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DEPARTMENT OF ECOLOGY State of Washington

Conditions in the Water Column - (Marine Flights)

2015

2015 - Monthly	*Conditions in Puget Sound and coastal bays*
2015 - Summary	*Previous years in summary*
Anomaly Details	*Monthly observations in historic context*
Our Stations	*Our stations in Puget Sound and coastal bays*

Glossary:

Transmission – Beam transmission measuring how clear the water is

DO – Dissolved oxygen in the water

In situ fluorescence – Concentration of photo pigments to estimate phytoplankton abundance

Higher – Higher values than a reference baseline over many years that is specific to the month and region in question

Lower – Lower values than a reference baseline over many years that is specific to the month and region in question

PDO – Pacific Decadal Oscillation

NPGO – North Pacific Gyre Oscillation

Boundary conditions: **WARM air and water temperatures!** Rivers run above normal carrying water from a melting snowpack. Large warm water anomaly is 1.5-2 °C above normal and lower salinity affect water density. As a result of mild weather, phytoplankton biomass near the surface is higher, but below, lower DO is spreading throughout Puget Sound. Water clarity is clearer in Hood Canal. The PDO is very positive, downwelling is at expected levels, and NPGO is down.

SUMMARY GREATER PUGET SOUND REGION – Much warmer water, lower salinity, and lower water density. Transmission is lower in North Sound due to Fraser River sediment, but is higher in Hood Canal. *In situ* fluorescence is very high due to mild conditions.

1. **San Juan-North Sound Region:** Much warmer, lower density, lower transmission, and lower DO, particularly at ADM001. Higher *in situ* fluorescence.

2. **Central Sound Region:** Much warmer, lower salinity, lower density, and lower DO. Higher *In situ* fluorescence.

3. **Whidbey Basin:** Much warmer, lower salinity, and lower density. Variable DO conditions - higher near river, lower at deep sites. Very low transmission throughout the water column, yet, higher *in situ* fluorescence at the surface.

4. **Hood Canal:** Much warmer, lower salinity, lower density, and lower DO. Higher transmission.

5. **South Sound:** Much warmer, lower salinity, lower density, and lower DO. Higher *in situ* fluorescence.

SUMMARY COASTAL BAYS REGIONS – Much warmer. Transmission is very low at a few stations. In situ fluorescence was generally higher.

1. **Grays Harbor:** Much warmer, lower DO, and lower transmission.

2. **Willapa Bay:** Much warmer, lower DO, and lower transmission confined to a few stations. Very high fluorescence.

Glossary (explain abbreviations and terms)

Boundary conditions: **WARM air and water temperatures!** Fraser River flows remain high whereas flows in other rivers are declining. Water is very warm, with lower salinity and density. Lower DO is everywhere, except in Hood Canal. Phytoplankton biomass is higher in most of Puget Sound, but not at the Coast. Water conditions is clearer in Puget Sound. The PDO is very positive, downwelling is at expected levels, and the NPGO is down.

SUMMARY GREATER PUGET SOUND REGION – Much warmer, fresher, and as a consequence, less dense. Lower DO, particularly in North and South Sound. Fluorescence is higher. Transmission is high with expected values regionally confined to North and South Sound.

1. **San Juan-North Sound Region:** Much warmer, fresher, and less dense. Much lower DO overall. High transmission regionally confined to North Sound. Higher *in situ* fluorescence.

2. **Central Sound Region:** Much warmer, fresher, and less dense. Lower DO, especially at depth. Very high transmission. Higher *in situ* fluorescence.

3. **Whidbey Basin:** Much warmer, fresher, and less dense. Lower DO, especially at depth. Bloom and super saturation of DO at station PSS009. Regionally variable *in situ* fluorescence.

4. **Hood Canal:** Much warmer, fresher, and less dense with lower DO at depth. Regionally variable *in situ* fluorescence.

5. **South Sound:** Much warmer, fresher, less dense, and much lower DO. Near the surface, higher *in situ* fluorescence.

SUMMARY COASTAL BAYS REGIONS – Much warmer, lower transmission, and lower DO particularly in Willapa Bay.

1. **Grays Harbor:** Much warmer and fresher towards the ocean. Lower DO and transmission.

2. **Willapa Bay:** Much warmer and fresher towards the ocean. Much lower DO and transmission.

Glossary (explain abbreviations and terms)

Boundary conditions: **Very warm**, sunnier. Short and strong rain events cannot compensate low rain-fed river flows. In contrast, snow-fed rivers are running high. Lower salinity is everywhere in Puget Sound in response to rain and changes in ocean source water of "the blob". **DO is lower**. The PDO is very positive, downwelling is at expected levels, and NPGO is down.

SUMMARY GREATER PUGET SOUND REGION – Much higher temperatures with lower salinity, lower density, and much lower DO. Transmission regionally higher. High *in situ* fluorescence is confined to South Sound.

1. **San Juan-North Sound Region:** Much higher temperatures with lower salinity and density, especially around the San Juan Islands. Much lower DO.
2. **Central Sound Region:** Much higher temperatures with decrease in salinity and density. Much lower DO. Regional variations in transmission. Higher *in situ* fluorescence.
3. **Whidbey Basin:** Much higher temperatures with lower salinity, density, and DO. Higher transmission.
4. **Hood Canal:** Much higher temperatures with lower salinity and density. Lower DO confined to greater depth. Regional variations in transmission.
5. **South Sound:** Much higher temperatures with lower salinity and density. Higher transmission. (DO not assessed).

SUMMARY COASTAL BAYS REGIONS – Much higher temperature with lower salinity, density, and DO.

1. **Grays Harbor:** Much higher temperature with lower salinity and density.
2. **Willapa Bay:** Much higher temperature with lower salinity, density, and DO.

Glossary (explain abbreviations and terms)

Boundary conditions: Air temperatures are normal, but precipitation is low. Fraser River continues to run high whereas rivers in Washington are running very low. **Ocean temperatures and PDO remain significantly above normal,** while upwelling conditions are at expected levels.

SUMMARY GREATER PUGET SOUND REGION – Deep water very warm, fresher, and less dense. Surface warm with expected salinity and density. DO lower at depth, but increasingly expected near surface. Very low transmission in North Sound. *In situ* fluorescence regionally variable.

1. **San Juan-North Sound Region:** Lower salinity and warmer. Low DO confined to Rosario Strait and by Port Townsend. Higher DO in Admiralty Reach at depth. Higher *in situ* fluorescence.

2. **Central Sound Region:** Deep water much warmer, fresher, and less dense. Warm surface water. At depth, expected salinity and density. Lower DO confined to deeper water. Higher *in situ* fluorescence.

3. **Whidbey Basin:** Warmer water with lower DO confined to deeper water. Very high transmission. Very low *in situ* fluorescence.

4. **Hood Canal:** Much warmer, fresher, less dense, and lower DO confined to deeper water. Much higher transmission.

5. **South Sound:** Much warmer and fresher. Generally lower DO. Much higher transmission and *in situ* fluorescence.

SUMMARY COASTAL BAYS REGIONS – Warmer, but otherwise expected.

1. **Grays Harbor:** Warmer, but otherwise expected.

2. **Willapa Bay:** Warmer, but lower *in situ* fluorescence.

Glossary (explain abbreviations and terms)

Boundary conditions: Air temperatures were higher with very little precipitation. River flows were generally very low, yet the Fraser River is still near expected values. Ocean conditions were significantly warmer than normal. Near the coast, upwelling lowered otherwise warmer water temperatures of the Blob to expected temperatures.

SUMMARY GREATER PUGET SOUND REGION – Water was warmer and less dense. DO was lower, but less than in previous months. DO saturation has become expected, except in Hood Canal. Super-saturation of DO was ubiquitously high across at surface, yet transmission was higher.

