Changes to water properties in Rivers Inlet, British Columbia from 1951 to 2017

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Outline

• Introduction to Rivers Inlet
  – Biological and cultural significance of Rivers Inlet
• Overview of Rivers Inlet dataset
• Description of Rivers Inlet water types
• Seasonal cycle of water types
  – Links between large scale winds and intermediate water properties
• Interdecadal variability of water types
• Summary and future research
Introduction to British Columbia

Jackson et al., JGR Oceans, 2015
Introduction to Rivers Inlet

• Rivers Inlet is a fjord on British Columbia’s central coast
• It is about 45 km long and 3 km wide
• The average depth is 295m and the sill depth is about 137 m at low tide (Pickard, 1961)
• The mouth of Rivers Inlet is exposed to Queen Charlotte Sound
• There are several major rivers and dozens of tributaries that bring freshwater to Rivers Inlet
Rivers Inlet sockeye salmon 1948 - 2012

• University of British Columbia collected data from 1951-1987 and 2008-2010
• Fisheries and Oceans Canada collected data from 1990-2017
• Hakai Institute collected data from 2012-2017
Seasonal cycle and predictability of water types
Rivers Inlet water types

- Based on seasonal differences, we define the following water types:
  - Surface water (0-10m)
  - Near-surface water (10-50m)
  - Intermediate water (50-145m)
  - Deep water (145 m to bottom)
Seasonal cycle of water types

- **Solar radiation**
- **Freshet**
- **Oxygen utilization?**

**Surface (0-10m)**
- Seasonally trapped heat

**Near-Surface (10-50m)**
- Influenced by upwelling and downwelling

**Intermediate (50-145m)**
- Influenced by upwelling

**Deep (145-330m)**
Influence of seasonal large scale winds

• The mouth of Rivers Inlet is about 150 km from the edge of the shelf break, where seasonal wind shifts force upwelling and downwelling

• To address how important upwelling and downwelling is in Rivers Inlet, shelf break winds from 51°N, 131°W were examined
  – Wind data are from 1967 to 2016

• Following Foreman et al. (2011), the Cumulative Upwelling Index (CUI) was calculated from the Bakun Index
  – CUI was calculated for 2, 3, 4, 6, 8, 12, and 14 weeks before observations in Rivers Inlet
Influence of CUI on salinity

These results suggest that the salinity of intermediate water in Rivers Inlet can be predicted by large-scale winds.

- **Intermediate Water (100m)**
  - Equation: $y = 2.6 \times 10^{-4} x + 32.8$
  - $R^2 = 0.8$

- **Deep Water (200m)**
  - Equation: $y = 4.34 \times 10^{-5} x + 33.2$
  - $R^2 = 0.34$
Predictability of intermediate water oxygen

Modeled oxygen = -0.000350*CU1 + 3.45

$R^2 = 0.7$
Interdecadal trend of water types
Temperature time series with seasonal cycle removed

- Surface, near-surface and intermediate waters warmest during Blob
- Deep waters warmest during 1998 and 2016 El Nino
- There was no trend in salinity or density
Crawford and Pena (2016) showed oxygen increased from about 1950 to 1980 and decreased from about 1980 to 2008.
Summary

• A time series of temperature, salinity and oxygen was constructed from Rivers Inlet, British Columbia from 1951 to 2017
• Based on seasonal trends, Rivers Inlet water types can be defined as:
  – Surface (0 to 10 m)
  – Near-surface (10 to 50 m)
  – Intermediate (50 to 145 m)
  – Deep (145 m to bottom)
Summary

• The salinity of Rivers Inlet intermediate water is very well correlated with winds observed at the shelf break, about 150 km away
  – This suggests that large scale winds transport intermediate water into Rivers Inlet

• A statistically significant warming from 1951-2017 was observed:
  – Intermediate water warmed from about 7 to 7.6°C
  – Deep water warmed from about 6.6 to 7.3°C

• Oxygen in all layers appears to have increased since 2010