Publication No. 14-03-071

DEPARTMENT OF ECOLOGY State of Washington

Eyes Over Puget Sound

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

Surface Conditions Report

March 24, 2014

Guest Contribution:
Teizeen Mohamedali,
Mindy Roberts,
Ecology

Start here

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

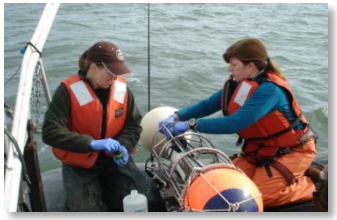
Marine conditions from 3-24-2014 at a glance

LONG-TERM MARINE MONITORING UNIT

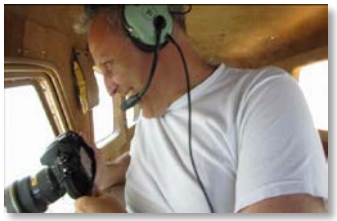
Mya Keyzers
Laura Hermanson
Joe Leatherman

Skip Albertson

Julia Bos
Suzan Pool



Dr. Christopher Krembs



Guest: Dr. Brandon Sackmann, Integral

Personal flight log p. 4

Sensor packages lowered out of the belly of the seaplane!

Weather conditions p. 6

Daily air temperatures have been below average for the past days, yet are increasing as expected along with sunlight. River flows are above normal.

Water column p. 7

Colder, saltier conditions are developing, particularly in the northern regions. Oxygen has stabilized around expected ranges. The recent fall in temperatures has affected Central Sound and Hood Canal. Starting this year, South Sound is showing high salinities.

Aerial photography p. 11

Visible blooms confined to bays, otherwise low blooming activity. Debris lines in Hood Canal and Quartermaster Harbor. Oil sheens in Gig Harbor and Carr Inlet.
High numbers of Jellyfish only in East Sound.

Ferry and satellite p. 36

Landsat captures mudslide. Turbid water in Whidbey Basin leads to strong fronts and gradients. Downwelling-favorable conditions earlier in the month move turbid water northward along the coast.

What we know about nitrogen in Puget Sound?

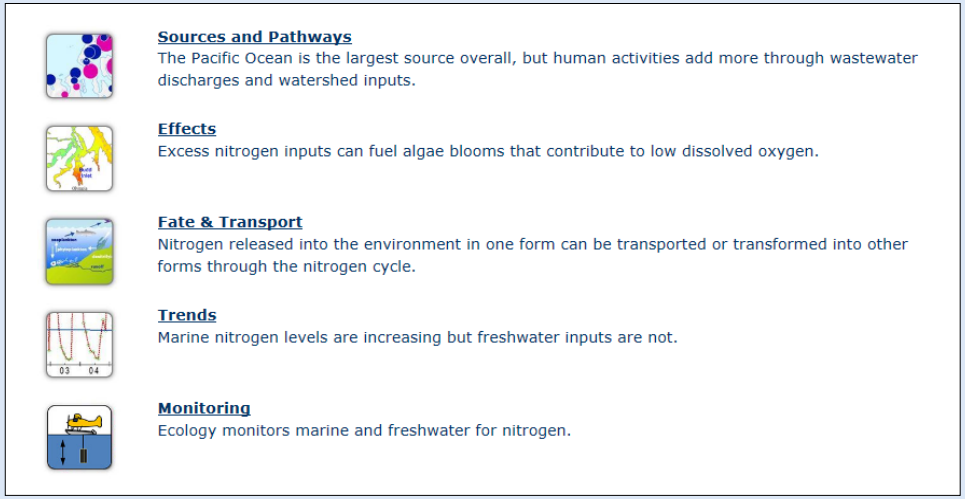
Flight log | Weather | Water column | Aerial photos | Ferry and Satellite | Moorings

By: Teizeen Mohamedali, Mindy Roberts

New Webpage: Nitrogen in the Puget Sound Ecosystem

Find out about nitrogen in the Puget Sound ecosystem at this link, including nitrogen sources, effects, fate and transport, trends, and monitoring:
http://www.ecy.wa.gov/programs/eap/Nitrogen/Index.html

This work was funded by a National Estuary Program grant.



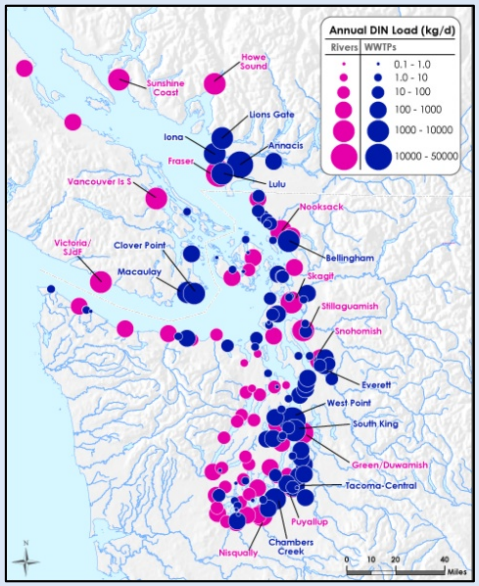
Sources and Pathways
The Pacific Ocean is the largest source overall, but human activities add more through wastewater discharges and watershed inputs.

Effects
Excess nitrogen inputs can fuel algae blooms that contribute to low dissolved oxygen.

Fate & Transport
Nitrogen released into the environment in one form can be transported or transformed into other forms through the nitrogen cycle.

Trends
Marine nitrogen levels are increasing but freshwater inputs are not.

Monitoring
Ecology monitors marine and freshwater for nitrogen.



Report: Nitrogen Loading to Puget Sound

If you would like more details on sources of nitrogen and other nutrients, this report presents the most comprehensive estimates to date of nutrient loading from rivers, wastewater treatment plants, and other sources of nutrients to Puget Sound and the Straits Georgia and Juan de Fuca:
https://fortress.wa.gov/ecy/publications/summarypages/1103057.html

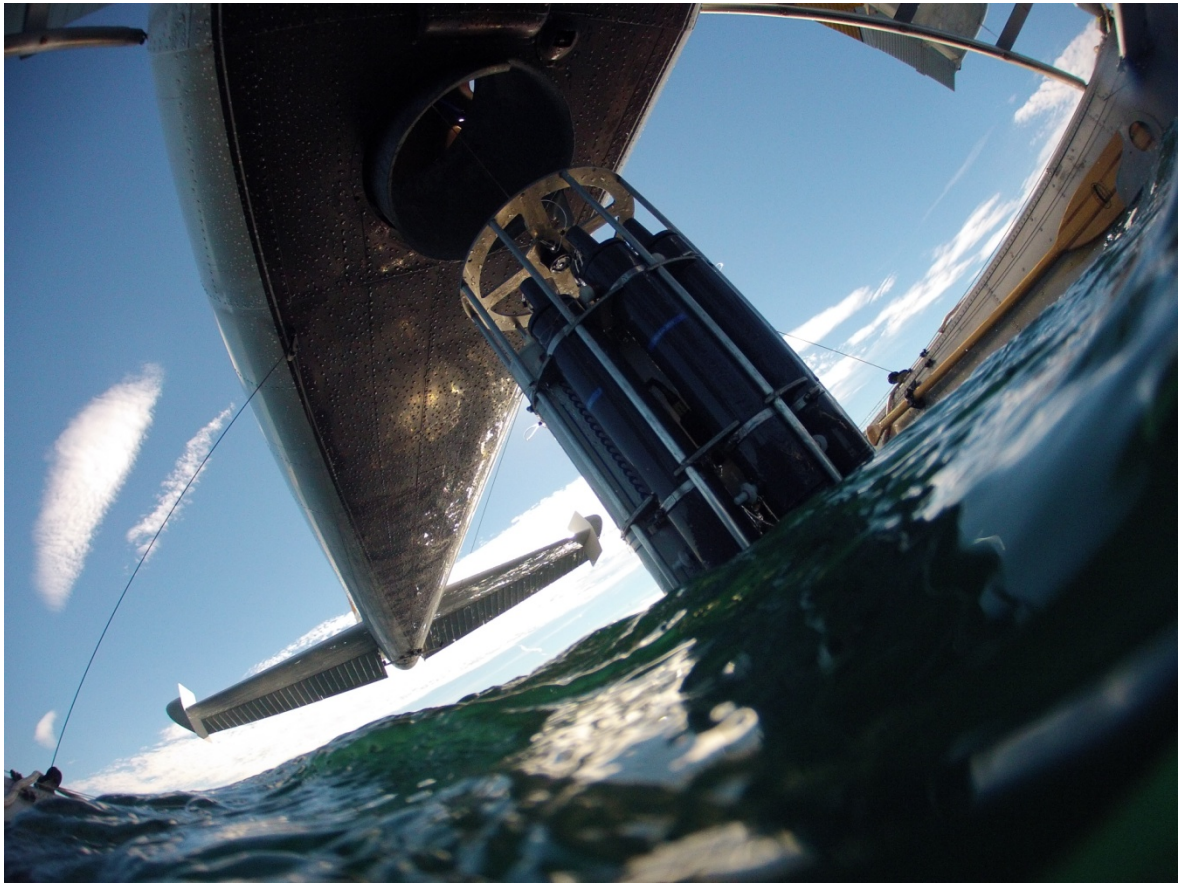
These loading estimates were used in a dissolved oxygen model of Puget Sound - a link to the final report on modeling results, including results of future modeling scenarios under climate change and population growth scenarios will be included in a future issue of EOPS when it is published.

How do we measure water quality?

Once we land on station, our “CTD package” is lowered into the water from the belly of the seaplane.

This package collects data with numerous electronic instruments in addition to the CTD (conductivity, temperature, and depth recorder). It also measures dissolved oxygen, pressure, water clarity, fluorescence (a measure of chlorophyll *a*), pH, and PAR (photosynthetically active radiation).