1. **San Juan-North Sound Region:** n.a.
2. **Central Sound Region:** Warmer and less dense water with overall lower DO and higher transmission.
3. **Whidbey Basin:** n.a.
4. **Hood Canal:** Warmer and less dense water with lower DO. Higher transmission and lower *in situ* fluorescence.
5. **South Sound:** Warmer and less dense water with lower DO. Higher transmission and lower *in situ* fluorescence.

SUMMARY COASTAL BAYS REGIONS – Saltier and denser water. Water temperatures cooler than in Puget Sound which suggests the influence of upwelled water. Higher transmissivity of the water.

1. **Grays Harbor:** n.a.
2. **Willapa Bay:** Saltier and denser water with expected temperatures. Higher transmission

Glossary (explain abbreviations and terms)

Boundary conditions:
June was hot, dry, and sunny. Mean June temperatures ranked as the warmest on record. River flows were low, and the Fraser River transitioned from above normal to below normal. Upwelling was strong, PDO was in warm phase, and NPGO was negative.

SUMMARY GREATER PUGET SOUND REGION – Warmer water temperatures. Regionally lower salinity in the San Juan Islands paired with lower DO. Transmission was variable in the North and higher in Hood Canal and Central.

1. **San Juan-North Sound Region**: Water temperature are higher. Salinity and density are lower. Lower DO confined to San Juan Islands. Transmission was regionally variable.
2. **Central Sound Region:** Higher water temperatures, but very high transmission.
3. **Whidbey Basin:** Higher water temperatures, with regionally variable DO concentrations. Transmission was lower and *in situ* fluorescence was higher.
4. **Hood Canal:** Higher water temperatures. Transmission higher and *in situ* fluorescence higher.
5. **South Sound:** Higher water temperatures.

SUMMARY COASTAL BAYS REGIONS – Density, temperature, and salinity were all higher while DO was lower.

1. **Grays Harbor:** Higher water temperature, density, and salinity.
2. **Willapa Bay:** Higher water temperature, density, and salinity but lower DO.

Glossary (explain abbreviations and terms)

Boundary conditions:
Hot, dry, and sunny weather with record average temperature at SeaTac. Total precipitation and river flows were below normal. Only the Nisqually River showed above-normal flows toward the end of the month. Coastal upwelling was normal, the PDO was in the warm phase, and NPGO was negative.

SUMMARY GREATER PUGET SOUND REGION – Much warmer and variable DO which was higher in Whidbey Basin and South Sound and low in Central Basin and southern Hood Canal. Transmission was higher in Central Sound and *in situ* fluorescence was higher in South Sound.

1. **San Juan-North Sound Region:** Warmer water. *In situ* fluorescence was regionally more variable than normal.
2. **Central Sound Region:** Much warmer, saltier, and clearer water (higher transmission), but lower DO.
3. **Whidbey Basin:** Much warmer and higher DO (especially at surface and in shallow areas). *In situ* fluorescence was more variable than normal.
4. **Hood Canal:** Much warmer with lower DO at intermediate depth.
5. **South Sound:** Much warmer and higher DO coinciding with regionally higher *in situ* fluorescence.

SUMMARY COASTAL BAYS REGIONS – Much warmer, lower DO with very low water transmission data (turbid water). Higher *in situ* fluorescence confined to Willapa Bay.

1. **Grays Harbor:** Much warmer and much lower transmission (turbid water).
2. **Willapa Bay:** Warmer saltier and denser. Lower DO with new minima at mid-bay sites. Transmission was lower and *in situ* fluorescence was higher.

Glossary (explain abbreviations and terms)

Boundary conditions: August air temperatures were warmer than normal which match very high sea surface temperatures in the NE Pacific. The PDO remained significantly above normal. Precipitation in western Washington was higher than normal, although river flows remained below normal, particularly for the Fraser River. Upwelling was typical for August.

SUMMARY GREATER PUGET SOUND REGION – Much warmer and saltier water with lower DO confined to South Sound and Hood Canal.

1. **San Juan-North Sound Region:** Much higher temperature and salinity with higher DO confined to the San Juan Islands.
2. **Central Sound Region:** Much higher temperature and salinity.
3. **Whidbey Basin:** Much higher temperature, higher salinity confined to the south. Lower transmission (less water clarity) than expected.
4. **Hood Canal:** Much higher temperature, higher salinity confined to the north, and lower than expected density and DO at depth. *In situ* fluorescence was higher.
5. **South Sound:** Much higher temperature and higher salinity at depth. Both DO and *in situ* fluorescence were lower than expected.

SUMMARY COASTAL BAYS REGIONS – Much warmer water with lower DO and *in situ* fluorescence, particularly in Willapa Bay.

1. **Grays Harbor:** Much higher temperature and lower DO and *in situ* fluorescence.
2. **Willapa Bay:** Much higher temperature and denser water, towards Naselle. Much lower DO and unexpected high variability of *in situ* fluorescence.

Glossary (explain abbreviations and terms)

Boundary conditions:
Ocean conditions remain warm, but air temperatures cooled off during September. Clouds and precipitation are higher to the north. River flows returning to near normal as is upwelling on the coast. An unremarkable month weather-wise.

SUMMARY GREATER PUGET SOUND REGION – Much higher temperatures and salinities. Lower DO confined to Hood Canal and South Sound. Transmission was higher than expected.

1. **San Juan-North Sound Region:** Higher temperatures.
2. **Central Sound Region:** Higher temperatures and salinities.
3. **Whidbey Basin:** Higher temperatures and salinities. Much lower transmission and higher *in situ* fluorescence. Low DO near Skagit River.
4. **Hood Canal:** Higher temperatures and salinities, yet the water surface is cooling. Unexpected variable DO - lower at surface and in the north. Higher DO at depth at south end of Hood Canal. Transmission was higher and *in situ* fluorescence was lower.
5. **South Sound:** Higher temperatures and salinities. Lower DO except in shallow finger inlets. Transmission was higher.

SUMMARY COASTAL BAYS REGIONS – Lower salinity and density. Lower DO confined to Willapa River.

1. **Grays Harbor:** Low salinity and density, but higher transmission.
2. **Willapa Bay:** Large gradient in salinity and density within bay. Much lower DO confined to Willapa River. Lower than expected *in situ* fluorescence.

Glossary (explain abbreviations and terms)

Boundary conditions: Air temperatures were much warmer. Although precipitation was near normal, there were several instances of heavy rainfall that broke daily records. PDO and ENSO were very much in the warm phase and NPGO was significantly below normal, yet the seasonal transition from upwelling to downwelling was expected.

SUMMARY GREATER PUGET SOUND REGION – Higher temperature and higher salinity confined to South Sound and Hood Canal.

1. **San Juan-North Sound Region:** n.a.
2. **Central Sound Region:** Higher temperatures and transmission.
3. **Whidbey Basin:** n.a.
4. **Hood Canal:** Higher temperatures and salinities. Low DO confined to southern Hood Canal. Transmission much higher which is indicative of clearer water.
5. **South Sound:** Higher temperatures and salinities. Higher *in situ* fluorescence.

SUMMARY COASTAL BAYS REGIONS – Lower DO confined to Willapa Bay. Much lower transmission.

1. **Grays Harbor:** Higher transmission which is indicative of clearer water.
2. **Willapa Bay:** Lower DO and transmission.

Glossary (explain abbreviations and terms)

Boundary conditions: Air temperature were below normal. Precipitation levels were above normal, particularly for South Sound. One wet period was interspersed with above normal rain. River flows were mostly above normal. Weak downwelling with the ENSO and PDO remaining in the warm phase.

SUMMARY GREATER PUGET SOUND REGION – Warmer and saltier than normal. Lower DO confined to some regions in South and North Sound. High transmission confined to Hood Canal.

