Publication No. 13-03-076

DEPARTMENT OF ECOLOGY State of Washington

Eyes Over Puget Sound

Surface Conditions Report, July 15, 2013

Guest contribution by the: Encyclopedia of PUGET SOUND (page 3)

Start here

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

Marine conditions from 7-15-2013 at a glance

LONG-TERM MARINE MONITORING UNIT

Mya Keyzers
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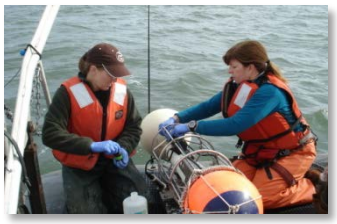
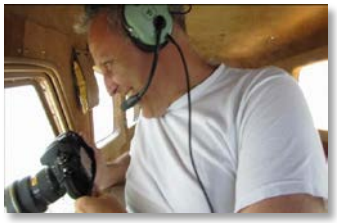


Dr. Christopher Krembs



Dr. Brandon Sackmann

Personal flight log p. 4

Winds blowing from the north in Central Sound change flight plans and surface water.

Weather conditions p.6

Sunshine levels are high. Rivers are running below normal. Air temperatures have been cooler and are increasing. Northerly winds began to blow on 6/28 in Central Sound.

Water column and mooring p.7 , p.39

After 2 years of favorable conditions with colder temperatures and higher oxygen, Puget Sound waters are turning warmer, resulting in lower dissolved oxygen.

Aerial photography p. 11

Olive-brown bloom being blown in from the north moves past Seattle. Many large algal mats and floating organic material in South Sound, Hood Canal, and Sinclair Inlet. Red-brown algal blooms and jellyfish patches in Budd, Totten, and Eld Inlets.

Ferry and satellite p. 36

Phytoplankton bloom in Whidbey Basin, northern Hood Canal and Central Basin (between Elliott Bay and the Triple Junction). Thermal imagery from earlier in the month reveals patterns of near-surface mixing.

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

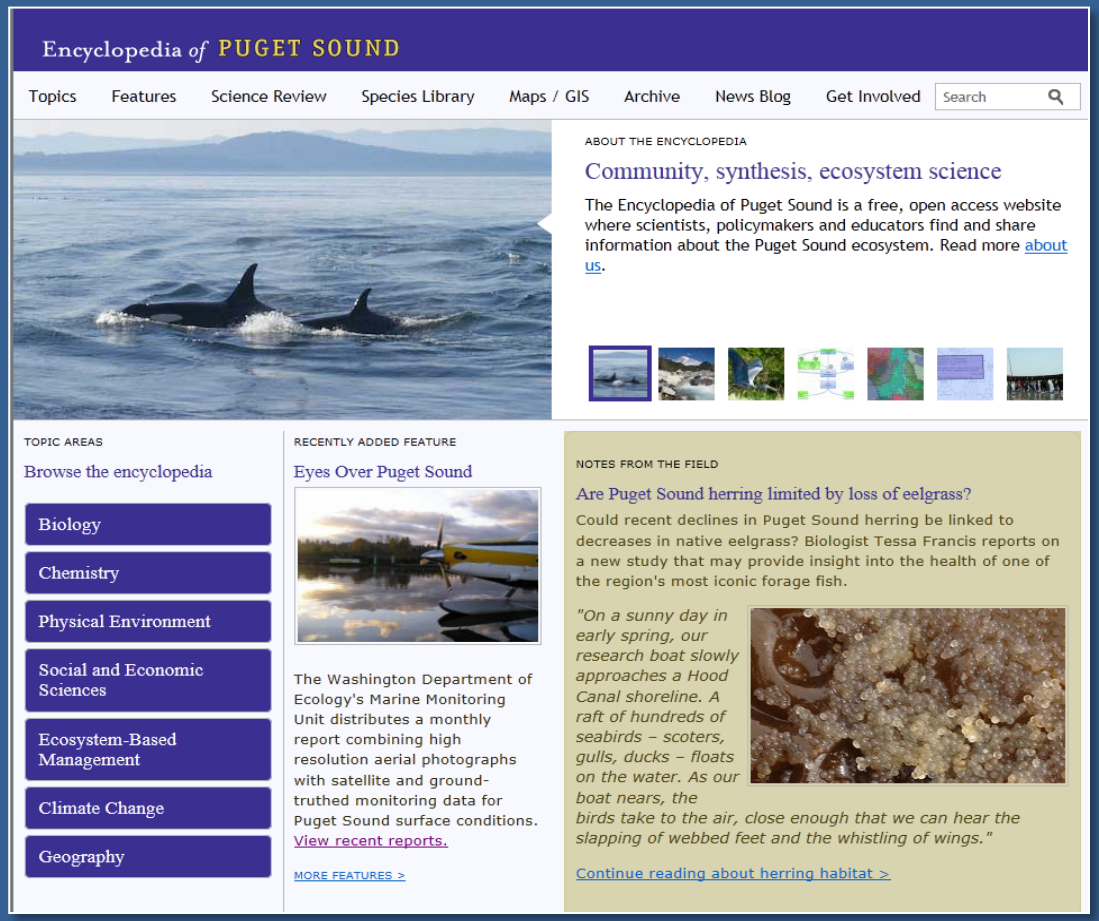
Guest Contribution

The Encyclopedia of Puget Sound is published by the University of Washington's Puget Sound Institute.

It represents the collective knowledge of leading experts from state and federal agencies, academic institutions, and Puget Sound area tribes.

It is intended as a primary source for synthesized and integrated scientific information about the Puget Sound and Salish Sea watersheds.

Visit the Encyclopedia of Puget Sound pages at:
http://www.eopugetsound.org/



Personal flight log 7-15-2013

Central Sound Flight

Loading gear from the lab to the van

A patchwork in Olympic Mountains and turquoise water of Hood Canal

Loading gear onto plane

Van loaded and ready to go

Monday, there wasn't a cloud in the sky and the temperatures were hot. You would think it would be the perfect day for sampling by float plane. But even in July, winds can often help or hinder a flight. With a tail wind, a flight can be shortened dramatically. With strong winds, whitecaps, and waves, the float plane cannot land.

The Puyallup River's journey from Mt. Rainier to Commencement Bay

Often, we consider wind patterns in changing the order of stations we fly to. With yesterday's strengthening northerly wind, we had to skip stations. When a station is missed, we sample it on another flight during the month. Luckily, we have two more flights this month.

Weather patterns from 7-1-2013 to 7-15-2013

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

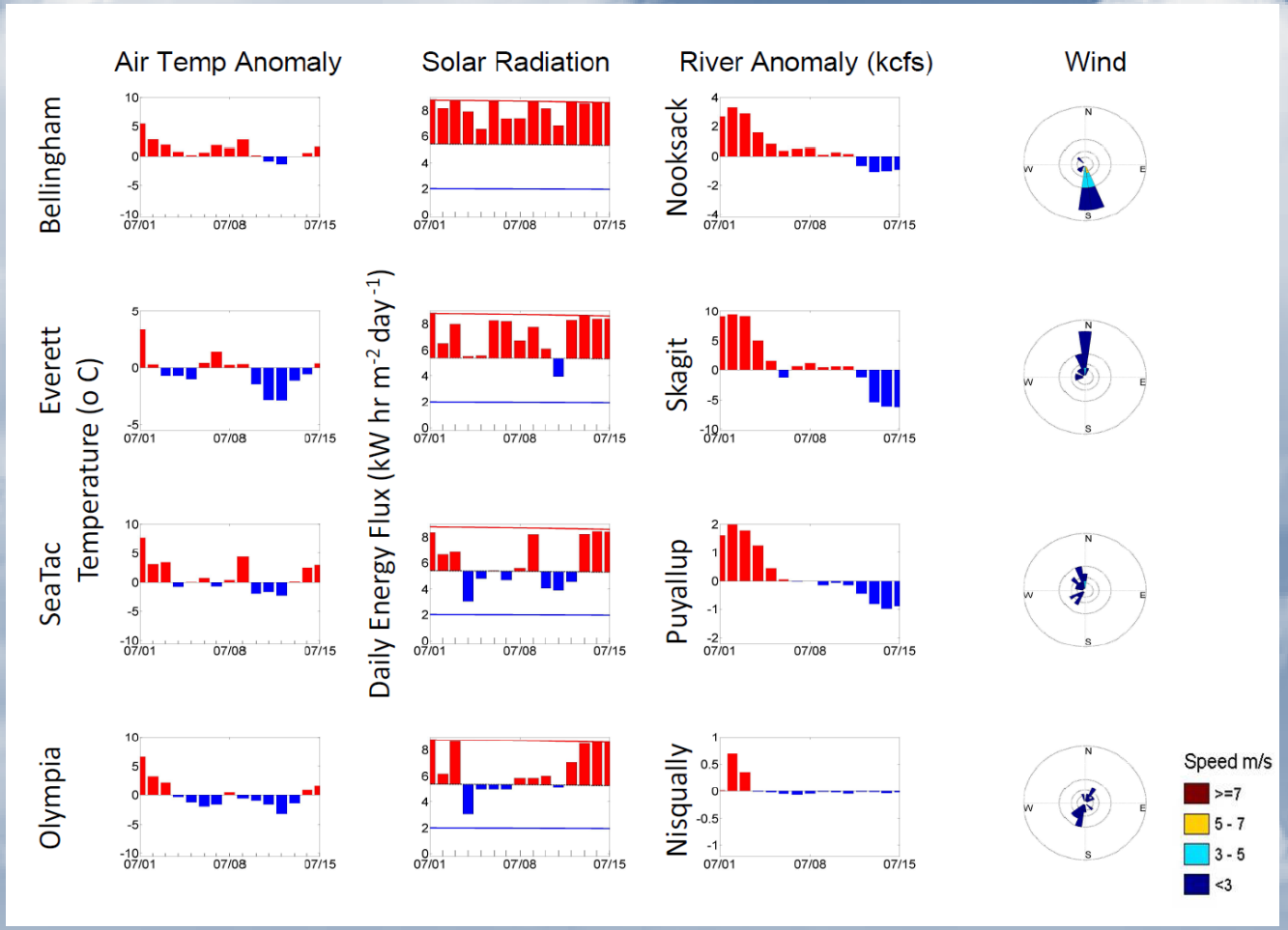
Summary:

Air temperatures are increasing again after a short cooling period in early July.

Sunshine levels in the north have been above normal for the past several days.

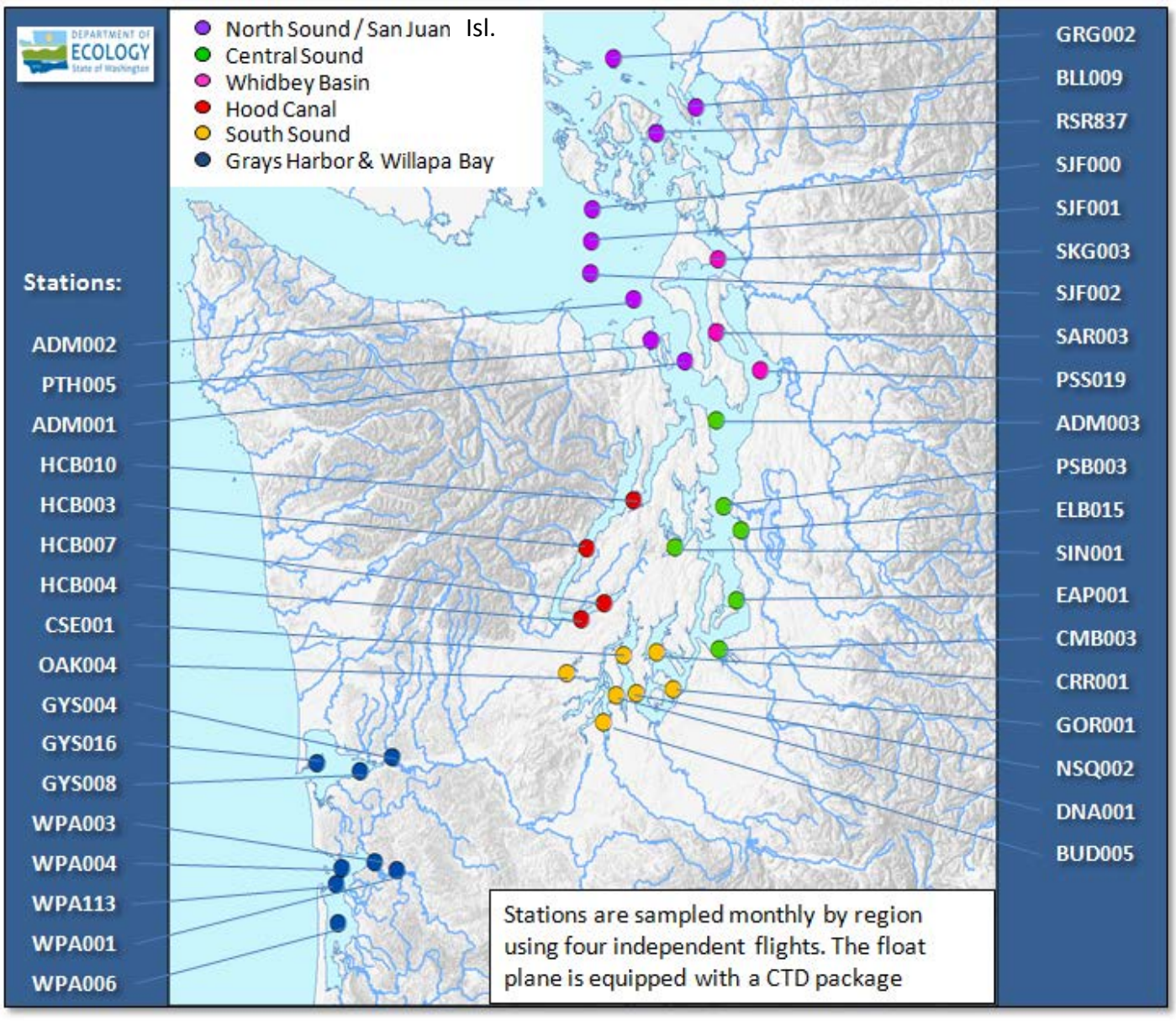
Rivers are now running below normal.

