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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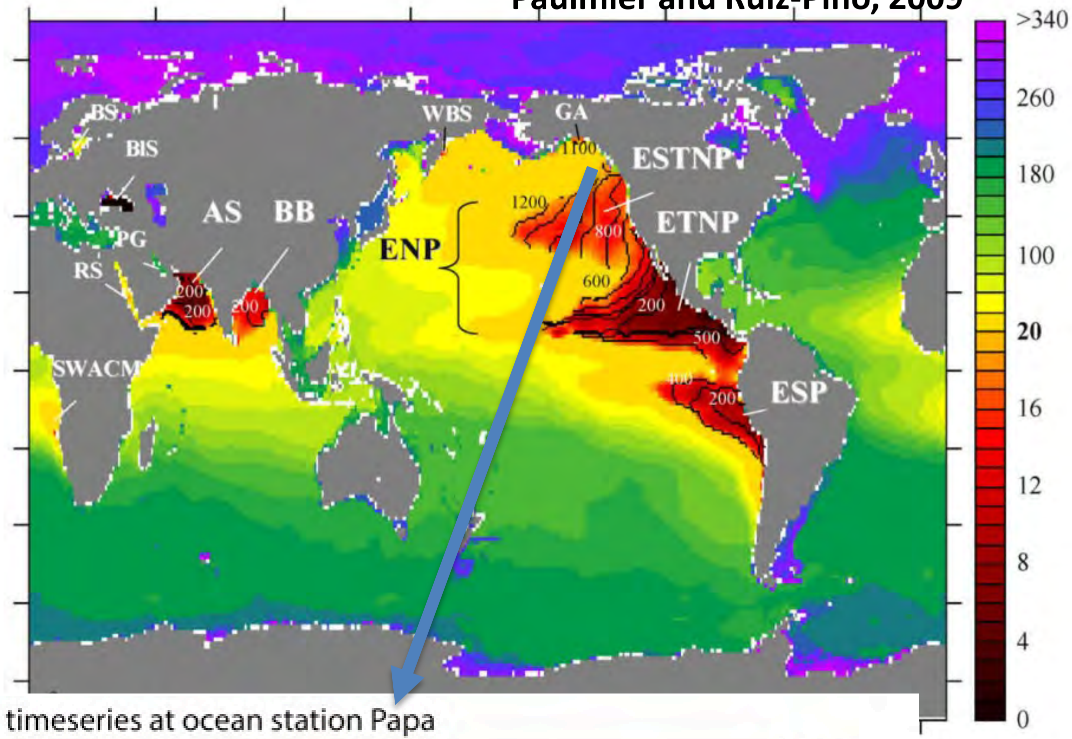
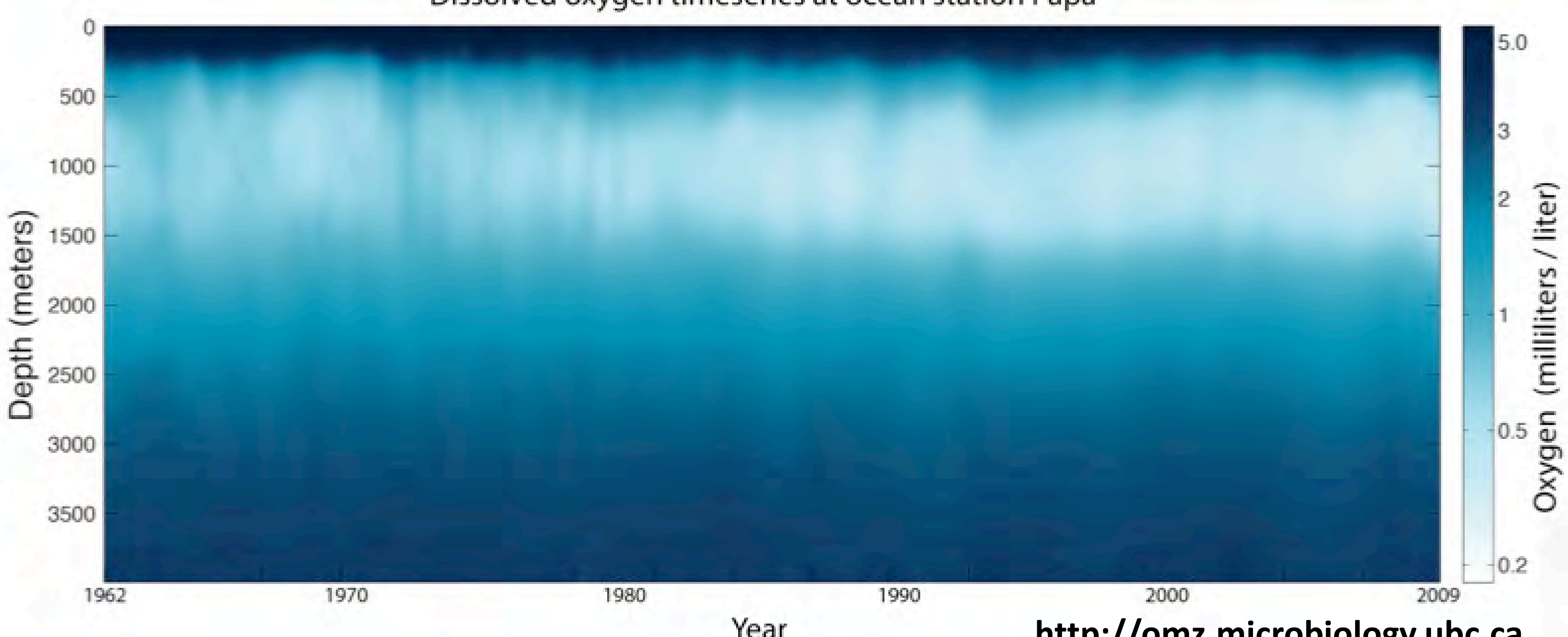
Expanding OMZ in the Northeast Pacific

