Publication No. 13-03-075

DEPARTMENT OF ECOLOGY State of Washington

Eyes Over Puget Sound

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

Surface Conditions Report
June 17, 2013

Visit our 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 6-17-2013 at a glance

LONG-TERM MARINE MONITORING UNIT

Mya Keyzers
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David Mora

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Dr. Brandon Sackmann

Personal flight log p. 3

Puget Sound on fire! Stunning views of a second *Noctiluca* bloom this year from up high.

Weather conditions p.5

Rivers are running below normal.
Air temperatures and sunshine start climbing above expected values, southerly winds in most places.

Water column and mooring p.6 , p.38

After 2 years of favorable conditions with colder temperatures and higher oxygen, Puget Sound waters are turning warmer, resulting in lower dissolved oxygen. A big *Noctiluca* bloom left its imprint on dissolved oxygen.

Aerial photography p. 10

The second large *Noctiluca* bloom this year extends from Everett to Tacoma. Red-brown blooms in Port Townsend, Discovery Bay, and Bellingham Bay. Large algal mats or organic material observed in many places. Jellyfish patches increasing in Budd, Totten, and Eld Inlets.

Ferry and satellite p. 35

Landsat 8 and Victoria Clipper ferry data help document the spatial and temporal extent of the large *Noctiluca* bloom seen in central Puget Sound.

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

North Sound Flight

Mya, Christopher and Joe, go team!

Recent conditions created the perfect scenario for…

Noctiluca to bloom yet again!

The real show came at the end of the day when we got to Edmonds and started to see a bright orange Noctiluca bloom. It was huge! It persisted all the way to South East Passage. It was the most extensive bloom I have ever seen. Every direction you looked - there it was. It's as if Puget Sound was on fire!

North Sound Flight

Christopher collecting a phytoplankton sample at our Skagit Bay station, CTD in background.

"The size of this bloom made me wonder…. Why is it happening in the Main Basin and not in South Sound? Why is it happening again? Why don't we know more about its appearance and ferocious appetite for phytoplankton? Could it be that our imprint on Puget Sound is artfully surfacing to remind us of our daily connection to the Sound? Could these large blooms be a clue of a shift in the food chain?" –Mya

Weather patterns from 6-3-2013 to 6-17-2013

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

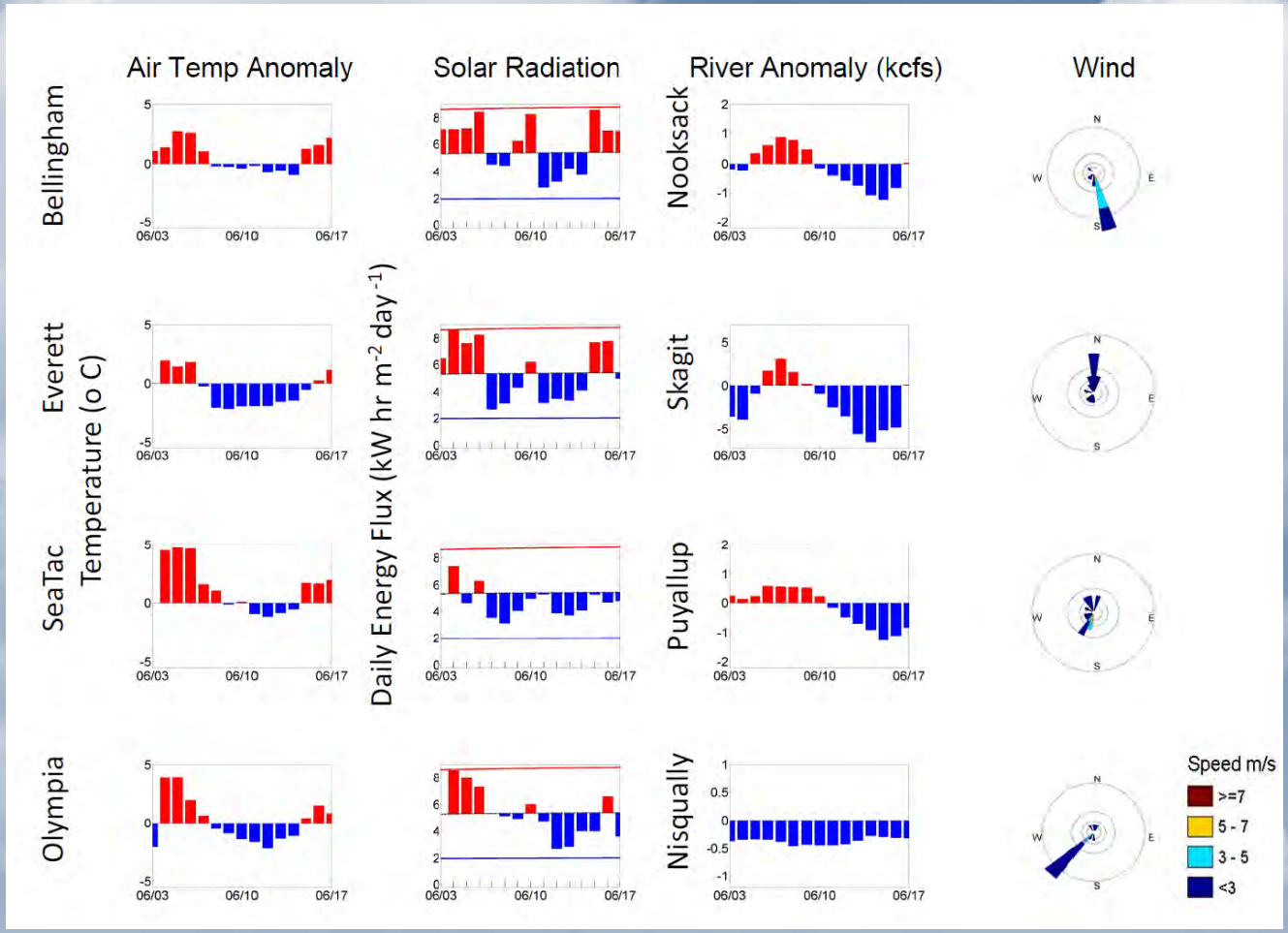
Summary:

Air temperatures have increased to above normal levels for the past several days after a colder period.

Sunshine levels in the north have been above normal for the past several days following a cloudy period.

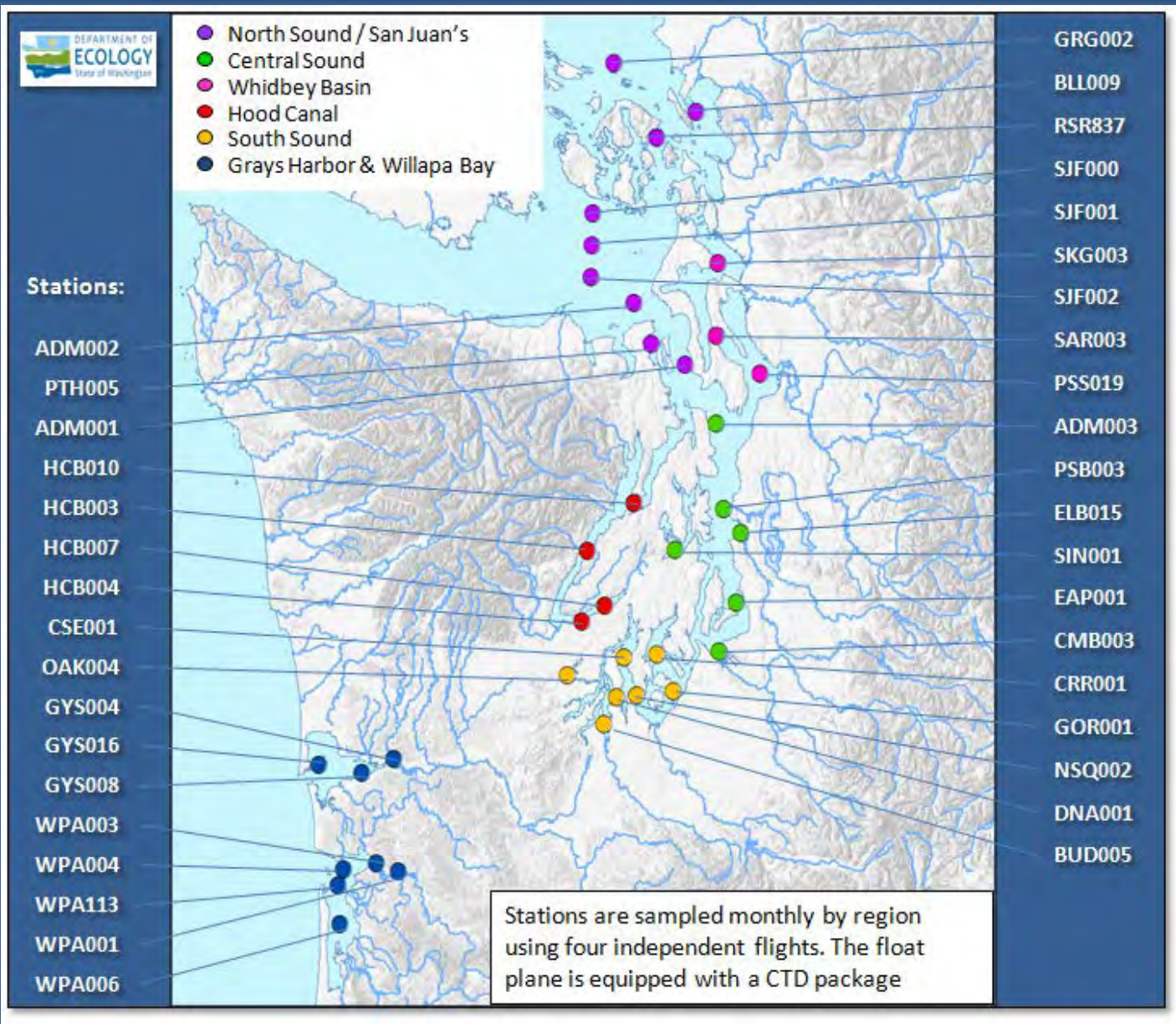
Rivers have been running much below normal.

Winds have mostly been from the south to southwest with the exception in Central Sound.



