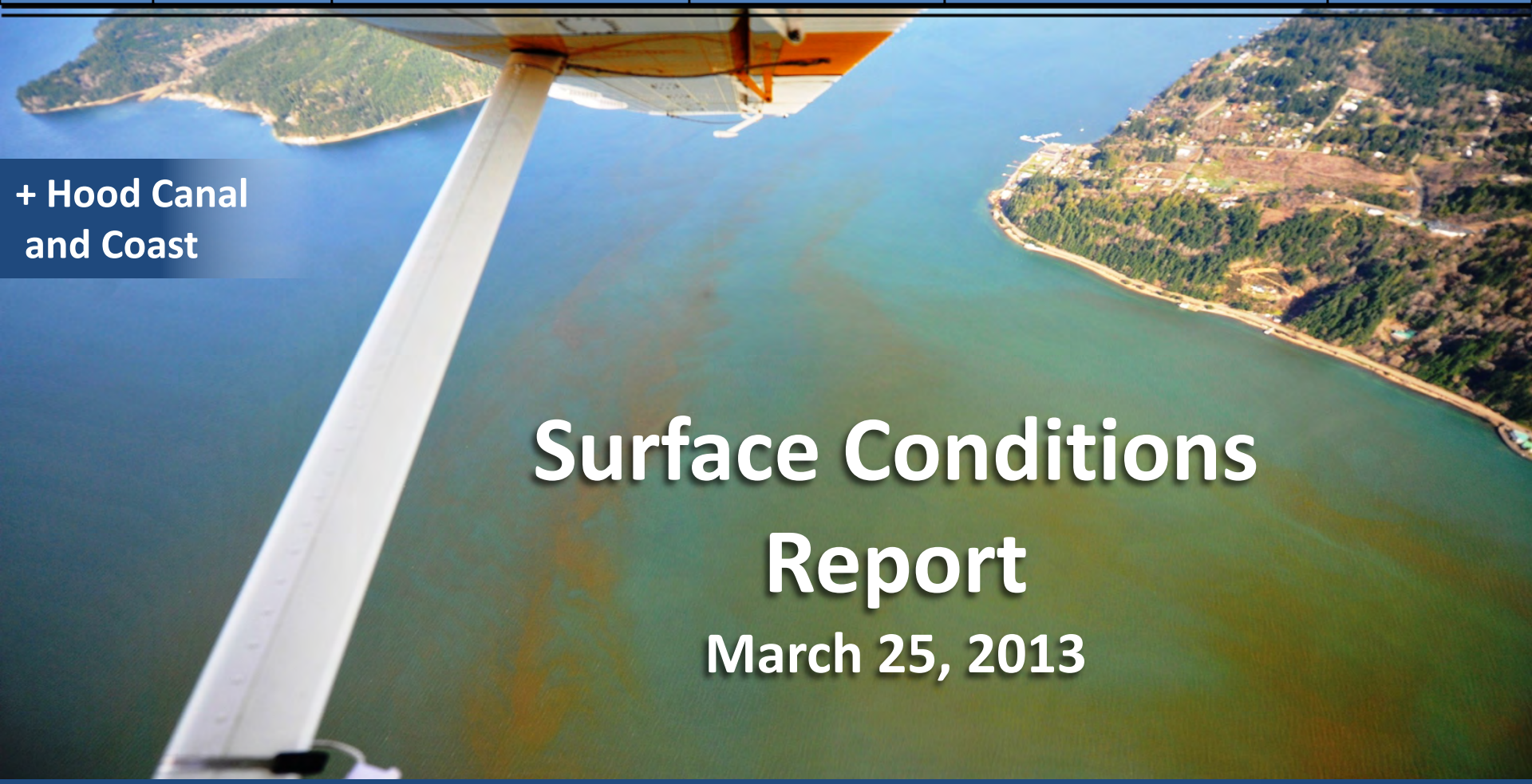
Publication No. 13-03-072

DEPARTMENT OF ECOLOGY State of Washington

Eyes Over Puget Sound

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



+ Hood Canal and Coast

Surface Conditions Report

March 25, 2013

We have a new website (http://www.ecy.wa.gov/programs/eap/mar_wat/)

Start here

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

Marine conditions from 3-25-2013 at a glance

LONG-TERM MARINE MONITORING UNIT

Mya Keyzers
Laura Friedenberg
Joe Leatherman

Skip Albertson

Julia Bos
Suzan Pool
David Mora

Dr. Christopher Krembs

Guest: Dr. Brandon Sackmann

Personal flight log p. 3

Wonderful Willapa Bay, from a bird's-eye view.

Weather conditions p.5

Air temperatures and sunshine were below normal but are rising. Rivers are running above normal in central & north regions, the Nisqually in south Puget Sound is flowing below normal.

Water column and mooring p.6 , p.30

In Puget Sound, ocean climate indices explain much of the variability in temperature, salt and oxygen. Nutrients, however, are increasing while sub-surface phytoplankton is declining!

Aerial photography p. 10

Large red-orange-brown bloom in southern Hood Canal. Jellyfish still going strong in southern inlets. The spring phytoplankton bloom is picking up in Puget Sound.

Ferry and satellite p. 29

MODIS satellite confirms bloom in Hood Canal and high sediment discharge from the Elwha River. Victoria Clipper IV is still in shipyard for annual maintenance. No data available.

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

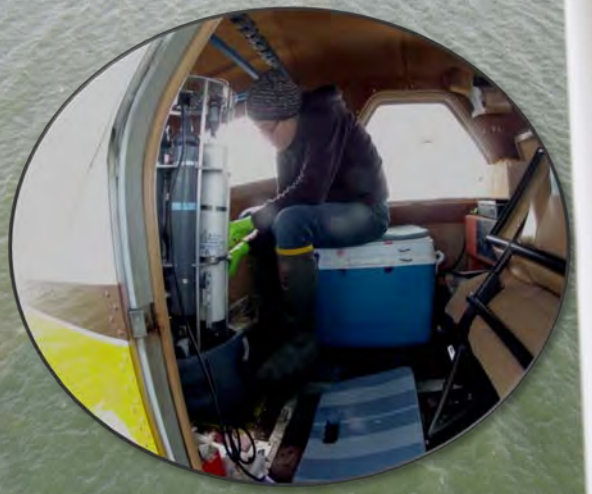
Personal flight log 3-25-2013

Coast Flight: Willapa Bay and Grays Harbor

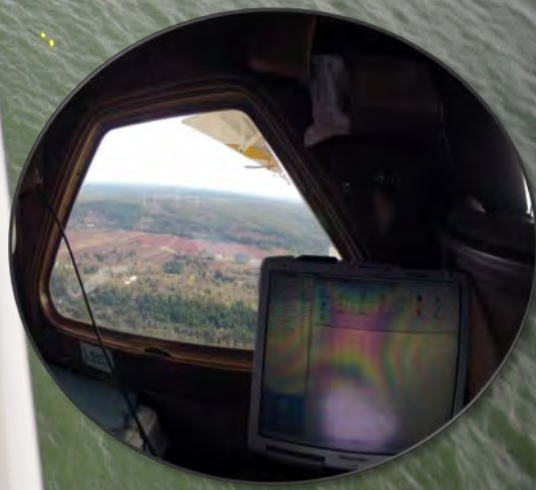
Joe and Christopher.

We combined the EOPS with our routine flight and sampled all of our stations. We then flew to higher elevation to take pictures. I got to see Willapa Bay from a whole new perspective at 2500 ft. It is such a beautiful and unique place.

Mya collecting data.



Uploading data with cranberry fields in the background.



Coast Flight: Willapa Bay and Grays Harbor

The large mouth of Willapa Bay.

We have tried to get to the coast all month, and finally the weather allowed us to go. When it comes to field work, patience and determination are key.

Weather patterns from 1-1-2013 to 3-25-2013

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

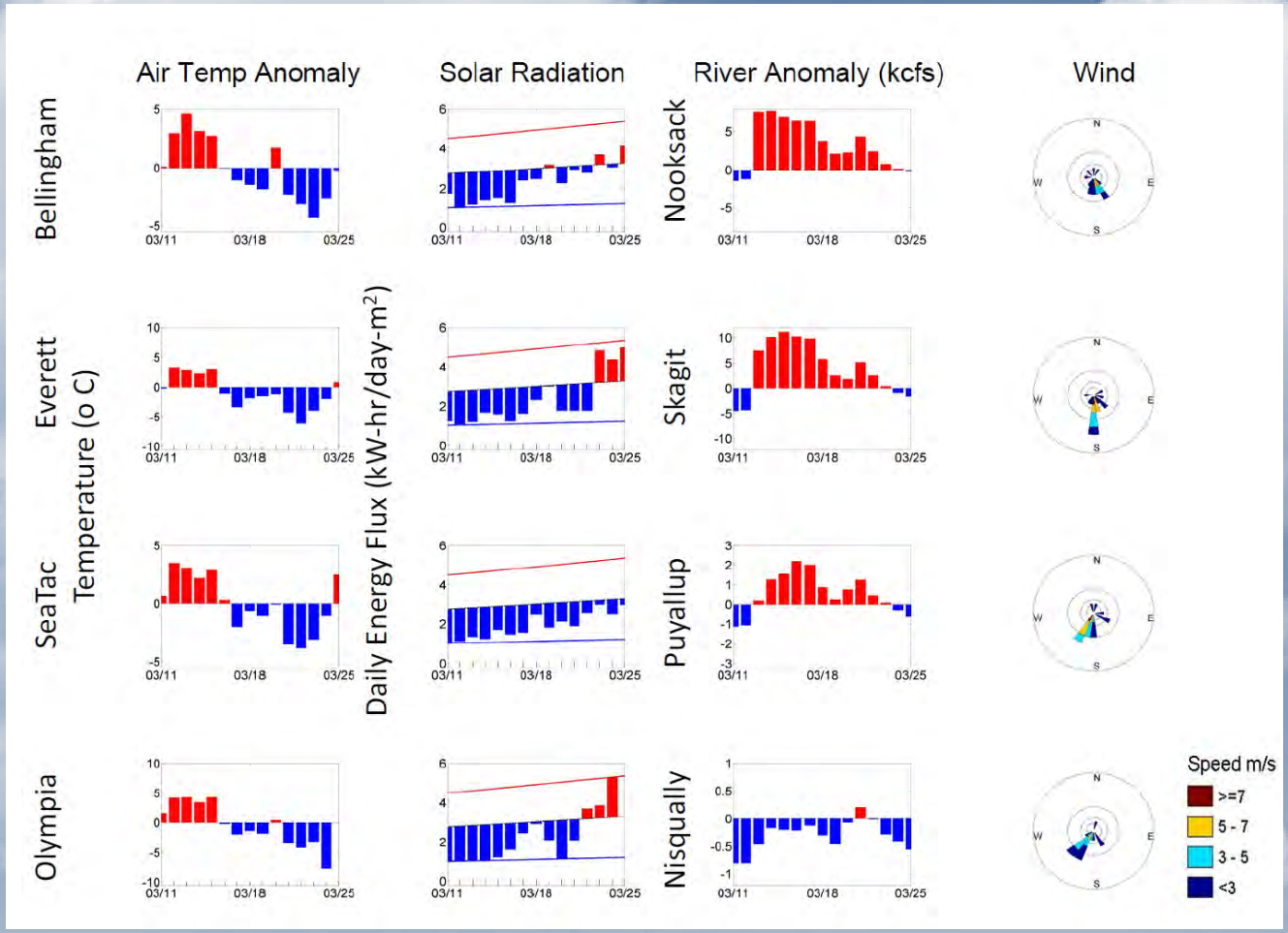
Summary:

Air temperatures have been below normal over Puget Sound for the past several days.

