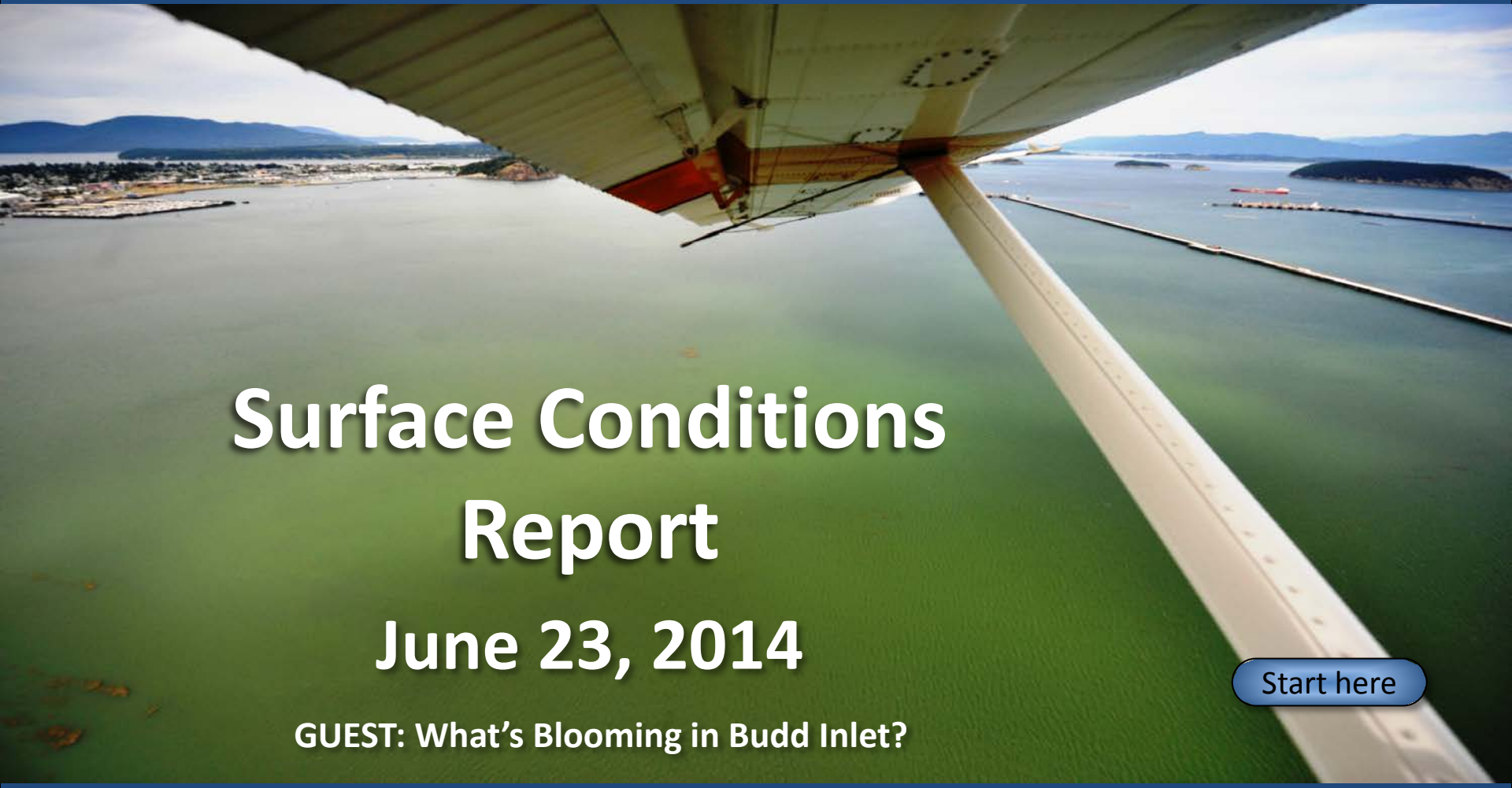
Publication No. 14-03-074

DEPARTMENT OF ECOLOGY State of Washington

Eyes Over Puget Sound



Surface Conditions Report

June 23, 2014

Start here

GUEST: What's Blooming in Budd Inlet?

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

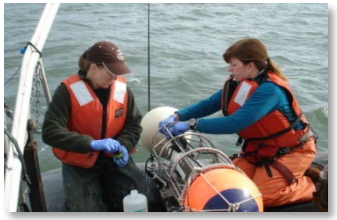
Marine conditions from 6-23-2014 at a glance

LONG-TERM MARINE MONITORING UNIT

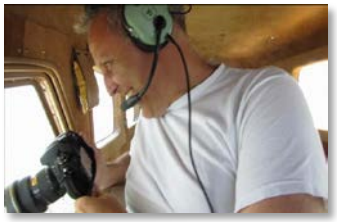
Mya Keyzers
Laura Hermanson
Joe Leatherman

Skip Albertson

Julia Bos
Suzan Pool



Dr. Christopher Krembs



Carol Maloy

Personal field log
p. 4
Meet our marine mooring program with Suzan Pool.

Weather conditions
p. 6
Onshore winds have been keeping the Puget Sound lowlands cool and cloudy, but sunlight and warmer temperatures returned before the flight.

Water column
p. 8
In early 2014, colder, saltier conditions developed throughout Puget Sound with lower oxygen in Whidbey Basin, Central and South Sound. Hood Canal remains unusually cold.

Moorings
p. 38
In the Mukilteo moorings, water masses are distinct, temperature is similar to last year, and salinity and dissolved oxygen are lower than the last few years.

Aerial photography
p. 11
Large organic mats of surface debris in Hood Canal, Padilla Bay and Lay Inlet. Many patches are macro-algae. Strong red-brown bloom in Discovery Bay and East Sound and parts of Georgia Basin. Sediment rich water north of San Juan Islands. Jelly fish are increasing in numbers.

Ferry and satellite
p. 36
High-tech hitch-hiking the state ferries. A collaborative effort.

A Phytoplankton Monitoring Program

GUEST: What's Blooming in Budd Inlet?

Eyes Over Puget Sound aerial photos of Budd Inlet plankton blooms inspired a partnership between Stream Team and the Pacific Shellfish Institute to collect water quality and phytoplankton data from lower Budd Inlet. This summer marks the 3rd year of plankton monitoring during the summer months. Sampling takes place every Thursday from mid-June to mid-September at the Port Plaza dock and the public is welcome to participate.

Young scientists gather at Port Plaza to collect data: weather, water temperature, salinity, secchi disk and phytoplankton.
Contact: ppyle@ci.olympia.wa.us

What's Blooming in Budd on June 19th?
Ceratium fusus and *Dinophysis* (shown) as well as *Noctiluca and Coscinodiscus.*
Contact: aimee@pacshell.org

After the plankton samples are collected, they are taken to LOTT's WET Science Center and projected onto a big screen. Here, volunteers generate a species list and perform cell counts on phytoplankton species known to produce biotoxins. This information is shared with other monitoring programs such as Eyes Over Puget Sound, SoundToxins, and Washington Department of Health. For more information about this program, go to www.pacshell.org/whats-blooming-in-budd.asp or www.streamteam.info/getinvolved/calendar/

Kids test their identification skills on a fresh plankton sample.

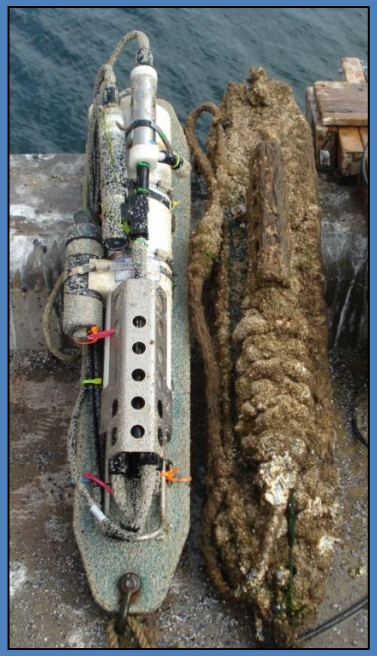
Personal field impression 6-23-2014

Using moorings to measure marine water quality

Along with our monthly sampling, we deploy moored sensors in Puget Sound. The moorings measure temperature, salinity, and dissolved oxygen at fixed depths around the clock. Data are being analyzed to increase our knowledge and understanding of Puget Sound water circulation and quality.

Sensors are typically in the water for up to 6 weeks. During this time, the sensors become mildly to heavily attached with sea critters such as sea stars, barnacles, anemones, nudibranchs, and shrimps. Therefore, we routinely retrieve, clean, test, and re-deploy the sensors.

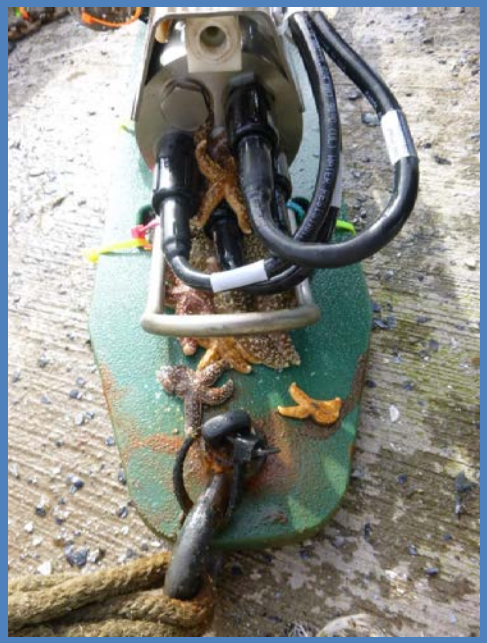
Retrieving the mooring at the Mukilteo station.



Near-bottom sensor (left) has little biofouling compared to near-surface sensor (right) with barnacles.

Personal field impression 6-23-2014

Using moorings to measure marine water quality



Our near-bottom sensor has baby sea stars!

During this routine maintenance, we run tests to check that our sensors are performing as expected. These tests compare sensor measurements with water samples for dissolved oxygen and salinity.

Field staff working on sensors

Field bath for conducting sensor performance tests

Also, data recorded by the sensors are saved to a computer and brought back to the office for further analysis.

Weather of the past two weeks before 6-23-2014

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:

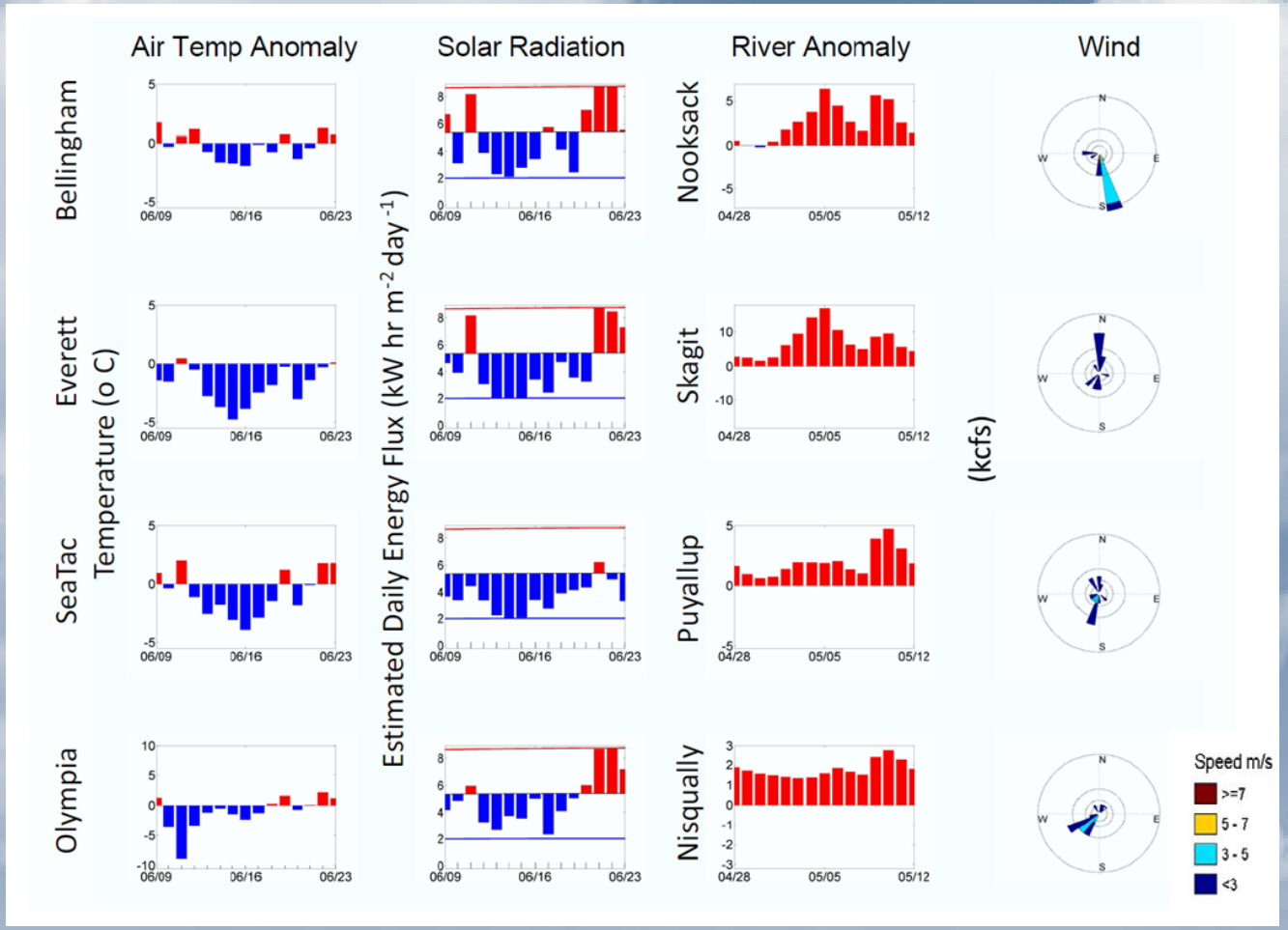
Air temperatures. The air was warm on the day of the flight, but had been slightly below average during the previous week and higher than normal two weeks prior.

Sunshine levels have increased during the past two days, but were generally low for the past week prior to that.

River flows have been above normal.

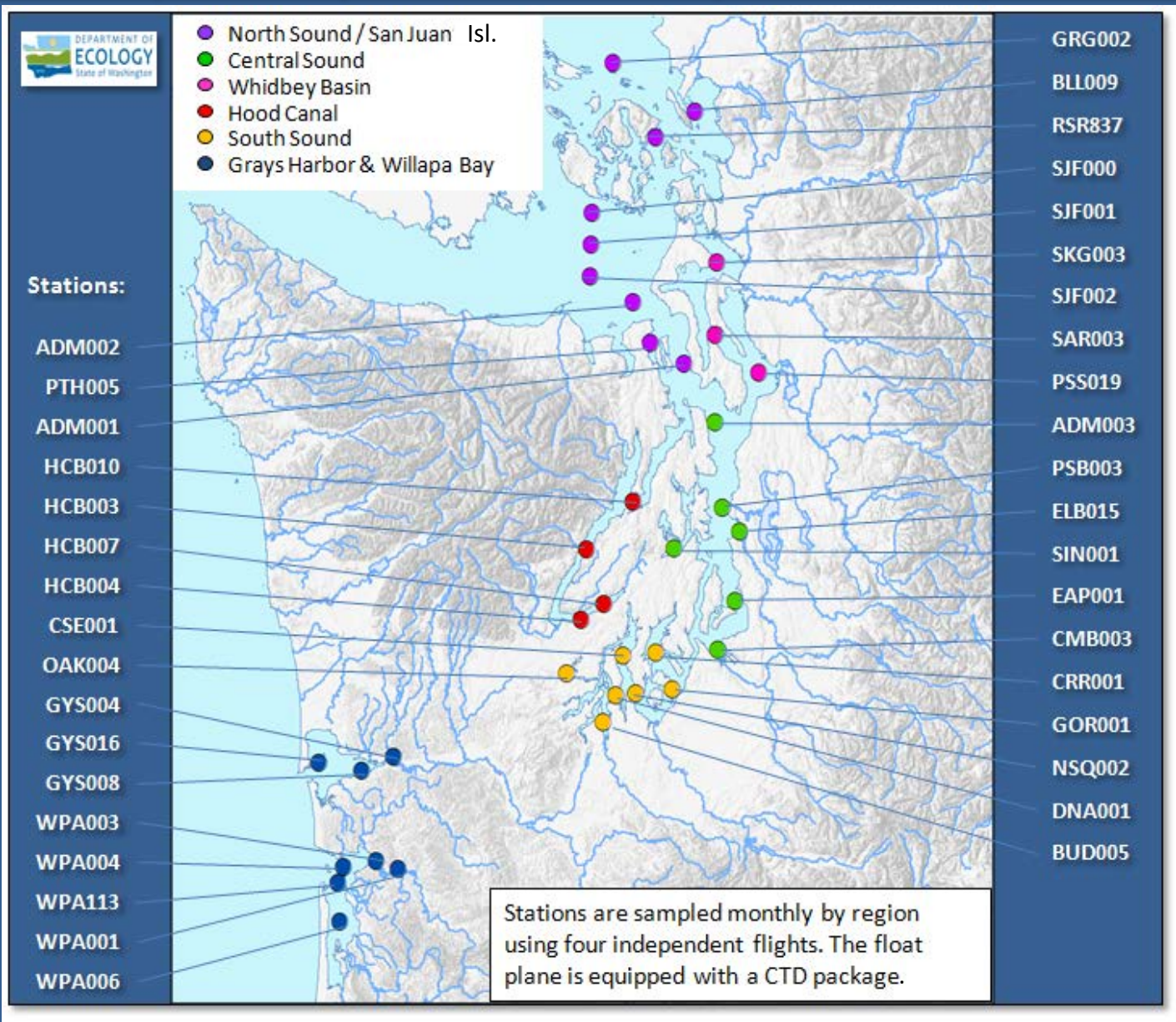
Winds have primarily been from the south up until the day of the flight.

- 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



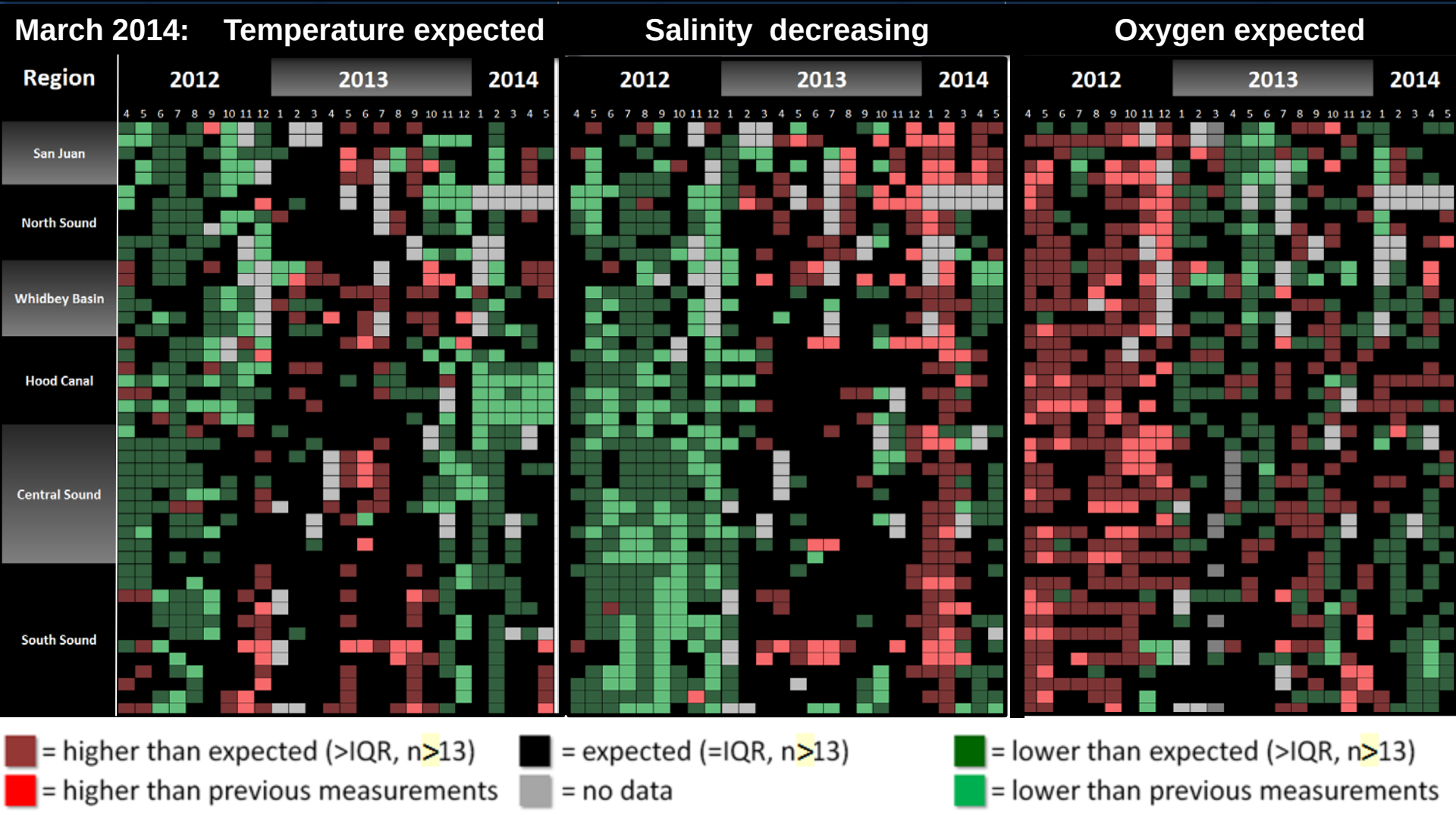
We use a chartered float plane to access our monthly monitoring stations most cost effectively.

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



The 2012 colder, fresher, higher oxygen conditions are gone. In 2013, Puget Sound was warmer, with normal salinity. Lower oxygen conditions appeared in the northern areas early in the year. In early 2014, colder, saltier conditions developed throughout Puget Sound with lower oxygen in Whidbey Basin, Central and South Sound. Hood Canal remains unusually cold.