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 Puget Sound



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

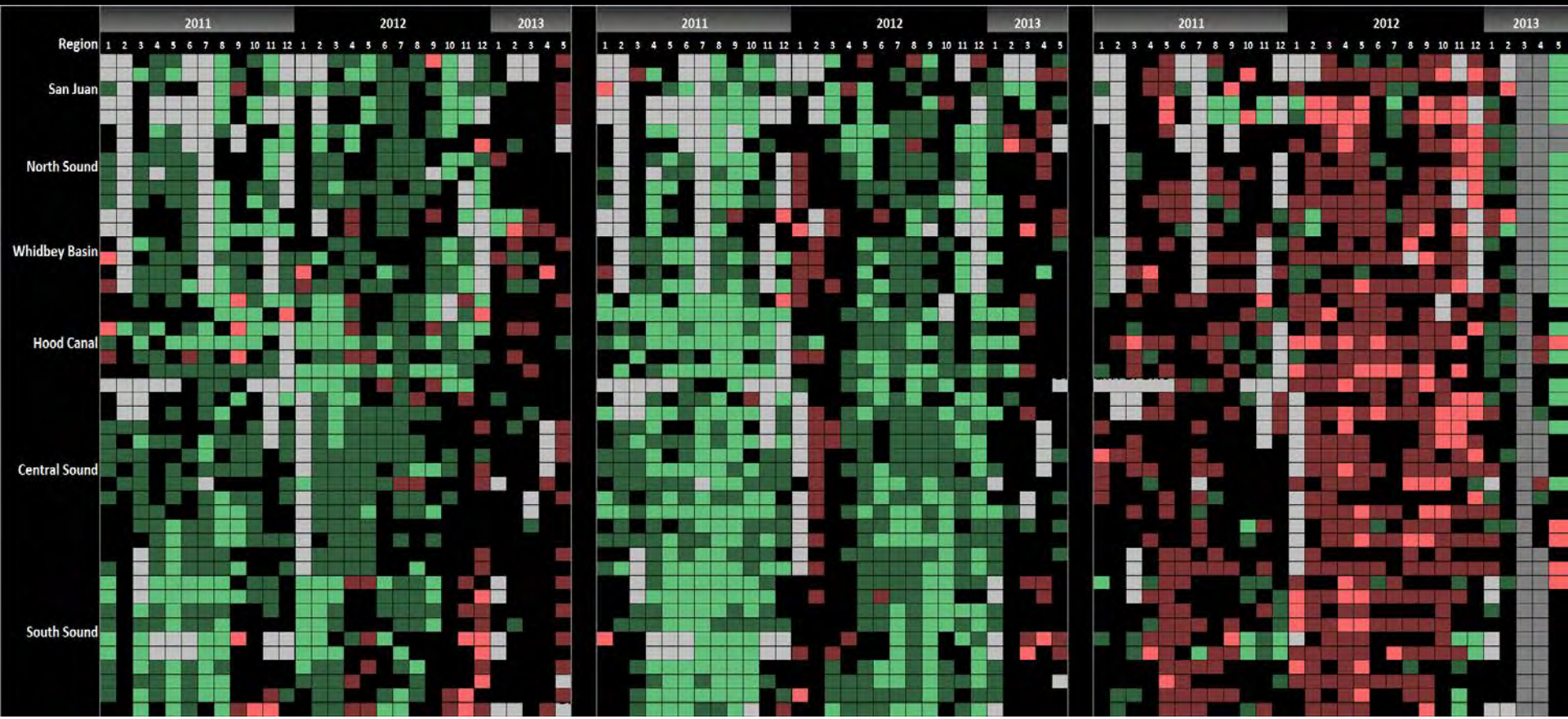
Start here

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

Temp: 2013 is warming **Salinity: Increasing?** **Oxygen: Decreasing?**



= 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

Puget Sound water conditions are changing again! Compared to 2011-2012, when waters were colder and fresher with higher oxygen, values are closer to expected this year. A sensor check prevented Mar. and Apr. oxygen data from being available for this report. Each pixel is a monthly survey at each station.

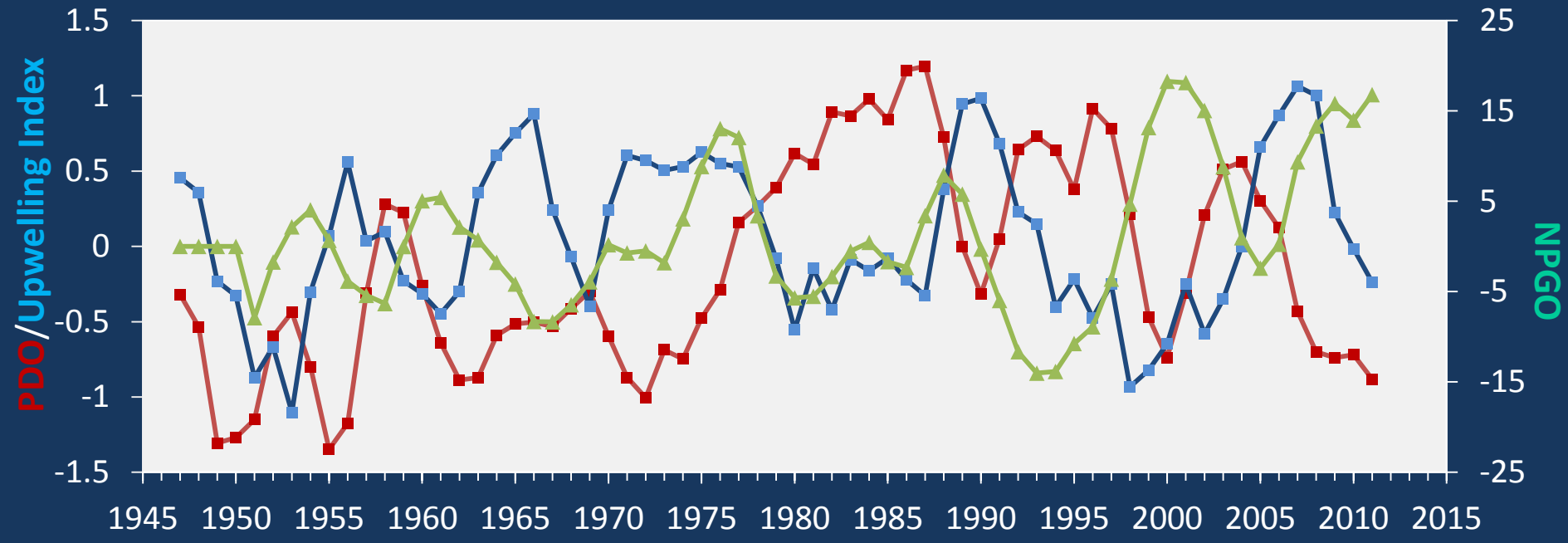
The ocean affects water quality: Ocean Climate Indices

a) Pacific Decadal Oscillation Index (**PDO**) *...(explanation)*

b) Upwelling Index *(anomalies)* (**PFEL**) *...(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

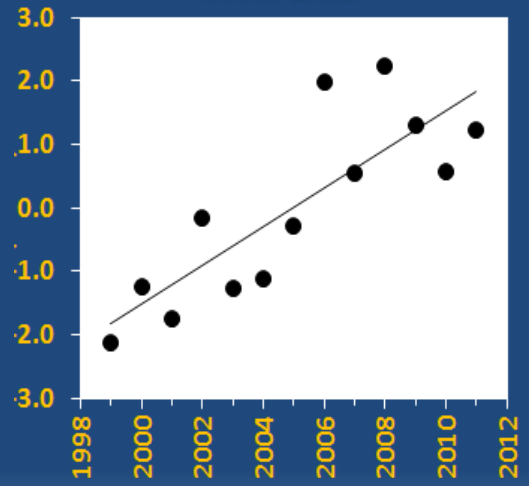
Nitrate

Phosphate

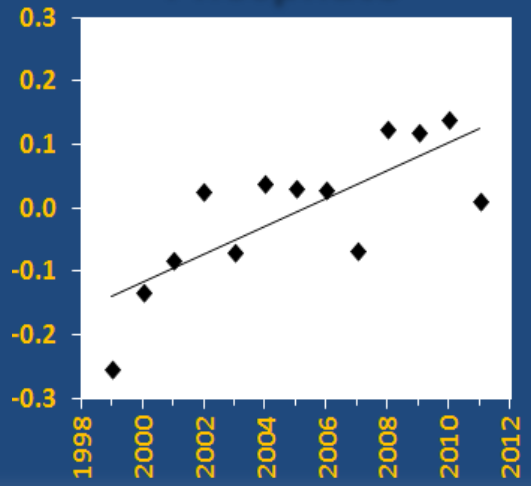
Changing Nutrient Balance

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

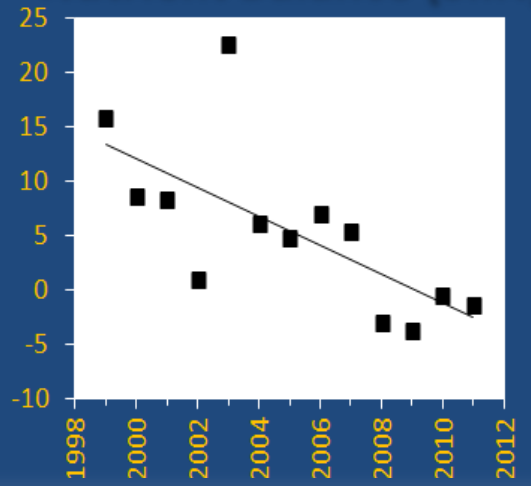
Nitrate



Phosphate



Nutrient Balance (Si:N)



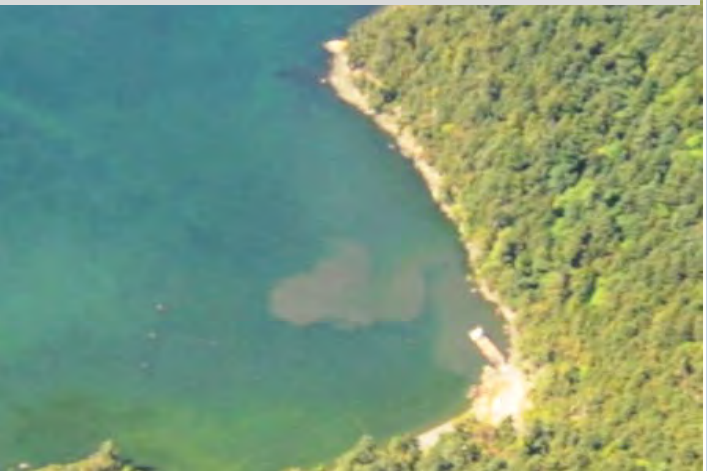
Summary: Aerial photography 6-17-2013

Second *Noctiluca* bloom extending from Everett to Tacoma. Red-brown blooms in Port Townsend & Bellingham Bay. Large algal mats or organic material in may places. Jellyfish patches increasing in Budd, Totten, and Eld Inlets.

Start here

Oil sheen outside Gig Harbor

Ship stirring up sediment, Blakely Island



Front

Mixing and Fronts: 2 3 6

Fronts in the Strait near Lopez Island, Squamish Bay and Port Townsend.

Jellyfish: Present in increasing numbers Budd, Eld, Totten Inlets.

Plume

Suspended sediment:

High sediment load from Nooksack River.

Bloom

Visible blooms: 2 4 5 8 9 10 11 12 13 14 15 16 17 18 19 20

Red: Main Basin, Henderson Inlet.

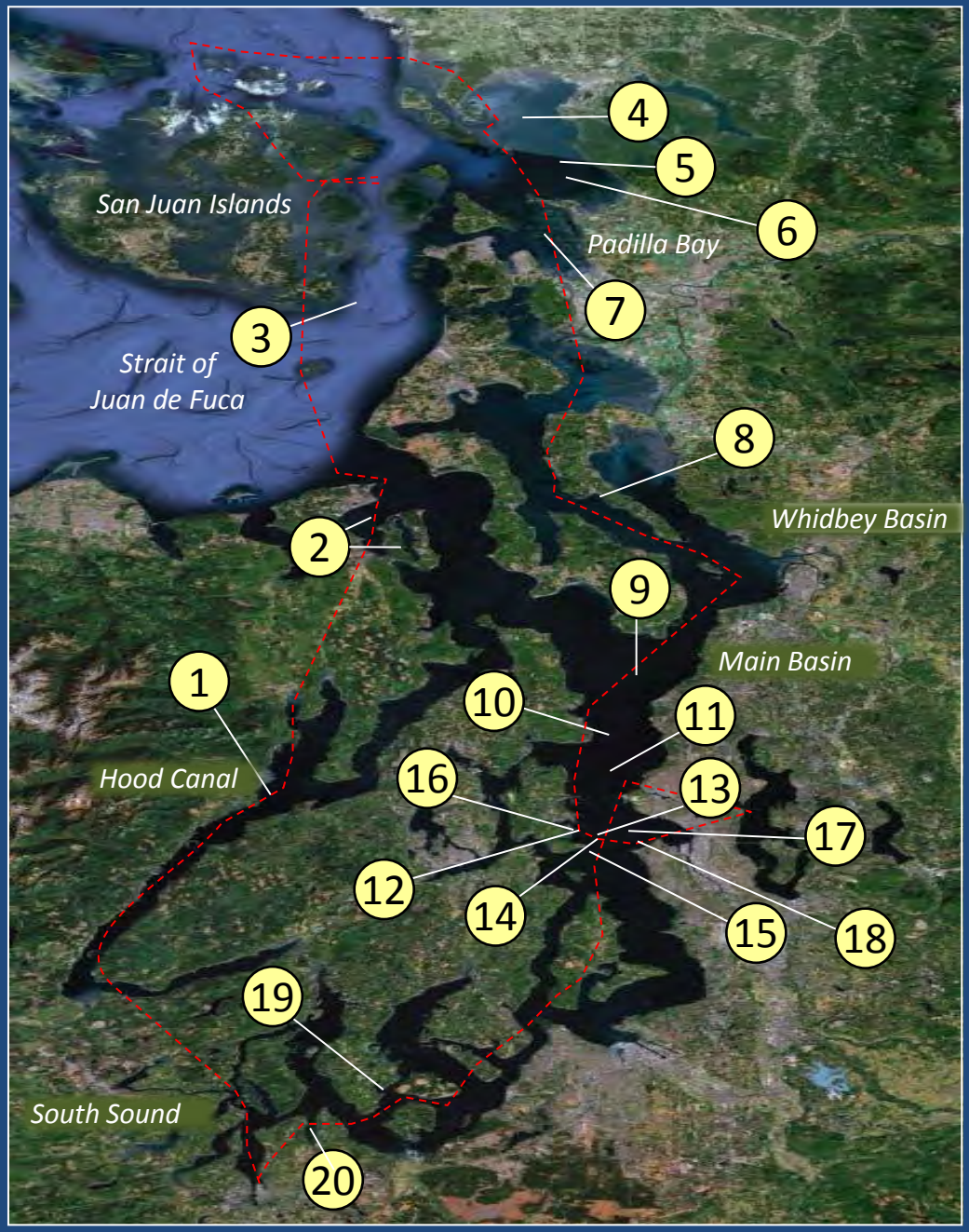
Brown: Port Townsend, Discovery Bay, Bellingham Bay.