1. **San Juan-North Sound Region:** Warmer and saltier than normal with lower DO.
2. **Central Sound Region:** Warmer, less dense, and higher *in situ* fluorescence.
3. **Whidbey Basin:** Warmer with lower transmissivity (low water clarity).
4. **Hood Canal:** Warmer with much higher transmissivity (high water clarity).
5. **South Sound:** Warmer and saltier with lower DO.

SUMMARY COASTAL BAYS REGIONS – Cooler otherwise expected.

1. **Grays Harbor:** Cooler, higher DO, and lower transmissivity (low water clarity).
2. **Willapa Bay:** Cooler and lower transmissivity (lower water quality).

Glossary (explain abbreviations and terms)

Boundary conditions: Temperatures an precipitation were above normal. December 2015 was the wettest on record in Olympia.

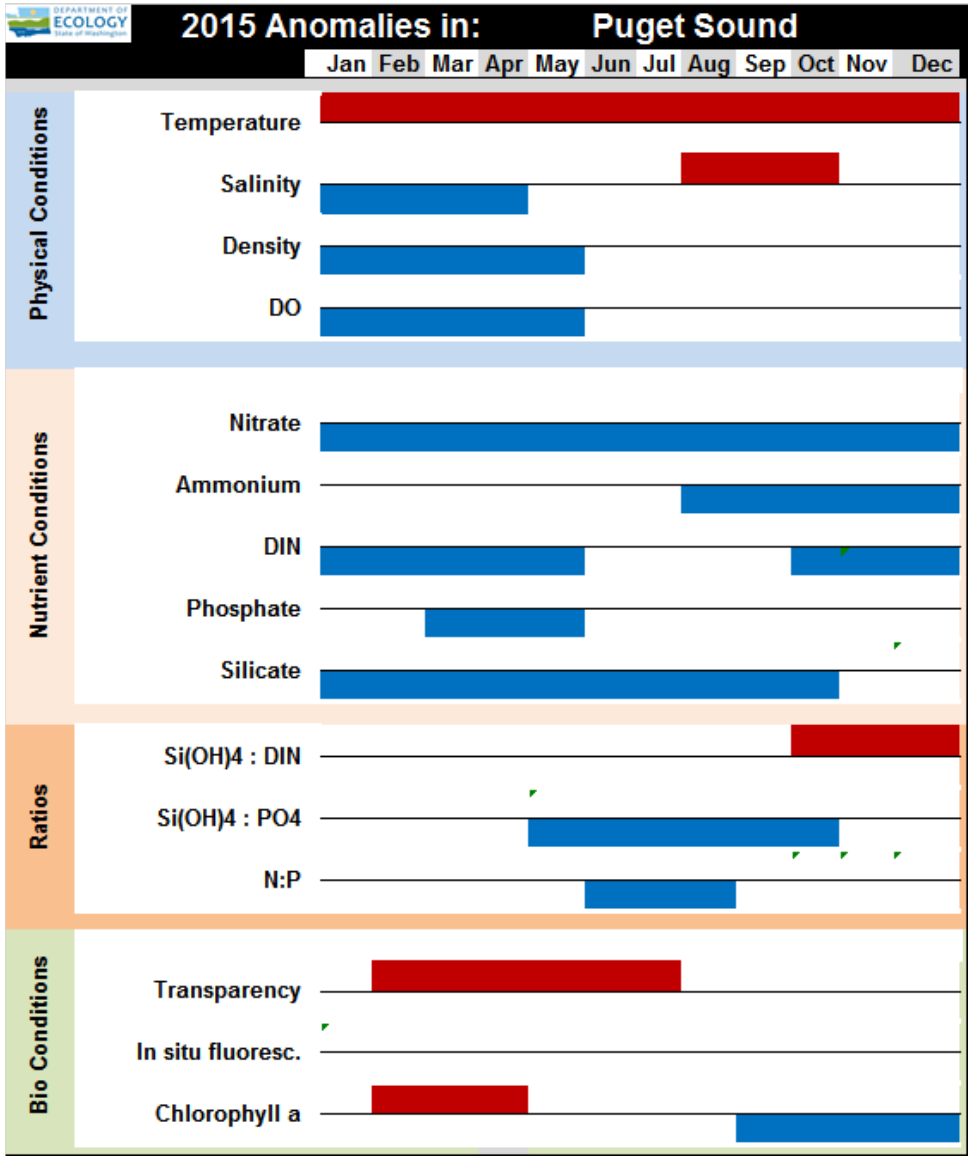
SUMMARY GREATER PUGET SOUND REGION – Fresher, warmer, and less dense. Lower surface DO confined to Hood Canal. Very low transmissivity (low water clarity).

1. **San Juan-North Sound Region:** Fresher, warmer, and less dense.
2. **Central Sound Region:** Fresher, warmer, and less dense. Low transmissivity (low water clarity) confined to the surface. In situ fluorescence was higher.
3. **Whidbey Basin:** Fresher, warmer, and less dense. Low transmissivity (low water clarity).
4. **Hood Canal:** Fresher, warmer, and less dense. Lower surface DO.
5. **South Sound:** Fresher, warmer, and less dense. Low transmissivity (low water clarity).

SUMMARY COASTAL BAYS REGIONS – Fresher and less dense. DO undersaturated as a result of fresher water. DO levels otherwise expected. Very low *in situ* fluorescence.

1. **Grays Harbor:** Fresher and less dense.
2. **Willapa Bay:** Fresher and less dense. Very low in situ fluorescence.

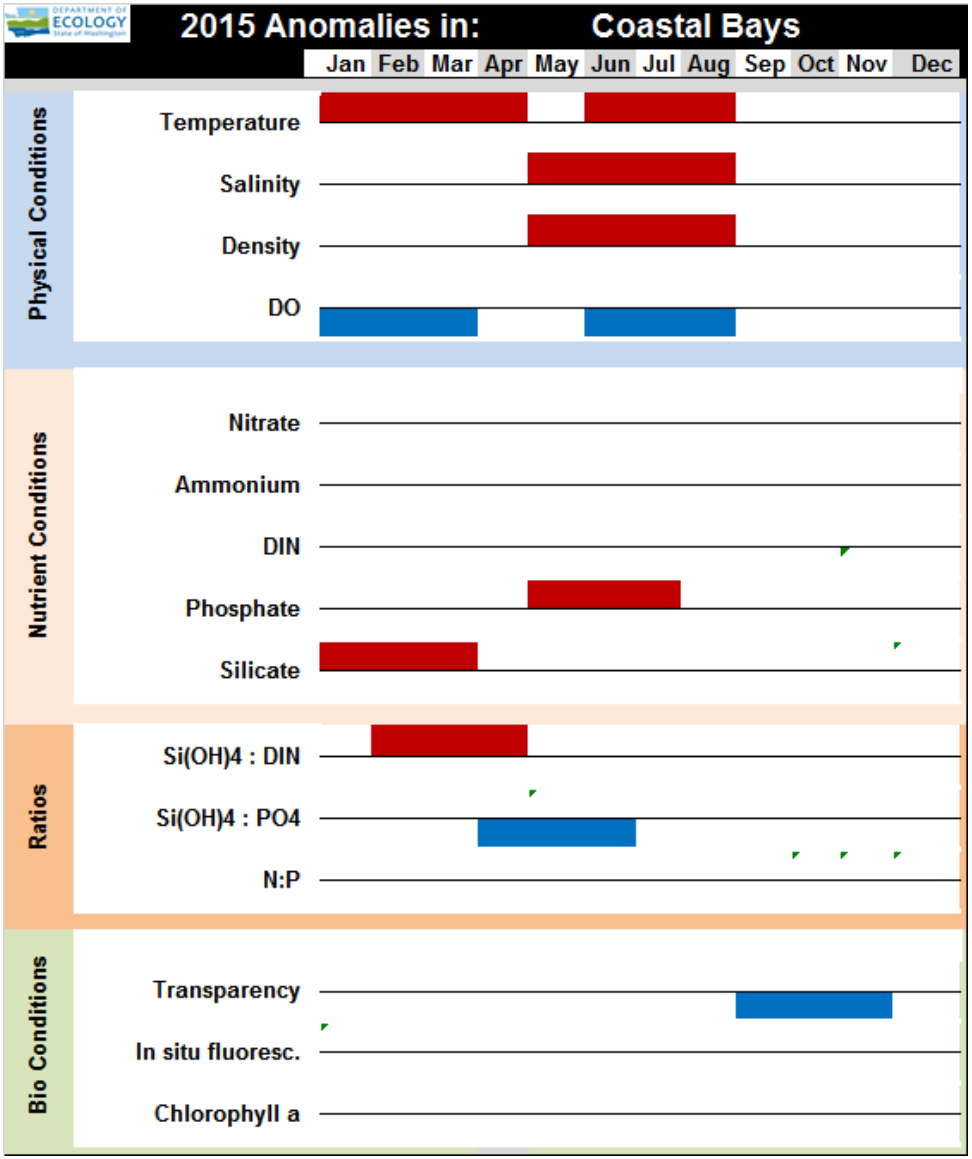
Glossary (explain abbreviations and terms)



