Ocean Acidification Processes along the Pacific Coast

Richard A. Feely[1], Brendan Carter[1], Nina Bednarsek[1,2], Simone R. Alin[1] and Jan Newton[3]

[1]Pacific Marine Environmental Laboratory/NOAA
[2]Southern California Coastal Research Project
[3]University of Washington

Outline

- Anthropogenic CO_2 Increases
- Effect of Increasing Revelle Factor

California OA Task Force Webinar
May 29, 2018

On behalf of the project scientists at PMEL and our many national and international partners

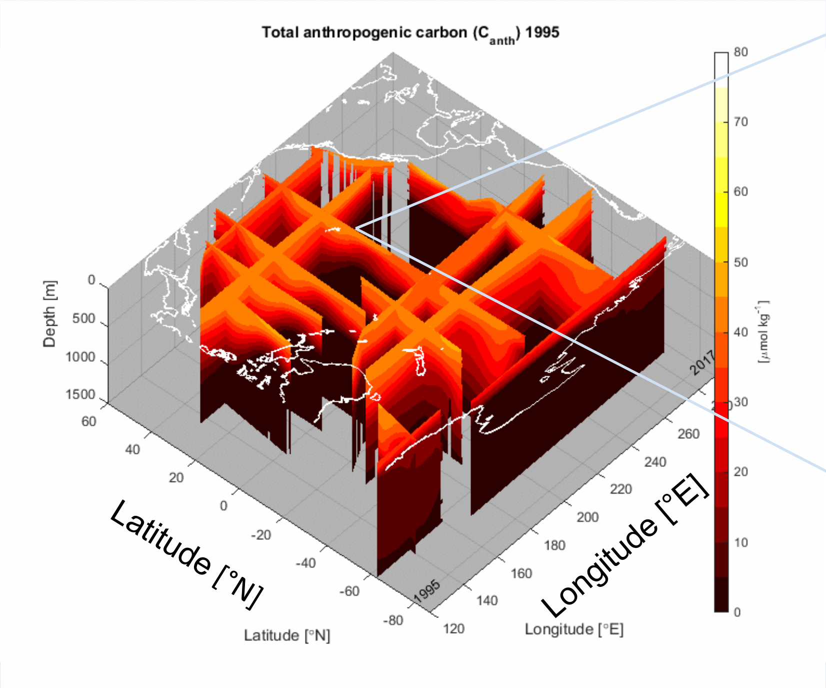
NOAA OCEAN ACIDIFICATION PROGRAM

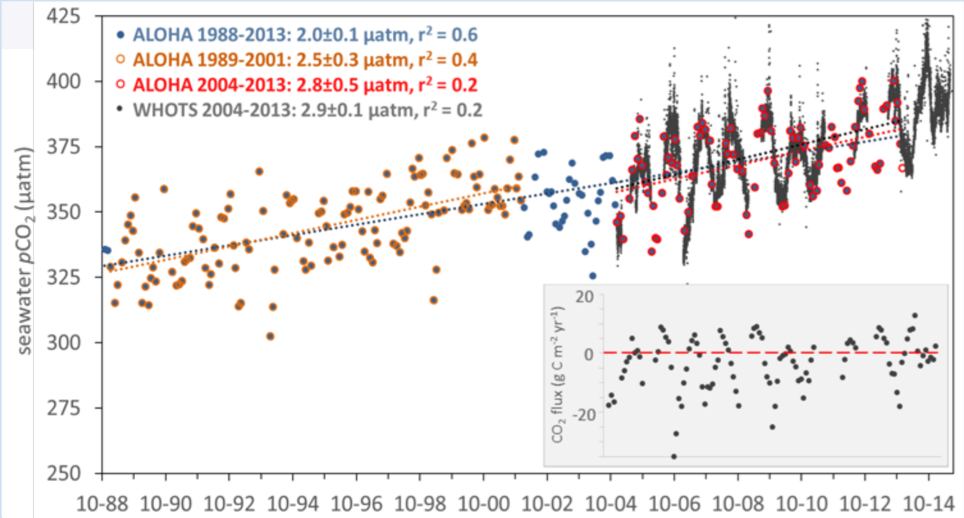
IOOS Integrated Ocean Observing System

Photo credit: Meghan Shea

Anthropogenic Carbon Dioxide Concentrations and pCO_2 Increase in the North Pacific

Pacific anthropogenic carbon from 1995 to 2015 [μmol kg^{-1}]