Green: Saratoga Passage, Filucy Bay.

Debris

Debris: 1 2 5 6 7 8 9 10 11 12 13 14 15 16 17

Mostly *Noctiluca* in many places. Also organic material rafts in Squamish Bay, Padilla Bay, Port Townsend, and Hood Canal.



Seattle: H. tide: 12:29 PM , L. tides: 6:33 AM, 5:43 PM

Aerial photography navigation guide, 6-17-2013

Click on numbers

Flight Information:

Morning flight, 1-3: ----
Low visibility, clouds, calm

Afternoon flight, 4-20: ----
Good visibility, wind increasing from the south.

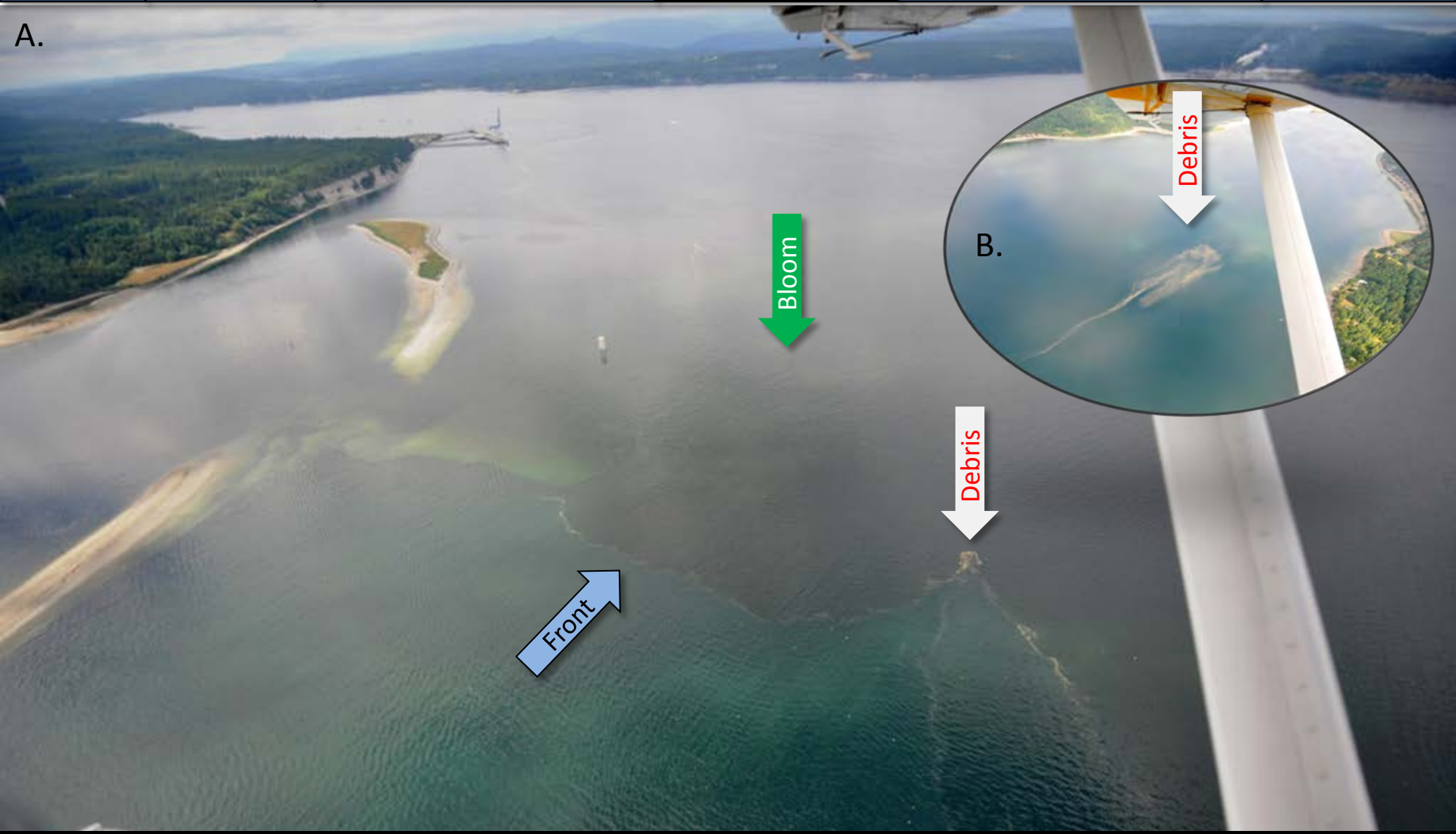
Observation Maps:

Central & North Sound

South Sound

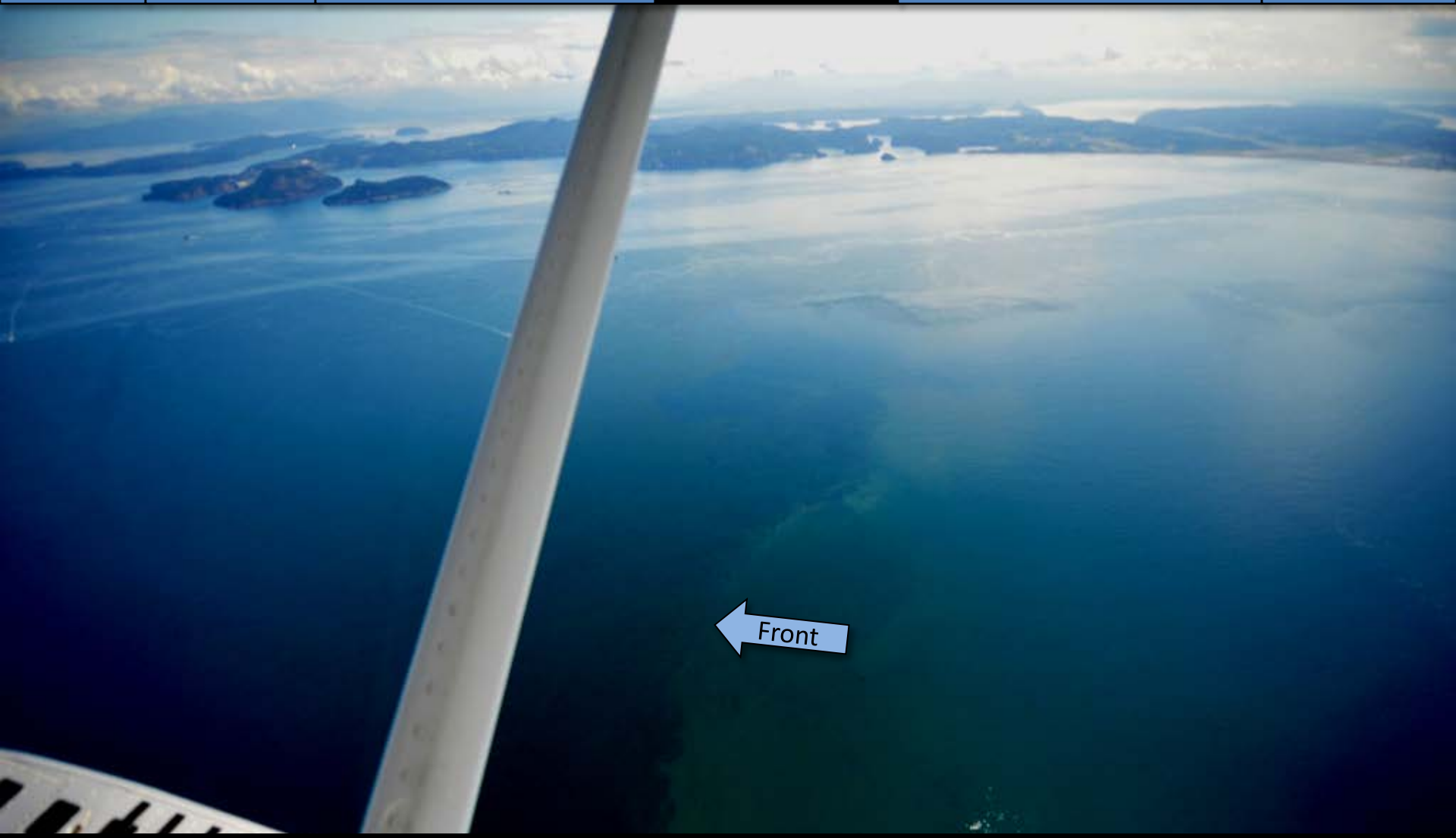
Organic material accumulating along a convergence. Many clouds obstructing the view.

Location: Scenic Beach State Park (Near Seabeck, Hood Canal), 9:41 AM.