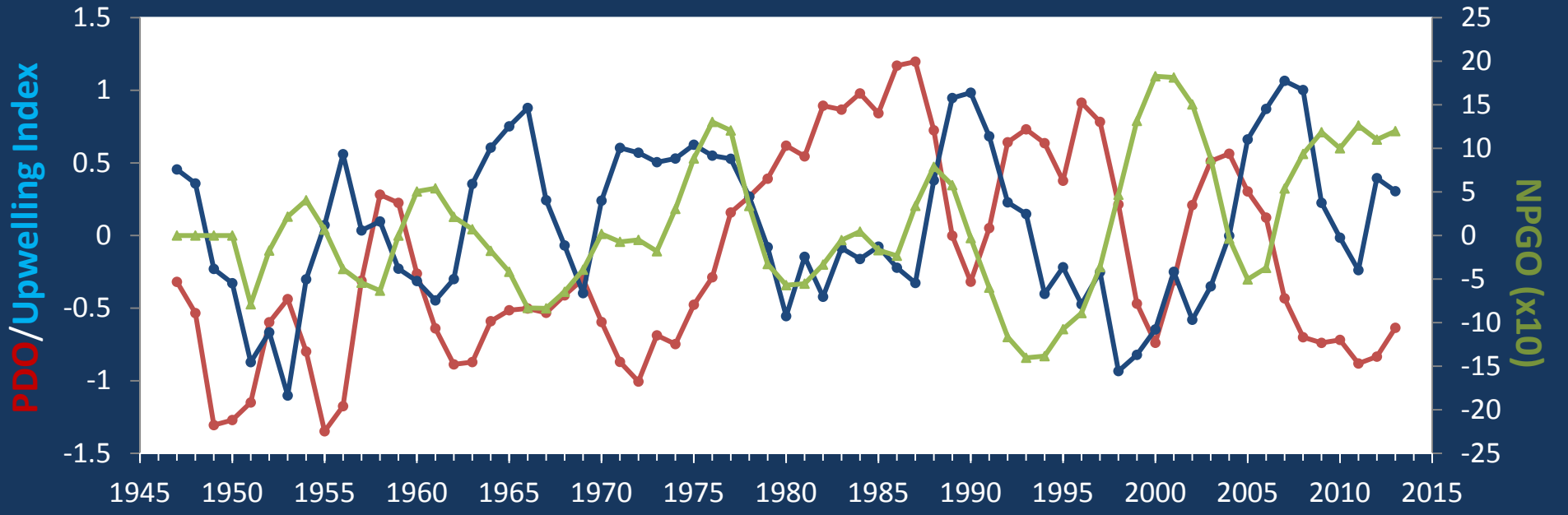
The ocean affects water quality: Ocean Climate Indices

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

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

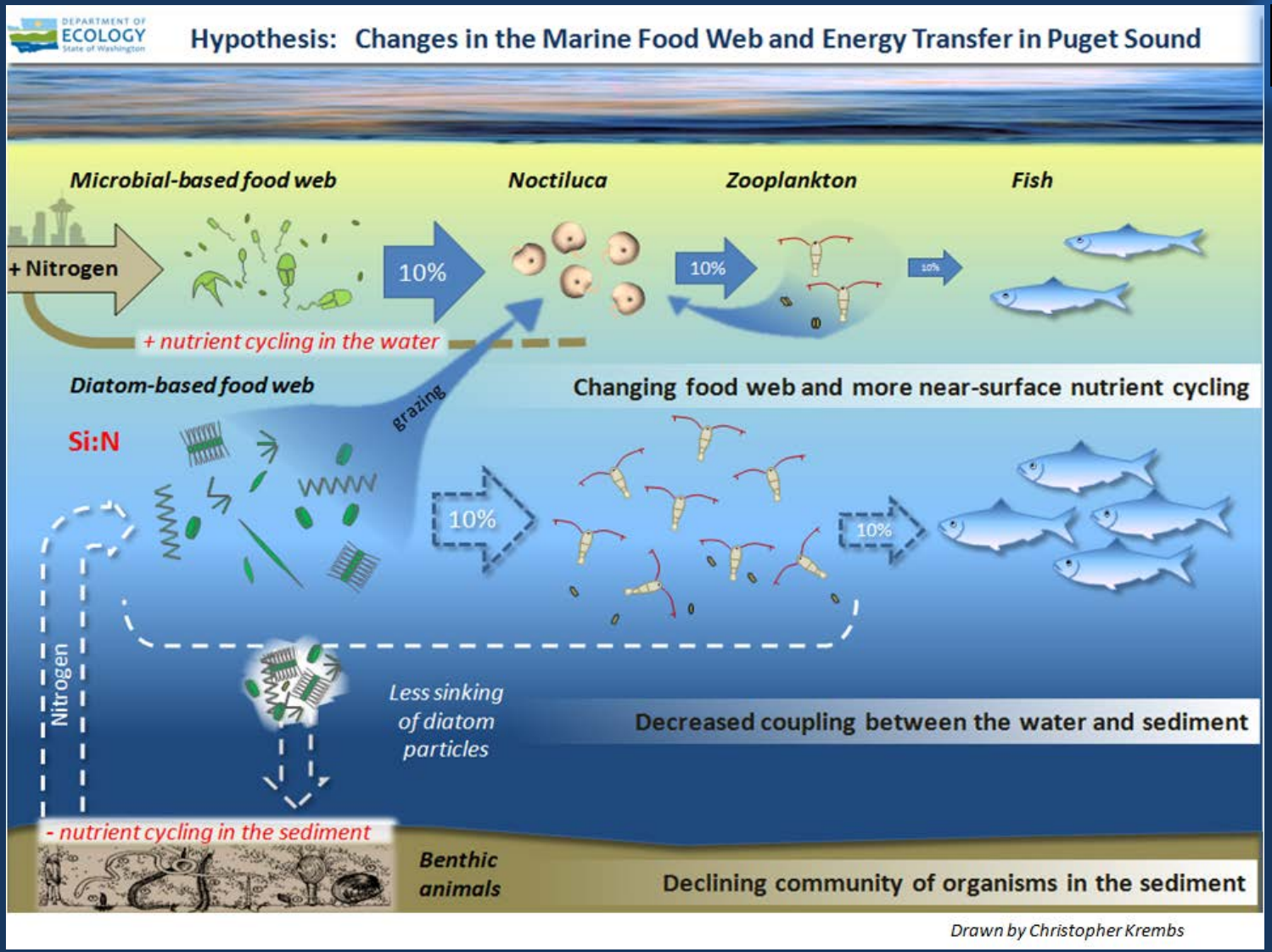
c) *North Pacific Gyre Oscillation Index (**NPGO, productivity**)* (explanation)

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]

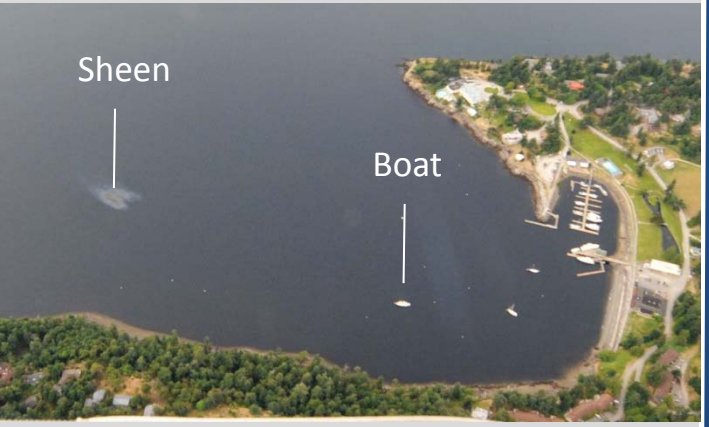
[Follow the experts]

Summary: Aerial photography 6-23-2014

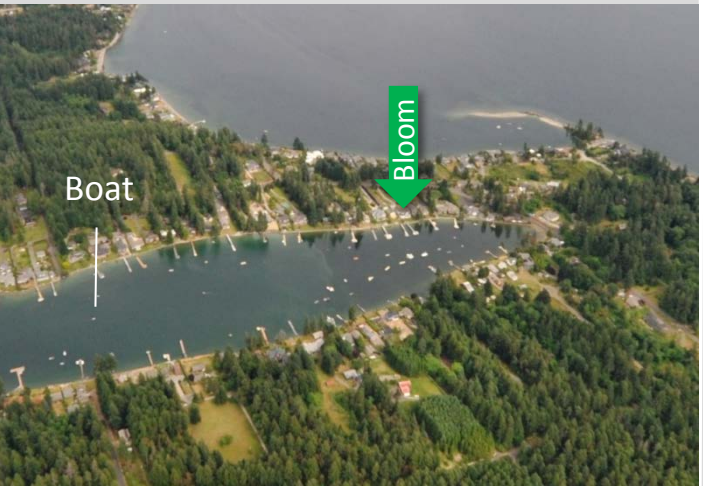
Large organic mats of surface debris in Hood Canal, Padilla Bay and Lay Inlet. Many patches are macro-algae. Strong red-brown bloom in Discovery Bay and East Sound and parts of Georgia Basin. Sediment rich water north of the San Juan Islands. Jelly fish are increasing in numbers.

Start here

Oil sheen in Cascade Bay, East Sound



Localized bloom, Horsehead Bay, Carr Inlet



Front

Mixing and Fronts:
Fronts in the Straits, along Frazer river plume and Rosario Strait. Hood Canal and Central Sound with smaller tidal fronts. 2 3 5 6 7 8 9 10 14 Click on numbers

Jellyfish: Jellyfish patches increasing in Budd, Eld Inlets and Hood Canal. 1

Plume

Suspended sediment:
Large sediment in Frazer River plume. Port Susan decreasing sediment near surface. 7 8 11

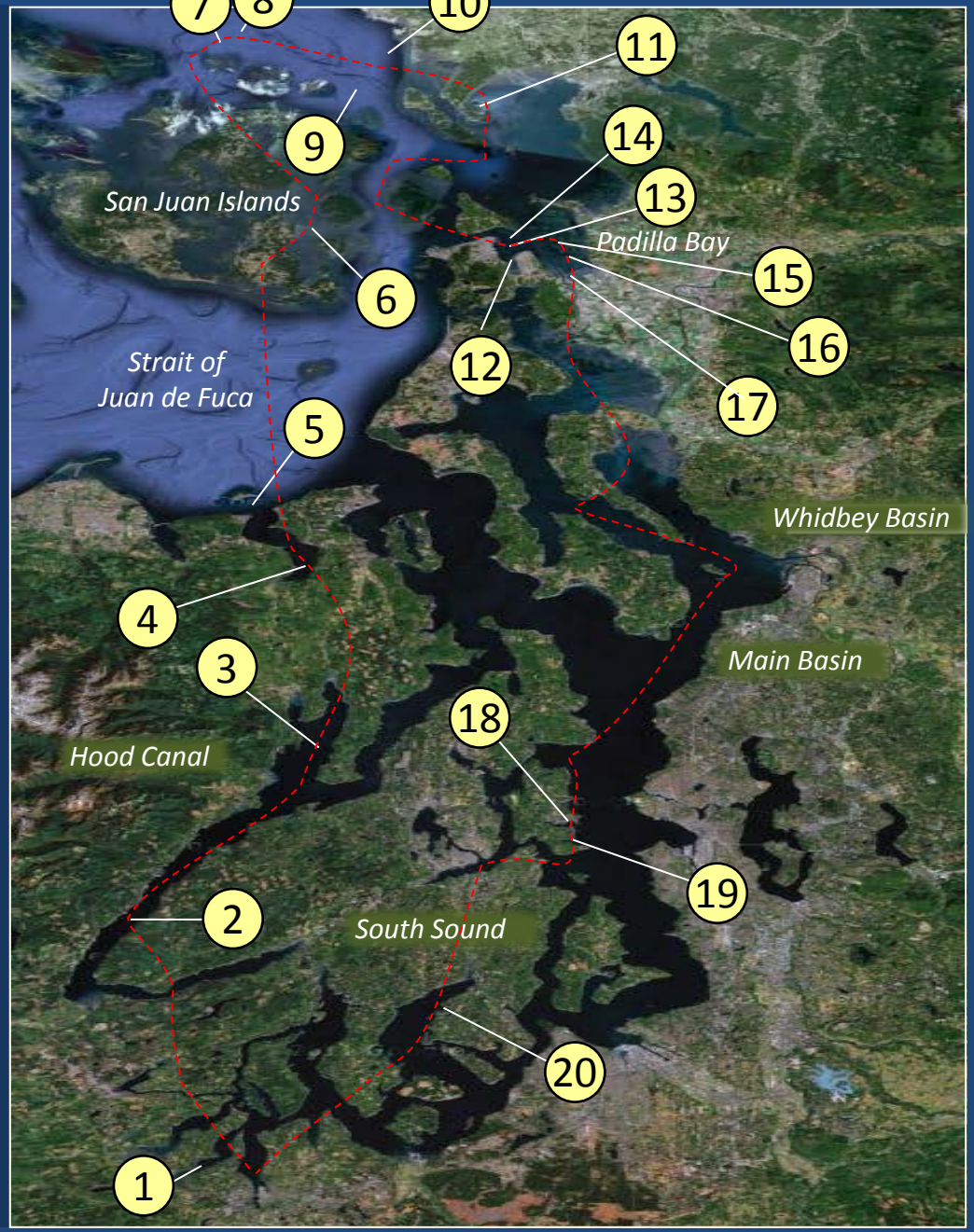
Bloom

Visible blooms: 4 5 6 10 12 13 14 18 19 20
Green-brown: Central Sound near Bainbridge Is., Carr Inlet and Saratoga Passage.
Red-brown: Discovery Bay, East Sound, Utsalady Bay.
Green: Fidalgo Bay.
Green macro-algae: Padilla Bay, Hood Canal, Sinclair Inlet.