Winds have mostly been from the south to southwest with the exception of Central Sound (2nd wind plot from top). Here, wind began blowing from the north around June 28.



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.

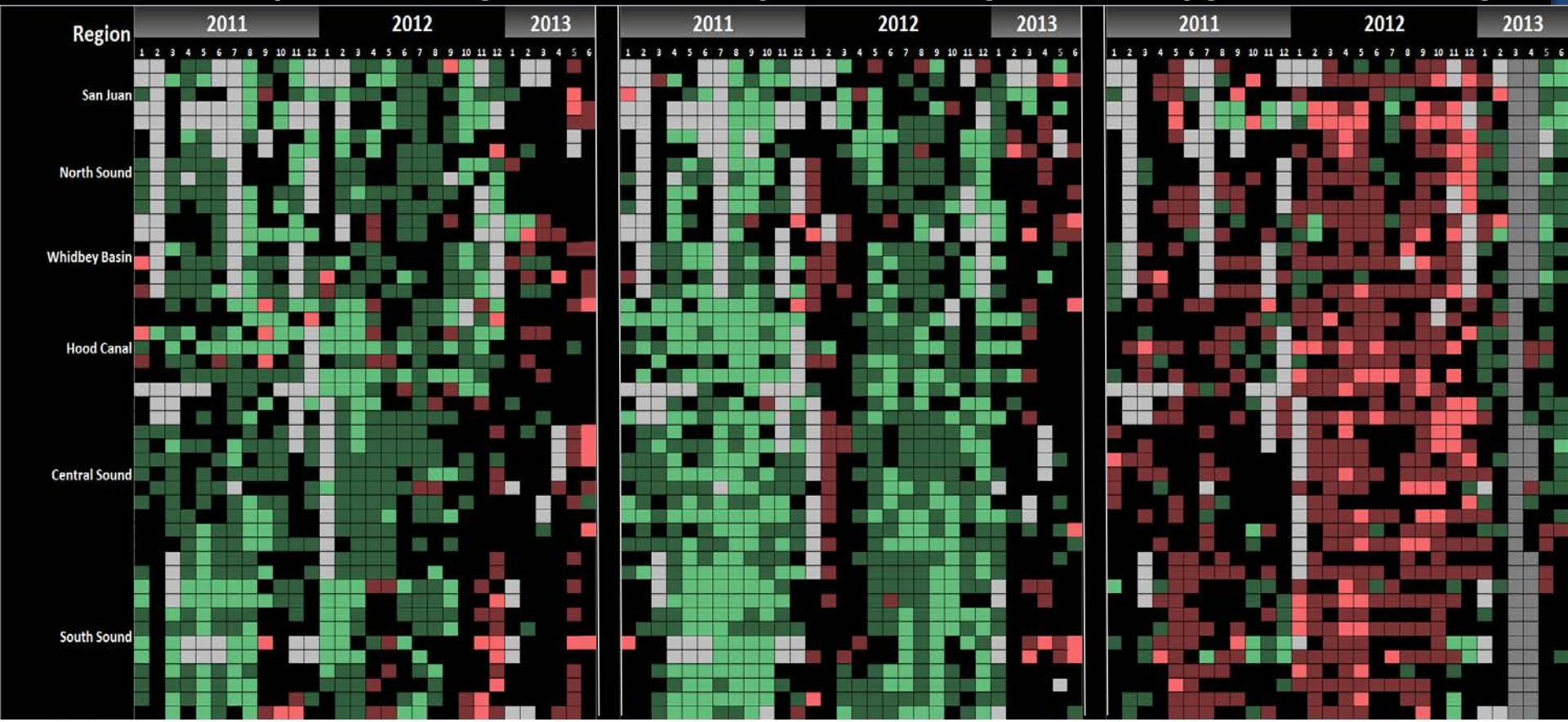
Start here

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

In 2013: Temp. is warming **Salinity is increasing?** **Oxygen is 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 beginning to show signs of warmer temperatures and decreasing oxygen. Each pixel is a monthly survey at a single station.

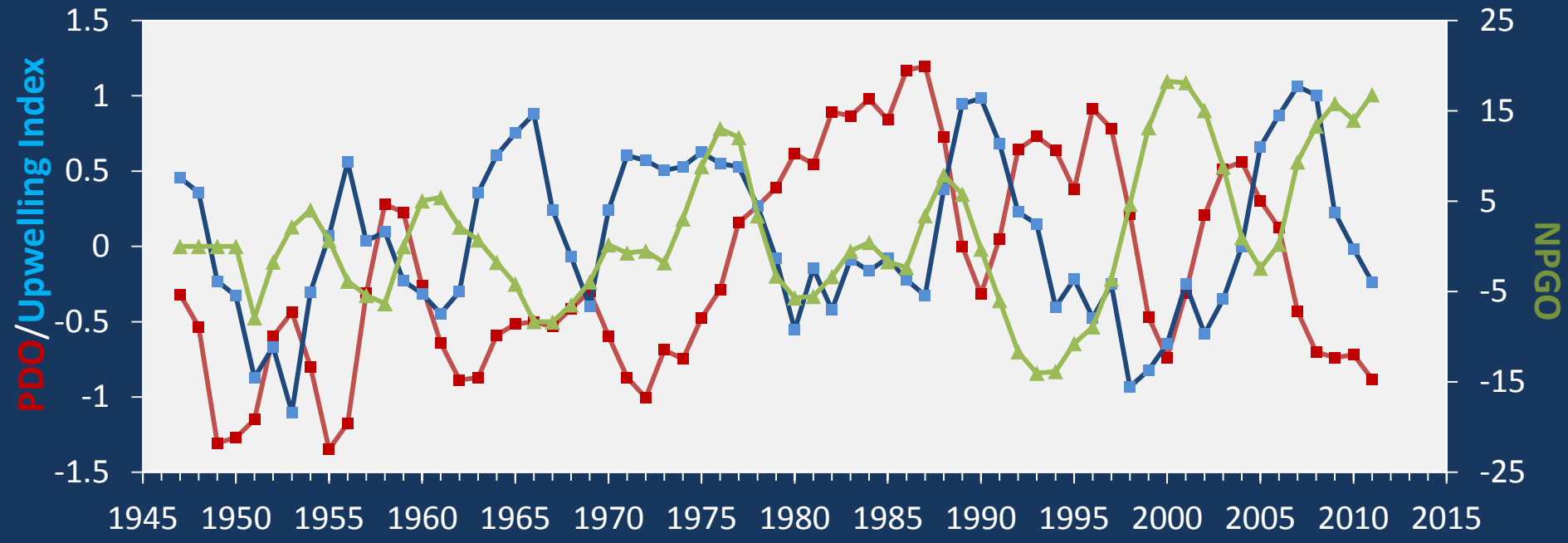
The ocean affects water quality: Ocean Climate Indices

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

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

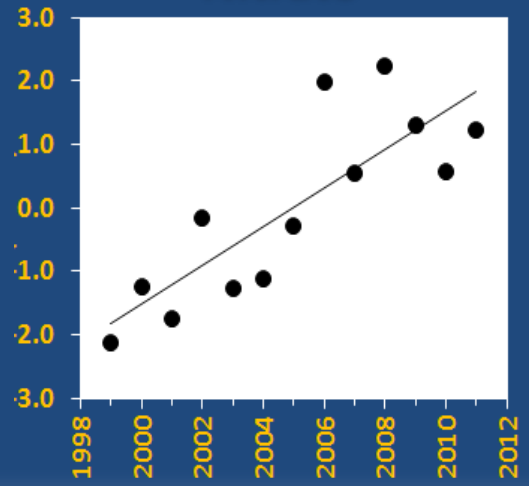
Get the data and trends from us!

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

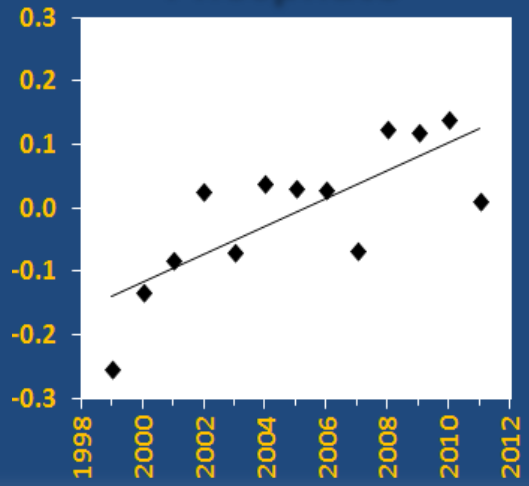
Algae bloom, Budd Inlet 2010

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

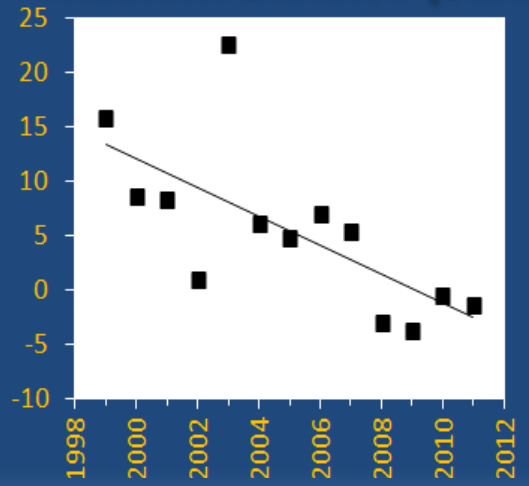
Nitrate



Phosphate



Nutrient Balance (Si:N)



Summary: Aerial photography 7-15-2013

Olive-brown bloom, blown in from the north, is moving past Seattle. Many large algal mats and floating organic material are present in South Sound, Hood Canal, and Sinclair Inlet. Red-brown algal blooms and jellyfish patches in Budd, Totten, and Eld Inlets.

Start here

Small red-brown bloom, Hidden Cove Park

Debris island near Hamma Hamma R.

Front

Mixing and Fronts:
Pronounced fronts near Blake Island, Rich and Agate Passages, and Hood Canal. Olive-brown water flowing southward. 5 9 10 11 12 13 14 15 16 17

Jellyfish: Present in increasing numbers in Budd, Eld, and Totten Inlets and in Hood Canal at depth. 2 11 20

Plume

Suspended sediment:
High sediment load from Puyallup River and wave exposed beaches. 11 12 13 14 17

Bloom

Visible blooms: 1 2 6 7 8 9 10 11 12 13 14 15 16 18 19 20

Red: Budd, Eld, Totten, Henderson, and Sinclair Inlets.

