Eyes Over Puget Sound:

Eyes Over Puget Sound: Strategies to increase the impact and effectiveness of long-term marine monitoring programs.

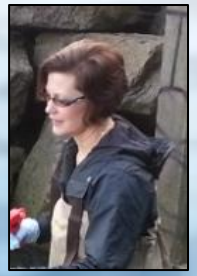
DEPARTMENT OF ECOLOGY State of Washington

PSEMP

Carol Maloy

Christopher Krembs

Julianne Ruffner



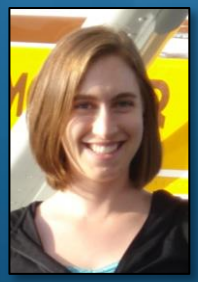
Julia Bos

Mya Keyzers

Suzan Pool

Skip Albertson

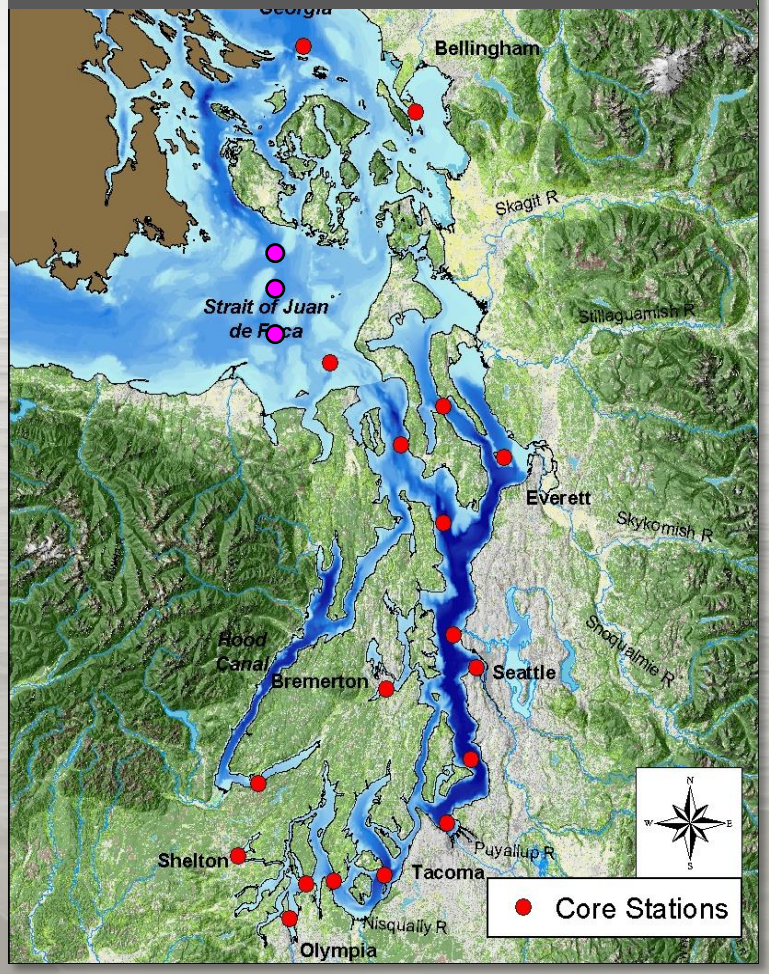
Laura Friedenberg



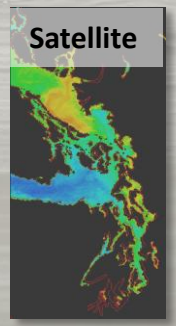
Brooke McIntyre

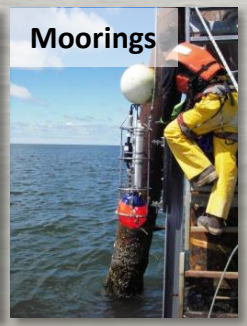
Measuring long-term trends in eutrophication, dissolved oxygen and physical variables

Greater Puget Sound region



Water Quality variables measured monthly at 27 stations





Physical variables
- Temperature
- Salinity
- Density

Chemical variables
- Oxygen
- Nitrate
- Silicate
- Phosphate
- Ammonium
- Nutrient ratios
- pH

Bio-optical variables
- Water clarity
- Chlorophyll a
- Euphotic depth

Monthly Baselines 1999-2008

Strength of long-term monitoring programs

1. **Different perspective on processes operating on larger temporal and spatial scales**
2. **Opportunity for understanding variability and influencing factors over different scales**
3. **Objectivity through data**
4. **Warning systems for environmental change**
5. **Temporal and spatial context supporting focused studies**
6. **Logistical infrastructure and expertise**

Despite its undisputed value as a quantitative instrument, maintaining and committing to long-term monitoring programs is challenging:

1. **Resource competition with short-term studies**
2. **Inconsistency in funding and staff**
3. **Changes in methods as technology evolves**
4. **Lack of standardized procedures and consistent data quality**
5. **Wide range of temporal and spatial scales**
6. **Trade-offs between representative measurements and local impacts**

Dilemma of long-term monitoring programs providing exclusively data

- **Data collection, management, QC, and instrument maintenance often dominate the activities to the detriment of data workup and presentation.**

- **Providing only data limits the program to shine to a hand full of data users. → Few people that can advocate for the value of the program.**

The combination of data and stories let a program shine!

How do you create that without additional resources?

Strategies to increase the impact and effectiveness of long-term marine monitoring programs (story material)

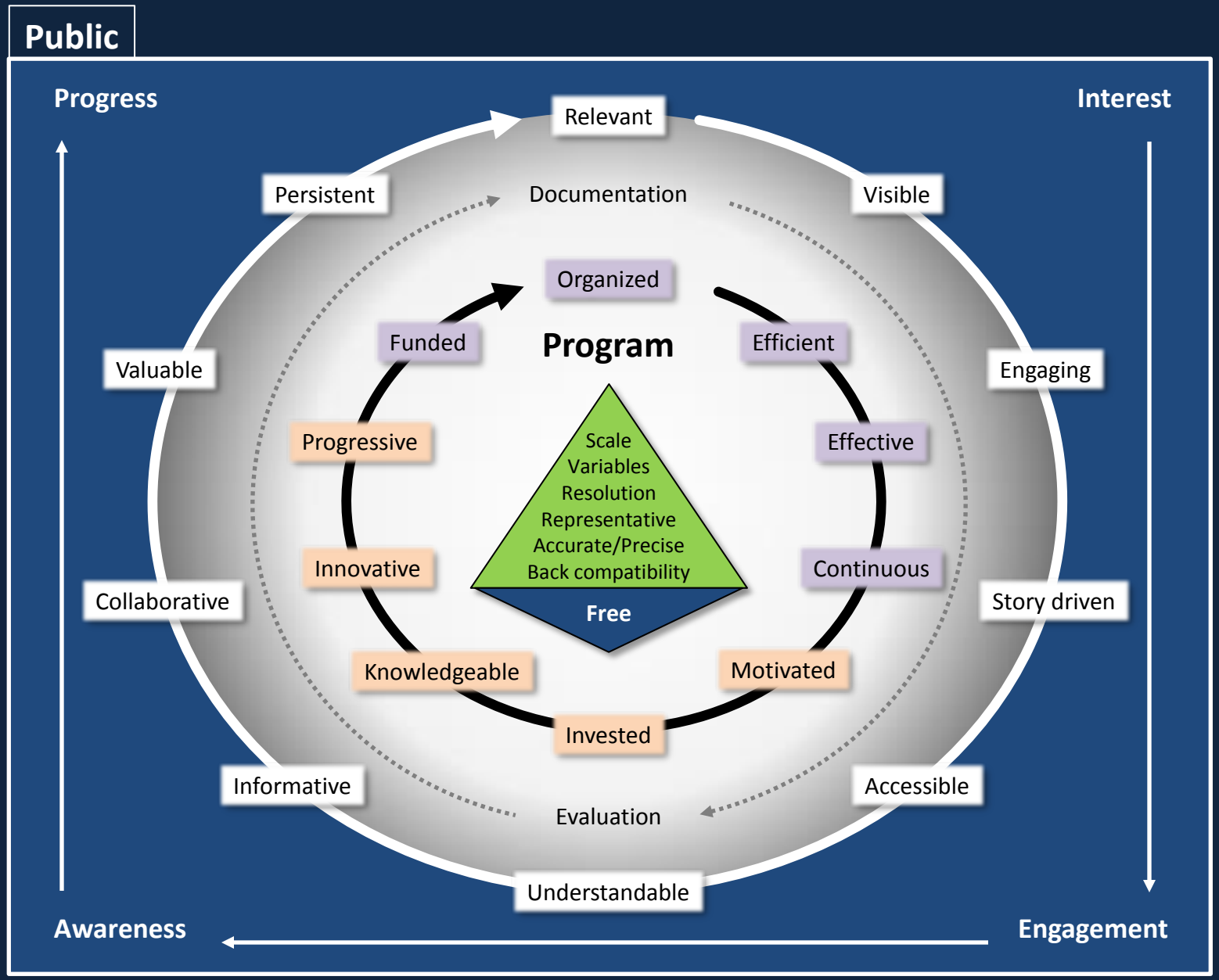
We humans like to think on human scales (time and space)

Image rich to engage more people

Headline driven information bits

- **The ocean and air remain warm with sunshine and dry weather across the region.**
- **Puget Sound is a lot warmer going into the new year.**
- **Hood Canal is, breaking its low temperature stint.**
- **Patches of jellyfish are overwintering in finger inlets of South Sound.**

Deliver on a time scale that humans like to think in (within a few days)


Public
Progress
Interest
Relevant
Persistent
Documentation
Visible
Organized
Funded
Program
Efficient
Valuable
Engaging
Progressive
Scale
Variables
Resolution
Representative
Accurate/Precise
Back compatibility
Effective
Innovative
Continuous
Collaborative
Story driven
Free
Knowledgeable
Motivated
Invested
Informative
Accessible
Evaluation
Understandable
Awareness
Engagement

What is EOPS?

Just collecting data and writing reports is not enough…

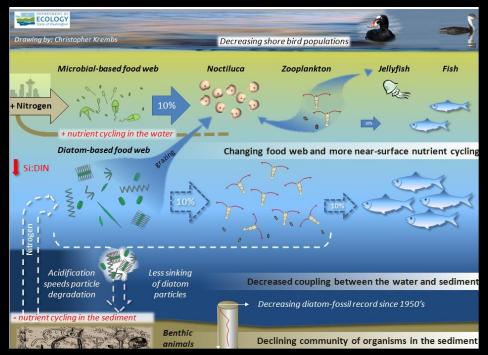
Publication No. 14-03-080

DEPARTMENT OF ECOLOGY State of Washington

Eyes Over Puget Sound

Flight log | People | Water column | Aerial photos | Hypothesis | Start here

2014 Review



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

EOPS

Multiple perspectives…

Be informed within 2 days

1. Everybody is informed about their backyard marine environment.
2. Free educational material.
3. Access for more information + data.

