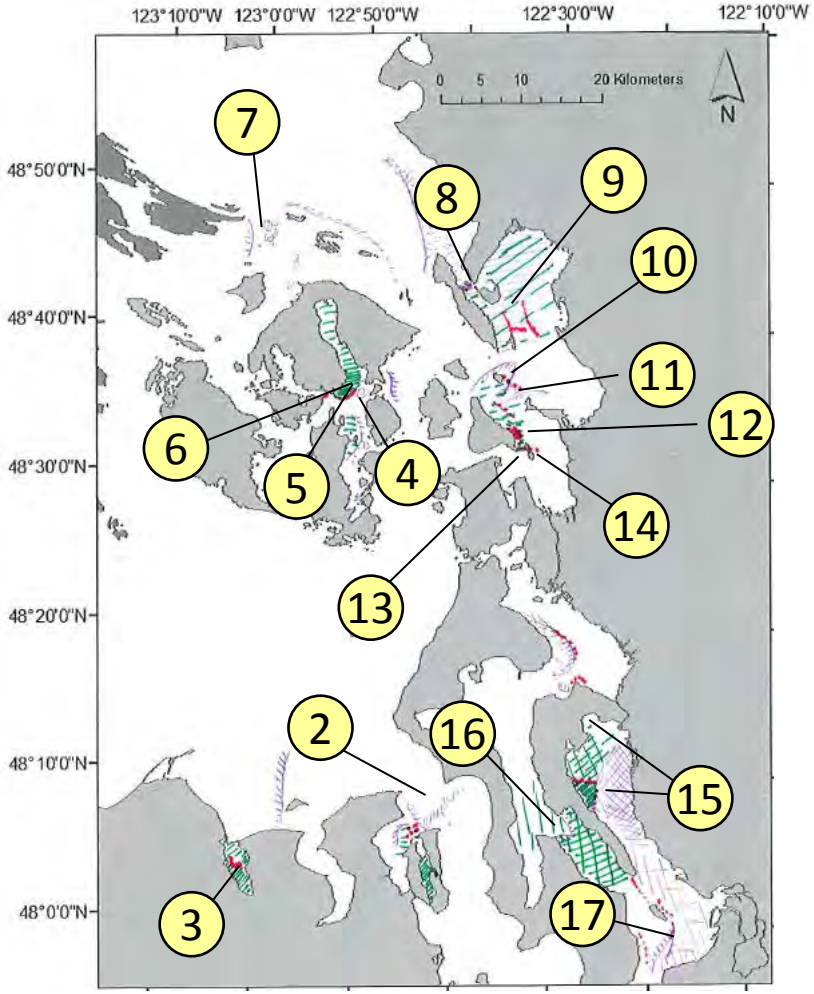
Navigate

Date: 4-21-2014

Central Sound



North Sound/San Juans



Numbers on map refer to picture numbers for spatial reference

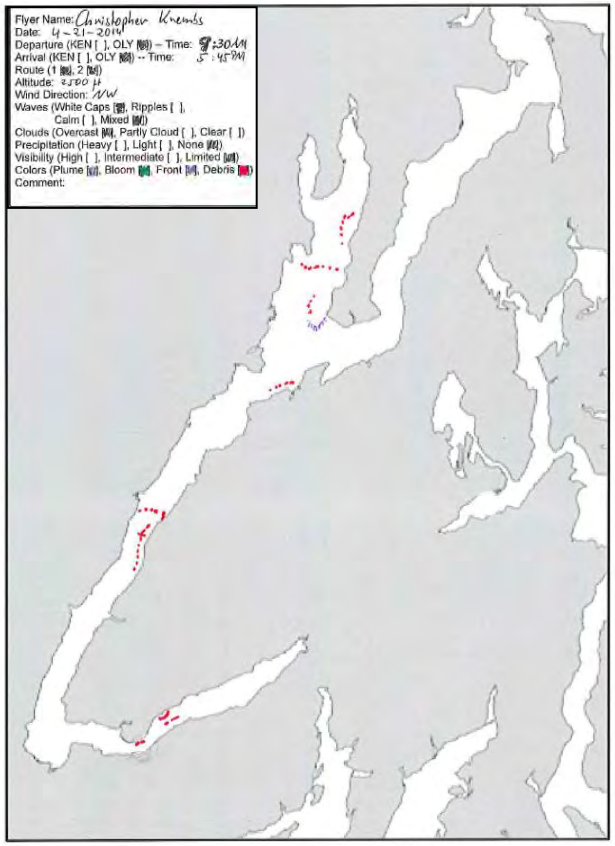
DEPARTMENT OF ECOLOGY State of Washington