Overview: Puget Sound

Consistently high temperature and low nitrate prevailed, with low silicate through the fall. Lower salinity, density, DO, DIN, phosphate occurred with high chlorophyll and transparency during the first half of the year. During the summer, high salinity and altered nutrient ratios containing phosphate persisted. In the fall, reduced forms of nitrogen affected Si:DIN ratios and chla was low.

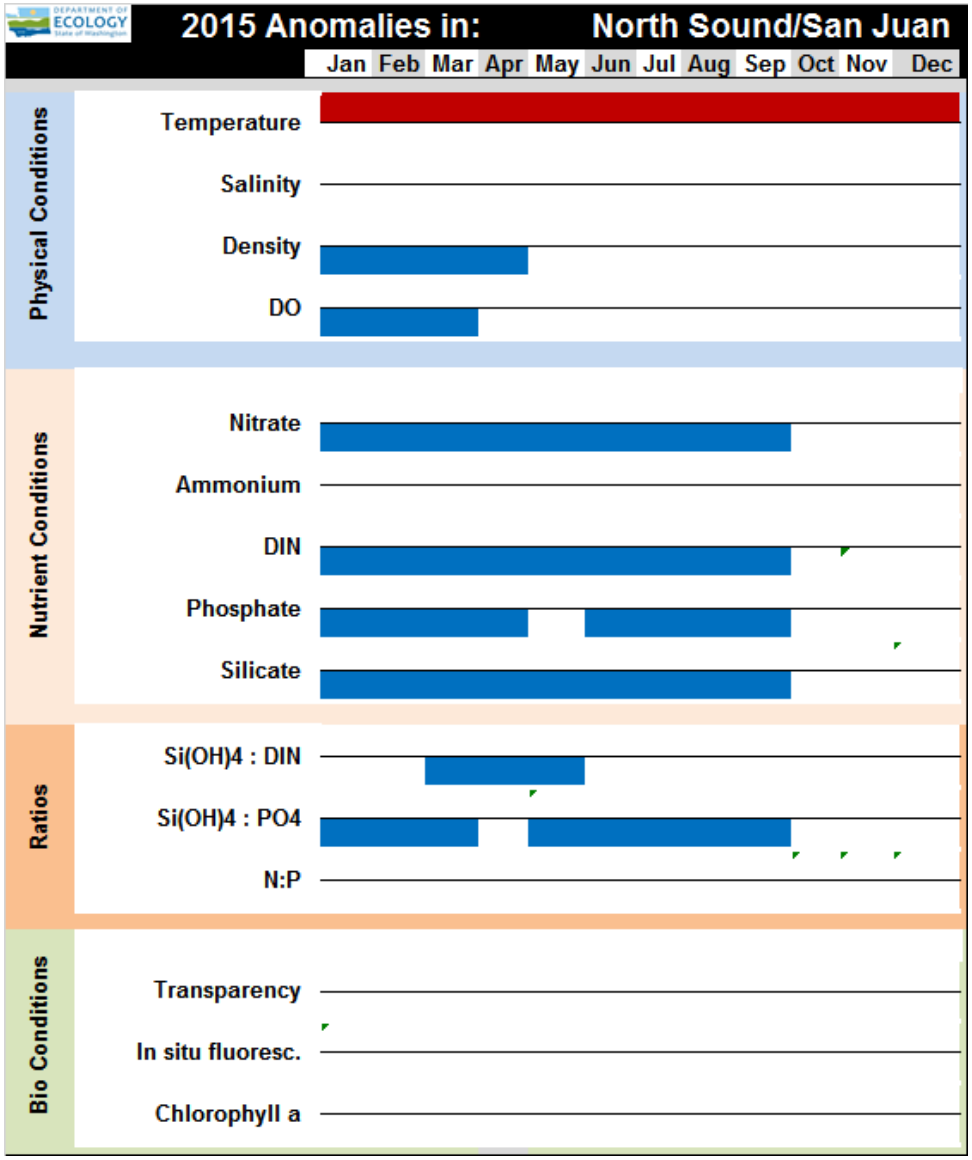
Figure legend
Anomalies persisting for 3 months can be assumed to be real patterns above the noise level. Graphic showing the relationship of positive (**red**) and negative (**blue**) anomalies between 15 variables persisting for 3 or more months. No color shows expected conditions.



Overview: Coastal Bays

In the spring, temperature, silicate and Si:DIN were high while DO was low. In summer, high temperature persisted and salinity, density and phosphate were high as well while DO and the Si:PO_4 ratio were low. Transparency was lower in the fall.