Sunshine levels have been below normal, but on the rise.

Rivers have been running above normal in central to northern regions, but trending lower; the Nisqually in south Puget Sound has been flowing below normal.

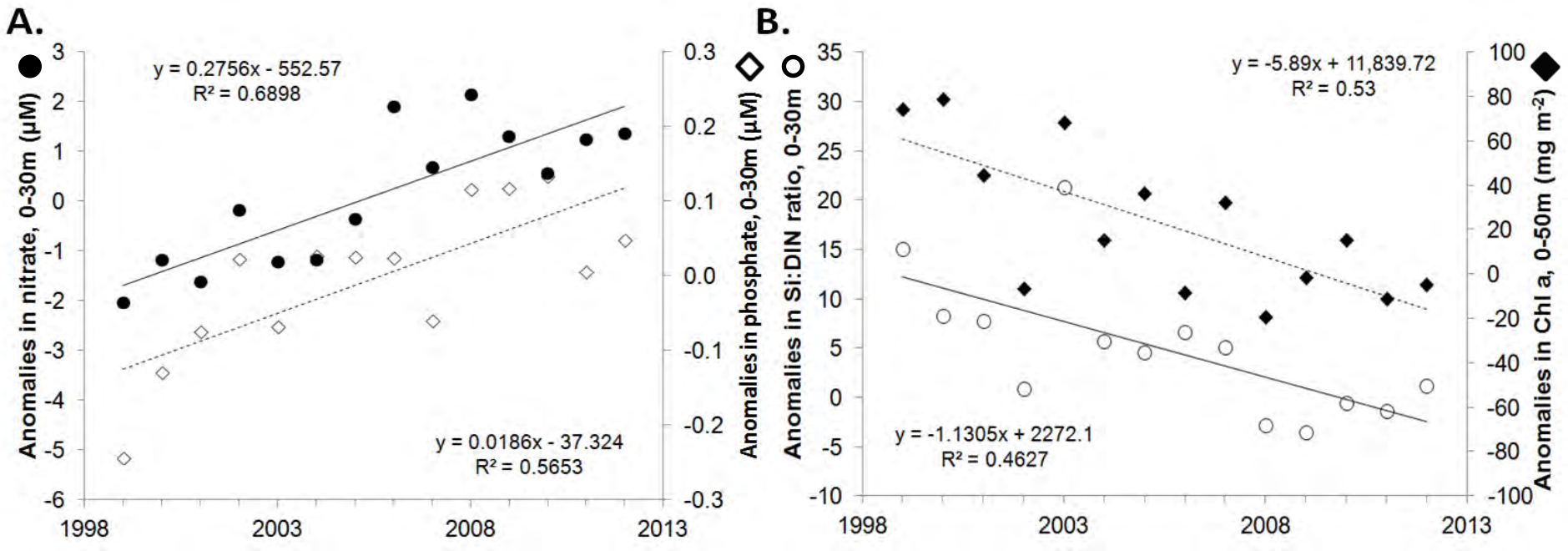
Winds have been mostly from the south.



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

Puget Sound-wide changes in algal growth conditions

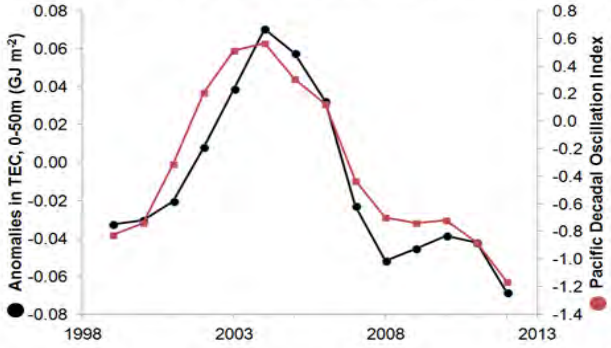
1. Nutrients are increasing and their balance is shifting.
2. EOPS is documenting large and frequent algal blooms at the surface.
3. Yet, below the surface chlorophyll *a* (proxy for algal biomass) is declining.



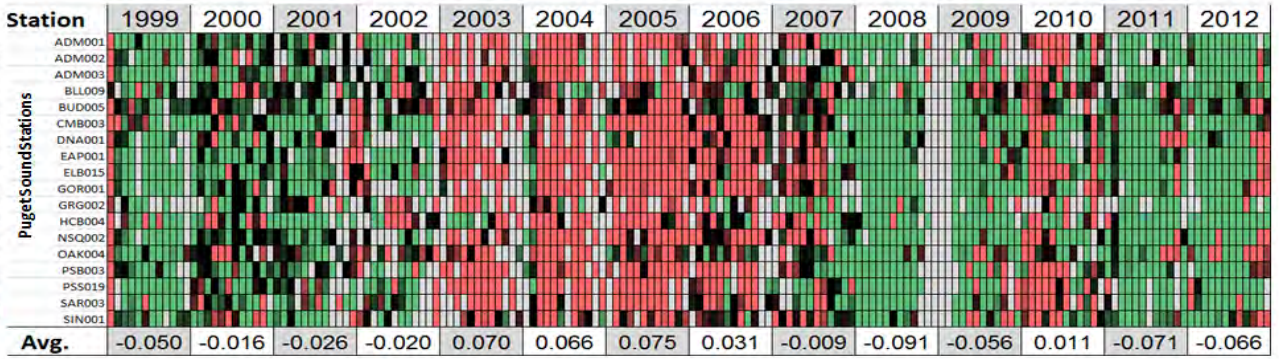
Increasing macro-nutrients nitrate and phosphate (A), shifting balance in the silicate to dissolved inorganic nitrogen ratio (Si:DIN) and declining chl a over 0-50 m (B) point to significant long-term shifts in the growth conditions of the lower trophic food web. Annual anomalies are calculated relative to baseline conditions established from 1999 to 2008. While nitrogen and phosphate significantly increased at a rate of 3 µM and 0.3 µM per decade, respectively, chl a and ratios in Si:DIN have significantly declined at rates of 65 mg (chl a m^{-2}) and 10 (Si:DIN) units per decade. Significance is based on Spearman Rank Corr. Coef. p=<0.05 .

Ocean-climate indices explain some patterns in Puget Sound

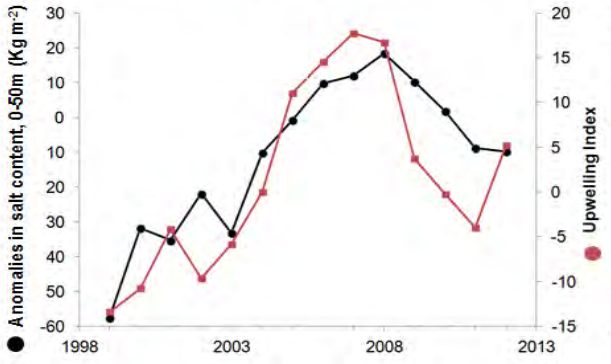
A. Pacific Decadal Oscillation Index



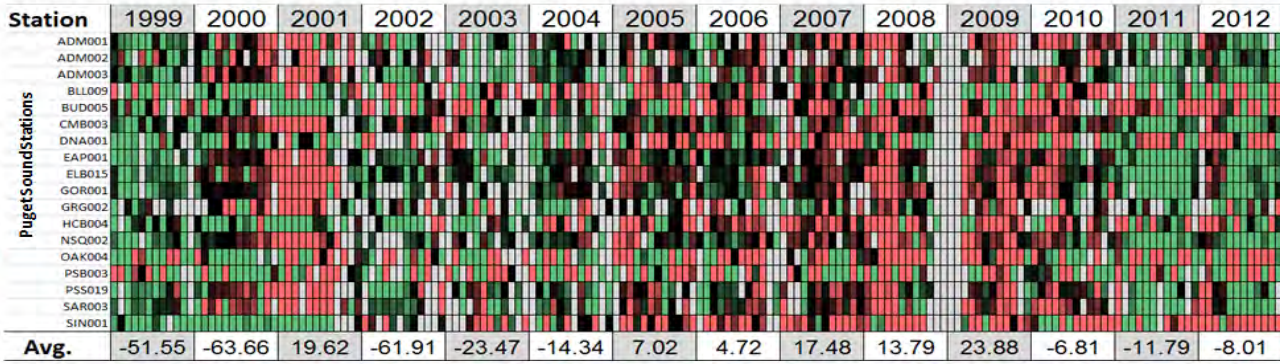
B. *Anomalies in Thermal Energy Content (TEC) (GJ m^{-2}), 0-50 m in Puget Sound*



C. Upwelling Index (NOAA)



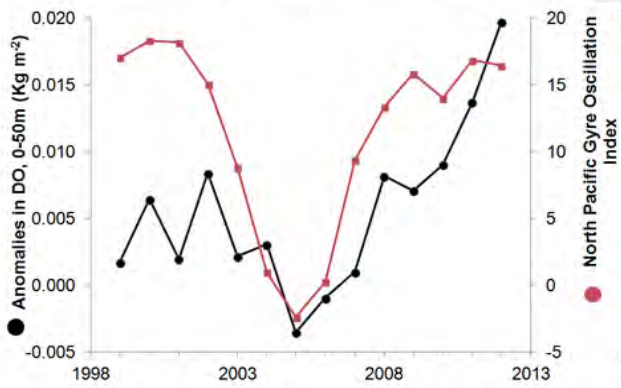
D. *Anomalies in Salt Content (Kg m^{-2}), 0-50 m in Puget Sound*



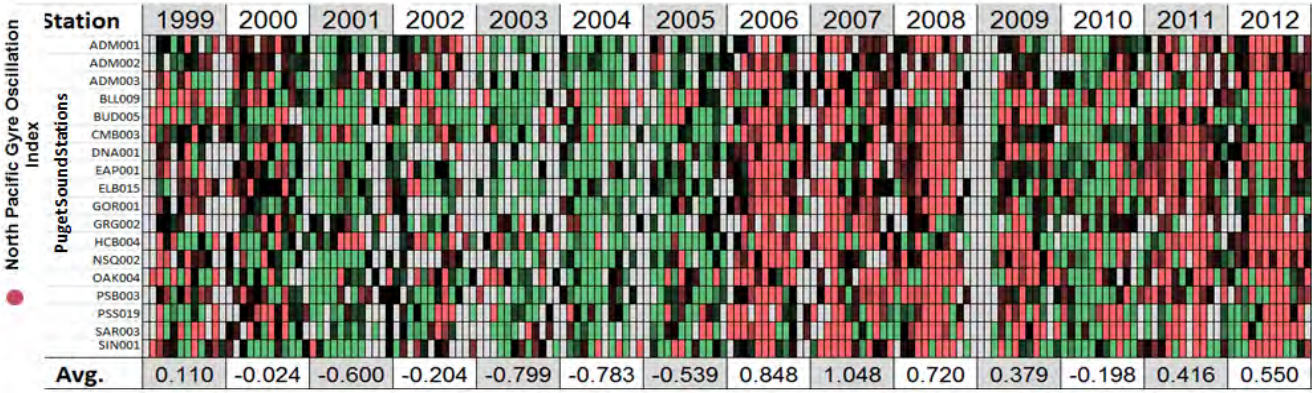
A) Yearly averaged anomalies in thermal energy content of 0-50 m correlate significantly with the Pacific Decadal Oscillation Index in Puget Sound (both series are shown as a 3-year running average). B) Monthly anomalies in the thermal energy content (0-50 m) for individual stations. Red indicates anomalies higher than the 75th percentile; green indicates anomalies lower than the 25th percentile; black values fall near the median; gray denotes missed sampling events. C) The Upwelling Index at 48°N, 125°W correlates significantly with Puget Sound salt content in the 0-50 m layer. D) Monthly anomalies in salt content at individual stations. Significant correlations (Spearman Rank Correl, p <0.05) are based on 3-year running averages of ocean indicators correlating with Puget yearly Puget Sound wide averages of the anomalies.

