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Variability in water column respiration in Salish Sea waters and implications for coastal and ocean acidification

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Response of water-column processes and pelagic organisms to long-term change.
Variability in respiration of Salish Sea waters and implications for coastal and ocean acidification

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2018 Salish Sea Ecosystem Conference

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upwelling of "corrosive" water of marine origin

atmospheric inputs

remineralization of organic matter (respiration)

$pCO_2$
The image depicts a diagram illustrating the processes involved in marine carbon cycling.

- **Atmospheric Inputs**: This section is marked with a checkmark, indicating a confirmed process.
- **Upwelling of “Corrosive” Water of Marine Origin**: This process is also confirmed with a checkmark.
- **Remineralization of Organic Matter (Respiration)**: This section has a question mark, suggesting it is an area of uncertainty or further investigation.

These processes are integral to the carbon cycle, influencing the levels of CO2 in the atmosphere and the ocean.
Three Key Questions

1. How does pelagic respiration vary throughout the year?

2. What are representative rates of respiration in surface and deep waters of the Salish Sea?

3. What are the environmental factors that control respiration?
Gong Buoy

Maps courtesy of Suzanne Shull (PBNERR)
Water column profiles are conducted ~monthly in deep waters adjacent to Padilla Bay. Respiration is measured in surface and deep waters.

Water column profile data from January 2016 – March 2018
Spring freshet, well mixed water column

Summer thermal stratification

Intrusion of upwelling derived deep water

Cold, dense, well mixed water column in winter
pH is high in surface waters during summer, while underlying deep water has more corrosive conditions (pH<7.5). pH in fall and winter is low.

Water column profile data from January 2016 – March 2018
1. How does pelagic respiration vary throughout the year?

Respiration is higher in the resource-rich, warmer summer months and consistently lower in deep waters.
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Respiration is higher in the resource-rich, warmer summer months and consistently lower in deep waters.
2. What are representative rates of respiration in surface and deep waters of the Salish Sea?

Respiration varies in Salish Sea waters, higher and more variable in surface waters, consistently low in deep waters.

Deep water respiration is remarkably similar among over 100 sites - 5.8 µg O$_2$ L$^{-1}$ h$^{-1}$ (0.15 mg O$_2$ L$^{-1}$ d$^{-1}$); n = 110
3. What are the environmental factors that control respiration?

Temperature

There is a strong temperature dependence of respiration that reveals a $Q_{10}$ value $>2$. 

\[
y = 0.0265x - 0.1454 \\
R^2 = 0.6586 \\
n = 88
\]
3. What are the environmental factors that control respiration?

Experimental data reveal a similar positive response to temperature (slope = 0.04; $Q_{10} = 2.5$)

\[ R = 0.04 \times \text{temp} - 0.18; \]
\[ r^2 = 0.55 \]
3. What are the environmental factors that control respiration?

Resource supply (chlorophyll)

\[ y = 0.0497x + 0.0471 \]

\[ R^2 = 0.5204 \]

\[ n = 88 \]

Respiration also increases in response to chlorophyll – proxy for algal DOM/POM as well as phytoplankton respiration.
Conclusions and implications...

• Respiration of deep waters is predictable (~6 μg O₂ L⁻¹ h⁻¹)
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• Respiration responds strongly to increases in temperature and organic matter inputs – both of which we predict will increase with climate change

• A 5°C increase would almost double rates of respiration (and yield a corresponding increase in production of CO$_2$)
Conclusions and implications...

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• A 5°C increase would almost double rates of respiration (and yield a corresponding increase in production of CO₂)

• Contribute rates to the coupled hydrodynamic-water quality model for oxygen and pH in the Puget Sound/Salish Sea.