Observations in Hood Canal and South Sound

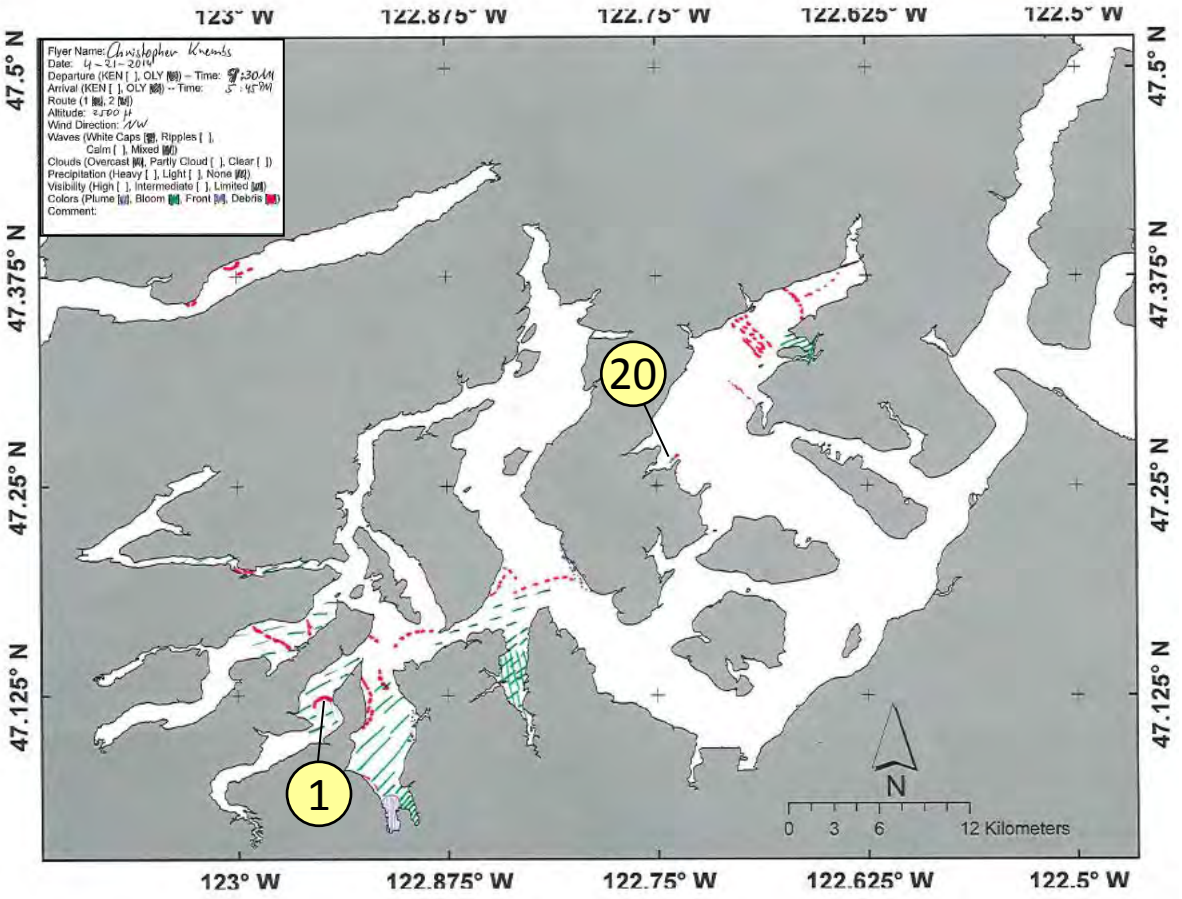
Navigate

Date: 4-21-2014

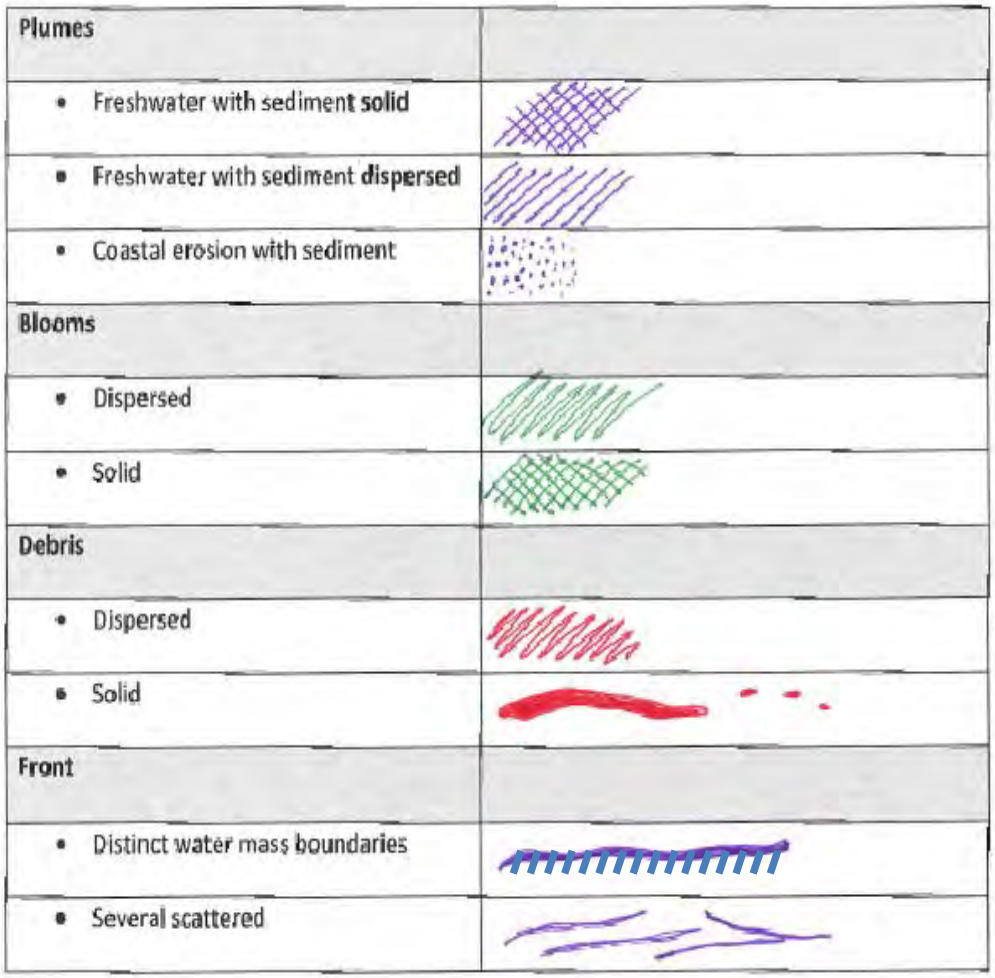
Hood Canal



South Sound



Numbers on map refer to picture numbers for spatial reference



