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CBP05 Coastal Biology/Biogeochemistry

PH and PCO2 TIME SERIES FROM THE OCEAN OBSERVATORIES INITIATIVE ENDURANCE ARRAY

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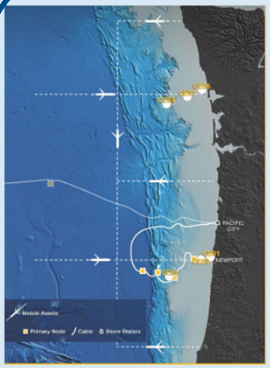
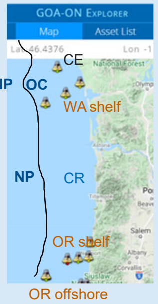
Measurements: Locations

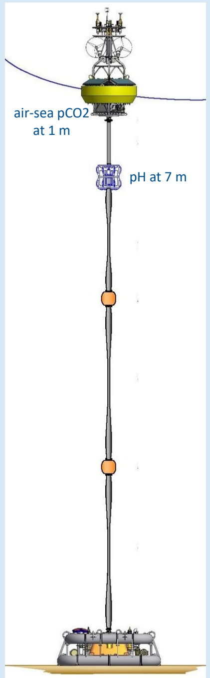




Left: OOI measurements are located in a relatively well-studied area. We review the seasonal and interannual variability in the context of Fassbender *et al.* (2018). OOI WA moorings are generally consistent with the Outer Coast (OC) region identified in their work. OOI OR moorings are south of the Columbia River (CR) and generally resemble the North Pacific (NP) region.

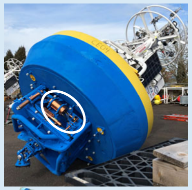
Above: OOI makes multidisciplinary measurements in the NE Pacific as part of the Regional Cabled Array and the Endurance Array. Here we focus on pCO2 and pH measurements made from Endurance Array coastal surface moorings at the Oregon shelf (80 m, CE02) and offshore (575 m, CE04) sites and the Washington shelf (87 m, CE07) and offshore (542 m, CE09) sites.

The full scope of the OOI Endurance Array was deployed in spring 2015. Data are available from oceanobservatories.org and have been shared with IOOS organizations including the Global Ocean Acidification Observation Network (GOA-ON, upper right).



Above: WA shelf mooring, 87 m depth (components not to scale)

Measurements: pCO2 and pH Instruments



Above: For air-sea pCO2, OOI uses Pro-Oceanus CO2-Pro air-sea pCO2 system (white outline) mounted at the base of the buoy. We compare the seasonal cycles returned by this system with regional measurements compiled by Fassbender *et al.* (2018).

Above: For in water pH, OOI uses the Sunburst SAMI pH (gold outline). On the moorings, this is mounted on an instrument frame at 7 m. On the inshore moorings, there is also a Sunburst pCO2 (white outline). We also compare the seasonal cycles returned by SAMI-pH with Fassbender *et al.* (2018).

Data processing and quality control

All sensors undergo calibration by manufacturers after each deployment.

Wherever possible, overlapping mooring deployments of 2-4 days are used to assess performance of old and newly deployed sensors (see Wingard *et al.*, 2020)

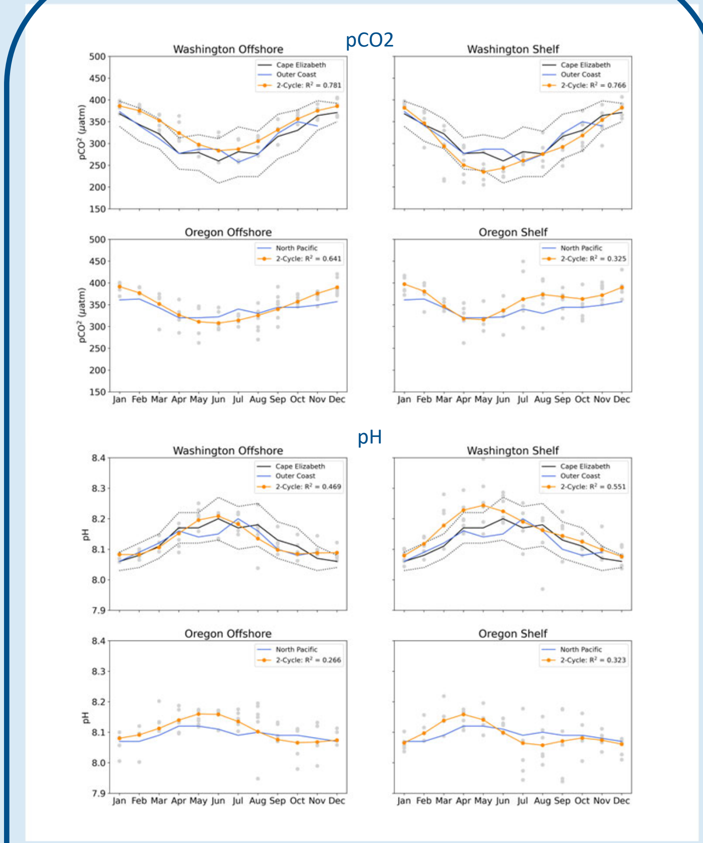
Co-located shipboard CTD/bottle samples are taken during maintenance cruises (see Wingard *et al.*, 2020)

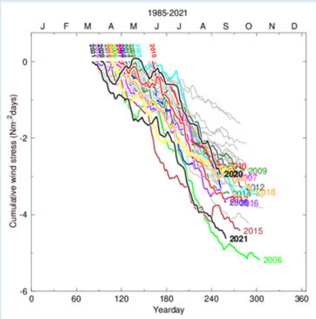
OOI holds yearly meetings with instrument manufacturers to review quality of refurbishment work, components, updates to firmware, refurbishment schedule etc.