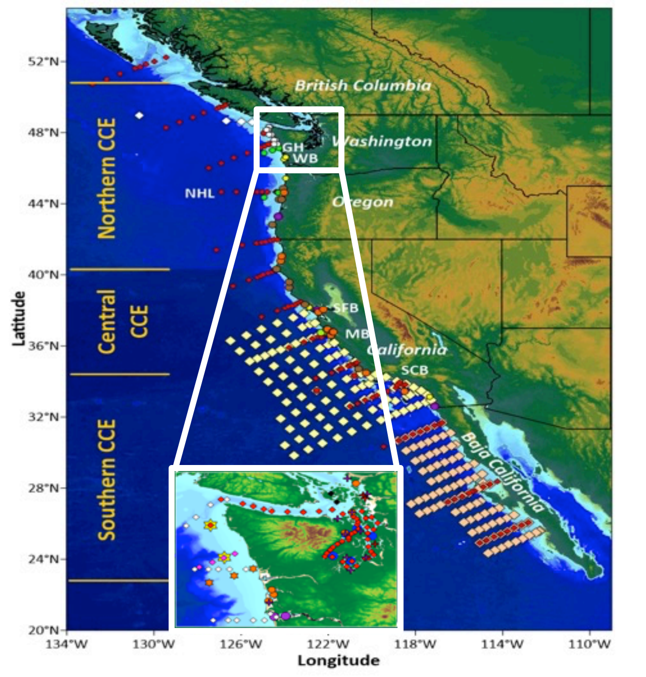


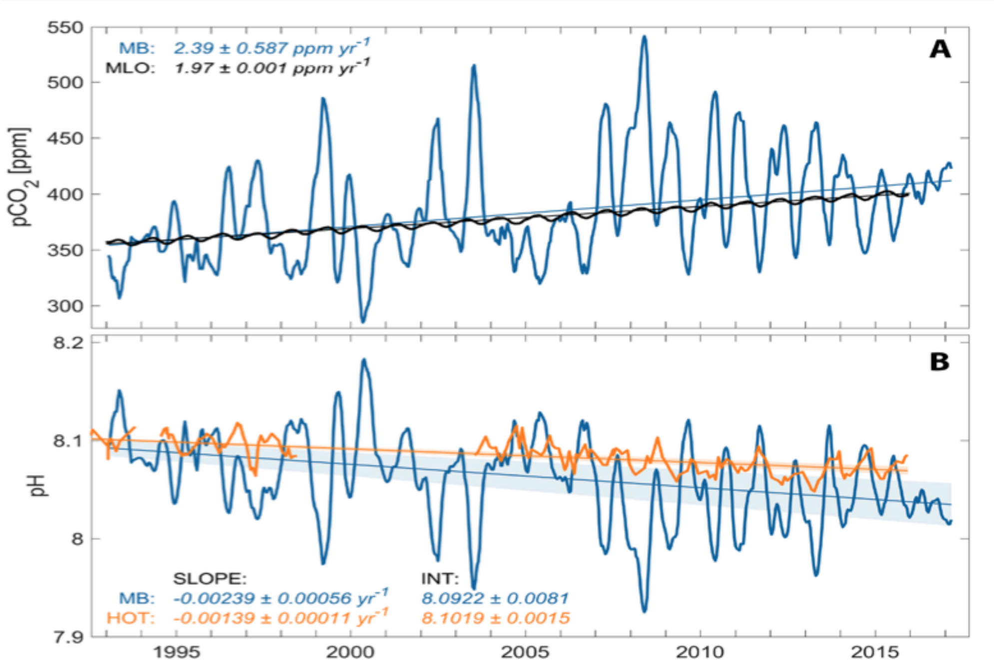


Accomplishments: Repeat hydrography (left) continues to demonstrate the growing global ocean CO_2 sink while fixed time series stations (top) illuminate how interannual events, such as "the blob," impact CO_2 flux (from Carter et al. 2017; Carter et al. in prep; Feely et al. 2018; Sutton et al. 2017)

An Integrated Federal-State West Coast Ocean Acidification Observing Network

Tuned to local/regional needs and providing real-time information to stakeholders and partners via the IOOS Pacific Region Ocean Acidification Data Portal (ipacoa.org)