EOPS offers multiple perspectives

- Different levels of detail (overview -> detail)
- Present observations in historical context (temporal context)
- Observations from different vantage points (spatial context)
- Beauty and challenges of Puget Sound

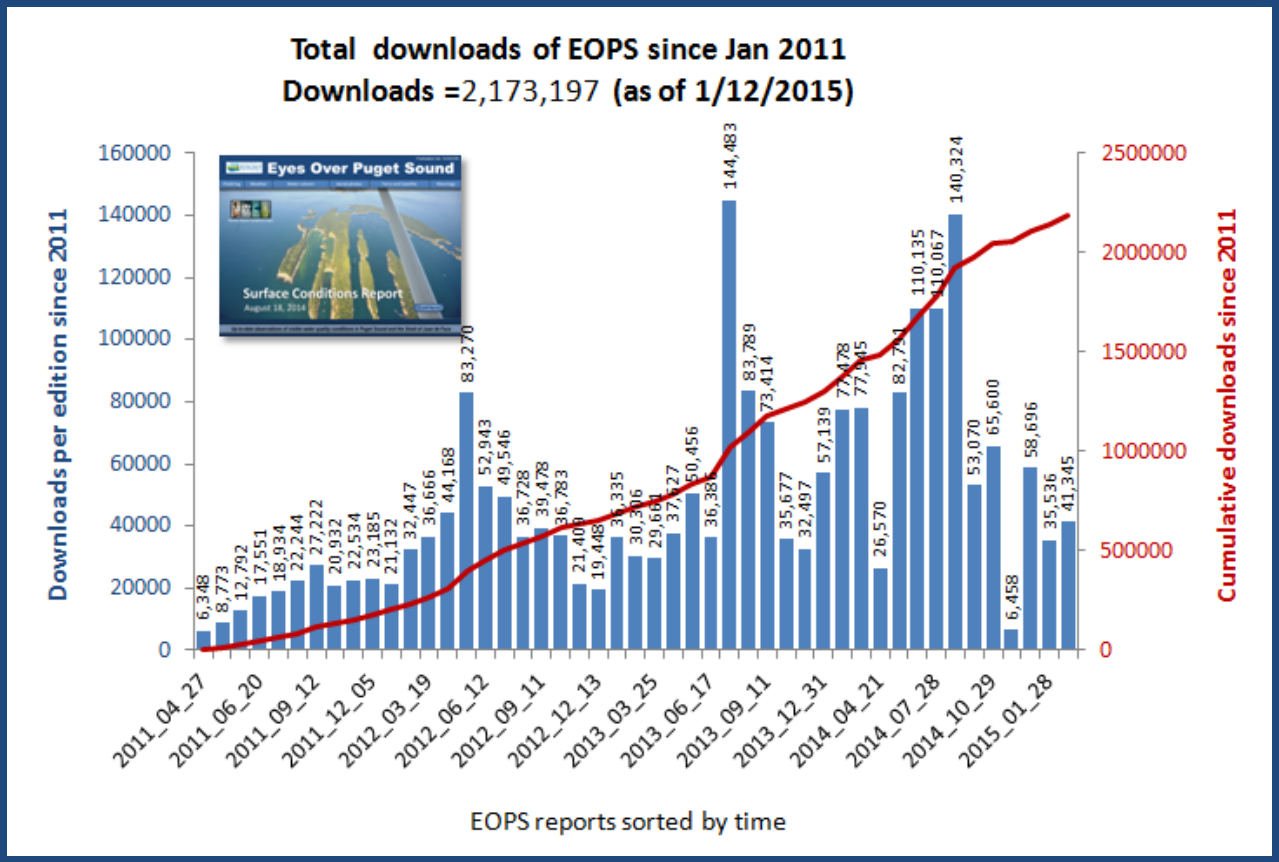
EOPS high public resonance

Steady interest

> 600 Listserve subscribers

General interest

Over 2 million downloads!



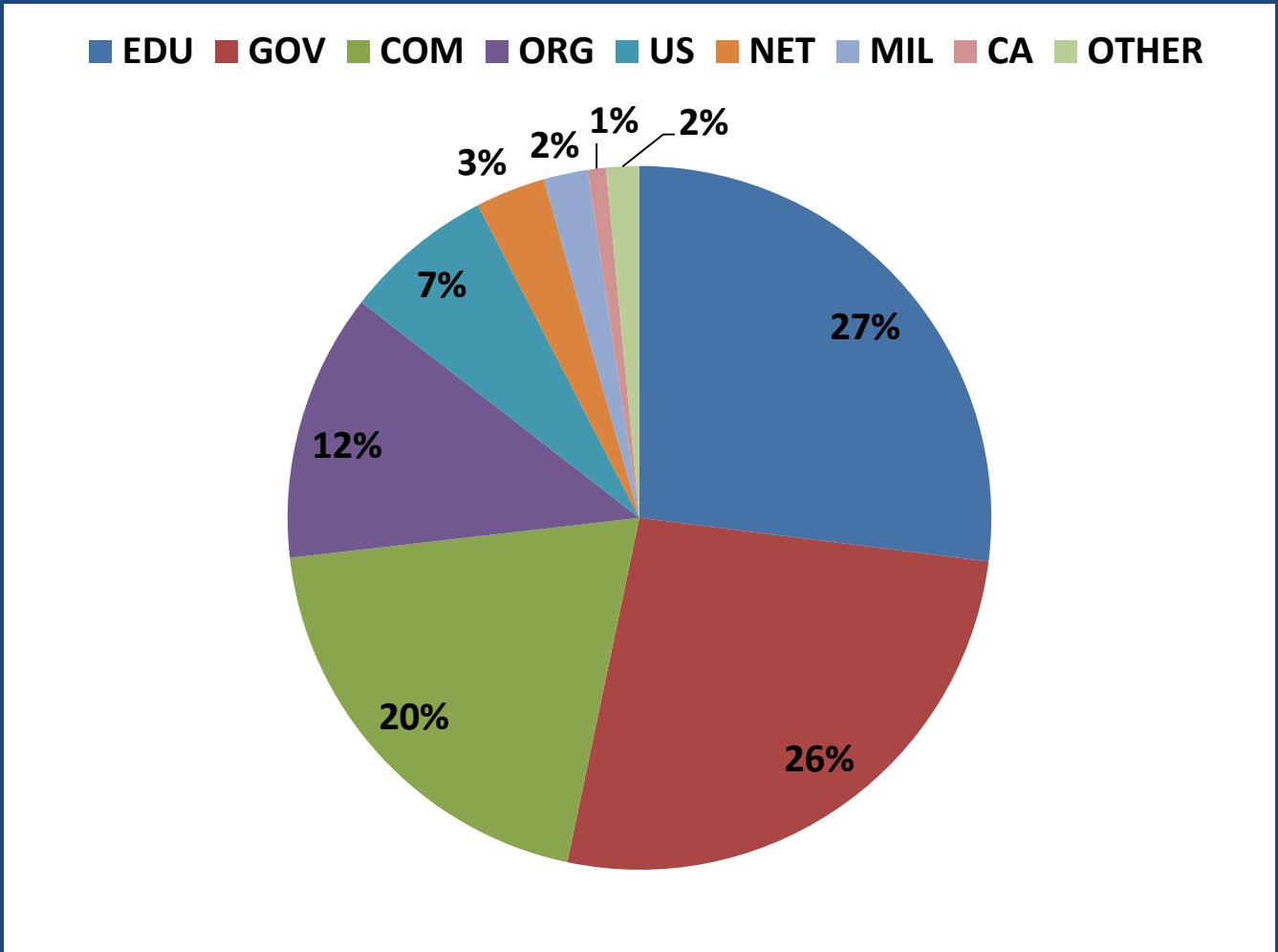
Who are the potential users?

Listserver
600 subscribers

Avg 46,000 downloads per edition

Public readers not accounted for

EOPS spreads via social media



What does EOPS provide?

TEMPORAL PERSPECTIVE:

A combined presentation of present field conditions and 14 years of historical data.

SPATIAL PERSPECTIVE:

A spatial and temporal coverage that matches the scale of local, climatic and oceanic processes that permeate the monitoring network.

BEING INFORMED ABOUT THE PRESENT CONDITION, (useful for decision making)

Only information, image-rich-story-driven, published two days after visiting the field.

MORE INVESTED AND EMPOWERED PUBLIC:

EOPS creates impact on a very tangible, human scale. Staff gain visibility and positive feedback and are also more invested.

IMPROVED WORKFLOW AND BETTER DATA

Public visibility motivates!

Monthly reporting with a 2-day turnaround streamlines operations.

How do you do that without additional resources?

The benefits of combining QC routines with environmental condition updates

- **QC in temporal, spatial context results in better data quality**

- **QC on present/recent conditions:**
  - **reduce error propagation**
  - **prevent backlogs**
  - **establish sense of control and relevance**
  - **fosters positive feedback**

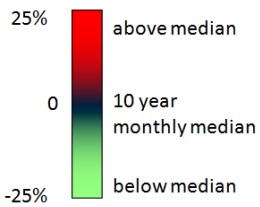
- **Reporting relative to a baselines facilitates stories telling, better QC and easier communication across programs.**

A focus on anomalies combines temporal scales and <u>leverages</u> the strength of long-term monitoring programs

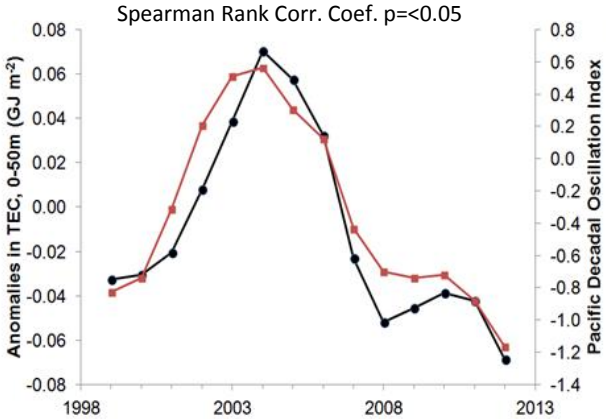
Ocean boundary conditions impact PS water quality

A-B **Sea Surface Temperature -** Pacific Decadal Oscillations Index

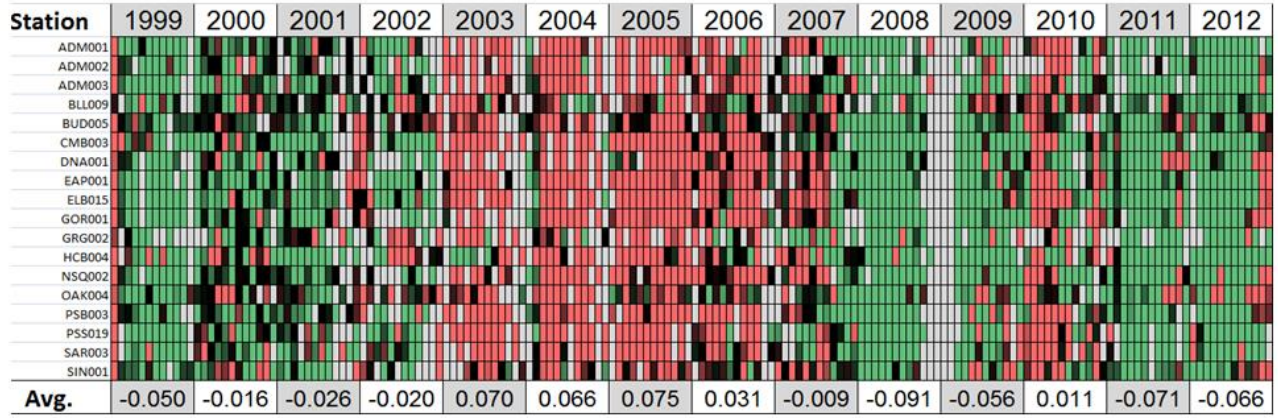
C-D **Upwelling -** Upwelling Index (anomalies)