- 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



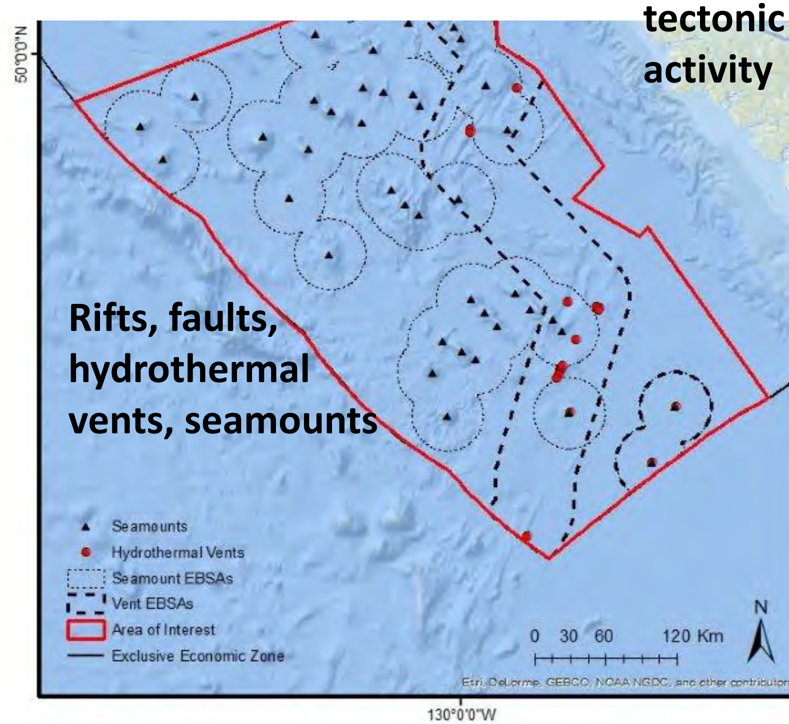


http://omz.microbiology.ubc.ca

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



Canada's Largest MPA

AOI Seamounts and classification

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

Malcolm R. Clark[a,*], Les Watling[b], Ashley A. Rowden[a], John M. Guinotte[c], Craig R. Smith[b]
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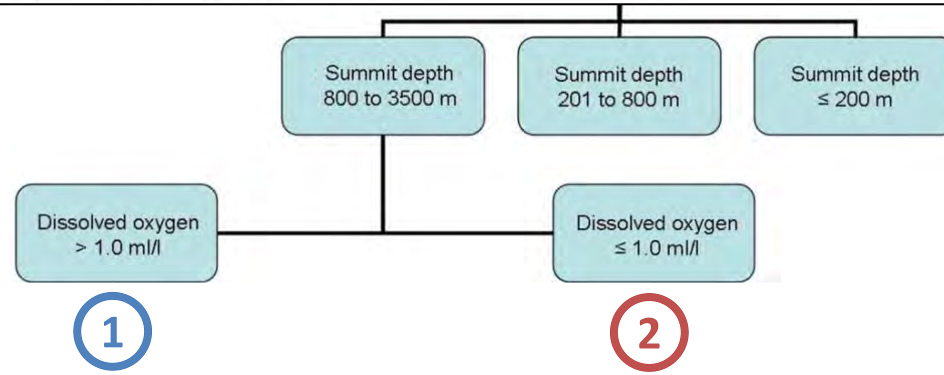
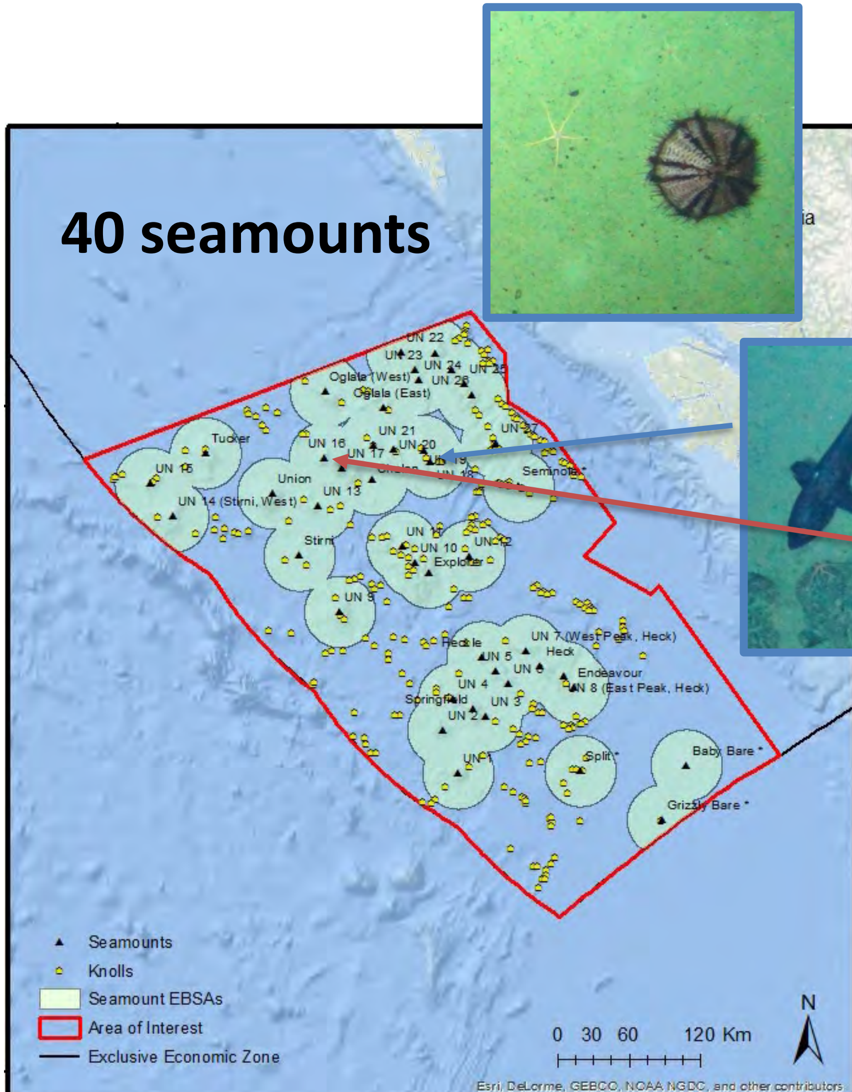
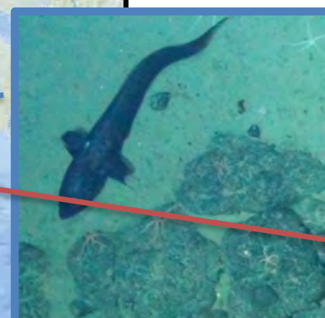


40 seamounts





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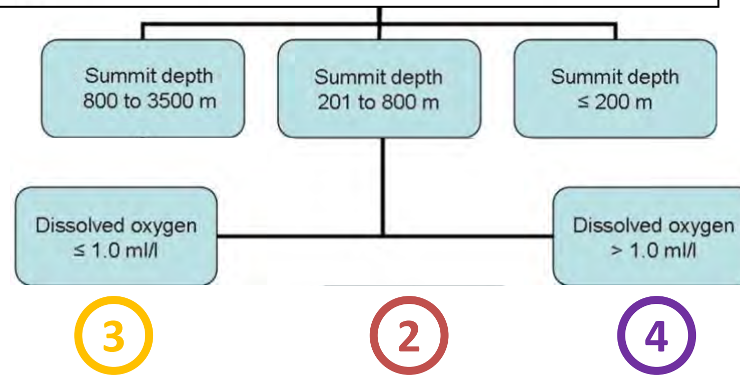
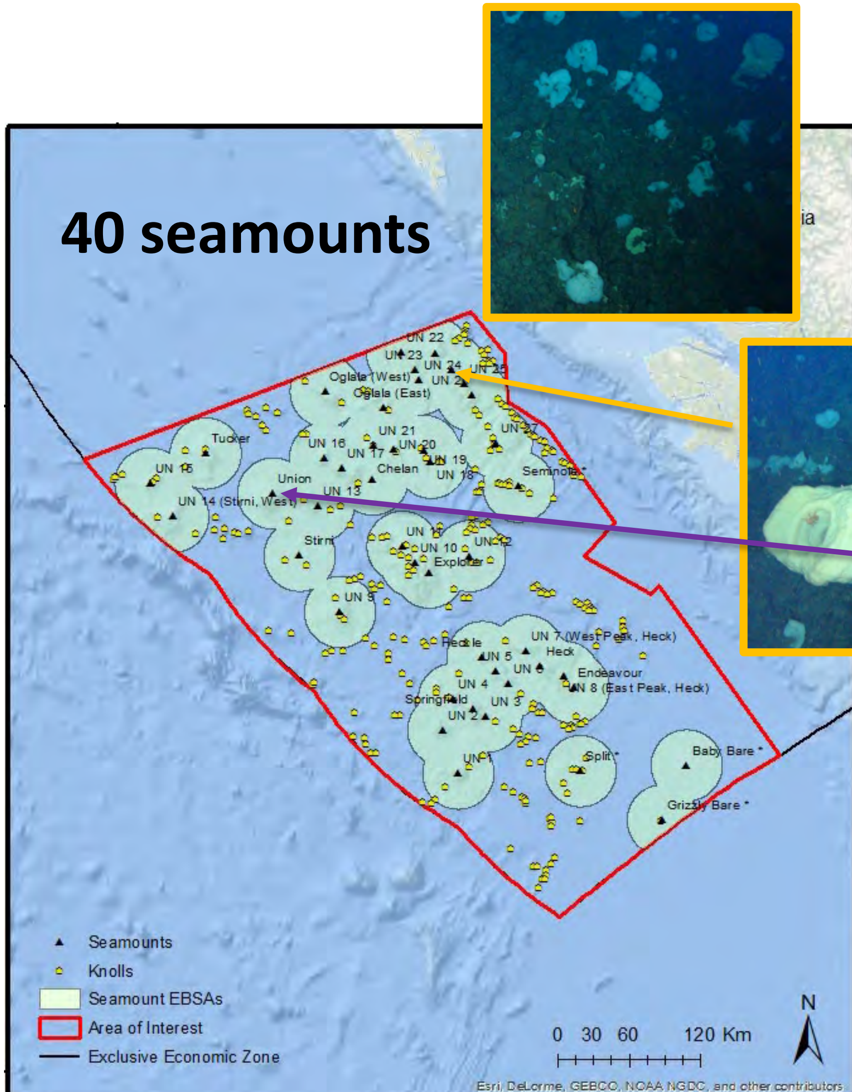
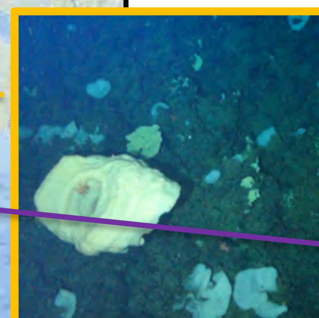
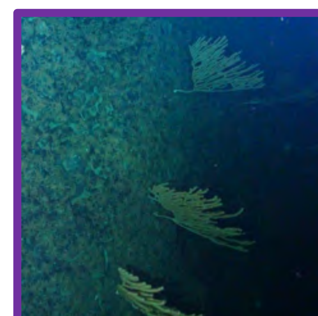
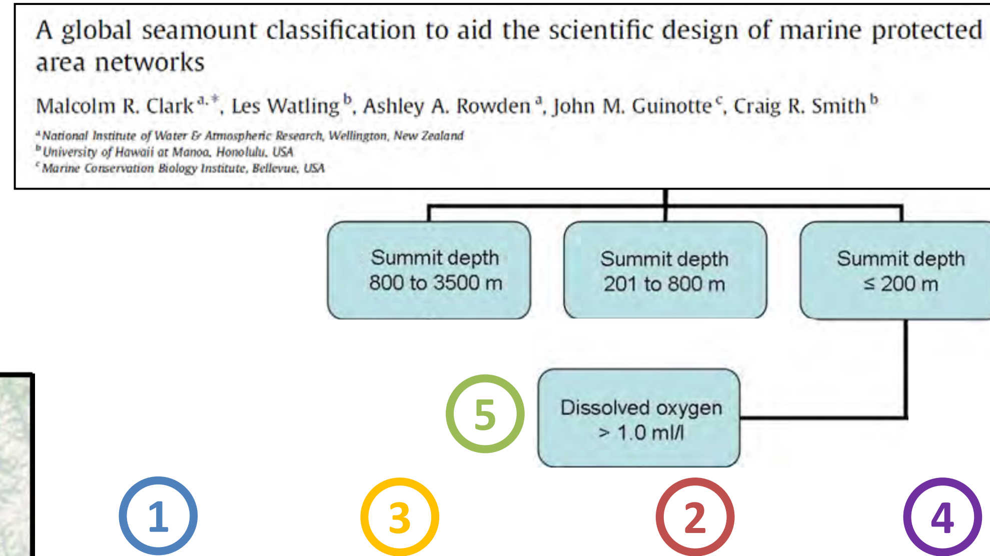








