

# Eyes Over Puget Sound

Summary

Art & Smoke

Nutrients & Context

Marine water

Aerial photos

Data

## Surface Conditions Report: October 2022



*Up-to-date observations of water quality conditions in Puget Sound and coastal bays*

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LONG-TERM MARINE MONITORING UNIT



Artists corner

## Artists corner, [p. 4](#)

Showcasing the natural beauty of Puget Sound through photography.



Thanking all staff since 1999

## Nutrients & context, [p. 8](#)

A healthy food web has at its base a balance of nutrients. An imbalance can create favorable conditions for less-desirable species.



Field team: Natalie Coleman,  
Holly Young

## Marine conditions, [p. 13](#)

Mostly expected conditions in October, with warmer and saltier water at the coast.



Dr. Christopher Krembs

## Aerial photography, [p. 14](#)

Blooms continuing in multiple terminal bays. Numerous patches of jellyfish in Budd Inlet and Liberty Bay. Sediment is visibly transported by the Puyallup River. Resuspended sediment along shorelines in Totten Inlet, in some places mixed with soil. Air conditions smoky.



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## As in a pandemic, the battle against invasive species may well depend on early actions

By Christopher Dunagan, May 24, 2021



European green crab // Photo: Kelly Martin, Washington Sea Grant

While not a direct threat to human health, [European green crabs](#) could take a heavy toll on native shellfish, destroy eelgrass beds important to salmon and forage fish, and consume commercial clams and oysters with financial losses to the shellfish industry.

[Read article](#)

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*Showcasing the natural beauty of Puget Sound through photography from engaged artists in our communities and from unique vantage points.*



*“The fish head”: Am I the only one seeing a fish here?*

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*"The race": Speed boats passing the Tacoma Narrows bridge*

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## Low air quality moves into Puget Sound region

by KOMO News Staff | Monday, October 10th 2022

☰ **KOMONEWS**

Itchy eyes and constant campfire smell in the air thanks to wildfire smoke over the Puget Sound region. The eastern part of King County dealt with some of the worst air quality.



©StevenLuong

*A smoky downtown Seattle (Photo: Steven.T.luong Photography)*

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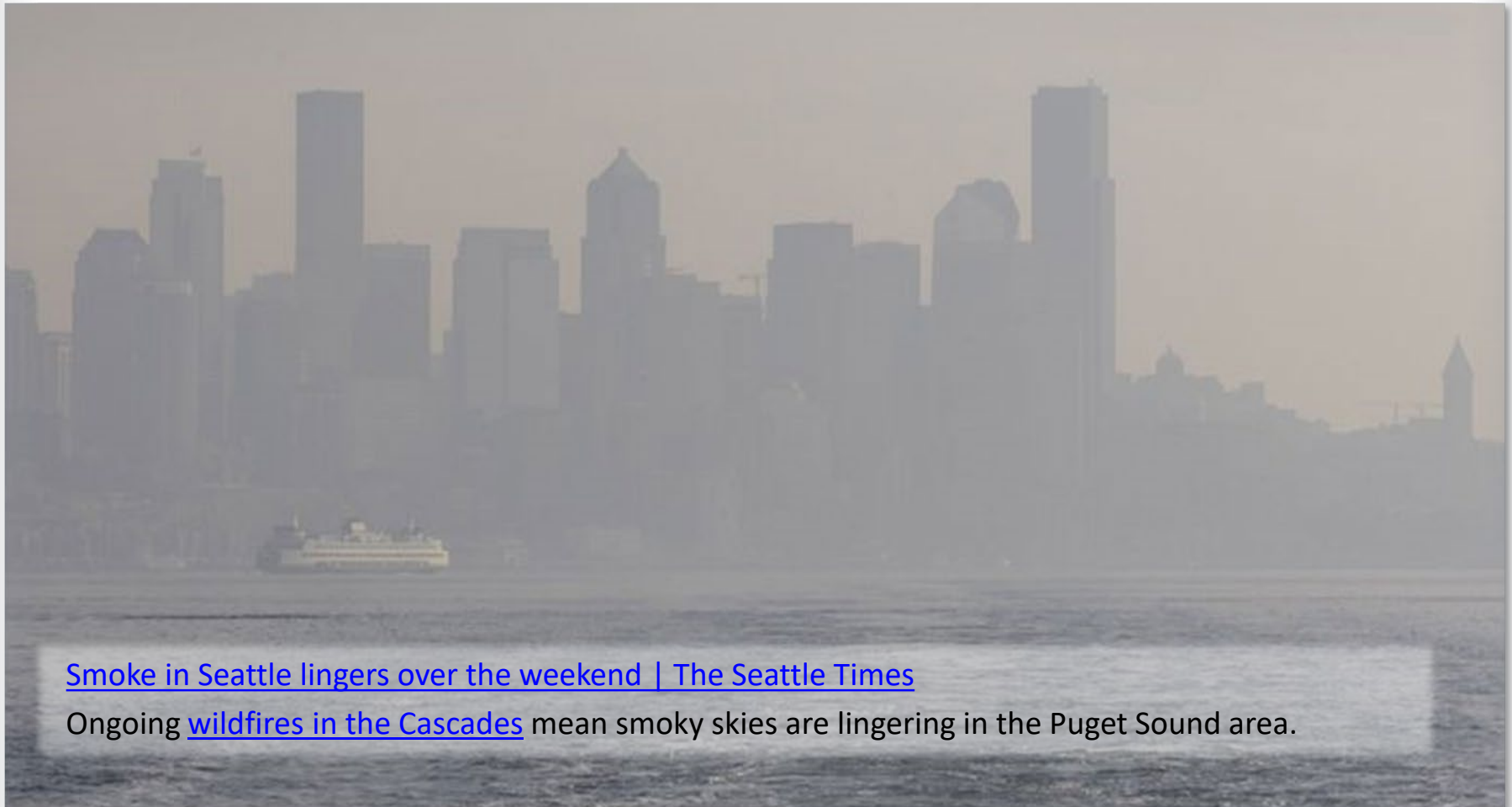
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## Smoke in Seattle lingers over the weekend

Oct. 9, 2022 at 11:43 am Updated Oct. 10, 2022



[Smoke in Seattle lingers over the weekend | The Seattle Times](#)

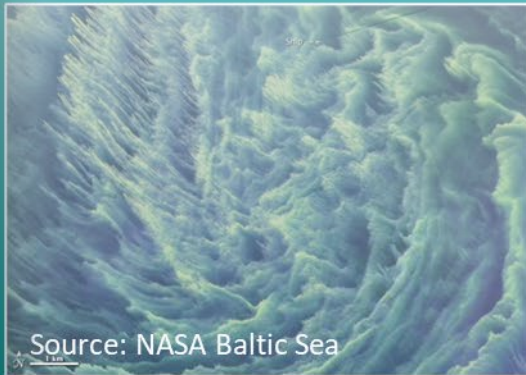
Ongoing [wildfires in the Cascades](#) mean smoky skies are lingering in the Puget Sound area.

## A healthy food web has at its base a balance of nutrients

### N-limited (unbalanced)

High phosphate concentration attracts nitrogen fixers

At a nitrogen-to-phosphate ratio below about 4, blue green algae start dominating the phytoplankton community.



Blue-green algae

### Balanced and productive

Lipids are major constituents of diatoms ([read](#)). Puget Sound's cold-water food web relies on diatoms and their lipids.

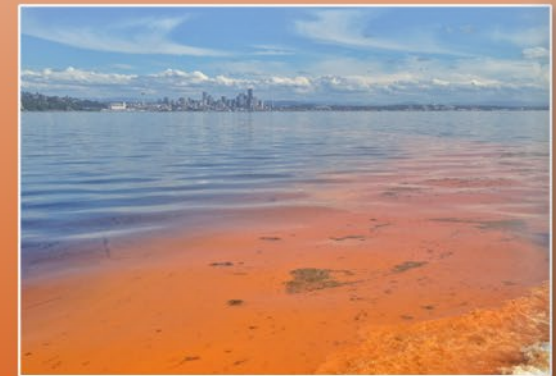


Fish rich in lipids

### P-limited (unbalanced)

High org nitrogen concentrations supports microbial food webs

At a nitrogen-to-phosphate ratio above about 20, flagellates start dominating the phytoplankton community.