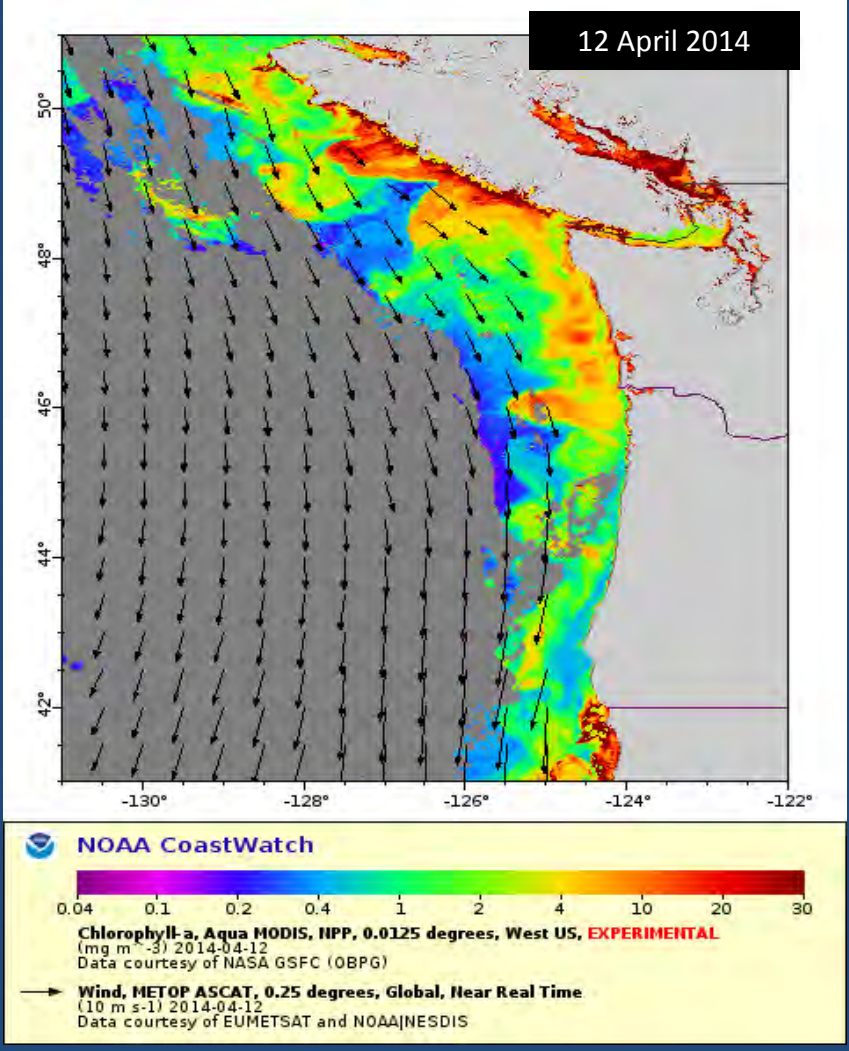
Comments:
Maps are produced by observers during and after flights. They are intended to give an approximate reconstruction of the surface conditions on scales that connect to and overlap with satellite images in the section that follows.