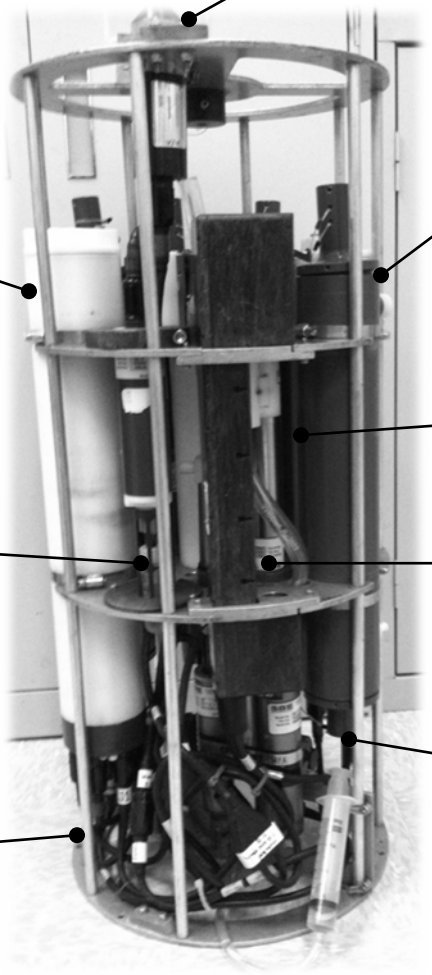
Picture on right:
The CTD package is engineered to fit through the round opening when deployed from the belly of the seaplane (viewed with the fish eye lens).



Anatomy of the marine flight CTD package

To collect water samples at various depths, water bottles, called Niskins, are also part of the CTD package.

From the Niskins, we take water samples for dissolved oxygen, chlorophyll *a*, nutrients (nitrogen, phosphate, silica), and salinity.



Weather of the past two weeks before 3-24-2014

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 have been below average for the past four days, but were warmer on flight days.

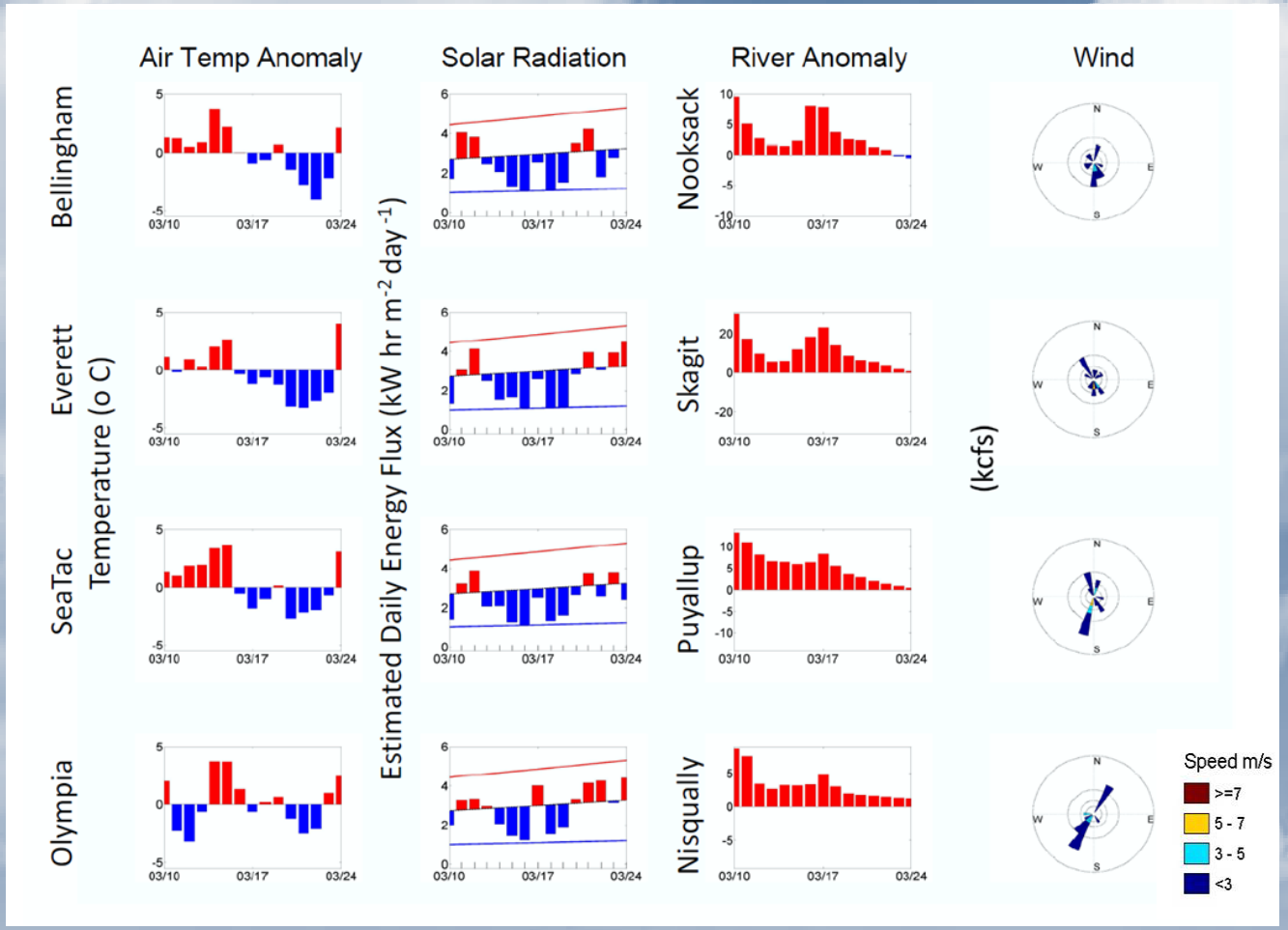
Sunshine is making an appearance, but only for a few days at a time.

River flows have been above normal, but are trending lower.

Winds have alternated between weak from the north and moderate from the south.

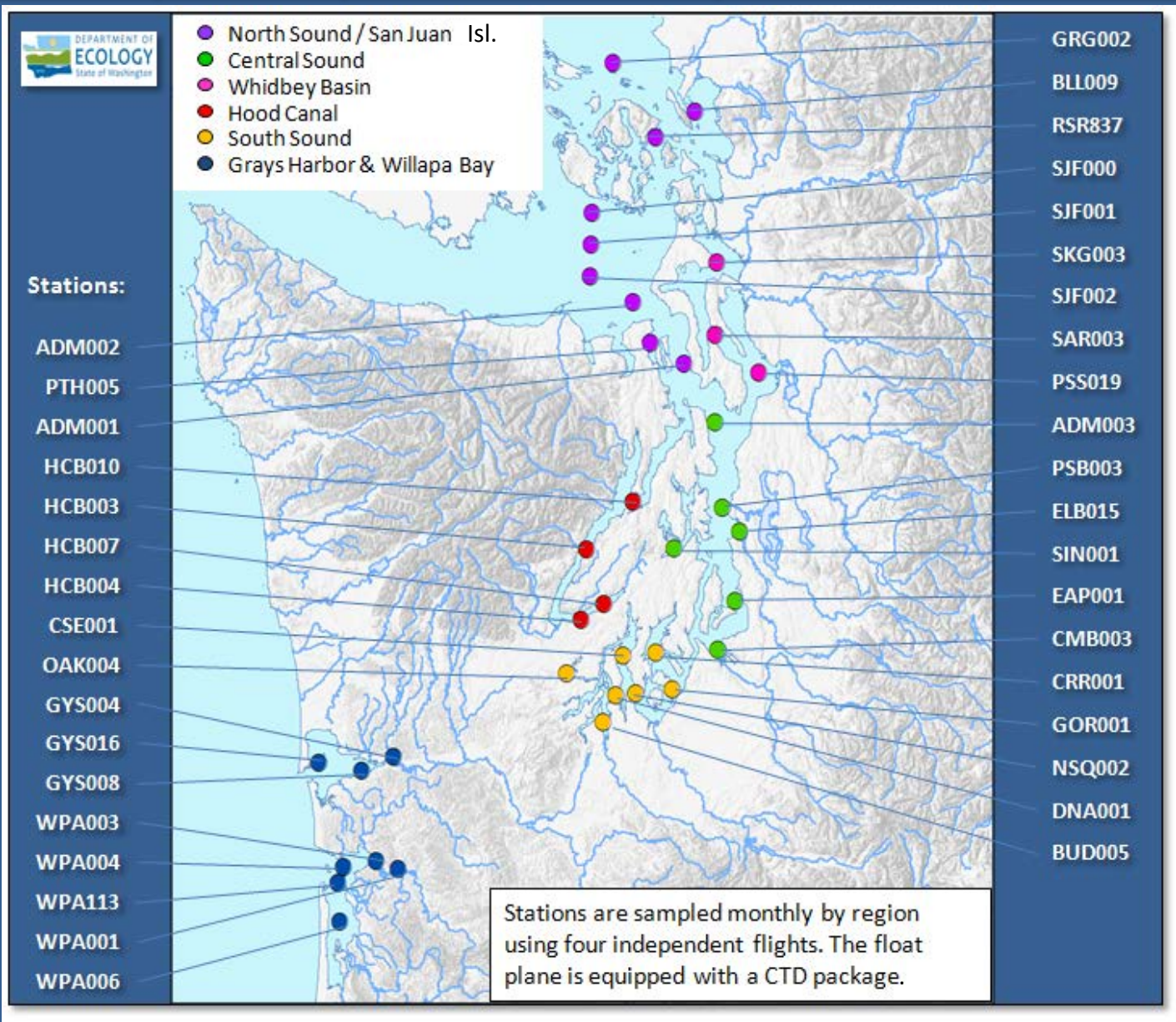
Higher than expected

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

Jan. 2014: Temperature lower | Salinity higher northward | Oxygen normalizing

= higher than expected (>IQR, n>13)
= higher than previous measurements
= expected (=IQR, n>13)
= no data
= lower than expected (>IQR, n>13)
= lower than previous measurements

The 2011-2012 colder, fresher, higher oxygen conditions changed. Colder saltier conditions are developing, particularly in the northern regions. Oxygen has stabilized again around expected ranges. The recent fall in temperatures has particularly affected Central Sound and Hood Canal. Starting this year, South Sound is showing high salinities in many places.