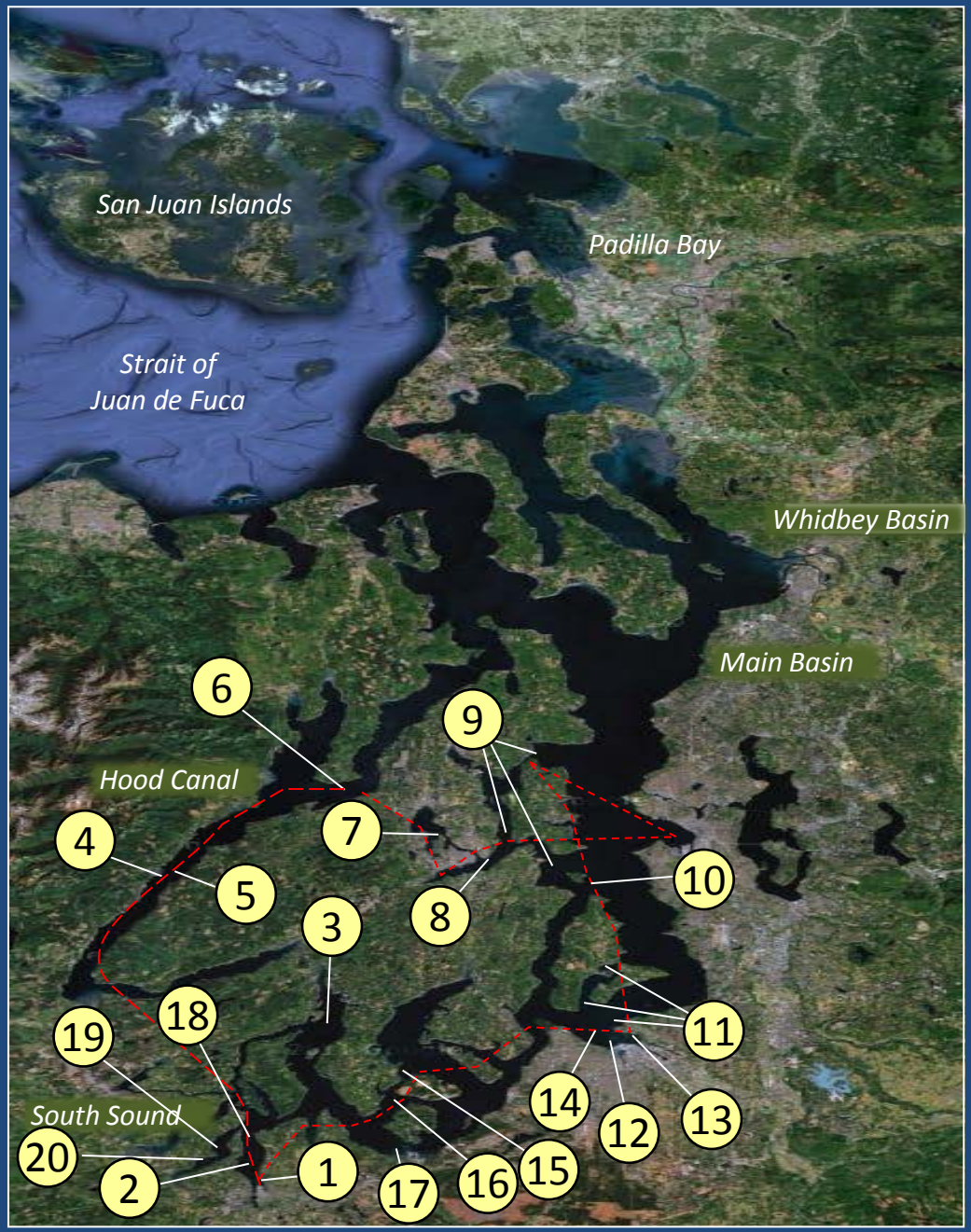
Brown: Main Basin, Commencement Bay, Case Inlet, and Drayton Passage.

Green: Commencement Bay.

Debris

Debris: 1 2 3 4 5 7 8 9 11 14 15 16 17 18 20

Very abundant in South Sound, Commencement Bay, Hood Canal, Dyes and Sinclair Inlets, and Port Madison.



Seattle: H. tide: 10:42 PM , L. tides: 4:50 AM, 4:11 PM

Aerial photography navigation guide, 7-15-2013

Click on numbers

Flight Information:

Morning flight, 1-6: – – -
Good visibility calm

Afternoon flight, 7-20: - - - -
Good visibility, wind increasing from the north.

Observation Maps:

Central Sound & Hood Canal

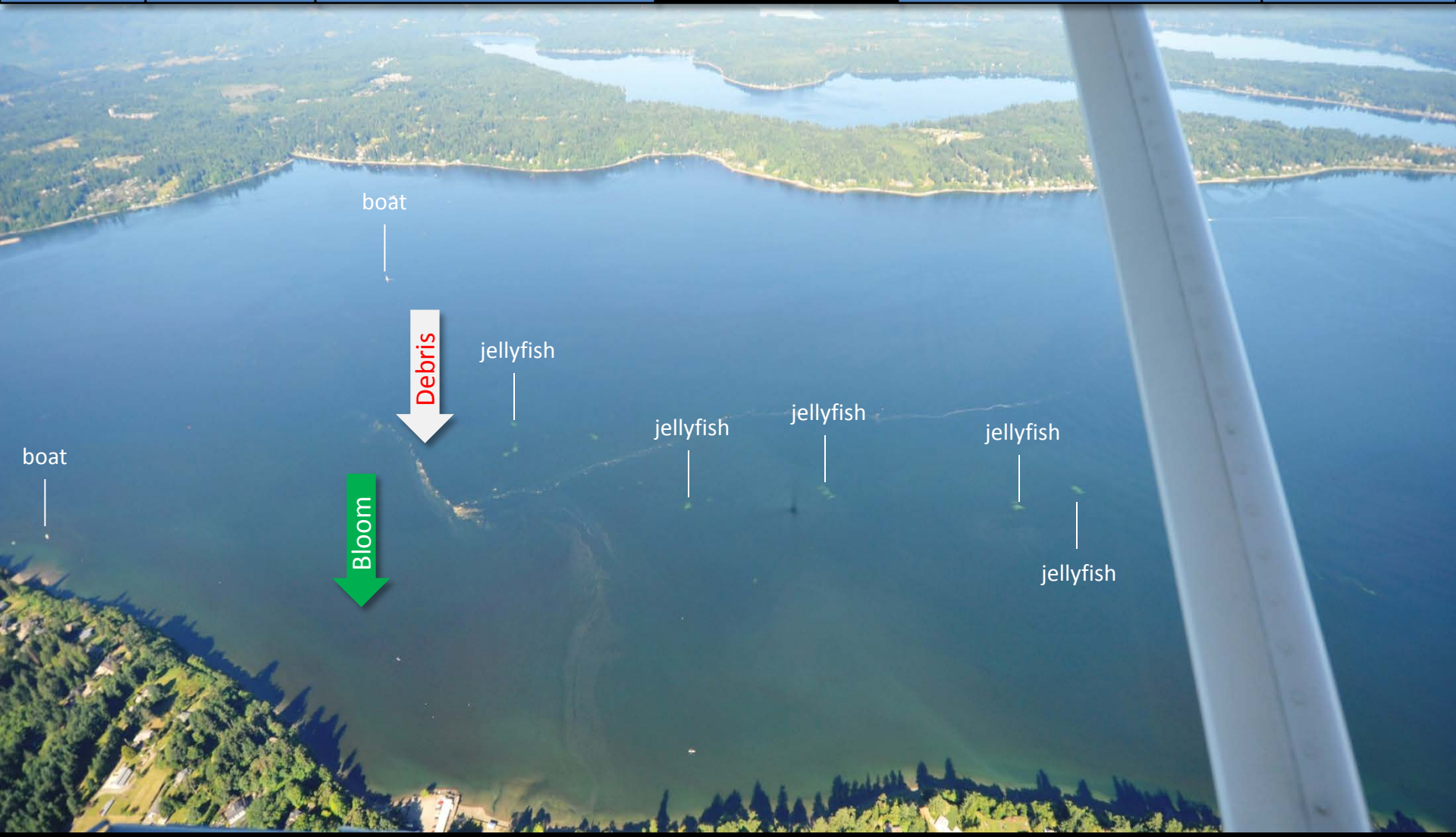
South Sound

Aerial photography 7-15-2013

Vertical net tows were conducted on 7/17/13 at West Bay Marina (WBM), Port of Olympia near Anthony's Hearthfire (HF), Swantown Marina's Boatworks in East Bay (STM), Boston Harbor Marina (BHM). Phytoplankton concentrations were very dense in lower Budd Inlet (WBM & HF) and dominated by the dinoflagellates *Ceratium fusus* and *Akashiwo sanguinea*. Concentrations were lighter at East Bay and Boston Harbor. For more detailed information, contact Pacific Shellfish Institute (aimee@pacshell.org, www.pacshell.org).

Red-brown bloom and organic debris (macroalgae).

Location: Swantown Marina (Budd Inlet, South Sound), 9:39 AM.

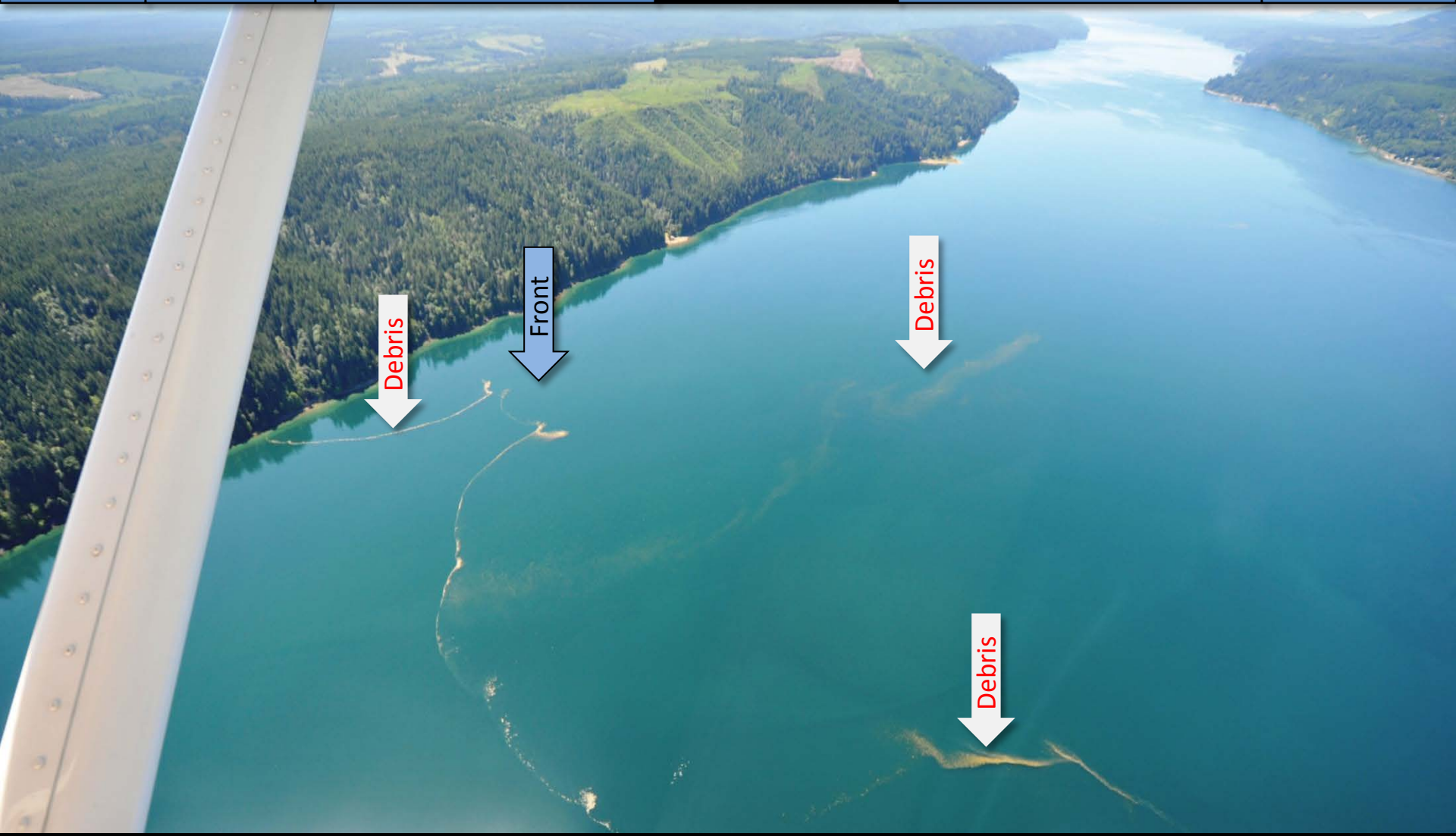


Red-brown bloom, organic debris (macroalgae), and jellyfish patches.
Location: Budd Inlet (South Sound), 9:41 AM.

Large lines of organic surface debris and a weak olive-brown bloom.
Location: Case Inlet near Pickering Passage (South Sound), 9:55 AM.

Aerial photography 7-15-2013

Large drifting mats of organic material at surface.
Location: Hamma Hamma River (Hood Canal), 11:13 AM.



Large drifting mats of organic material at surface partially delineating a front.

Location: Hamma Hamma River (Hood Canal), 11:59 AM.

Olive-brown water moving in from the north with tides, waves, and strong northerly winds.

Location: Little Beef Harbor, Dabob Bay (Hood Canal), 12:08 PM.

Large debris rafts (algal mats) lining up parallel to wind direction.

