***Supplementary Material***

**Marine CO2 Patterns in the Northern Salish Sea**

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**Supplemental Text 1:** A number of ancillary datasets were utilized in this study. Hourly wind speed, wind direction, and sea surface temperature data were provided by Environment Canada from weather buoy 46131 (http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/waves-vagues/data-donnees/data-donnees-eng.asp?medsid=C46131). Composite (day and night averaged) Advanced Very High Resolution Radiometer (AVHRR) local area coverage (LAC) 1.1 km sea surface temperature data from the NOAA Polar Orbiting Environmental Satellite (POES) were provided by NOAA CoastWatch (http://coastwatch.pfel.noaa.gov/data.html#). Hakai Institute oceanographic station QU39 CTD data were obtained through the institute’s data portal (hecate.hakai.org) and processed using standard CTD data handling protocols. Atmospheric xCO2 from the Representative Concentration Pathway (RCP) 8.5 (Riahi et al., 2011) acquired from the RCP Database Version 2.0 (http://www.iiasa.ac.at/web-apps/tnt/RcpDb/dsd?Action=htmlpage&page=welcome) and converted to pCO2 assuming 1 atm of pressure.

**Supplemental Text 2:** The pattern of NSS along-axis cumulative wind stress, as determined using daily mean wind speed and direction from Environment Canada weather buoy 46131 (Figure 1), showed rapid growth at the start of the year due to the occurrence of strong winter storms with southeasterly winds, with an inflection when wind stress became predominantly negative that is associated with the occurrence of northwesterly winds through the summer months (Supplemental Figure 5). A second inflection occurred in the fall when wind stress transitioned to mainly positive values associated with southeasterly winds. Spring and fall transitions defined based on these inflection points (Huyer et al., 1979; Pierce et al., 2006) were used to delineate summertime winds that then allowed for the rate of energy transfer from the wind to be calculated (Supplemental Figure 6). Using CTD data collected at oceanographic station QU39 (Figure 1), the potential energy needed to mix the upper water column can be expressed relative to the density gradient between the surface ocean and a reference layer (Hauri et al., 2013). For this calculation, reference layers of 10 m and 20 m were used because during the summertime high-CO2 events, seawater with a 21 kg m-3 density anomaly () reached the surface, and this density layer has typically been found near 20 m and meaning that vertical mixing extended to at least this depth. This layer surfaced when the energy imparted on the upper ocean from the wind surpassed the potential energy needed to mix the upper water column (Figure 7).

**Supplemental Table 1:** Data source, number of measurements, timing and collection method, observing period, and digital object identifiers for CO2 system datasets presented in this study.