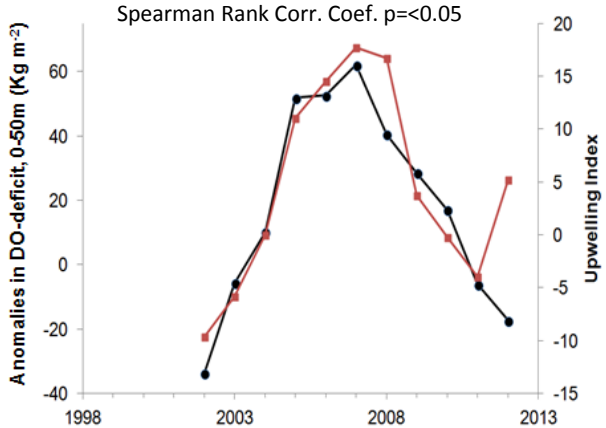
A. Pacific Decadal Oscillation Index



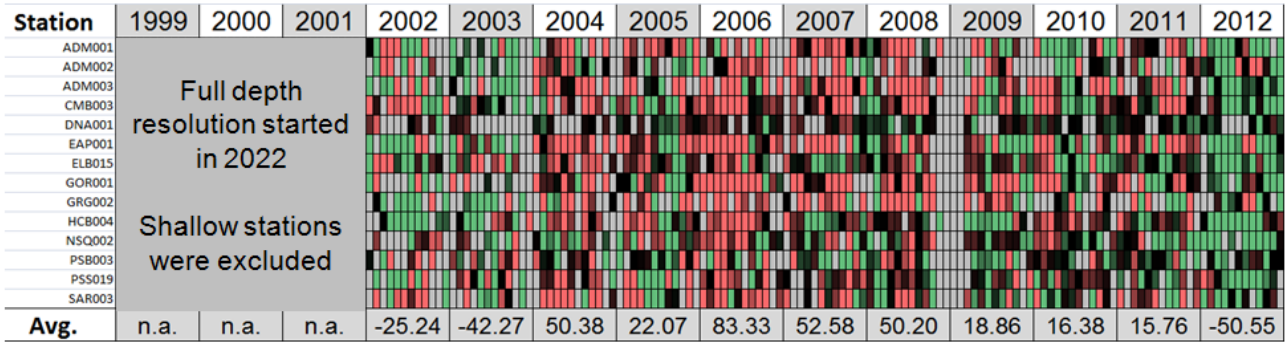
B. *Anomalies in Thermal Energy Content, 0-50m*



C. Upwelling Index (NOAA)



D. *Anomalies in Dissolved Oxygen Deficit, 0-50m*



How do we do it?

Leveraging our flight time

- Empty transit flights Seattle - Olympia with camera on board
- Document blooms, debris, animal aggregations, oil sheens, water boundaries
- Unique perspective, minimal extra cost

Over time we can establish maps of surface features

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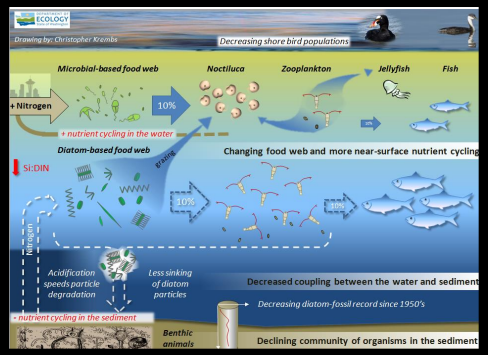

Up-to-date observations of visible water quality conditions in Puget Sound and the Strait of Juan de Fuca

Marine conditions from 2-17-2015 at a glance

LONG-TERM MARINE MONITORING UNIT

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Laura Hermanson
Joe Leatherman

Skip Albertson

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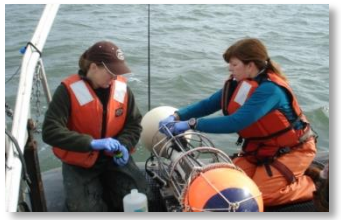
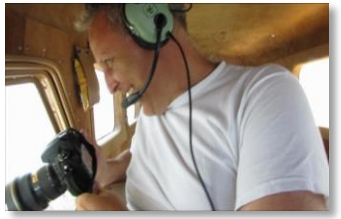


Dr. Christopher Krembs



Guest:
Dr. Brandon Sackmann, Integral

Please give us feedback

Personal field log p. 4
Why do I love Puget Sound?

Climate conditions p. 6
The air temperatures and ocean conditions remain warm. Rivers are above normal except at the coast (Chehalis). The past week has generally been sunny and dry across the region.

Water column p. 7
Puget Sound is a lot warmer at the end of 2014 with new maximum temperatures observed throughout the Sound! The higher dissolved oxygen and cold temperature anomalies in Hood Canal are disappearing.

Moorings p. 37
Compared to past years, 2015 starts with warmer water and lower salinity at Mukilteo. Dissolved oxygen is rebounding.

Aerial photography p. 10
Patches of jellyfish persist in finger inlets of South Sound. First signs of growing phytoplankton are seen where water is turning green. Otherwise, the surface waters are nice shades of blue and green and, as expected, carry sediment near rivers.

Ferry and satellite p. 36
Victoria Clipper is in the shipyard

Editorial assistance provided by: Suzan Pool, Carol Maloy

Personal Field Impression 2-15-15

I ♥ Puget Sound

What do you love the most about Puget Sound?

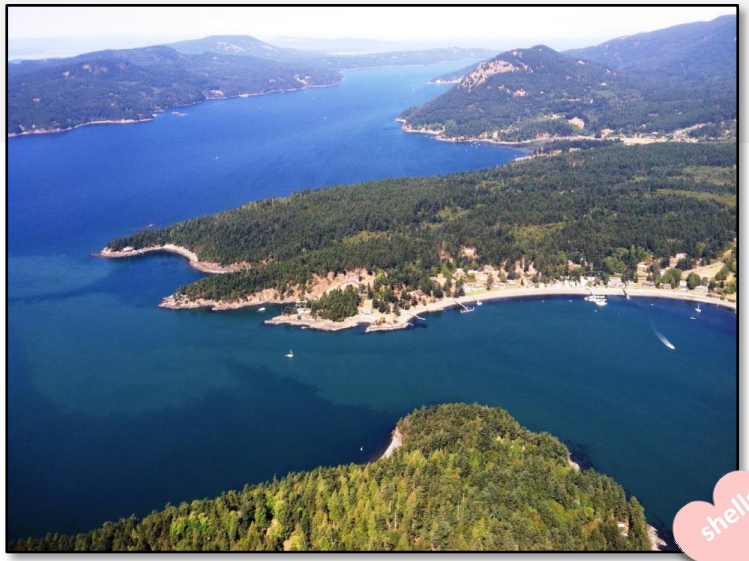
People that are curious and care

Wondrous marine life

Islands and hidden bays

Charismatic marine mammals

Personal Field Impression 2-15-15



Miles of diverse coastline

Sea anemones in orange and white

Glacial flour and river plumes

Unique geological features

shells

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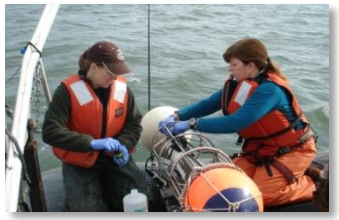

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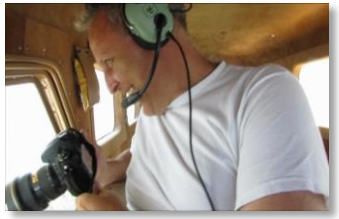

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Climate and natural influences before 2-17-2015

New section! **Climate and natural influences** are conditions that influence our marine waters, including weather, rivers, and the adjacent ocean (previously called Weather). For an explanation of the figure, see: http://www.ecy.wa.gov/programs/eap/mar_wat/weather.html, page 26.

Summary:

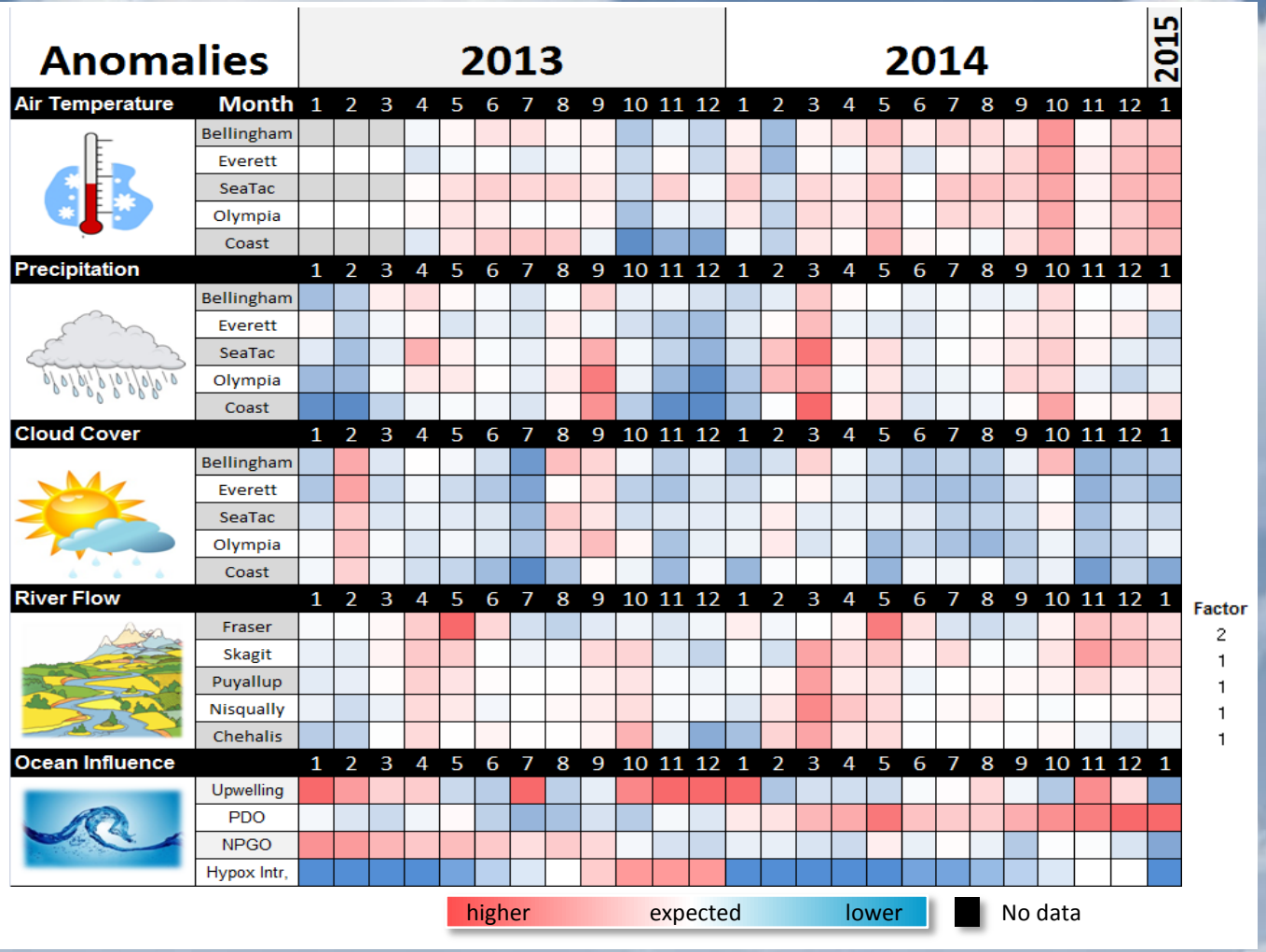
Air temperatures remain above normal, continuing a 10-month trend.

Precipitation has been below normal for the past week and month in the Central Puget Sound region.

Sunshine has been abundant for the past five days and above normal for the winter.

River flows are above normal across the Puget Sound region, but below normal at the coast (Chehalis River).

PDO remains in the warm phase, and upwelling is below normal.