Ocean-climate indices explain some patterns in Puget Sound

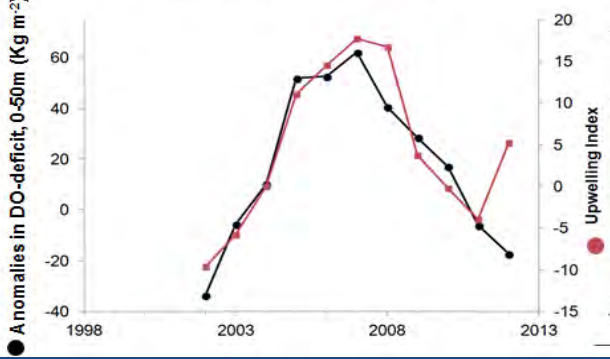
A. North Pacific Gyre Oscillation Index



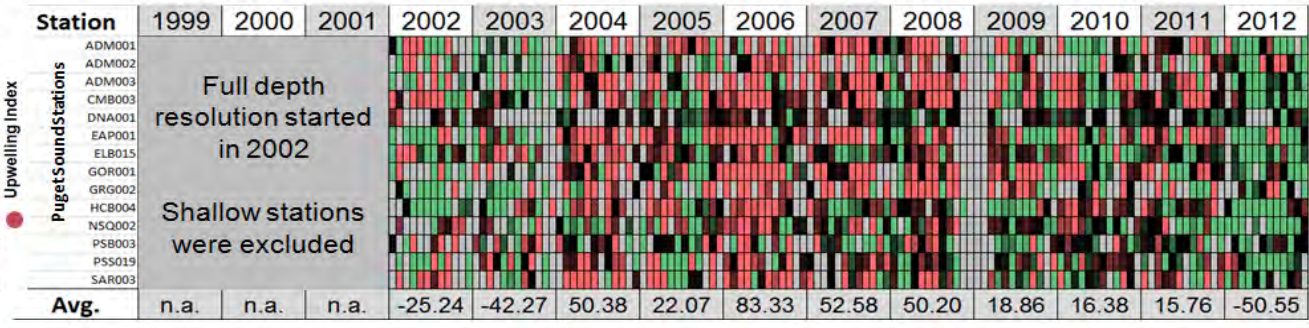
B. *Anomalies in Dissolved Oxygen Content (Kg DO m^{-2}), 0-50 m in Puget Sound*



C. Upwelling Index (NOAA)



D. *Anomalies in Dissolved Oxygen Deficit (Kg DO m^{-2}), > 20 m in Puget Sound*



A) The North Pacific Gyre Oscillation Index correlates significantly with dissolved oxygen anomalies in Puget Sound. B) Monthly anomalies in the dissolved oxygen content (0-50 m) for individual stations. Red indicates anomalies higher than the 75th percentile; green indicates anomalies lower than the 25th percentile; black values fall near the median; gray are missed sampling events. C) The Upwelling Index at 48°N, 125°W significantly correlates with annual anomalies in the oxygen deficit from 20 m to the bottom in Puget Sound. D) Monthly anomalies in the dissolved oxygen deficit (>20 m) shown for individual stations. The oxygen deficit is the amount of oxygen required to achieve 100% saturation in seawater at ambient conditions. Significant correlations (Spearman Rank Correl, p <0.05) are based on 3-year running averages of ocean indicators correlated with annual averages of anomalies in Puget Sound.

Get the data and trends from us?

We observe increasing nutrients and changing algal biomass patterns in Puget Sound:

Algae bloom Budd Inlet 2010

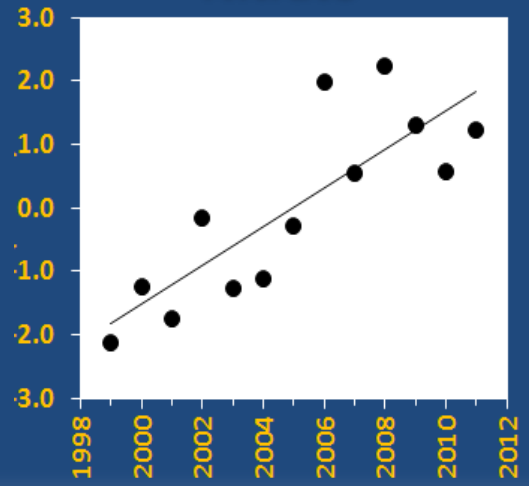
Nitrate

Phosphate

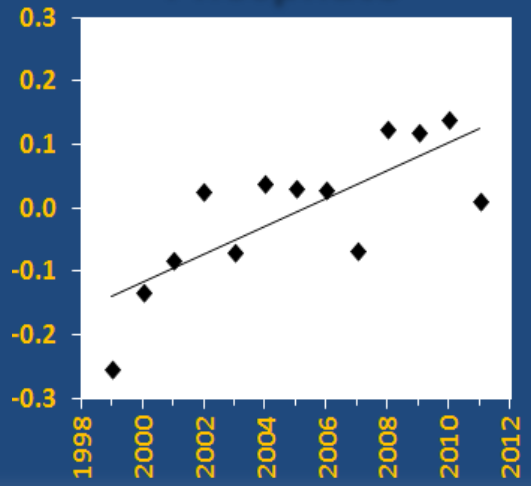
Changing Nutrient Balance

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

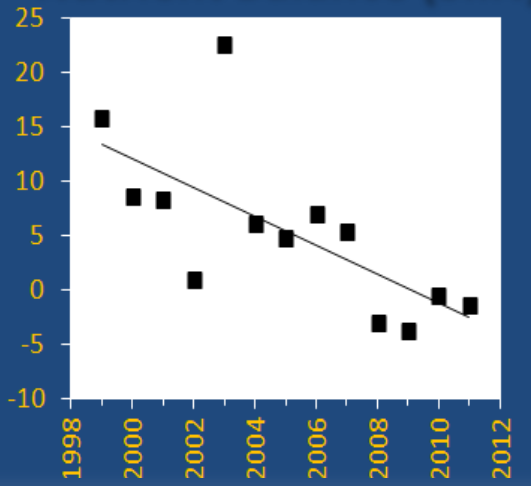
Nitrate



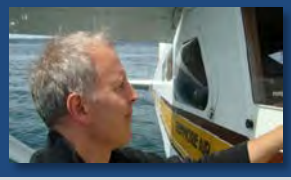
Phosphate



Nutrient Balance (Si:N)



Summary: Aerial photography 3-25-2013



Jellyfish aggregations continue to go strong in southern inlets. Strong bloom in Hood Canal. Large prop wash in Seattle waterway.

Start here

What you see from Seattle to the sea

Mya, Joe and Christopher in the plane.

Front

Mixing and Fronts: 3 6 7

Fronts along river plumes and the beach.

Jellyfish: 1 2

Abundant in Budd, Eld and Totten Inlets.

Plume

Suspended sediment: 1 2 4 5 15

Natural and several human sediment activities.

Bloom

Visible blooms: 3 6 7 8 9 10 11 12 13 14

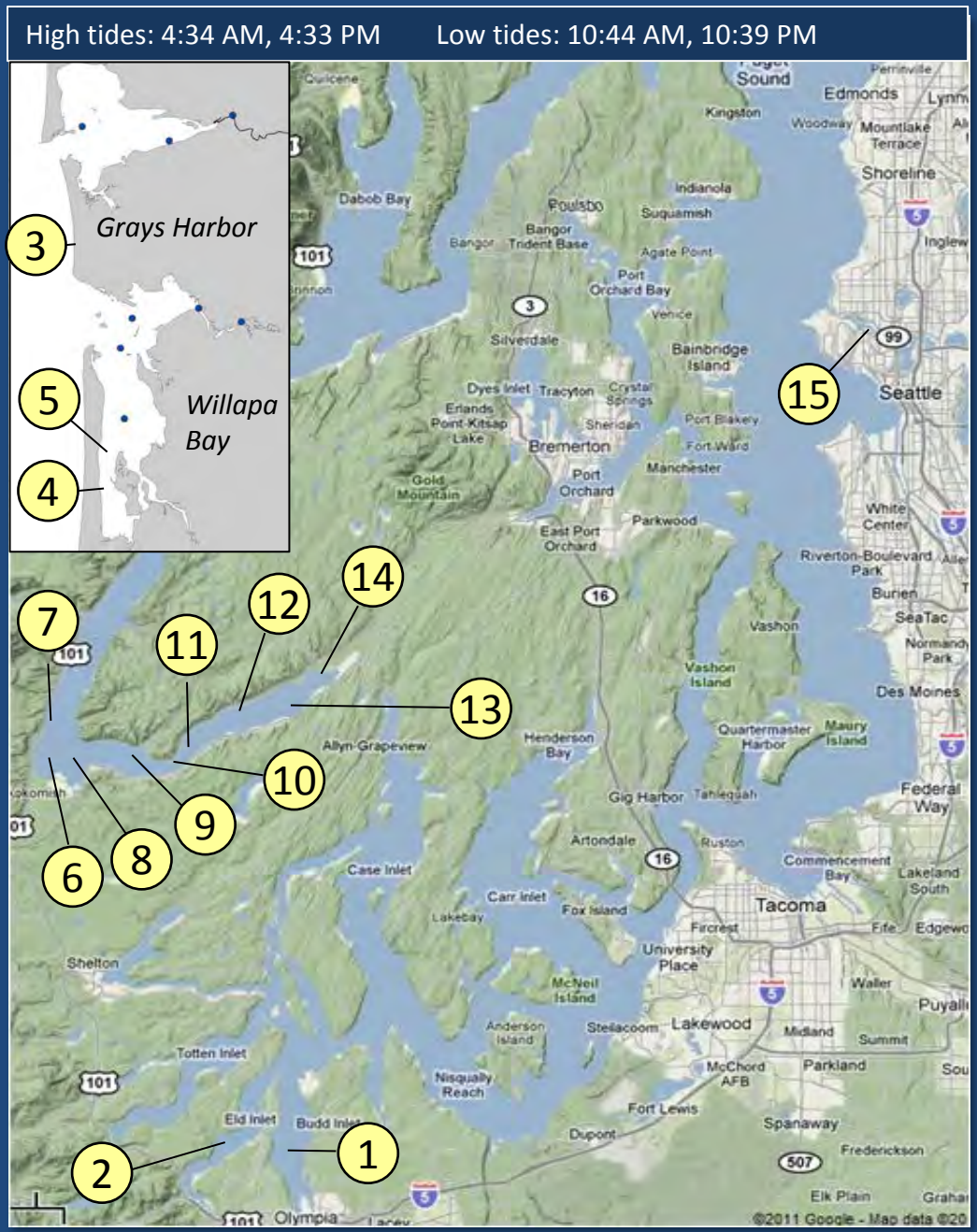
Red-orange-brown bloom in Hood Canal.