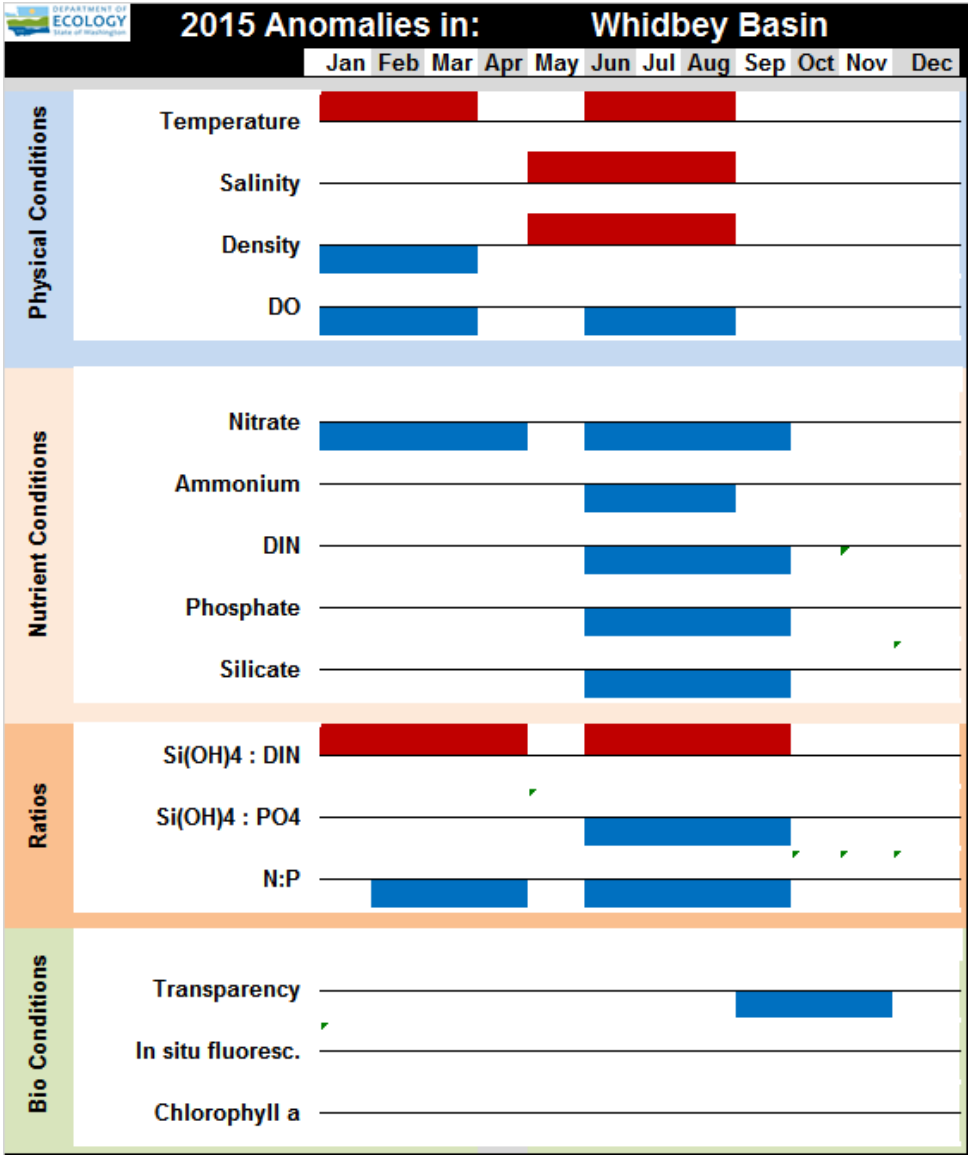
Figure legend
Anomalies persisting for 3 months can be assumed to be real patterns above the noise level. Graphic showing the relationship of positive (**red**) and negative (**blue**) anomalies between 15 variables persisting for 3 or more months. No color shows expected conditions.



Region: North Sound San Juan

The beginning of the year started with low DO and density, while high temperatures persisted all year long. Nitrate, DIN, phosphate and silicate were lower for the majority of the year, driving down particularly the Si:PO4 ratio.

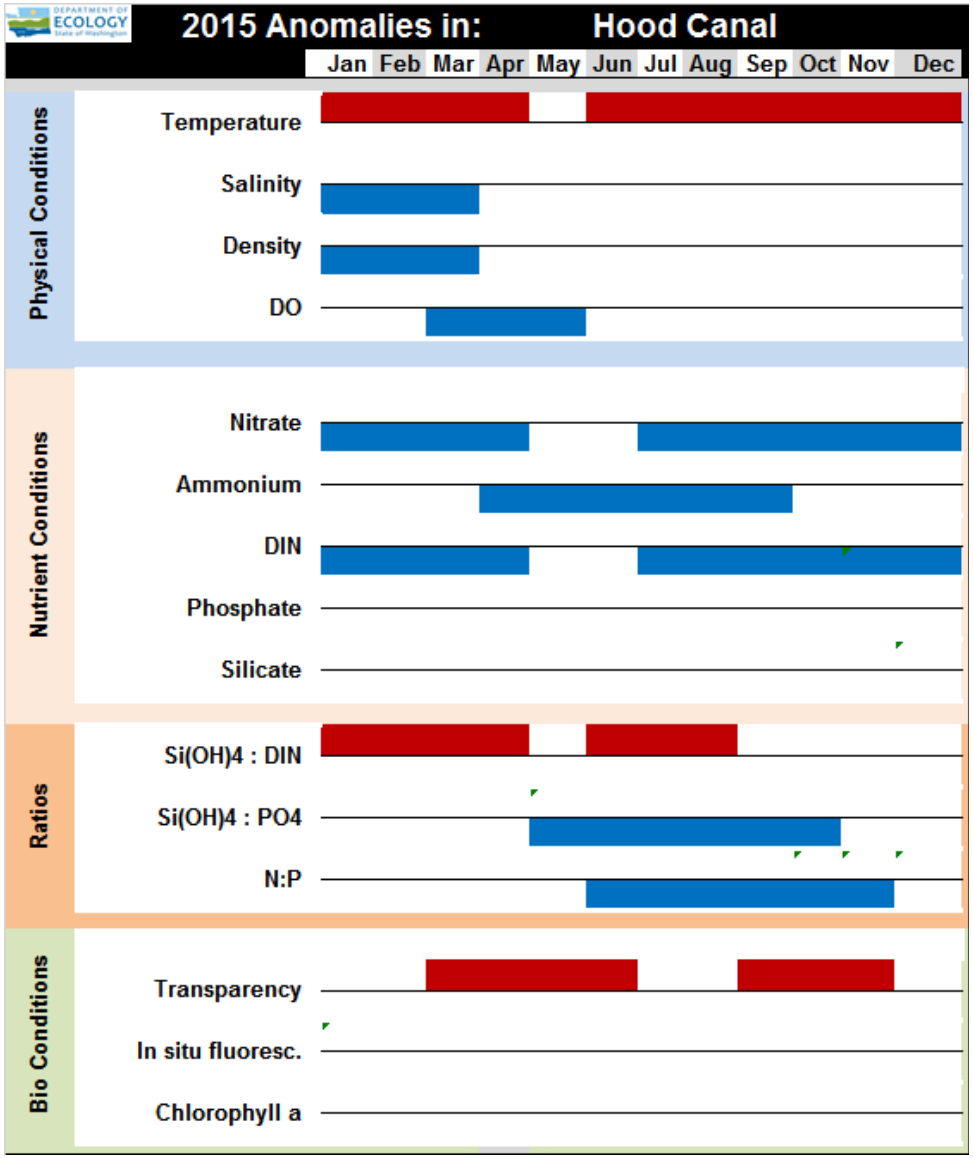
Figure legend
Anomalies persisting for 3 months can be assumed to be real patterns above the noise level. Graphic showing the relationship of positive (**red**) and negative (**blue**) anomalies between 15 variables persisting for 3 or more months. No color shows expected conditions.



Region: Whidbey Basin

Whidbey Basin was warmer, with lower density, DO, nitrate, N:P and high Si:DIN ratios in spring. In an unusual summer, temperature, salinity and density were high along with the Si:DIN ratio. DO, and all nutrients including some ratios were low. Water clarity was lower in the fall.