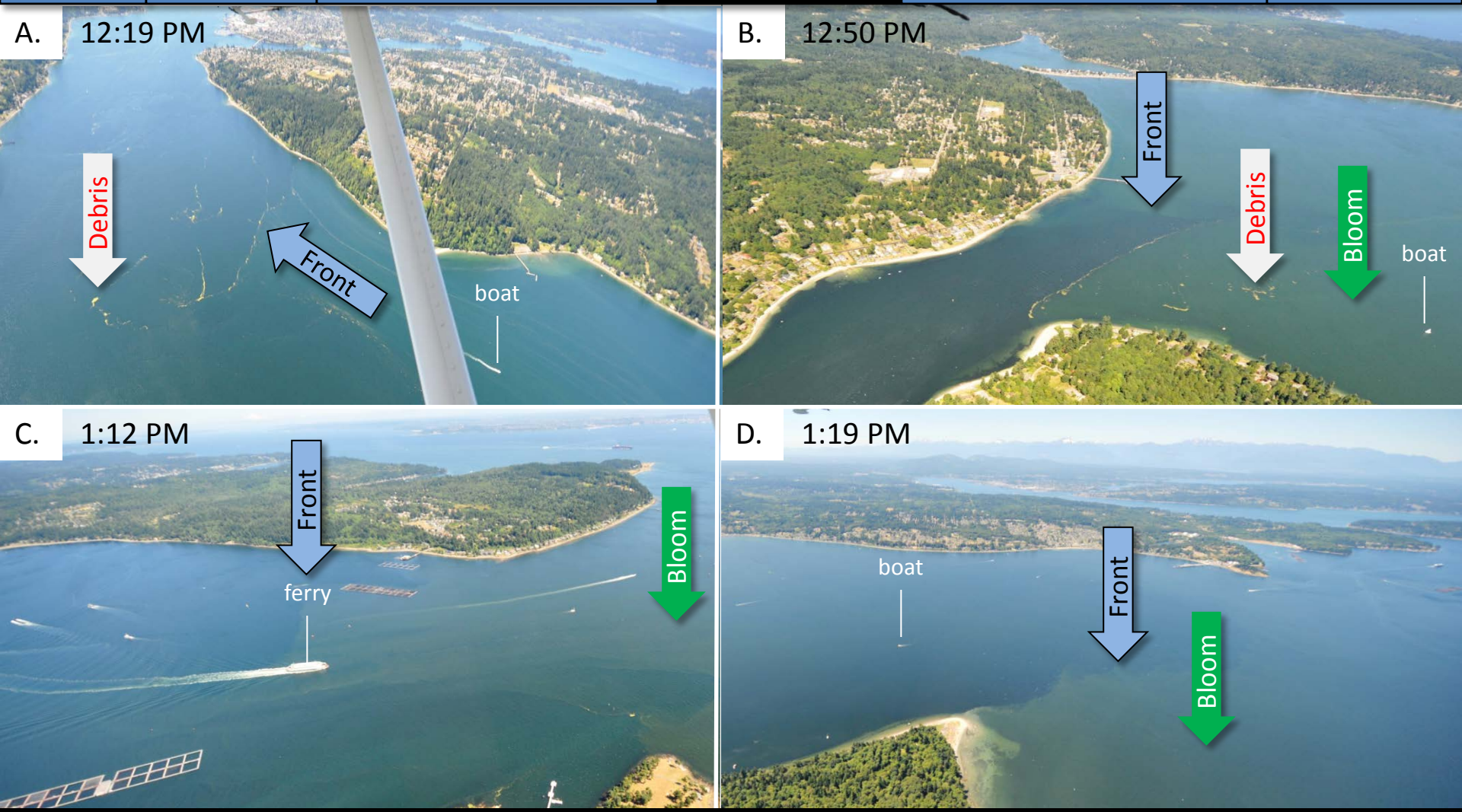
Location: Dyes Inlet (Kitsap Peninsula), 12:11 PM.

Aerial photography 7-15-2013

Large debris rafts (algal mats) following water movement.

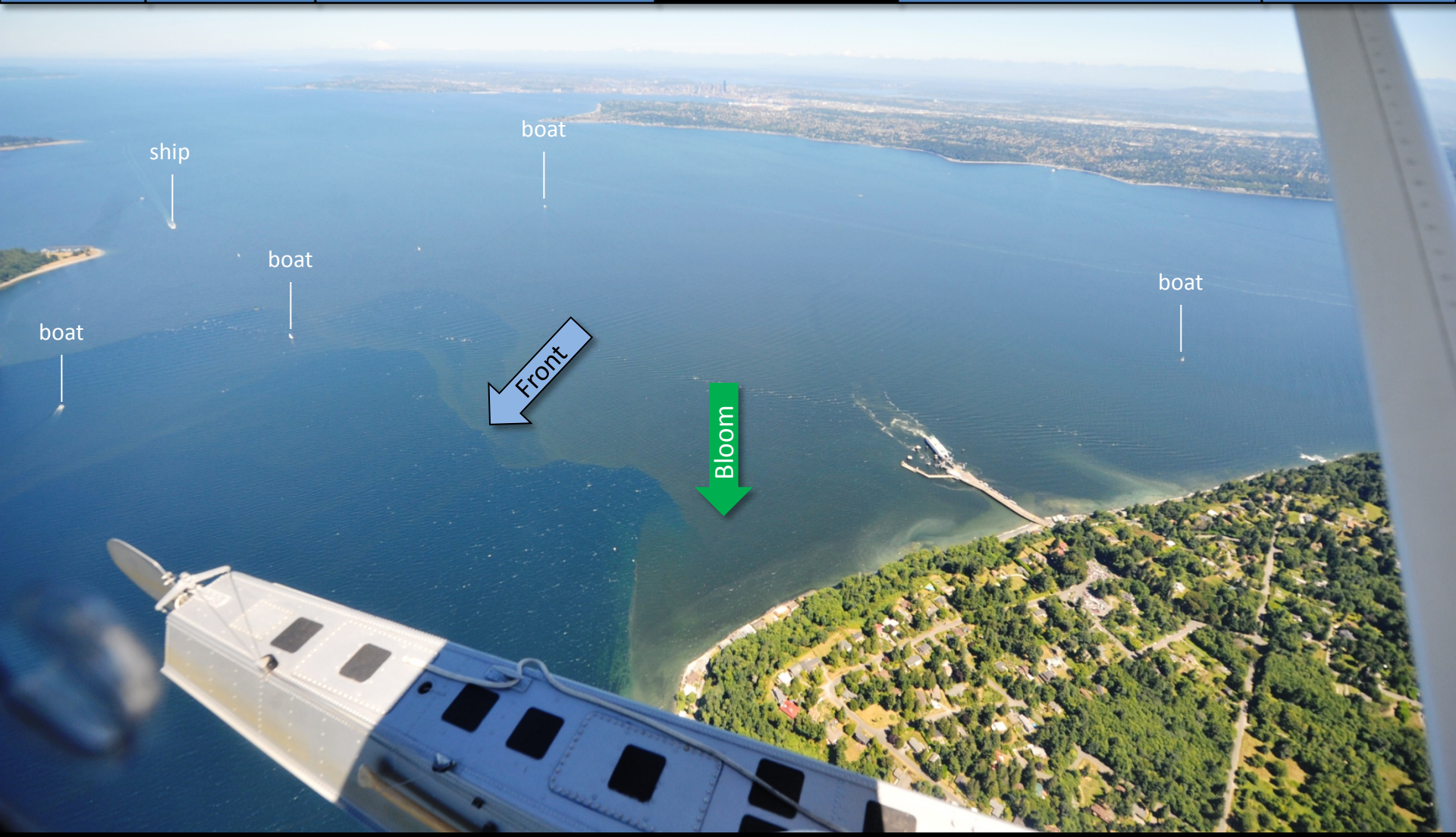
Location: Sinclair Inlet (Kitsap Peninsula), 12:15 PM.

Aerial photography 7-15-2013



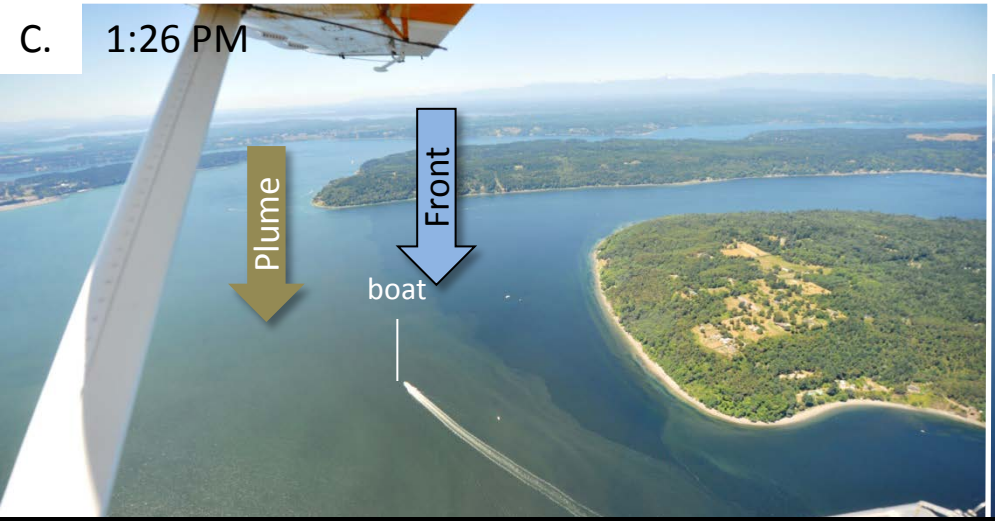
Debris rafts and discolored water from blooms show water movement and fronts.
A. Sinclair Inlet, B. Agate Passage C. Rich Passage D. Off Blake Island.
Location: Near Bainbridge Island (Kitsap Peninsula).

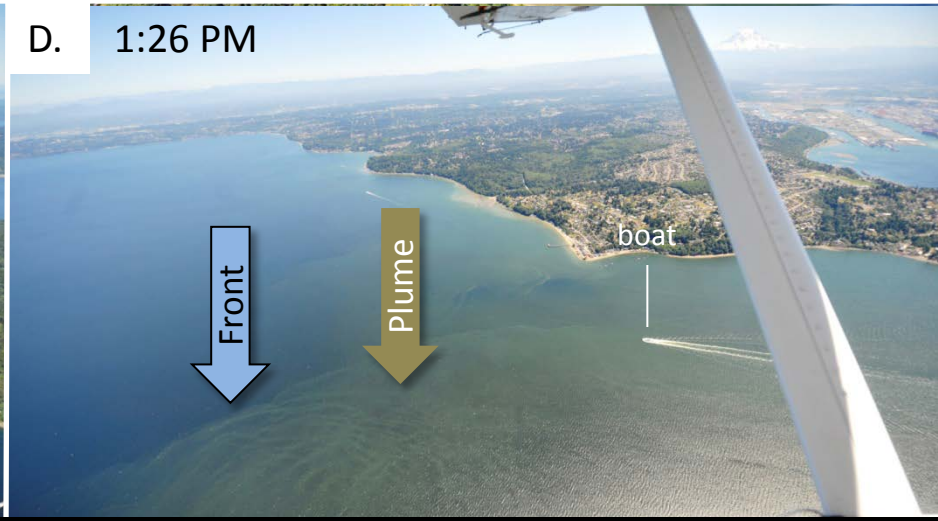
Aerial photography 7-15-2013



Olive-brown water blown in by northerly winds meets clearer water from Colvos Passage.

Location: North Vashon Island (Central Basin), 1:20 PM.





Algal bloom and jellyfish? A & B. Quartermaster Harbor. Puyallup River plume near C. Entrance to Quartermaster Harbor and D. Dash Point. Location: South Central Basin.

Puyallup River Plume and olive-brown water (algal bloom?)

Location: Commencement Bay (South Central Basin), 1:28 PM.