Red-brown bloom beginning in Sinclair Inlet.

Debris

Debris: 2 6 7 14

Occasional debris lines near rivers.



Aerial photography navigation guide, 3-25-2013

Click on numbers

Flight Information:

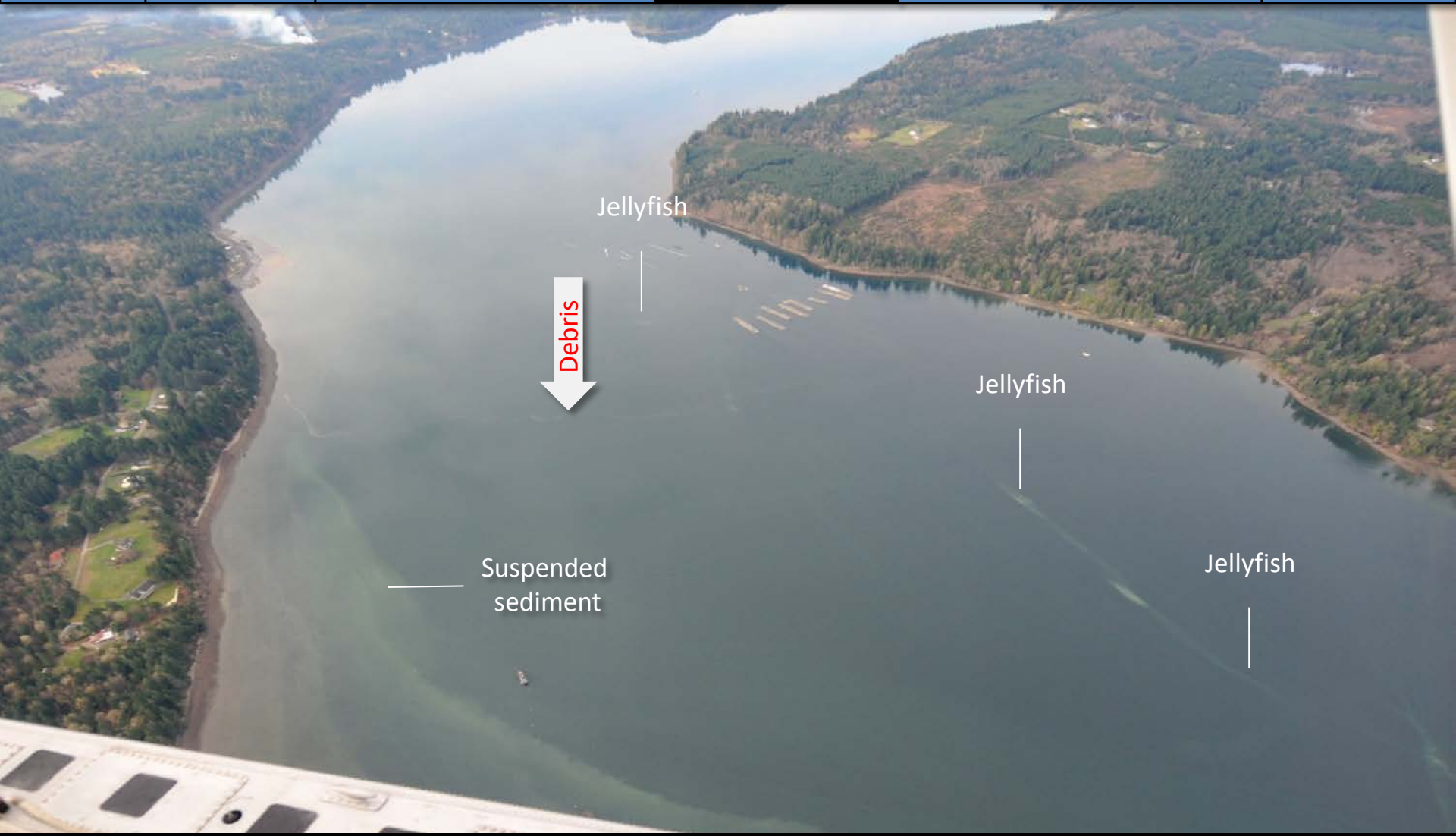
- **Full day flight:**
  Variable visibility, some cloud reflections on water, calm

Observation Maps:

Go to map

Jellyfish aggregations, wooden barge and sediment trail.

Location: Budd Inlet (South Sound), 9:38 AM



Suspended sediment and patches of jellyfish. Location: Totten Inlet, 9:46 AM

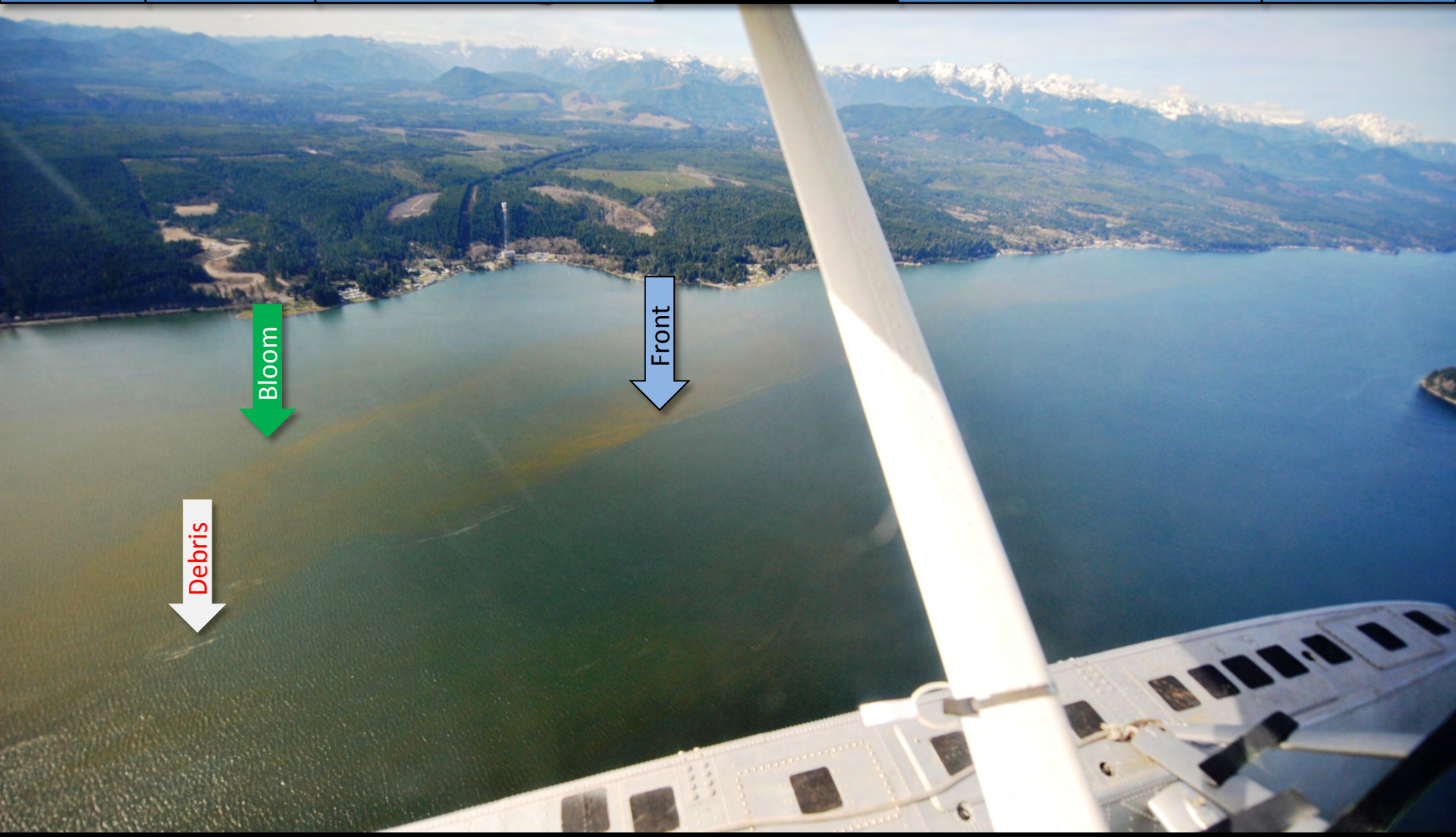
Nearshore plankton bloom and front of Columbia River plume water.
Location: Between Grays Harbor and Willapa Bay, Coast, 11:37 PM

Shellfish growers preparing their shellfish beds. Location: Willapa Bay, 1:11 PM

Shellfish growers preparing their shellfish beds. Location: Willapa Bay, 2:01 PM

Large and intense red-orange-brown plankton bloom and surface debris.