Debris

Debris: 1 2 3 4 5 6 7 8 9 10 12 13 14 15 16 18 19 20
Very abundant in Padilla Bay and Hood Canal and Georgia Basin. Smaller surface debris from remnant Noctiluca bloom in bays of Bainbridge Island and around Blake Island.

Seattle Tides: H. tide: 1:52 AM 4:32 PM, , L. tide: 9:05 AM,9:22 PM



Aerial photography and navigation guide

Date: 6-23-2014

Click on numbers

Flight Information:

Morning flight, photos 1-11
Clouds and cloud reflections

Afternoon flight, photos 12-20:
Haze, strong winds and swell

– – – Flight route

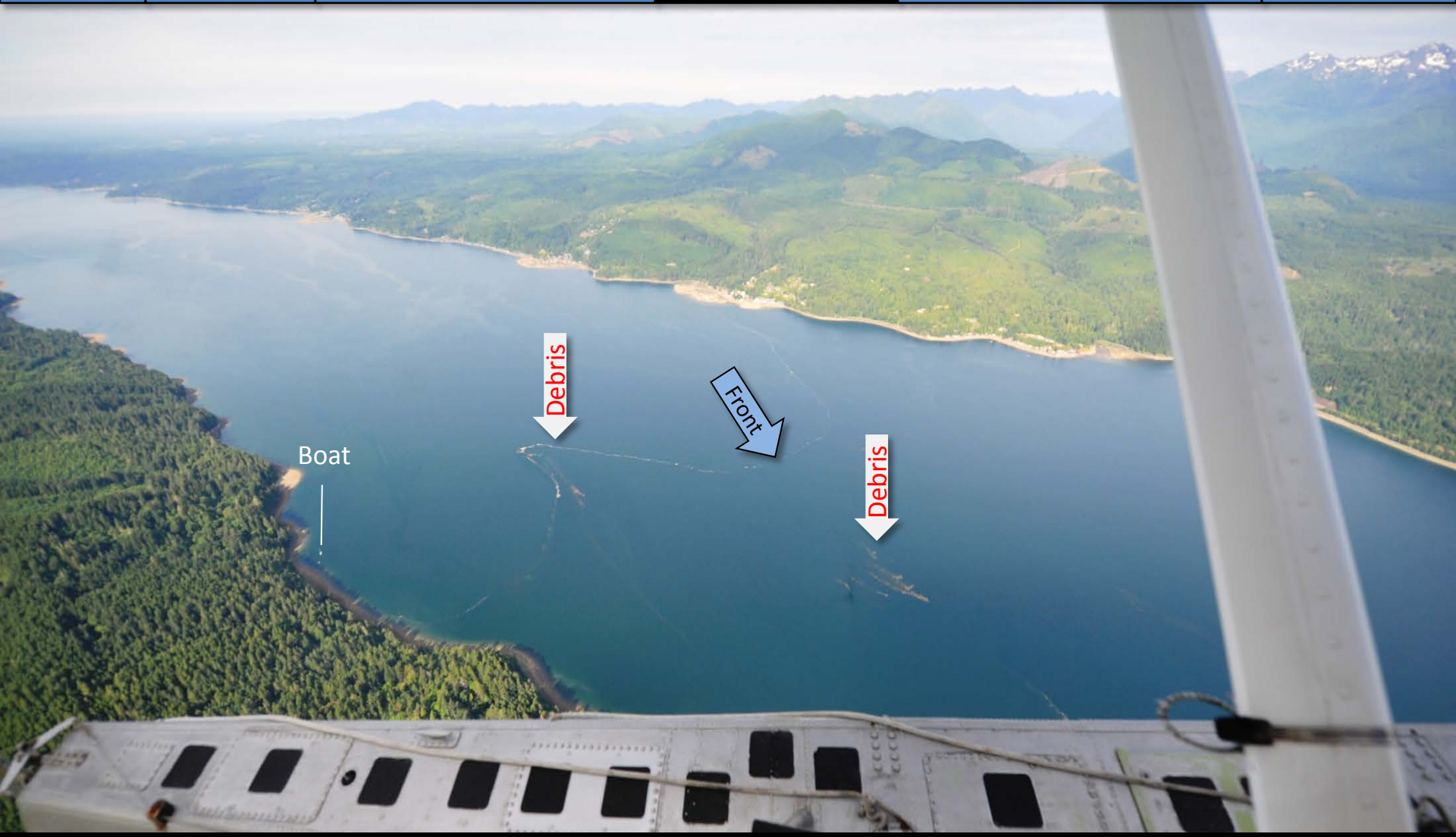
Observation Maps:

Central and North Sound

Hood Canal and South Sound

Large patch of organic surface debris, multiple jellyfish patches, and cloud reflections.

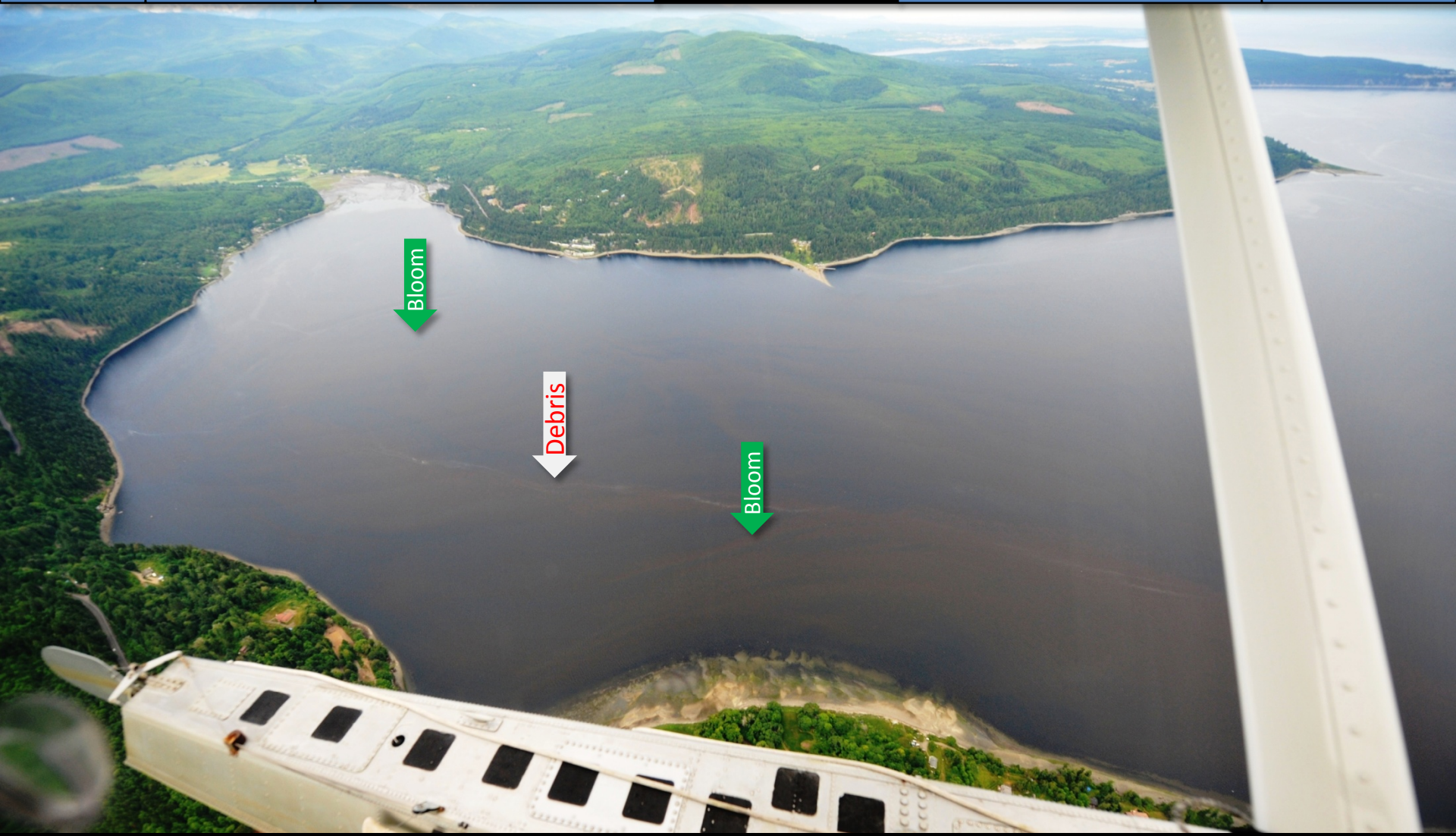
Location: Eld Inlet (South Sound), 9:19 AM.



Multiple debris lines and patches accumulating along front .
Location: *Dewatto Bay,* Hood Canal, 9:31 AM.

Debris lines of organic material accumulating along front.

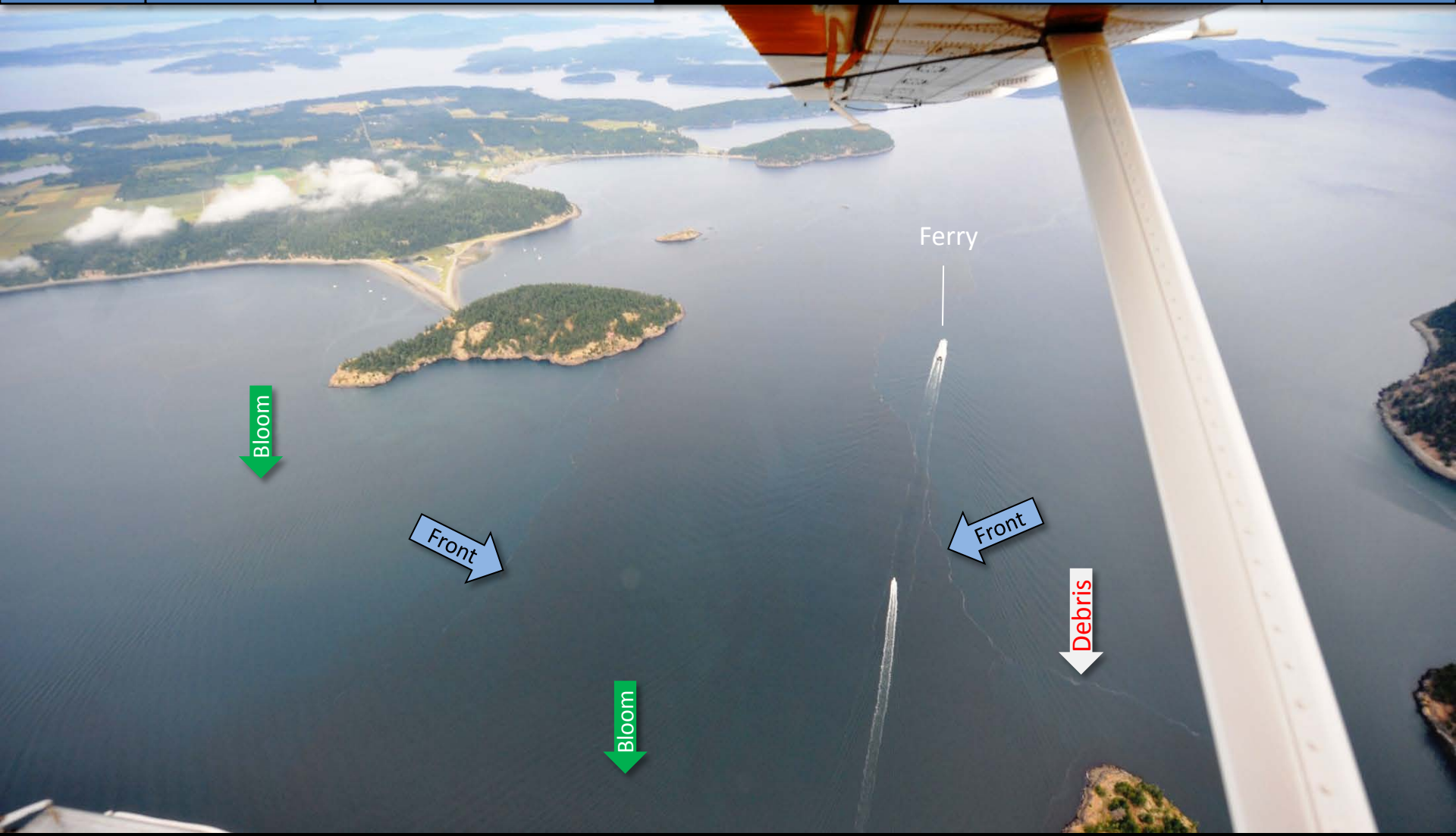
Location: Across Jackson Cove, Dabob Bay (Hood Canal), 9:42 AM.