AOI Seamounts and classification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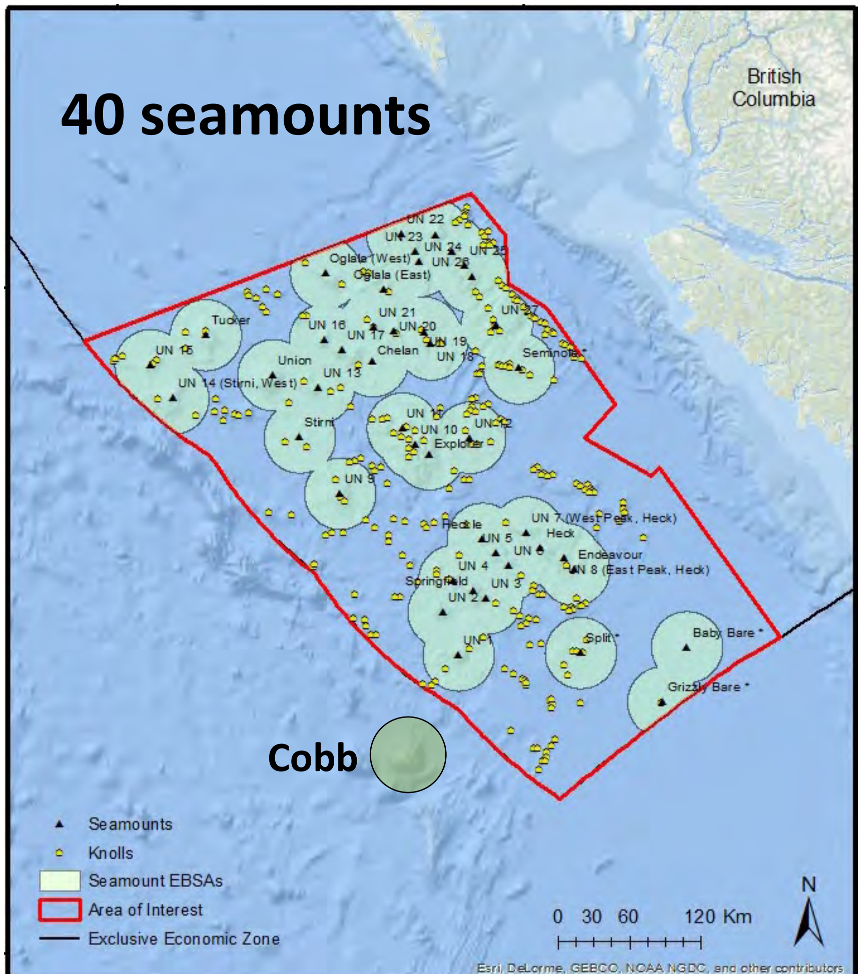
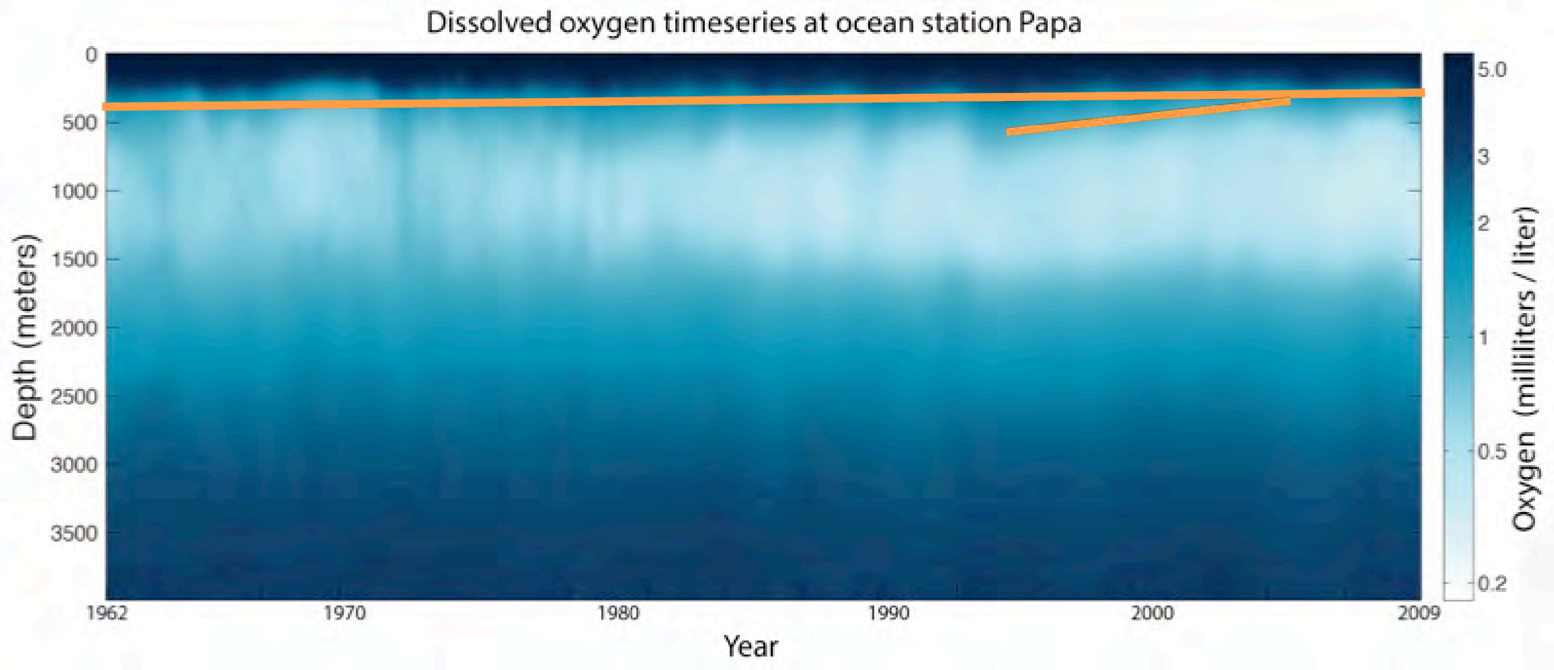


- 4 classes of seamount in the Offshore Pacific AOI
- 5 classes if nearby Cobb is included