Red tides, flagellates



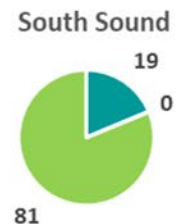
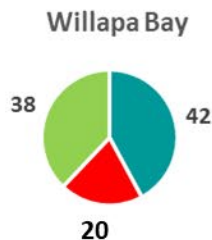
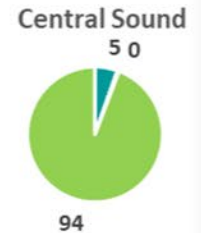
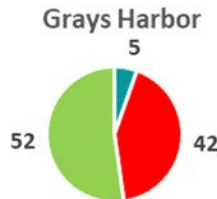
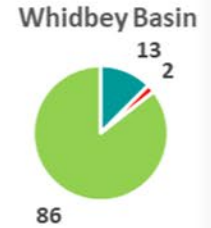
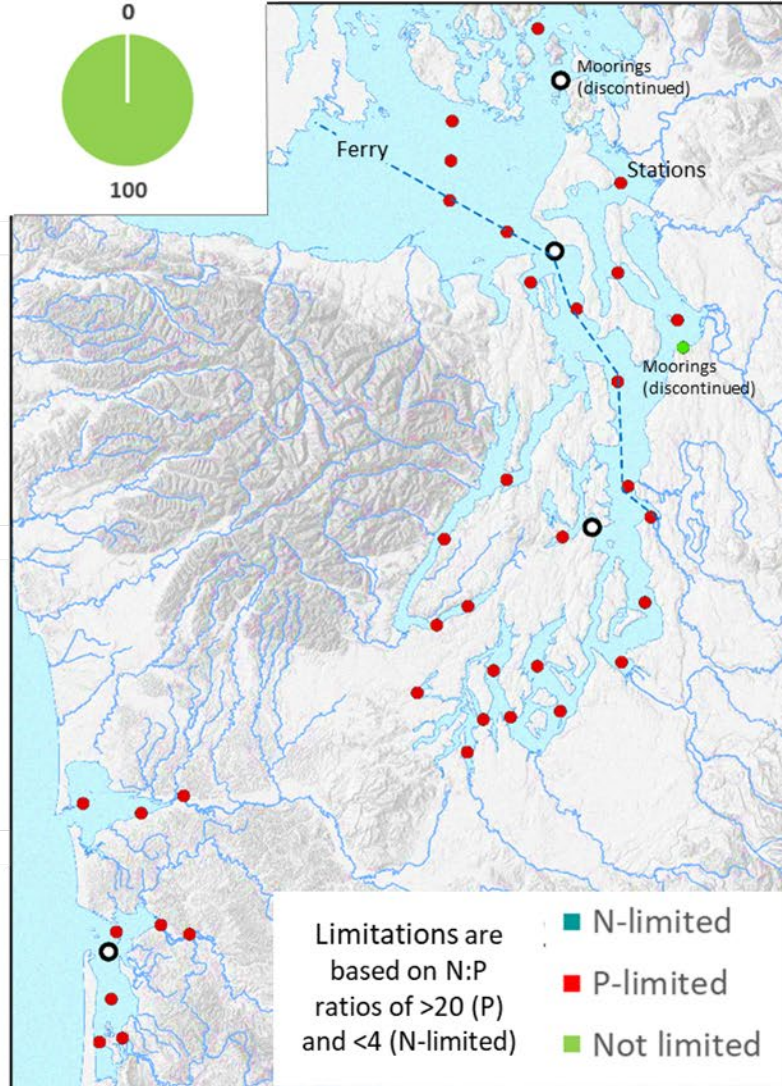
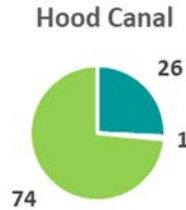
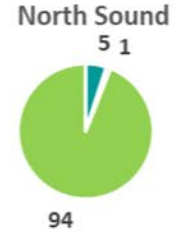
## Ecology data 1999-2018

Nutrients are the building blocks for phytoplankton. When in balance, a healthy mix of species thrives.

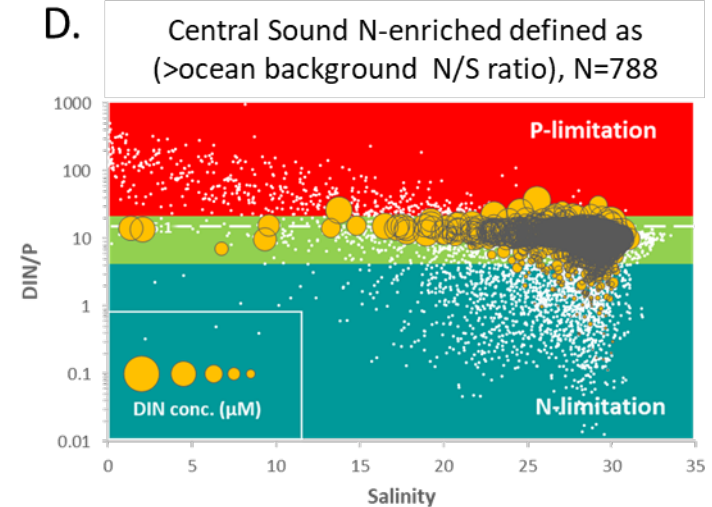
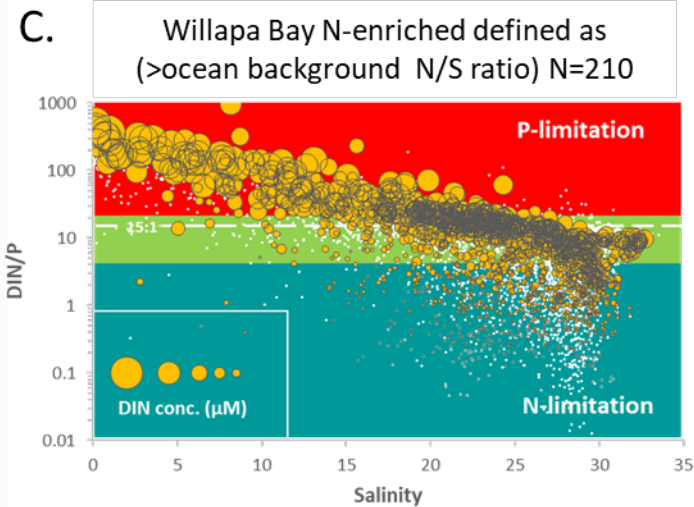
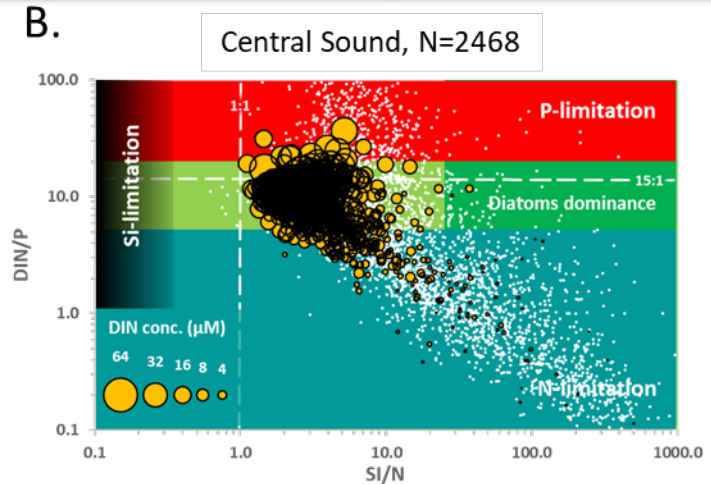
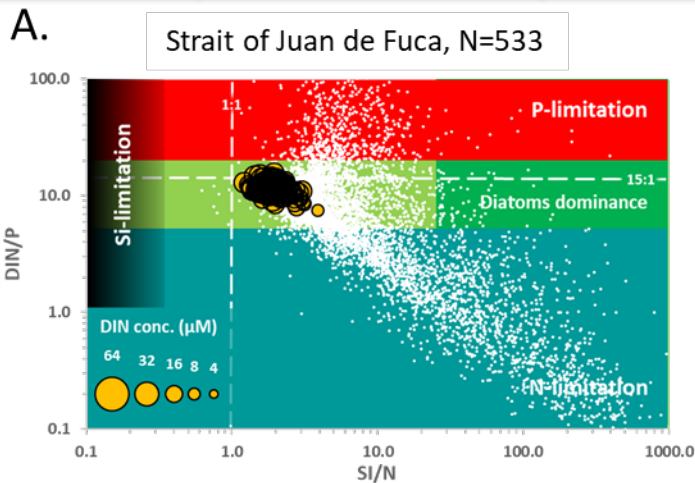
Limitation of a nutrient can result in species shifts and exclusion of beneficial species.

Phosphate (P) limitation can promote flagellates and HABs.

Nitrogen (N) limitation can promote blue green algae and HABs.



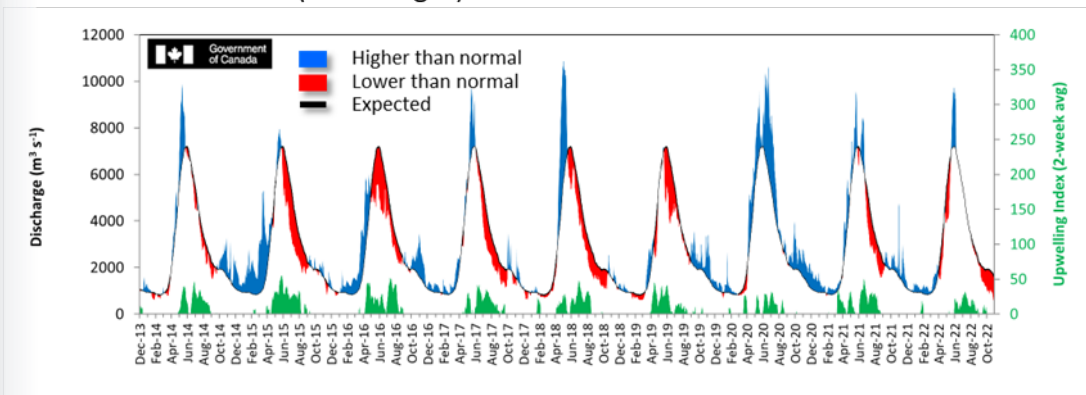
Numbers represent percentage of all samples 1999-2018 0-10 m



A, B. Nutrient N and P limitation has been observed in our data from 1999-2018 (white dots = all data). Silica limitation (<1) has not been observed. Lower DIN concentrations (bubble plots) and optimal Redfield N-to-P and Si-to-N ratios are desired. A. Examples of balanced nutrient ratios near Redfield 15:1. B. & D. Occasional above Redfield 15:1 at a salinity of 25. C. N-to-P ratios above Redfield 15:1 at low salinity, suggesting river N sources.