Aerial photography 7-15-2013

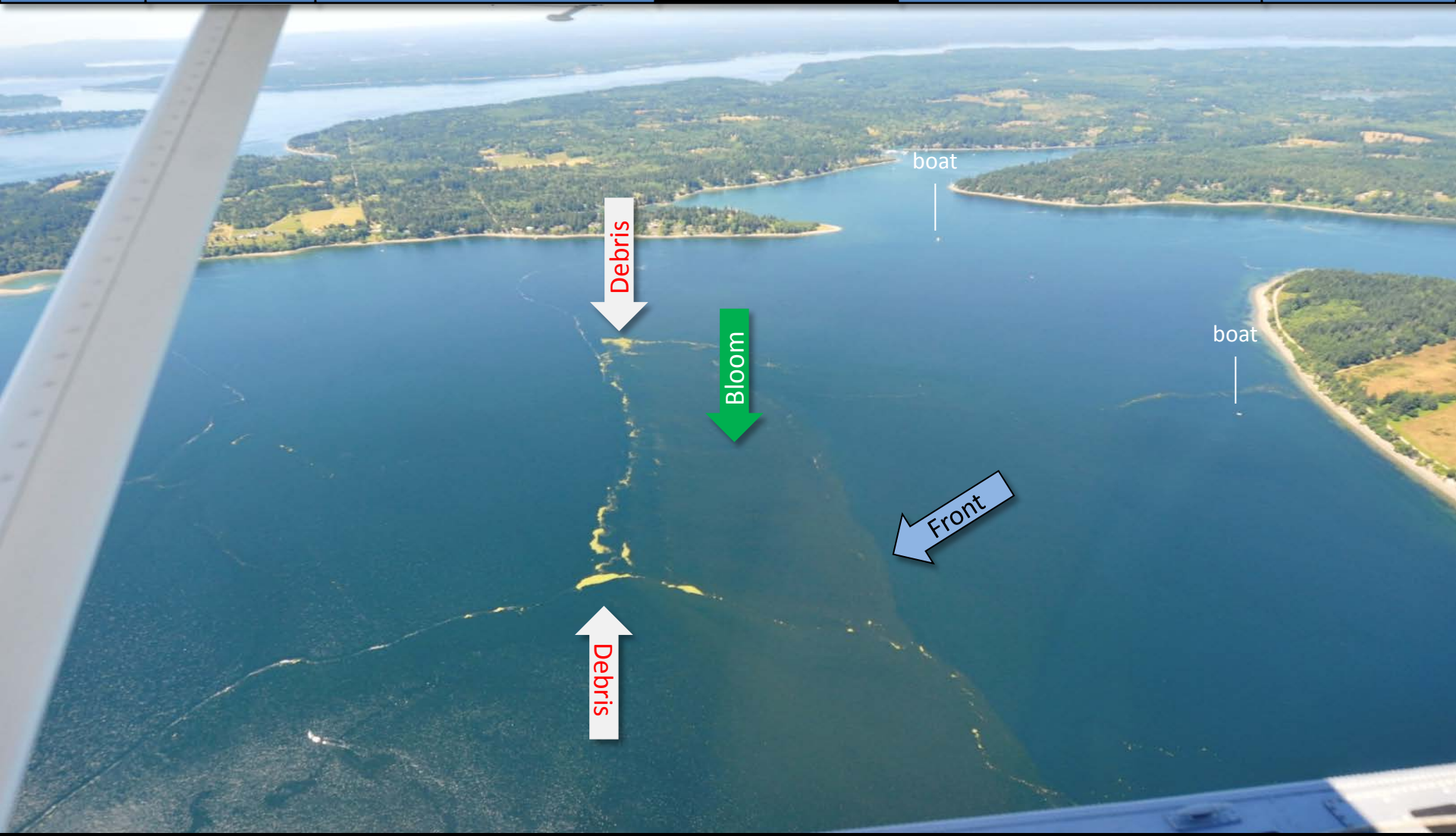
Puyallup River Plume and a sand bar

Location: Commencement Bay (South Central Basin), 1:29 PM.

Puyallup River Plume, olive-brown and yellow-green water (algal bloom?), and organic debris.
Location: Commencement Bay (South Central Basin), 1:31 PM.

Large debris rafts (algal mats) following water movement into Carr Inlet.

Location: Pitt Passage Island (South Sound), 1:37 PM.

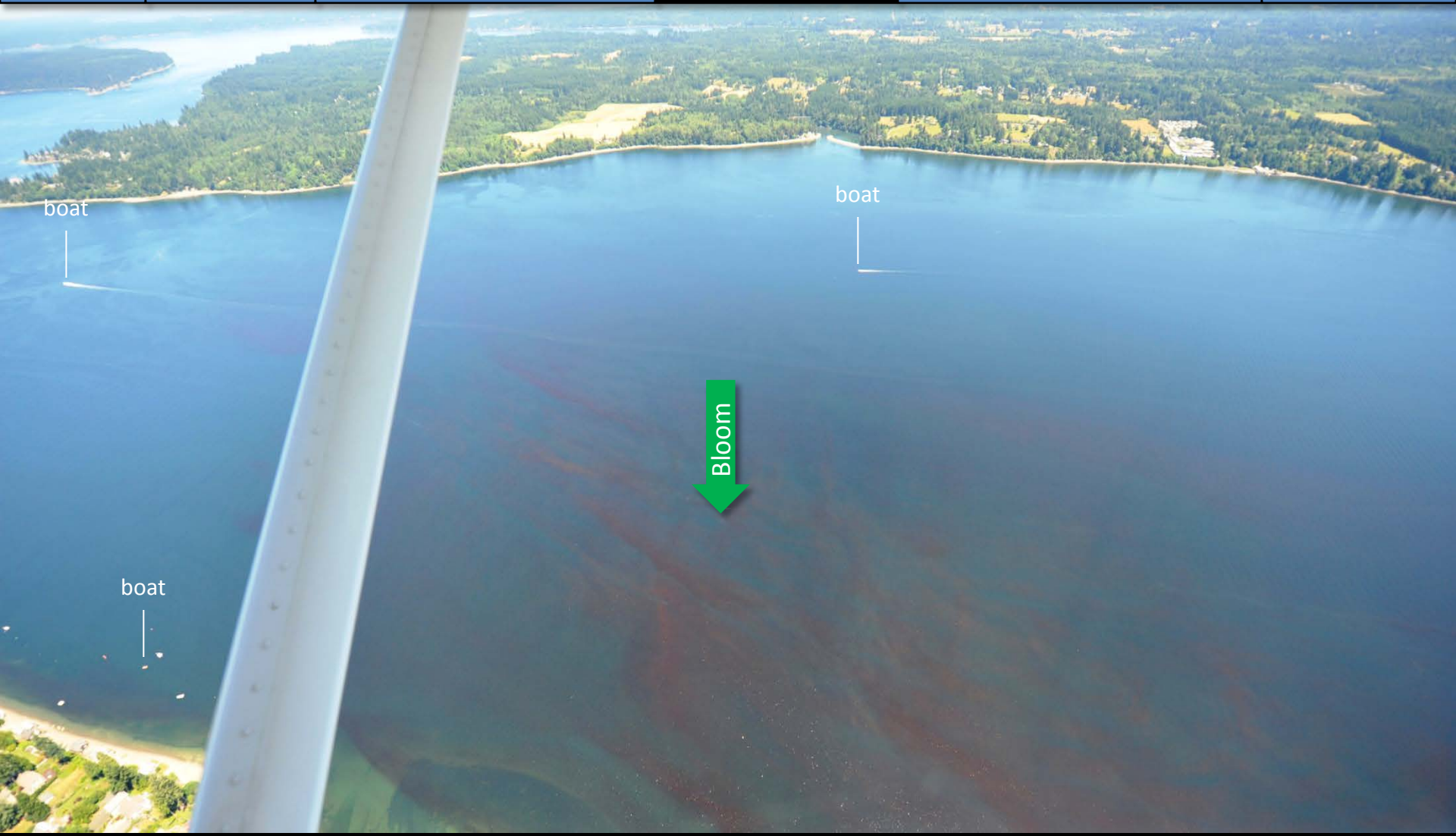


Large debris rafts (algal mats) and olive-brown algal bloom following water movement.
Location: West of Anderson Island (South Sound), 1:38 PM.

Large debris rafts (algal mats) following water movement.

Location: Nisqually Reach (South Sound), 1:41 PM.

Aerial photography 7-15-2013



Red-brown algae bloom near the surface.

Location: Budd Inlet (South Sound), 1:45 PM.

Red-brown bloom near the surface and organic debris.

Location: Eld Inlet (South Sound), 1:46 PM.

Aerial photography 7-15-2013

Orange and red-brown bloom and patches of jellyfish near the surface.

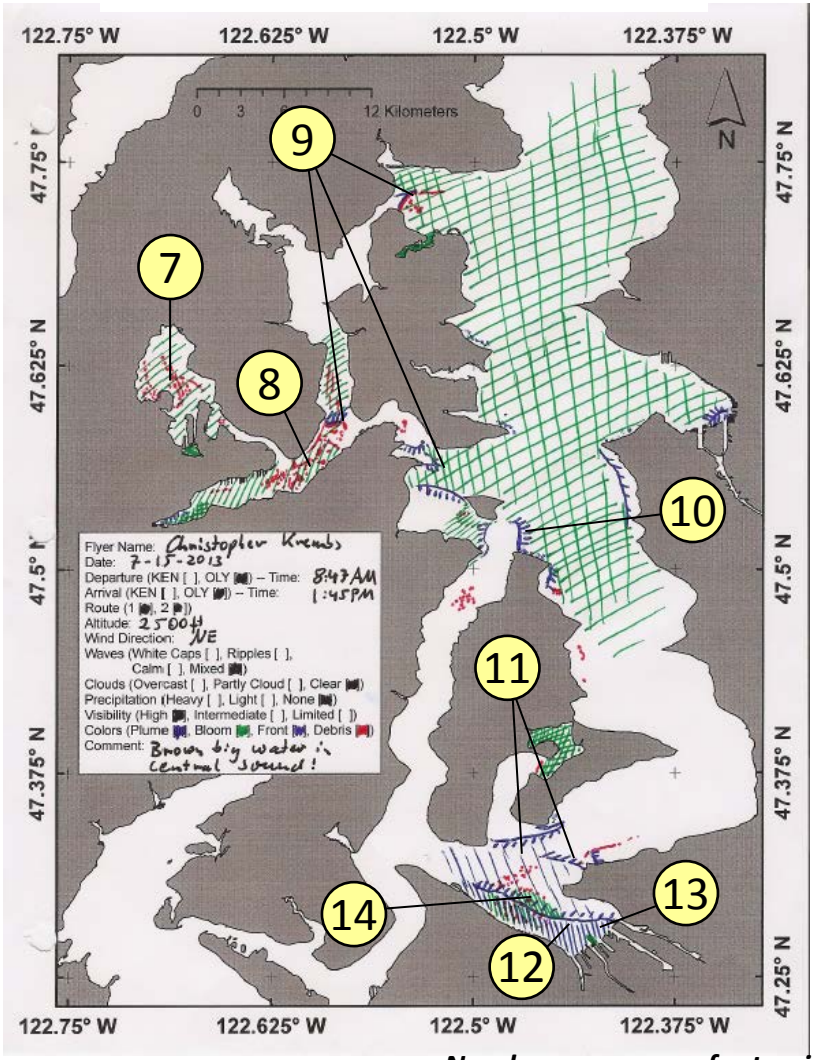
Location: Eld Inlet (South Sound), 1:47 PM.