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.

Guest: Ferry and satellite observations 4-21-2014

Upwelling-favorable conditions off the Washington coast stimulate a spring phytoplankton bloom!!!



Guest:
Brandon Sackmann
Contact: bsackmann@integral-corp.com

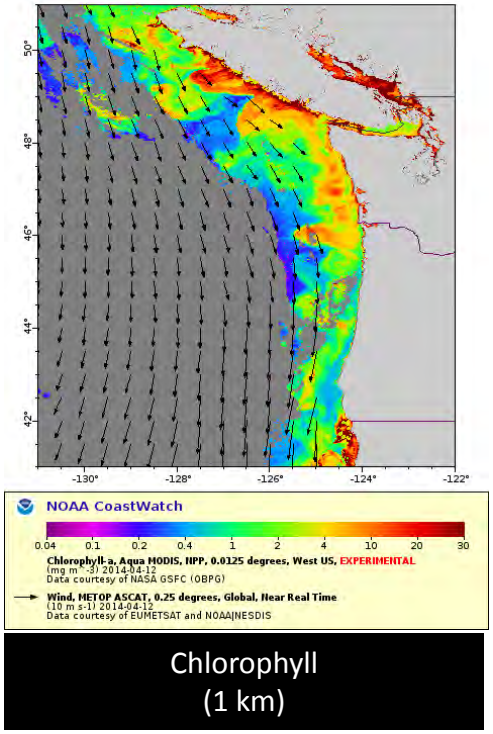
Start here

Victoria Clipper IV leaving Elliott Bay

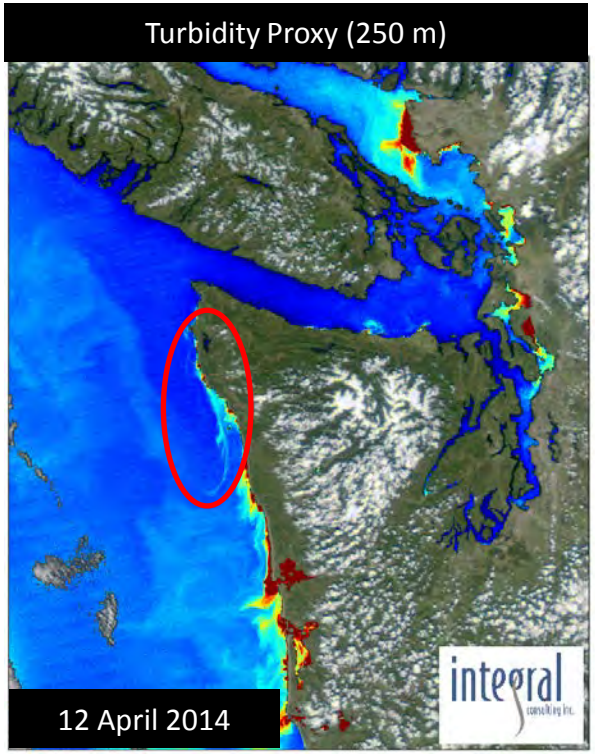
No *Victoria Clipper* data available – Hardware upgrades in progress!!!