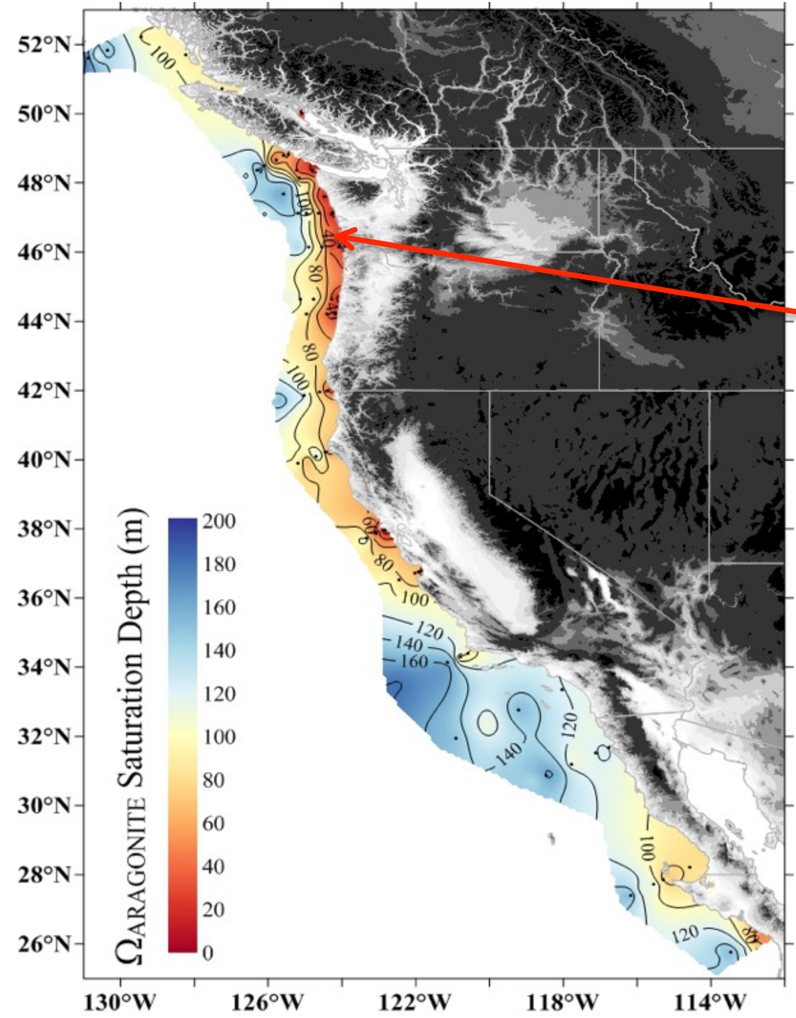




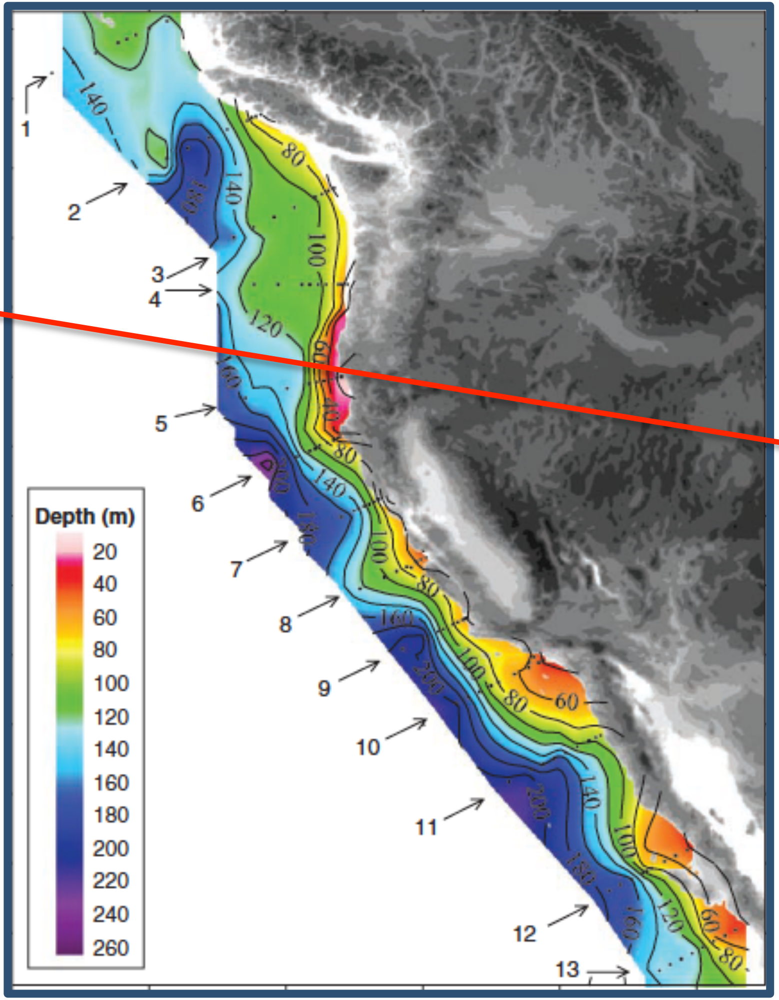
Alin et al. 2015, in press (L); Chavez et al. 2017 (R)

- Increasing CO_2 levels in the ocean increases its acidity (lowers its pH). These processes are faster in California coastal waters due to the combined effects of acidification, upwelling, and local carbon and nutrient sources.
- Observations and modeling studies indicate that local anthropogenic carbon and nutrient sources provide significant contributions to local acidification but vary widely depending on location.