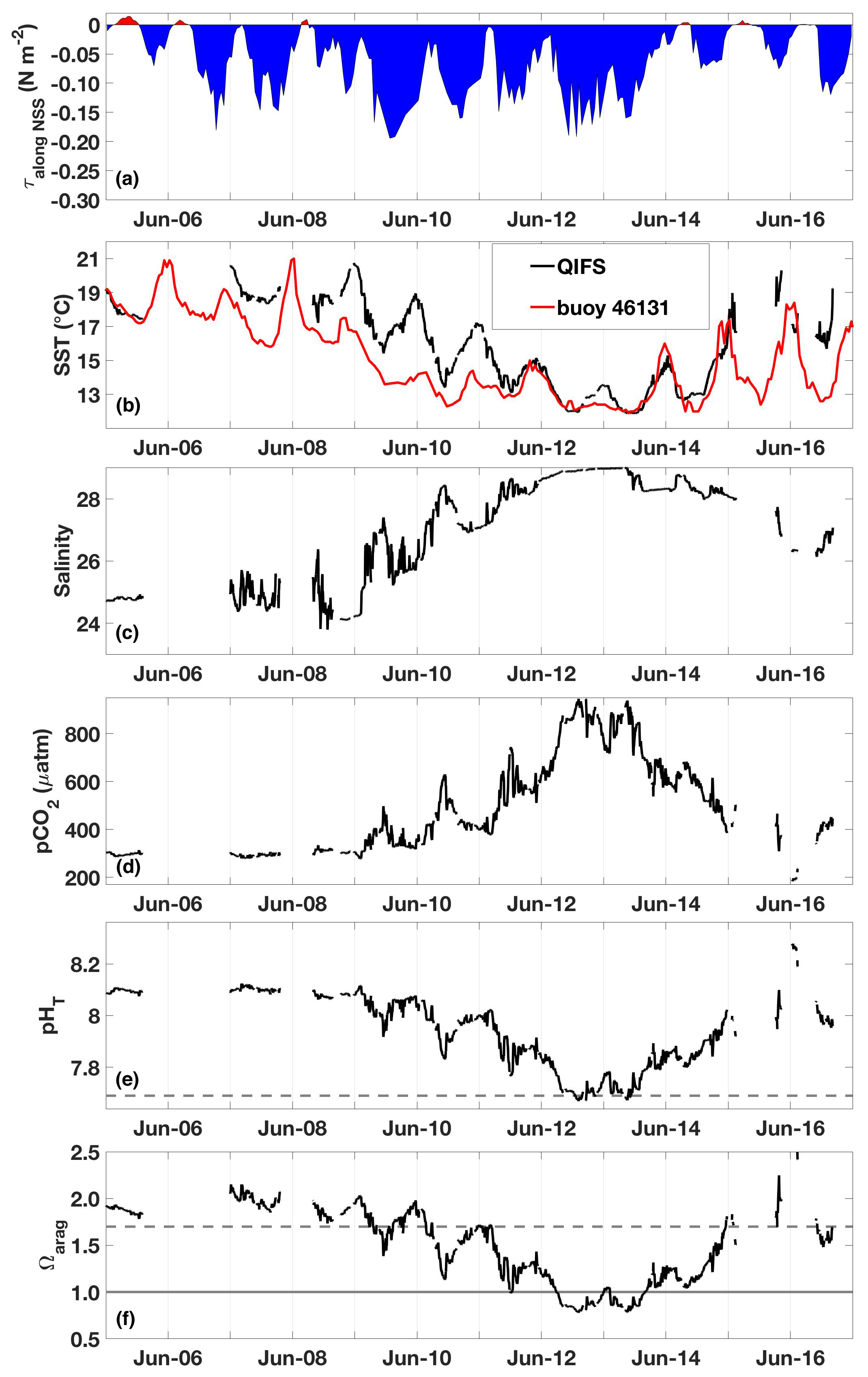
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| --- | --- | --- | --- | --- |
| Data Source | Number of Measurements | Timing / Data Collection Method | Observing Period | Digital Object Identifier |
| QIFS SUPERCO2/BoL | 246825 | year-round / flow-through analyzer | Dec. 18 2014 - Jun. 1 2018 | http://dx.doi.org/10.21966/1.437736  http://dx.doi.org/10.21966/1.614670  http://dx.doi.org/10.21966/1.715729 |
| Sentry Shoal SeaFET | 82413 | seasonal / in situ probe at 1 m | Jul. 19 2016 - Dec. 1 2016; Jul. 25 2017 - Oct. 24 2017 | http://dx.doi.org/10.21966/1.715693 |
| NOAA WCOA2016 | 65 | single research cruise with CTD-Rosette | Jun. 5 2016 - Jun. 6 2016 | http://dx.doi.org/10.21966/1.715784 |
| Hakai Institute station QU39 | 662 | year-round / full water column discrete samples collected by Niskin bottles with messengers | Jan. 19 2016 - Dec. 11 2017 | http://dx.doi.org/10.21966/1.715738 |
| Pacific Salmon Foundation (PSF) | 399 | seasonal / surface and 20 m discrete samples collected by Niskin bottles with messengers | Jul. 26 2016 - Oct. 19 2017 | http://dx.doi.org/10.21966/1.715740 |
| Sawmill Bay Shellfish | 90 | seasonal / surface discrete samples collected by hand | May 9 2016 - Dec. 13 2016 | http://dx.doi.org/10.21966/1.715756 |
| Mac’s Oysters, LTD. (MO) | 28 | seasonal / surface discrete samples collected by hand | Jul. 5 2017 - Sep. 4 2017 | http://dx.doi.org/10.21966/1.715756 |
| Fanny Bay Oysters (FBO) | 57 | year-round / surface discrete samples collected by hand | Apr. 18 2017 - Nov. 29 2017 | http://dx.doi.org/10.21966/1.715756 |
| Deep Bay Field Station (DB) | 90 | year-round / surface discrete samples collected by hand | Jan. 13 2017 - Mar. 24 2018 | http://dx.doi.org/10.21966/1.715756 |