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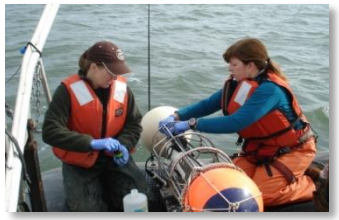

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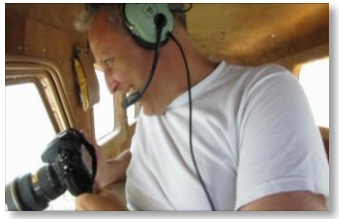

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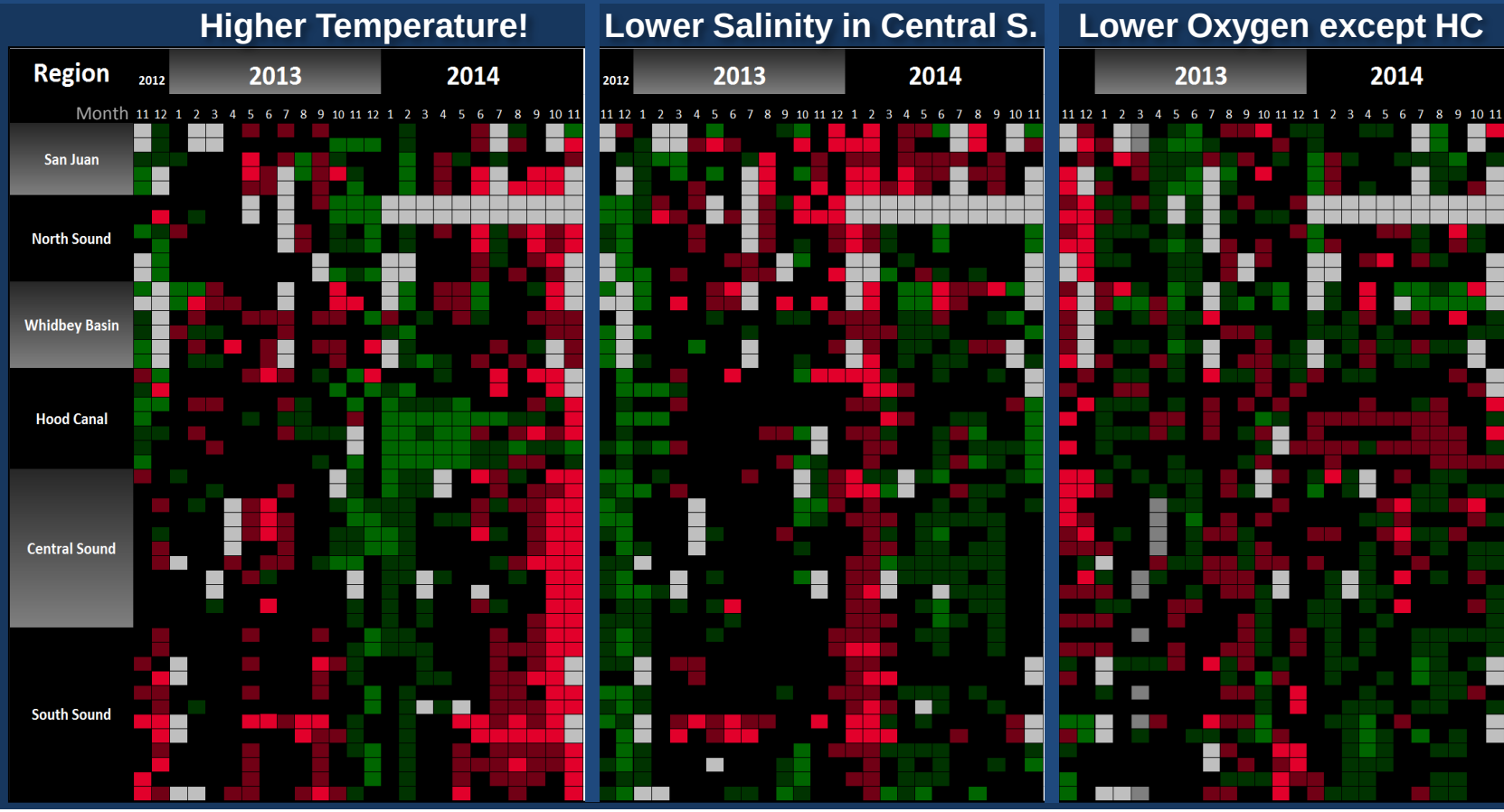
Physical conditions tracked in statistically historic context

In 2014, conditions were dominated by **warm water** during summer and fall, associated with the NE Pacific Ocean warm surface anomaly. In October and November, temperatures were the highest on our record since 1989. In 2014, salinity was higher and later, waters south of Admiralty Reach became fresher. Oxygen was mostly lower except in Hood Canal where a high anomaly persisted into the fall.

Nov. 2014:

Red boxes show that the water measured in fall 2014 is warmer than any of our measurements since 1999

Explore profiles at all stations



= 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

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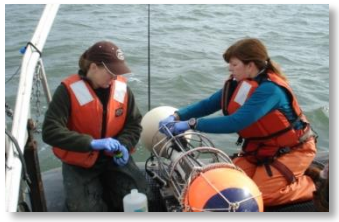

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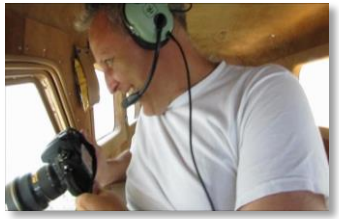

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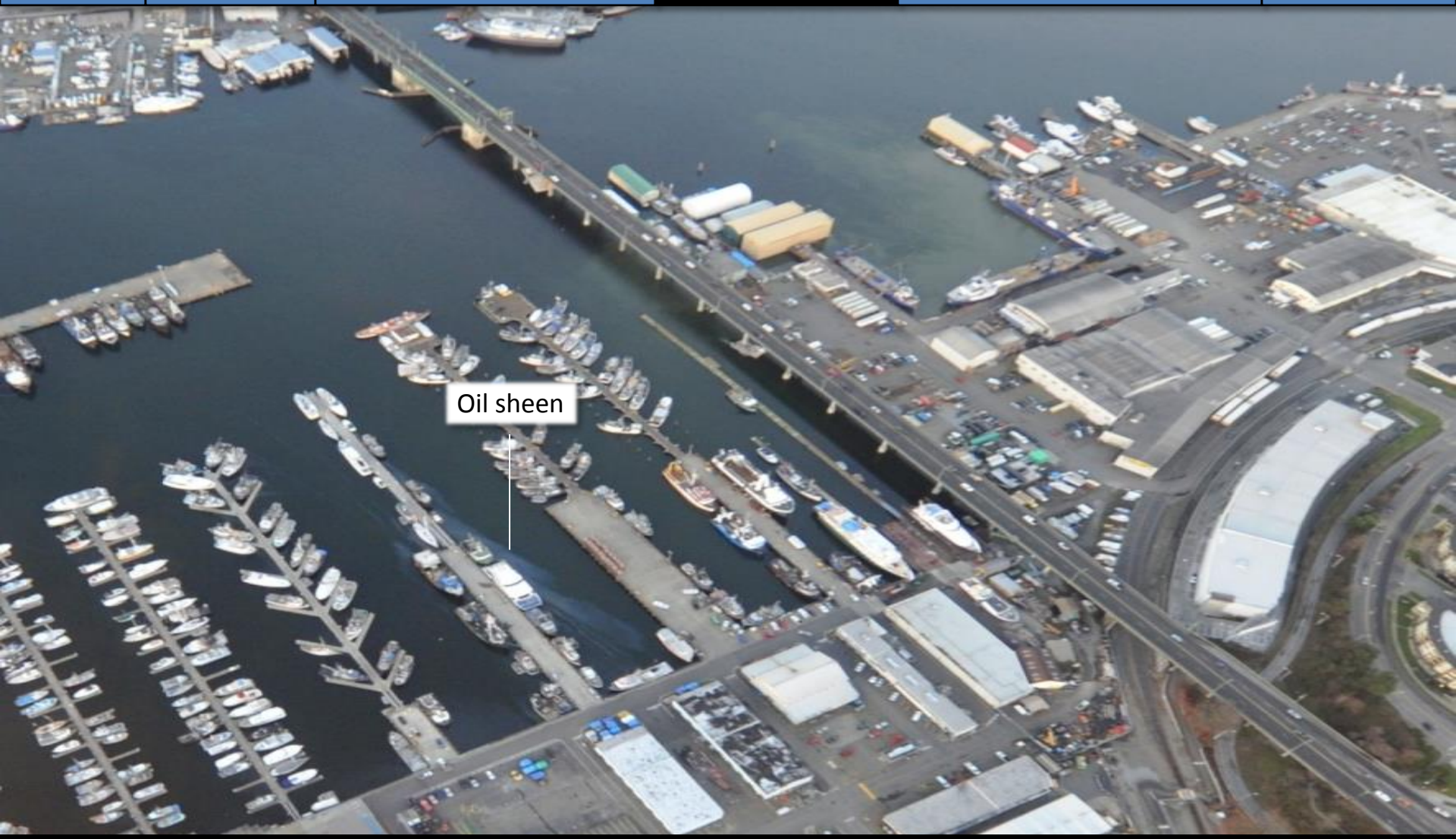
Let me take you on some flights

Aerial photography 1-15-2013

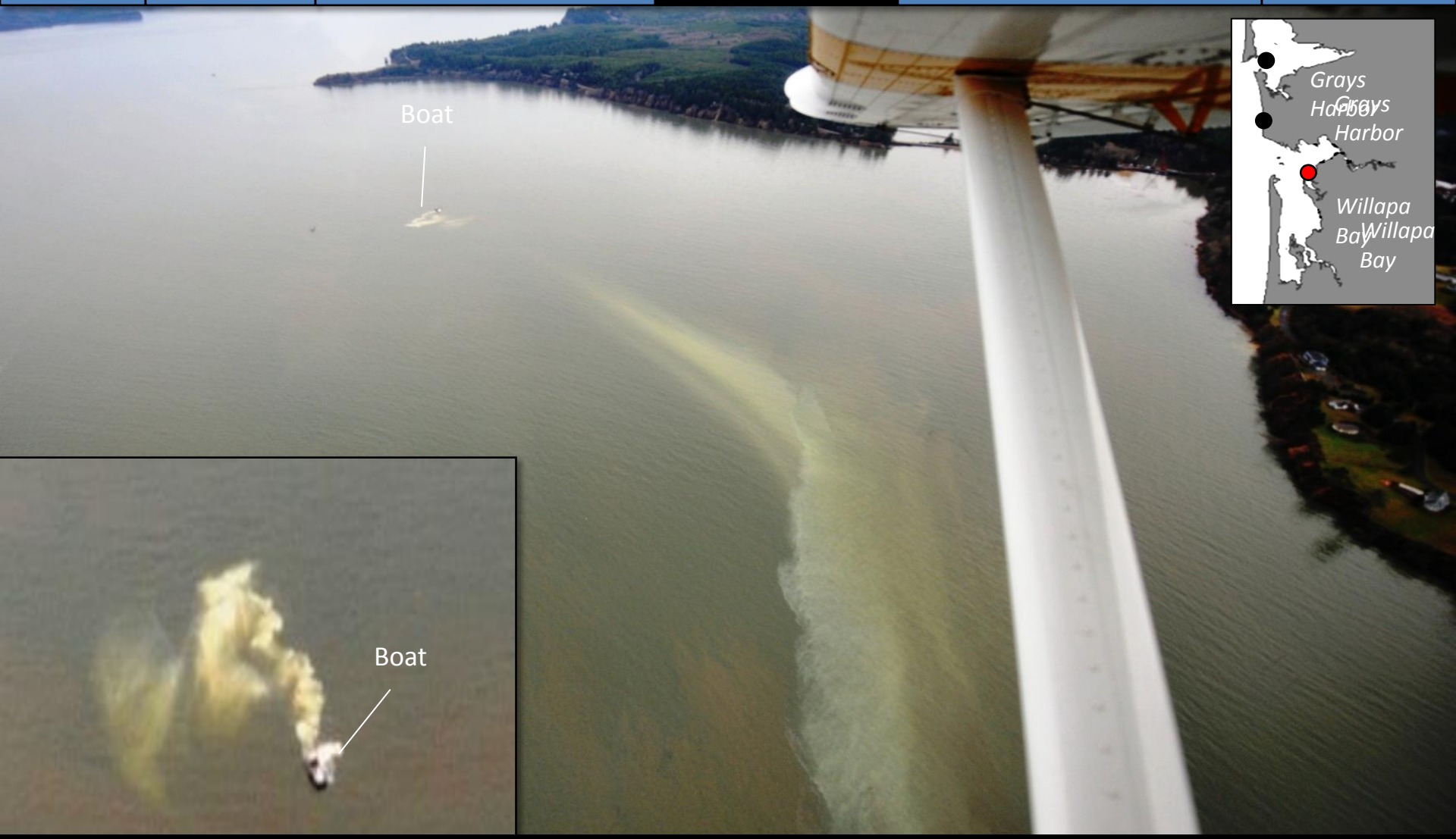
Oil sheen, extending deep into waterways. Location: Salmon Bay (Seattle), 4:32 PM