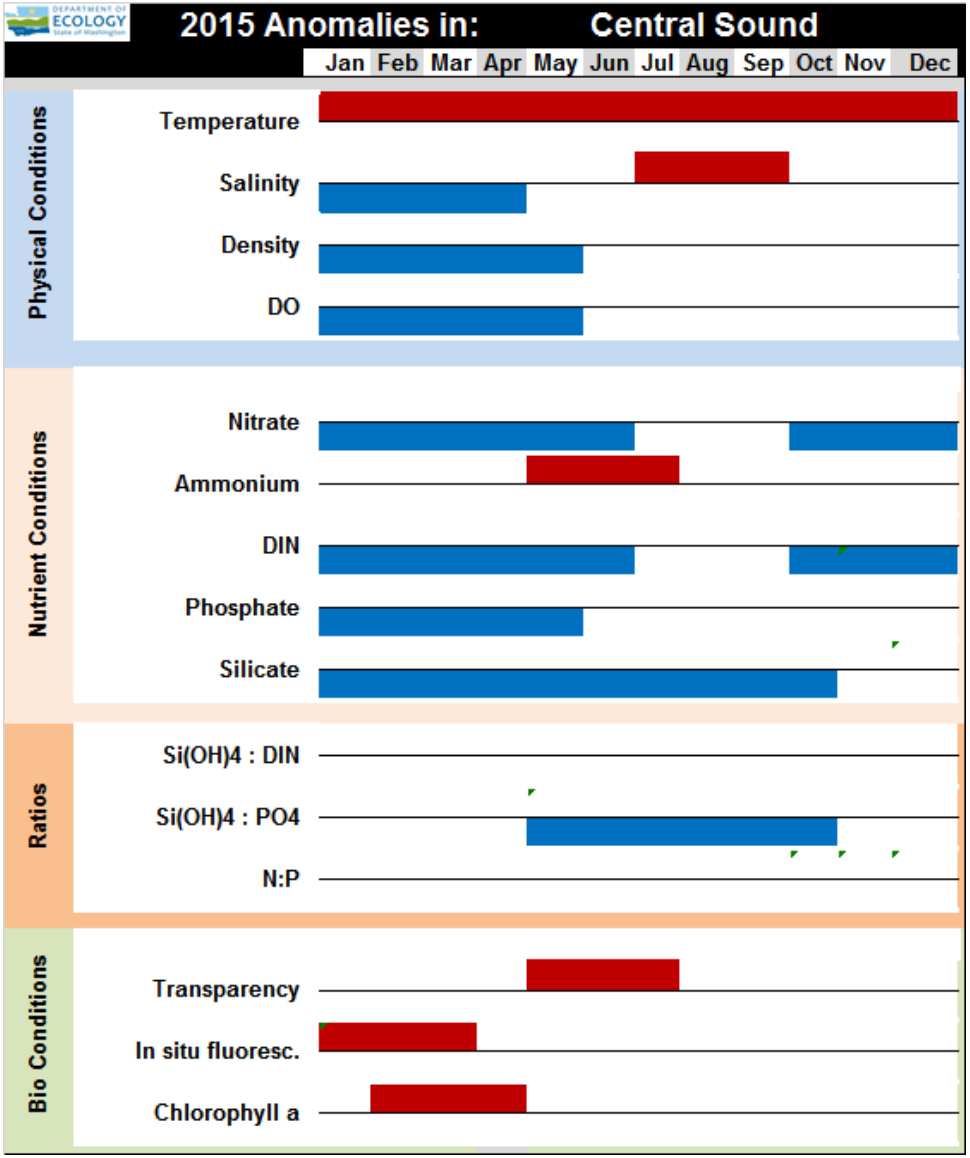
Figure legend
Anomalies persisting for 3 months can be assumed to be real patterns above the noise level. Graphic showing the relationship of positive (**red**) and negative (**blue**) anomalies between 15 variables persisting for 3 or more months. No color shows expected conditions.



Region: Hood Canal

Temperature and water clarity were higher the entire year while nitrate and DIN were lower. In the spring, salinity and density were lower. Dissolved oxygen and forms of nitrogen were lower affecting the Si:DIN ratio. From summer into fall, ammonium and Si:P and N:P were low.

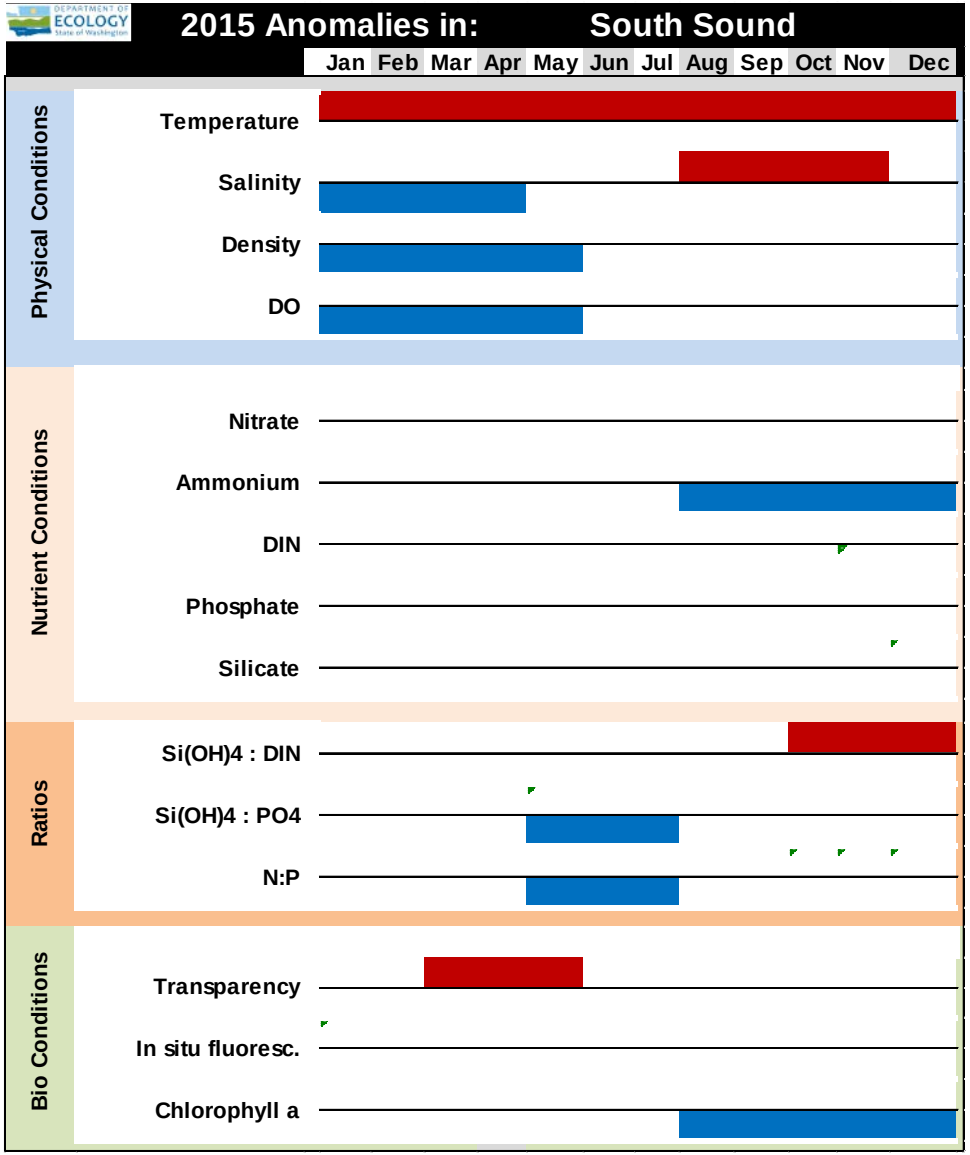
Figure legend
Anomalies persisting for 3 months can be assumed to be real patterns above the noise level. Graphic showing the relationship of positive (**red**) and negative (**blue**) anomalies between 15 variables persisting for 3 or more months. No color shows expected conditions.



Region: Central Sound

Temperature was high throughout the year. Spring brought low conditions for physical variables and most nutrients while chla was higher. Summer was marked by high salinity, ammonium and clear water while late fall brought low nitrate and DIN.