**Supplemental Table 2:** Uncertainties for various CO2 system parameters computed at mean temperature (11.61°C), salinity (26.26), pCO2 (441 µatm), pHT (7.99), Alkinorganic (1851 µmol kg-1), TCO2 (1736 µmol kg-1) using a MATLAB CO2SYS error propagation routine that includes uncertainty in the carbonic acid dissociation constants (Orr et al., 2018). Uncertainties for CO2 system parameters computed for BoL and SeaFET inputs used factory reported temperature (0.002°C) and salinity (0.001; based on conductivity uncertainty at mean temperature) for both SBE 45 and SBE 37 sensors. Uncertainties for CO2 system parameters computed from discrete TCO2 and pCO2 measurements used with factory reported uncertainty in the NIST traceable thermometer (0.2°C) and uncertainty in YSI probe salinity based on the standard deviation (0.11) about a mean difference of 0.01 for 85 measurements of CRMs with known salinity.

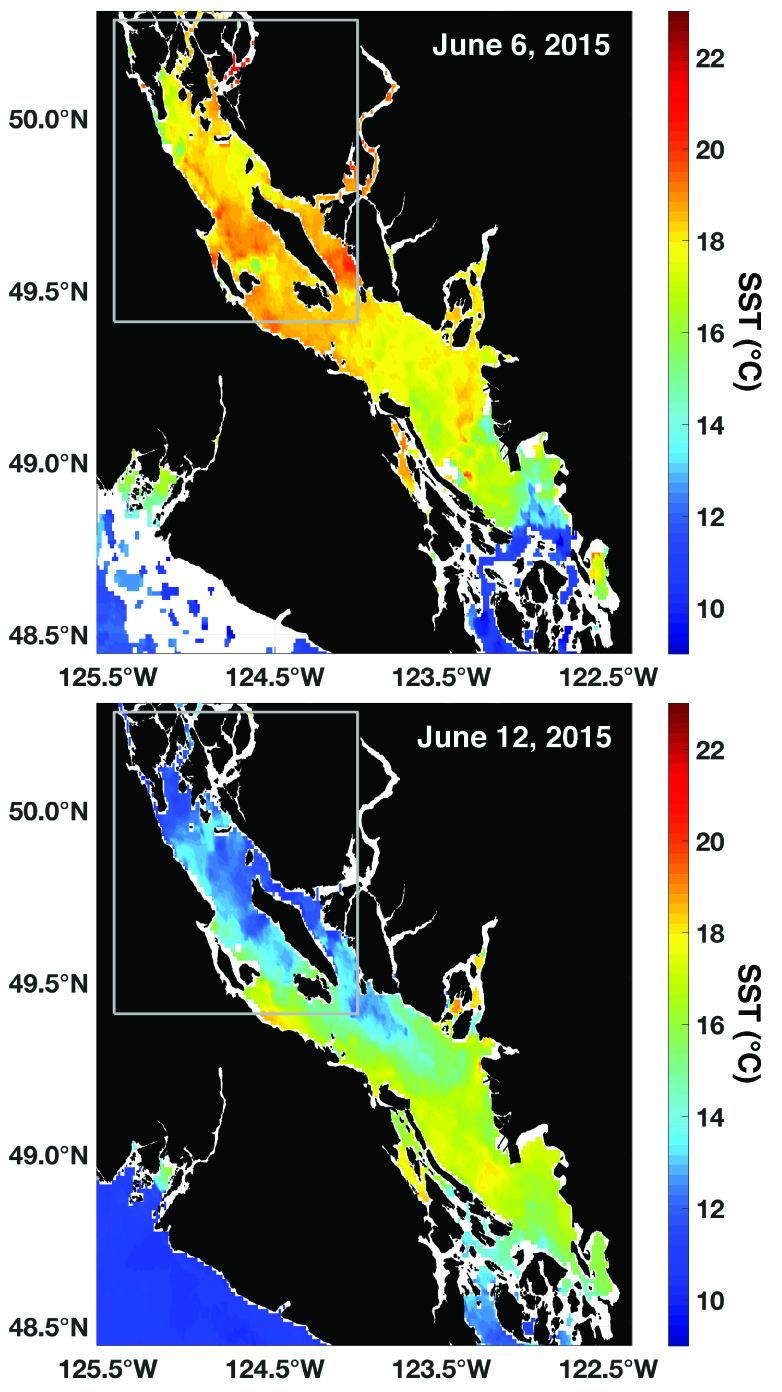
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| Input parameters | pCO2 (µatm) | Alkinorganic  (µmol kg-1) | TCO2  (µmol kg-1) |  | pHT |
| Continuous pCO2- Alkinorganic (S) | 6.61 | 22.47@ | 20.42 | 0.031 | 0.009 |
| Continuous pHT- Alkinorganic (S) | 15.03 | 22.47@ | 22.04 | 0.039 | 0.014& |
| Discrete TCO2-pCO2 | 6.61 | 6.13 | 5.2 | 0.023 | 0.008 |