Aerial photography 1-15-2013



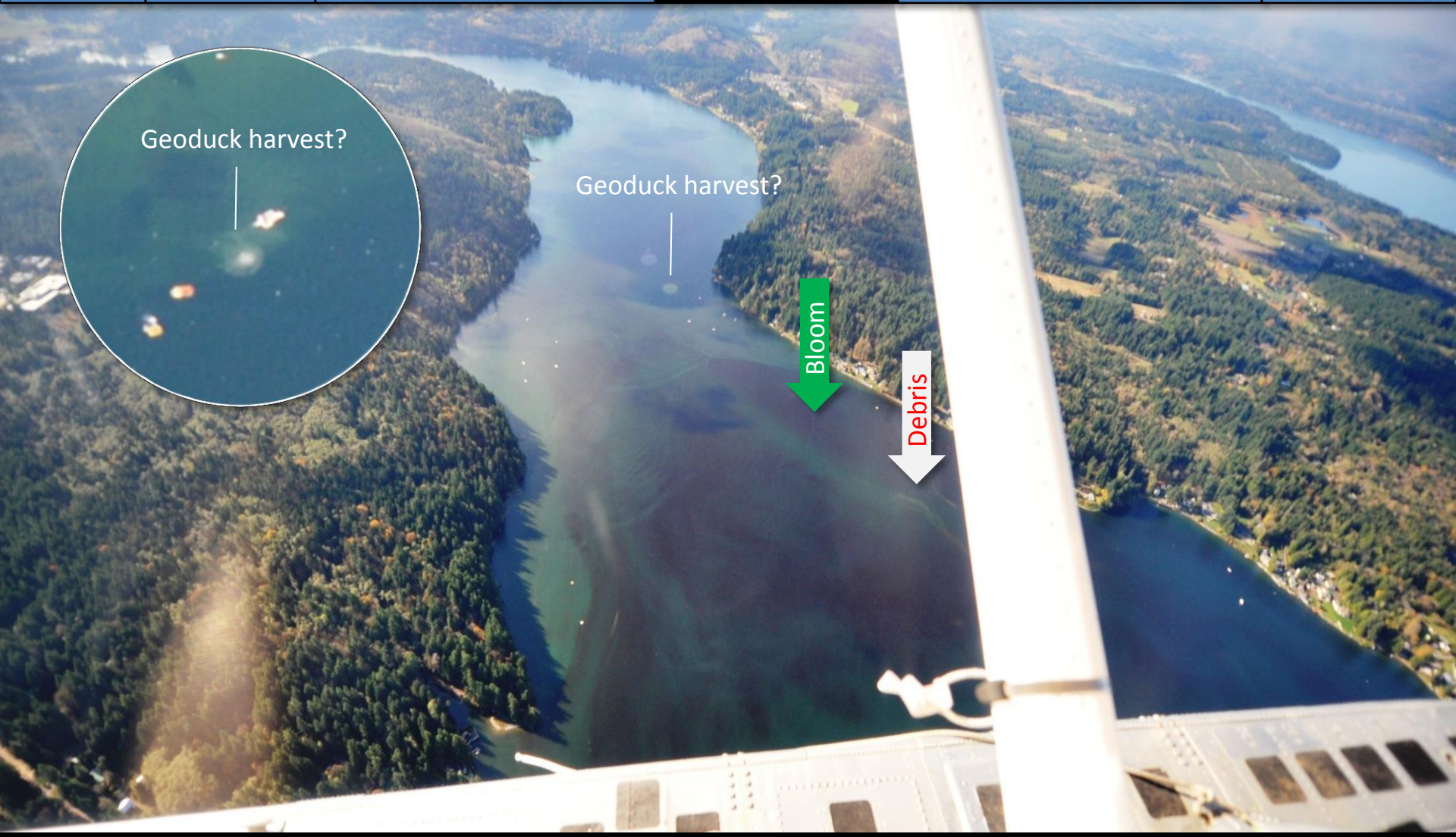
Oil sheen between vessels. Location: Salmon Bay (Seattle), 4:33 PM

Aerial photography 12-13-2012



Willapa shellfish grower applying local ground up oyster shells to improve clam substrate.
Location: West of Bone River (Willapa Bay), 12:53 PM

Aerial photography 11-08-2012



Red-brown algal bloom and jellyfish and turquoise water. Location: Eld Inlet (South Sound), 12:56 PM

Aerial photography

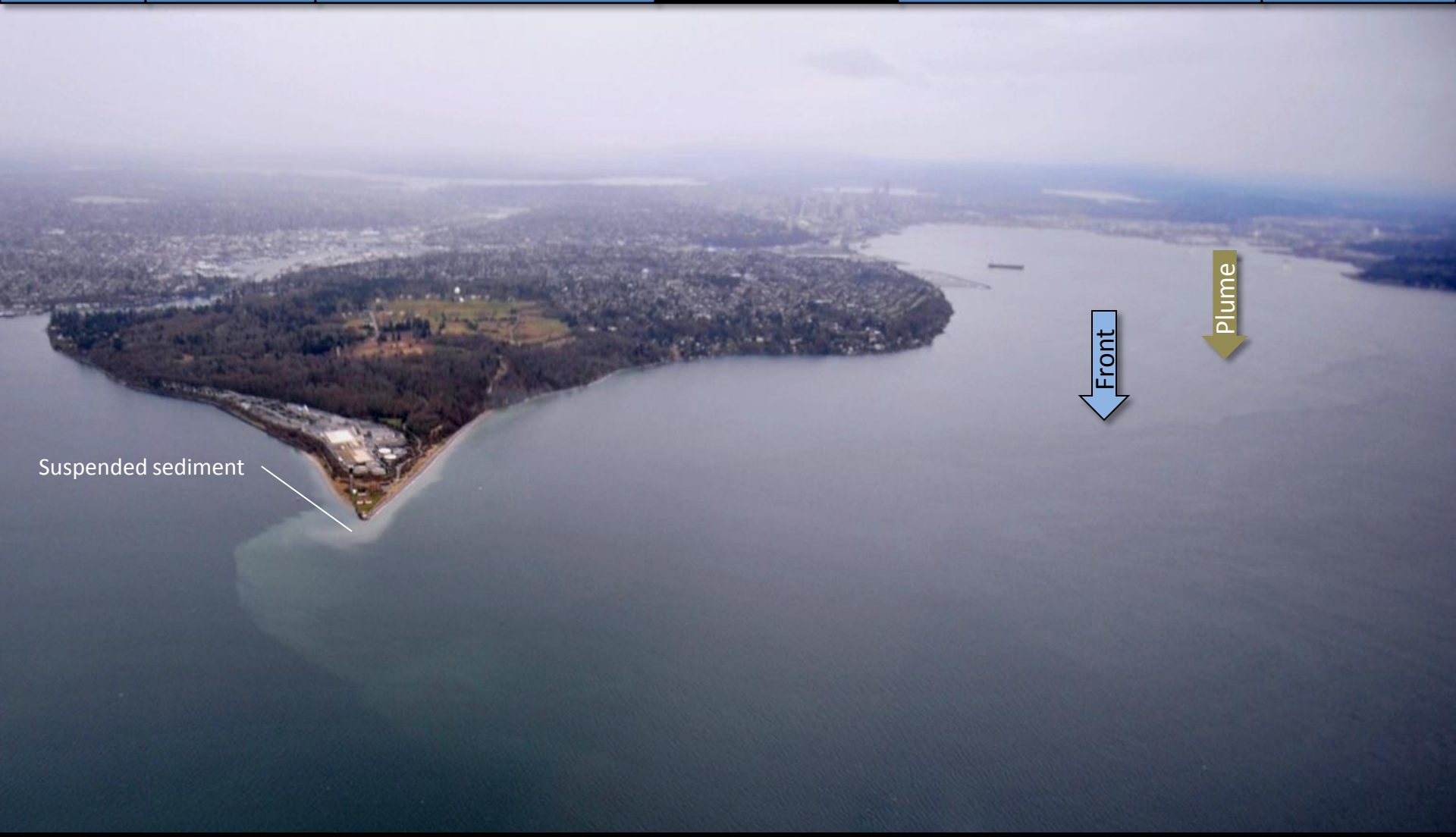
Eddy with suspended sediment. Location: McNeil Island (South Sound), 4:20 PM

Aerial photography 2-26-2013

Large tidal eddy carrying suspended sediment with debris lines.