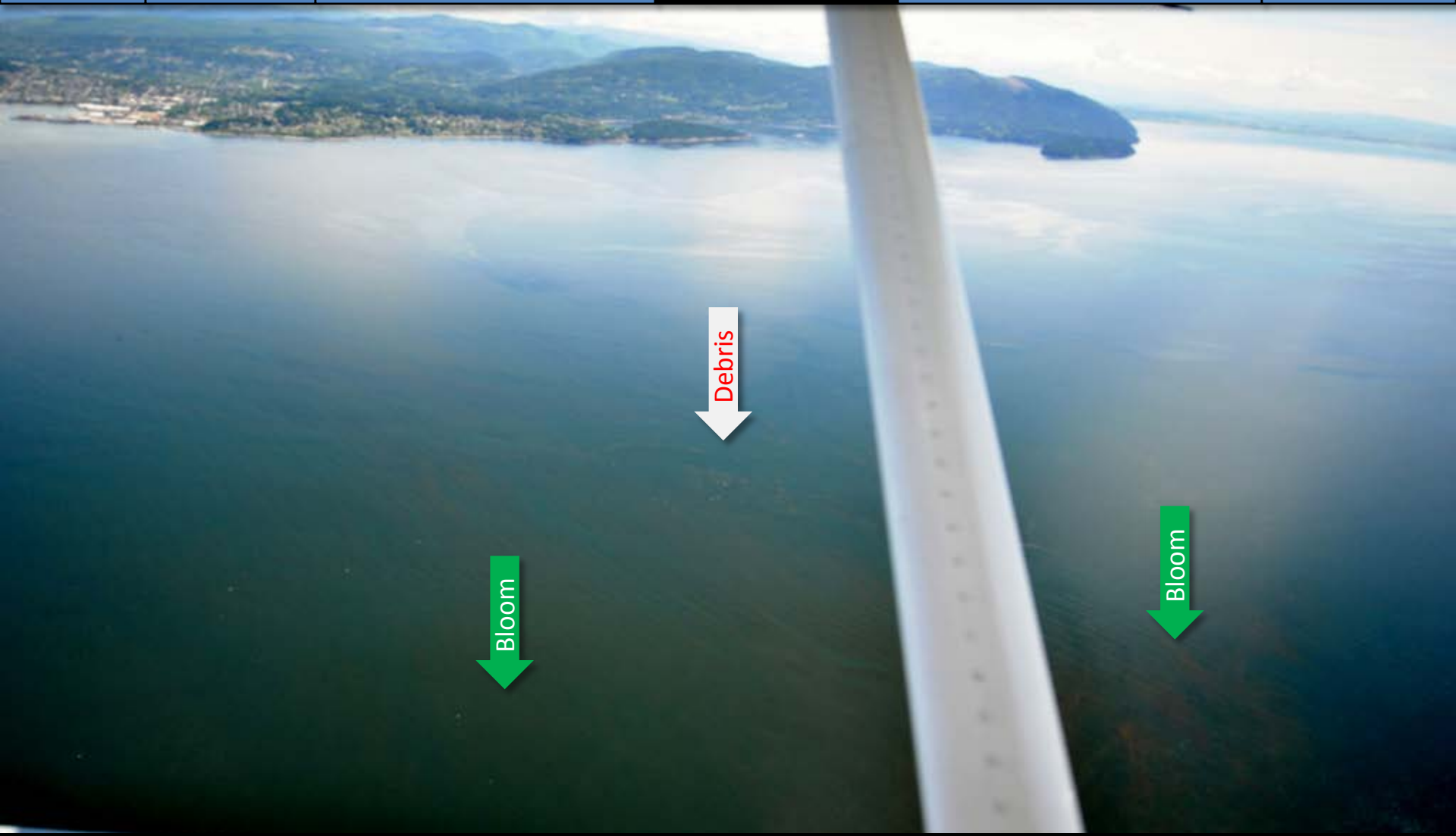


A. Strong phytoplankton bloom and front. B. *Drifting algal mat in Kilisut Harbor.*
Location: Port Townsend (Admiralty Reach), 10:10 AM.

Aerial photography 6-17-2013



Front with two water masses in the Strait of Juan de Fuca west of Deception Pass.
Location: Above southern tip of Lopez Island (Strait Of Juan de Fuca), 11:34 AM.



Red-brown phytoplankton bloom and organic material at surface.

Location: Bellingham Bay (North Sound), 1:32 PM.

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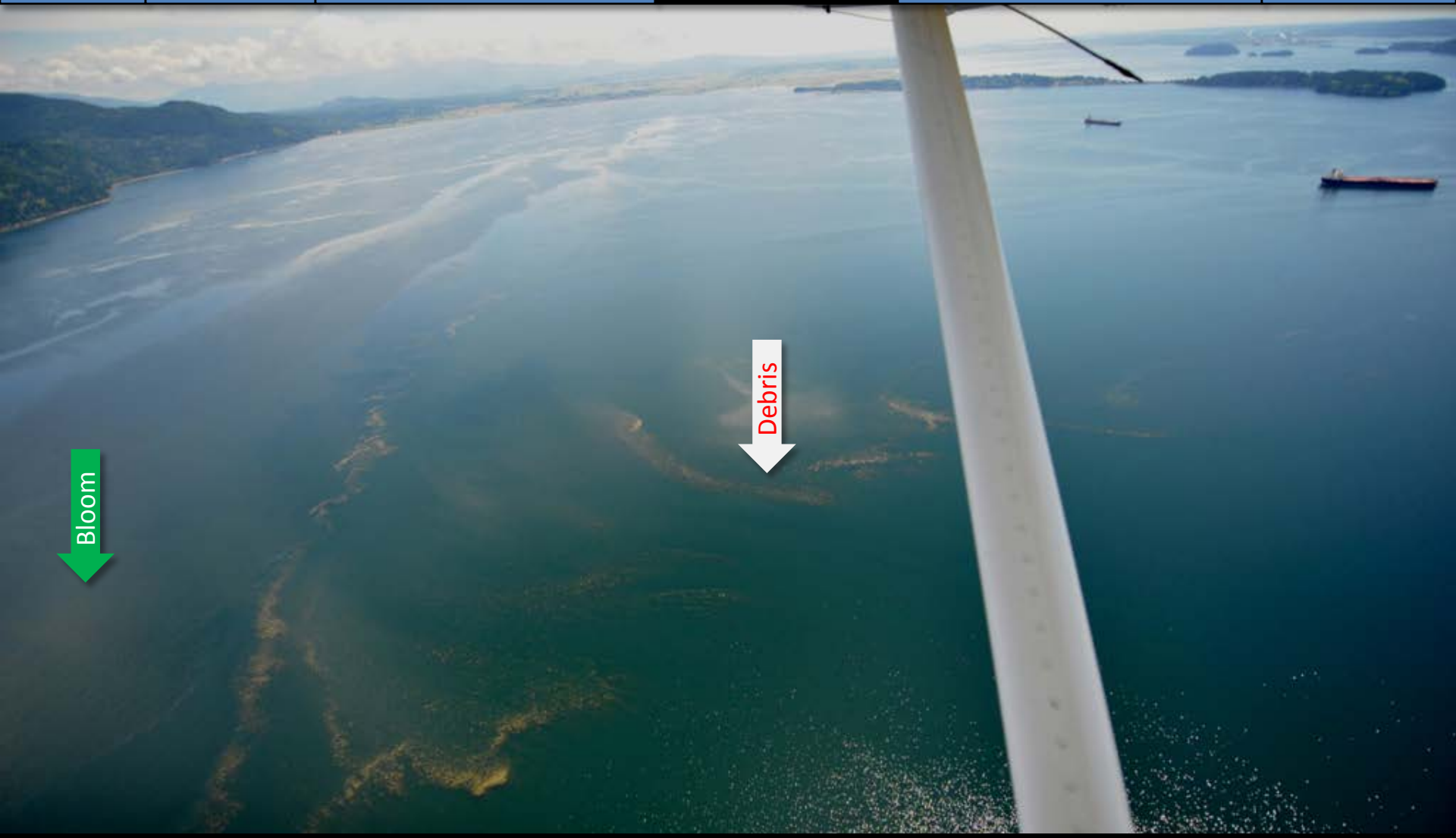
Aerial photography 6-17-2013



Red-brown phytoplankton bloom and abundant organic material at surface.

Location: Samish Bay (North Sound), 2:02 PM.

Aerial photography 6-17-2013

Abundant organic material at surface.

Location: Samish Bay (North Sound), 2:03 PM.

Patches of organic material at surface over shallow water.

Location: Padilla Bay (North Sound), 2:08 PM.

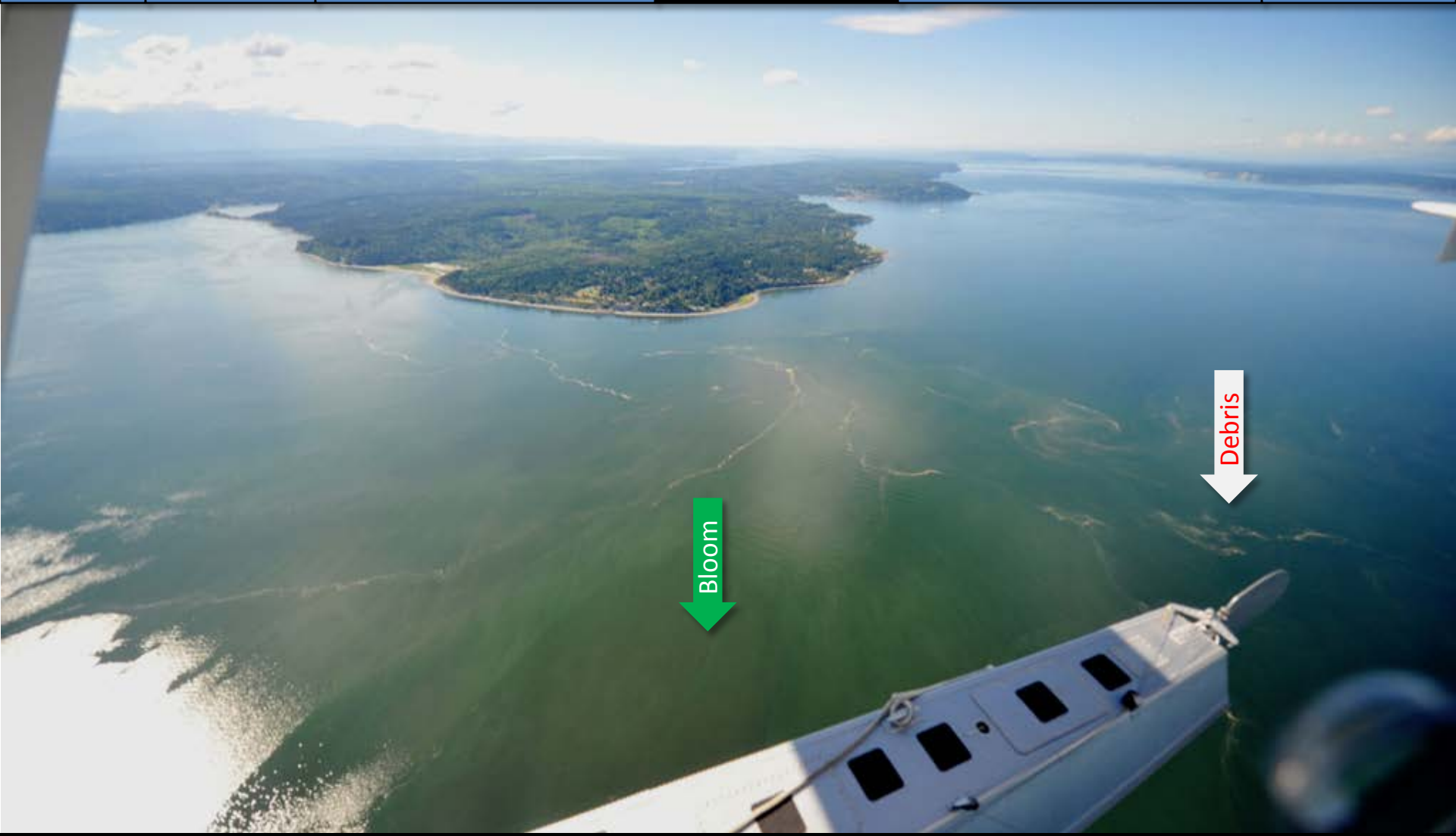
Organic material accumulating in bands at surface. Green bloom and many centimeter-sized organic particles in the water. Location: Saratoga Passage (Whidbey Basin), 2:55 PM.

Aerial photography 6-17-2013

Noctiluca bloom beginning to accumulate at surface in bands.

Location: North of Edmonds (Central Basin), 4:52 PM.

Aerial photography 6-17-2013



Noctiluca bloom beginning to accumulate at surface in bands following large eddies.

Location: Port Madison (Central Basin), 4:53 PM.

Noctiluca bloom at surface in very long bands.