Guest: Ferry and satellite observations 4-21-2014

In mid-April strong upwelling-favorable winds (blowing from north to south) helped to stimulate a large phytoplankton bloom off the Washington Coast.



Chlorophyll
(1 km)



High-resolution MODIS-Aqua true color and turbidity products reveal thin, turbid filaments that stretch and extend southward under the strong northerly winds

Future Focus of Mooring Operations

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

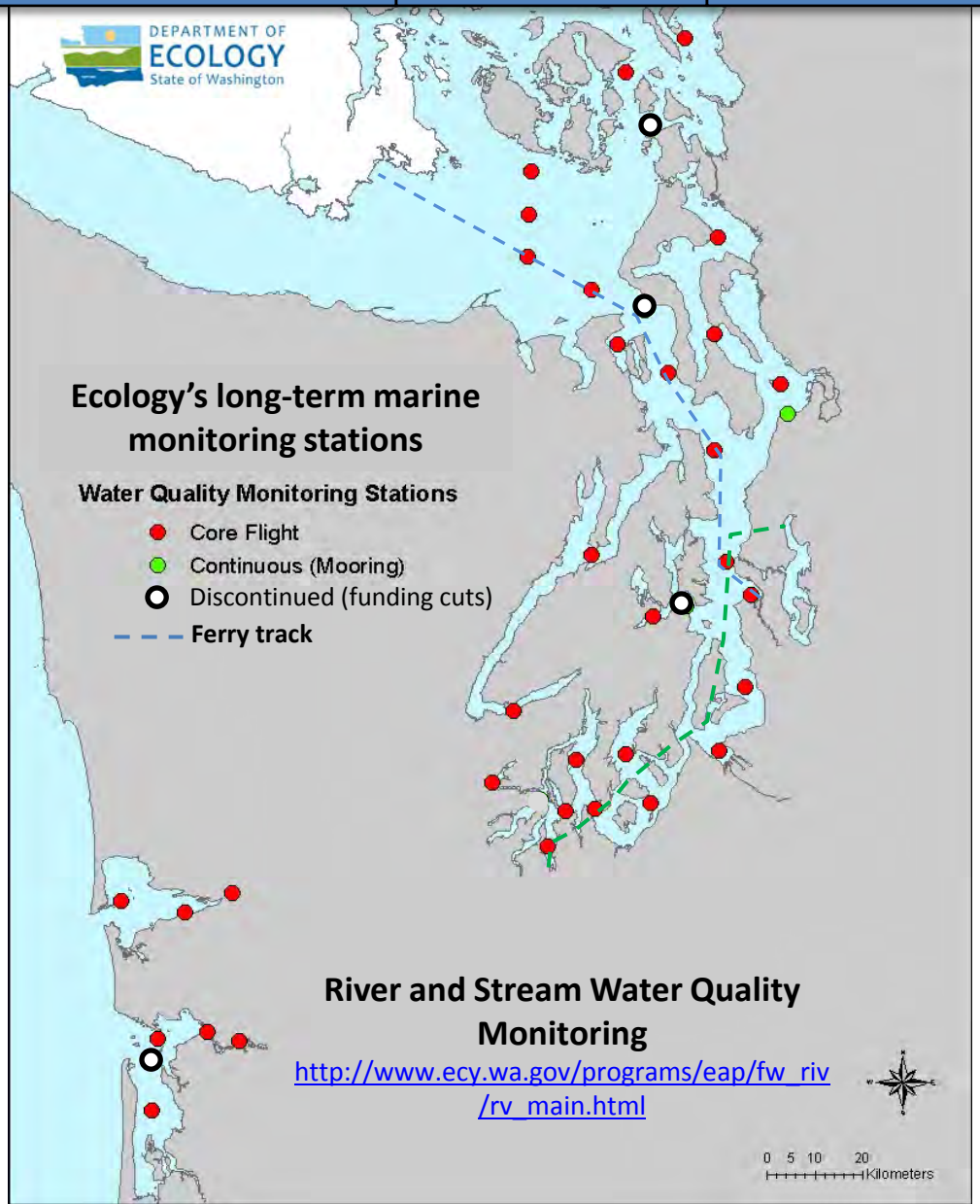
Flight log	Weather	Water column	Aerial photos	Ferry and Satellite	Moorings

Long–Term Monitoring Network

christopher.krembs@ecy.wa.gov

Access core monitoring data:

http://www.ecy.wa.gov/apps/eap/marinewq/mwdataset.asp



Real–Time Sensor Network

Suzan.Pool@ecy.wa.gov

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

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.