Location: Nisqually Reach looking into Dana Passage (Central Sound), 3:08 PM

Aerial photography



Beach erosion and Duwamish River plume. Location: Off West Point (Seattle), 3:01 PM

Aerial photography 11-2-2010

Sediment load from the Pyallup Location: Browns Point Light House Park, Commencement Bay

Aerial photography 7-31-2012

Puyallup River plume entering Tacoma Narrows. Location: Point Defiance (Tacoma) 5:38 PM

Aerial photography

Long foam lines persist after ships have passed - Elliott Bay to Admiralty Reach , 3:38 PM

Aerial photography

Carr Inlet with large patches of macroalgae, 8:00 AM

Aerial photography

Macro -algae aggregates. Location: North of Shillshole, Seattle (Central Sound), 4:46 PM

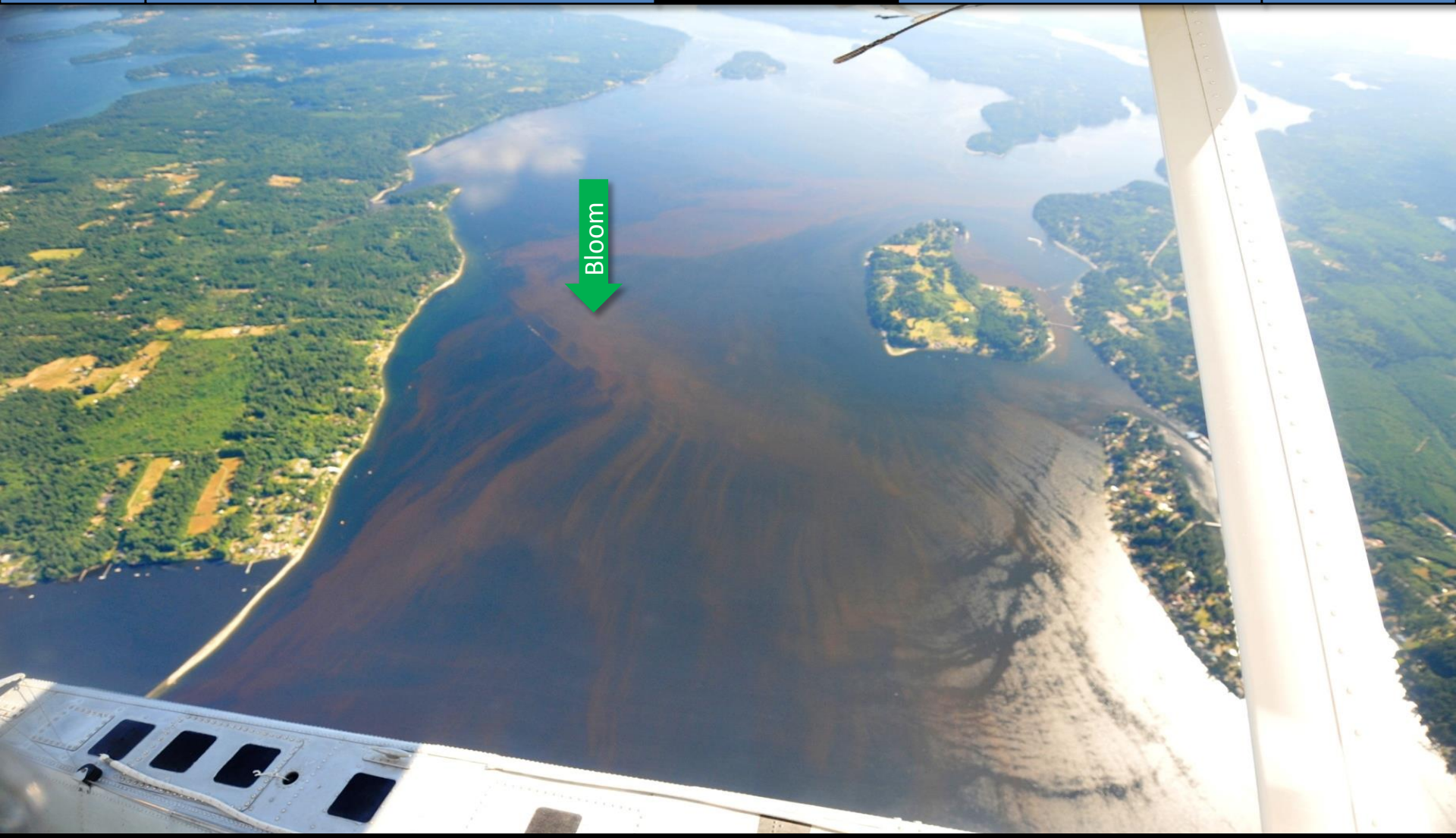
Aerial photography 9-11-2012

Red-brown and bright green-yellow algae blooms. Location: Dyes Inlet (Bremerton) 5:40 PM

Aerial photography

Red-brown bloom. Location: Quartermaster Harbor (Vashon Island), 4:32 PM

Aerial photography 7-31-2012



Extensive red-brown bloom. Location: Case Inlet (South Sound), 4:33 PM

Aerial photography 7-31-2012

Red-brown and turquoise blooms, jellyfish (+ cloud reflections). Location: Budd Inlet (South Sound), 4:56 PM

Microbial food web: The importance of the micro-grazer Noctiluca in Puget Sound

Noctiluca surface aggregations looking south into Central Basin, Puget Sound, Washington, USA

Aerial photography June 2011

Noctiluca filaments drifting at the surface east of Vashon Island, looking onto Des Moines. The eastern tip of Vashon Island can be seen to the right 4:44 PM

Aerial photography 6-12-2012

Large *Noctiluca* bloom in Central Sound. Location: Bainbridge Island (Central Sound), 8:07 AM

Aerial photography 6-12-2012

Large *Noctiluca* bloom in Central Sound. Location: Bainbridge Island (Central Sound), 8:08 AM

Aerial photography 9-11-2012

Patches of jellyfish and red-brown algae bloom. Location: Budd Inlet (South Sound), 4:45 PM

Aerial photography 2-26-2013

Patches of jellyfish in the head of the inlet. Location: Sinclair Inlet, 2:35 PM

Ferry and Satellite

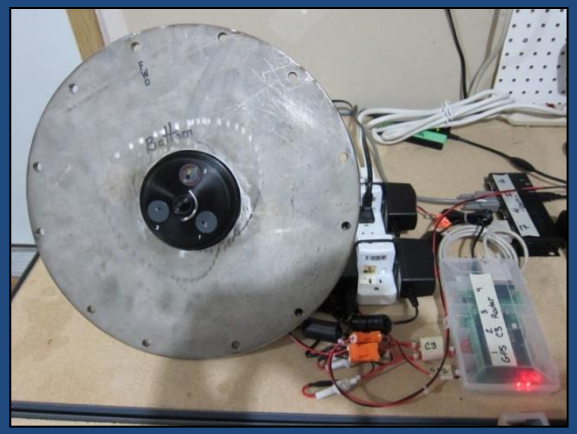
Brandon Sackmann

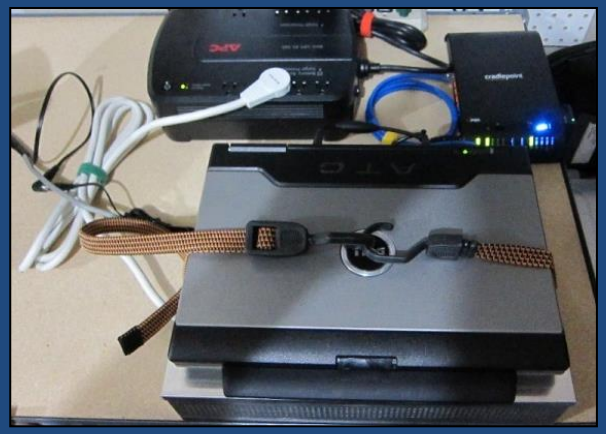
Ferry Monitoring

Water Quality Indicators

(Deployed 14 May 2010)

- Phytoplankton (Chlorophyll *a* fluor.)
- Turbidity
- Sea Surface Temperature
- River water (CDOM)
- Salinity (Apr. 2012)





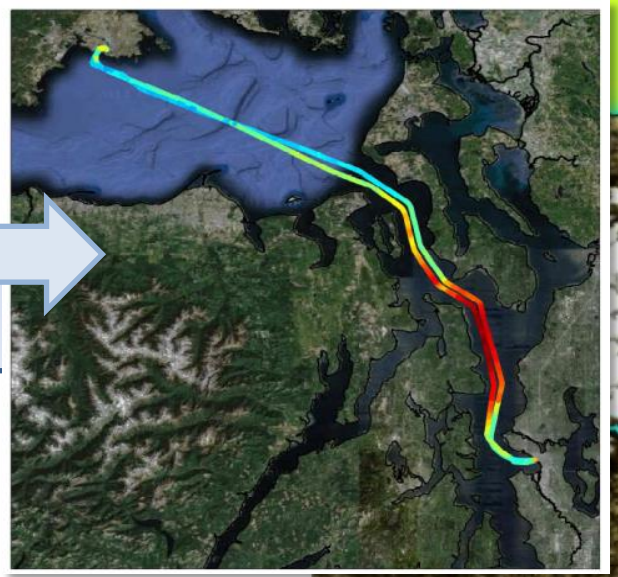
Ferry Monitoring

- Advantages
  - Cost-effective data collection
    - 100 m spatial resolution (5 sec.)
    - 4-hr temporal resolution
  - Regular schedules/Reliable
    - 80 mile long transect (35 mph)
    - 1-2 times **daily** (year-round)
- Daily data pickup
- Simplicity helps ensure a sustainable program…