@RMSE of Alkinorganic (S) relationship

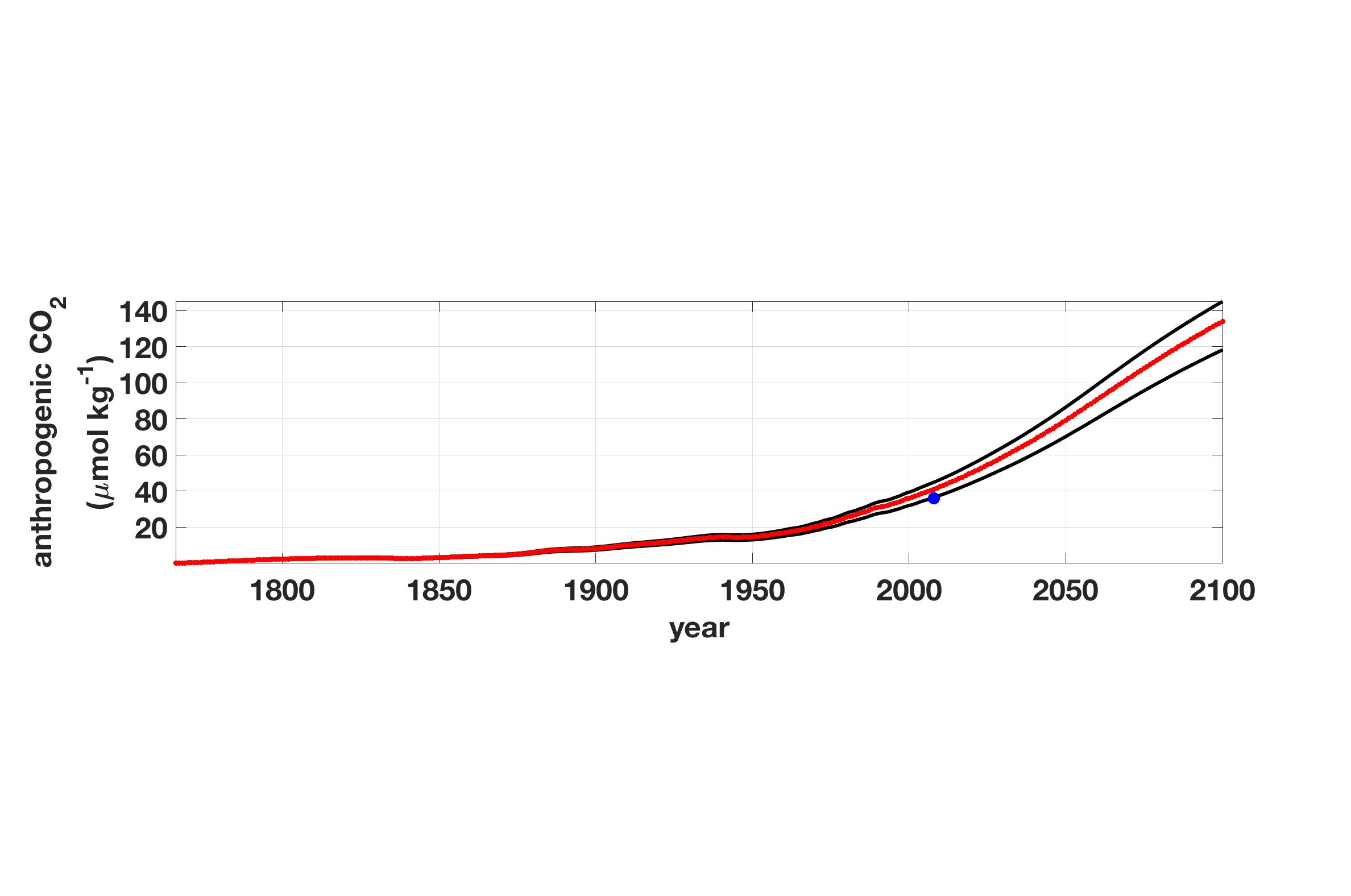
&from Miller et al. (2018)