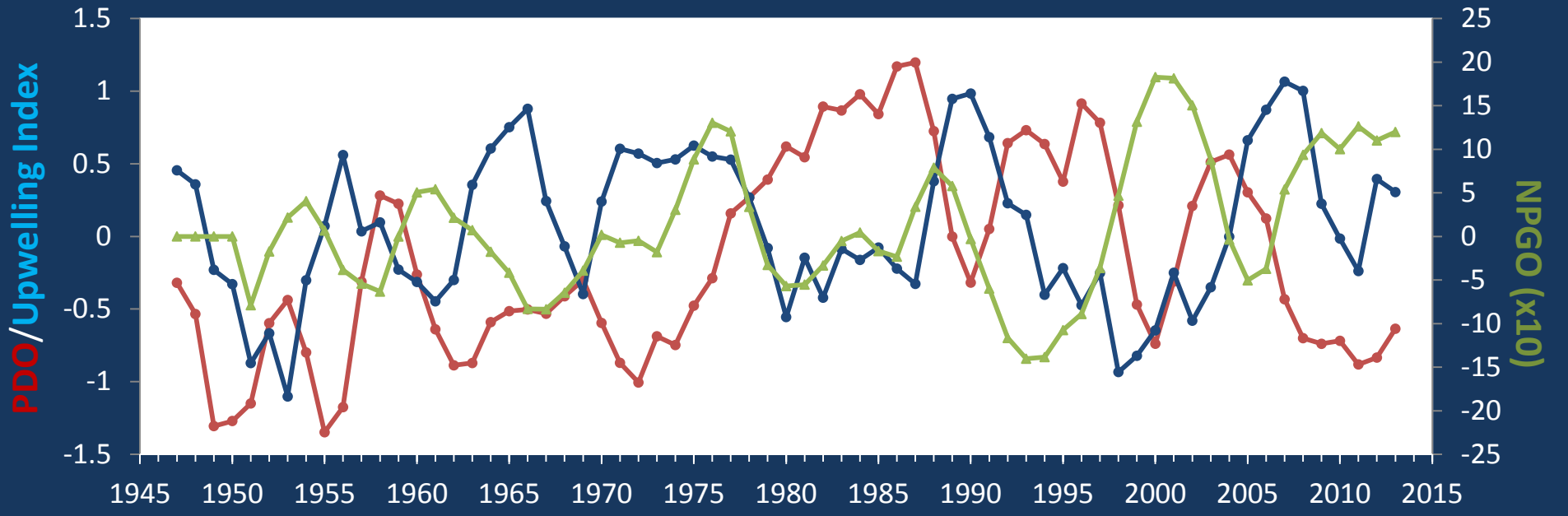
The ocean affects water quality: Ocean Climate Indices

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

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

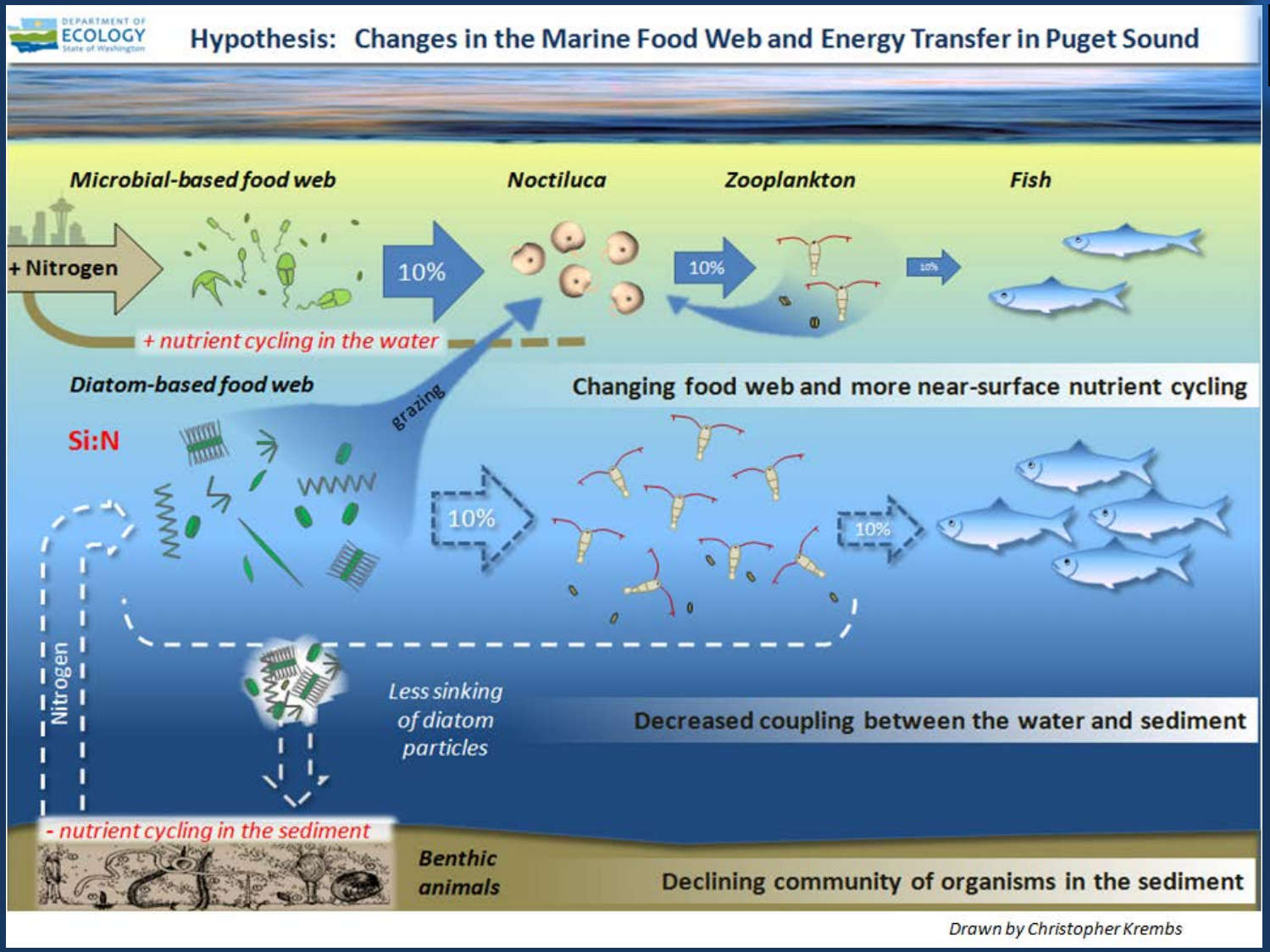
c) *North Pacific Gyre Oscillation Index (**NPGO, productivity**)* *(explanation)*

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 3-24-2014

Suspended sediment, Lake Union, Seattle

Very green water, Horsehead Bay, Carr Inlet

Blooms of strong color confined to smaller bays (Sequim, Scow, and East Bay), otherwise little blooming activity. Debris lines in Hood Canal and Quartermaster Harbor. Oil sheens in Gig Harbor and Carr Inlet. Jellyfish increasing in numbers only in East Sound.

Start here

Front

Mixing and Fronts:
Tidal fronts in Admiralty Reach and Hood Canal near Pleasant Harbor. River plumes relatively small.
1 7 Click on numbers

Jellyfish: Large patch seen only in East Sound. 12

Plume

Suspended sediment:
Little suspended sediment except for Port Susan and Stillaguamish River estuary.
1 14 16 17 18

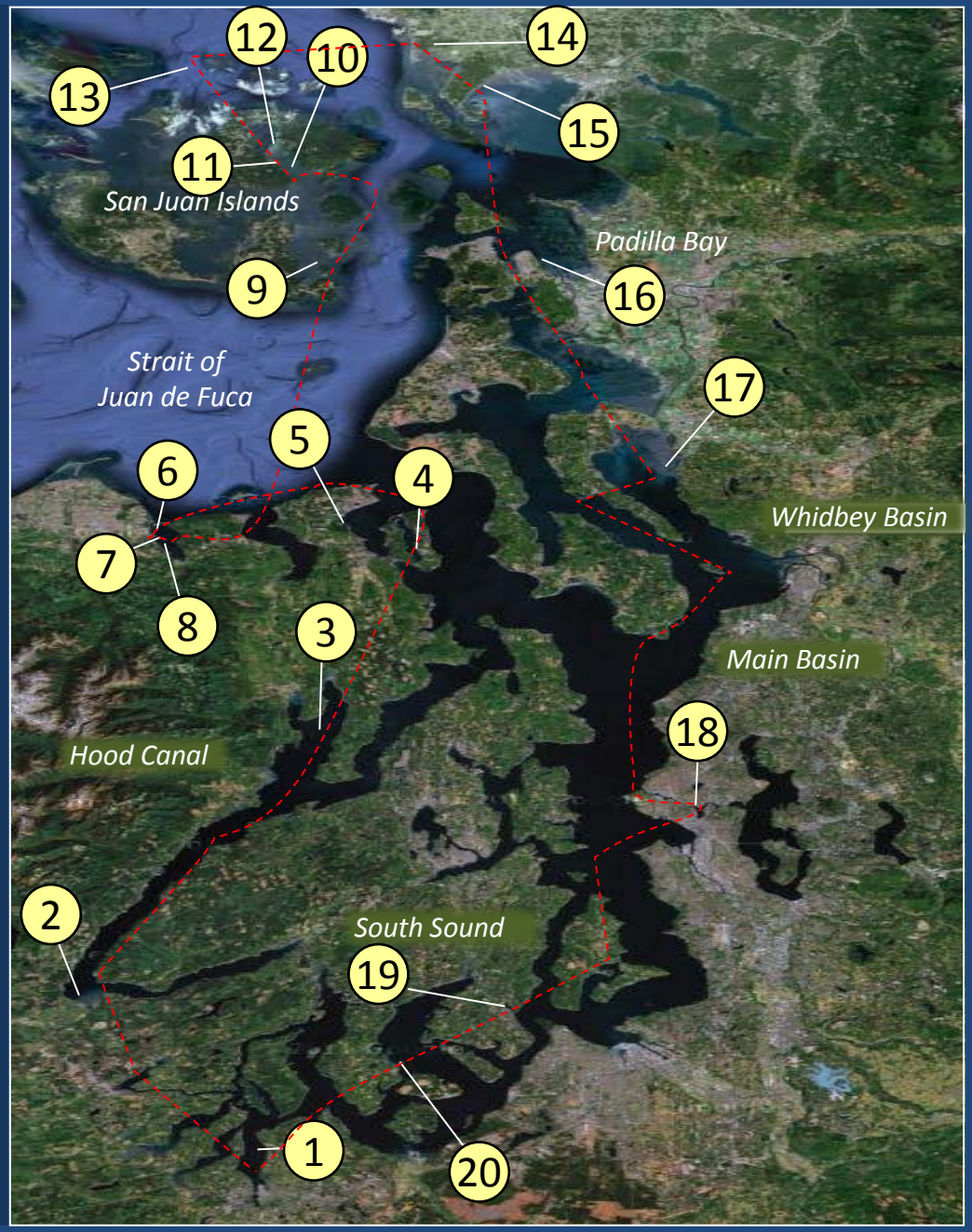
Bloom

Visible blooms:
Overall greenish color suggesting spring bloom is underway.
Orange-red: East Sound
Red-brown: Scow Bay, Glen Cove
Green: Horsehead Bay 4 5 6 7 8

Debris

Debris: 3 4 6 7 8 10 11
Abundant only in Hood Canal and Sequim Bay. Some larger patches near Edmonds.