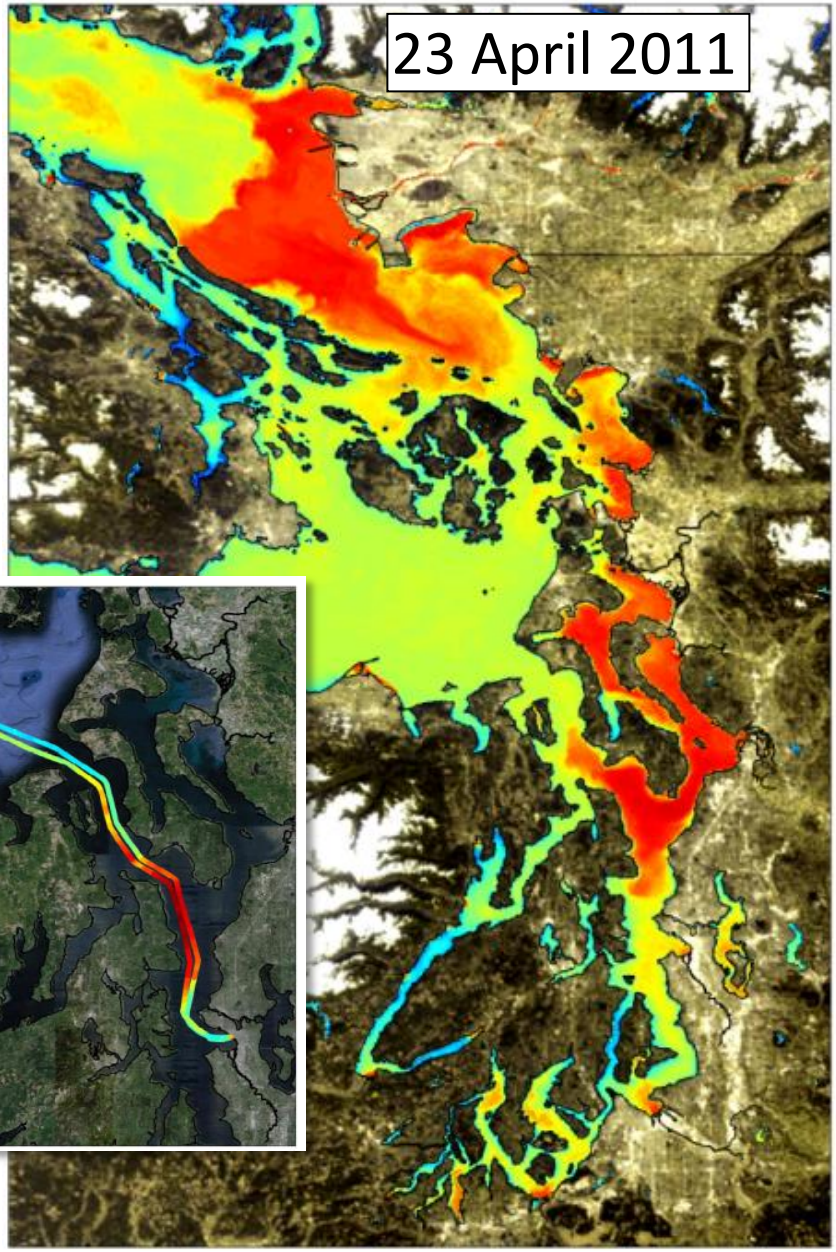
Seaplane → Ferry → Satellite

Eyes '*Over*' Puget Sound

Eyes '*On*' Puget Sound



Chlorophyll

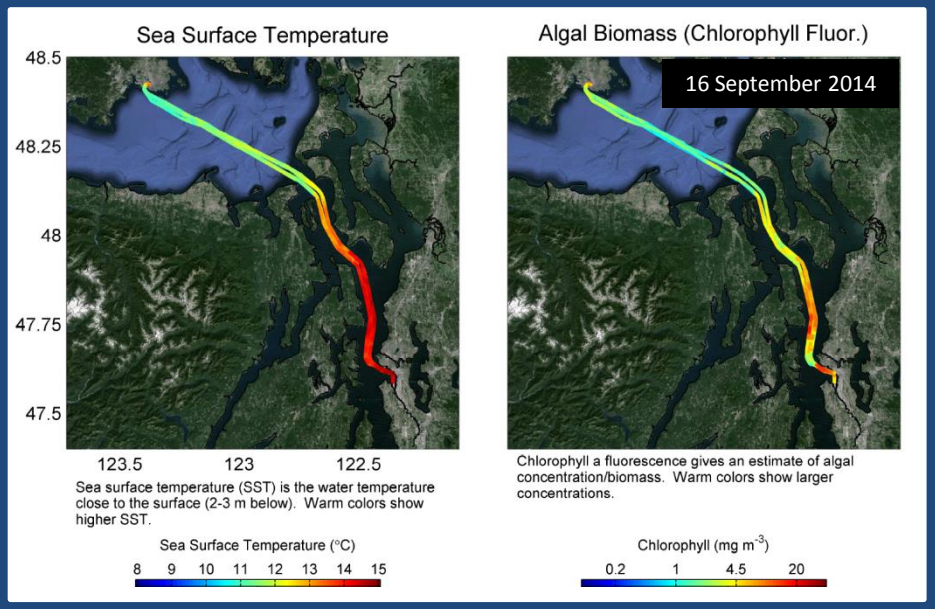


Ferry and satellite observations 9-16-2014

Hardware upgrades on the *Victoria Clipper IV* successfully restored near real-time data collection as of July 23, 2014; we are back online!

Brandon Sackmann
Contact: bsackmann@integral-corp.com

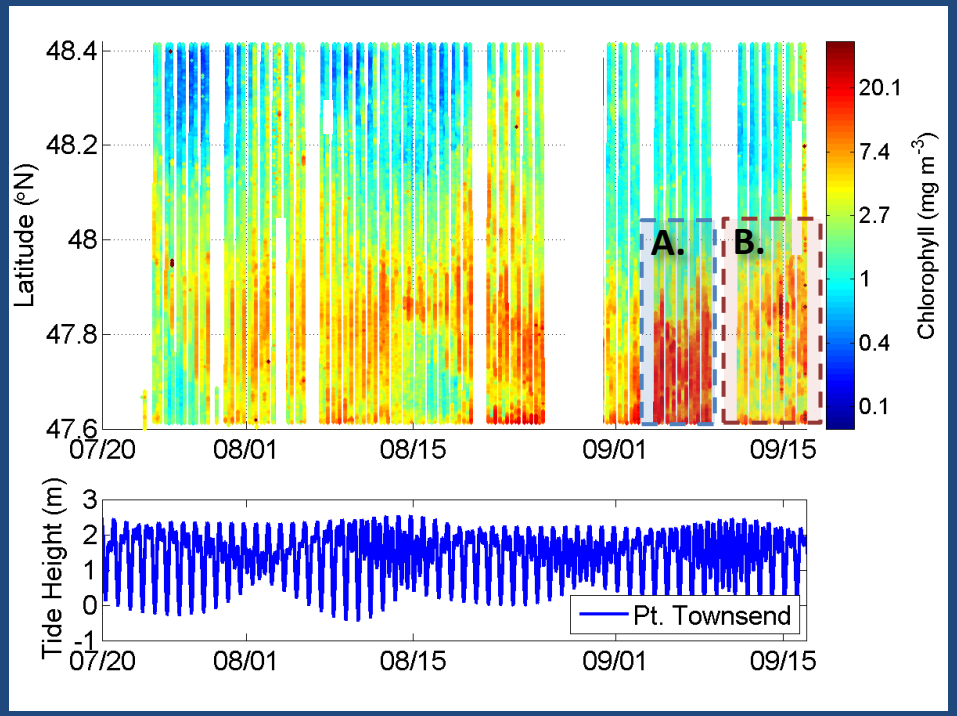
Start here

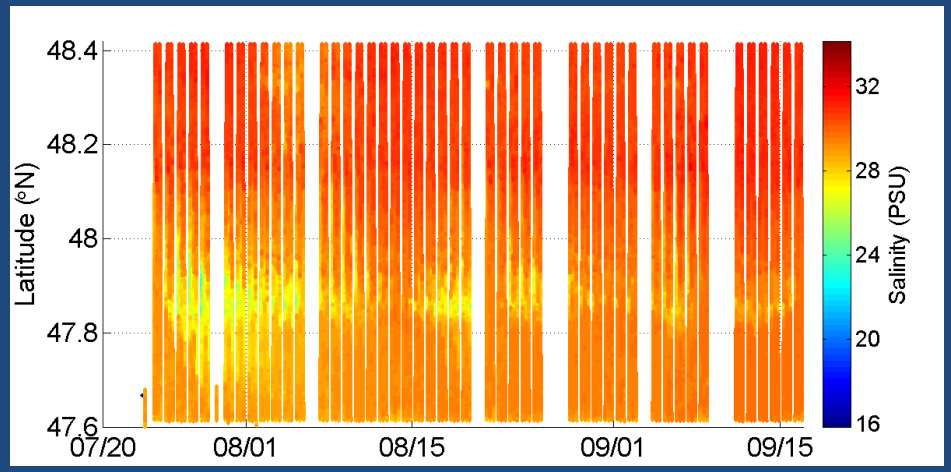


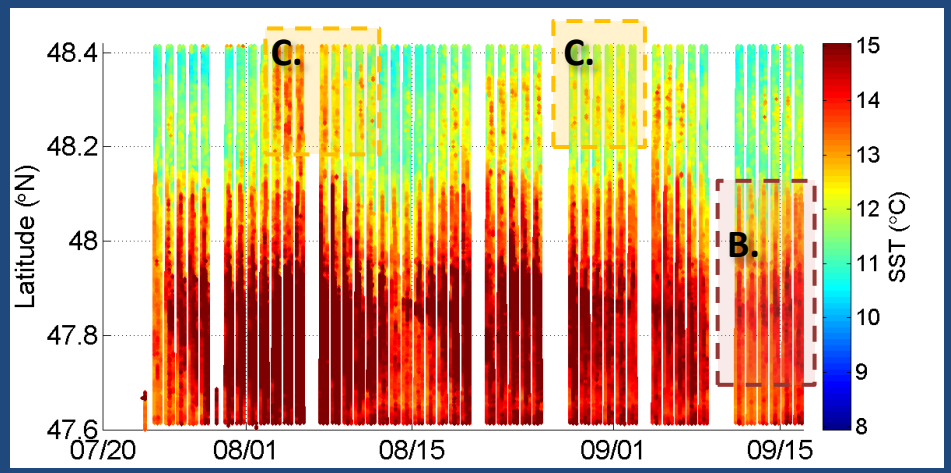
Current Conditions:

Bloom in central Puget Sound begins to fade as temperatures cool; max temperatures generally <15 °C. MODIS reveals extensive bloom at entrance to Strait of Juan de Fuca. Thermal imagery from Landsat 8 shows warmer water in Strait of Georgia, Whidbey Basin, and finger inlets of South Puget Sound.

Ferry and satellite observations 9-16-2014



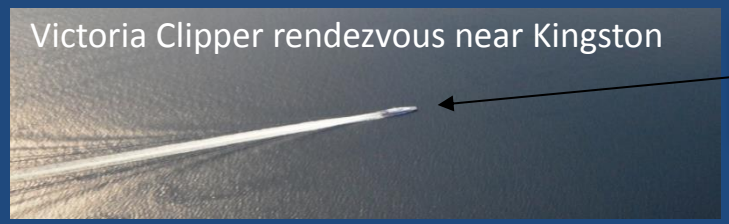




A. Strong algae bloom in central Puget Sound during first week of September.

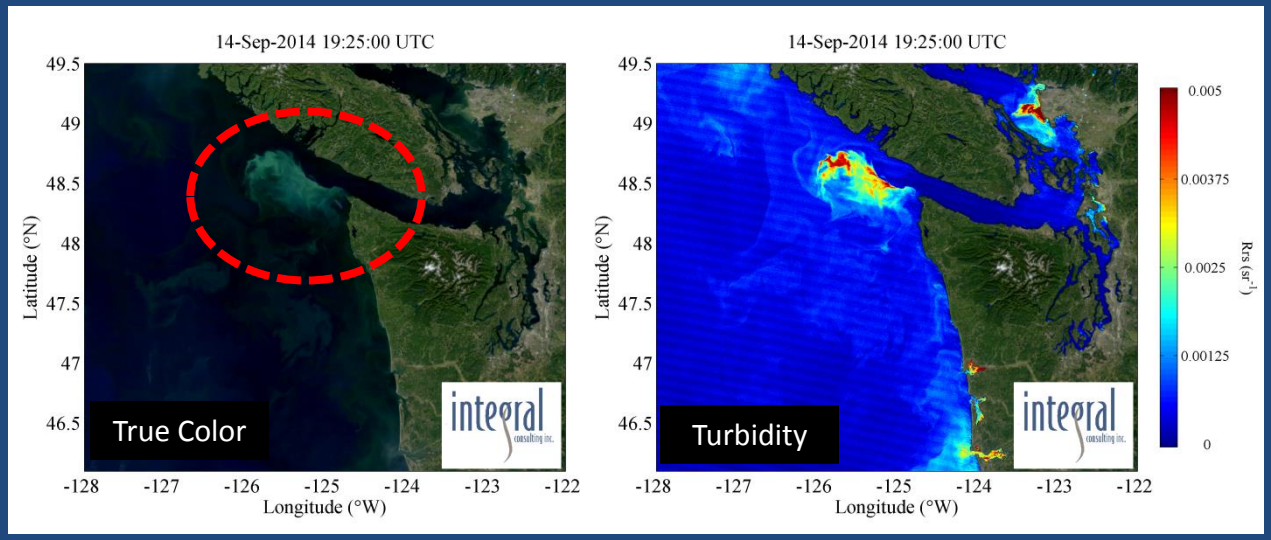
B. Stratification shows signs of weakening (temperature is declining indicating mixing) and bloom is dissipating.