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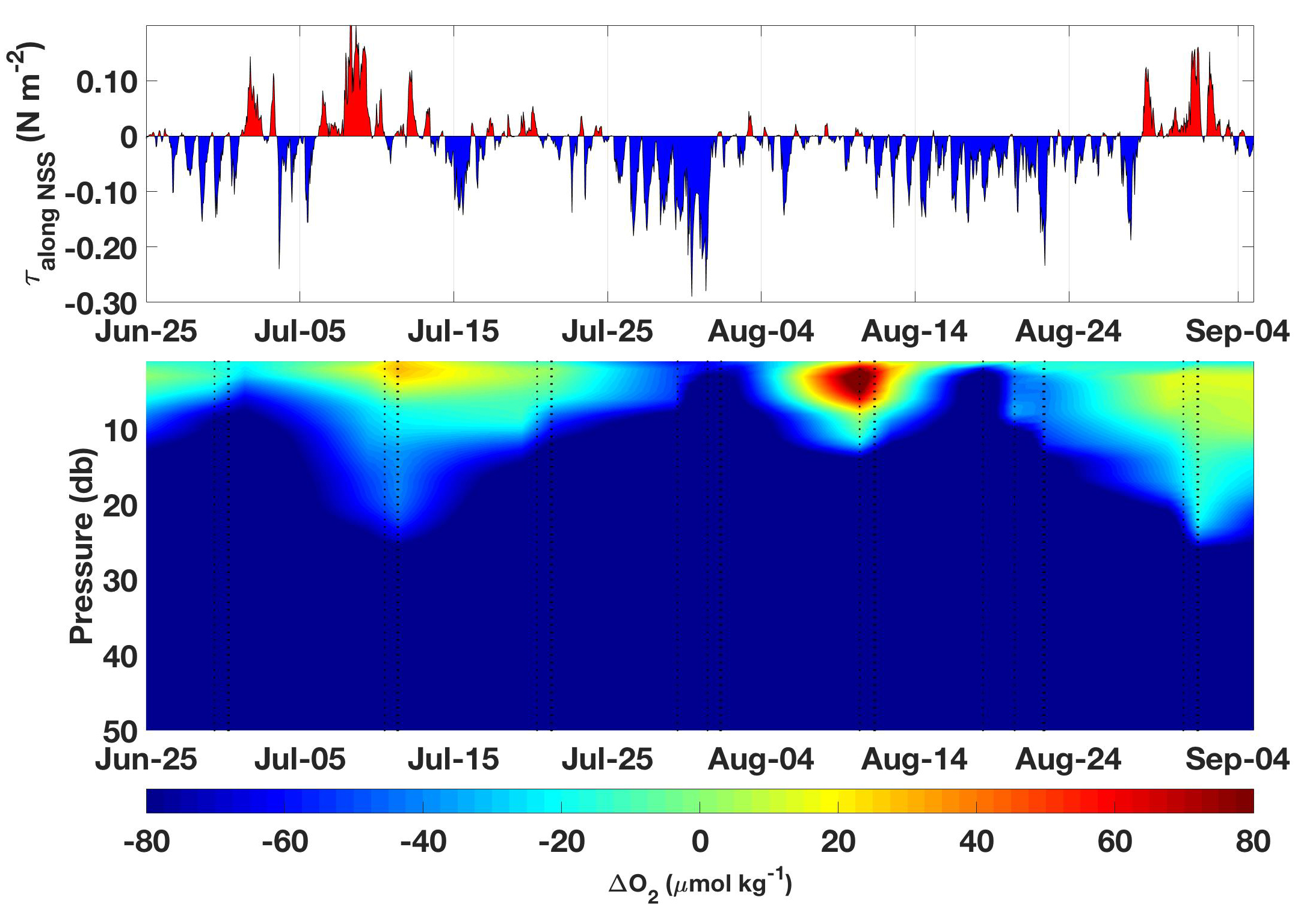
**Supplemental Figure 1:** Observations made during the June 2015 high-CO2 event, including: (a) along-axis wind stress (N m-2) from buoy 46131, (b) SST (°C) from QIFS and buoy 46131, (c) salinity, (d) seawater pCO2 (µatm), (e) pHT, and (f) . All QIFS data are black while buoy 46131 data are red. The horizontal line in panel (e) marks pHT = 7.69, and the horizontal lines in panel (f) mark = 1 (solid gray) and = 1.7 (dashed gray).