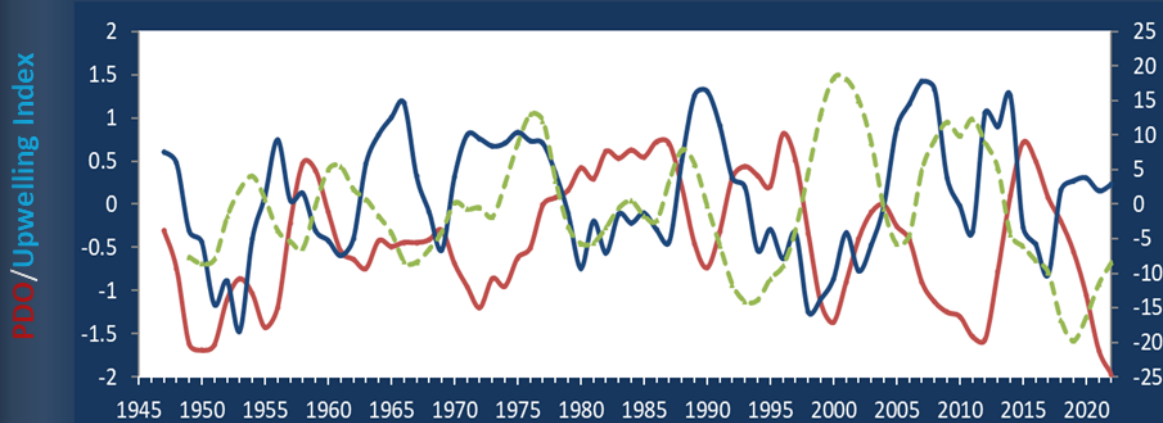
Historically, the peaks of coastal upwelling and the [freshet](#) are in sync.

## Fraser River (at midnight)



The Fraser River is the major driver of [estuarine circulation](#) and water exchange between the Salish Sea and the ocean. Fraser River flows in October were lower than normal. Upwelling off the coast was also weaker this year suggesting less upwelled water entrainment into Puget Sound.

## Three-year running average of PDO, Upwelling, and NPGO Indices

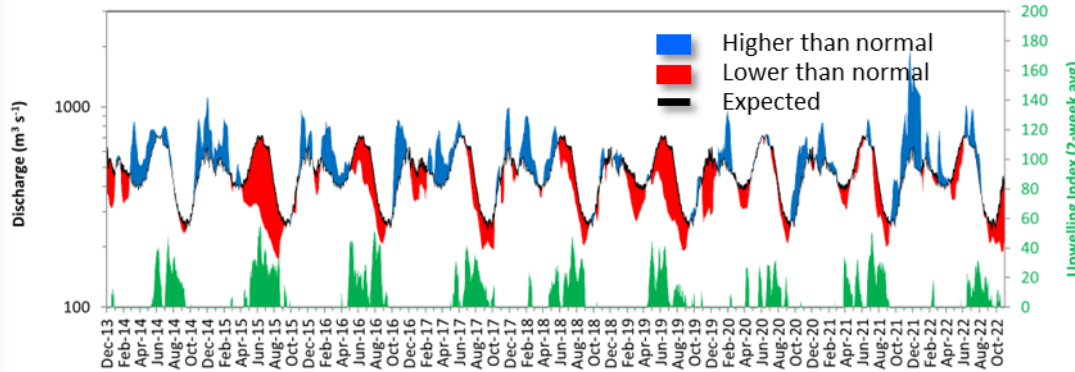


How do ocean boundary conditions affect the quality of water the Salish Sea exchanges with the ocean?  
 Water has cooled (PDO). Upwelling (Upwelling Index [anomaly](#)) is around expected level. Productivity in the eastern Pacific is low but increasing again (NPGO; last updated Sep 2022).

Pacific Decadal Oscillation Index (PDO, [temperature](#), [explanation](#)). Upwelling Index (anomalies) ([Upwelling](#), [low oxygen](#), [explanation](#)). North Pacific Gyre Oscillation Index (NPGO, [productivity](#), [explanation](#)).

The Skagit River is the largest freshwater source for Puget Sound. It is a regulated river.

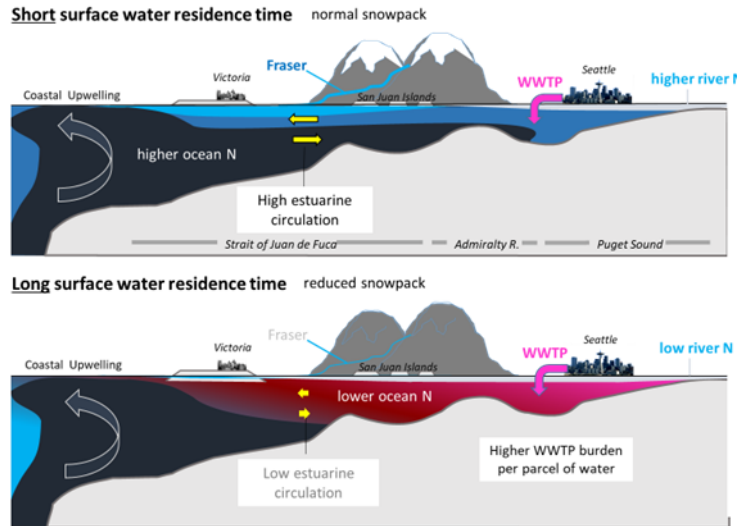
**Skagit River (at midnight USGS)**



The Skagit River freshet is no longer clearly pronounced because the river is a regulated system for hydroelectric power generation. However, drought years and low flows can be seen in the river's discharge data. In 2022, flows dropped below normal in fall. Upwelling was weak in 2022.

Normal river flows drive **"natural"** nutrient inputs and **keep the water cool.**

Low river flows **change the nutrient balance and make water warmer.**



Rivers strengthen estuarine circulation in the Salish Sea. This is important in the summer.

Upwelled ocean water provides cool, nutrient-rich water.

For that to happen, we need northerly winds and good river flows (a good snowpack) during periods of water exchange through Admiralty Reach (neap tides).

River flows and upwelling in the summer influence our water quality.



Field team: Natalie Coleman,  
Holly Young

## Marine Water Conditions: 2022 temperature, salinity, and dissolved oxygen

### Coastal Bays

T: *Higher*

S: *Higher*

DO: *Variable*

### Salish Sea

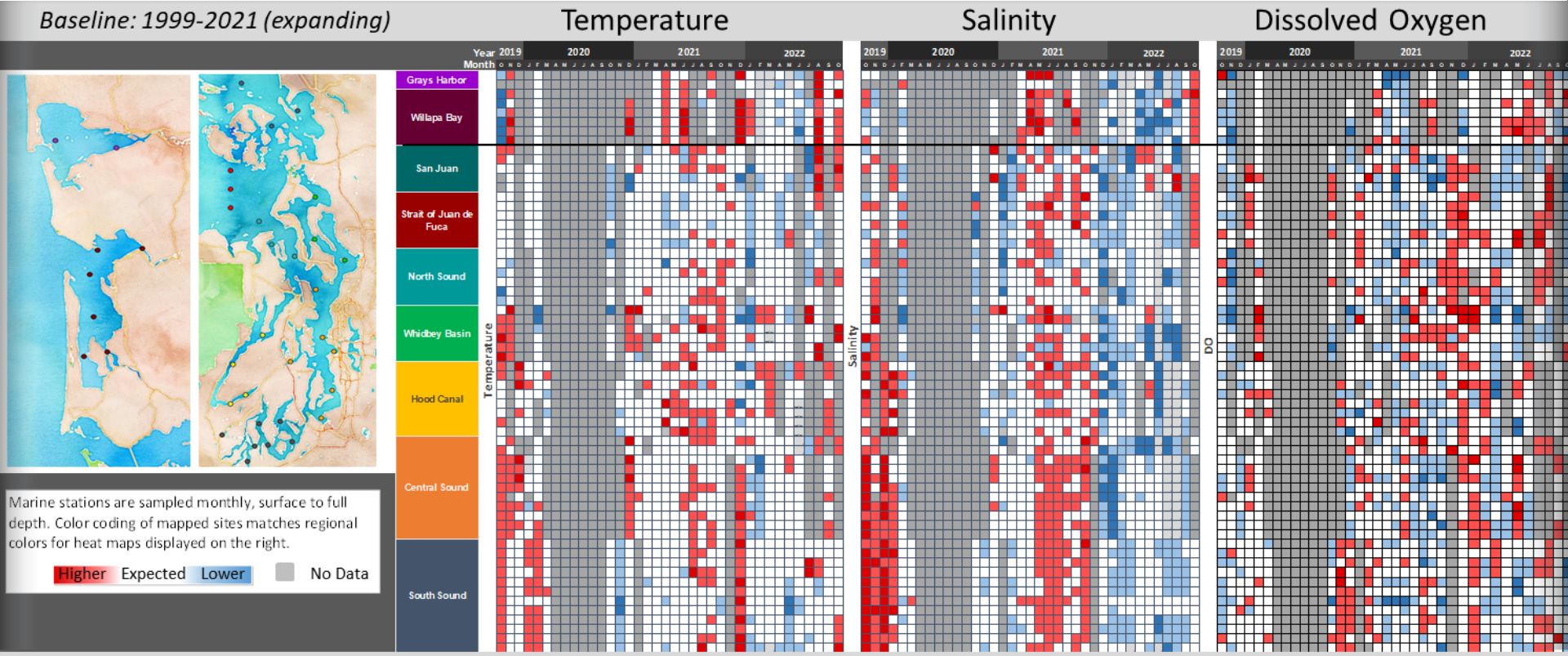
T: Expected

S: Mostly expected, higher in the Straits & San Juans

DO: Expected


The year 2022 was relatively normal for temperature and oxygen concentrations and lower in salinity, reflecting a lot of rain in spring. In contrast, 2019 and 2021 were saltier.