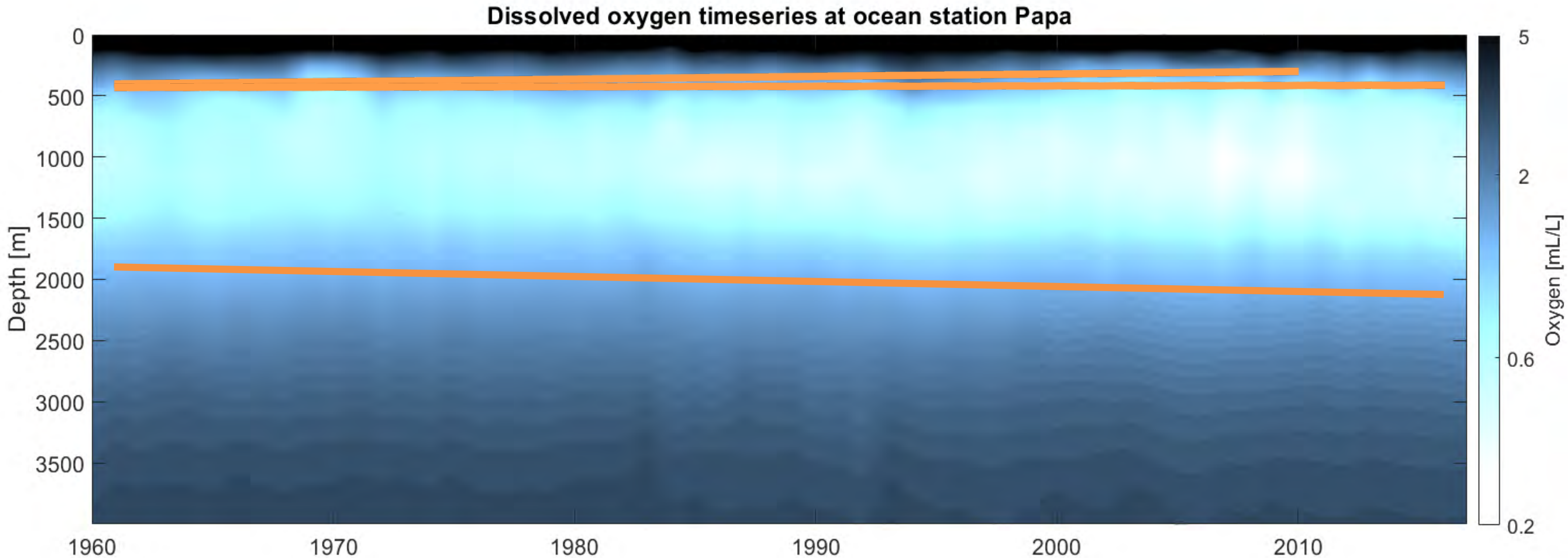
OMZ at Station Papa



- 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

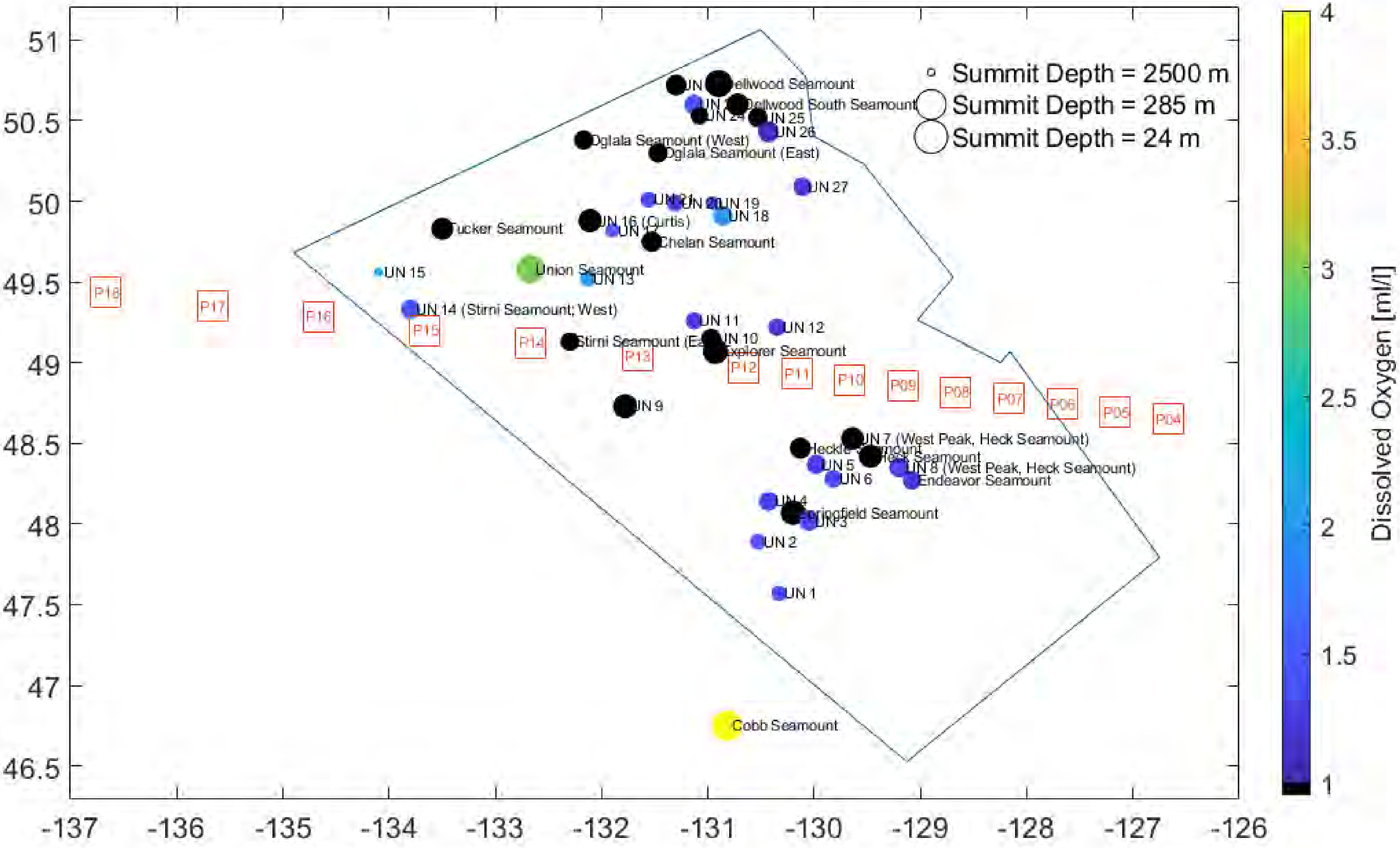


- Trends

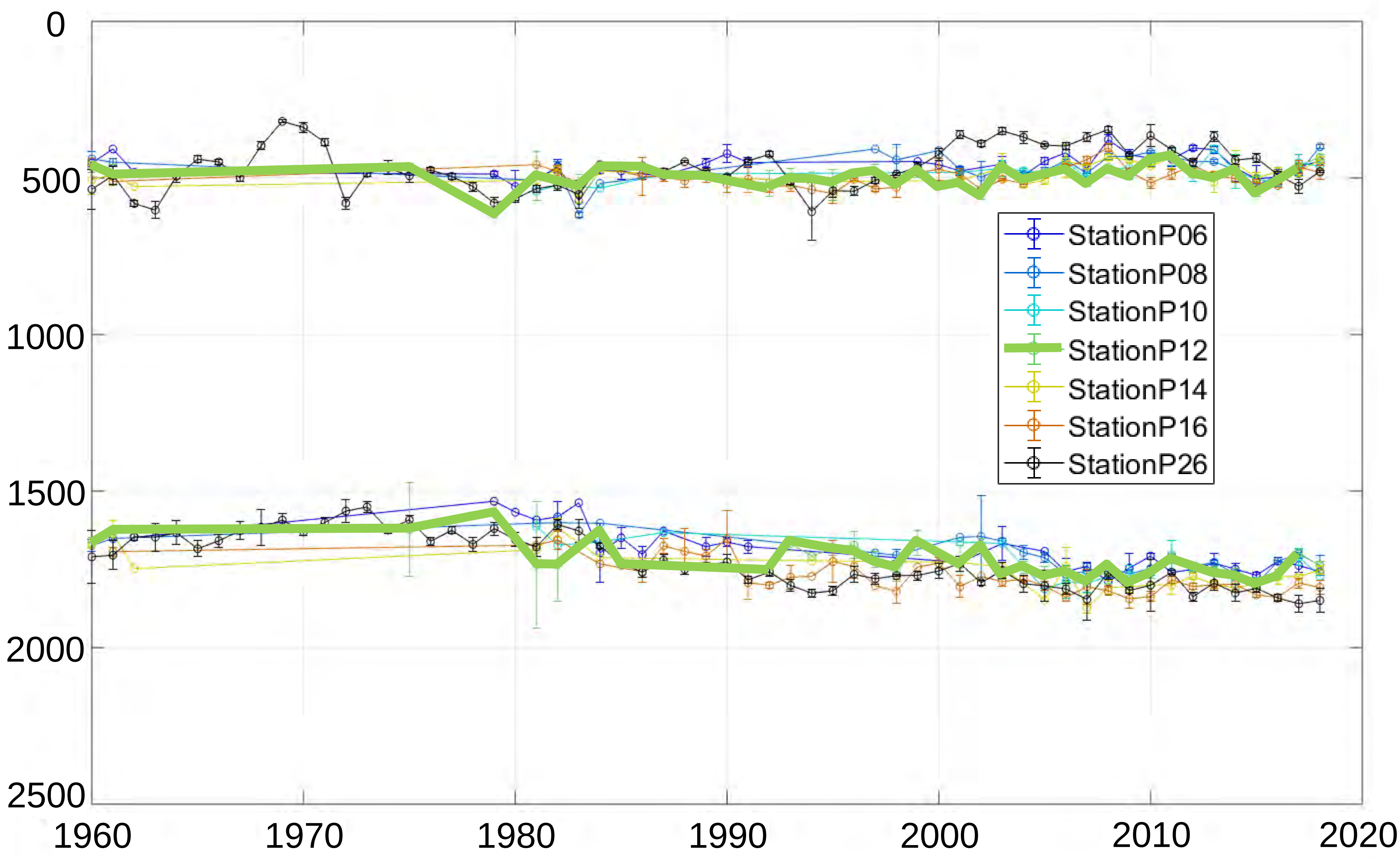
→ deepening of lower boundary of OMZ (continues unabated)