Aragonite Saturation Depth (m) (2016)



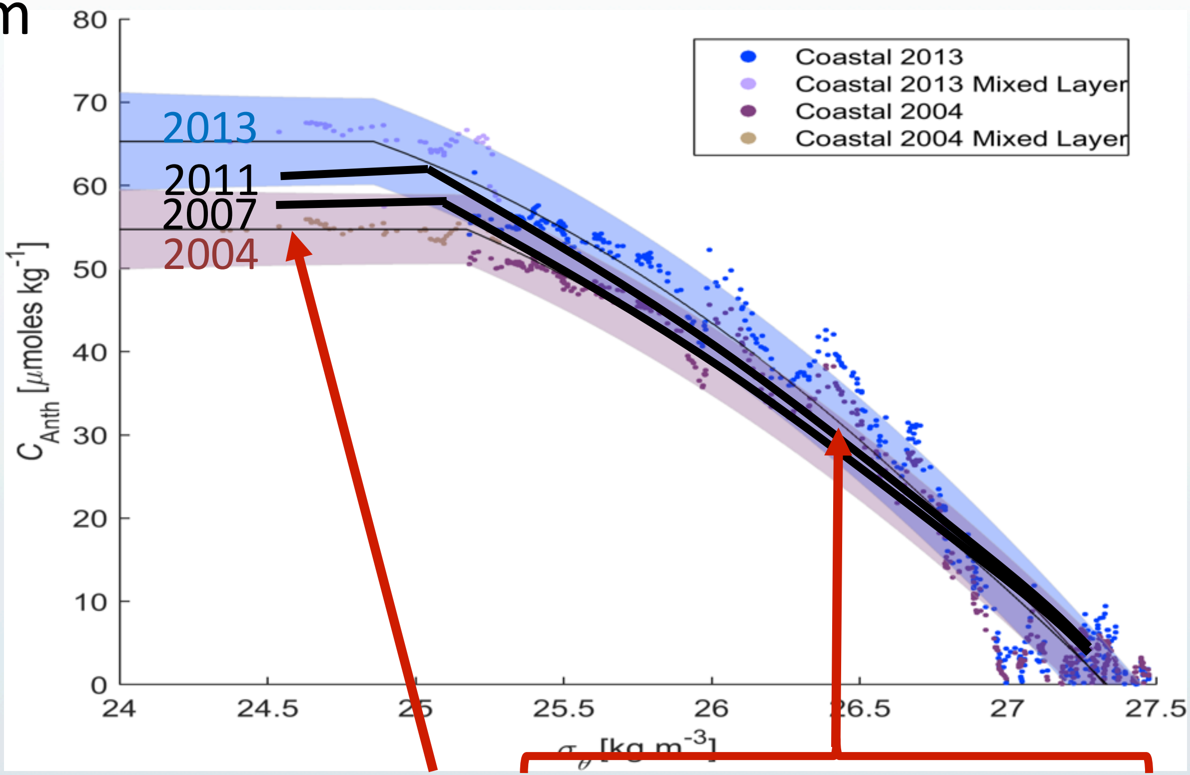
Aragonite Saturation Depth (m) (2007)



NOAA West Coast Cruise 8 May – 6 June 2016 compared with May-June 2007

Aragonite saturation depth indicates strong upwelling near the coast from northern California to Vancouver Island.