Baseline: 1999-2021 (expanding)



Marine stations are sampled monthly, surface to full depth. Color coding of mapped sites matches regional colors for heat maps displayed on the right.

Higher Expected Lower No Data



Blooms, some colorful, are continuing in multiple terminal bays. Numerous patches of jellyfish are seen in Budd Inlet and Liberty Bay. Sediment is visibly transported by the Puyallup River and resuspended along shorelines in Totten Inlet, in some places mixed with soil. It was smoky!

[Start here](#)

Landing over Swantown Marina, Olympia



Front

### Mixing and fronts:

Small fronts along freshwater plumes of creeks and rivers.

### Jellyfish and fish:

In Budd Inlet and Liberty Bay.



Plume

### Suspended sediment:

Sediment is visibly transported by the Puyallup River and resuspended along shorelines in Totten Inlet, in some places mixed with soil.



Bloom

### Visible blooms:

Red-brown blooms in Budd, Henderson and Sinclair Inlets and Liberty Bay.

Turquoise bloom in Quartermaster Harbor and parts of Budd Inlet.



Debris

### Debris:

Pretty much absent.



Ongoing [wildfires in the Cascades](#) mean smoky skies lingered in the Puget Sound area

## Aerial navigation guide

Date: 10-10-2022

Click on numbers



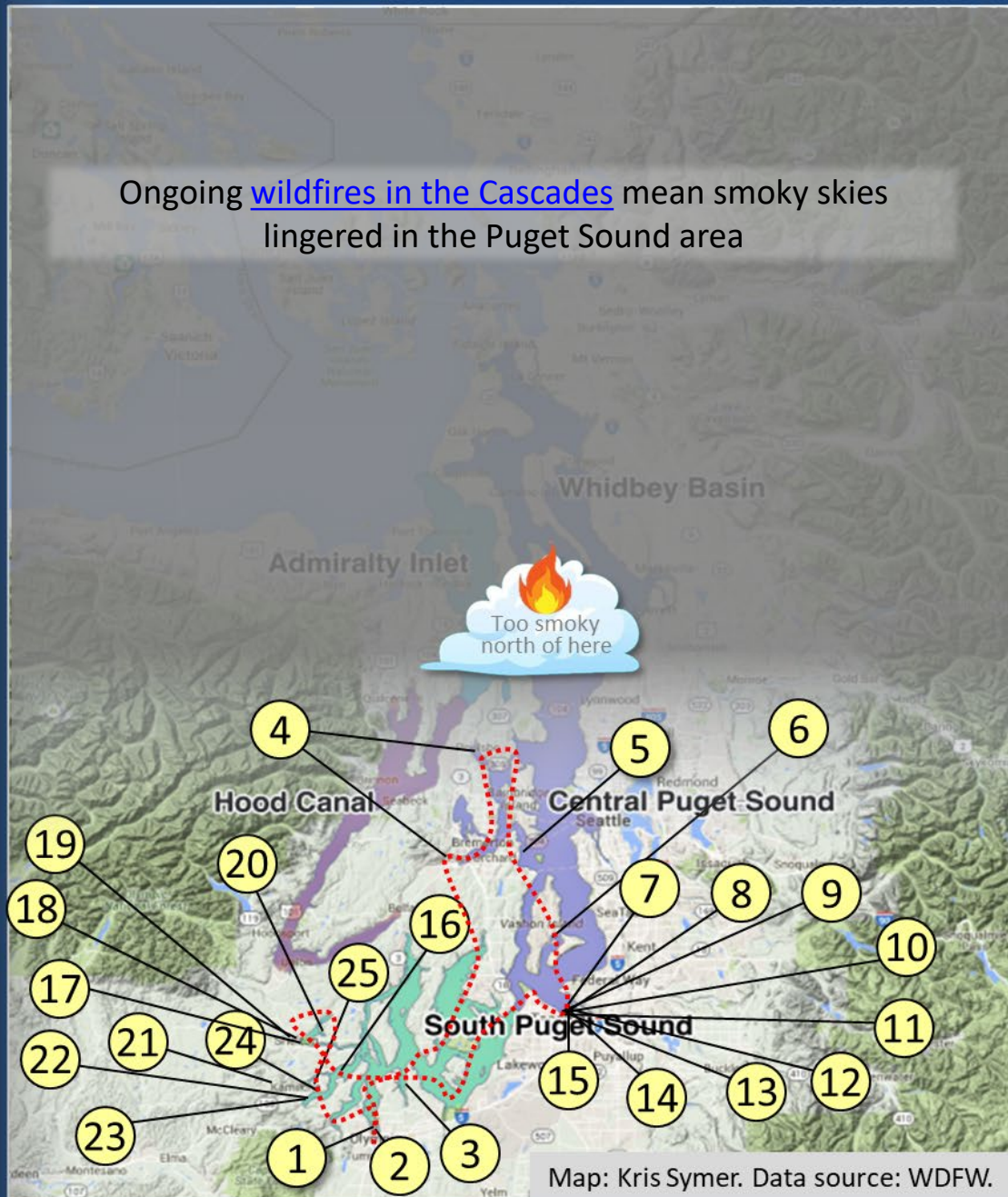
26 27  
28 29

### Flight Observations

Intermediate visibility, Central Sound under thick smoke blanket

Tide data from 10-10-2022 (Seattle):

Time	Pred	High/Low
06:00 AM	10.66	H
11:49 AM	2.85	L
05:45 PM	11.51	H

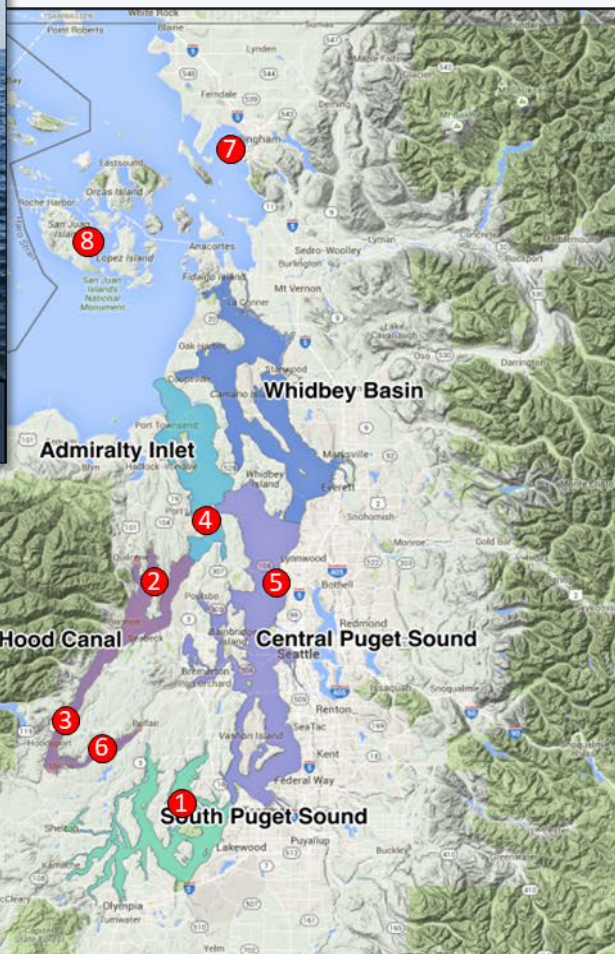




## Connecting aerial observation with data from ORCA moorings



Nick Michel-Hart,  
John Mickett, UW/APL.



[NANOOS NVS Data Explorer](#)



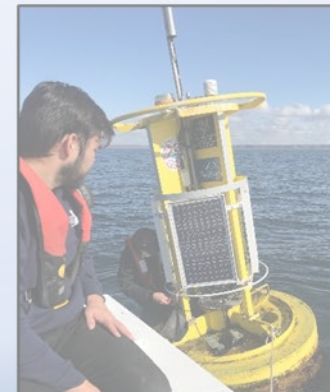
View products by mooring:

### Puget Sound

- 1 [Carr Inlet](#)
- 2 [Dabob Bay](#)
- 3 [Hoodsport](#)
- 4 [Hansville](#)
- 5 [Point Wells](#)
- 6 [Twanoh](#)

### Salish Sea

- 7 [Bellingham Bay](#)
- 8 [Friday Harbor](#)



Thayne Yazzie, NWIC,  
Robert Daniels, UW/APL



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Patches of jellyfish and a red-brown and turquoise blooms. Location: Budd Inlet (South Sound), 11:57 AM