Aerial photography observations in Central Sound

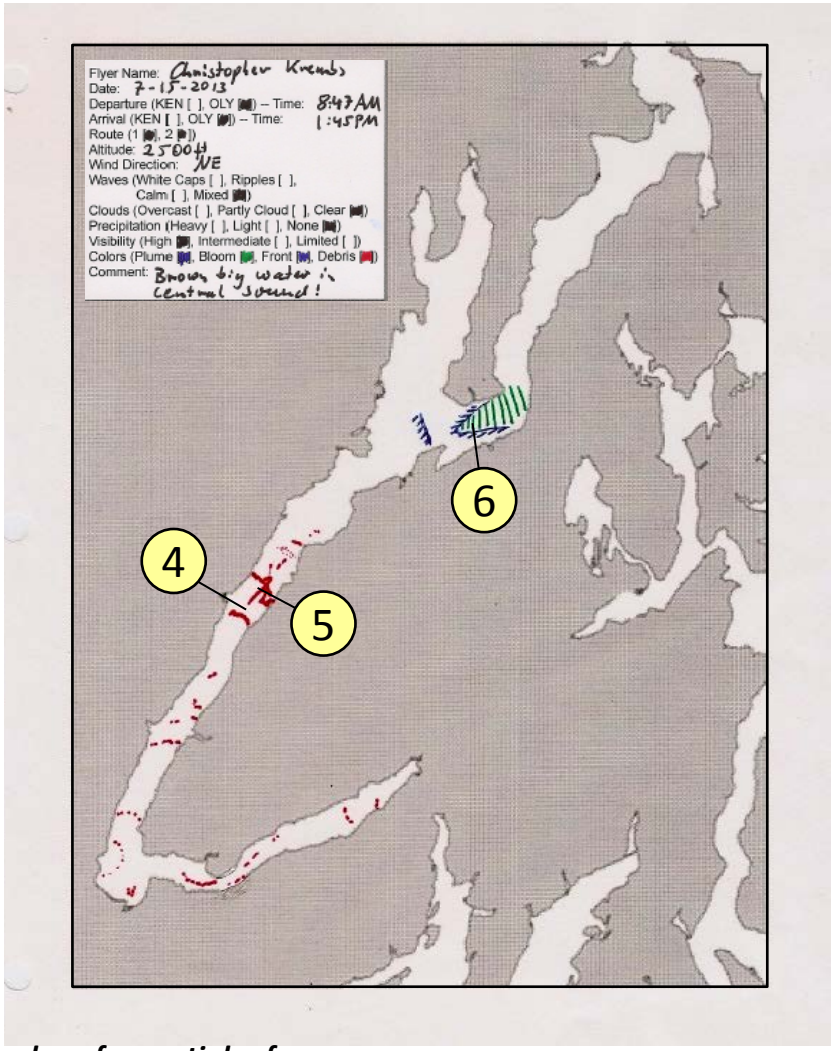
Navigate

Date: 7-15-2013

Central Sound



Hood Canal



Numbers on map refer to picture numbers for spatial reference

DEPARTMENT OF ECOLOGY
State of Washington

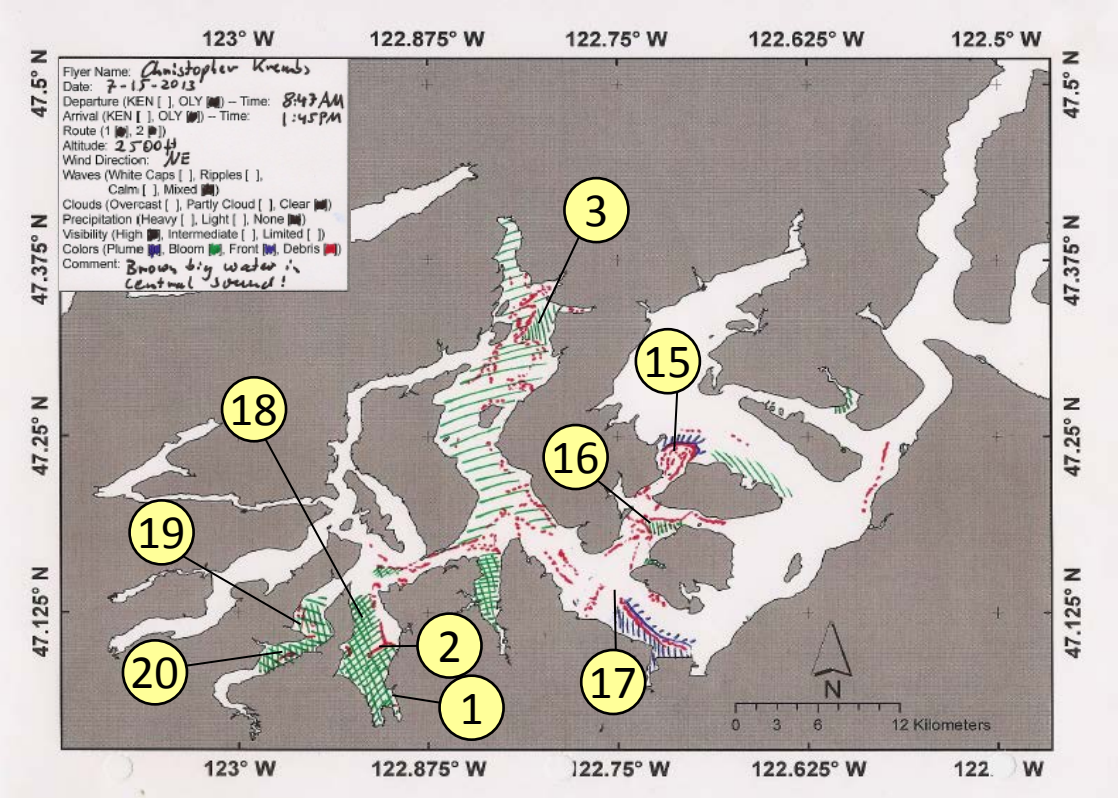
Aerial photography

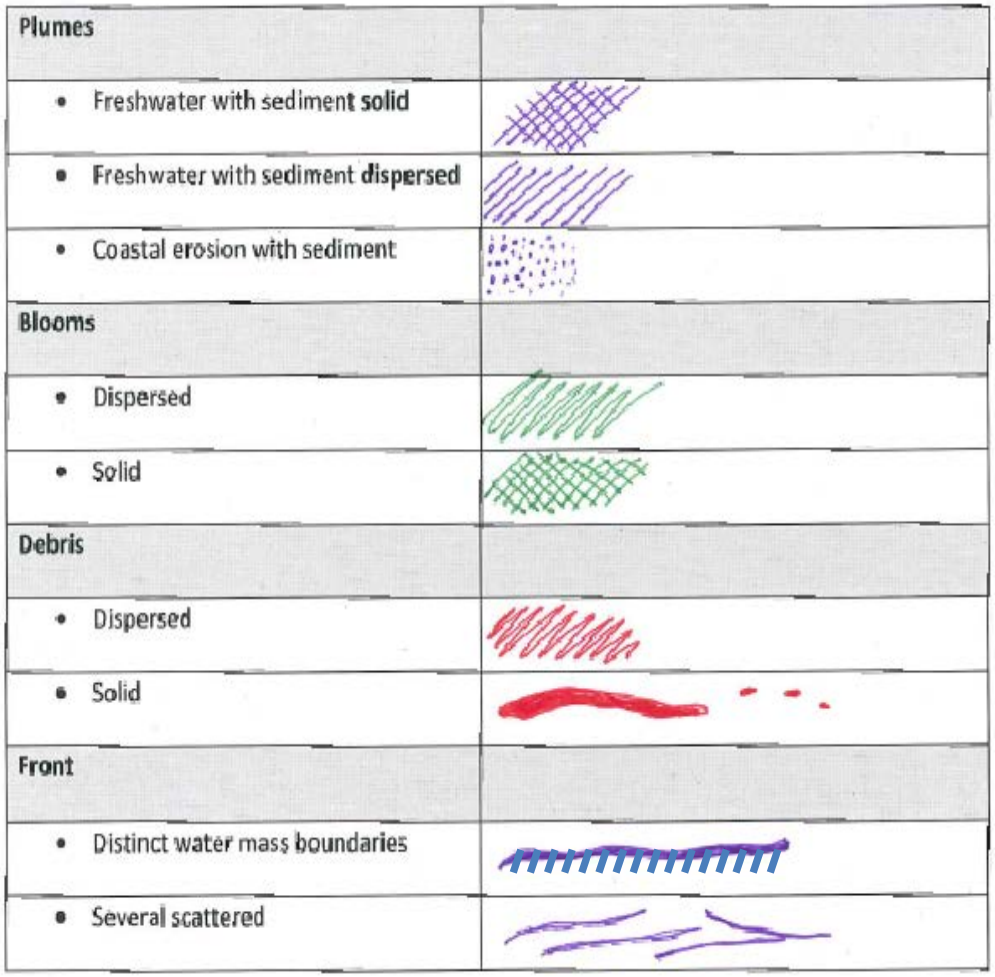
Observations in South Sound: 7-15-2013

Navigate

Numbers on map refer to picture numbers for spatial reference

South Sound



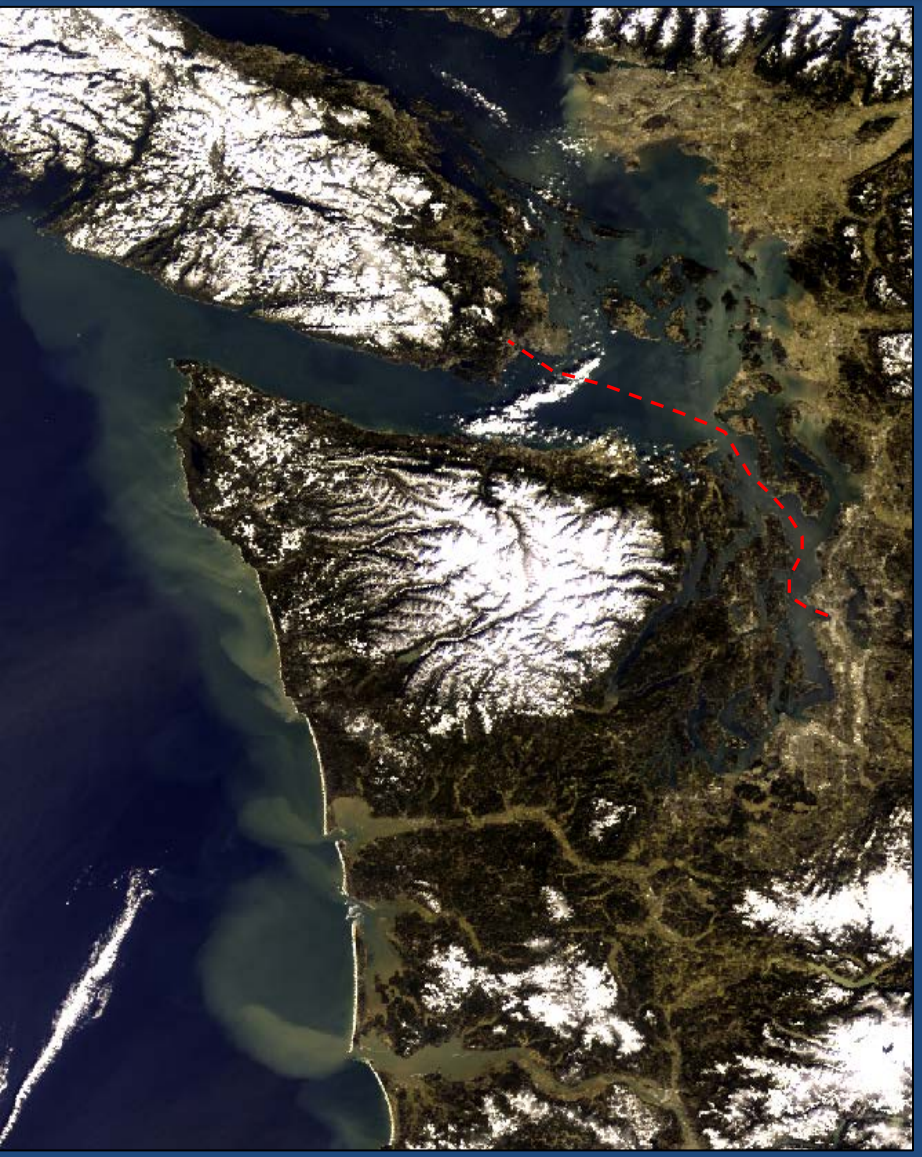


Comments:
Maps are produced by observers during and after flights. They are intended to give an approximate reconstruction of the surface conditions on scales that connect to and overlap with satellite images in the section that follows.

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 7-15-2013



Brandon Sackmann
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bsackmann@ecy.wa.gov

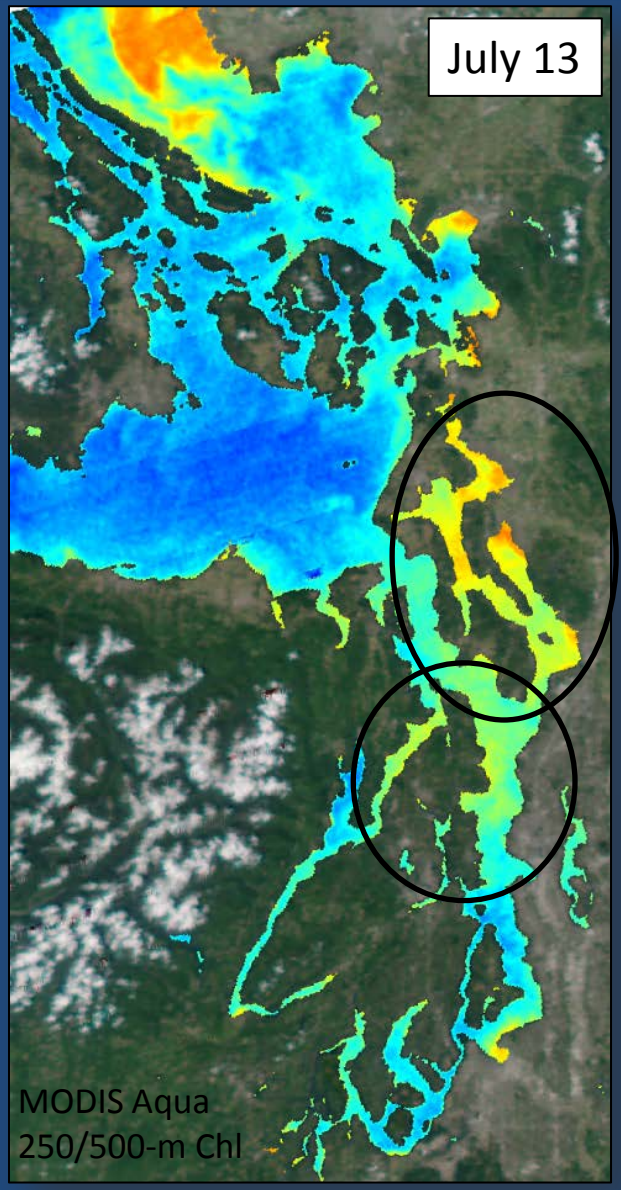
Start here

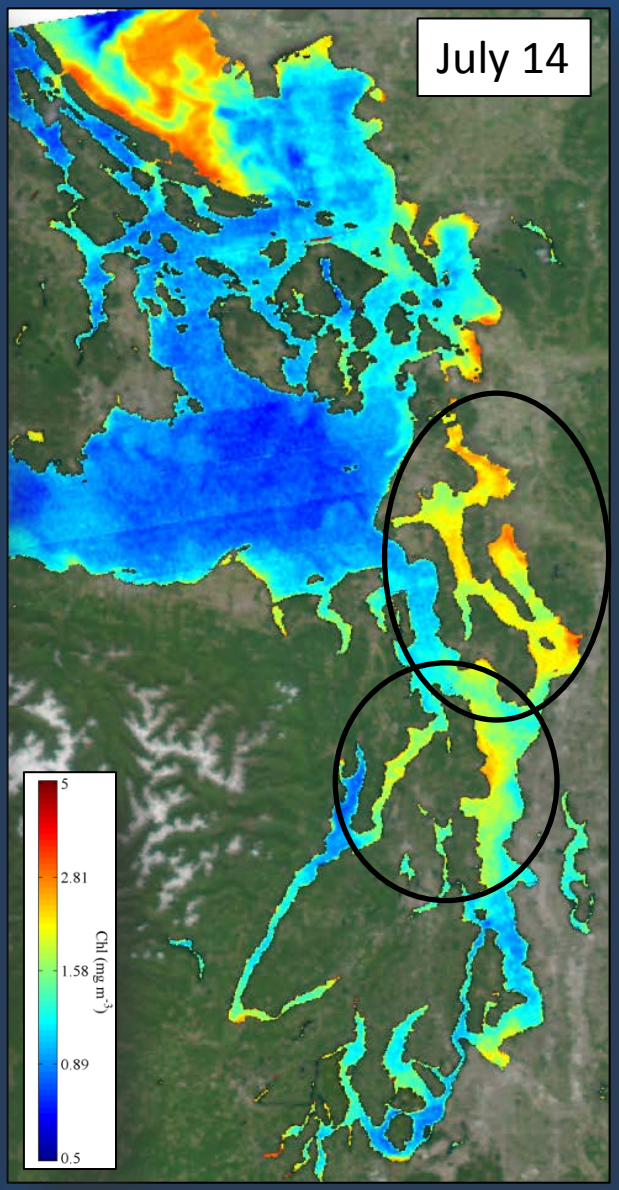
Current Conditions:

Phytoplankton bloom in Whidbey Basin, northern Hood Canal and Central Basin (between Elliott Bay and the Triple Junction). Thermal imagery from earlier in the month reveals patterns of near-surface mixing.