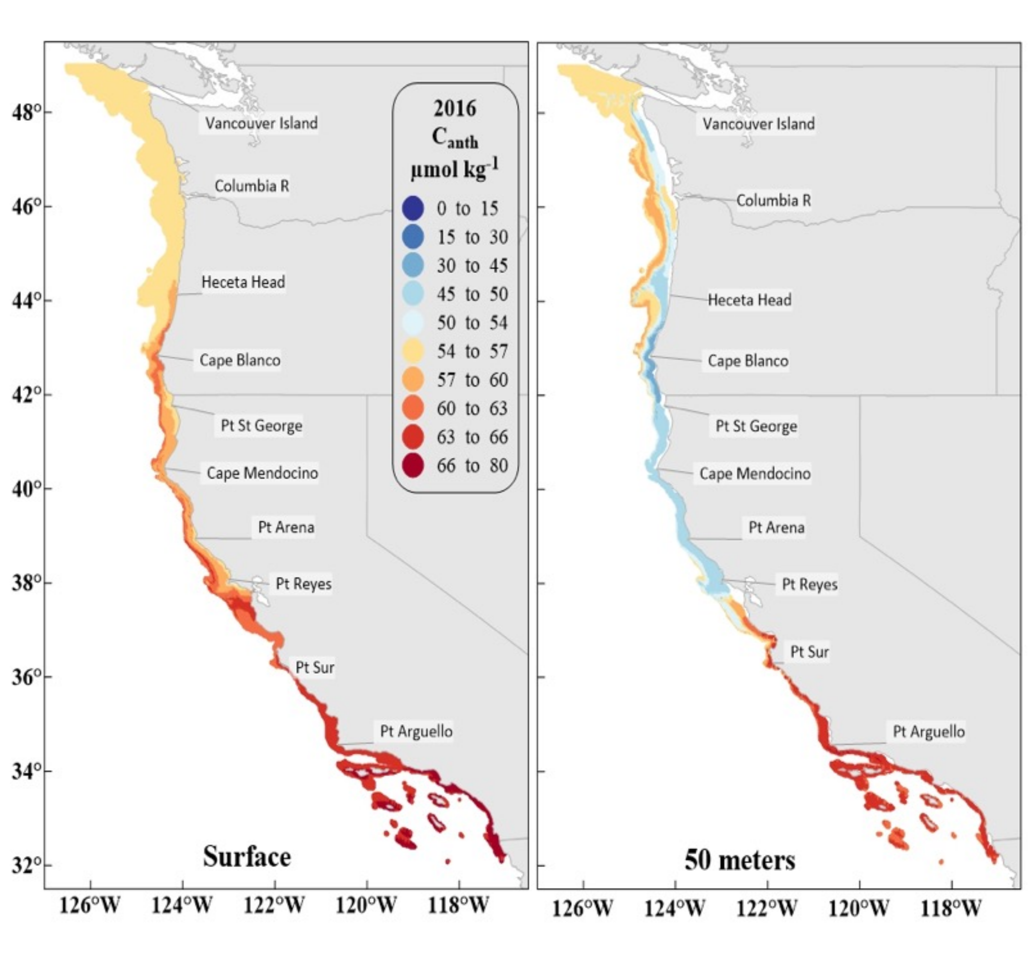
Anthropogenic CO_2 vs potential density in the California Current System



Anthropogenic CO_2 is calculated from PO2 Repeat Hydrography cruises in 2004 and 2013 and then interpolated onto California Current System potential density surfaces.

$$C_{\text{Anth}} = \min\left(\overline{C_{\text{ML}}} \;,\; A\left(\frac{(\sigma_\theta - \overline{\sigma_\theta})}{s_{\sigma_\theta}}\right)^2 + B\left(\frac{(\sigma_\theta - \overline{\sigma_\theta})}{s_{\sigma_\theta}}\right) + C \right)$$