Red-brown bloom and line of organic debris.
Location: Discovery Bay, (Strait of Juan de Fuca), 9:52 AM.

Red-brown bloom and line of organic debris stretching into water between Protection Island.

Location: Discovery Bay, (Strait of Juan de Fuca), 9:57 AM.



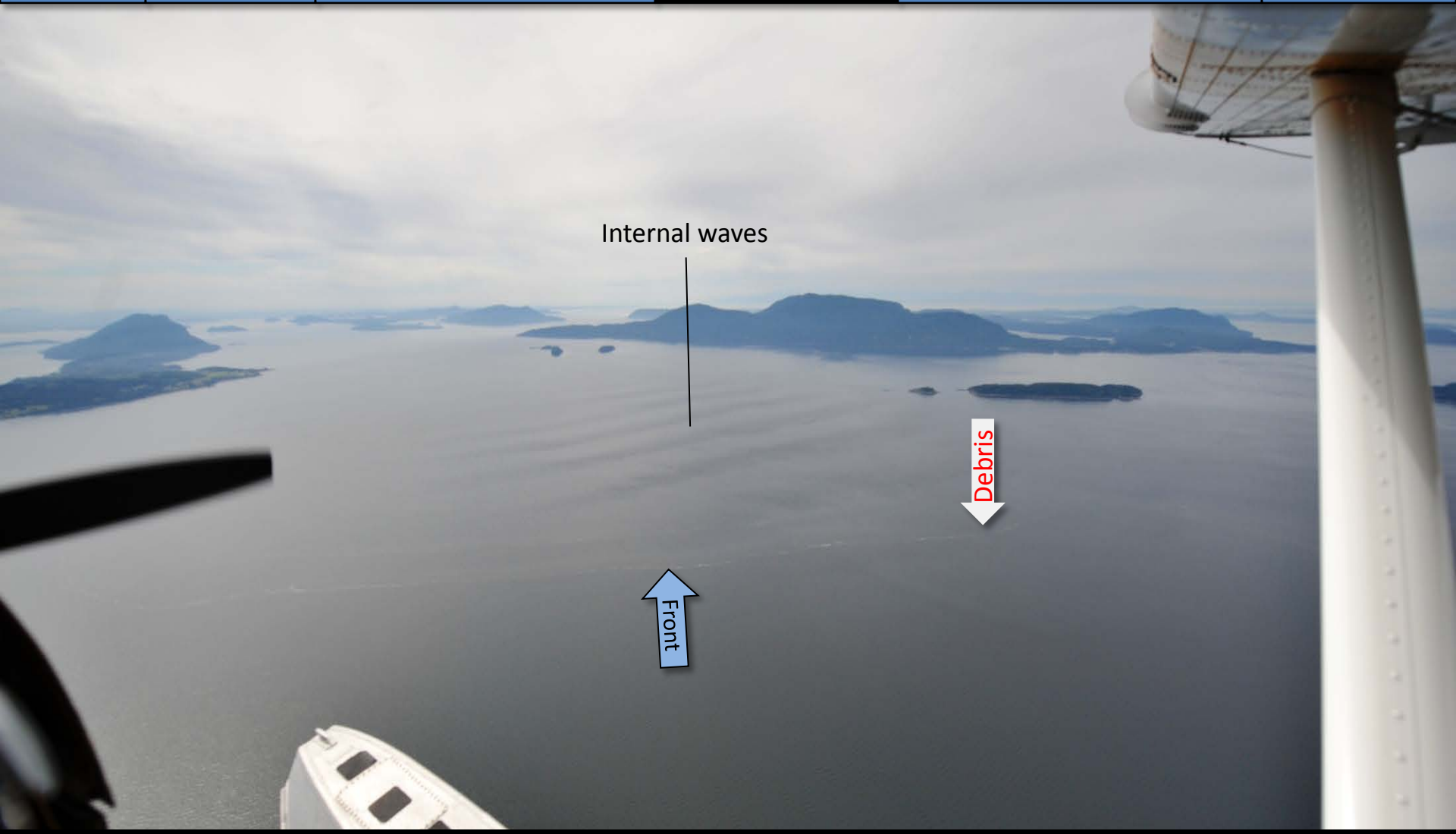
A ribbon of water with a red brown bloom lined with organic debris heading east parallel to Anacortes ferry track. Location: Lopez Sound, (San Juan Islands), 10:14 AM.

Ribbons of sediment-rich water and debris lines from Frazer River melt water.

Location: North of Patos Island (Georgia Basin), 10:26 AM.

Ribbons of sediment-rich water and debris lines from Frazer River melt water flowing southward.

Location: North of Patos Island (Georgia Basin), 10:26 AM.



Bands of large internal waves interacting with the water surface to form patterns.
Location: North of Rosario Strait (Georgia Basin), 11:18 AM.

Aerial photography 6-23-2014

Lines of organic surface debris gathering along fronts.
Location: Near Lummi Bay (Georgia Strait), 11:19 AM.

Aerial photography 6-23-2014

Sediment rich water of the Nooksack flowing into Bay.

Location: Portage Bay (Bellingham Bay), 11:58 AM

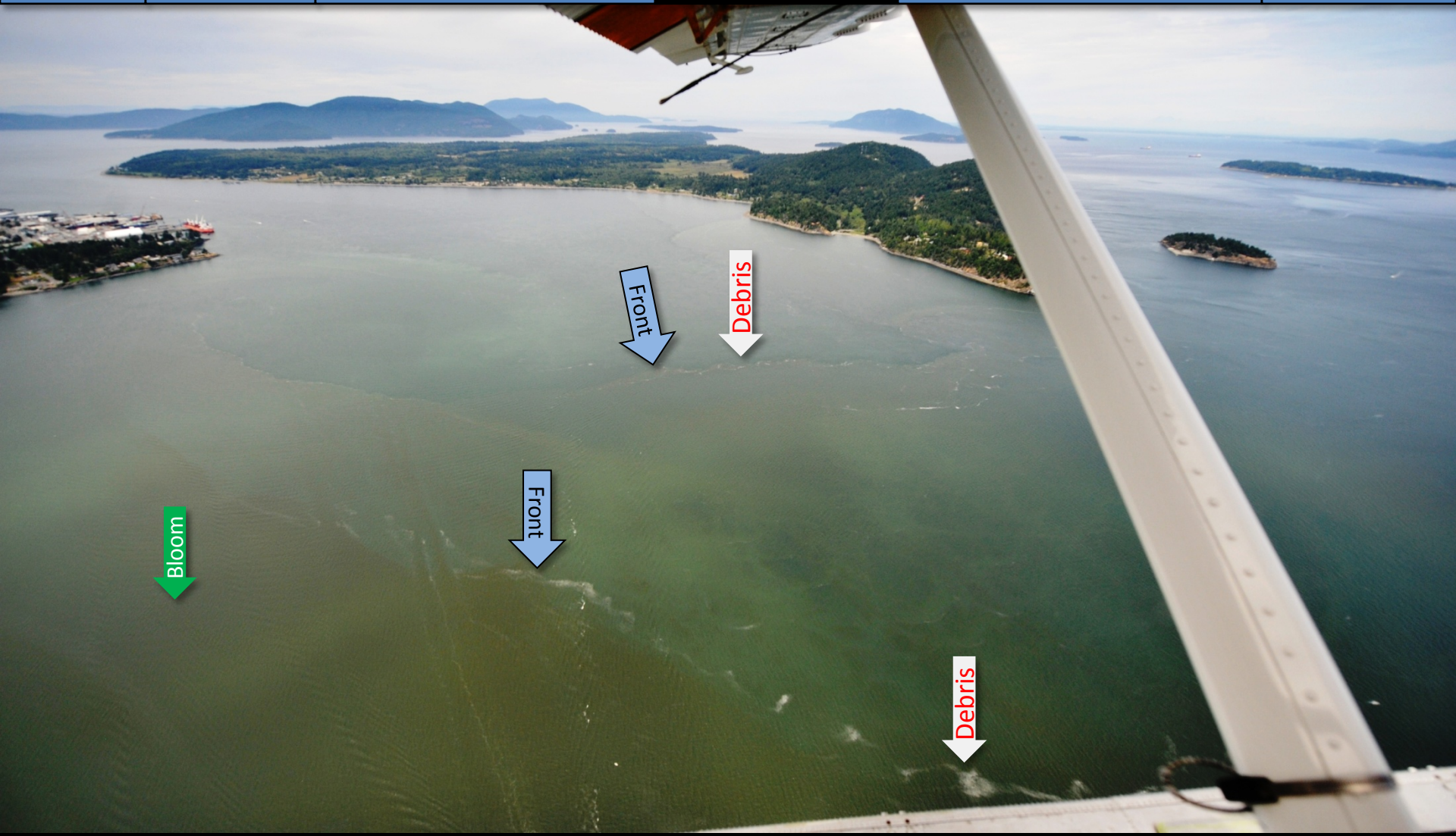
Mats of organic material from macro-algae and intense green phytoplankton bloom stain water .

Location: Fidalgo Bay (North Sound), 12:44 PM

Aerial photography 6-23-2014

Long lines of organic surface debris and water of different color leaving Padilla Bay via Guemes Channnel .
Location: Anacortes (North Sound), 12:45 PM.

Aerial photography 6-23-2014



Long lines of organic surface debris and water of different color leaving Padilla Bay via Guemes Channnel .

Location: Anacortes (North Sound), 12:45 PM.

Aerial photography 6-23-2014

Large mats of floating organic surface debris above seagrass beds.

Location: Padilla Bay (North Sound), 12:47 PM.

Large mats of decaying organic surface debris above seagrass beds.
Location: Padilla Bay (North Sound), 12:47 PM.

Thick mats of macro-algae competing with seagrass for space near Indian Slough estuary.

Location: Padilla Bay (North Sound), 12:48 PM.

Debris line and phytoplankton bloom

Location: Eagle Harbor (Central Sound), 4:01 PM.

Red-brown phytoplankton bloom entering bay from the north.
Location: Blakely Harbor (Central Sound), 4:01 PM.

Large mats of organic surface debris from macroalgae and bloom.

Location: Lay Inlet (Carr Inlet), 4:14 PM.