Data are reviewed by operators with human in the loop (HITL) and automated QC of processed data.

Real time automated QC is in development.

Seasonal and interannual variability





Above: Cumulative upwelling season wind stress from 1985-2021 (Pierce and Barth, 2022). 2015 (brown) and 2021 (black) are two of the strongest upwelling years, yet their pCO2 responses (see events) are quite different.

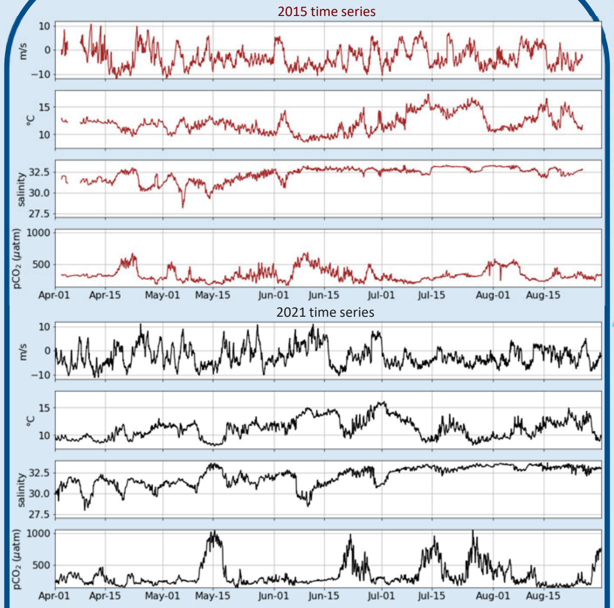
Above: OOI (blue, orange) mooring seasonal cycles and monthly averages (gray) for pCO2 (top) and pH (bottom). For context, OOI mooring cycles are plotted together with *Fassbender et al.* (2018) (black) regional seasonal cycles. WA moorings are compared with the Fassbender *et al.* Outer Coast (OC) region. OR moorings are compared with the Fassbender *et al.* North Pacific (NP) region.

Variability is highest in spring and summer (see scatter of monthly averages (gray dots).

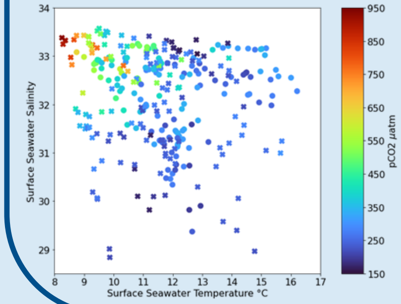
pCO2 values greatly exceed atmospheric values (~400 µatm) at times in the summer.

The highest monthly pCO2 averages are seen at the Oregon shelf site. As shown in the event variability section, these occur primarily in the summer of 2021.

Oregon Shelf Mooring Event pCO2 Variability



Above: Time series of N-S wind, SST, SSS, and pCO2 for 2015 and 2021. While equatorward, upwelling favorable winds are similar in strength both years, the response in water properties is quite different. Relative to 2015, 2021 shows colder, saltier water with higher pCO2 brought to the surface. Evans *et al* (2011) noted similar variability over the Oregon shelf in summer 2008 with pCO2 in excess of 1000 µatm.



Left: Daily-averaged pCO2 as a function of sea surface temperature and salinity from April to August 2015 (•), and 2021 (x)

Greater pCO2 variability occurs in 2021. 2015 had similar upwelling winds (see interannual variability) but lower variability. This may be due to lingering effects of the regional 2014-2016 marine heat wave (warm blob) which reduces upwelling of cold, salty, high pCO2 water.

Conclusions

OOI pH and pCO2 (fCO2) data are consistent with historical regional measurements.

There is geographic variability in the timing and magnitude of the seasonal cycle. Shelf seasonal variability precedes offshore and OR precedes WA. Monthly averages show significant year-to-year variability.

Strong variability at synoptic meteorological scales also exists. It is stronger at the OOI shelf sites and in particular at the Oregon shelf mooring.

While wind forcing is important, underlying changes in the upwelling source water affect the carbonate system. SST and SSS variability consistent with the 2014-2016 warm blob are linked to reduce pCO2 variability in 2015. In 2021, higher variability and higher peaks are seen.

Long term trends, diurnal variability and relationships to other biologically important variables (*e.g.*, NO3) are as yet largely unexplored in these data.

References

Evans *et al.* (2011) *J. Geophys. Res.* Oceans, 116 (C5), DOI: (10.1029/2010JC006625)

Fassbender *et al.* (2018), *Earth Syst. Sci. Data*, 10, 1367–1401, 2018 https://doi.org/10.5194/essd-10-1367-2018

Pierce, S. and J. Barth. (2022), Wind stress, cumulative wind stress, and spring transition dates: data products for Oregon upwelling-related research, Available from: /http://shadow.ceoas.oregonstate.edu/damp/windstress/ (Accessed 1 Feb 2022)

Wingard *et al* (2020), Protocol for the Assessment and Correction of Moored Surface Water and Air pCO2 Measurements from the Ocean Observatories Initiative Endurance Array, AI44C-2440, presented at Ocean Sciences Meeting 2020, San Diego, CA, 20 Feb

OCEAN OBSERVATORIES INITIATIVE