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 7-15-2013





MODIS Aqua

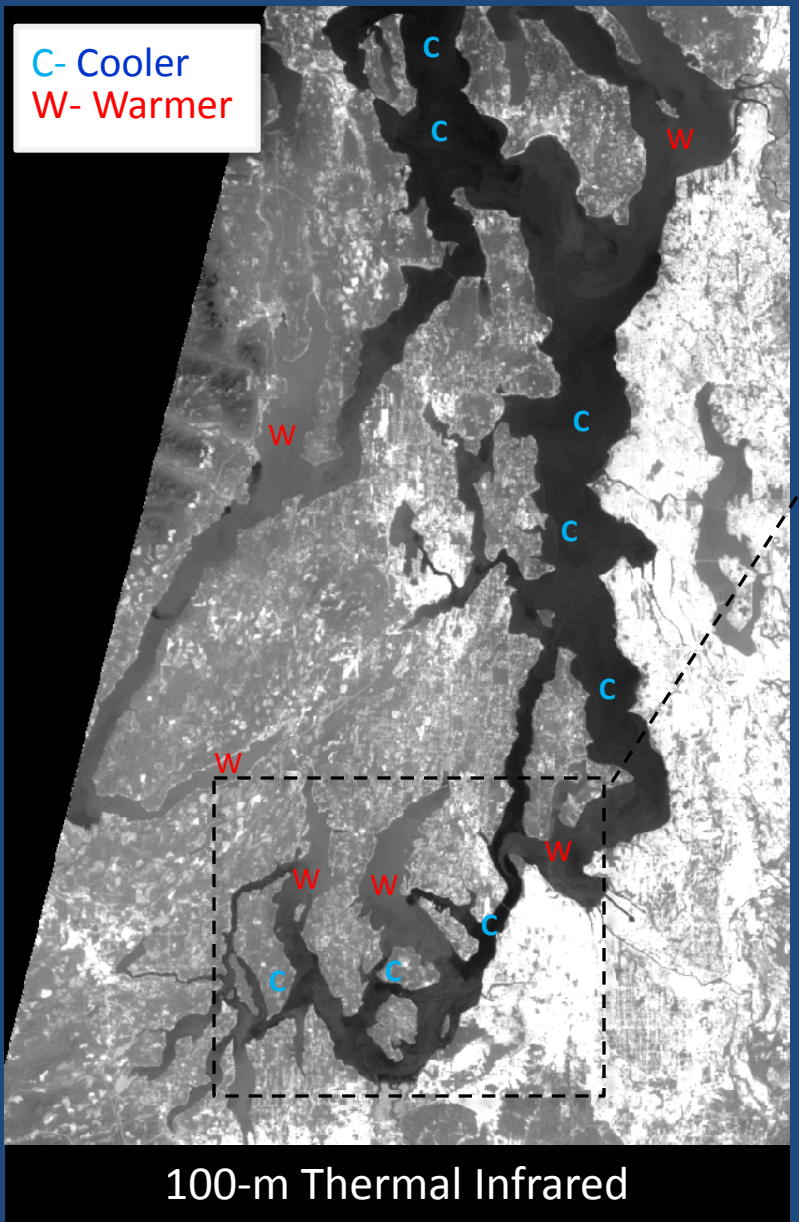
13-14 July 2013

Satellite ocean color imagery leading up to over flight on 7/15 reveals blooms in Whidbey Basin, northern Hood Canal and the Central Basin between Elliott Bay and the Triple Junction.

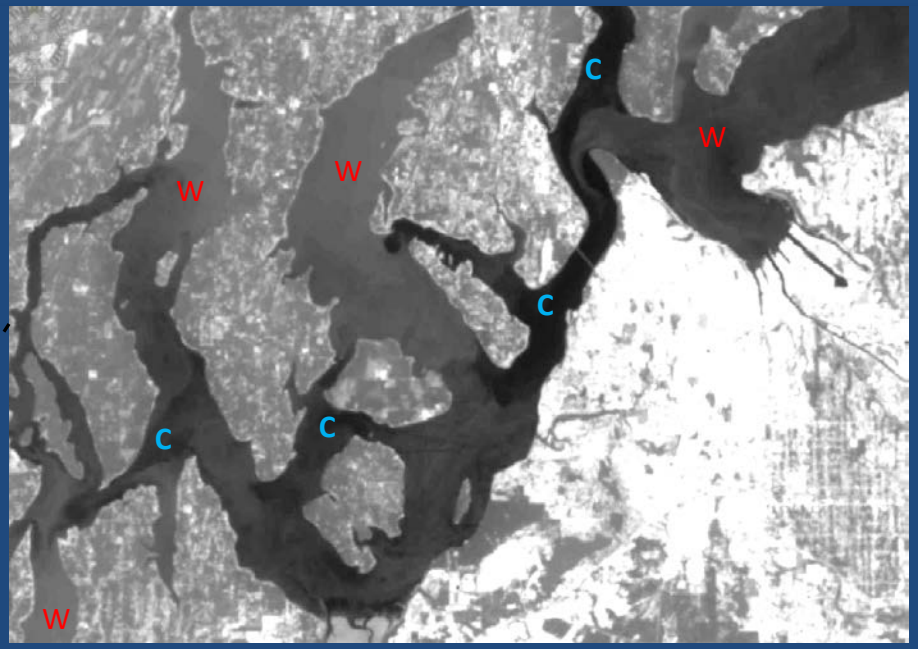
Lower chlorophyll values observed in the Strait of Juan de Fuca.

Fraser River plumes can be seen spreading out across the entire Strait of Georgia!

Ferry and satellite observations 7-15-2013



100-m Thermal Infrared



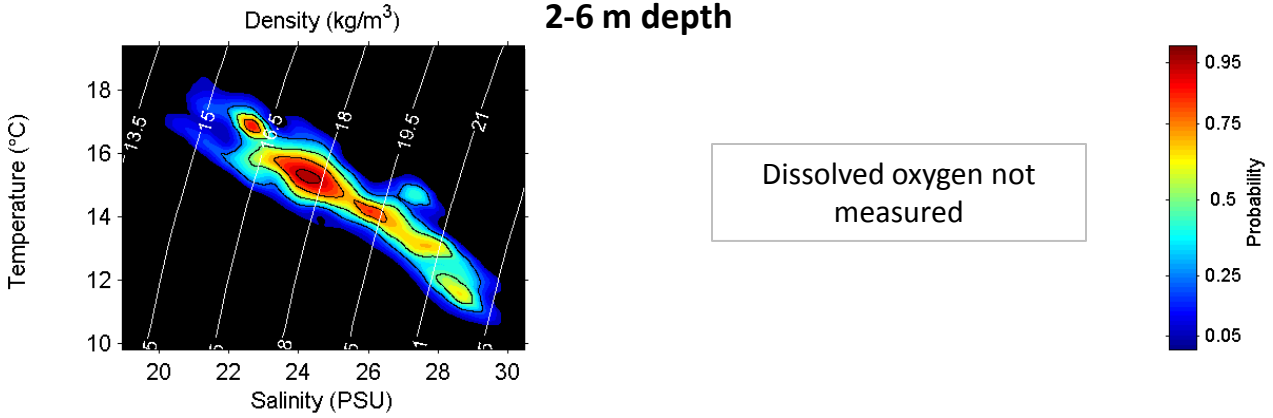
Landsat 8 helps visualize dynamic mixing processes in Puget Sound

3 July 2013

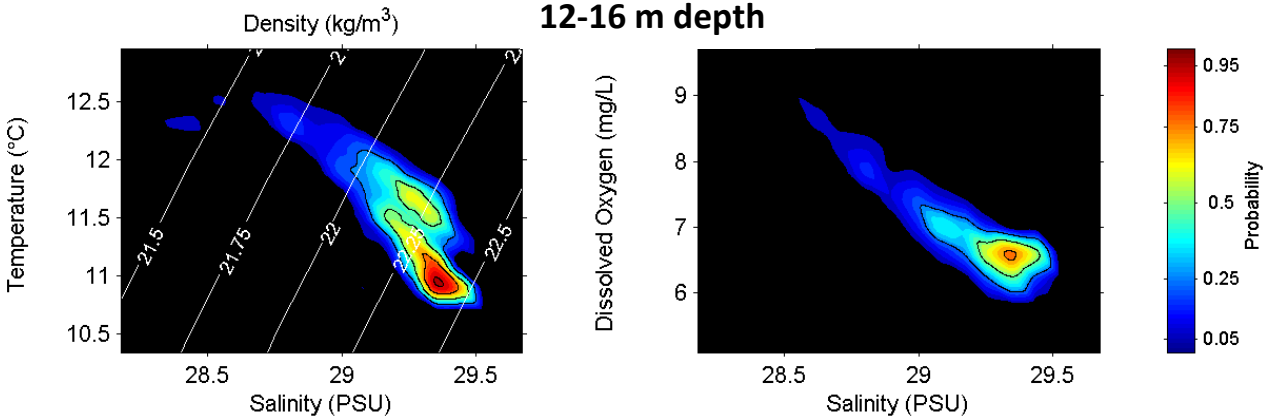
Earlier this month Landsat 8 captured a beautiful image of Puget Sound! Hi-resolution thermal imagery revealed increased mixing in narrow passages (cooler surface temperatures) and stratification (warmer surface temperatures) at terminal ends of many bays and inlets. Rivers are also adding warm water at the surface.

Mooring observations and trends 7-2-2013 to 7-15-2013

At our Mukilteo moorings, we observed distinct differences in salinity between the surface (24 PSU) and bottom (29.4 PSU) waters. In the bottom water layer, dissolved oxygen is lower while salinity is higher.



Left Panels: Density is defined by salinity and temperature. Probability of finding a specific density over the past two-week period can be shown in a T-S plot. High probability shown in warm colors.

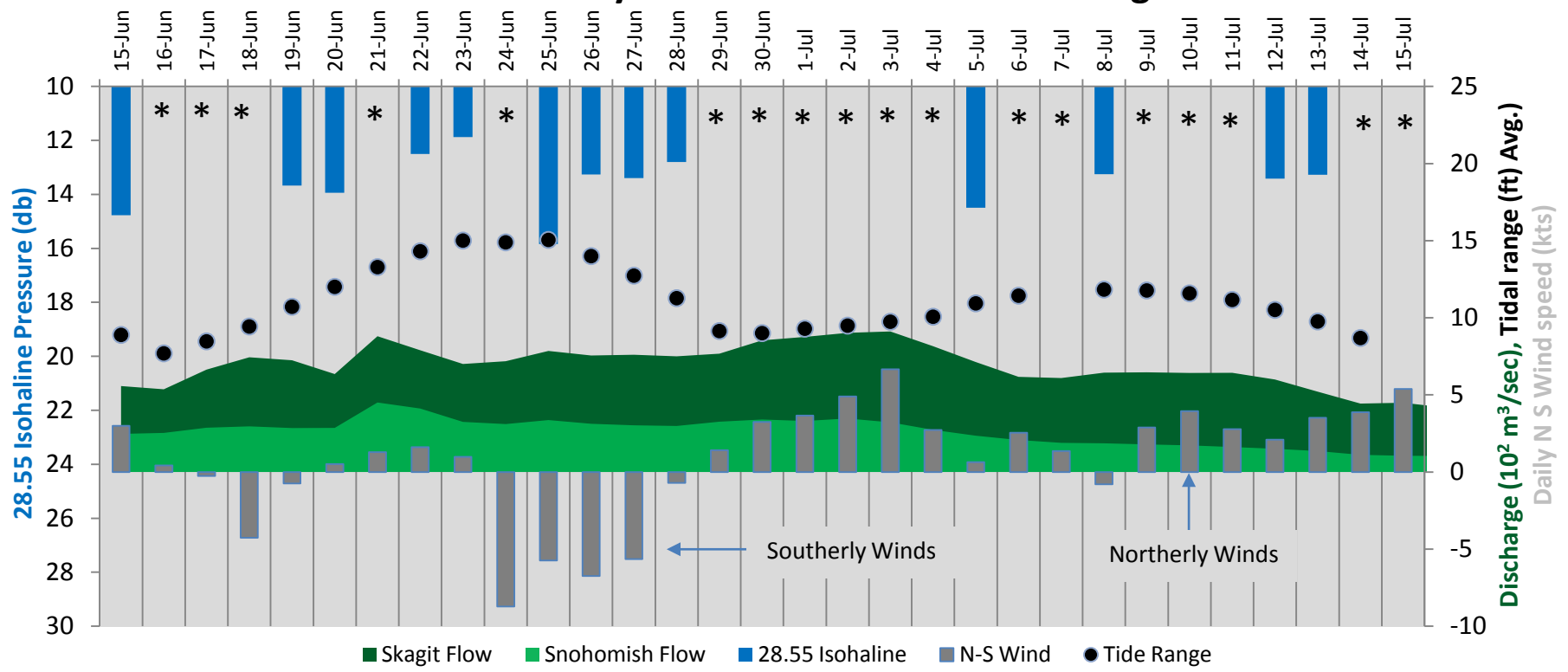


Right Panel: Dissolved oxygen concentration in relation to salinity. High probability shown in warm colors.