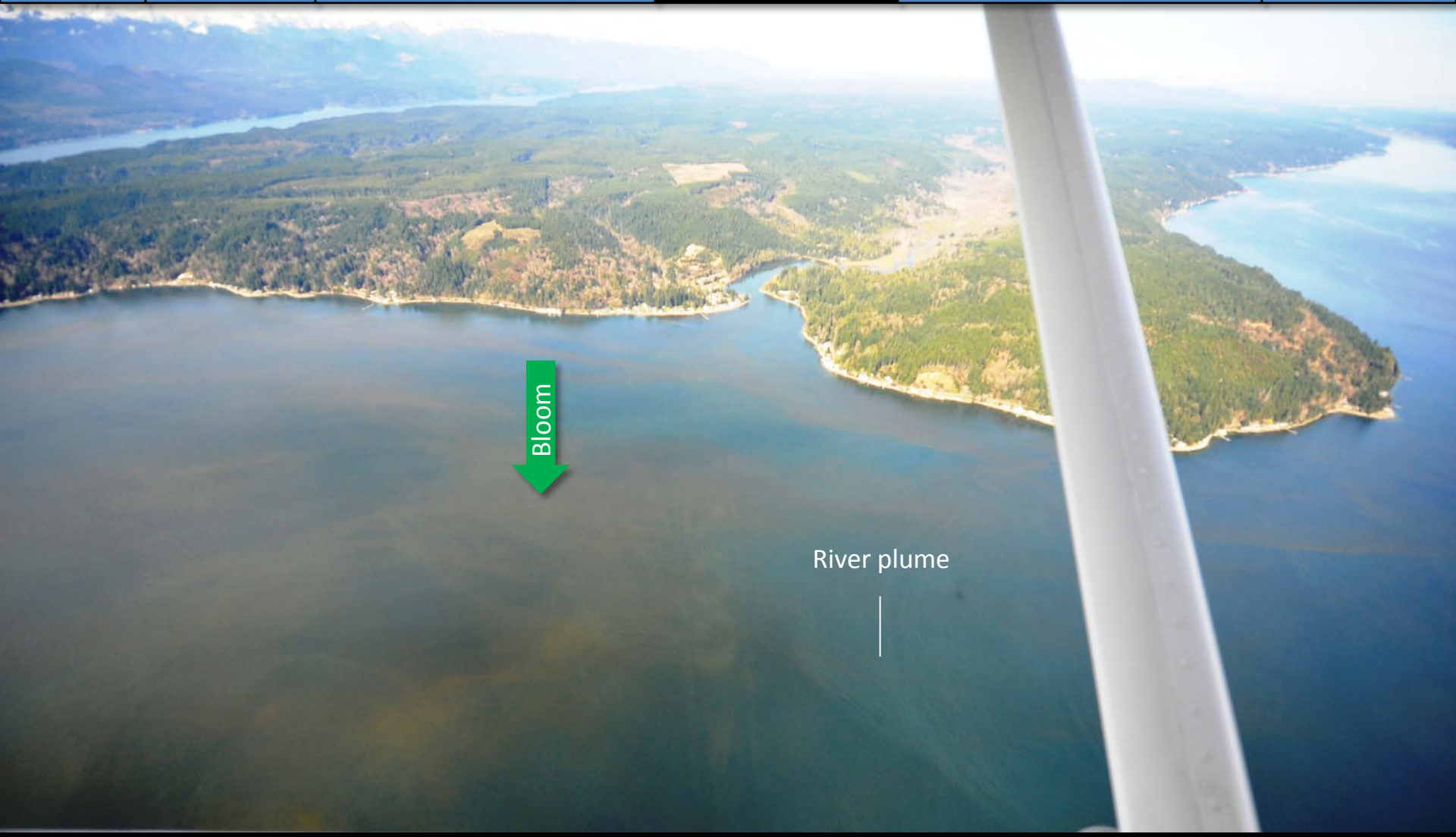
Location: Hood Canal, 3:27 PM



Large and intense red-orange-brown plankton bloom and surface debris.

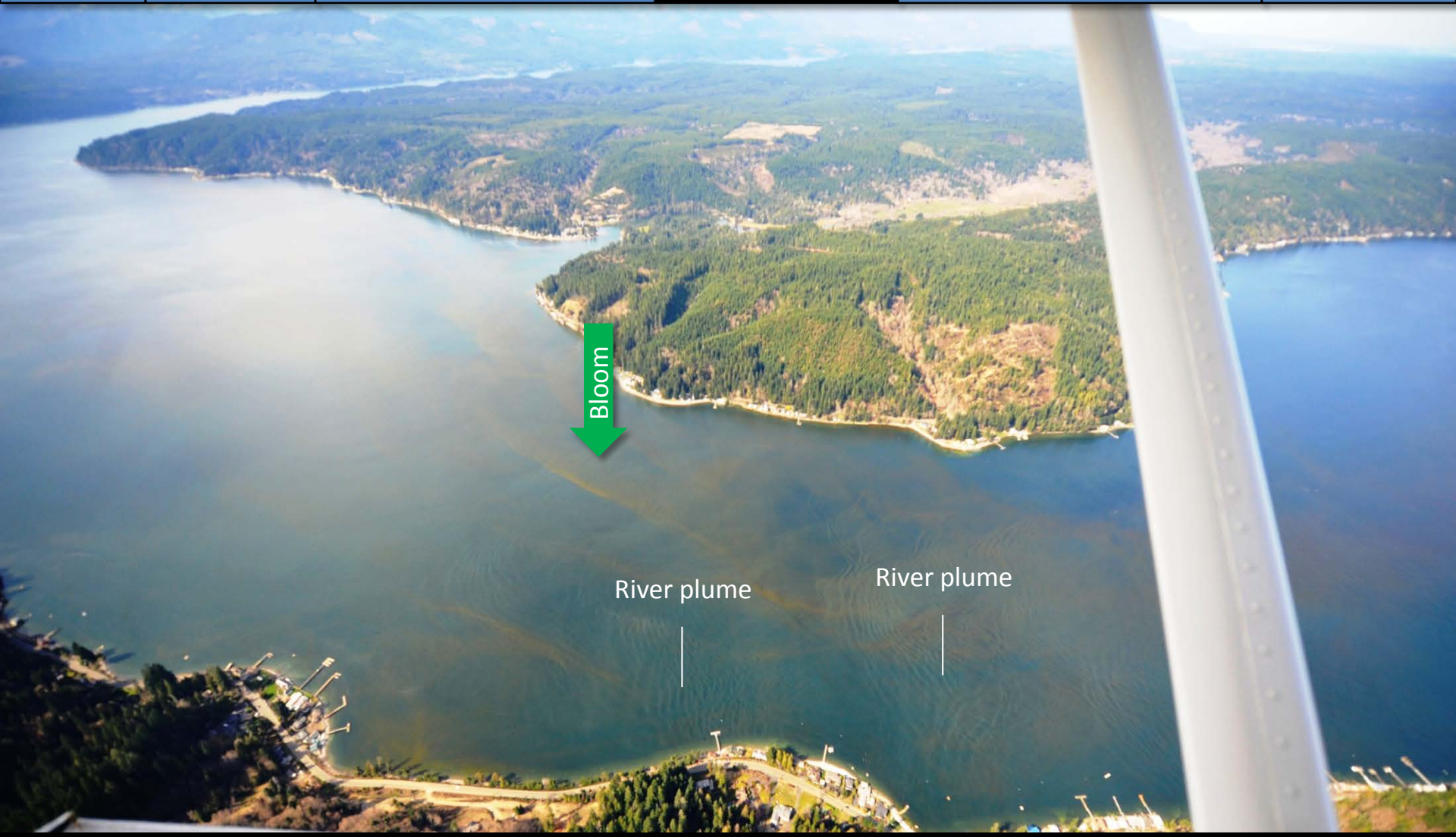
Location: Hood Canal, 3:27 PM

Large and intense red-orange-brown plankton bloom.
Location: Hood Canal, 3:28 PM



Large and intense red-orange-brown plankton bloom and river plume.

Location: Hood Canal, 3:31 PM



Large and intense red-orange-brown plankton bloom and river plume.

Location: Hood Canal, 3:32 PM

Large and intense red-orange-brown plankton bloom and river plume.

Location: Hood Canal, 3:33 PM

Aerial photography 3-25-2013

Large and intense red-orange-brown plankton bloom.

Location: Hood Canal, 3:35 PM

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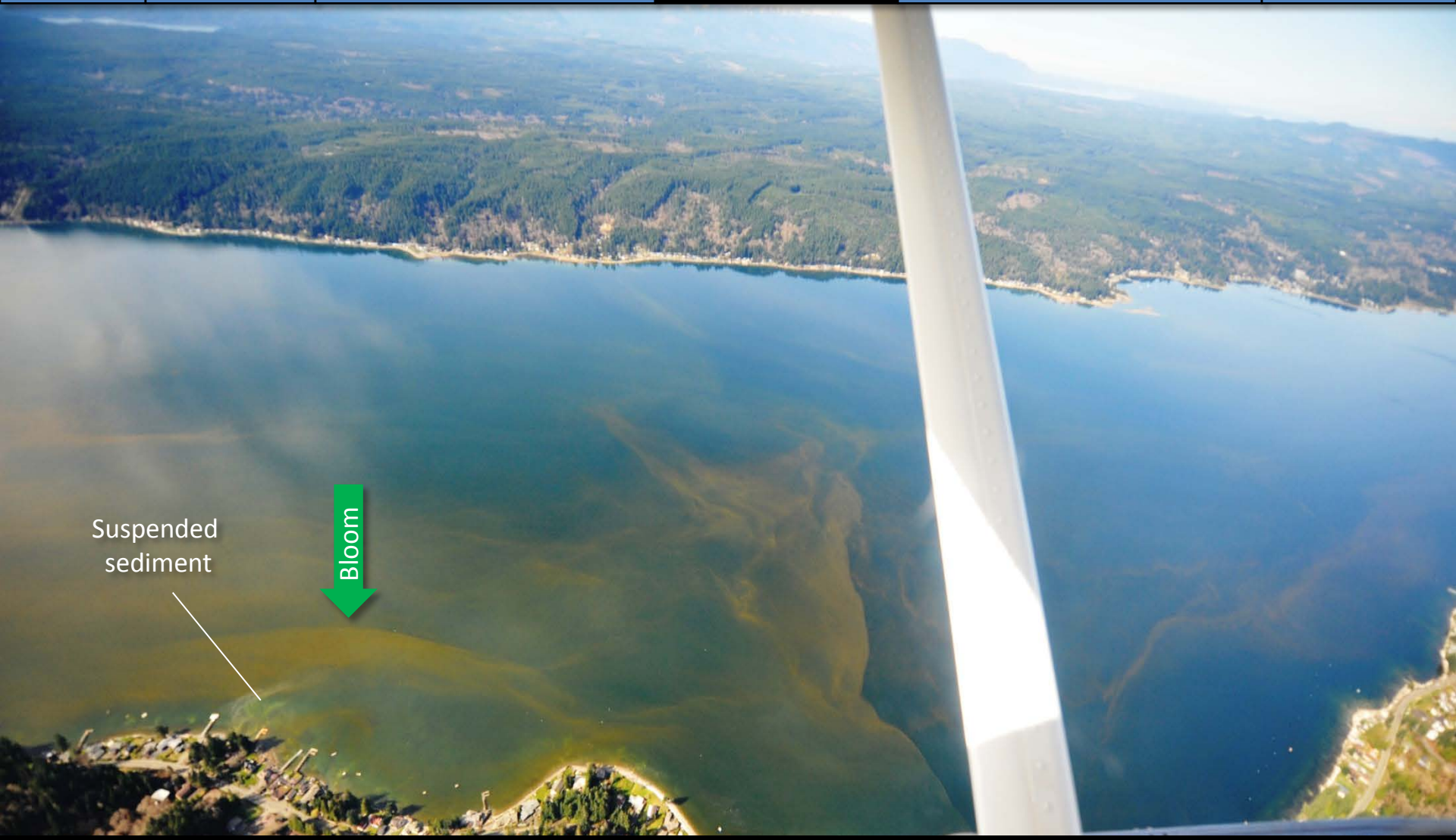
Aerial photography 3-25-2013



Large and intense red-orange-brown plankton bloom.