C. Weak tides in August and September associated with warmer temperatures in Strait of Juan de Fuca.

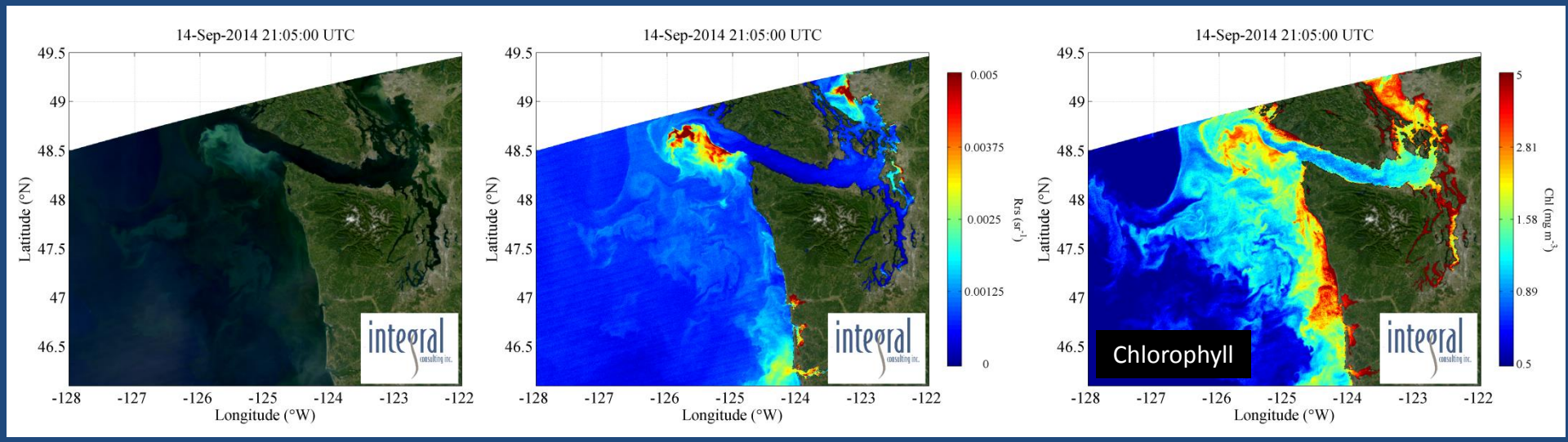


3:47 PM

Ferry and satellite observations 9-16-2014

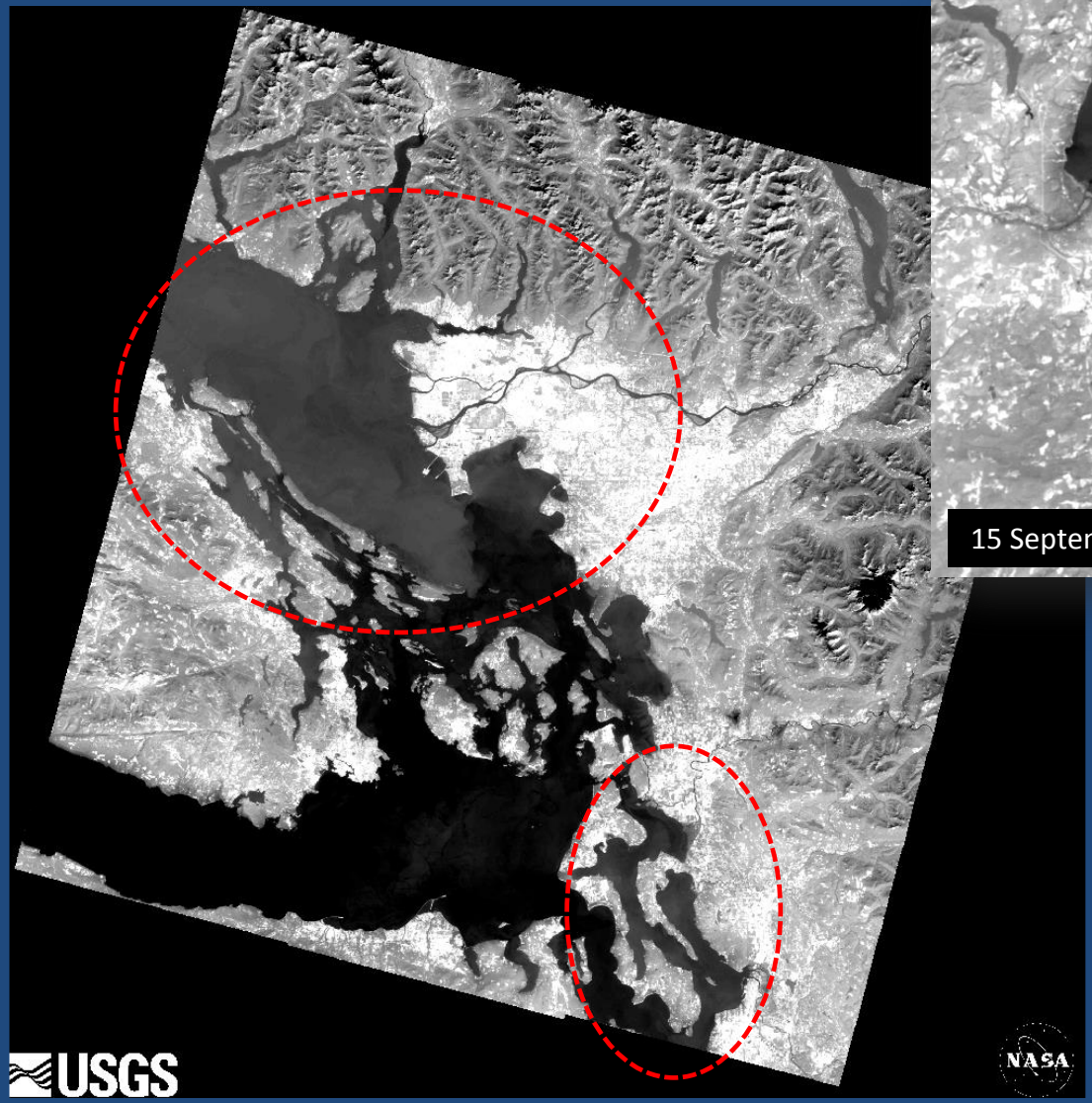


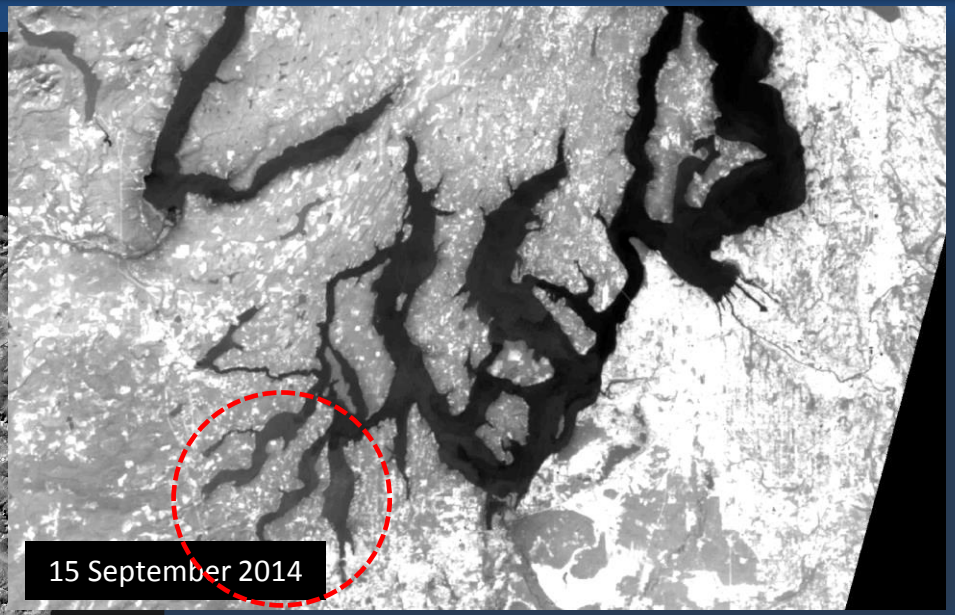
MODIS-Terra (top) and MODIS-Aqua (bottom) reveal intense offshore bloom near entrance to Strait of Juan de Fuca!



Imagery obtained from NASA's OceanColor WEB
http://oceancolor.gsfc.nasa.gov/

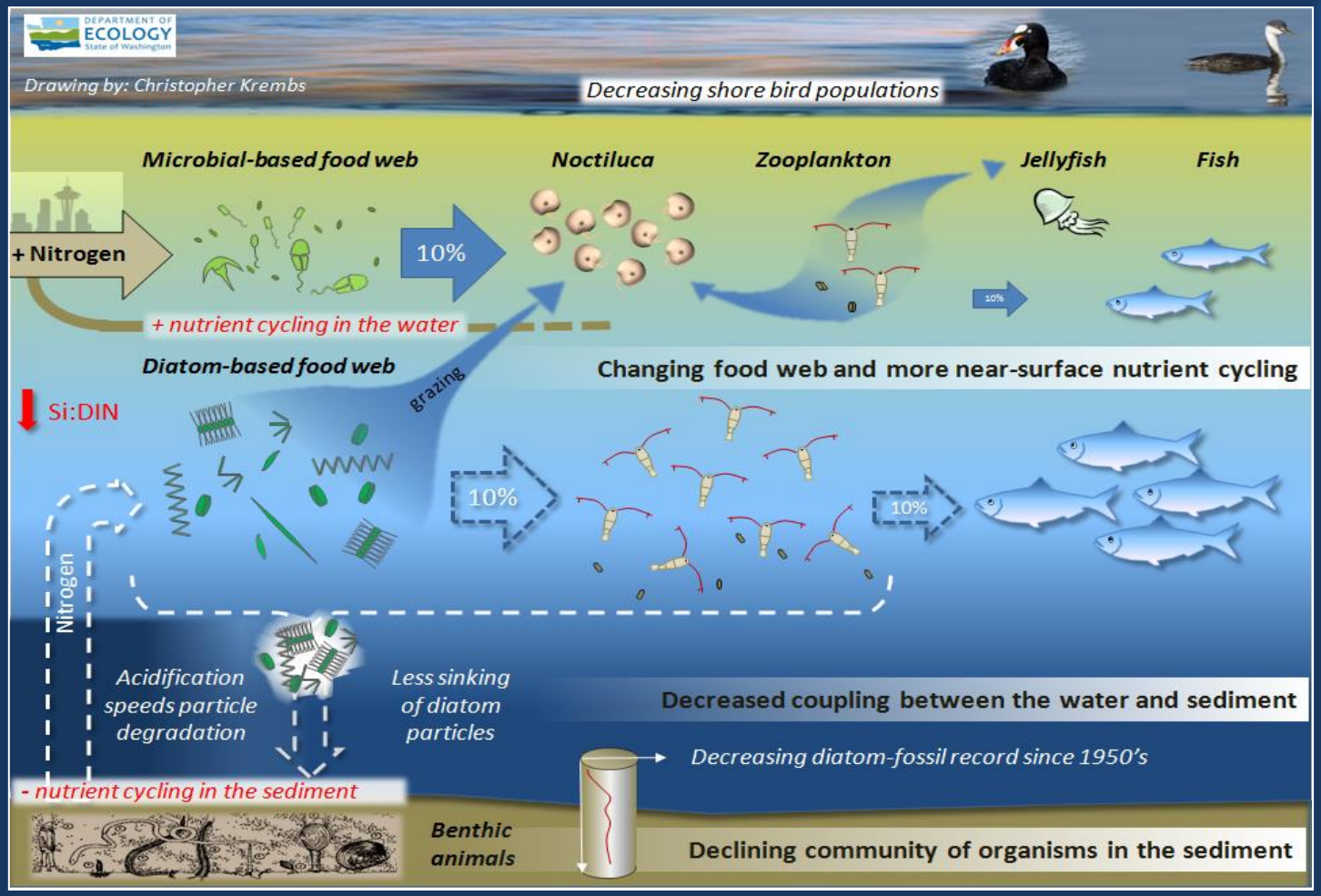
Ferry and satellite observations 9-16-2014





Thermal imagery from the Landsat 8 satellite show warm waters throughout Strait of Georgia and Whidbey Basin (left). Warmer temperatures were in finger inlets throughout South Puget Sound; cooler temperatures highlight areas experiencing increased mixing (top).

Hypothesis for combining a series of recent observations affecting energy and material transfer to higher trophic levels



Hypothesis!

Increases in nitrate concentrations could be caused by a top-down control on phytoplankton biomass.

Is *Noctiluca* a visible harbinger of a food web change?

Are changes in higher tropic levels part of a story of the low food web?

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EOPS

Increased focus on the environment

…Others are more engaged

We do a better job…

Information is better