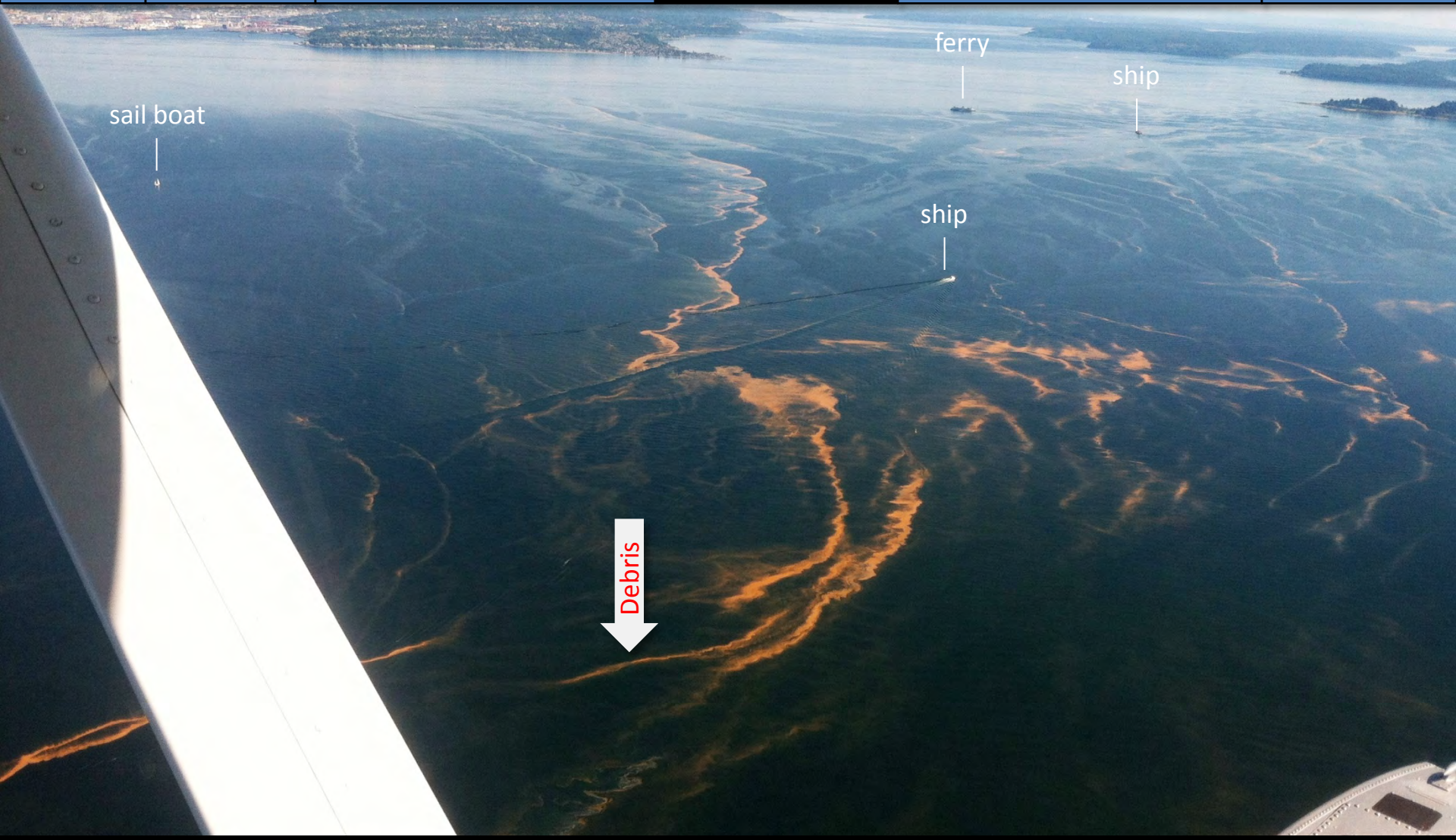
Location: Between Shilshole Bay and Bainbridge Island (Central Basin), 5:25 PM.

Aerial photography 6-17-2013

Noctiluca bloom at surface in very long bands.

Location: Between Bainbridge Island and Elliott Bay (Central Basin), 5:27 PM.

Aerial photography 6-17-2013



Noctiluca bloom at surface in very long bands.

Location: Between Bainbridge Island and Elliott Bay (Central Basin), 4:47 PM.

Aerial photography 6-17-2013

Noctiluca bloom at surface in very long bands.

Location: Between Bainbridge Island and Elliott Bay (Central Basin), 4:48 PM.

Aerial photography 6-17-2013

Noctiluca bloom at surface in very long bands.

Location: Between Bainbridge Island and Elliott Bay (Central Basin), 5:27 PM.

Noctiluca bloom at surface in very long bands.

Location: East of Bainbridge Island (Central Basin), 4:49 PM.

Noctiluca bloom at surface in very long bands. State ferry traveling towards Seattle.

Location: Elliott Bay (Central Basin), 4:50 PM.

Noctiluca bloom at surface in large patch washing onto public beach.

Location: Alki Beach, West Seattle (Central Basin), 4:51 PM.

Phytoplankton bloom in colors of green to brown.

Location: Filucy Bay across from McNeil Island (South Sound), 5:39 PM.

Green and red plankton bloom. Location: Henderson Inlet (South Sound), 5:43 PM.

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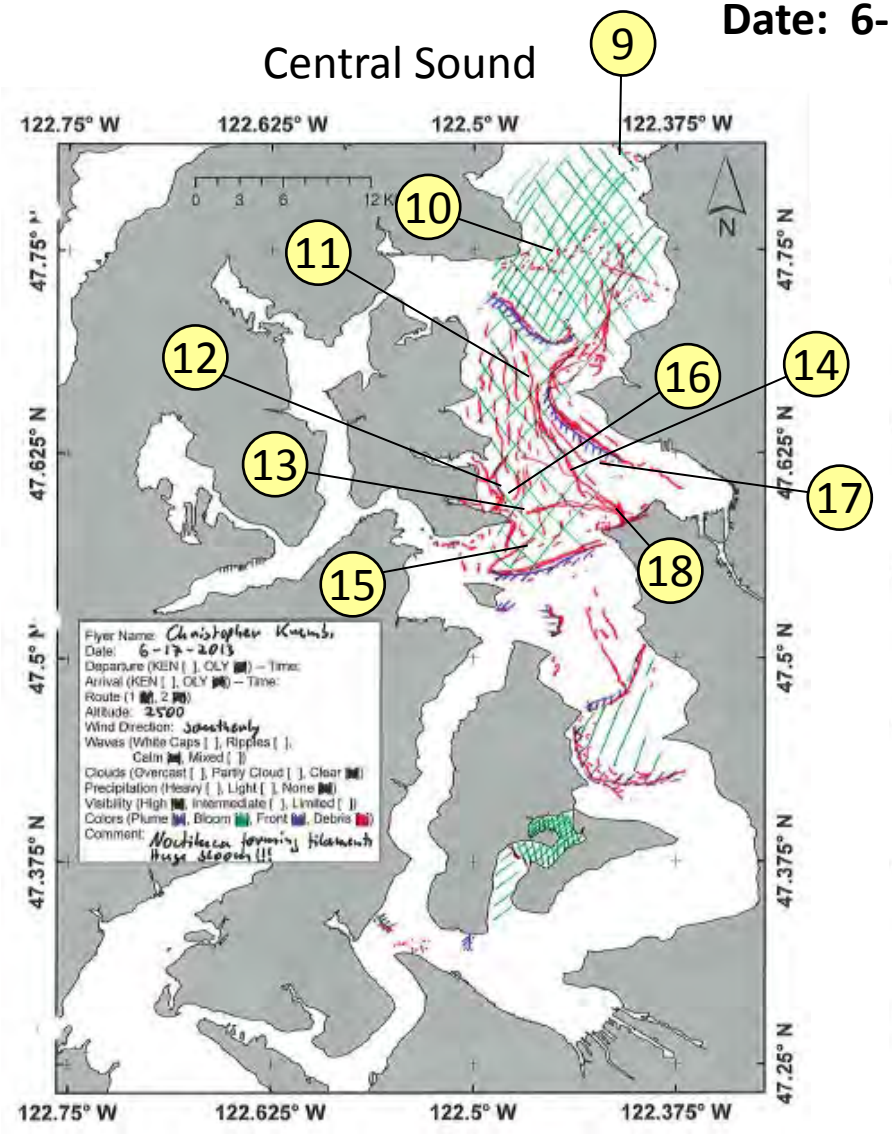
Aerial photography observations in Central Sound

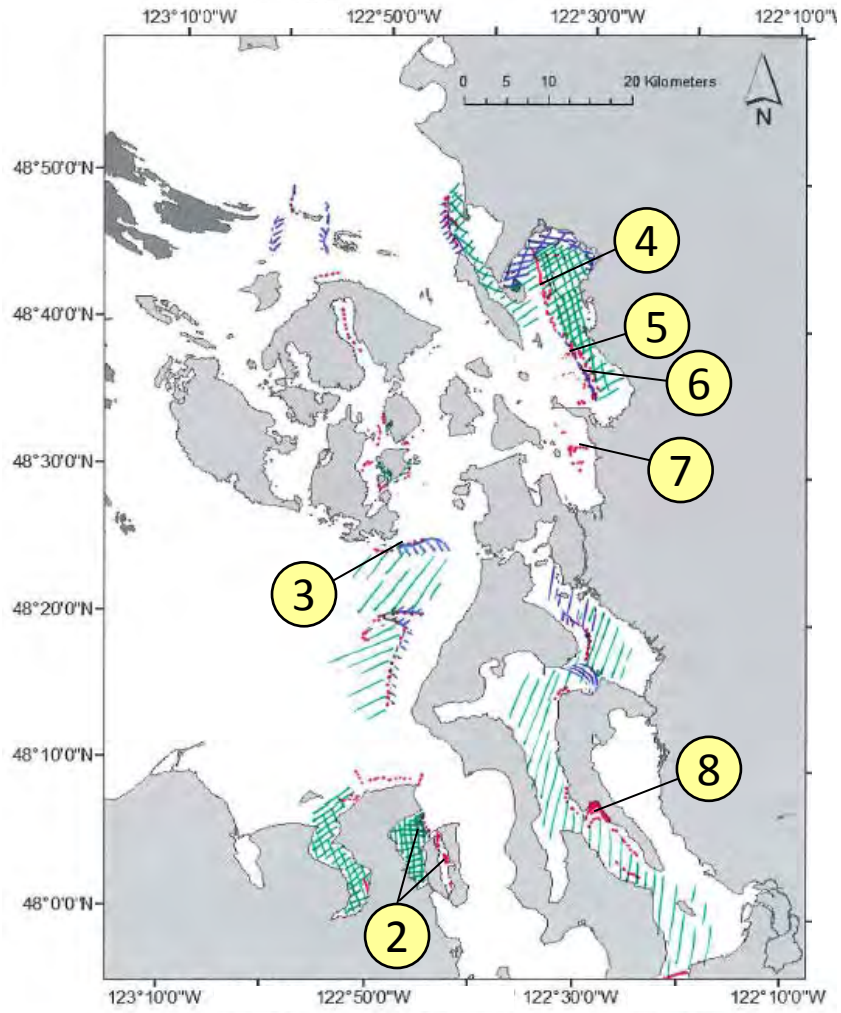
Navigate

Date: 6-17-2013

Central Sound



North Sound/San Juans



Numbers on map refer to picture numbers for spatial reference

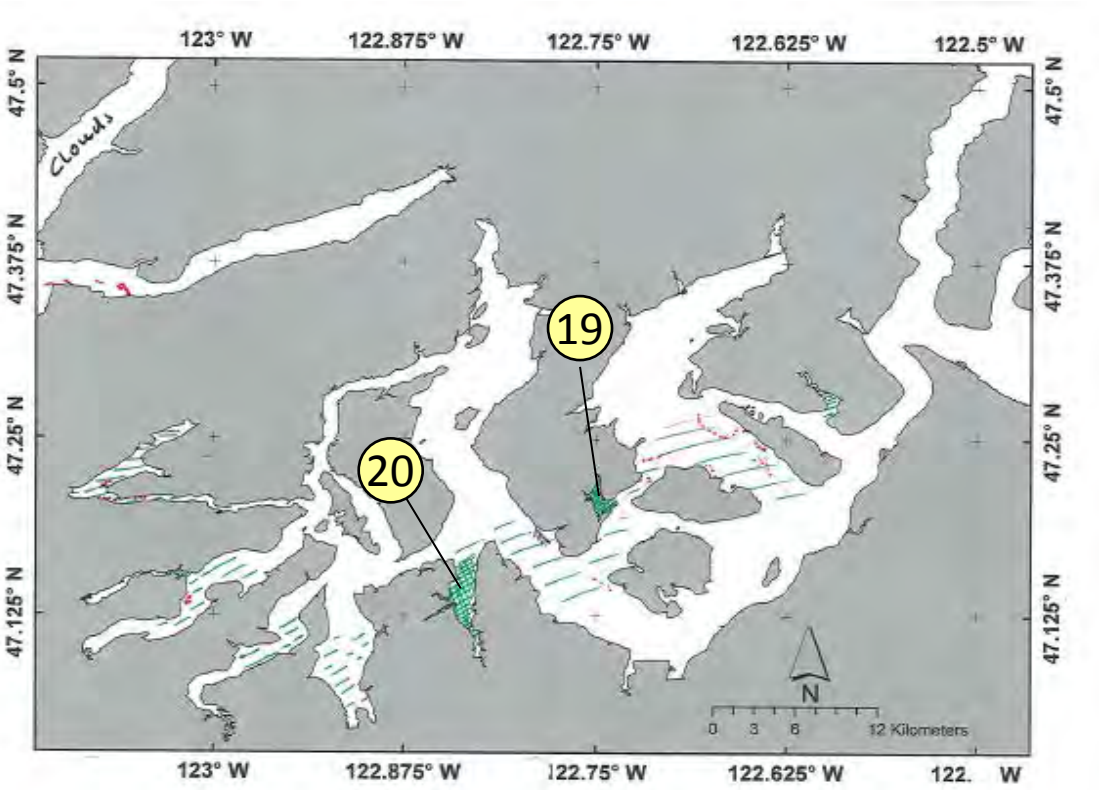
DEPARTMENT OF ECOLOGY
State of Washington