Location: Hood Canal, 3:35 PM

Aerial photography 3-25-2013

Large and intense red-orange-brown plankton bloom.
Location: Belfair State Park, Hood Canal, 3:38 PM

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Aerial photography 3-25-2013

Large sediment plume extending into waterway. Plume originated from the southern shore.

Location: Ballard ship canal (Seattle), 3:57 PM

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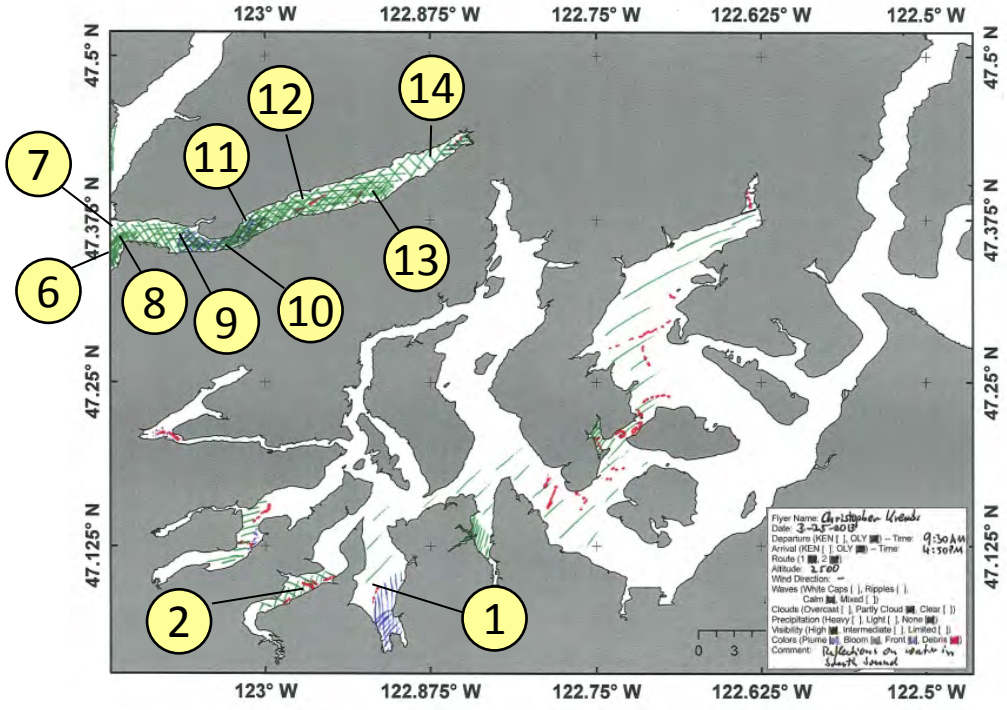
Aerial photography observations in Central Sound

Navigate

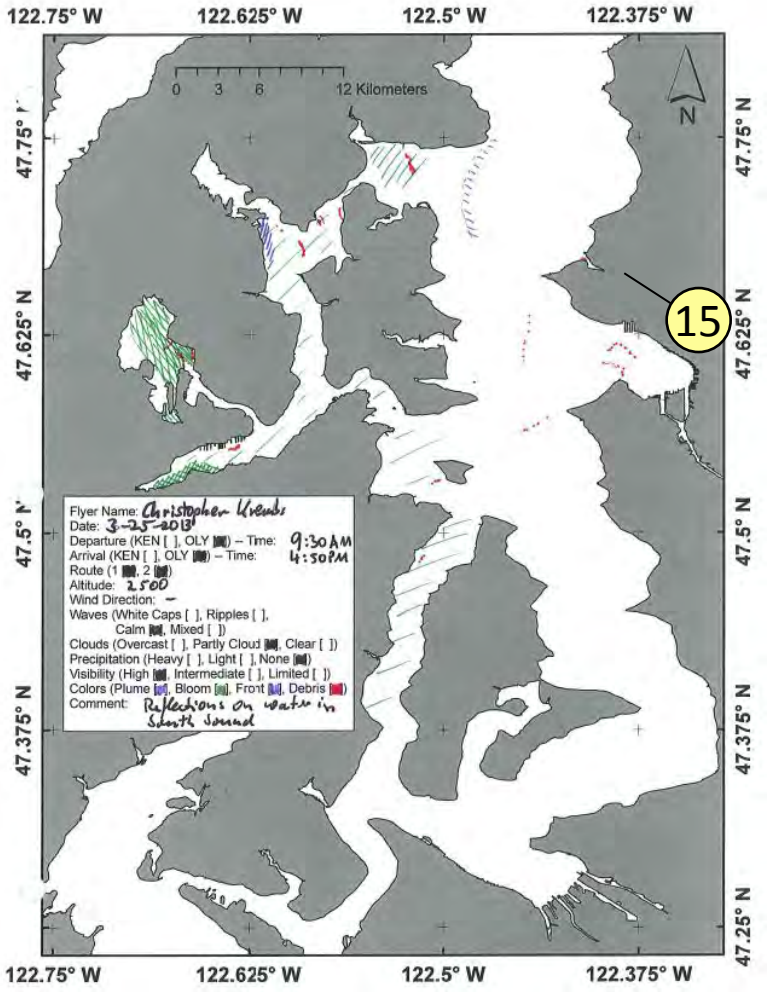
Date: 3-25-2013

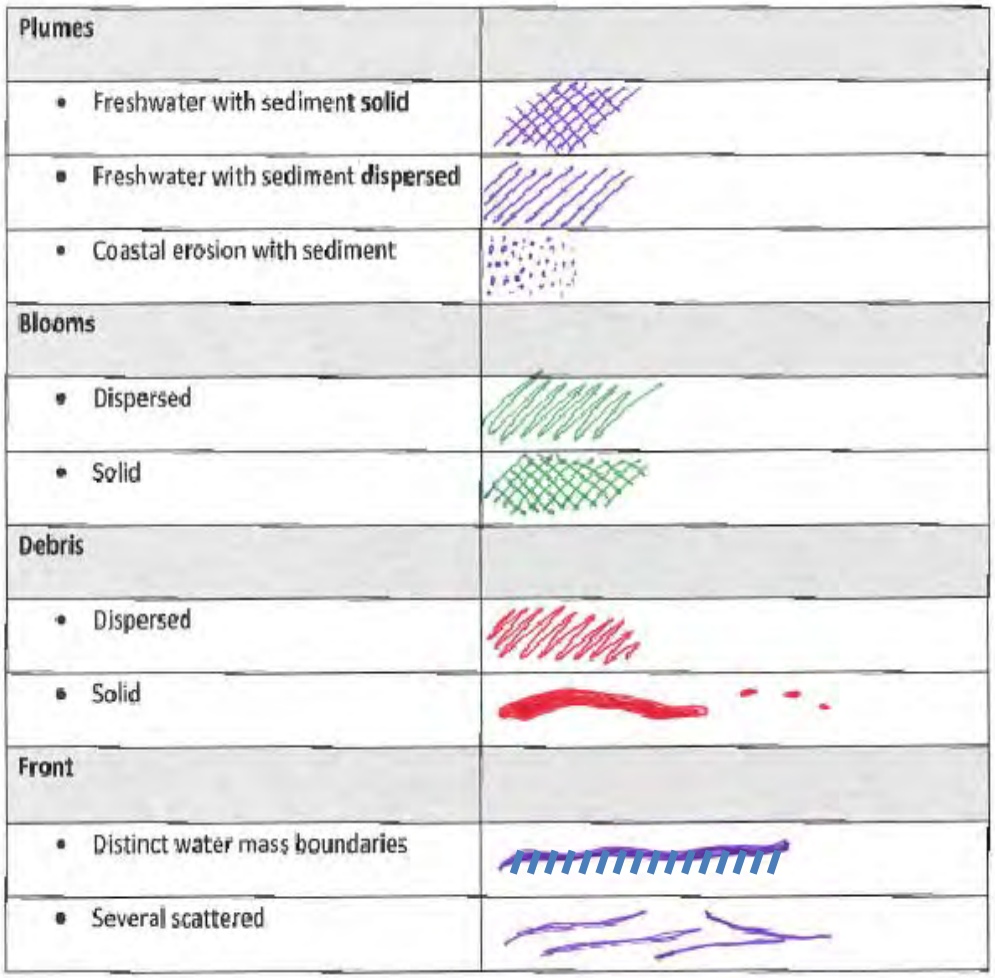
Morning and afternoon



Numbers on map refer to picture numbers for spatial reference

Afternoon



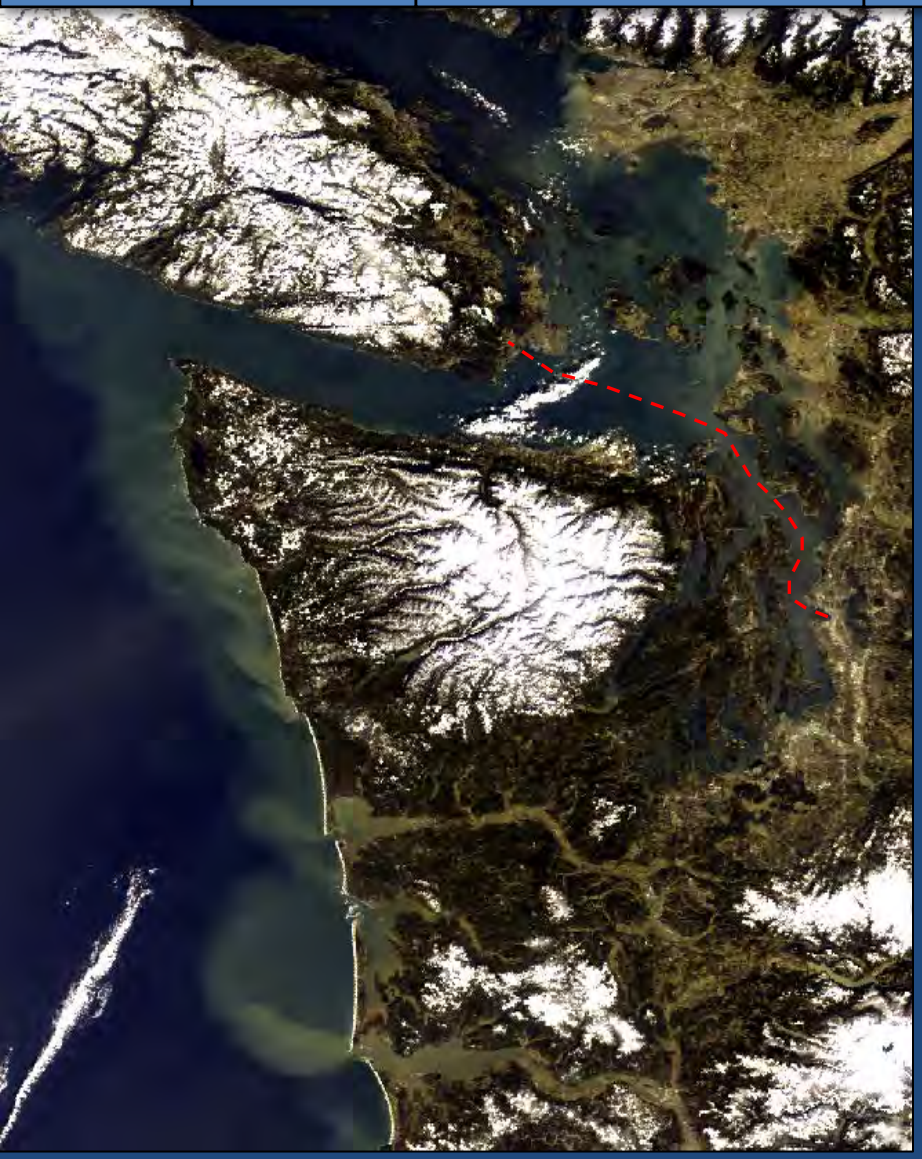


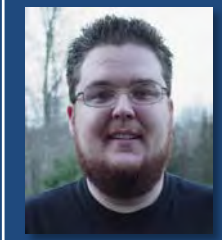
Comments:
Maps are produced by observers during and after flights. They are intended to give an approximate reconstruction of the surface conditions on scales that connect to and overlap with satellite images in the section that follows.