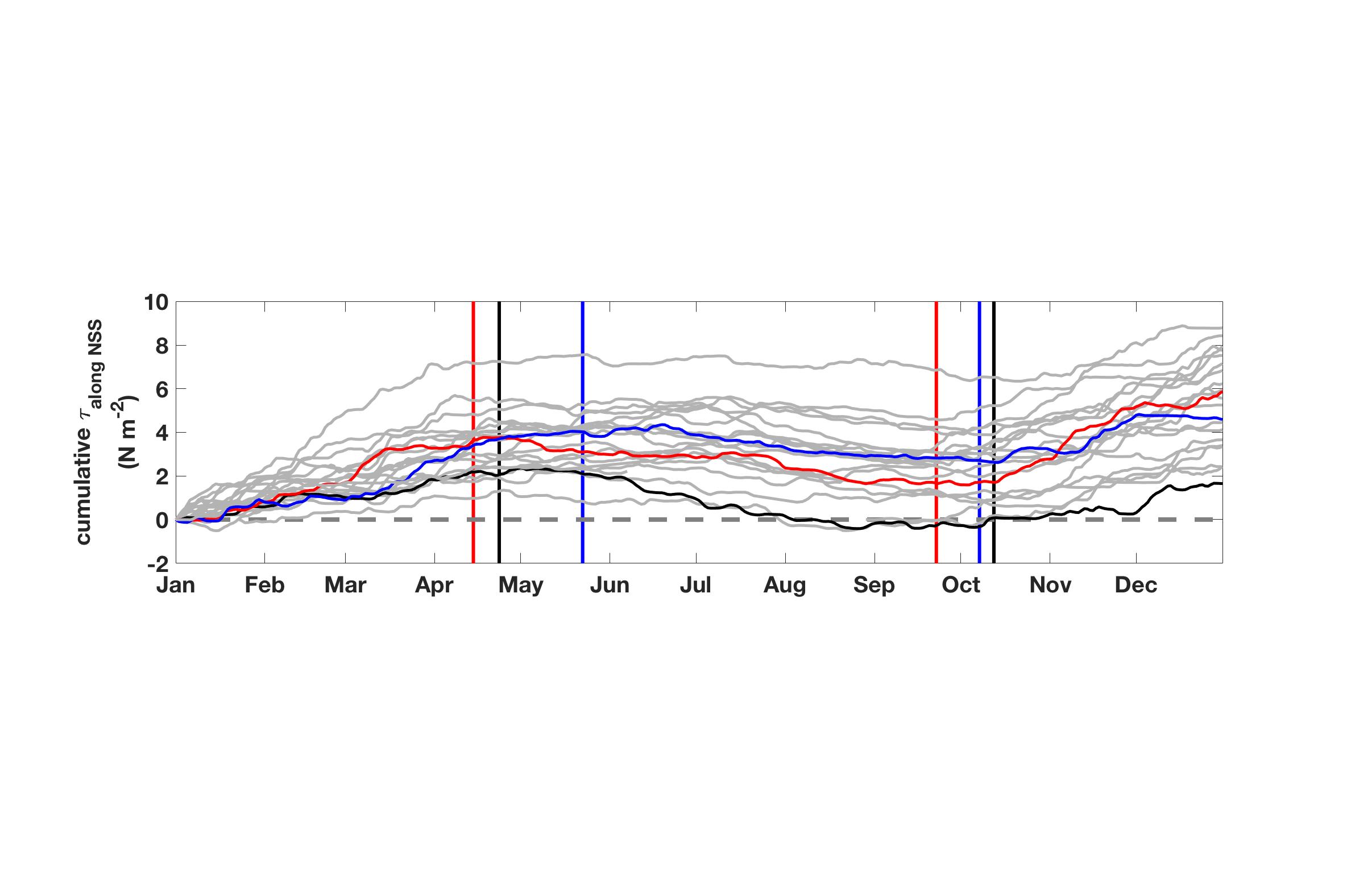
**Supplemental Figure 2:** NOAA Polar Operational Environmental Satellite (POES) Advanced Very High Resolution Radiometer (AVHRR) daily average (night and day passes) SST (°C) at the start (top) and peak (bottom) of the June 2015 high-CO2 events. The gray box marks the NSS as outlined in Figure 1.