Summary

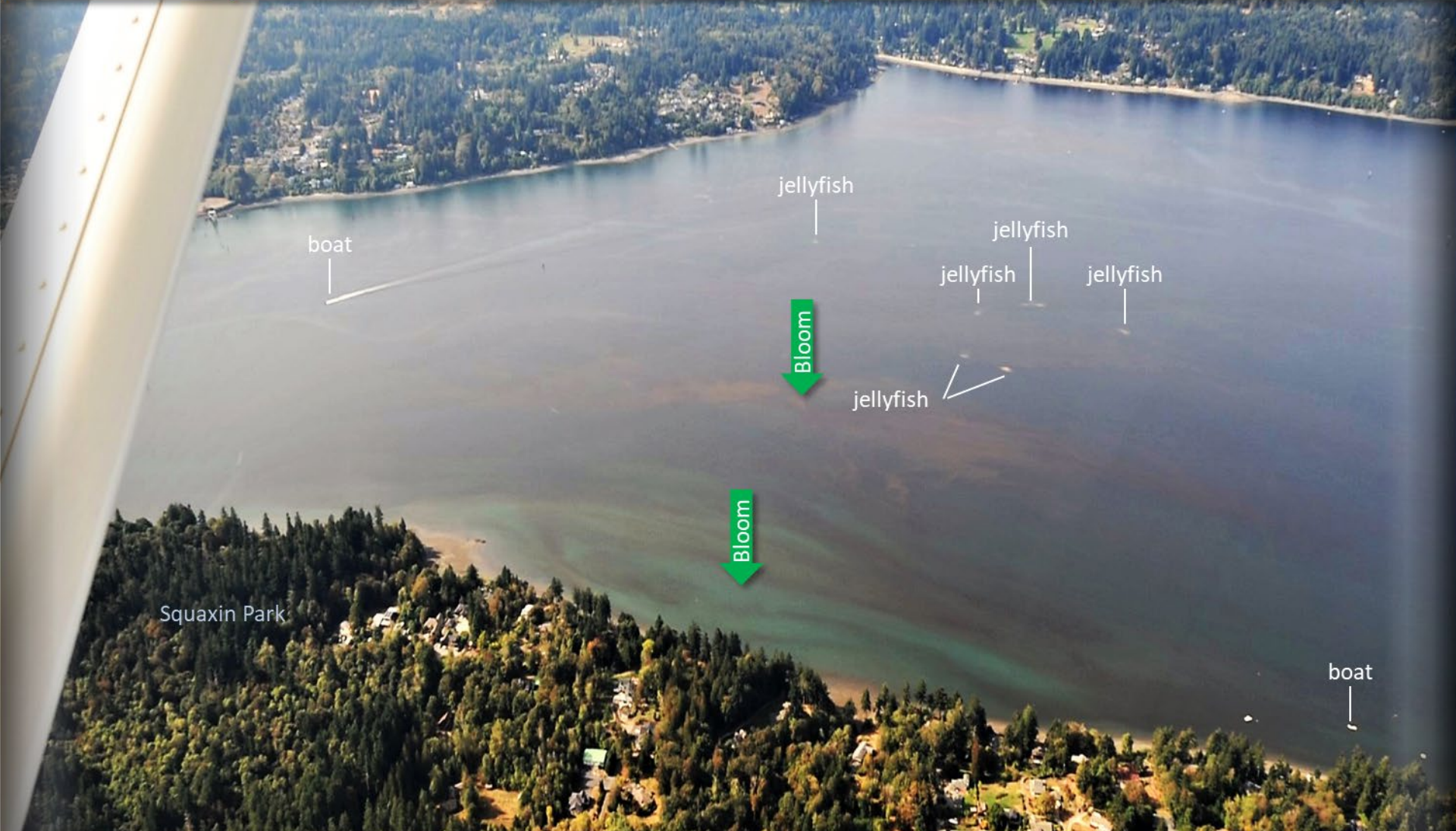
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Patches of jellyfish and a red-brown and turquoise blooms. Location: Budd Inlet (South Sound), 11:54 AM



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*A. Long ribbon of red bloom parallel to the shore of the outer bay, B. Patchy red-brown bloom inside the bay.*  
Location: Henderson Inlet (South Sound), 12:03 PM



Summary

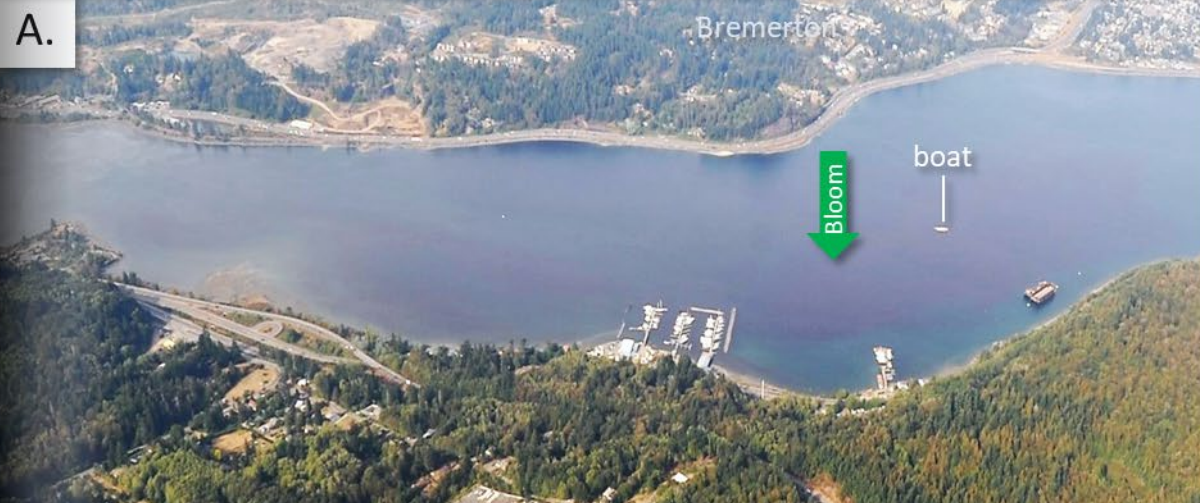
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*A Red bloom inside inlet B. Smoky air, C. Red bloom and jellyfish patches. D. Red-brown bloom north of front.*  
 Location: A. Sinclair Inlet, B. Bremerton, C. Liberty Bay, D. Entrance to Rich Passage (Central Sound). 12:20 PM



Summary

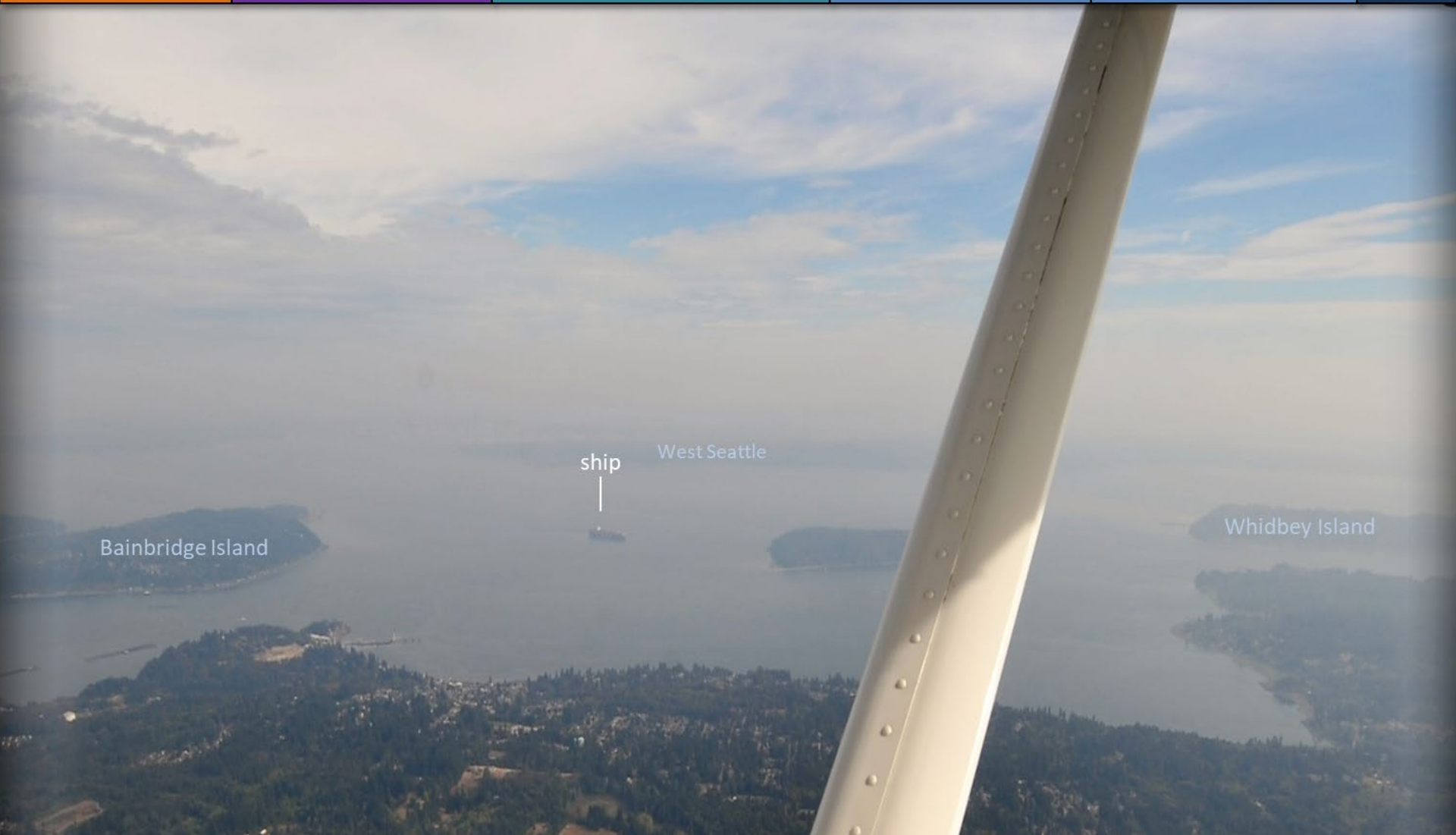
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*Smoky air moving in from the north forced the EOPS flight to return to South Puget Sound*  
Location: Rich Passage- Blake Island (Central Sound), 12:35 PM