Anthropogenic Carbon Distributions in 2016



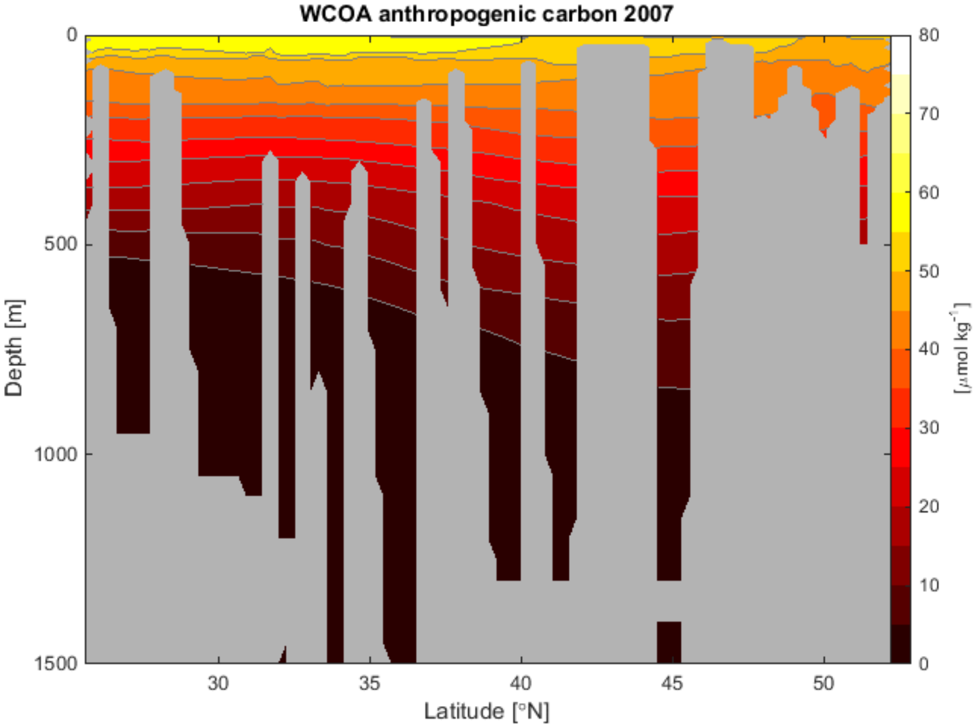
May-June 2016 C_{anth} µmolkg^{-1}

- High C_{anth} surface values (55-66 µmolkg^{-1}) offshore and to the south
- Low C_{anth} subsurface values (40-54 µmolkg^{-1}) in onshore waters from Hecata Head to Point Reyes
- Low C_{anth} waters everywhere below 100m

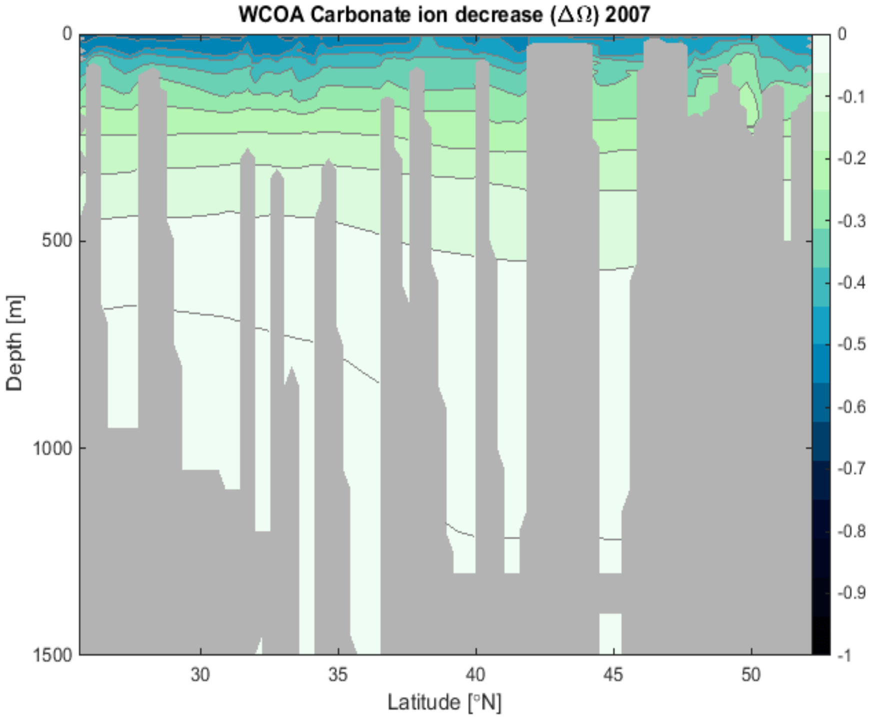
Feely et al., in prep

Evolution of chemical conditions in the California Current Ecosystem

Decadal trend in anthropogenic carbon concentration and aragonite saturation changes from the preindustrial to present