Seattle: H. tide: 12:07 AM 10:59 AM, , L. tide: 5:39 AM, 5:59 PM



Aerial photography and navigation guide

Date: 3-24-2014

Click on numbers

Flight Information:

Morning flight, photos 1-9:
Good visibility

Afternoon flight, photos 10-20:
Intermediate visibility

Flight route

Observation Maps:

Central and North Sound

Hood Canal and South Sound

Aerial photography 3-24-2014

Edge of sediment-enriched Deschutes River plume with patterns caused by internal waves.
Location: Budd Inlet (South Sound), 9:17 AM.

Clear water of the Skokomish River flowing into Annas Bay near Union.

Location: Hood Canal, 9:28 AM.

Debris accumulating in long lines where surface waters meet and flow together (convergences).

Location: Across Jackson Cove, Dabob Bay (Hood Canal), 9:46 AM.

Red-brown algal bloom in Scow Bay.

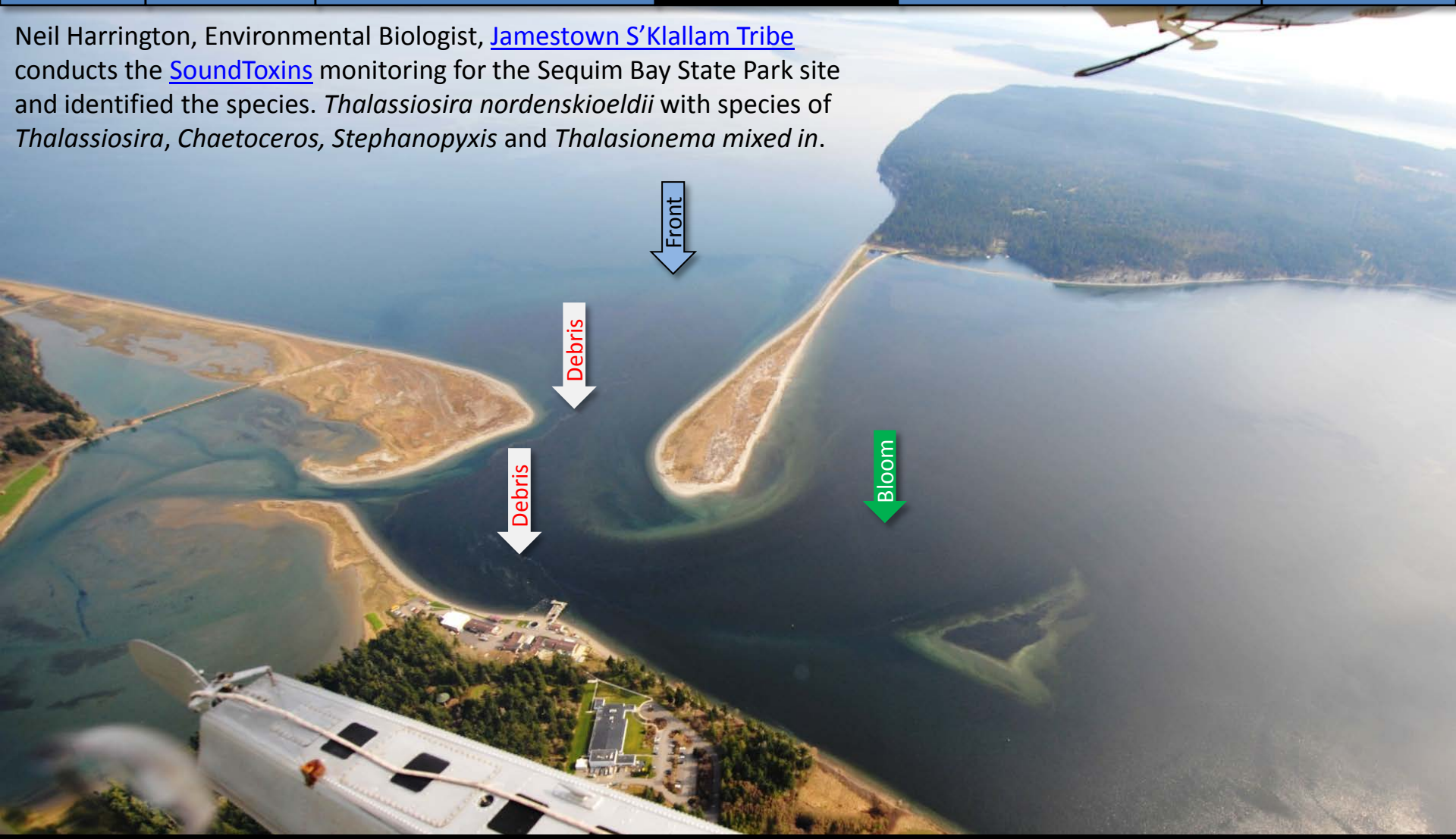
Location: Marrowstone Island (Admiralty Reach), 9:56 AM.

Lines of red-brown algal bloom developing in Glen Cove.
Location: Port Townsend Bay (Admiralty reach), 10:02 AM.

Strong red-brown algal bloom lined by milky water at entrance to Sequim Bay.

Location: Sequim Bay (Strait of Juan de Fuca), 11:06 AM.

Neil Harrington, Environmental Biologist, Jamestown S'Klallam Tribe conducts the SoundToxins monitoring for the Sequim Bay State Park site and identified the species. *Thalassiosira nordenskioeldii* with species of *Thalassiosira*, *Chaetoceros, Stephanopyxis* and *Thalasionema mixed in*.



Strong red-brown algal bloom lined by milky water washing out of Sequim Bay.
Location: Sequim Bay (Strait of Juan de Fuca), 11:06 AM.

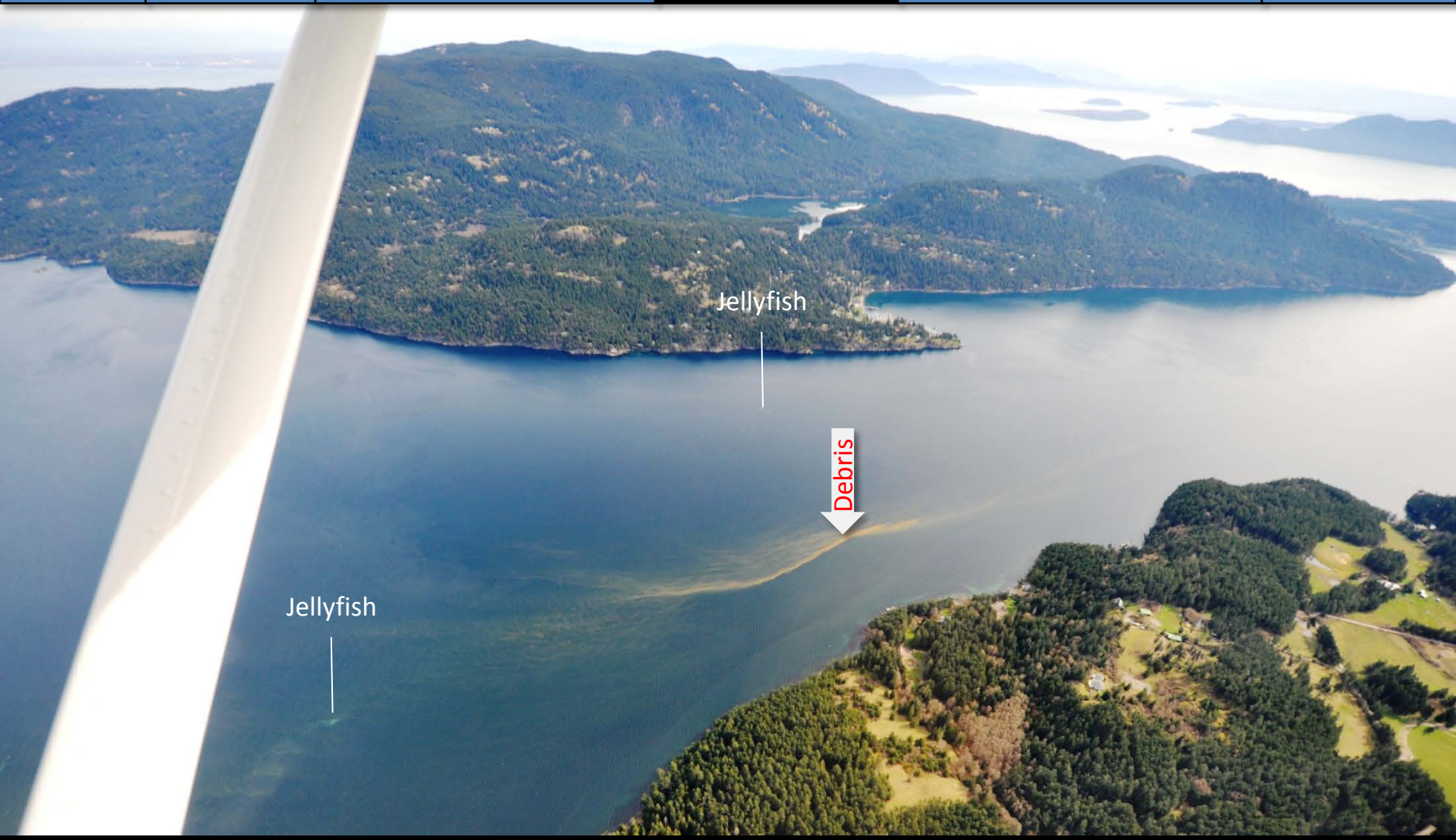
Strong red-brown algal bloom and long debris lines. Marina at Pitship Point stays clear of bloom.