→ upper boundary of OMZ shows weaker trend with the inclusion of 2007-2018 data

Trends in OMZ boundaries in AOI



Trends in OMZ boundaries in AOI



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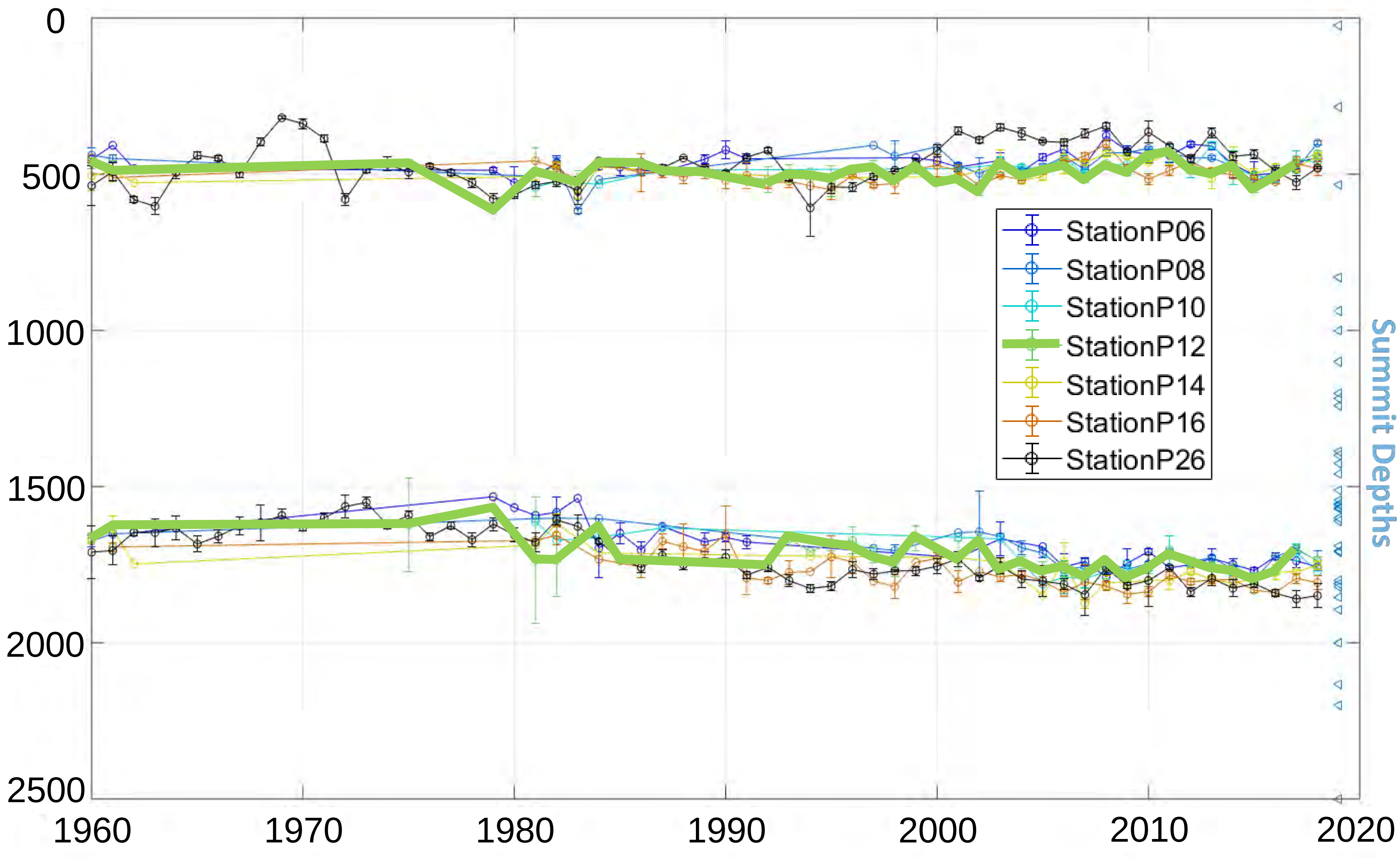
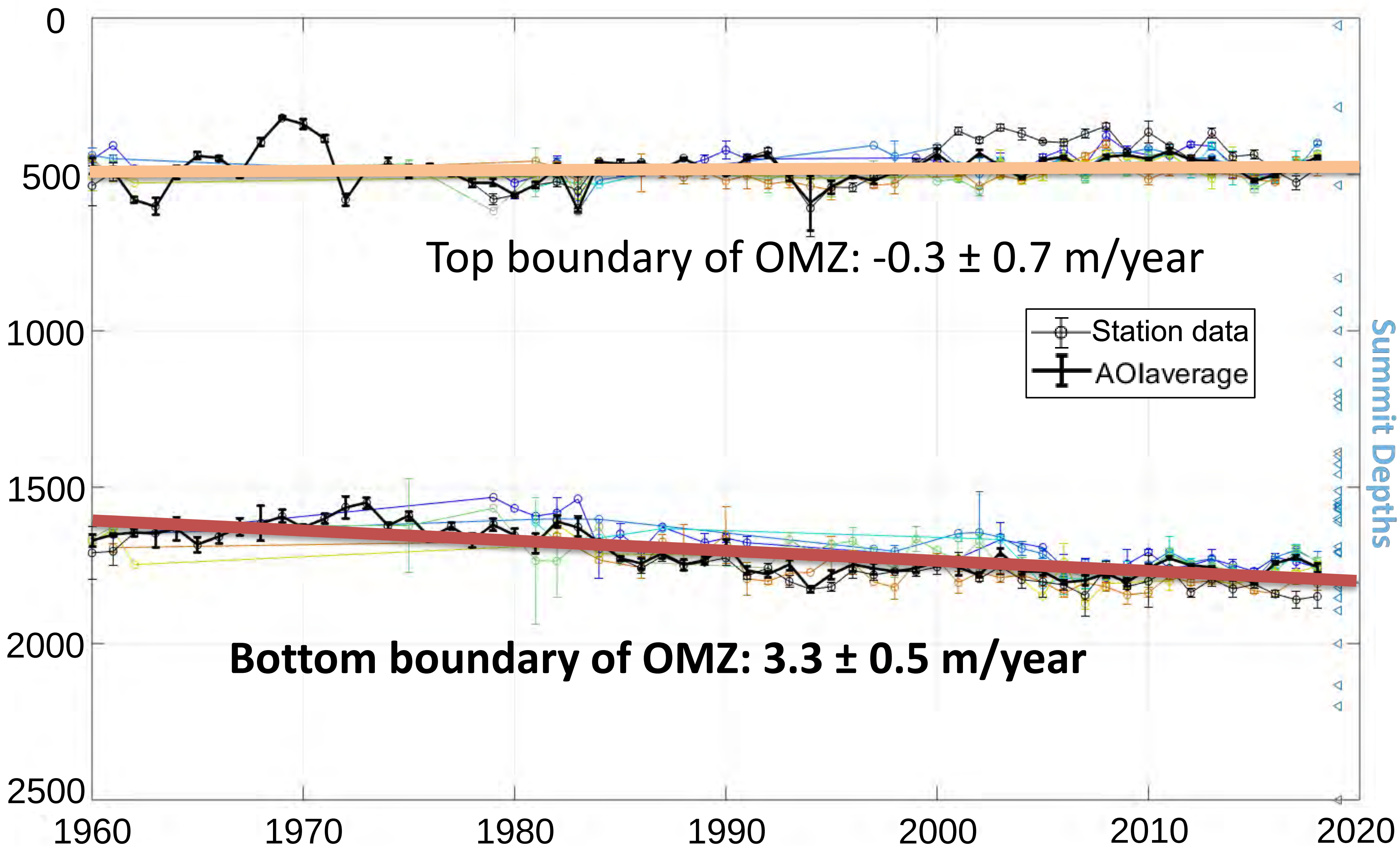
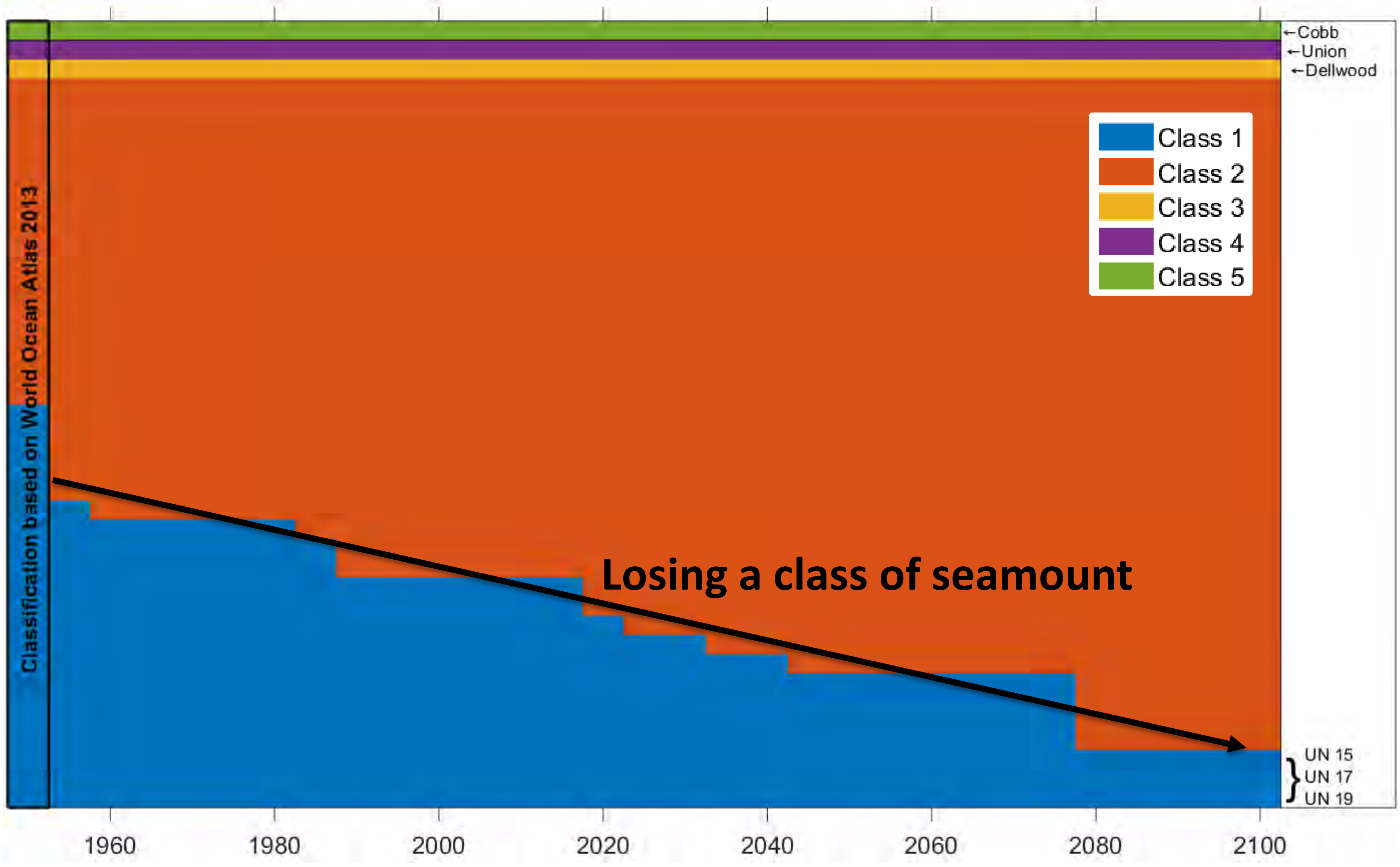