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**Supplemental Figure 3:** Annual mean (red), minima, and maxima (both black) anthropogenic CO2 inventories estimated for the NSS. The blue dot marks the 2008 value (36 µmol kg-1) reported for Puget Sound by Feely et al. (2010).



**Supplemental Figure 4:** Top panel is NSS along-axis wind stress (N m-2) from Environment Canada weather buoy 46131, and the bottom panel is **∆**O2 (measured O2 using a Sea-Bird Electronics SBE 63 oxygen optode– saturation; µmol kg-1) for the upper 50 m of the water column measured at station QU39. Both records span June 25, 2016 to September 4, 2016, ± 1 month around the 2016 high-CO2 event shown in Figure 5.



**Supplemental Figure 5:** Cumulative (N m-2) from Environment Canada weather buoy 46131 with spring and fall transitions defined for 2015 (black), 2016 (red), and 2017 (blue). Spring and fall transitions were defined based on the inflection points on cumulative curves that had been smoothed using a LOESS filter with a half power point equivalent to a 72-day running average. Gray lines are cumulative from 1997 to 2018.



**Supplemental Figure 6:** The rate of energy transfer from the wind to the surface ocean (mJ m-2 s-1) between the spring and fall transitions (Figure 8) for 2015 (black), 2016 (red), and 2017 (blue) calculated using the daily average wind speeds measured from Environment Canada weather buoy 46131.

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