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.

Ferry and satellite observations: 3-25-2013





Brandon Sackmann
Contact:
bsackmann@integral-corp.com

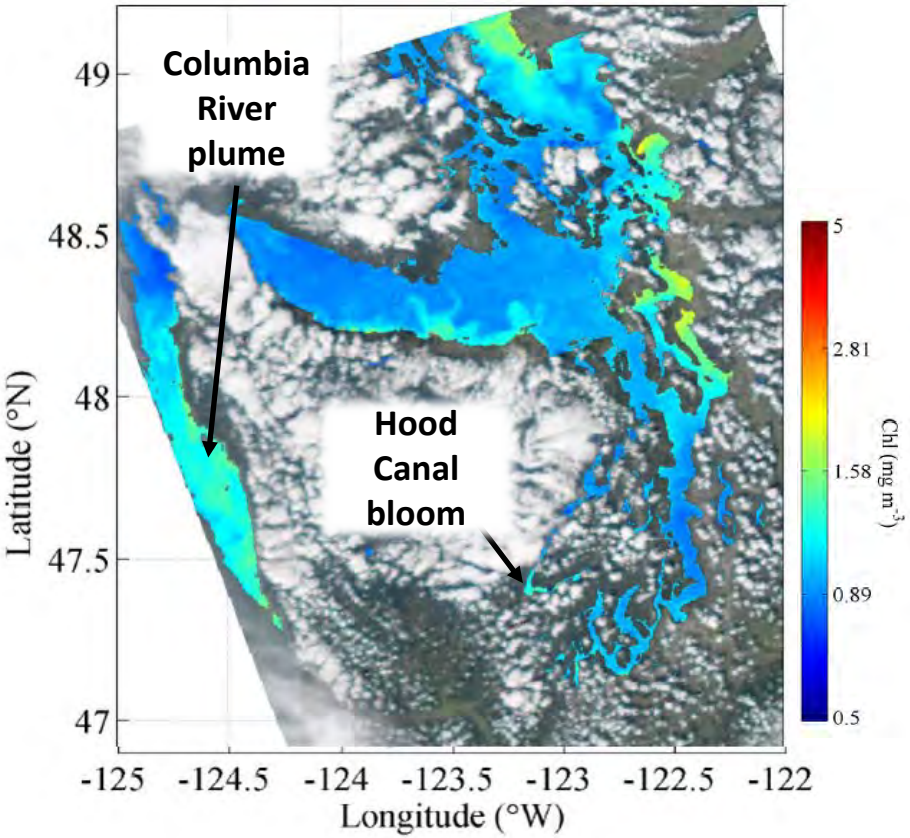
Current Conditions:
Bloom in Hood Canal picked up by MODIS. Victoria Clipper IV is still in the shipyard for annual maintenance. Sensors have been checked and will soon resume collecting data.

Annual Maintenance. No Data Available.

MERIS True Color image used for spatial context (19 February 2011) of the Victoria Clipper en route monitoring route (red dashes on map).

MODIS satellite: 3-23-2013, 1:45 PM (20:45 UTC)

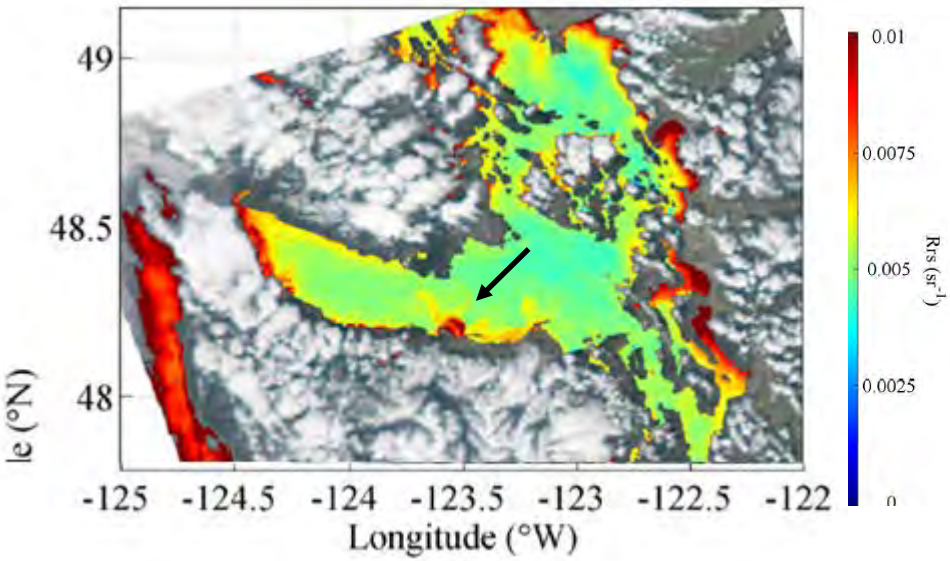
Phytoplankton Biomass



MODIS-A Product (NASA): Chlorophyll (Chl)
Processing Algorithm: 12gen, OC2 (SEADAS v6.2)

Turbidity Proxy

Lots of sediment discharging from the Elwha River after a dam removal.



MODIS-A Product (NASA): Remote sensing reflectance at 645 nm
Processing Algorithm: 12gen (SEADAS v6.2)

MODIS satellite qualitatively confirms Hood Canal phytoplankton bloom and coastal Columbia River plume extending north and entering Strait of Juan de Fuca. Sediment discharging from the Elwha River after a dam removal.

Mooring observations and trends 3-12-2013 to 3-25-2013

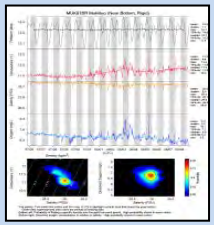
Summary: Temperatures are rising. Lower dissolved oxygen (DO) is associated with higher salinities, with peaks in DO occurring with distinct salinity dips, meaning fresher water has higher levels of DO.

Mukilteo, Whidbey Basin near Everett:

Mukilteo Dissolved Oxygen Conditions (12-16 m)

DO Max	8.1 mg/L	on 03/15	at 27 PSU	8.5 °C	14.6 m
DO Min	6.8 mg/L	on 03/20	at 29.4 PSU	8.4 °C	15.2 m

DO Avg	7.3
DO Trend	-0.3 mg/L
DO-Sal Corr	-0.85
DO-Temp Corr	0.2



Real-time data online (click)

Mukilteo Salinity (Sal) Conditions (12-16 m)

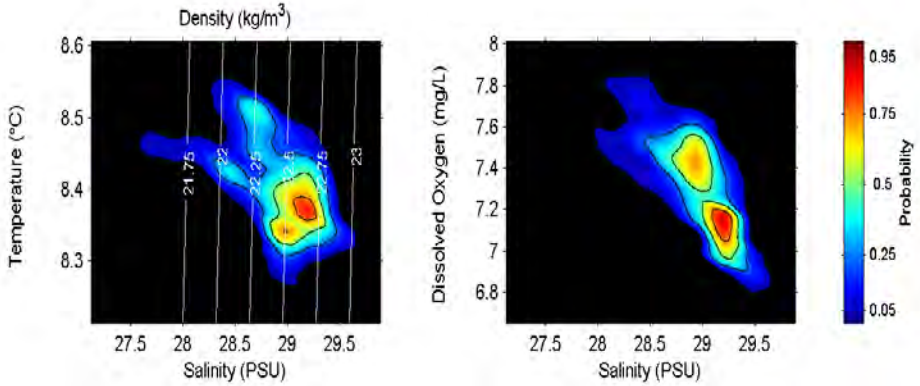
Sal Max	29.4 PSU	on 03/20	at 8.3 °C	14.5 m
Sal Min	25.9 PSU	on 03/17	at 8.6 °C	12.8 m

Sal Avg	28.9 PSU
Sal Trend	0.2 PSU

Mukilteo Temperature (T) Conditions (12-16 m)

T Max	8.7 °C	on 03/18	at 27.5 PSU	12.7 m
T Min	8.3 °C	on 03/13	at 29.1 PSU	15.5 m

T Avg	8.4 °C
T Trend	0.1 °C



Left Panel: Probability of finding a specific density over the past two-week period. 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 3-12-2013 to 3-25-2013

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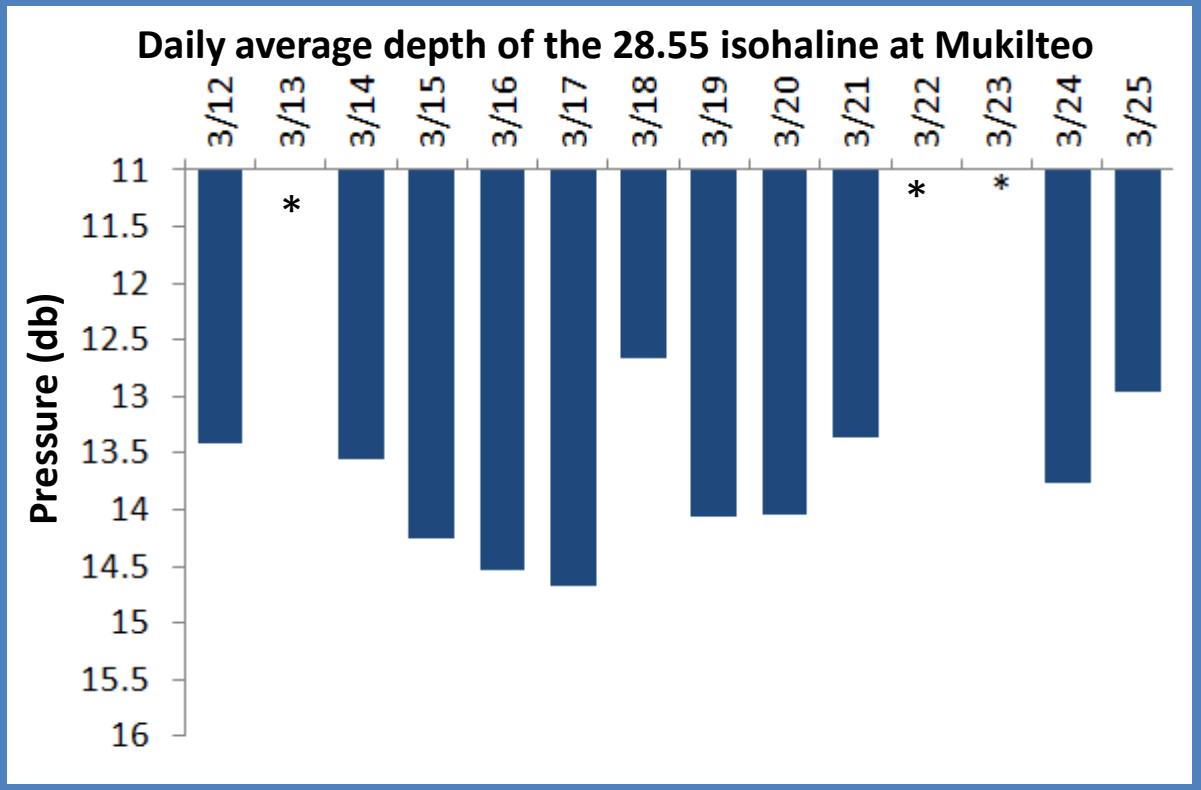
NANOOS

