Hypoxic Intrusions to Puget Sound From the Ocean

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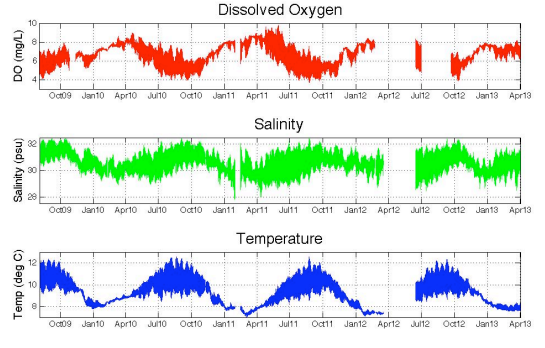
Observing Dissolved Oxygen Levels at Admiralty Inlet

Data Collection

Oceanic intrusions of dense, low dissolved oxygen water may be significant to the modulation of dissolved oxygen concentrations in Puget Sound. To observe these intrusions, sensors at Admiralty Inlet have been deployed to collect data for dissolved oxygen, salinity, temperature, pressure, and current velocity since August 2009.



Compiled hourly time series for all deployments for dissolved oxygen concentration (mg/L), salinity (psu), and temperature (°C), August 2009 – April 2013

Confirming Oceanic Source of Hypoxic Water:

- Low dissolved oxygen levels correspond with high salinity water and a narrow temperature range, suggesting an oceanic source
- Water from Puget Sound is expected to be fresher as result of the large river outflows
- Confirms that occurrences of low dissolved oxygen water at Admiralty Inlet can be paired with the dynamics of dense water intrusions

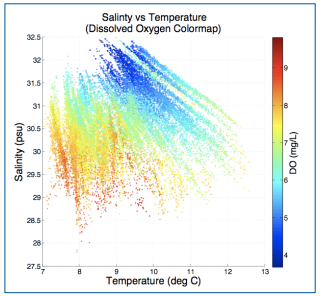


Diagram comparing salinity (psu) and temperature (°C) readings from CTDO at Admiralty Inlet from August 2009 to April 2013. Data colored according to corresponding dissolved oxygen concentration (mg/L)

Motivation:

- Hypoxic water in Puget Sound can be harmful to the ecosystem (e.g. Fish kills in Hood Canal)
- Important to understand the relative contribution to the overall system from the natural modulation of dissolved oxygen concentrations
- Understanding the driving forces involved can enhance predictability of hypoxia events

Objective

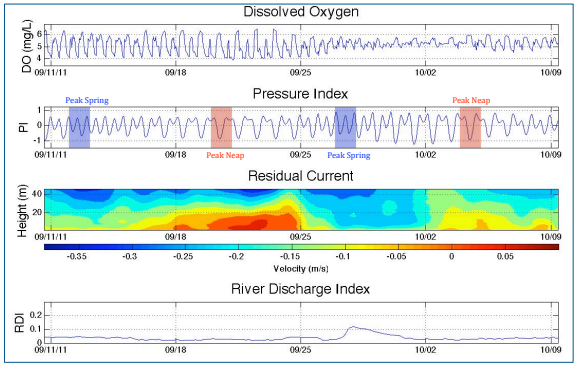
The primary goal of ongoing work will be to develop an Intrusion Index that will act as a quantitative indicator of the likelihood that low dissolved oxygen water will be transported over the sill at Admiralty Inlet and into the main basin of Puget Sound at a given time.

Analysis

Determining the role of forcing factors that control the development of hypoxic intrusions is necessary for designing an Intrusion Index. The primary forces expected to modulate dissolved oxygen concentrations at the mouth of Puget Sound are tidal conditions, coastal upwelling conditions, and river discharge levels.

Exchange Flow Over Admiralty Sill

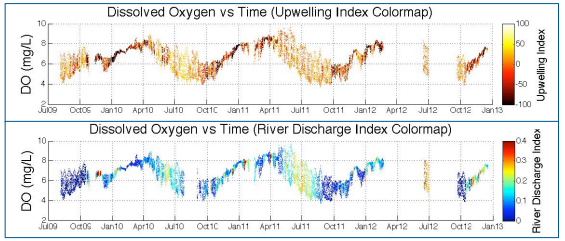
Intrusions of dense, low DO water are likely are related to strong estuarine exchange flows, which have been observed to occur during conditions for minimal tidal mixing, nominally the coincident maximum diurnal inequality and neap tides that occur during equinoxes [1].



Time series for dissolved oxygen concentration (mg/L), pressure index, residual current (m/s), and discharge index, at matching time scales for a four-week period in 2011 surrounding the autumnal equinox

Importance of Coastal Upwelling and River Discharge

Tidal conditions alone cannot predict intrusions of hypoxic ocean water to Puget Sound. Coastal upwelling and river discharge seem to play an important role in governing the availability of dense, low dissolved oxygen water to be transported into the Sound during exchange flows [1,2,6].



Time series of dissolved oxygen concentration (mg/L) from CTDO at Admiralty Inlet from August 2009 to December 2012. Data points in top plot colored according to an Upwelling Index obtained from the Pacific Fisheries Environmental Laboratory [7], lagged 7.25 days. Data points in bottom plot colored according to River Discharge Index computed for the 3 main rivers feeding Puget Sound [3,4,5]

Ongoing Work

Developing an Intrusion Index:

Two Part Index

1. Probability of Exchange Flow
   - *Based on tidal conditions and river discharge*
2. Availability of Hypoxic Water
   - *Based on upwelling conditions and river discharge*

Preliminary Conclusions

- **Confirmation of oceanic source of hypoxic water**
- **Confirmation of tidal signal**
  - **Importance of minimal mixing periods**
  - **Pressure as potential proxy for exchange flow**
- **Suggestion of sensitivity to coastal upwelling and river discharge**

References

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Acknowledgments

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