Mooring observations and trends 6-15-2013 to 7-15-2013

We report on thickness of the fresher water layer by monitoring our near-surface sensor. We define this thickness using 28.55 (±0.05) PSU. At Mukilteo (Whidbey Basin), winds, fortnightly tidal cycle, and declining river flows influenced the surface water layer thickness. The bottom sensor detects the fresher water less frequently, only 4 times in past two weeks. Freshwater input from rivers declined to below normal and Skagit River contributed the largest portion.

Thickness of surface layer at Mukilteo and influencing factors



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

River data from USGS science for a changing world

Mooring observations and trends 7-02-2013 to 7-15-2013

During the past two weeks, temperature and dissolved oxygen increased whereas salinity declined.

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

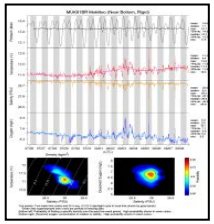
2-6 m depth

Mukilteo Salinity (Sal)

Sal Max	29.3 PSU	on 07/02	at 11.1 °C	5.8 db
Sal Min	17.5 PSU	on 07/09	at 17.6 °C	3.6 db
Sal Avg	25.1 PSU			
Sal Trend	0.3 PSU			

Mukilteo Temperature (T)

T Max	18.4 °C	on 07/09	at 21.1 PSU	3.3 db
T Min	11 °C	on 07/02	at 29 PSU	5.8 db
T Avg	14.7 °C			
T Trend	1.1 °C			



Real-time data online (click)

12-16 m depth

Mukilteo Dissolved Oxygen

DO Max	9.8 mg/L	on 07/09	at 9.7 PSU	28.7 °C	12.5 db
DO Min	4.2 mg/L	on 07/02	at 6.5 PSU	29.4 °C	10.9 db
DO Avg	6.9				
DO Trend	0.7 mg/L				
DO-Sal Corr	-0.68				
DO-Temp Corr	0.66				

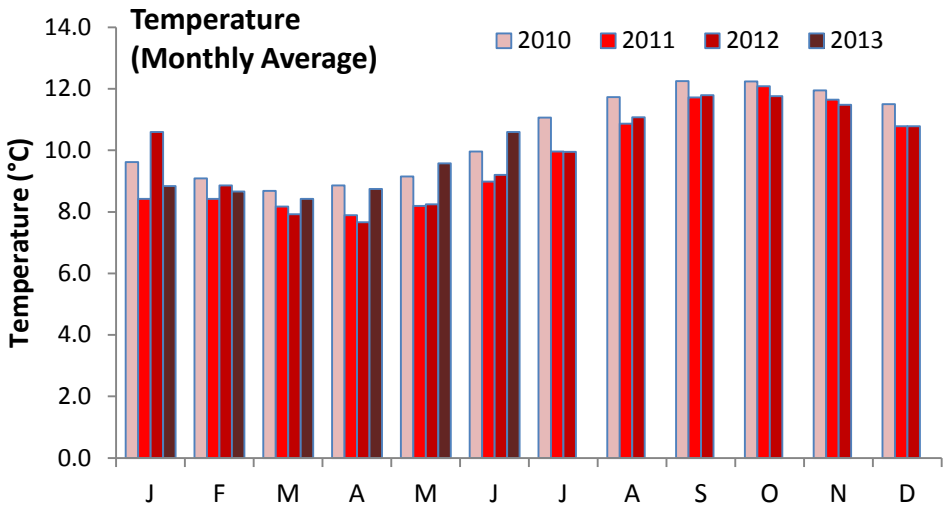
Mukilteo Salinity (Sal)

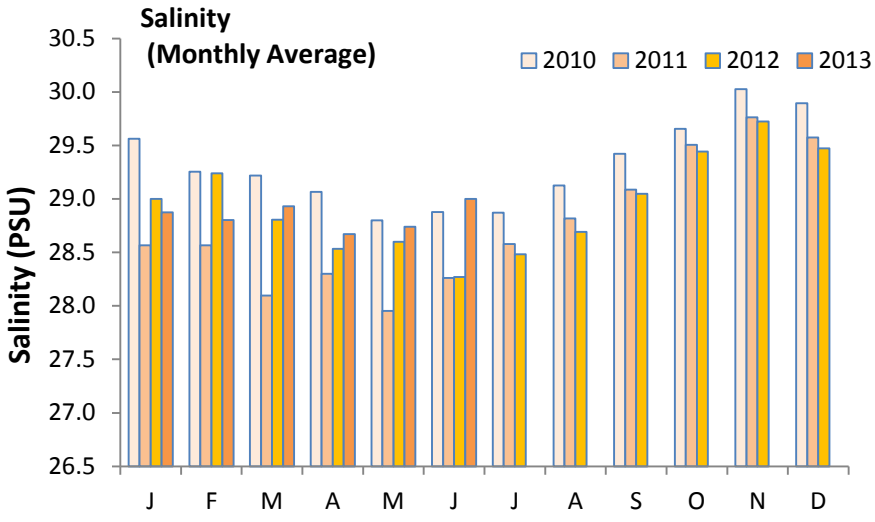
Sal Max	29.5 PSU	on 07/02	at 29.5 °C	10.7 db
Sal Min	28.3 PSU	on 07/07	at 29.1 °C	11.6 db
Sal Avg	29.2 PSU			
Sal Trend	-0.4 PSU			

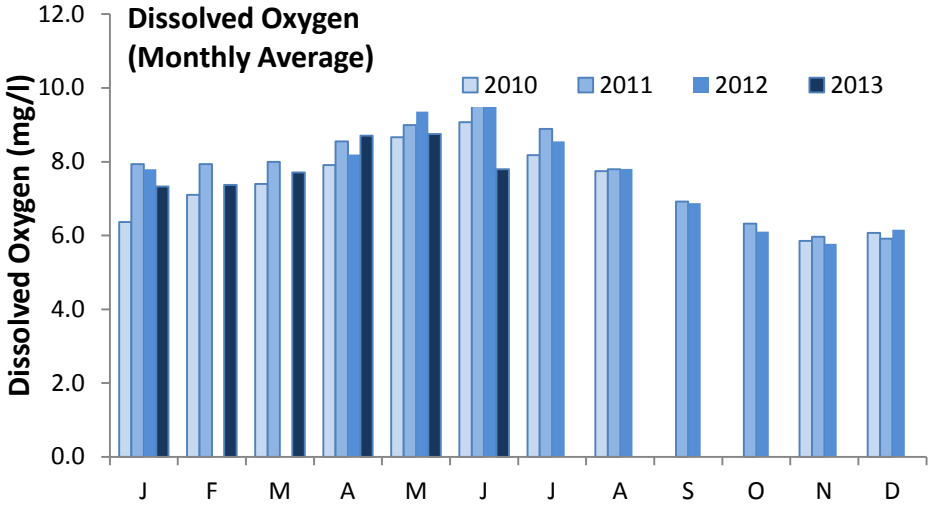
Mukilteo Temperature (T)

T Max	13.5 °C	on 07/09	at 9.7 PSU	13.5 db
T Min	10.7 °C	on 07/02	at 6.4 PSU	10.8 db
T Avg	11.3 °C			
T Trend	1.2 °C			

Mooring observations and trends Mukilteo 2010 to 2013







This slide shows data from our Mukilteo mooring capturing water exchange between the Main Basin and Possession Sound at 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 in 2013, trends are appearing to be similar to 2010 with relatively warmer water temperature, higher salinity, and lower dissolved oxygen.

Get data from Ecology's Monitoring Programs

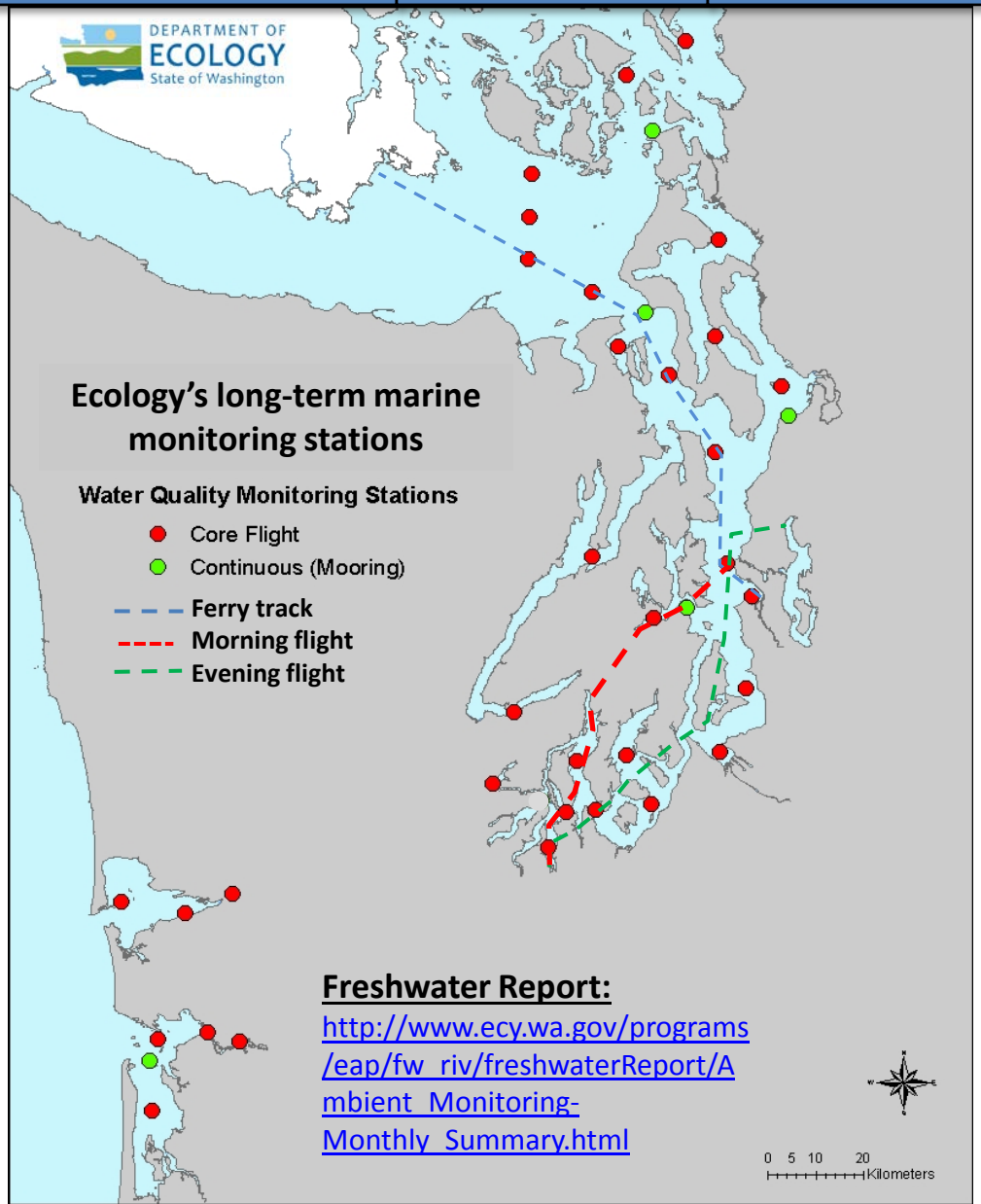
Flight log	Weather	Water column	Aerial photos	Ferry and Satellite	Moorings

Long–Term Monitoring Network

christopher.krembs@ecy.wa.gov

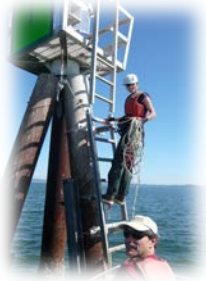
Access core monitoring data:

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.