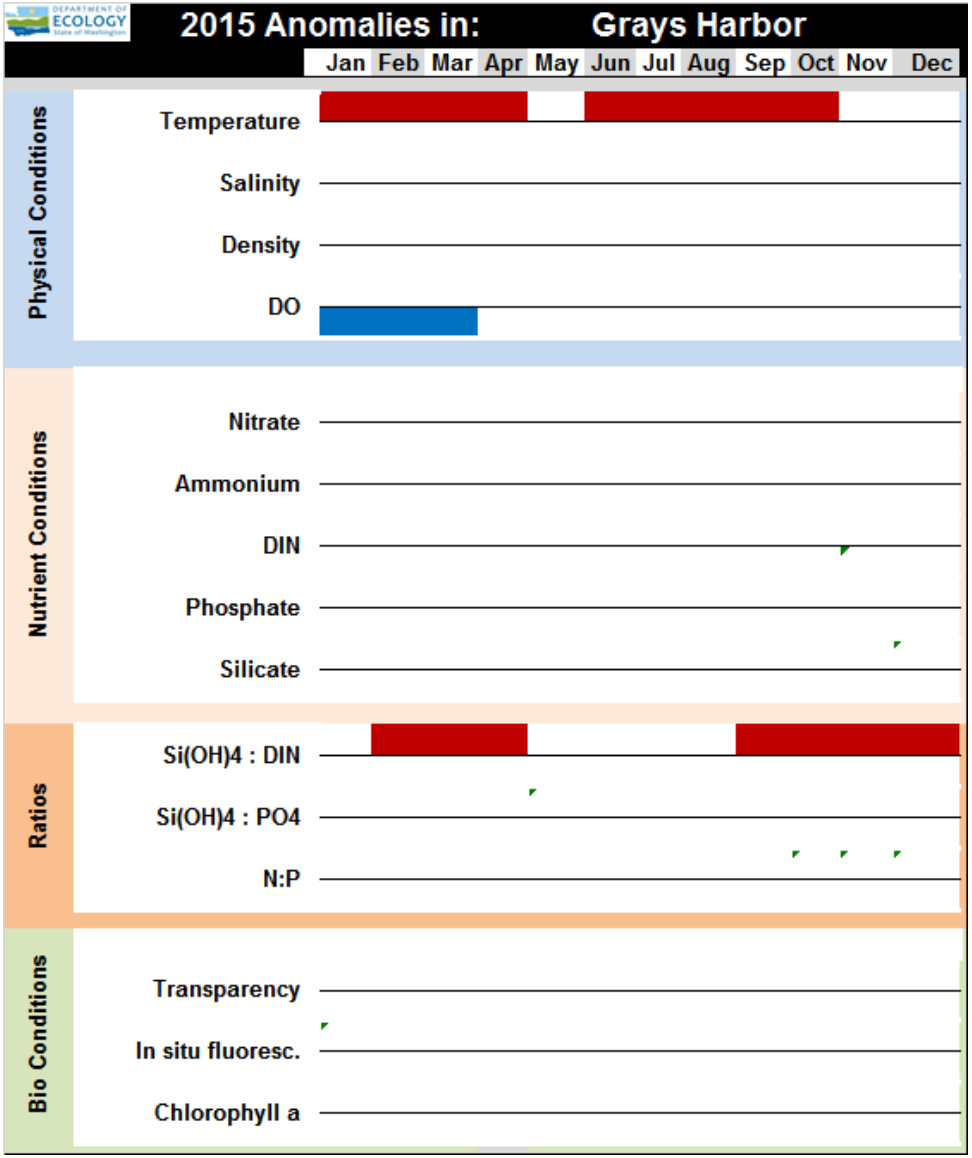
Figure legend
Anomalies persisting for 3 months can be assumed to be real patterns above the noise level. Graphic showing the relationship of positive (**red**) and negative (**blue**) anomalies between 15 variables persisting for 3 or more months. No color shows expected conditions.



Region: South Sound

Temperature was high all year. In the spring, most physical variables were low. Early summer brought clear water and altered nutrient ratios. Starting late summer, ammonium and chlorophyll were low while salinity and Si:DIN ratio were high.

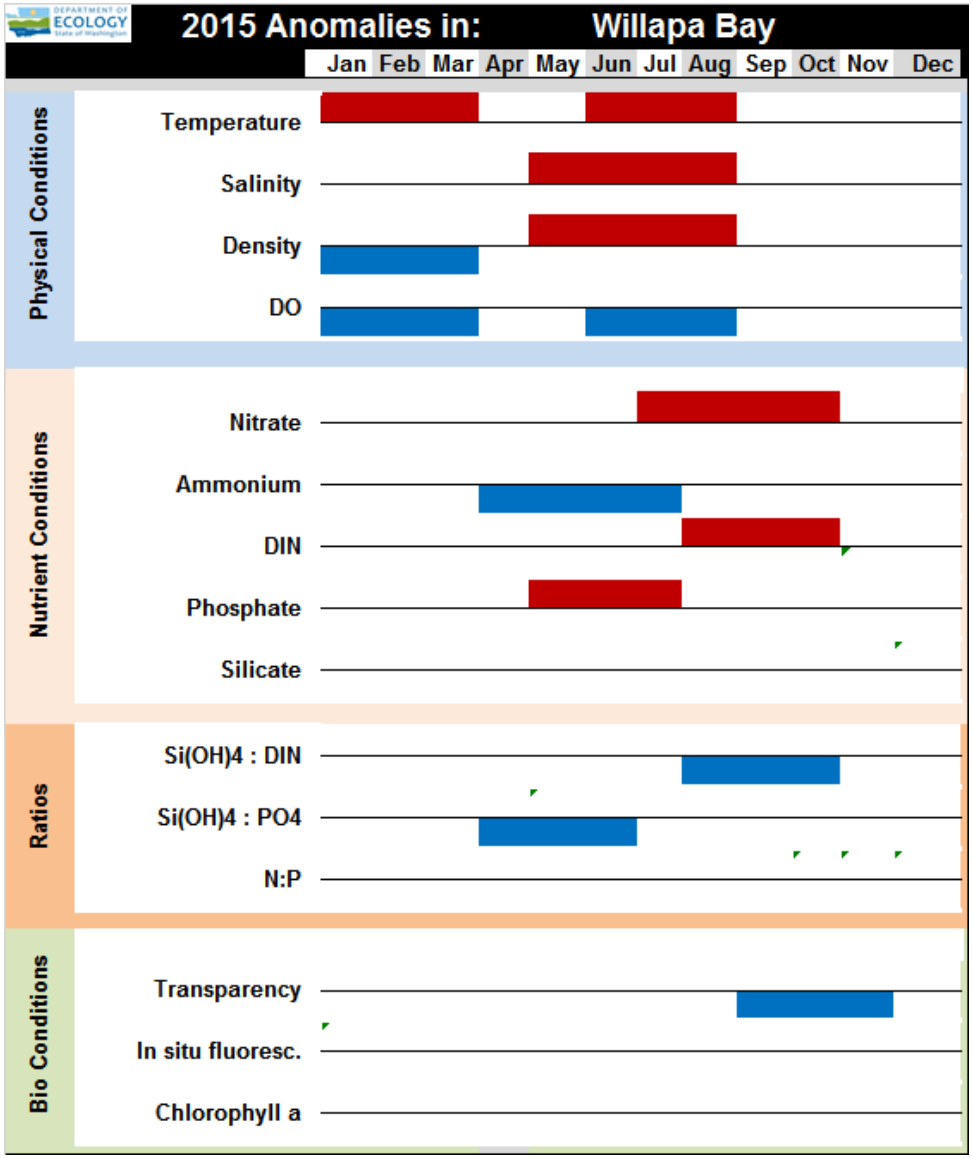
Figure legend
Anomalies persisting for 3 months can be assumed to be real patterns above the noise level. Graphic showing the relationship of positive (**red**) and negative (**blue**) anomalies between 15 variables persisting for 3 or more months. No color shows expected conditions.



Region: Grays Harbor

Temperature was high for most of the year. In the spring DO was low. The Si:DIN ratio was high in the spring and recurred in the fall.