Trends in OMZ boundaries in AOI

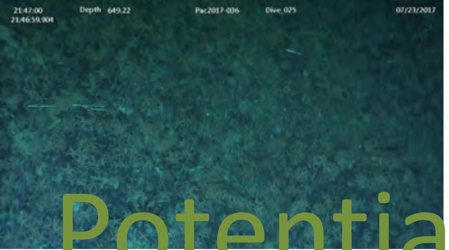


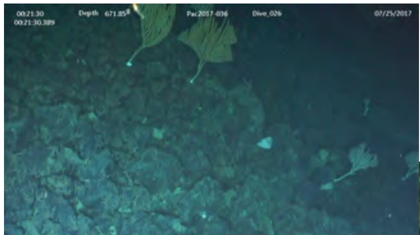
Trends in Seamount classification

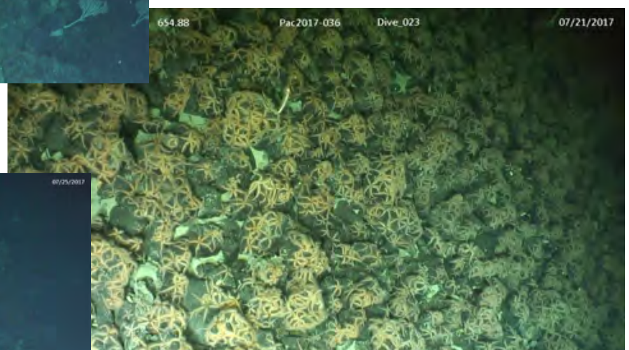


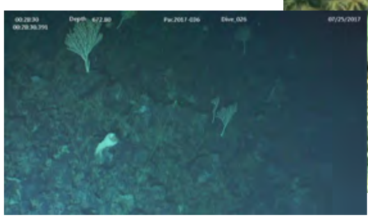
Depth: 650

Potential Impacts





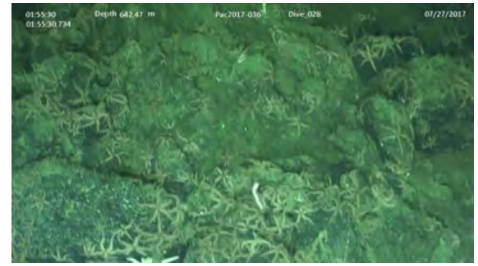


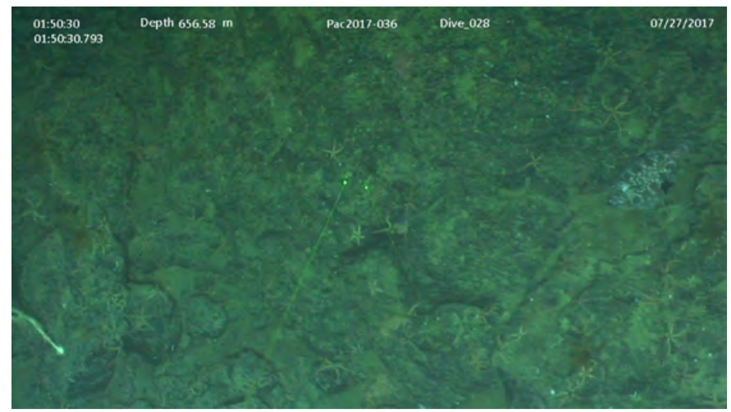


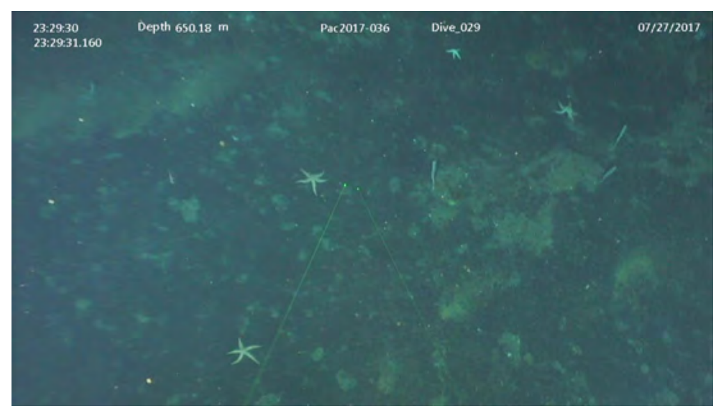
Union (Class 4, 300 m, >1 ml/l @ summit)