Location: Sequim Bay (Strait of Juan de Fuca), 11:11 AM.

Mud Bay is relatively clear for this time of year.

Location: Lopez Sound (San Juan Islands), 11:28 AM.

Orange-red bloom, likely Noctiluca, in East Sound.
Location: Orcas Island (San Juan Islands), 12:04 PM.



Orange-red bloom, likely Noctiluca, in East Sound.
Location: Orcas Island (San Juan Islands), 12:05 PM

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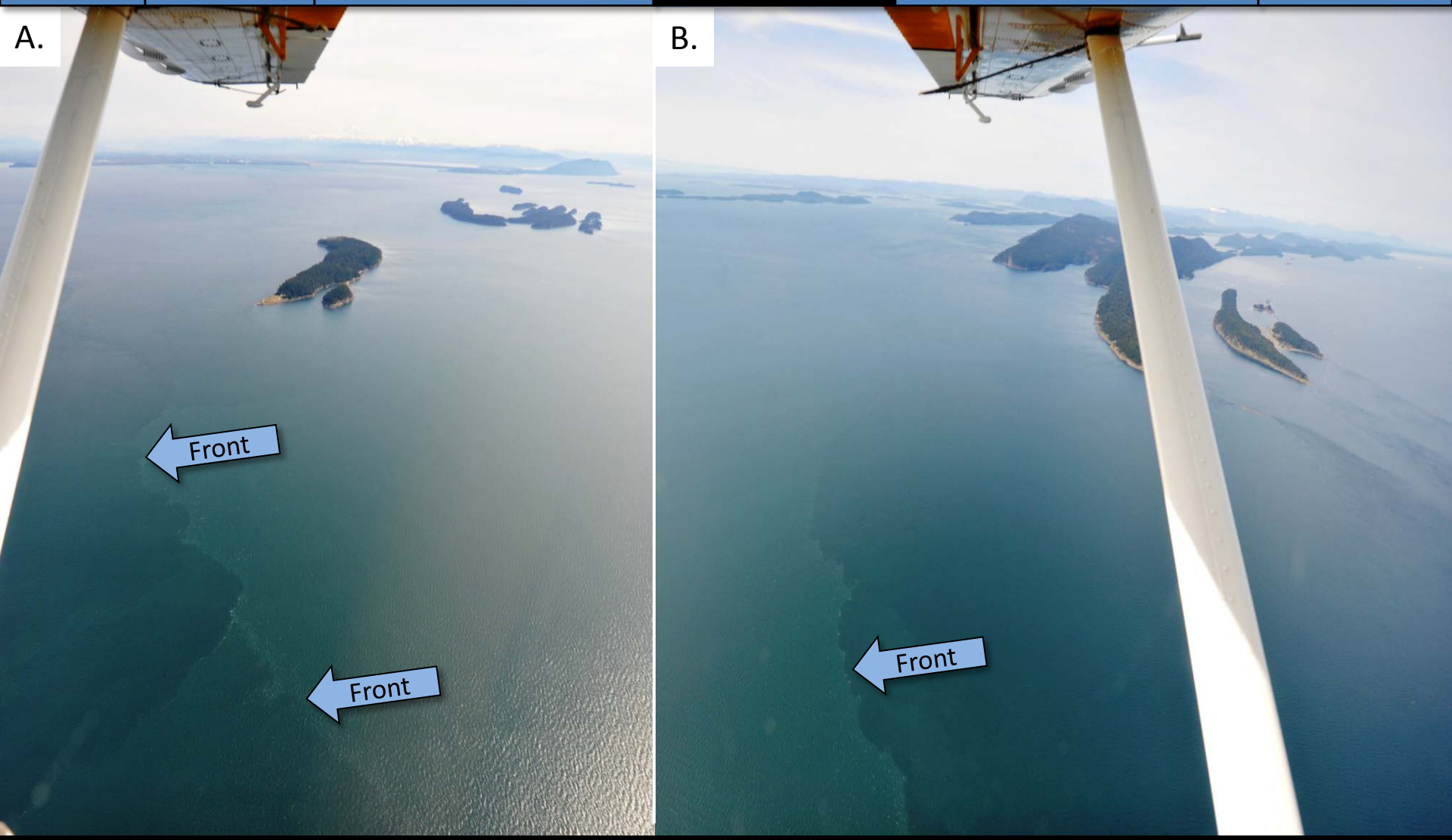
Aerial photography 3-24-2014

Multiple patches of jellyfish at the head of East Sound

Location: Orcas Island (San Juan Islands), 12:07 PM



Lighter-colored water surrounding San Juan Islands meets and forms fronts with Georgia Basin water.
Location: A. Patos Island, B. Saturna Island (Georgia Basin), 12:11 PM.

Aerial photography 3-24-2014

Brown/red-colored Red River water flowing into Lummi Bay. Suspended sediments in marine enclosure.

Location: Lummi Bay (Georgia Basin), 1:10 PM.

Undetermined dark substance flowing into bay west of Nooksack River estuary.
Location: Bellingham Bay (North Sound), 1:12 PM.

Aerial photography 3-24-2014

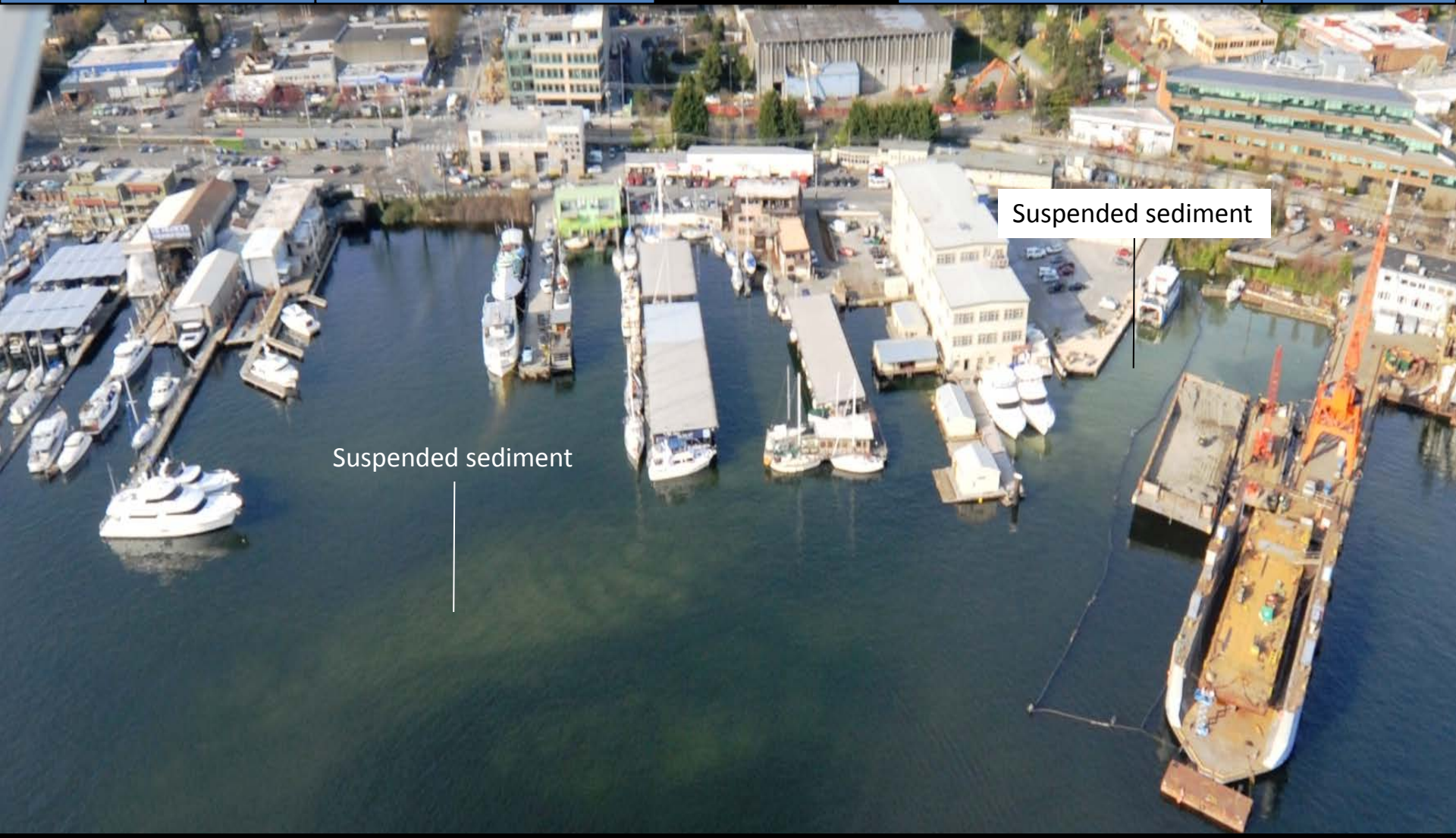
Sediment laden water leaving Swinomish Channel and entering Padilla Bay.

Location: Padilla Bay (North Sound), 2:10 PM.

A. Sediment-laden water entering Port Susan. B. Plume piling up against opposite shore.

Location: A. Stillaguamish River Estuary, B. Camano Island, Port Susan (Whidbey Basin), 2:48 PM.

