Extending observations further: using historic biogeochemical data to understand trends in Puget Sound

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**WHY USE HISTORICAL DATA?**

Increased understanding of biogeochemical changes over decadal scales is needed to help explain long-term water quality status and trends. Traditionally, monitoring programs use their own data. Here, other available data measured at different temporal scales are combined to explore deep dissolved oxygen and nutrient dynamics at a single location in Central Puget Sound, a deep inland estuary.

King County’s marine monitoring program began in the 1960’s to assess Puget Sound receiving waters for impacts from municipal wastewater discharges but did not become routine until the 1980’s. Data from the Atlas of Puget Sound (Collas et al., 1974) are included, with some data back to the 1930’s. Natural conditions and variability within a waterbody can at times mask anthropogenic impacts. Extended data records can help to inform water quality trends and management decisions to effectively address marine water quality.

**MARINE OFFSHORE MONITORING**

King County
- Sampled bi-weekly at 14 sites (monthly Jan & Dec and pre-2014)
- Full CTD profiles since 1998 (temperature, salinity, density, DO, fluorescence, PAR, transmissivity, nitrate)
- Discrete samples since 1994 for dissolved nutrients (ammonia, nitrate+nitrite, silica, orthophosphate), TSS, fecal indicator bacteria, chlorophyll-a
- Discrete samples since 1985 for dissolved oxygen by Winkler
- CTD and mooring data can be accessed: [http://green2.kingcounty.gov/marine](http://green2.kingcounty.gov/marine)

**Collias Atlas**
- Data available between 1932 – 1975
- Collection frequency varied from weekly (for spring in some years) to roughly quarterly, with some years missing
- Discrete samples for temperature, salinity, dissolved oxygen by Winkler, and dissolved nutrients (nitrate, nitrite, silica, orthophosphate, and some ammonia)
- Due to method constraints, nitrate was measured only at 50 m in 1933, and then again from 1965 – 1975 when large method improvements were made (Armstrong et al., 1967)
- Data obtained from UW, and can also be accessed through EPA STORE: [https://www.epa.gov/waterdata/water-quality-data-web](https://www.epa.gov/waterdata/water-quality-data-web)

**METHODS**

- This analysis focuses primarily on one site near Point Jefferson (shown as the purple star to the right), where both programs were co-located. This site is in the deepest part of Central Puget Sound (<280 m).
- Date ranges, sampling frequency, and data distribution explored
- King County samples at 1, 15, 25, 35, 50, 100, & 200 m discrete depths
- Collias data varies, collected primarily at 0, 10, 20, 50, 100, 200, & 250 m
- Deep data outside of the euphotic zone are examined first for trends.
- Detection limits have changed over time for King County nutrient analyses; however, no specific information for the Collias database. When values are below a reported detection limit, samples are substituted as ‘0’ if the limit for the purpose of this analysis. In deep data, these low values are not used for the parameters analyzed.

**WHAT ARE SOME CHALLENGES?**

**Objective 1: How does changing target sample depth impact our results? Application: Surface NO3**

In order to simulate and quantify the impact of the choice of depth for sample collection, typical target depths from the Collias and King County sampling programs are used as part of a bootstrapping method to determine uncertainty in depth integrated averages.

**Objective 2: Can we evaluate how method changes over time may impact our results? Application: Mid to Deep NO3**

In this case, historical data are not provided with any qualifiers or detection limits, so data are evaluated first in context of the last two decades. Ranges and parameter co-variates can be used to identify data for further scrutiny before including in trends over time. For nitrate, the samples have been in use since the 1990’s, reducing agents and procedures have made improvements (Mooorrh et al., 2001).

**Objective 3: Can this lead to improvements in understanding trends over time? Application: Deep O2**

The King County routine site (Pt. Jefferson) was co-located near the historical site, allowing for dissolved oxygen (DO) observations over an 85-year period. To assess trends, DO at 200 m was selected as the deepest depth with overlap by both King County and UW/Collias sampling.

**WHAT ARE SOME BENEFITS?**

- The seasonal component in DO (shown as the purple star to the right) suggests potential bias due to mixing at sills at the entrance.
- Identifying potential differences in historical data can help to inform water quality trends and management decisions to effectively address marine water quality.

**REFERENCES**

- Collias, McClary, & Barnes (1975), Benthic community structure, reference: 7/3.
- Reason, T.B., et al. (2005), 39th Conference on Oceanic Instruments and MOCCS.

**ACKNOWLEDGMENTS**

Data from UW/Collias study obtained from Ministry of Environment and UW Marine Science, University of Washington. Water data from NOAA Oceanographic Atlas (1930–1974) was first removed by subtracting the mean from a set of 16-yr period (2002 – 2017) from both datasets. Multiple linear regression was used on the anomaly with time, salinity, oxic zone, and seawater temperature in a correlation. As shown in the plot of monthly anomalies on the left (panel B), no significant temporal trend was found. A slight correlation with temperature is present (p=0.05).

**SUMMARY**

- In the absence of metadata and qualifiers, historical data requires careful evaluation before including in water quality status and trends, particularly due to method changes.
- Variance in a quality-assured database can be used to predict and identify outliers in a historical dataset, with an understanding that some relationships can change over decadal scales.
- Integrating samples over a depth range from upper water layers can be used to construct depths with different target depths, with an estimate of variance from continuous profiles.
- Next steps include assessing additional sites and parameters, such as chlorophyll-a, and water flow and input outputs, to better understand seasonal differences over time.
- For example, investigate if higher DO concentrations in May/June and lower nitrate levels in the summer may be a reflection of higher phytoplankton growth. In Puget Sound, deep waters are a mix of oceanic sources and surfacet water due to mixing at sills at the entrance.
- More work is needed in order to better understand drivers over decadal scales in Central Puget Sound, including any links to climate changes and oscillations in watershed loading over time.

**EXTENDING OBSERVATIONS FURTHER: USING HISTORICAL BIOGEOCHEMICAL DATA TO UNDERSTAND CHANGES IN AN ESTUARY**

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