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*Strong turquoise-green-brown bloom.* Location: Quartermaster Harbor (South Sound), 12:40 PM



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*Puyallup River plume, rich in glacial flour, discharging into Commencement Bay.*

Location: Commencement Bay (Central Sound), 12:44 PM



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*A wake left by a barge reveals how thin the sediment-laden Puyallup River plume is.*  
Location: Commencement Bay (Central Sound), 12:45 PM





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*The Puyallup River plume, with internal waves and patchy structure.*

Location: Commencement Bay (Central Sound), 12:45 PM



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*A well-defined plume and fronts at the mouth of the Puyallup River.*  
Location: Commencement Bay (Central Sound), 12:46 PM



Summary

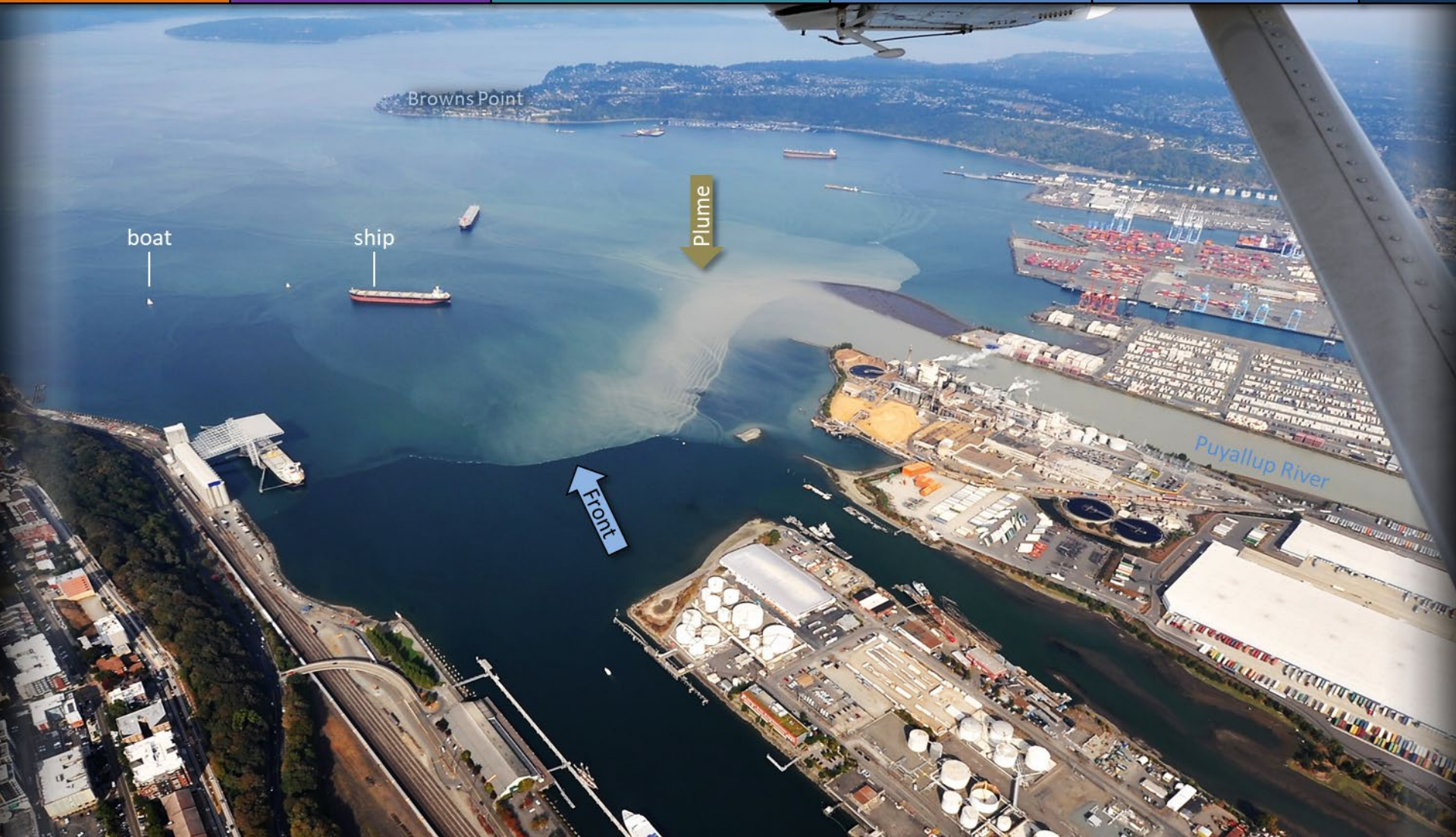
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*Puyallup River plume, carrying fine sediments (not reaching into the Voss Waterway).  
Location: Commencement Bay (Central Sound), 12:46 PM*



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*Puyallup River plume, seen from the river side.*

Location: Commencement Bay (Central Sound), 12:47 PM



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*Puyallup River plume seen from the river side.*  
Location: Commencement Bay (Central Sound), 12:47 PM



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*Puyallup River, a highly urbanized waterway.*

Location: Commencement Bay (Central Sound), 12:47 PM



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*A wake left by a barge illustrates how the thin sediment-laden Puyallup River plume spreads across the bay.*  
Location: Commencement Bay (Central Sound), 12:49 PM



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*A. Nearshore eddies with sediment suspension and deposition. B Larger geographical context.*

Location: Totten Inlet (South Sound), 1:10 PM





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*Oakland Bay seen from above Shelton, with Goldsborough Creek estuary.*

Location: Oakland Bay (South Sound), 1:15 PM



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*Plume of Goldsborough Creek extending into the bay.  
Location: Oakland Bay (South Sound), 1:15 PM*



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*Oakland Bay looking onto Shelton, with Goldsborough Creek estuary and Sierra Pacific Sawmill.  
Location: Oakland Bay (South Sound), 1:15 PM*



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A. Exposed mudflats in western portions of the bay. B-C. Chapman Cove with aquaculture rafts at low tide. Exposed mudflats with water from Campbell Creek. Location: Oakland Bay (South Sound), 1:17 PM



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Skookum Natural Area Preserve

*Exposed mudflats of the southern portions of the bay during low tide.*  
Location: Little Skookum Inlet (South Sound), 1:22 PM



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*Exposed mudflats of the southern portions of Oyster Bay during low tide.*  
Location: Totten Inlet (South Sound), 1:24 PM



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Kennedy Creek

diatoms

Kennedy Creek Natural Area Preserve

*Exposed mudflats of the southern portions of the bay during low tide, with epibenthic diatom mats (brown).*

Location: Totten Inlet (South Sound), 1:25 PM



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*Very brown suspended nearshore sediment on both sides of the bay. Plume of Kennedy Creek.*  
Location: Totten Inlet (South Sound), 1:25 PM





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A.



A. Suspended nearshore sediment on the eastern side of the bay (Hudson Cove). B. Aquaculture pens.  
Location: Totten Inlet (South Sound), 1:25 PM



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We add your observations to EOPS because we believe they matter.

- In the following pages you will find water quality issues that engaged and concerned citizens submitted to us.
- We feel that your observations should be shared side-by-side with aerial photo records.
- We encourage you to share your observations with us. Together we can document more.



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[Wikipedia](#) (shortened text):

Coccolithophores microscopic phytoplankton cells that are ecologically important and play significant roles in the [carbon cycle](#). They are of interest to those studying global [climate change](#) because their coccoliths are a [carbon sink](#). Management strategies are being employed to prevent [eutrophication](#)-related coccolithophore blooms, as these blooms lead to a decrease in nutrient flow to lower levels of the ocean.

Natalie Coleman 9/1/2022

A coccolithophore bloom from Hood Canal staining the water turquoise, observed and sent in by Natalie.



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*Aurelia sp.*

*“There was a HUGE smack of moon jellies in Sequim Bay that I saw this AM. Thousands. Went from north of the state park south to just before Schoolhouse Point. Closer to the Western shore”. - Amy Holms*