Aerial photography

Observations in South Sound: 6-17-2012

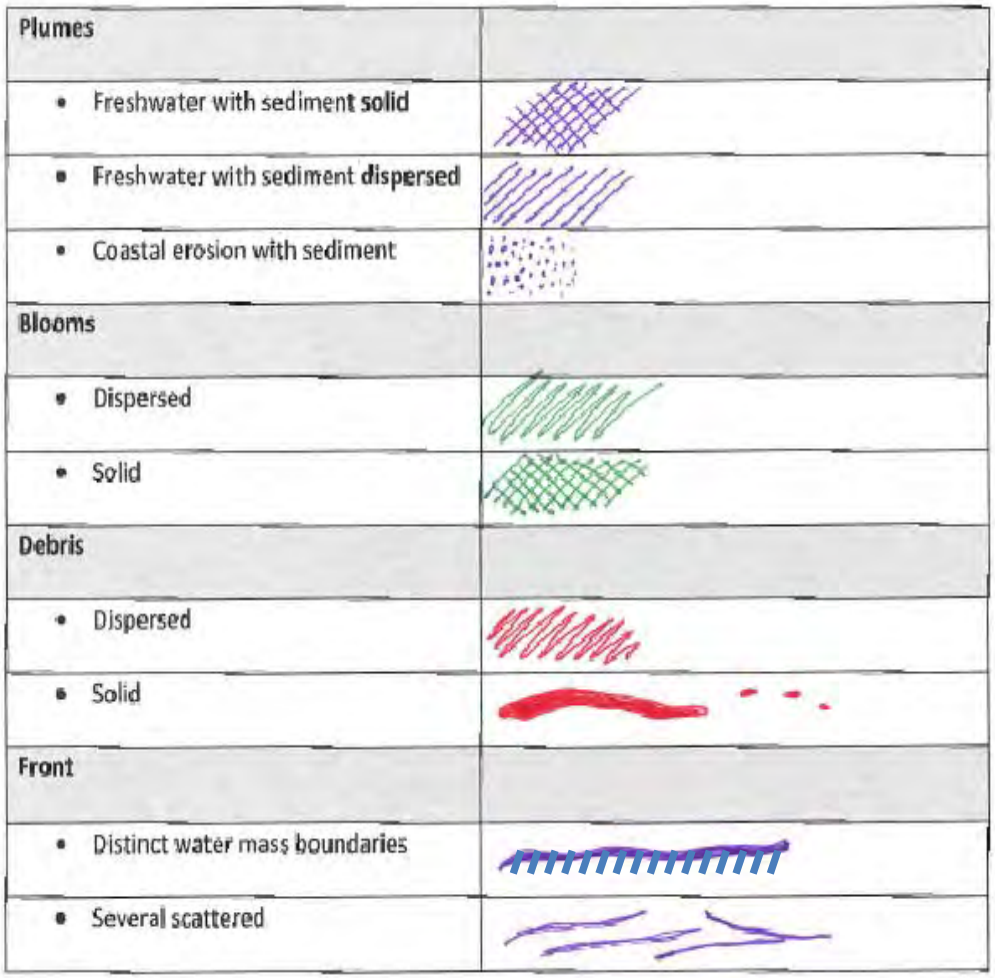
Navigate

South Sound



1 *Hood Canal very cloudy (1) not on map*

Numbers on map refer to picture numbers for spatial reference

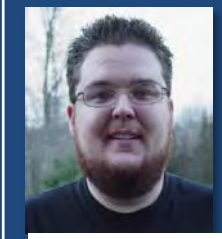


Comments:
Maps are produced by observers during and after flights. They are intended to give an approximate reconstruction of the surface conditions on scales that connect to and overlap with satellite images in the section that follows.

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”.

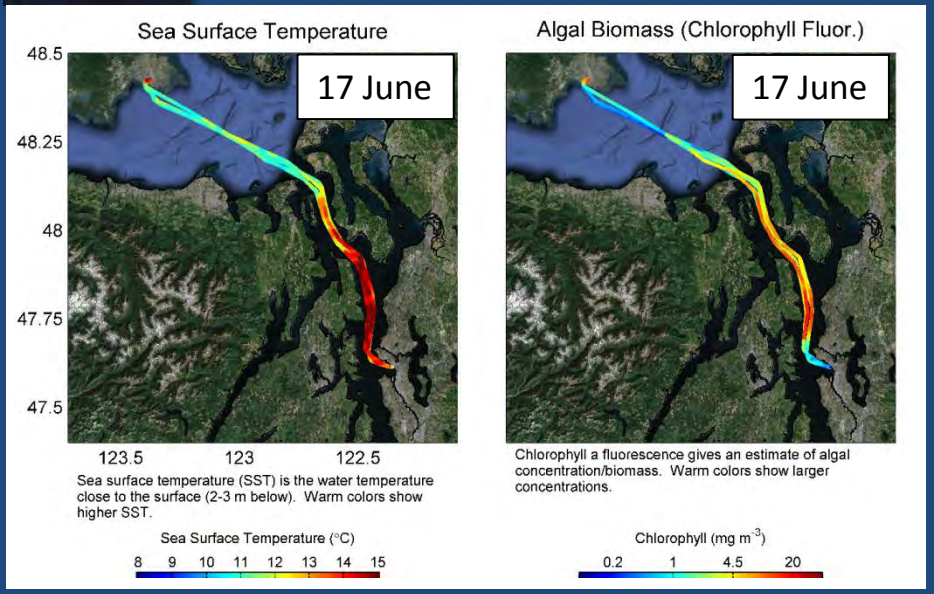
S.L. Moore, M. J. Allen. 2000. Distribution of Anthropogenic and Natural Debris on the Mainland Shelf of the Southern California Bight. Marine Pollution Bulletin, 40(1), 83–88.

Ferry and satellite observations 6-17-2013



Brandon Sackmann
Contact:
bsackmann@ecy.wa.gov

Start here

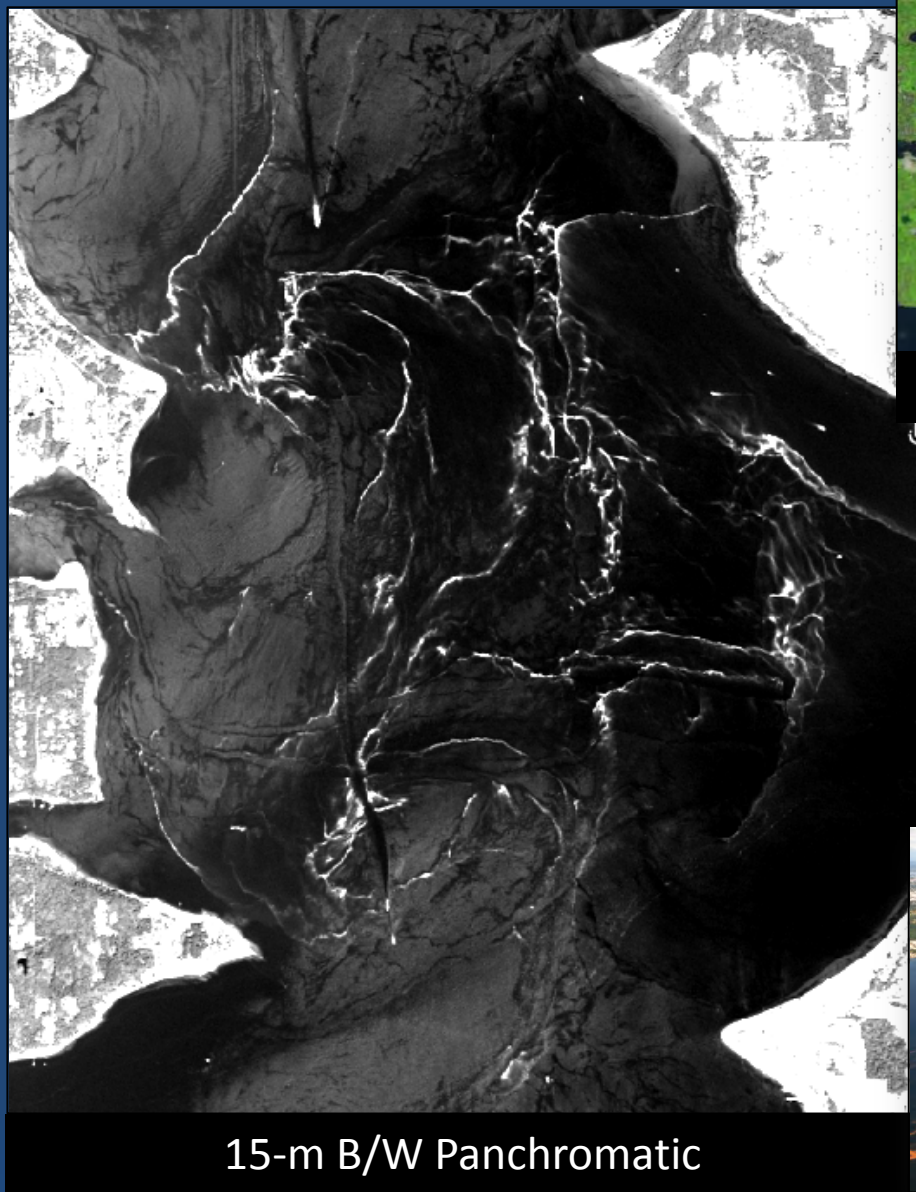


Current Conditions:

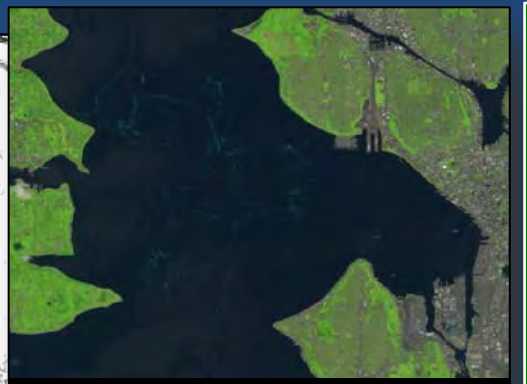
Warm, fresh water entering central Puget Sound from Whidbey Basin. Sea surface temperatures >15 °C. Moderate fluorescence north of Elliott Bay, outside area covered by intense *Noctiluca* bloom.

