Long-term variability in the Oxygen Minimum Zone and carbonate chemistry in the North East Pacific and potential impacts on seamount communities

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Expanding OMZ in the Northeast Pacific

- Oxygen Minimum Zones (OMZs) are oxygen starved regions of the ocean.
- OMZs are expanding due to:
  - Increased productivity in eutrophic coastal areas
  - Reduced ventilation of deep waters (increased stratification)

Paulmier and Ruiz-Pino, 2009

Dissolved oxygen timeseries at ocean station Papa

http://omz.microbiology.ubc.ca
Offshore Pacific AOI

- The Offshore Pacific Area Of Interest (AOI) contains 3 key Ecologically or Biologically Significant Marine Areas (EBSAs)
  - ~65% of AOI seafloor is in vent & seamount EBSAs
  - ~50% is in the North Pacific Transition Zone EBSA
  - 100% of Canadian hydrothermal vents are in AOI
  - 87% of Canadian seamounts are in AOI

High tectonic activity

![Map of Offshore Pacific AOI with EBSAs and seamounts]
AOI Seamounts and classification

A global seamount classification to aid the scientific design of marine protected area networks

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- Summit depth 800 to 3500 m
- Summit depth 201 to 800 m
- Summit depth \leq 200 m

Dissolved oxygen

- > 1.0 ml/l
- \leq 1.0 ml/l

1

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AOI Seamounts and classification

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- Summit depth 800 to 3500 m
- Summit depth 201 to 800 m
- Summit depth ≤ 200 m
- Dissolved oxygen ≤ 1.0 ml/l
- Dissolved oxygen > 1.0 ml/l

40 seamounts
AOI Seamounts and classification

- 4 classes of seamount in the Offshore Pacific AOI
- 5 classes if nearby Cobb is included
OMZ at Station Papa

- Trends

  upper boundary of OMZ shoaled from ~400 to 300 m between 1956 and 2006 (Whitney et al, 2007) and very quickly during 1993-2006
OMZ at Station Papa

**Trends**

- **deepening of lower boundary of OMZ** (continues unabated)
- **upper boundary of OMZ shows weaker trend with the inclusion of 2007-2018 data**
Trends in OMZ boundaries in AOl
Trends in OMZ boundaries in AOI
Trends in OMZ boundaries in AOI
Trends in OMZ boundaries in AOI

Top boundary of OMZ: $-0.3 \pm 0.7$ m/year

Bottom boundary of OMZ: $3.3 \pm 0.5$ m/year
Trends in Seamount classification

Losing a class of seamount
Potential Impacts

Corals → acidification?

**Union** (Class 4, 300 m, >1 ml/l @ summit)

**Dellwood** (Class 3, 550 m, <1 ml/l @ summit)

Depth: 650

DO<1 ml/l

Hard substrate
Ocean acidification in AOI

- Previous work has shown North Pacific is becoming more acidic
- Aragonite and Calcite saturation horizons are shoaling

Saturation depth [m] for calcite estimated from water column DIC and TA (Feely et al, 2002)

Using the difference between two cruises 1991/2 and 2005/6 (Feely et al, 2012)
**Ocean acidification in AOI**

- Most common cold-water corals in AOI are Octocorals (Haigh et al. 2015)

- Octocorals are made of the calcitic form of CaCO$_3$, which is less soluble under OA (Mucci et al. 1983)

- Some Octocorals have holdfasts that are made of the more soluble aragonitic form of CaCO$_3$ (Bayer and Macintyre 2001)

- $\Omega_{\text{calcite}} = 1$ is about the same as $\Omega_{\text{aragonite}} = 0.65$, a limit where large cold-water reefs near Hawaii are still found (Baco et al. 2017)
Horizon shoals with distance offshore, now include only P12 and P16 in AOI average

- Pre-2009 data were corrected using the PACIFICA adjustment table
- TA was estimated from a salinity relationship developed using nearshore data
Trend in $\Omega_{calcite}$ horizon in AOI

$\Omega_{calcite} = 1$ horizon: $-1.4 \pm 1.0$ m/year

Top boundary of OMZ: $-0.3 \pm 0.7$ m/year

Bottom boundary of OMZ: $3.3 \pm 0.5$ m/year
Seamount classification + Carbon

Stippling indicates seamount is above the calcite saturation horizon.

Union seamount is already undersaturated with respect to the aragonite and will become undersaturated with respect to calcite in the mid 2020’s.
Summary

• The Oxygen Minimum Zone continues to expand in the NE Pacific
  – Shoaling of upper boundary weaker than reported in past
• If trends continue, by 2200 the Canadian Offshore Pacific AOI/MPA will have lost one class of seamount
  – more seamounts have hypoxic conditions at summit
  – seamounts with summits below 1500m are most impacted
• Losing a class of seamount reduces biodiversity in MPA
  – Hypoxia at summit cascades down, likely affecting entire seamount ecosystem
• Coral distribution on Union seamount may change as the calcite saturation horizon is passing it presently
  – Story is unclear because corals are currently found at quite low saturation values on AOI seamounts
Thanks!