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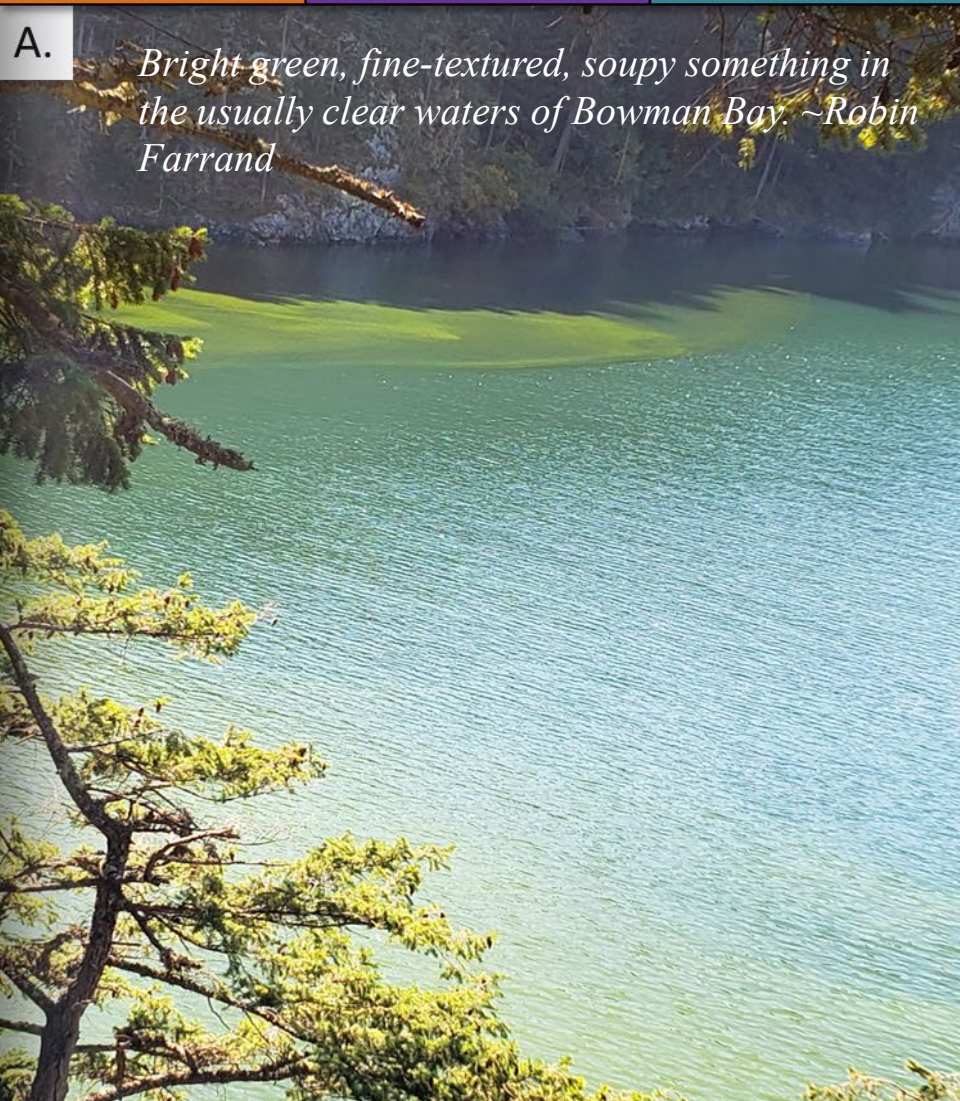
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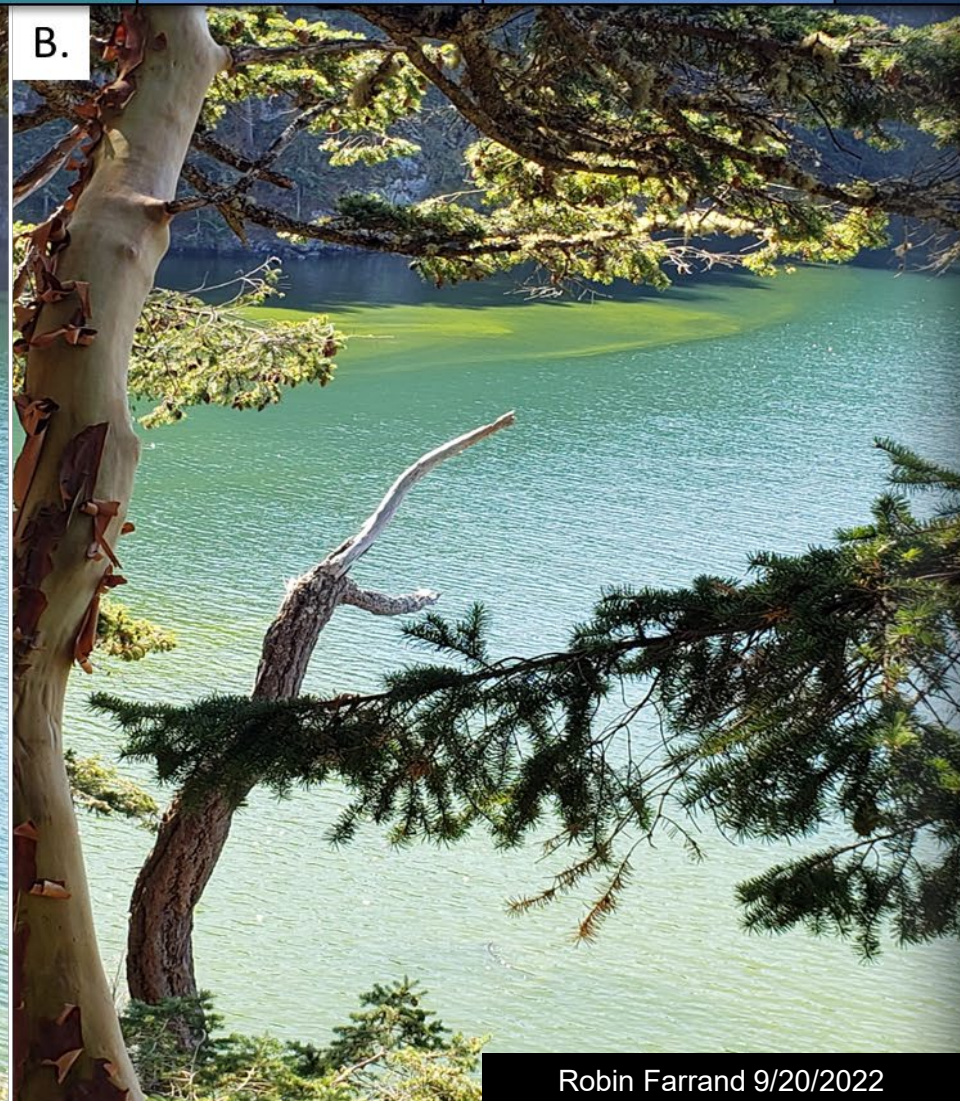
Data

A.

*Bright green, fine-textured, soupy something in the usually clear waters of Bowman Bay. ~Robin Farrand*



B.

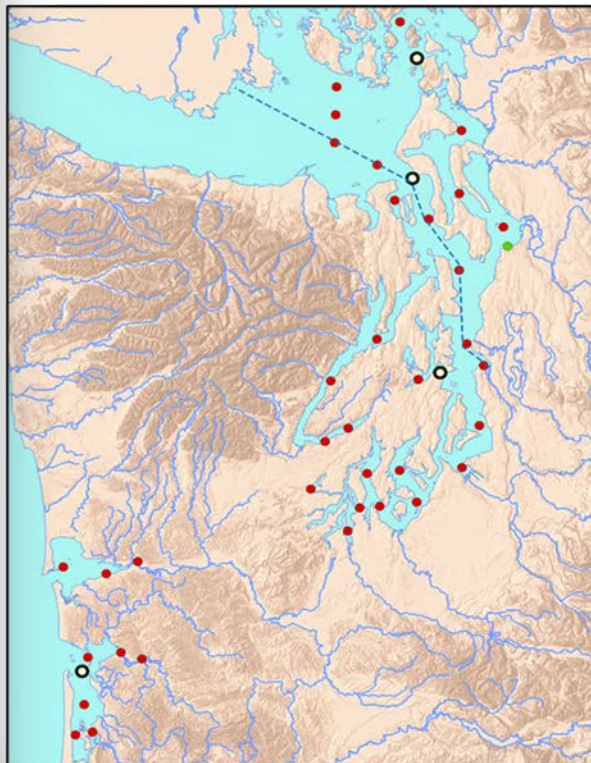


Robin Farrand 9/20/2022

Bright green bloom reoccurring near Deception Pass. Location: Bowman Bay, Fidalgo Island

## Long-term monitoring data from Puget Sound and coastal bays

- 39 stations sampled monthly
- 16 physical, chemical, biogeochemical parameters
- data from 1999-present



Natalie and Holly on our new Research Vessel, Salish SeaCat

Get your data

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**We have published 99 editions!**

**Find all previous Eyes Over Puget Sound editions at the end of this document.**

**Recommended Citation (example for September 2018 edition):**

Washington State Department of Ecology. 2018. Eyes Over Puget Sound: Surface Conditions Report, September 17, 2018. Publication No. 18-03-075. Olympia, WA.  
<https://fortress.wa.gov/ecy/publications/documents/1803075.pdf>.

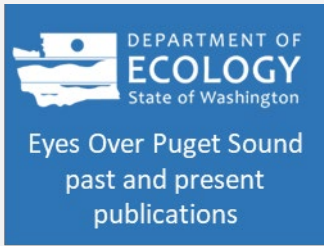


Many thanks to our business partners:  
Shannon Point Marine Lab (WWU), Swantown  
Marina, and Kenmore Air.