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

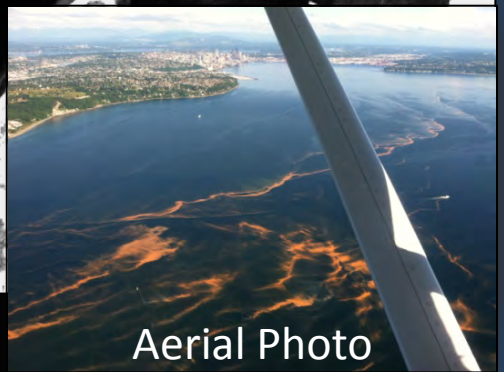
Ferry and satellite observations 6-17-2013



15-m B/W Panchromatic



30-m RBG Color-enhanced



Aerial Photo

Noctiluca bloom visible from space (Landsat 8)

17 June 2013

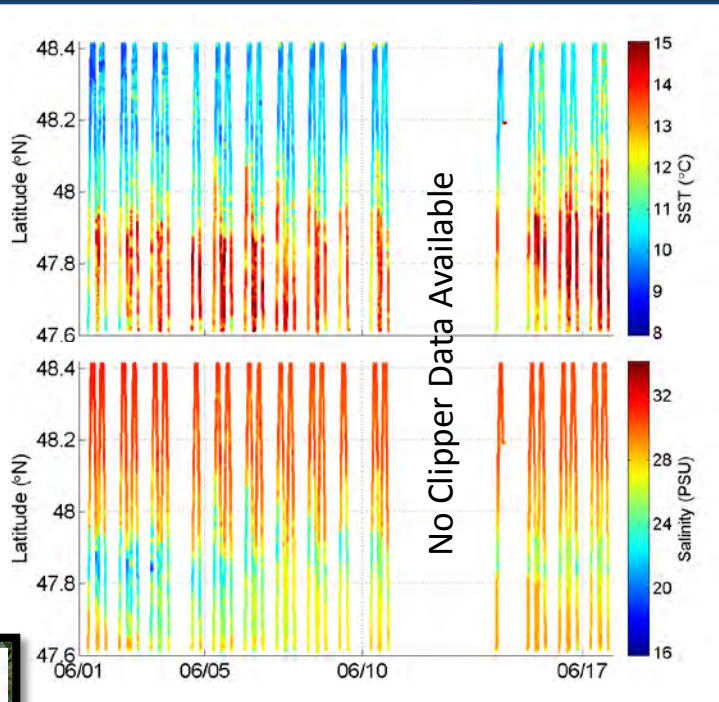
A new Landsat satellite sensor (launched 11 February 2013) and clear skies provided a synoptic snapshot of the intense *Noctiluca* bloom in central Puget Sound, located just outside of Elliott Bay.

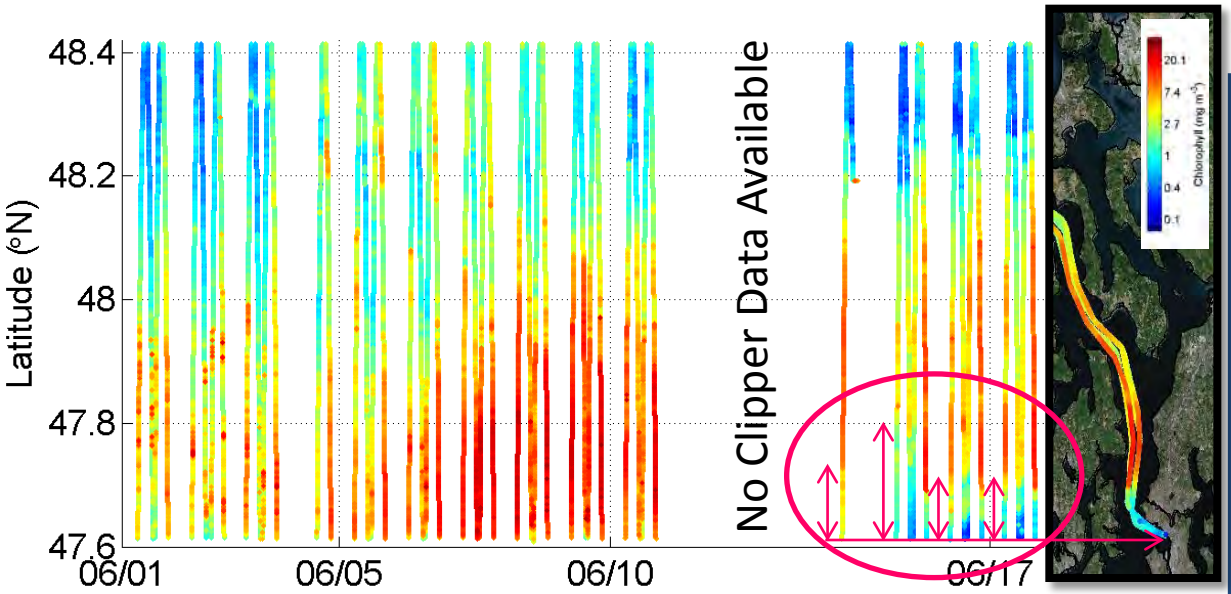
Ferry and satellite observations 6-17-2013

Clipper data suggests that the clearing of near-surface waters in response to the *Noctiluca* bloom may have began on 14 June .

On 15 June clearer surface water (due to grazing by *Noctiluca*) was observed as far north as 47.8 °N, near the Triple Junction (off the south tip of Whidbey Island).

On 16-17 June clearer surface water was confined to <47.7 N, closer to Elliott Bay.





This particular *Noctiluca* bloom has partially extended into the warmer/fresher waters seen entering central Puget Sound from Whidbey Basin. See page 19.

Mooring observations and trends 6-3-2013 to 6-17-2013

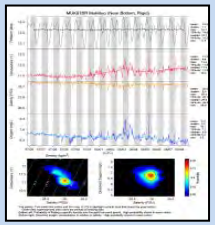
Summary: After a recent peak in dissolved oxygen (and phytoplankton bloom) on June 13, levels have dropped off sharply (>3.0 mg/L). The decline is coincident with the Noctiluca bloom. Lower DO would be consistent with heterotrophic respiration and the decrease of oxygen-producing phytoplankton from grazing.

Mukilteo, Whidbey Basin near Everett:

Mukilteo Dissolved Oxygen Conditions (12-16 m)

DO Max	11.1 mg/L	06/13	10.1 PSU	27.9 °C	11.7 db
DO Min	7.1 mg/L	06/17	7.3 PSU	29.2 °C	10.4 db

DO Avg	8
DO Trend	0.1 mg/L
DO-Sal Corr	-0.65
DO-Temp Corr	0.4



Real-time data online (click)

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

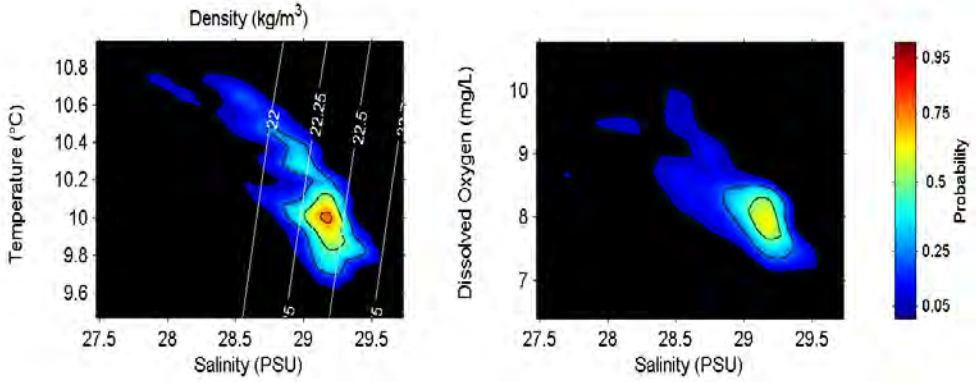
Sal Max	29.4 PSU	06/07	29.4 °C	9.8 db
Sal Min	27.3 PSU	06/12	28.8 °C	10.7 db

Sal Avg	29 PSU
Sal Trend	-0.4 PSU

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

T Max	12.5 °C	06/13	11.1 PSU	12.5 db
T Min	9.8 °C	06/06	7.5 PSU	9.8 db

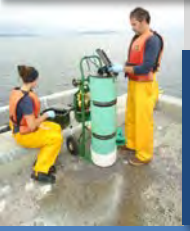
T Avg	10.4 °C
T Trend	1.2 °C



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.

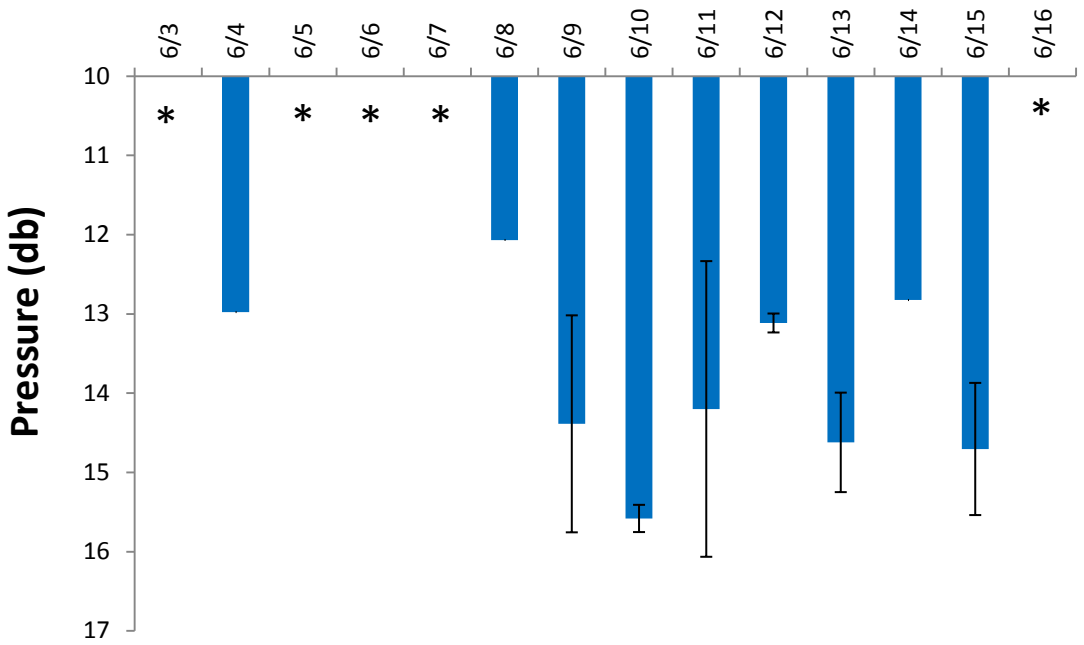
Mooring observations and trends 6-3-2013 to 6-17-2013



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

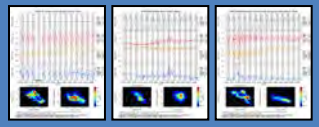
Summary: **The depth of the surface water layer varied around 12–15 m responding to a suite of local and distant marine and atmospheric factors that influence its character.**

We report on thickness of the fresher water layer by monitoring our near-surface sensor. This is another way to interpret the amount of freshwater entering Puget Sound.



** The pycnocline is shallower and outside our monitored depth range.*

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 decibars).