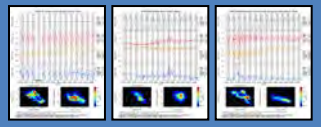
Go to our mooring website at: http://www.ecy.wa.gov/programs/eap/mar_wat/moorings.html

Summary: River flow continues to increase. In March, the freshwater layer was thicker than in February, indicated by increased depth of the 28.55 isohaline layer.

We report on thickness of the freshwater layer by monitoring our near-surface sensor. The pycnocline is often near the surface sensor (*). This is another way to interpret the amount of freshwater entering Puget Sound.



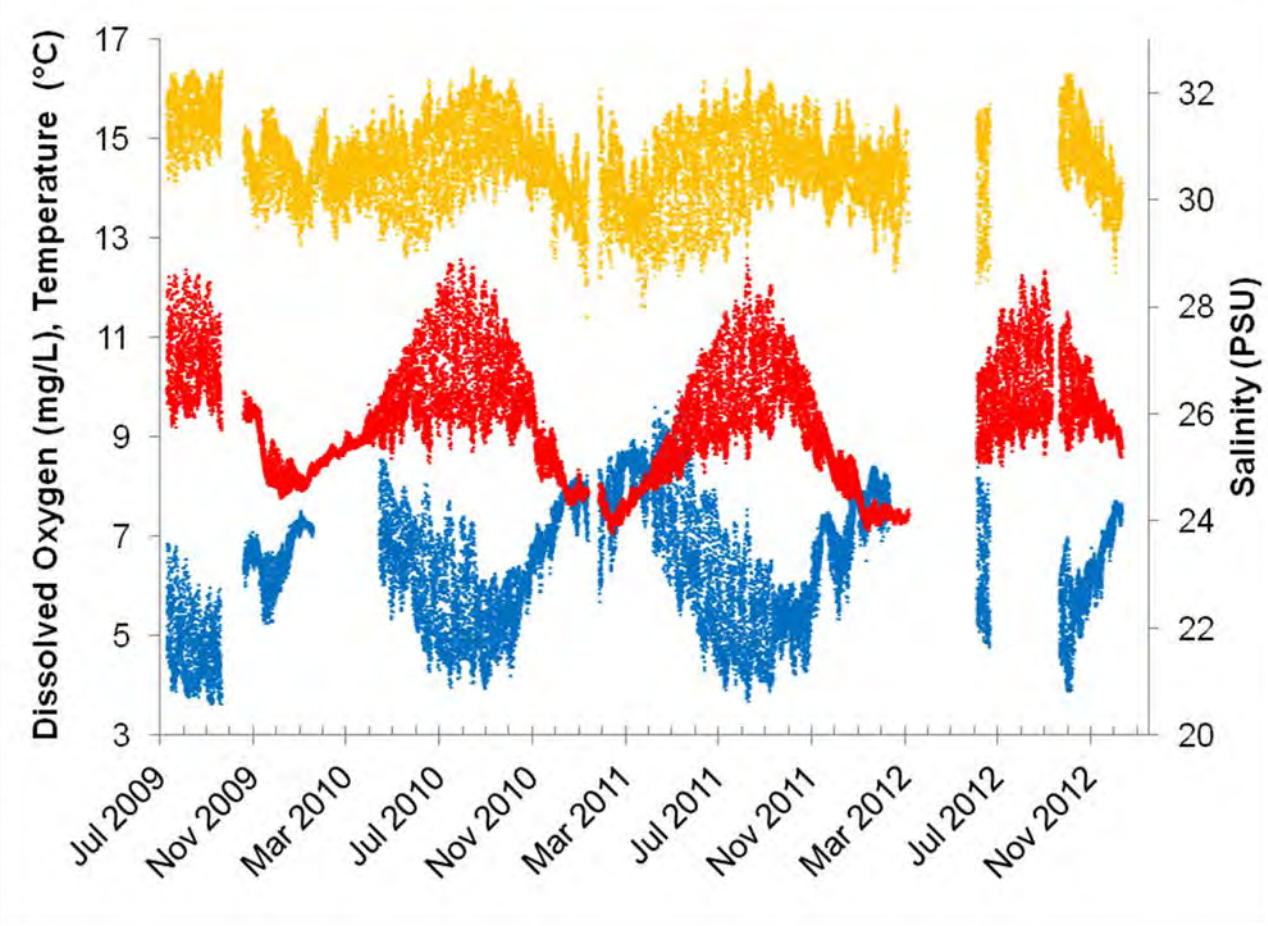
We track the depth of the isohaline where salinity is 28.55 (±0.05) to measure the thickness of the freshwater layer at our Mukilteo station. The near-surface sensor experienced tidal pressure variations of 11.0 to 16.0 meters (or dbar).



Real-time data online (click)

Mooring observations and trends Admiralty Reach 2009 to 2012

Periods of high variability coincide with times of strong upwelling.
Upwelled ocean water, low in oxygen, is effecting Puget Sound's water quality.



Admiralty Inlet mooring. The 2009-2012 plot shows seasonality and variability in temperature (red), dissolved oxygen concentration (blue) and salinity (yellow) collected on 30 min. intervals at 65-m depth.

(not shown in plot) Largest gradients across the sill occur during tidal exchanges when upwelled cold, salty, low oxygen Pacific Ocean water enters Puget Sound during flood tides and warm, fresh, more oxygenated water exits Puget Sound via Admiralty Reach during ebb tide. Small variability with lesser gradients prevail during winter.

Get data from Ecology's Monitoring Programs

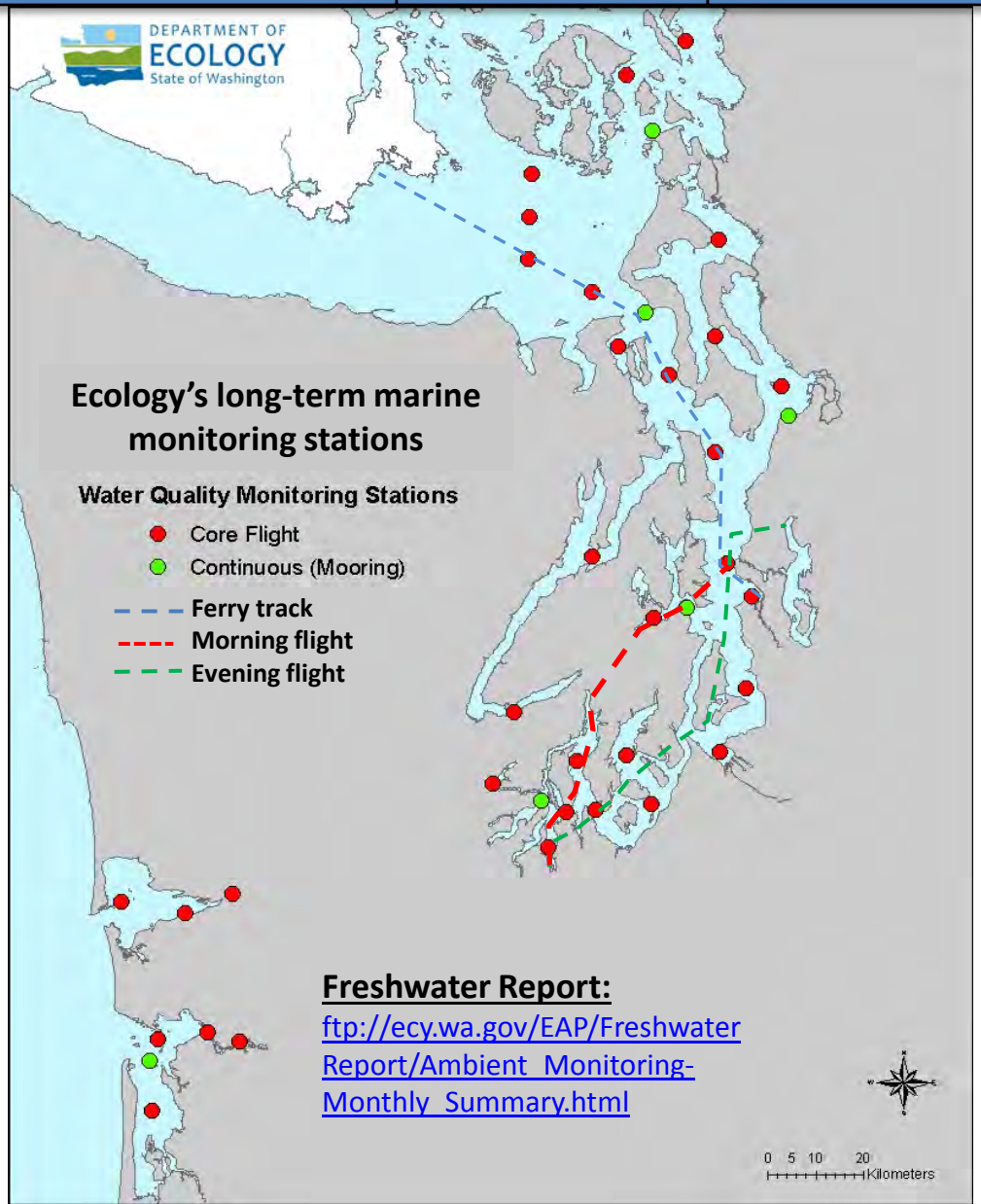
Flight log	Weather	Water column	Aerial photos	Ferry and Satellite	Moorings

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

brandon.sackmann@ecy.wa.gov

Access mooring data:

http://www.ecy.wa.gov/programs/eap/mar_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

We are looking for feedback to improve our products.

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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.