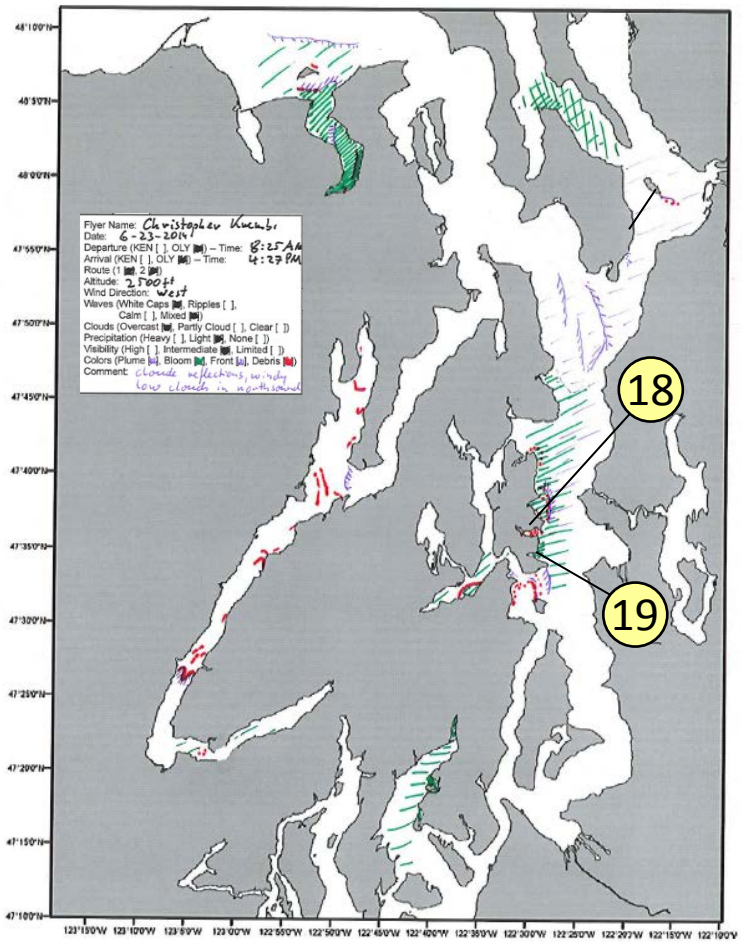
DEPARTMENT OF ECOLOGY State of Washington

Observations in Central and North Sound

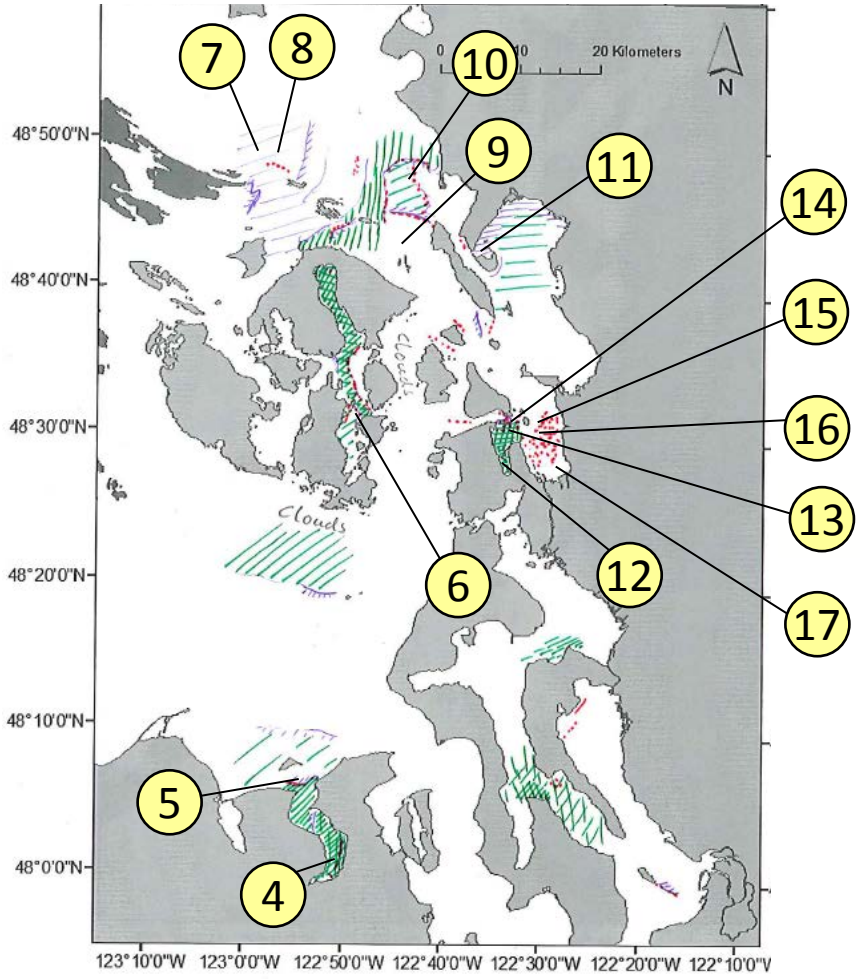
Navigate

Date: 6-23-2014

Central Sound



North Sound/San Juans



Numbers on map refer to picture numbers for spatial reference

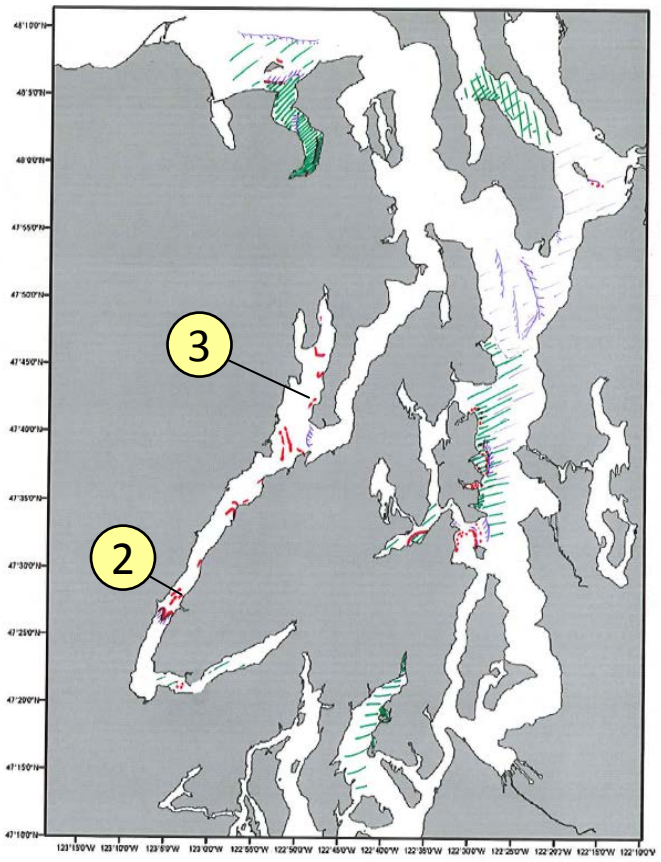
DEPARTMENT OF ECOLOGY State of Washington

Observations in Hood Canal and South Sound

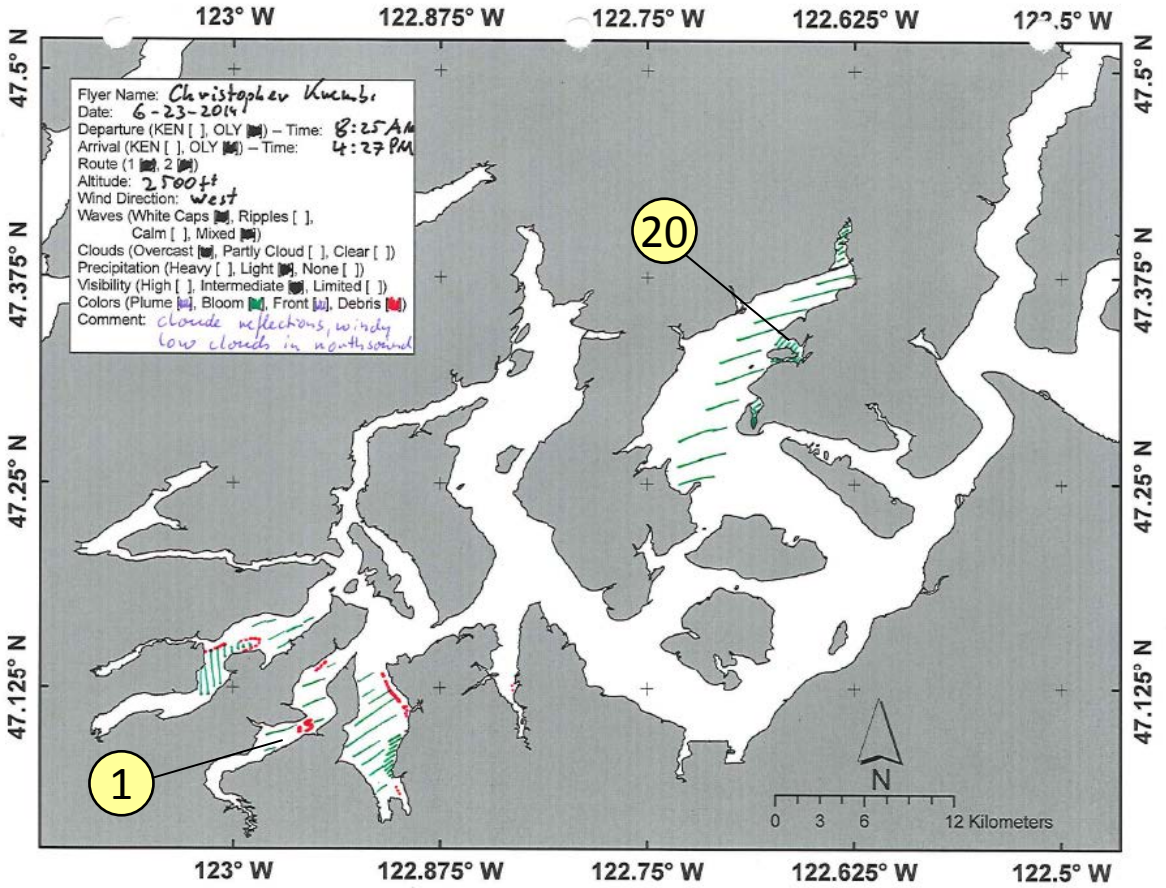
Navigate

Date: 6-23-2014

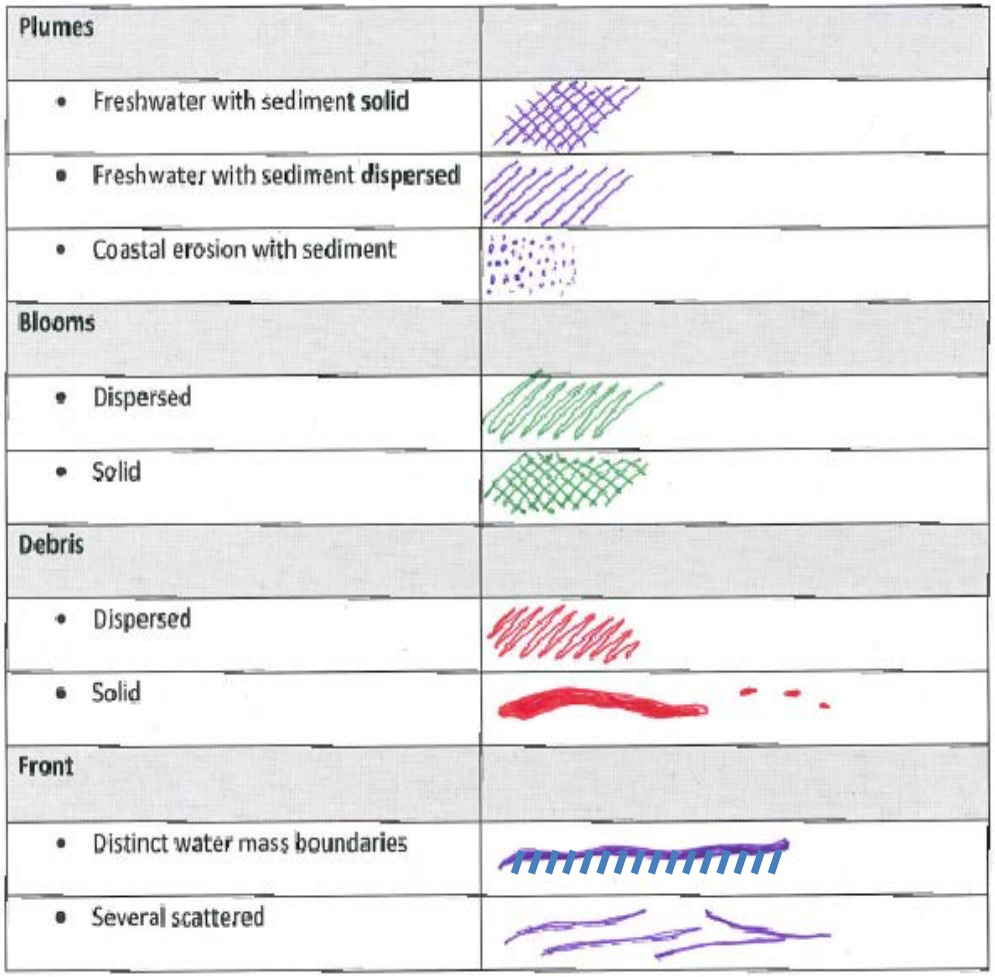
Hood Canal



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.