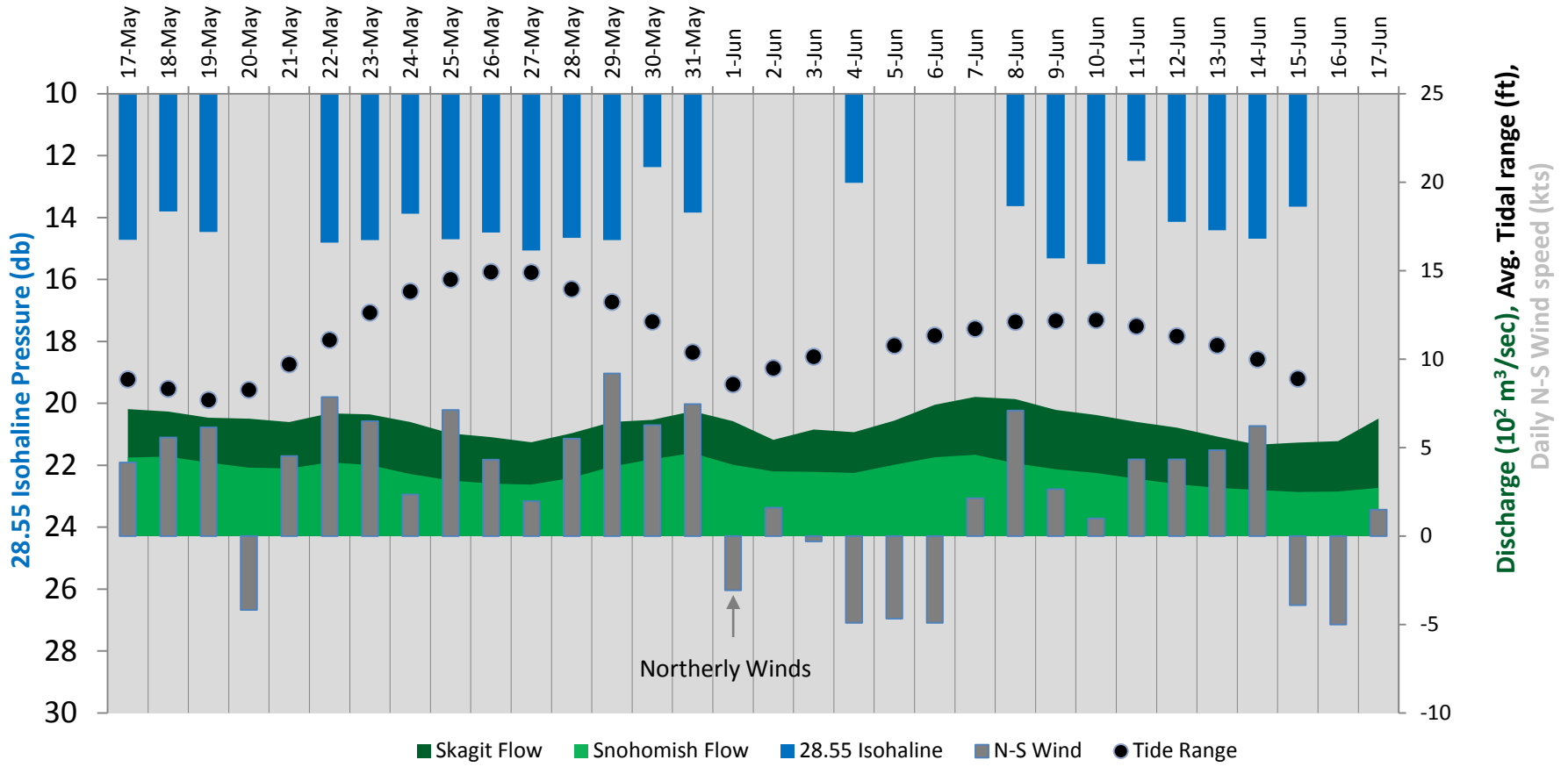


Real-time data online (click)

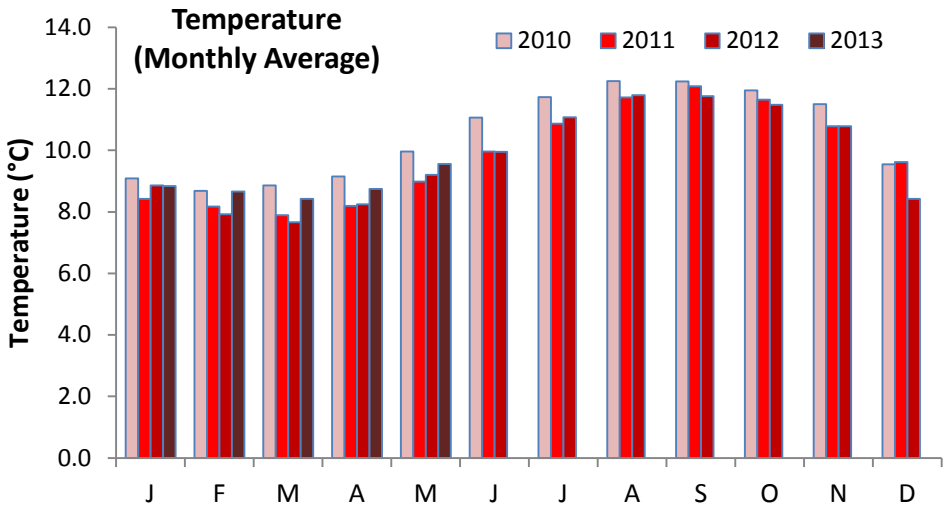
Mooring observations and trends 5-17-2013 to 6-17-2013

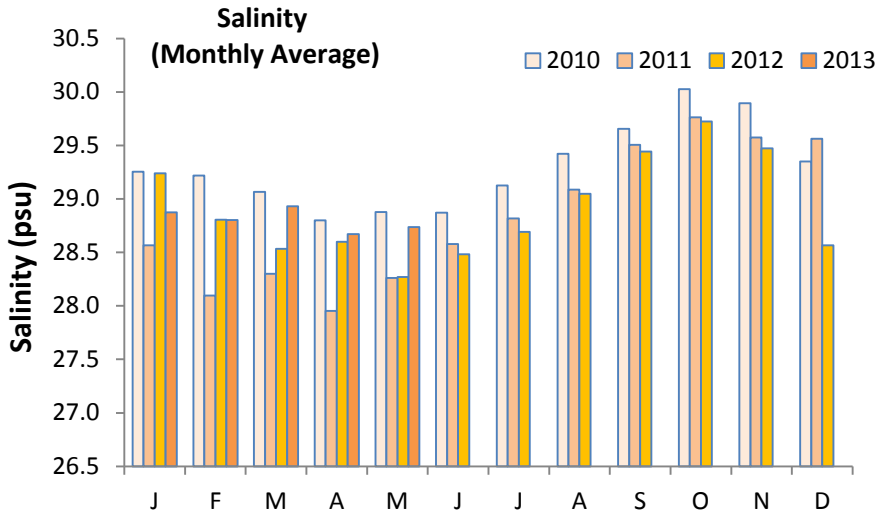
At Mukilteo (Whidbey Basin), the thickness of the surface water layer responded to winds and the tidal cycle (tidal range, black dots). A shallow pycnocline (<10 m and therefore above our sensor location, indicated by no blue bar) generally coincides with days of northerly winds. Freshwater input was relatively steady with water from the Skagit River contributing the largest portion.

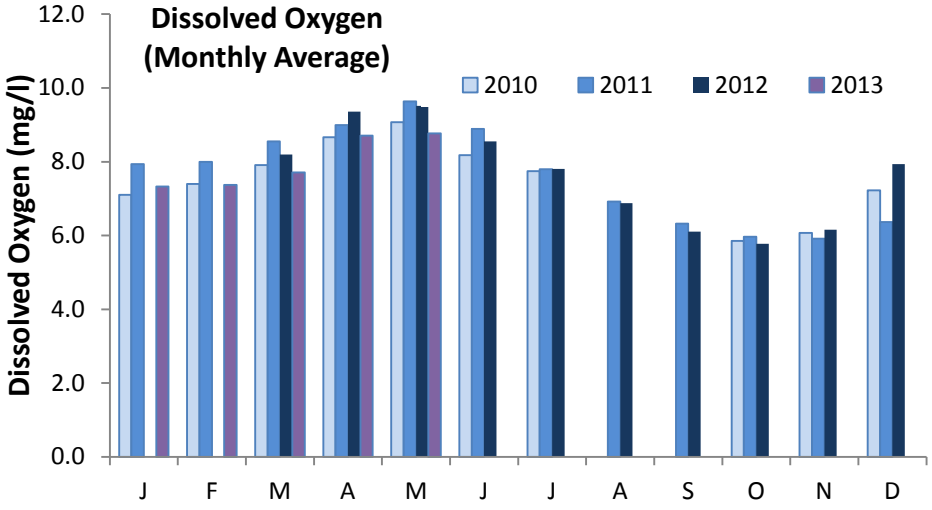
Thickness of surface layer at Mukilteo and influencing factors



Mooring observations and trends Admiralty Inlet 2010 to 2013







This slide shows data from our Possession Sound mooring (12-16 m). Inter-annual variability in temperature, salinity, and dissolved oxygen is shown over a
3.5 year period. All three variables show strong seasonality.

Thus far, 2013 appears similar to 2010 with relatively warmer water temperature, higher salinity, and lower dissolved oxygen.

Get data from Ecology's Monitoring Programs

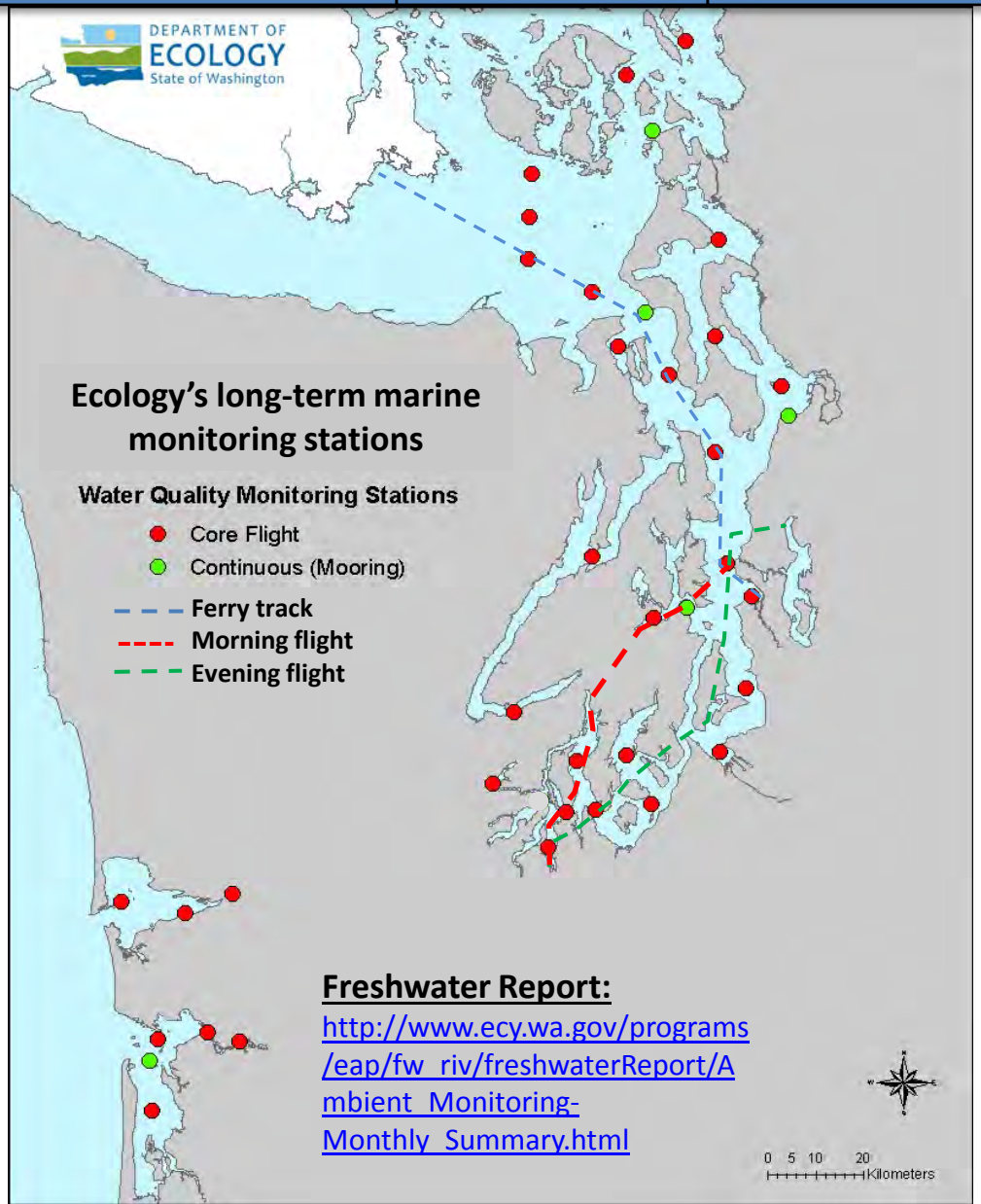
Flight log	Weather	Water column	Aerial photos	Ferry and Satellite	Moorings

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.