Aerial photography 3-24-2014



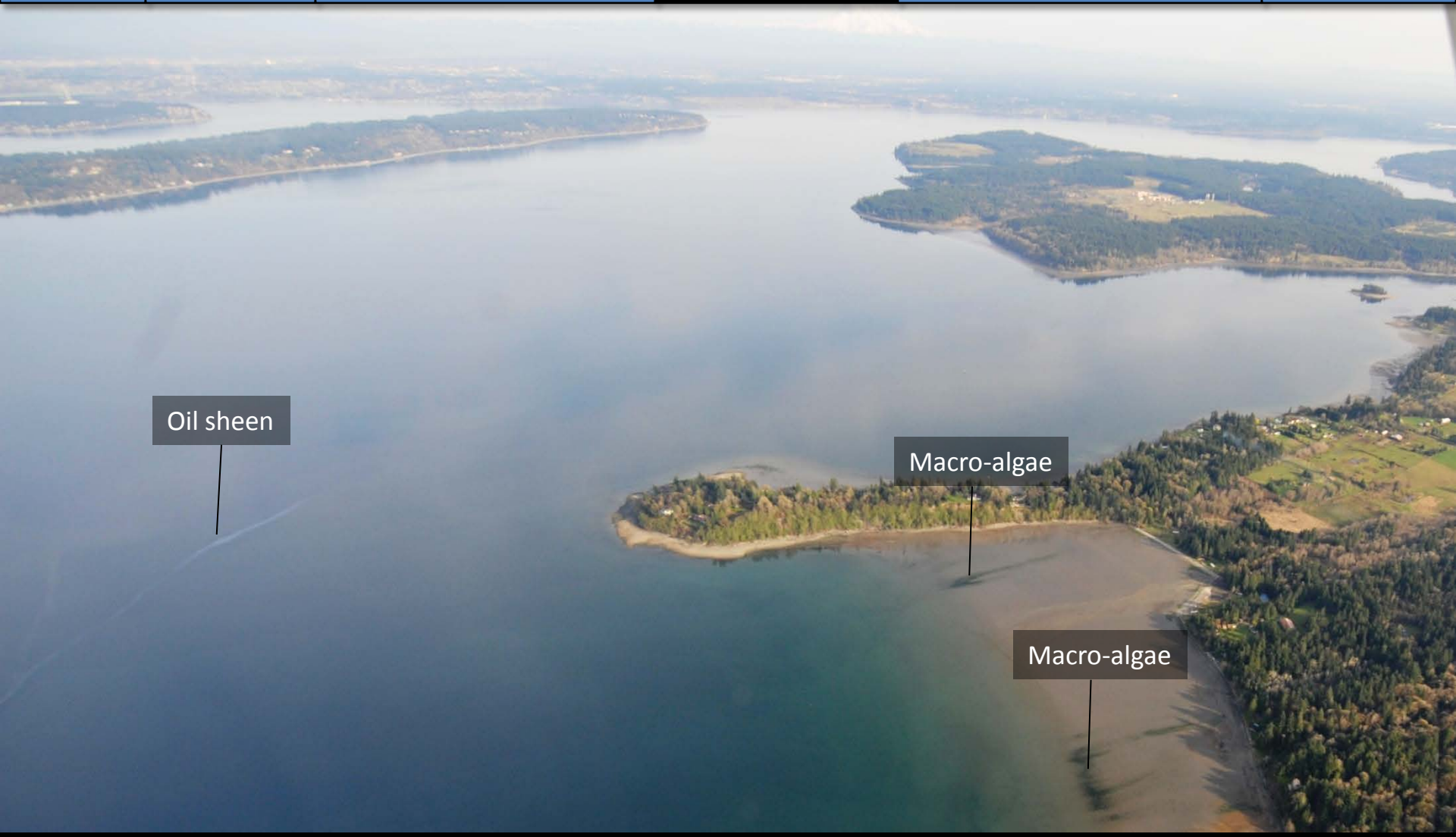
Sediment originating in between docks and spreading near Northlake Way.

Location: West of Gas Works Park, Lake Union (Seattle), 5:07 PM.

Oil sheen of significant length.

Location: Gig Harbor (Central Sound), 5:24 PM.

Aerial photography 3-24-2014



Oil sheen of significant length and green macro-algae developing on nearby beach.

Location: South Head (Carr Inlet), 5:32 PM.

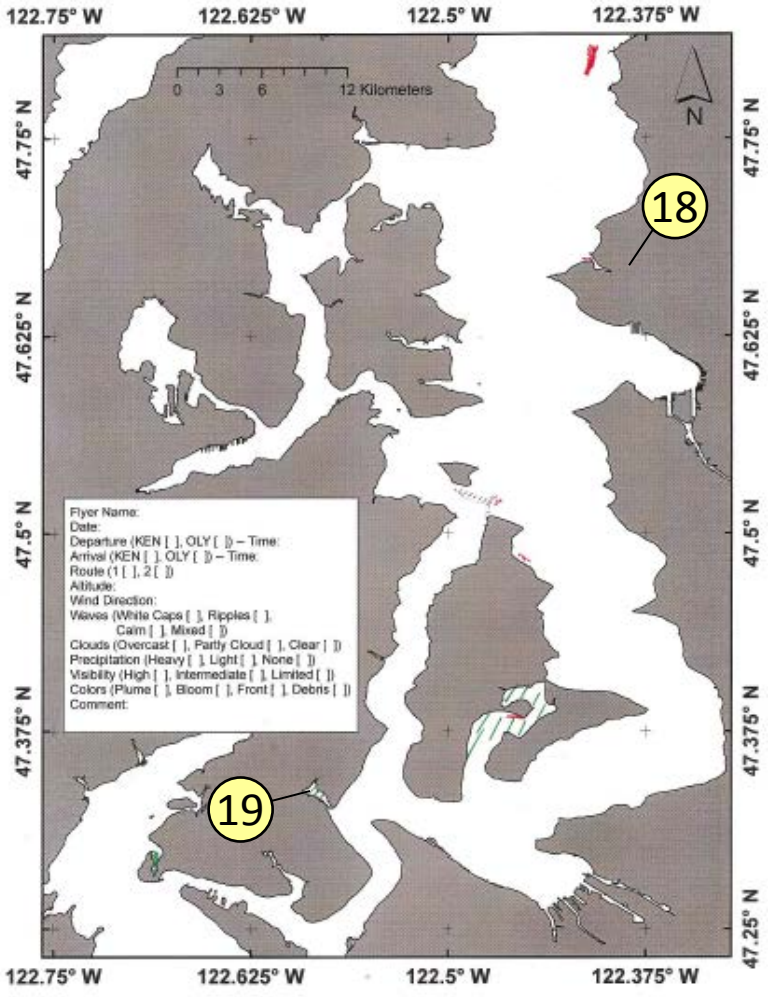
DEPARTMENT OF ECOLOGY State of Washington

Observations in Central and North Sound

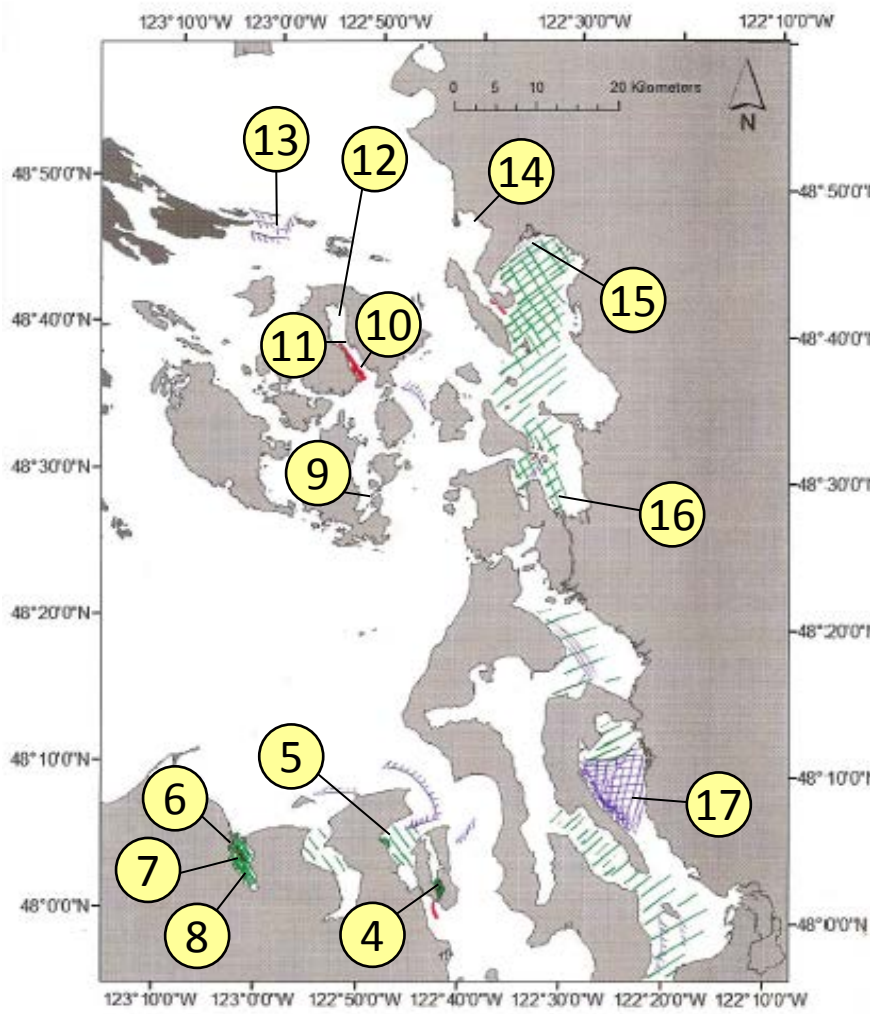
Navigate

Date: 3-24-2014

Central Sound



North Sound/San Juans



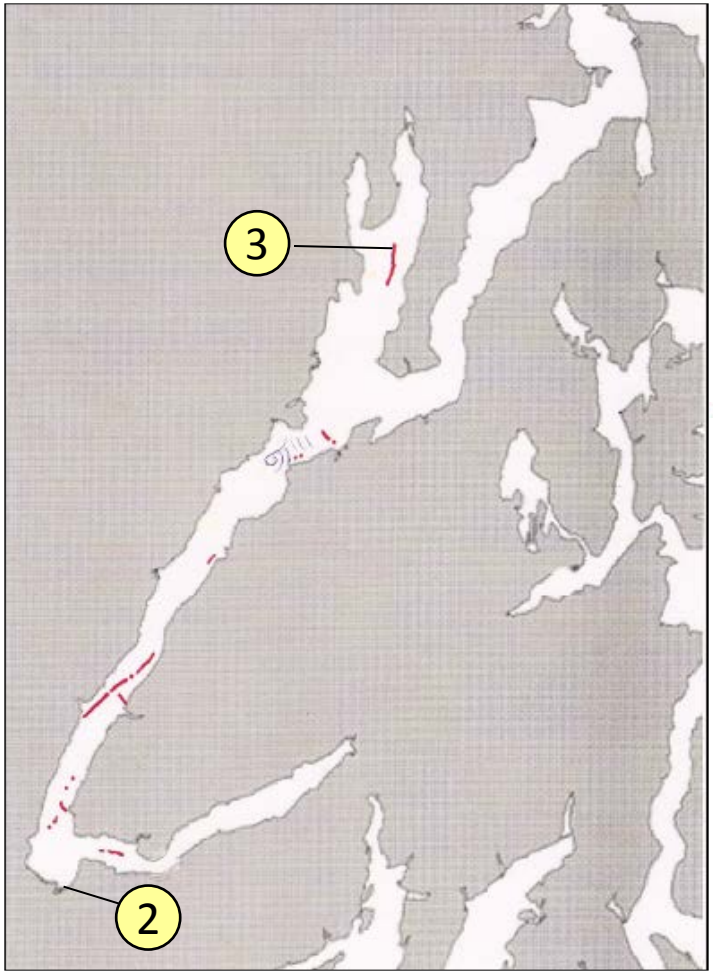
Numbers on map refer to picture numbers for spatial reference