Technology Hitches a Ride on the State Ferry!

WASHINGTON STATE FERRY MONITORING

A cost-effective collaboration: In 2013, Ecology partnered with the Applied Physics Laboratory at the University of Washington (APL-UW) to install instruments on Washington State Ferries (WSF) to provide surface-to-bottom measurements of current velocities across Admiralty Reach multiple times a day. These data will help us to understand and manage water quality (such as low dissolved oxygen, algal blooms, and ocean acidification) by quantifying oceanic intrusions into Puget Sound. APL-UW project web page

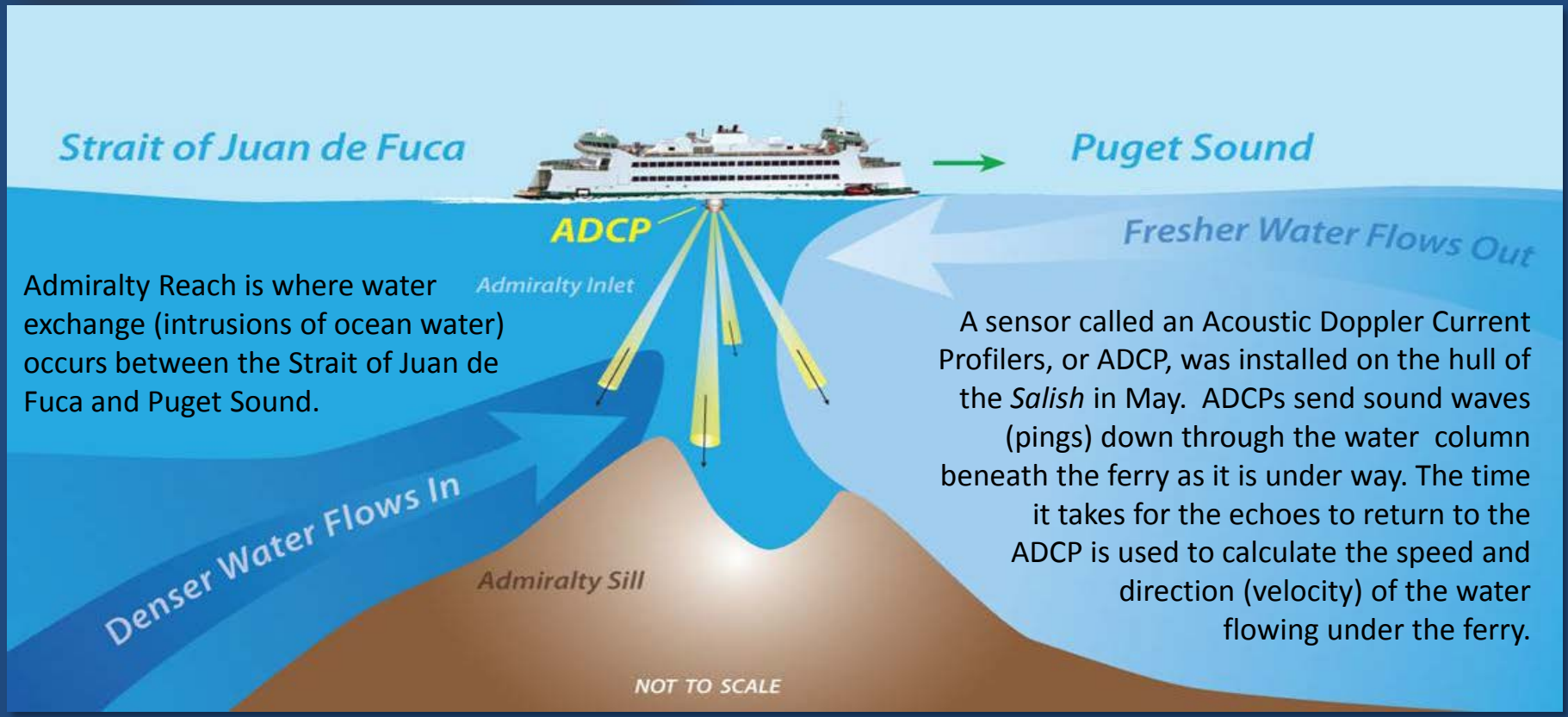
On board: Cotty Fay, WSF, Jim Thomson, APL UW (holding an ADCP), and Carol Maloy, Ecology.

Watch *on TV*

Technology Hitches a Ride on the State Ferry!

Working across agencies and institutions:
People on the ferry monitoring team from Ecology, WSF, Applied Physics Lab UW, Integral Consulting, and the Puget Sound Partnership.

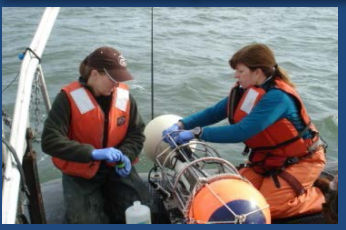
Read more on Ecology's Blog



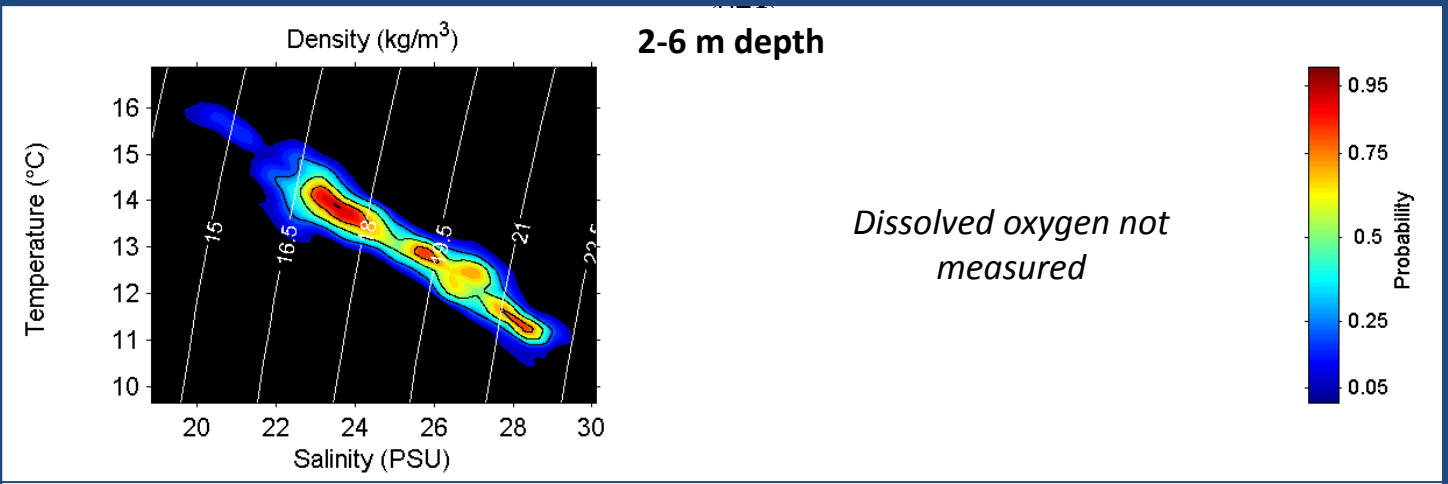
Admiralty Reach is where water exchange (intrusions of ocean water) occurs between the Strait of Juan de Fuca and Puget Sound.

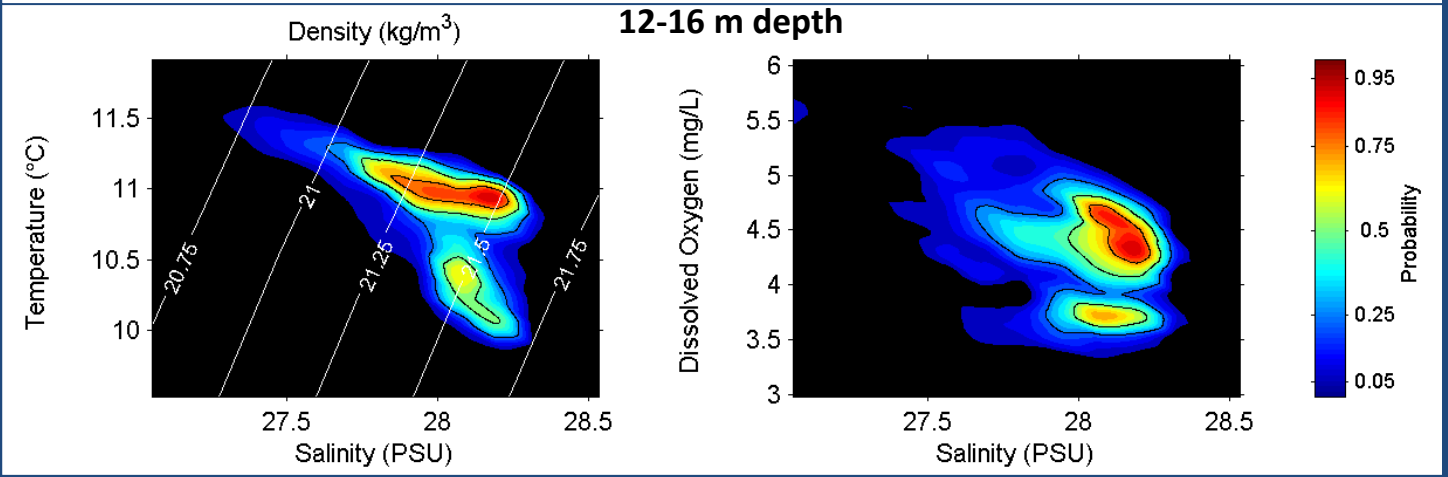
A sensor called an Acoustic Doppler Current Profilers, or ADCP, was installed on the hull of the *Salish* in May. ADCPs send sound waves (pings) down through the water column beneath the ferry as it is under way. The time it takes for the echoes to return to the ADCP is used to calculate the speed and direction (velocity) of the water flowing under the ferry.

Mooring observations and trends 6-10-2014 to 6-23-2014



At our Mukilteo moorings, we observed multiple water masses based on temperature, salinity, and dissolved oxygen. The near-surface sensor (2-6 m) most often measured salinity at 22-28 psu. The near-bottom sensor (12-16 m) measured two water masses, mainly around 28 psu at 11 °C. Dissolved oxygen was mostly between 4 and 5 mg/l.





Left Panels: Density is defined by salinity and temperature. 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.