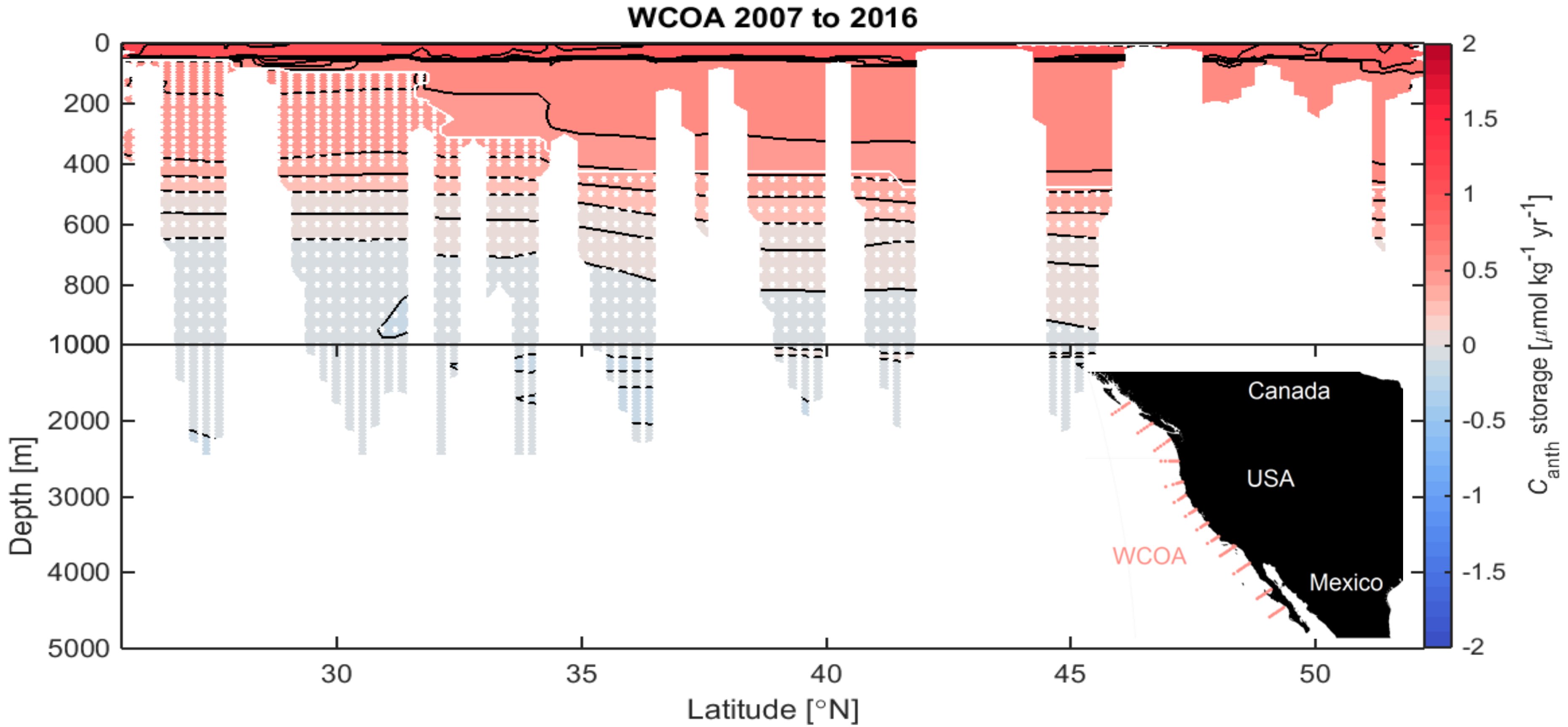
Anthropogenic CO_2 (μmol/kg)