DO<1 ml/l

Hard substrate



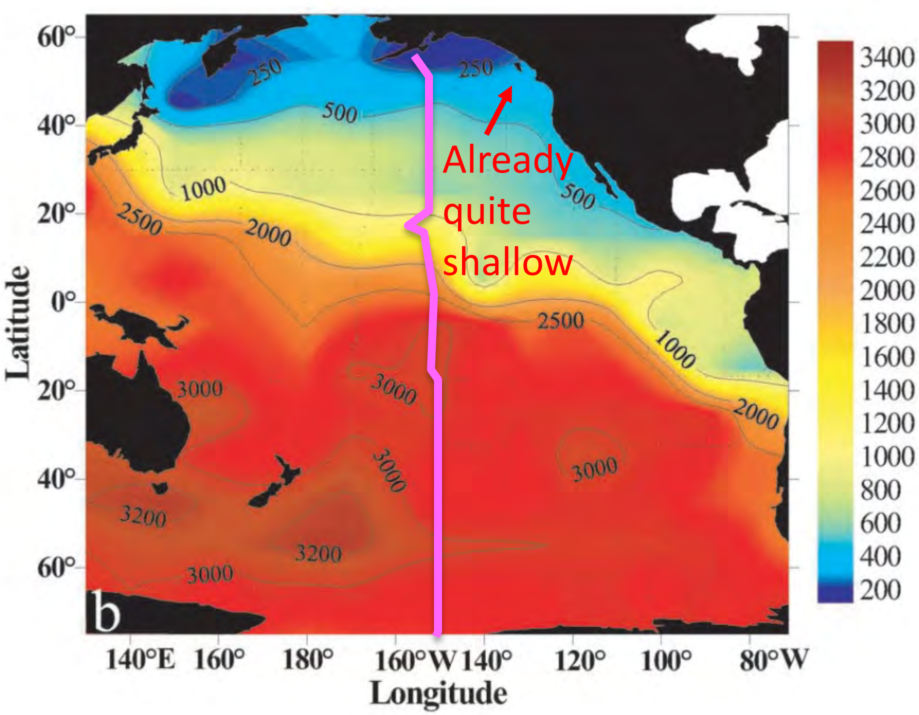




Dellwood (Class 3, 550 m, <1 ml/l @ summit)

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)

Table 1. Average Shoaling of the Aragonite Saturation Horizon (Ωarag = 1.0) and Decrease in the Aragonite Saturation State in the Upper 100 m in the South and North Pacific Due to the Uptake of Anthropogenic CO_2

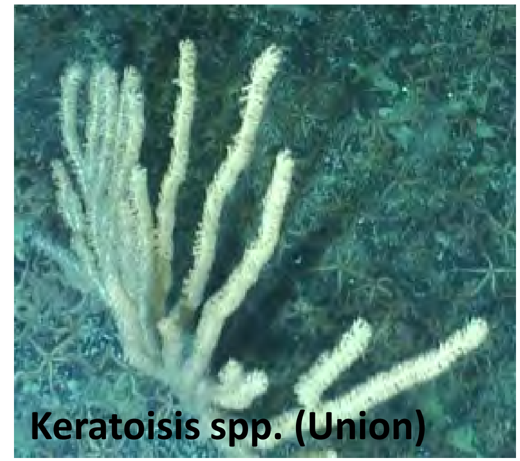
Region	P16 ($m\ yr^{-1}$)	P18 ($m\ yr^{-1}$)	P16 Ωarag Decrease ($\%\ yr^{-1}$)	P18 Ωarag Decrease ($\%\ yr^{-1}$)
South Pacific	2.01 ± 0.80	1.81 ± 0.85	0.34 ± 0.05	0.35 ± 0.05
North Pacific	0.81 ± 0.71[a]	1.14 ± 0.55	0.34 ± 0.07[a]	0.33 ± 0.01

[a]Includes PO2 value at the crossover point.

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)



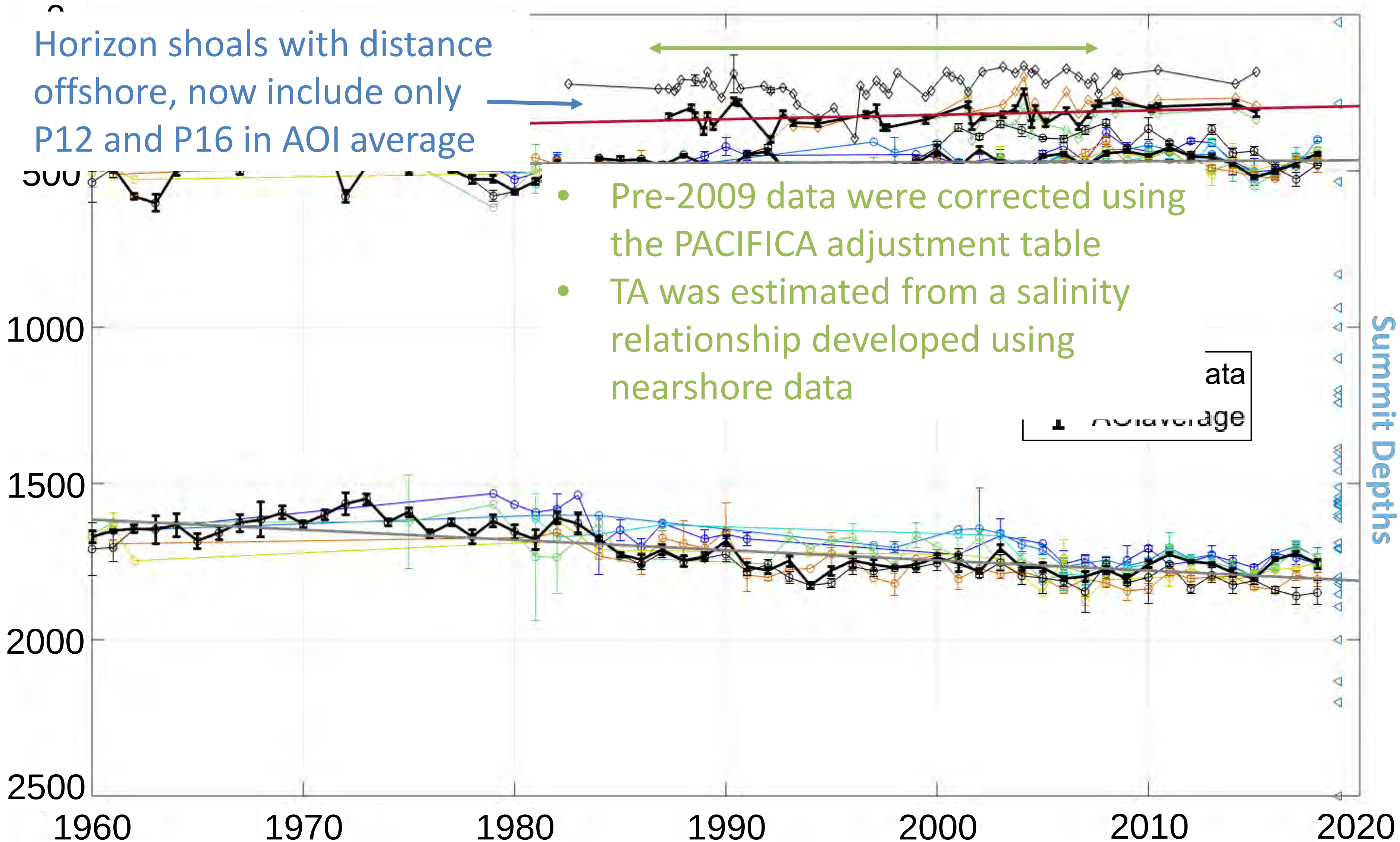
Isidella tentaculum (Union)