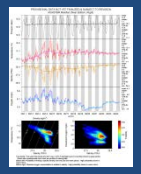
Mooring observations and trends 5-24-2014 to 6-23-2014

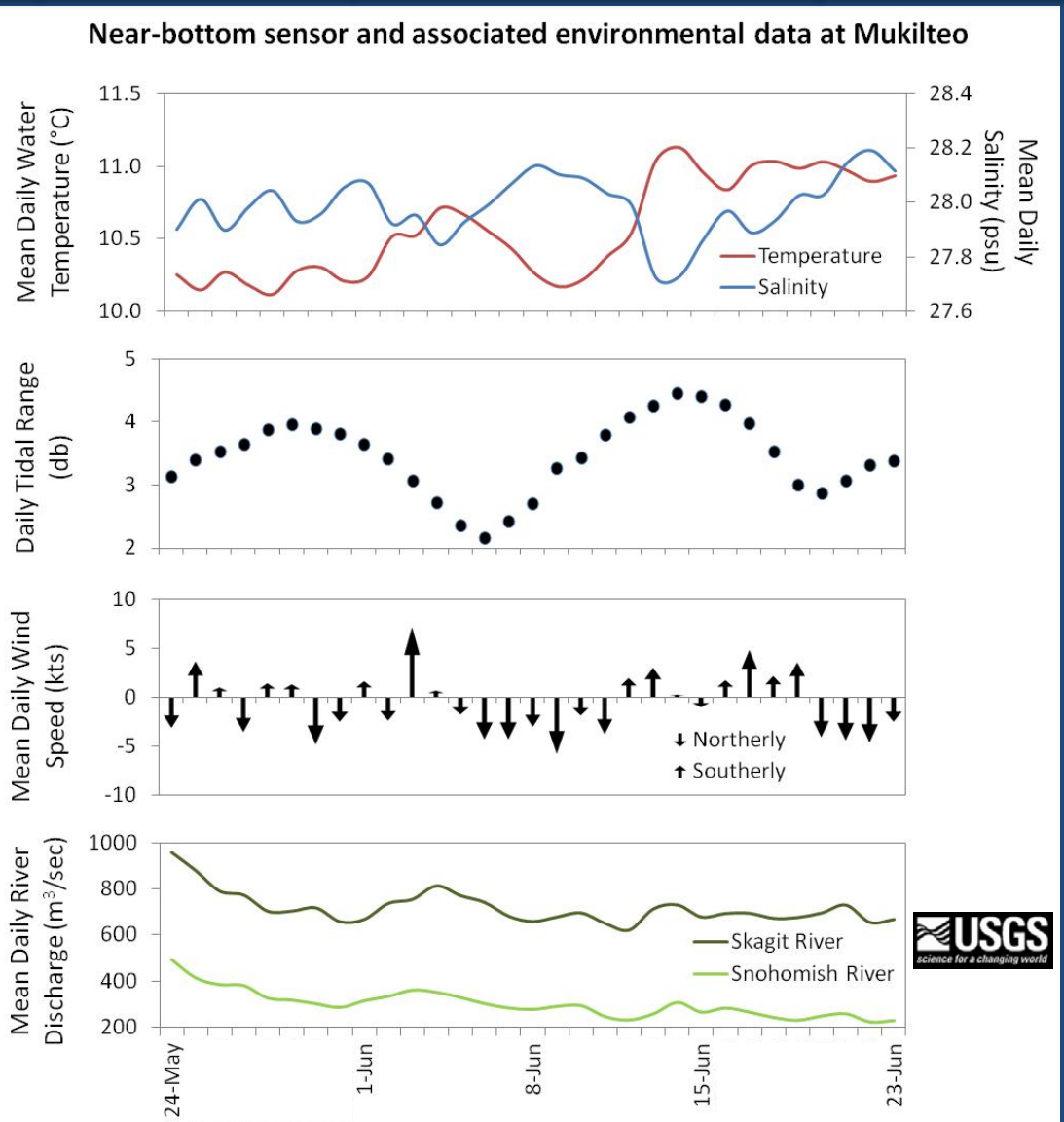
Our mooring station in Mukilteo is located in Whidbey Basin and near Everett. We present data of daily means for the past 31 days.

Daily means of temperature and salinity fluctuated in late May and mid-June and this trend seems to correspond with shifting winds. In the middle of the 31-day period, increasing tidal range and decreasing river flows seem to have slightly influenced increasing salinity and decreasing temperature.

Data are plotted in Pacific Standard Time. Wind data are from Paine Field in Everett. River flow data are from USGS.

Click on icon to view real-time data of the moorings





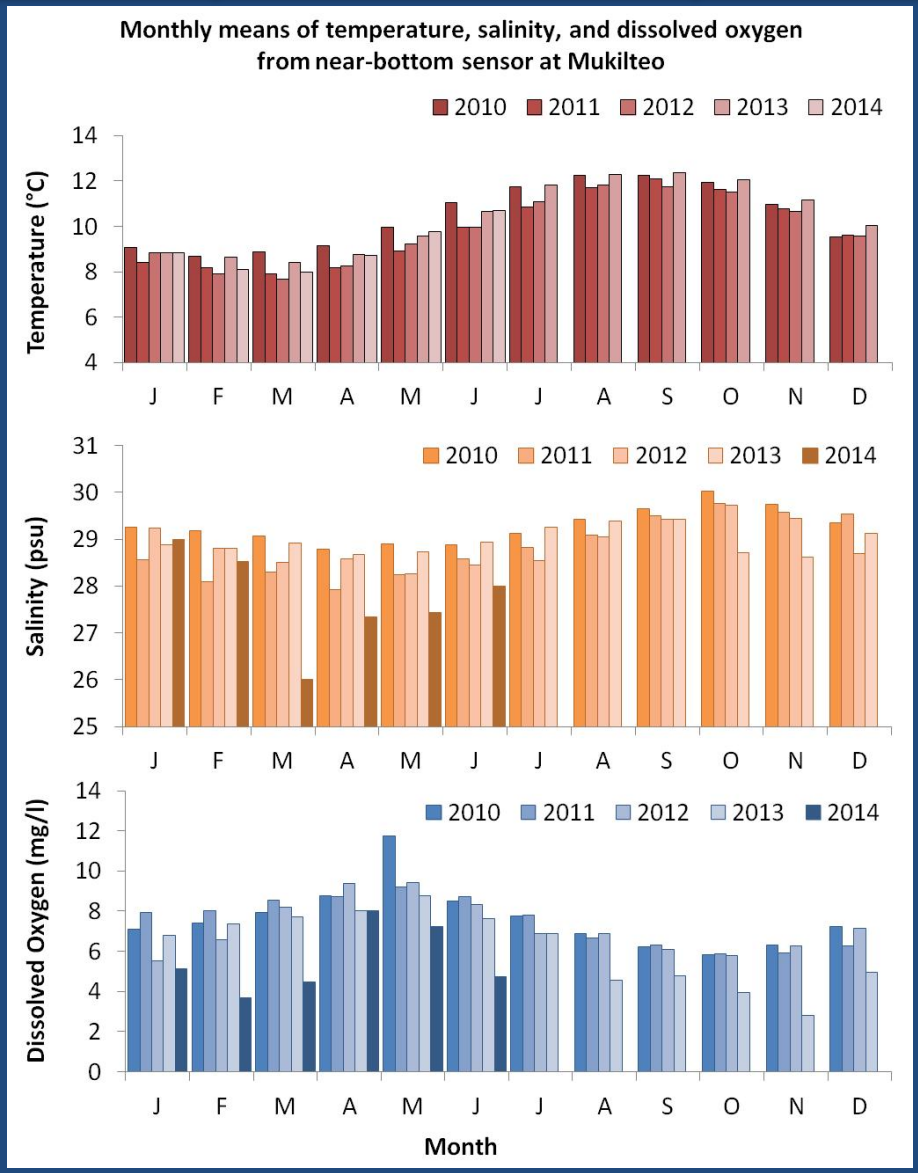
Mooring observations and trends Mukilteo 2010 to 2014

At the Mukilteo mooring, we use the near-bottom sensor (12- 16 m deep) to measure significant inter-annual variability in temperature, salinity and dissolved oxygen.

Inter-annual variability is shown over a 4.5-year period. All three variables show strong seasonality.

For 2014, trends in salinity and dissolved oxygen appear to decline whereas trends in temperature are similar to 2013. Sensor issues and biofouling have a potential effect on the lower salinity and dissolved oxygen measurements earlier this year.

Please note that data are provisional. Data are in GMT.



Get data from Ecology's Monitoring Programs

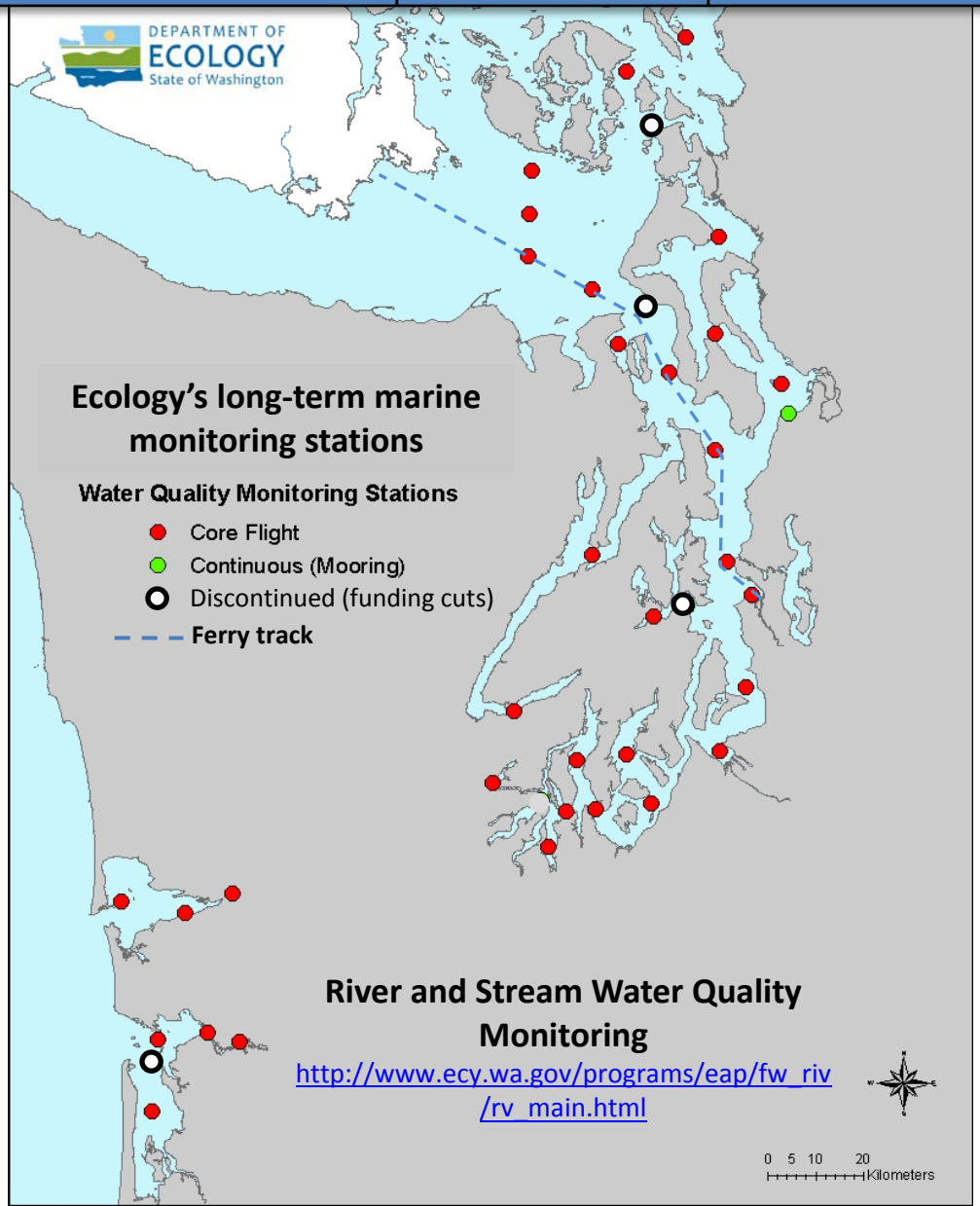
Field log	Weather	Water column	Aerial photos	Ferry and Satellite	Moorings

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

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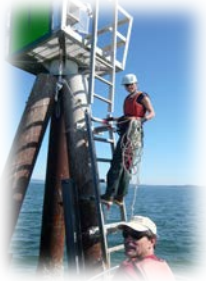

Access mooring data:

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.

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Marine Monitoring Unit
Environmental Assessment Program
WA Department of Ecology

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