Observations in Hood Canal and South Sound

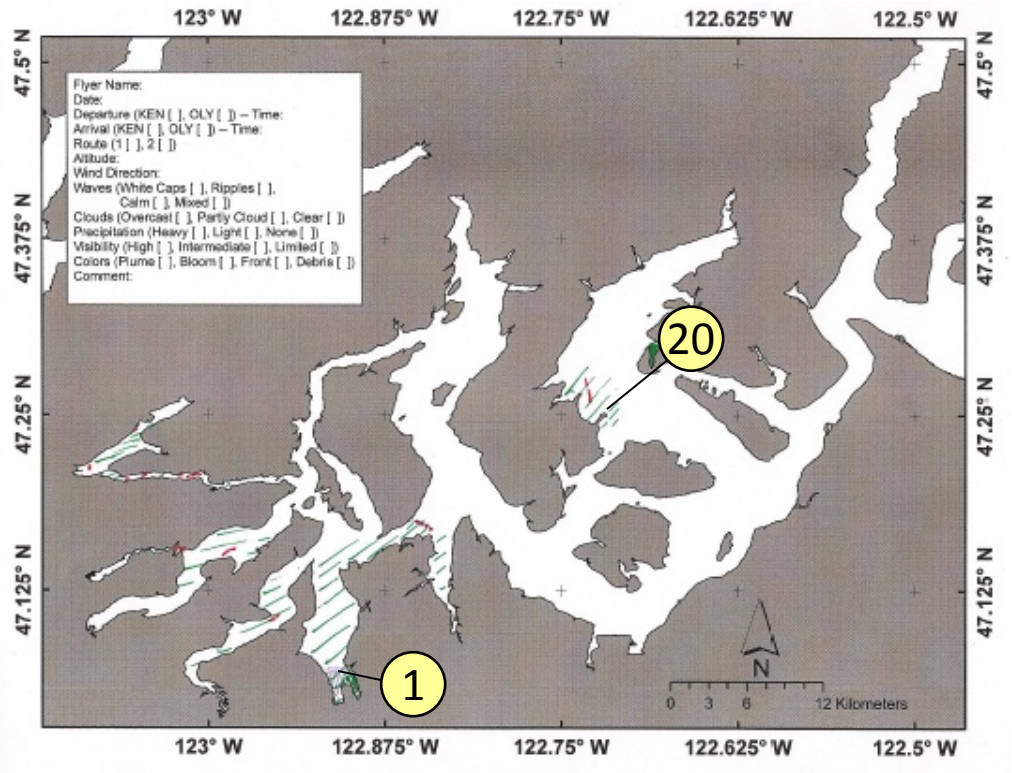
Navigate

Date: 3-24-2014

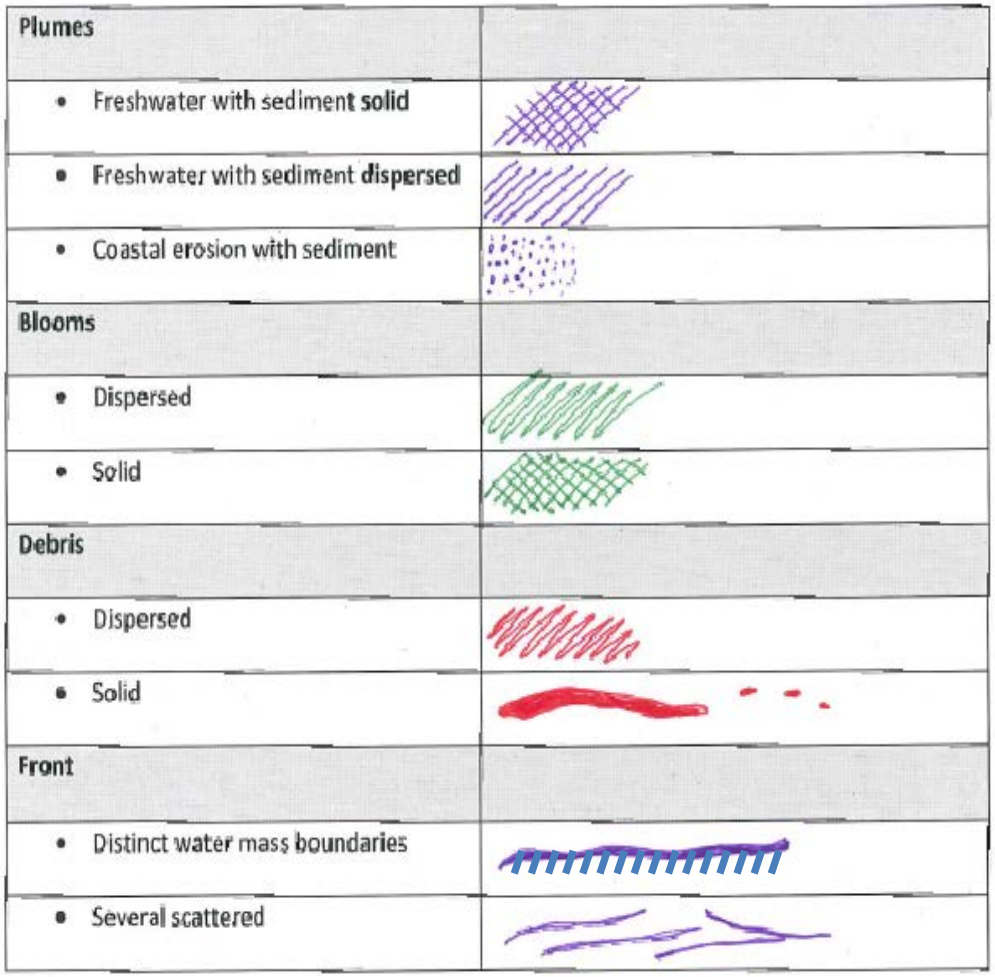
Hood Canal



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.

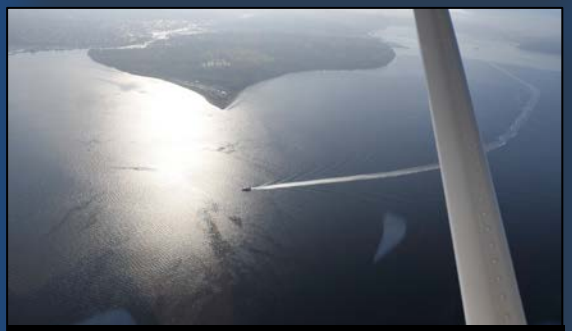
Guest: Ferry and satellite observations 3-24-2014

Mudslide in Stillaguamish watershead

Landsat 8 15-m Panchromatic
(Operational Land Imager)