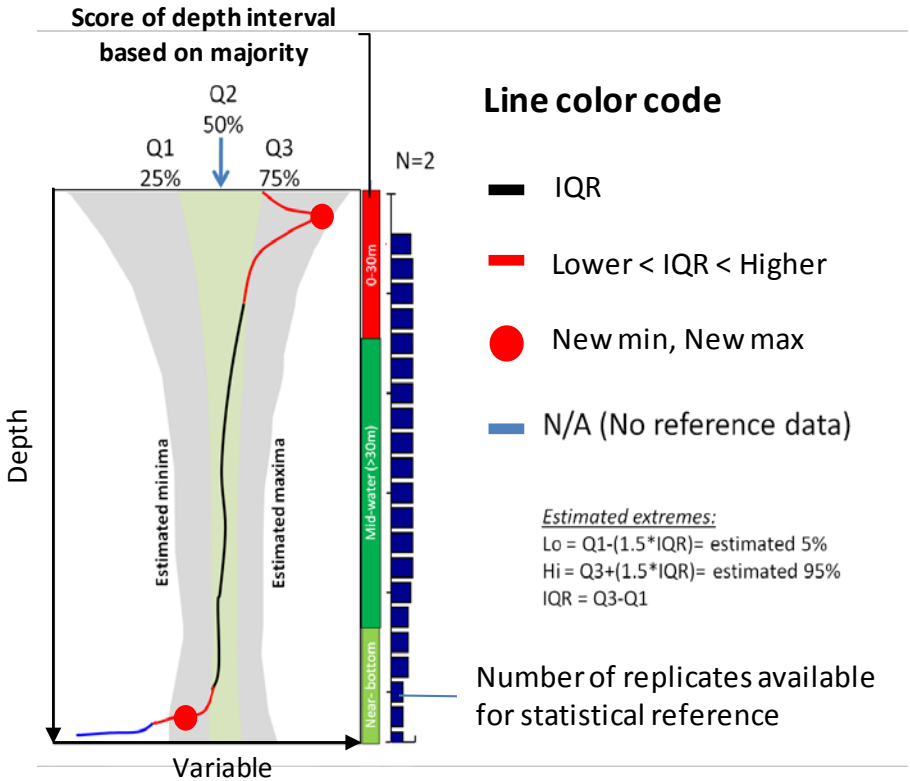
Figure legend
Anomalies persisting for 3 months can be assumed to be real patterns above the noise level. Graphic showing the relationship of positive (**red**) and negative (**blue**) anomalies between 15 variables persisting for 3 or more months. No color shows expected conditions.



Region: Willapa Bay

In the spring, temperature was high, with low density and DO. In summer, temperature remained high, and high salinity brought high density and low DO. Also in summer, ammonium and Si:PO4 was low, while phosphate was high. As summer progressed nitrate and DIN were elevated and Si:DIN became low. In the fall, water was less clear.

Figure legend
Anomalies persisting for 3 months can be assumed to be real patterns above the noise level. Graphic showing the relationship of positive (**red**) and negative (**blue**) anomalies between 15 variables persisting for 3 or more months. No color shows expected conditions.



A wealth of historical data allows us to place new CTD observations into the historical context of Ecology's long-term data record.

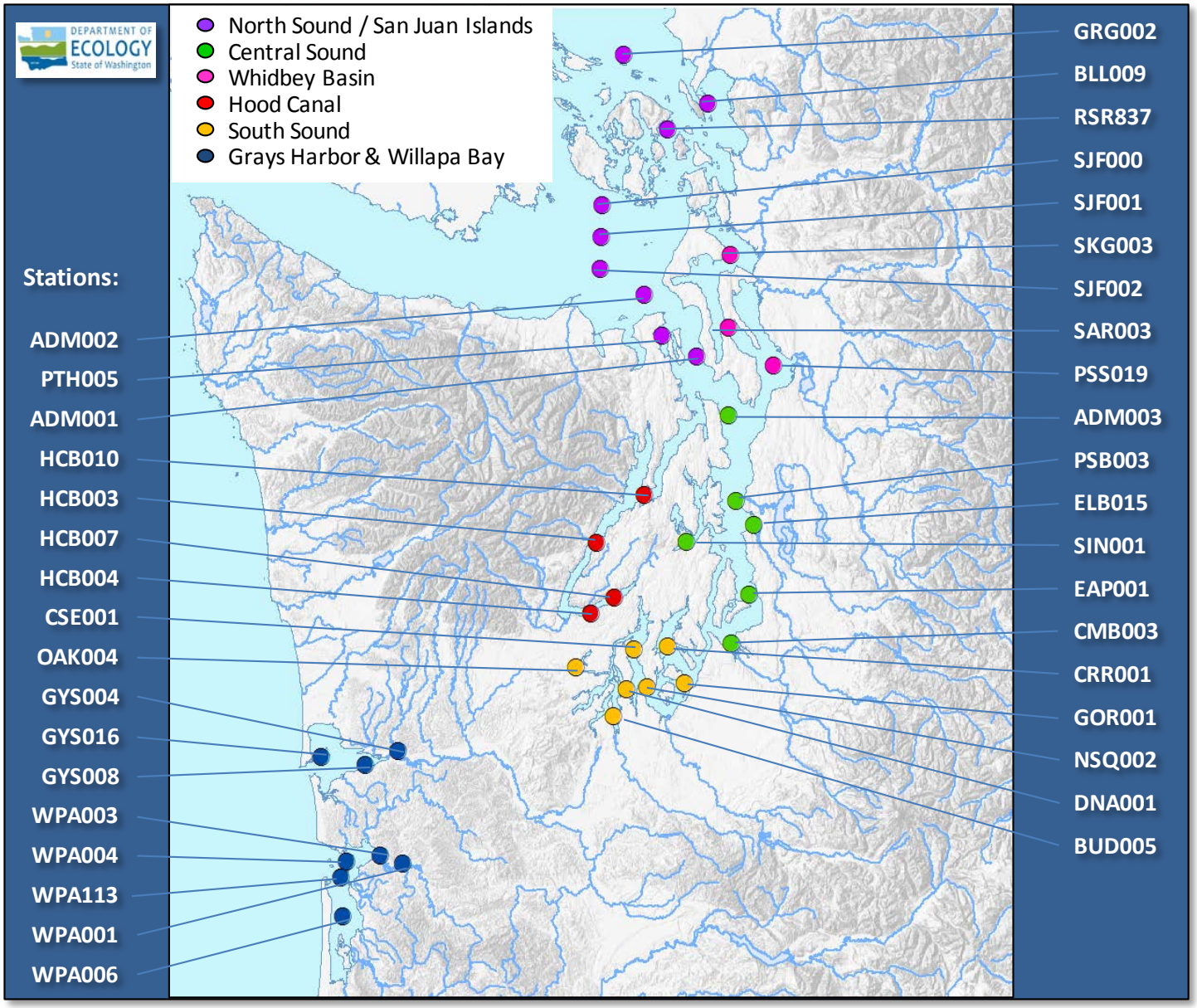
We use an increasing temporal reference framework of 1999-present to statistically define anomalies. Conditions that fall outside of a 50% observation envelope (second and third quartile) are considered ***"anomalies"***.

Graphically you can explore current anomalies in our monthly data updates.

Begin exploring anomalies, click here

How to read our graphics:

A **green background** describes the range into which 50% of our historical recorded data fall. Grey shows the 99% data envelope that we estimate from the interquartile range multiplied by 1.5. Pieces of the data line falling within the 50% envelope are colored **black**, data falling outside the 50% envelope are colored **red**. New extrema are emphasized with a red dot. If we sample a depth deeper than previously sampled we give the data line the color **blue**. Bars (dark blue) on the right indicate the number of observations (e.g. N=2). To illustrate if the entire water column section (<10m, 10-30m, >30m) is on average a "normal" or "***anomalous***" condition, we included a color coded vertical line. **Red** indicates on **average *anomalous* conditions**; **green** indicates on **average *normal* conditions**.



For detailed station information
click here

We use a float plane as a cost-effective means to collect marine samples throughout Washington's extensive marine waters.