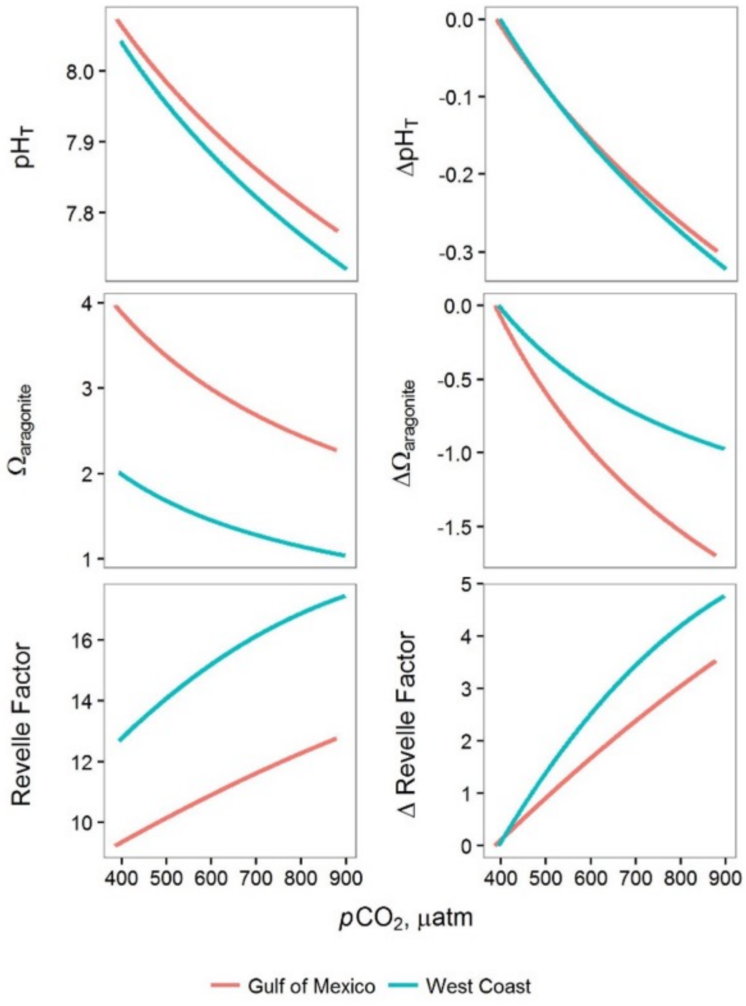


Change in aragonite saturation state

Evolution of chemical conditions in the California Current Ecosystem

Decadal trend in anthropogenic carbon rate of change in the water column





Surface water changes over time

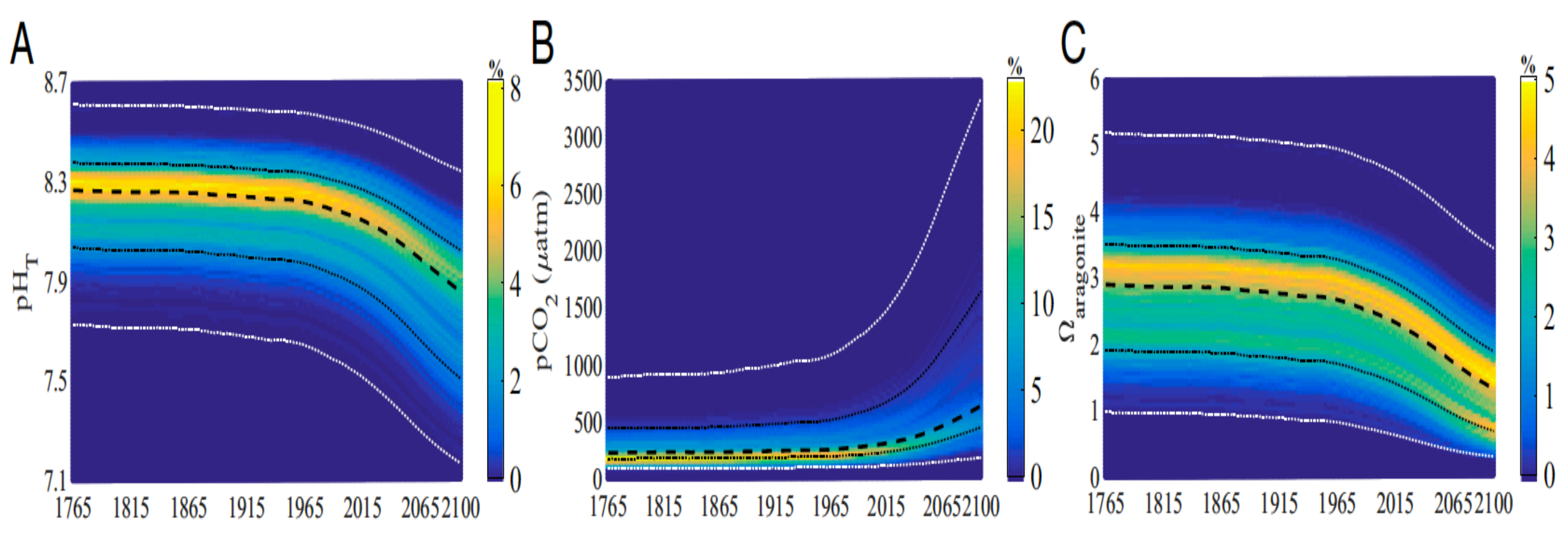
pH: lower in West Coast surface waters
similar decreases from present-day

Ω_{arag}: lower in West Coast surface waters
larger decreases in GOM from present

RF = $(\Delta pCO_2/pCO_2)/(\Delta DIC/DIC)$ changes more rapidly in the cooler West Coast waters

Feely et al (2018)

Past, Present and Future Impacts of Ocean Acidification



In coastal environments like the Salish Sea, the increasing anthropogenic carbon reduces the ability of the system to buffer natural variations in CO_2. This reduced buffering capacity leads to preferential amplification of naturally extreme low pH and high $pCO_{2(s.w.)}$ events above changes in average conditions, which outpace rates published for atmospheric and open-ocean CO_2 change. -Pacella et al., PNAS

Conclusions

- Our major challenge is to determine anthropogenic ocean acidification changes and biological responses against a backdrop of large natural variability. Approach to Solve: Collaborative Monitoring and Modeling
- Co-located chemical/biological field observations provide unique opportunities to observe and understand long-term changes as impacted by ocean acidification and hypoxia. Approach to Solve: Collaborative Monitoring and Modeling
- Oyster larvae, Pteropods and Crab larvae exhibit physiological responses that appear to be impacted by ocean acidification now. Approach to Solve: Continued Collaborative Field and Laboratory Studies