**Contact:**

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[Christopher.Krembs@ecy.wa.gov](mailto:Christopher.Krembs@ecy.wa.gov)  
Marine Monitoring Unit  
Environmental Assessment Program  
Washington State  
Department of Ecology

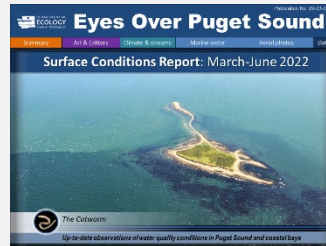
If you want to be added to our  
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[Christopher.Krembs@ecy.wa.gov](mailto:Christopher.Krembs@ecy.wa.gov)



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**February\_25\_2022**  
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**January\_7\_2022**  
[Publication No. 22-03-070](#)



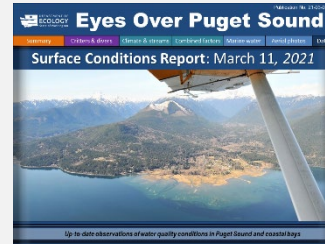
**September\_8\_2021**  
[Publication No. 21-03-075](#)



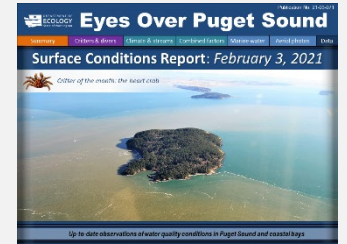
**June\_17\_2021**  
[Publication No. 21-03-074](#)



**April\_1\_2021**  
[Publication No. 21-03-073](#)



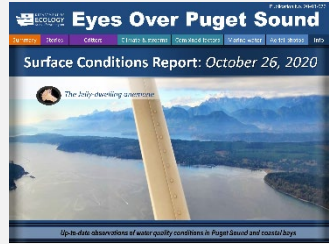
**March\_11\_2021**  
[Publication No. 21-03-072](#)



**February\_3\_2021**  
[Publication No. 21-03-071](#)



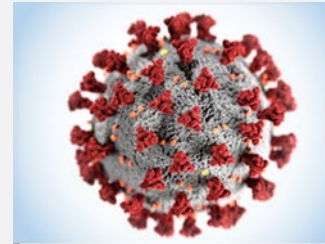
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[Publication No. 21-03-070](#)



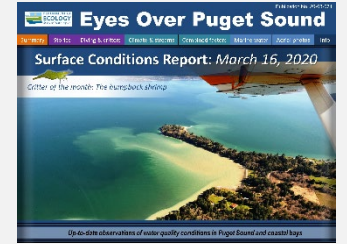
**October\_26\_2020**  
[Publication No. 20-03-073](#)



**September\_28\_2020**  
[Publication No. 20-03-072](#)



No coverage due to COVID-19 pandemic from April-September



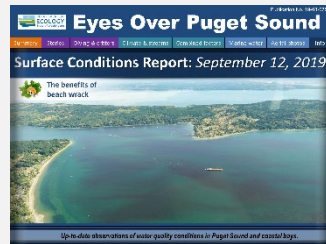
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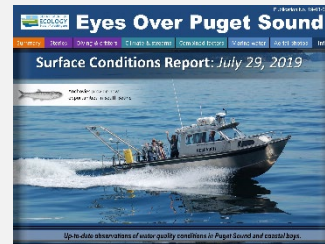
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**October\_30\_2019**  
[Publication No. 19-03-076](#)



**September\_12\_2019**  
[Publication No. 19-03-075](#)

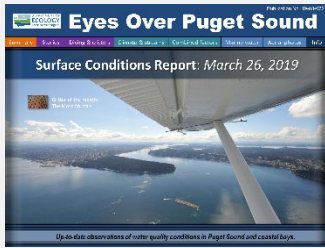


**July\_29\_2019**  
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**June\_4\_2019**  
[Publication No. 19-03-073](#)





**March\_26\_2019**  
[Publication No. 19-03-072](#)



**February\_21\_2019**  
[Publication No. 19-03-071](#)



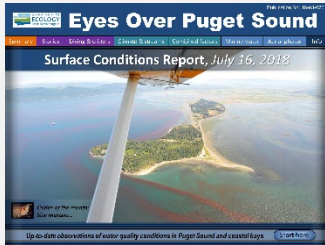
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**November\_6\_2018,**  
[Publication No. 18-03-075](#)



**September\_17\_2018,**  
[Publication No. 18-03-074](#)



**July\_16\_2018,**  
[Publication No. 18-03-073](#)



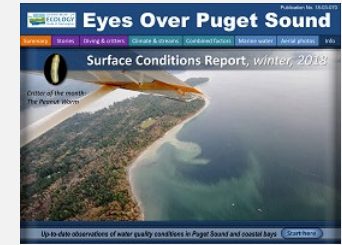
**June\_28\_2018,**  
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**May\_22\_2018,**  
[Publication No. 18-03-075](#)



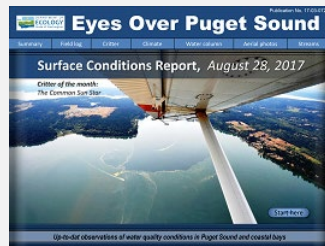
**April\_19\_2018,**  
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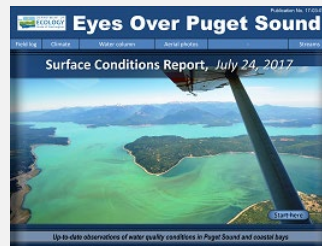
**Winter\_2018,**  
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**October\_31\_2017,**  
[Publication No. 17-03-073](#)



**August\_28\_2017,**  
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**July\_24\_2017,**  
[Publication No. 17-03-071](#)



**June\_6\_2017,**  
[Publication No. 17-03-070](#)



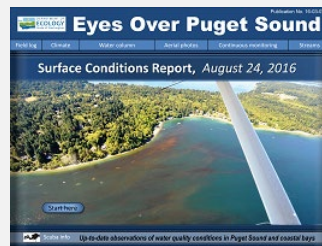
**December\_31\_2016,**  
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**November\_22\_2016,**  
[Publication No. 16-03-078](#)



**September\_26\_2016,**  
[Publication No. 16-03-077](#)



**August\_24\_2016,**  
[Publication No. 16-03-076](#)



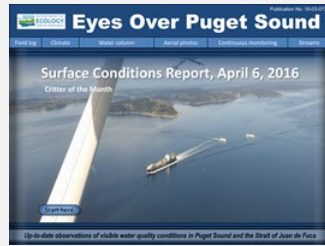
**July\_20\_2016,**  
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**June\_27\_2016,**  
[Publication No. 16-03-074](#)



**May\_2\_2016,**  
[Publication No. 16-03-073](#)



**April\_6\_2016,**  
[Publication No. 16-03-072](#)



**March\_16\_2016,**  
[Publication No. 16-03-071](#)



**February\_8\_2016,**  
[Publication No. 16-03-070](#)



**December\_30\_2015,**  
[Publication No. 15-03-080](#)



**December\_14\_2015,**  
[Publication No. 15-03-079](#)



**October\_6\_2015,**  
[Publication No. 15-03-078](#)



**September\_21\_2015,**  
[Publication No. 15-03-077](#)



**August\_8\_2015,**  
[Publication No. 15-03-076](#)



**July\_6\_2015,**  
[Publication No. 15-03-075](#)



**June\_8\_2015,**  
[Publication No. 15-03-074](#)



**April\_29\_2015,**  
[Publication No. 15-03-073](#)



**March\_24\_2015,**  
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**February\_17\_2015,**  
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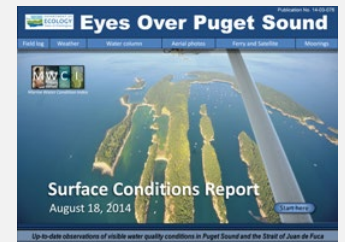
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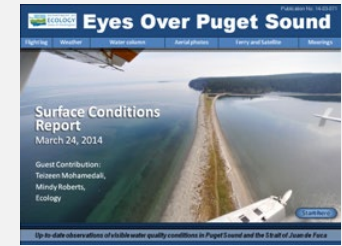
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**May\_12\_2014,**  
[Publication No. 14-03-073](#)



**April\_21\_2014,**  
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**March\_24\_2014,**  
[Publication No. 14-03-071](#)



**February\_4\_2014,**  
[Publication No. 14-03-070](#)



**December\_31\_2013,**  
[Publication No. 13-03-081](#)



**November\_21\_2013,**  
[Publication No. 13-03-080](#)



**October\_28\_2013,**  
[Publication No. 13-03-079](#)



**September\_11\_2013,**  
[Publication No. 13-03-078](#)



**August\_21\_2013,**  
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**July\_15\_2013,**  
[Publication No. 13-03-076](#)



**June\_17\_2013,**  
[Publication No. 13-03-075](#)



**May\_20\_2013,**  
[Publication No. 13-03-074](#)



**April\_8\_2013,**  
[Publication No. 13-03-073](#)



**Mar\_25\_2013,**  
[Publication No. 13-03-072](#)



**February\_26\_2013,**  
[Publication No. 13-03-071](#)



**January\_15\_2013,**  
[Publication No. 13-03-070](#)



**December\_13\_2012,**  
[Publication No. 12-03-081](#)



**November\_8\_2012,**  
[Publication No. 12-03-080](#)



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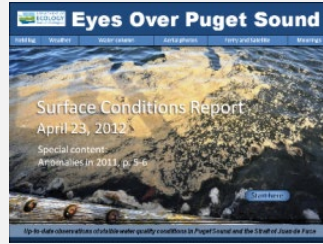
**July\_31\_2012,**  
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[Publication No. 12-03-075](#)



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**April\_23\_2012,**  
[Publication No. 12-03-073](#)



**March\_19\_2012,**  
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[Publication No. 12-03-071](#)



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[Publication No. 12-03-070](#)



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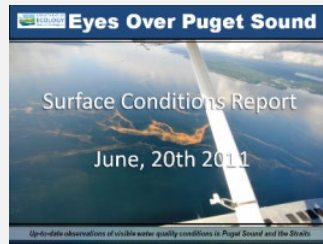
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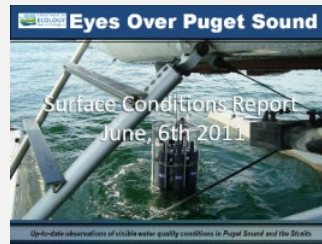
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**June\_6\_2011,**  
[Publication No. 11-03-075](#)



**May\_4\_2011,**  
[Publication No. 11-03-074](#)



**April\_27\_2011,**  
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