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

Start here

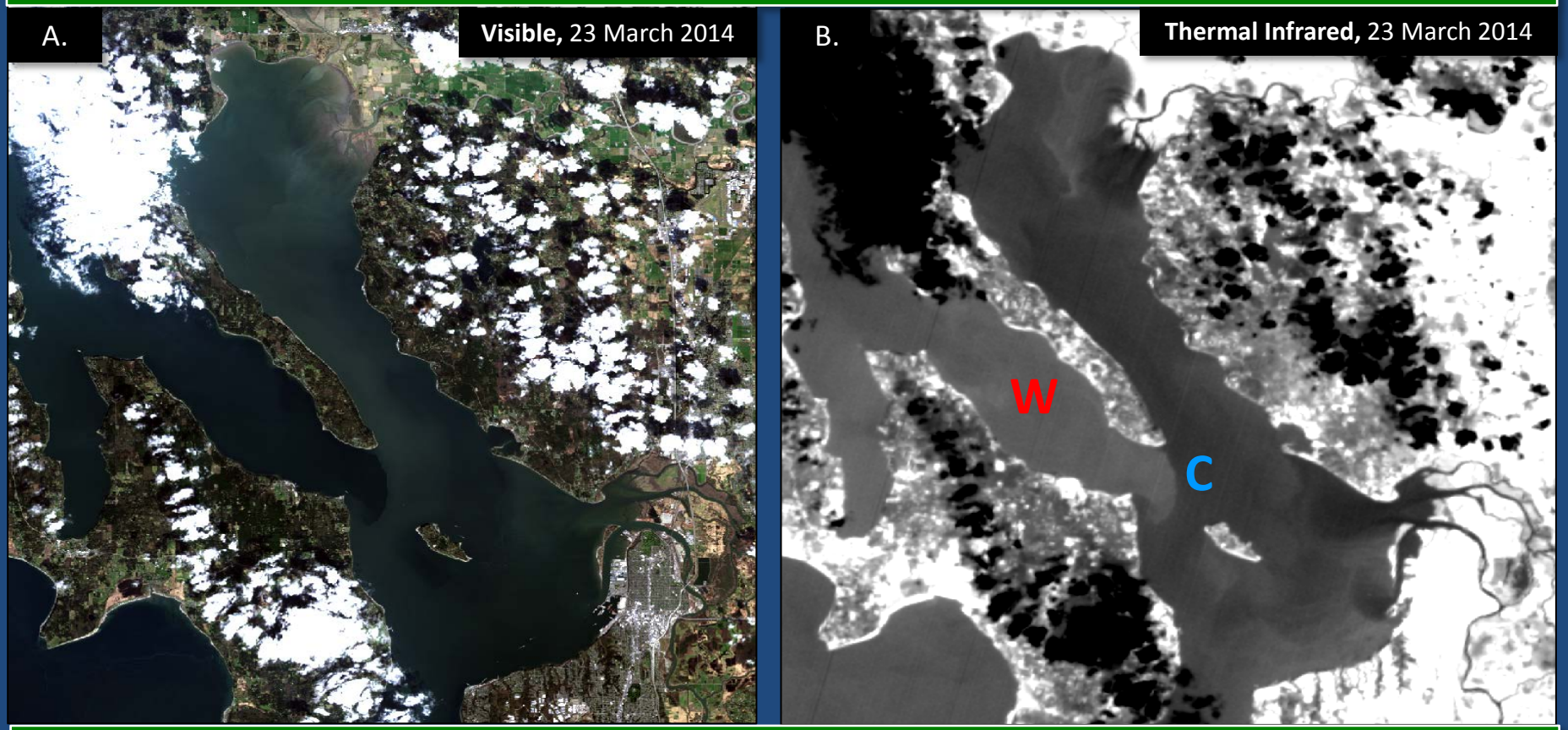


Victoria Clipper IV leaving Elliott Bay

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

Guest: Ferry and satellite observations 3-24-2014

A. Visible and B. Thermal Infrared Imagery (Landsat 8) Reveals Strong Fronts/Gradients in Whidbey Basin



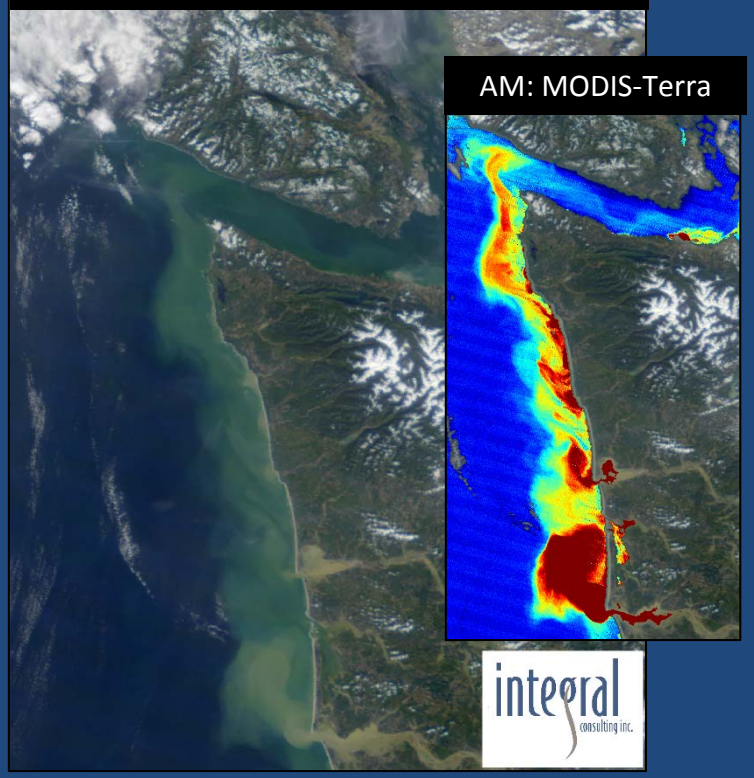
Turbid and cooler waters entering Port Susan and Possession Sound from the Stillaguamish and Snohomish rivers. A strong front can be seen near Gedney Island. Darker tones = cooler (C), lighter tones = warmer (W).

Guest: Ferry and satellite observations 3-24-2014

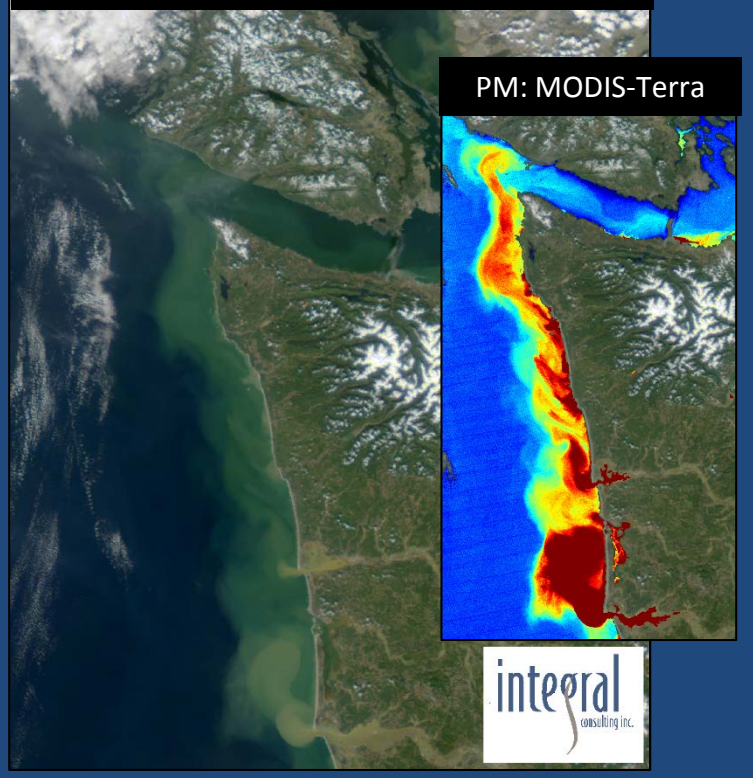
MODIS-Aqua and MODIS-Terra (Visible RBG and 250-m Turbidity Proxy)

-- Coastal Downwelling --

AM: MODIS-Aqua True Color, 11 March



PM: MODIS-Aqua True Color, 11 March



Downwelling favorable conditions (winds blowing from the south towards the north) push turbid water from the Columbia River towards the coast where it flows northward and eventually enters the Strait of Juan de Fuca.

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

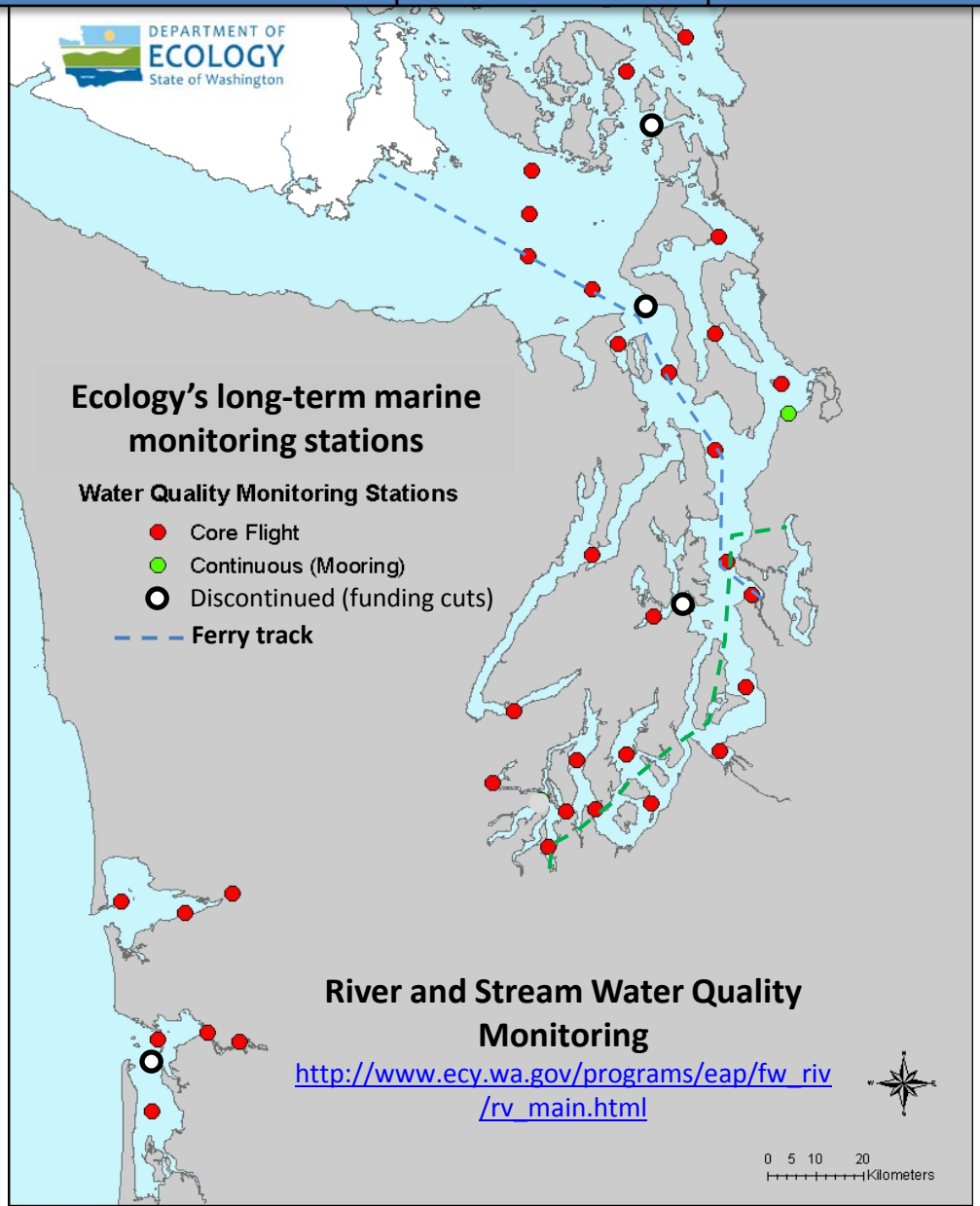
Flight log	Weather	Water column	Aerial photos	Ferry and Satellite	Moorings

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.