Photo credits: Ocean Exploration Trust, Northeast Pacific Seamount Expedition Partners

- 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)
- $\Omega_{calcite}$ = 1 is about the same as $\Omega_{aragonite}$ = 0.65, a limit where large cold-water reefs near Hawaii are still found (Baco et al. 2017)

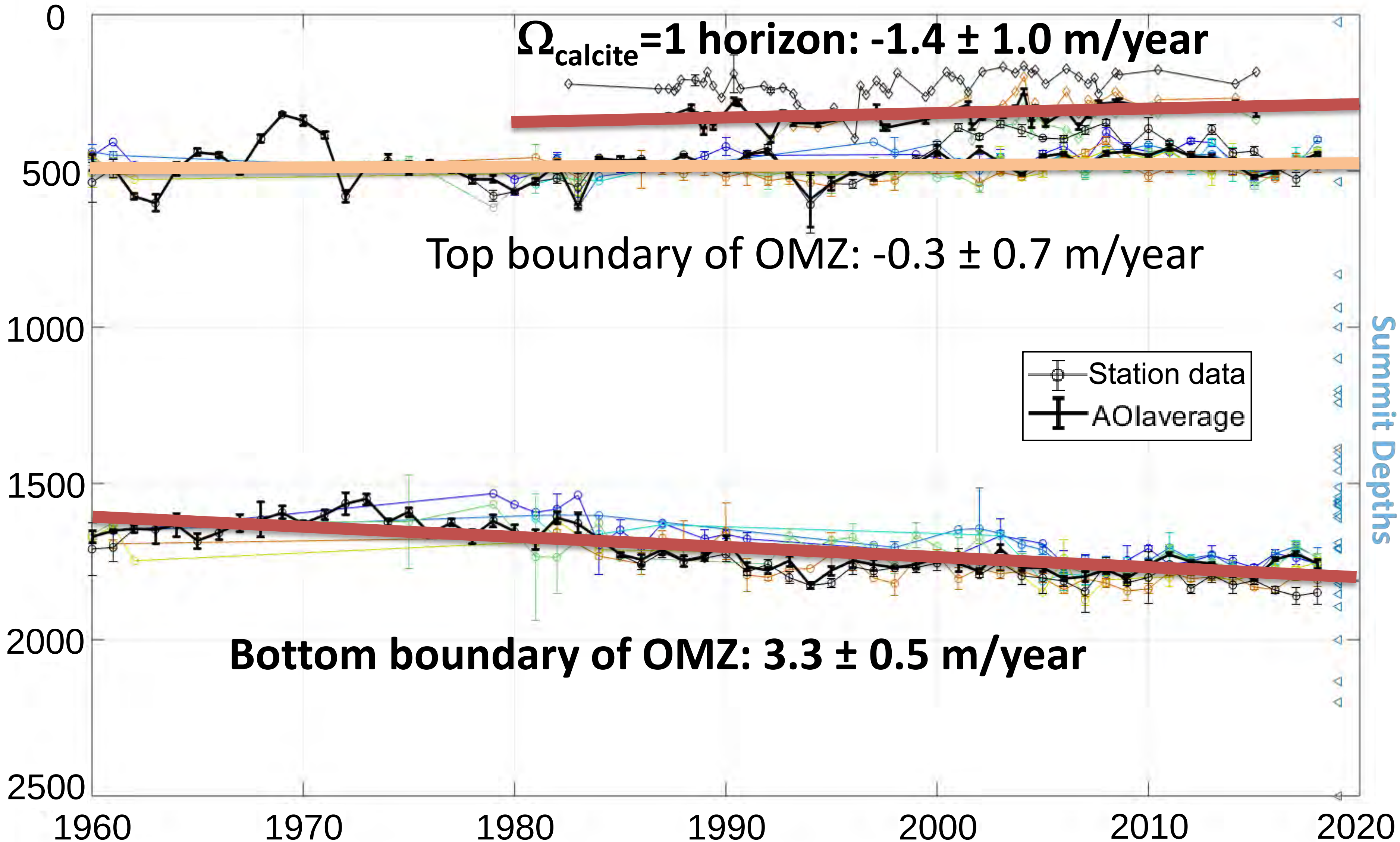
Trend in $\Omega_{calcite}$ horizon in AOI

Horizon shoals with distance offshore, now include only P12 and P16 in AOI average

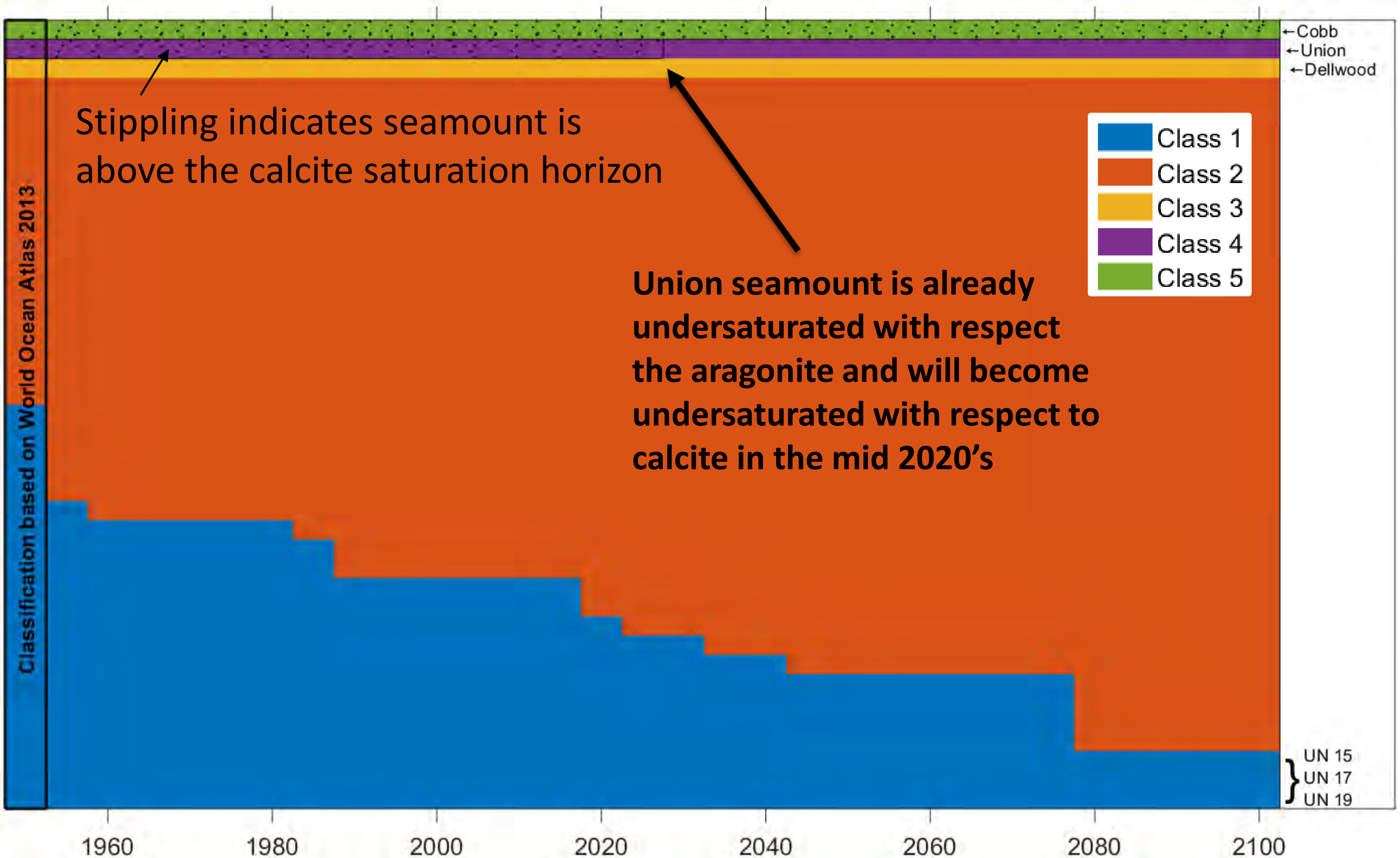


- Pre-2009 data were corrected using the PACIFICA adjustment table
- TA was estimated from a salinity relationship developed using nearshore data

Trend in $\Omega_{calcite}$ horizon in AOI



Seamount classification + Carbon



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!