Supplementary Material for:

Spring-neap tidal cycles modulate the strength of the carbon source at the estuary-coast interface

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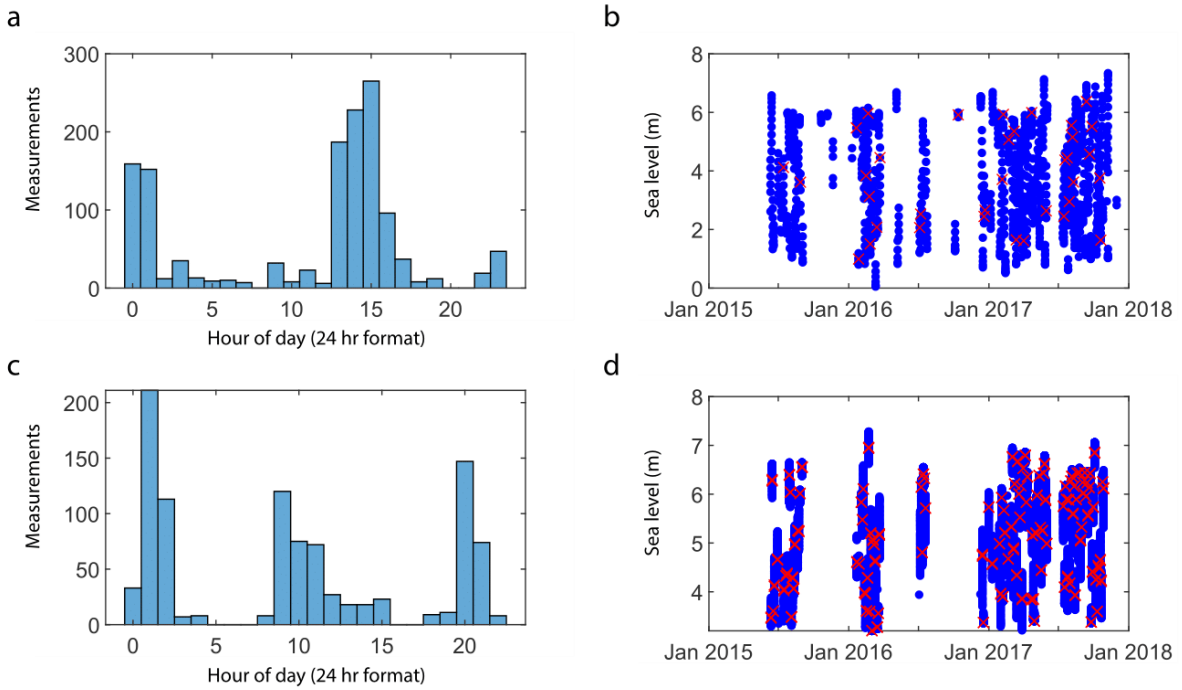

Fig. S1 Histograms showing the ship arrival time in Immingham port in the Humber Outer Estuary (**a**) and Cuxhaven port in the Elbe Outer Estuary (**c**), as well as the sea level at the arrival time (red crosses) compared to the usual sea level range (blue dots) in the Humber (**b**) and Elbe (**d**) Outer Estuaries.

The histograms in the Fig. S1 were obtained by selecting the measurements recorded between 0 ° and 0.02 °W – close to the arrival port in the Humber Estuary, and between 8.50 °E and 8.52 °E – close to the arrival port in the Elbe Estuary. The ship usually sails through the Humber Outer Estuary at 00 UTC, or 15 UTC and through the Elbe Outer Estuary at 01 UTC, 09 UTC, or 20 UTC. The sea level during the scheduled arrival time does not influence the ship sailing through the estuaries. There are fewer red crosses in Fig. S1b because the Humber sea level dataset we used reports data every 15 minutes, so there were fewer opportunities for an exact

association between the sea level data and the ship measuring exactly in our chosen location.

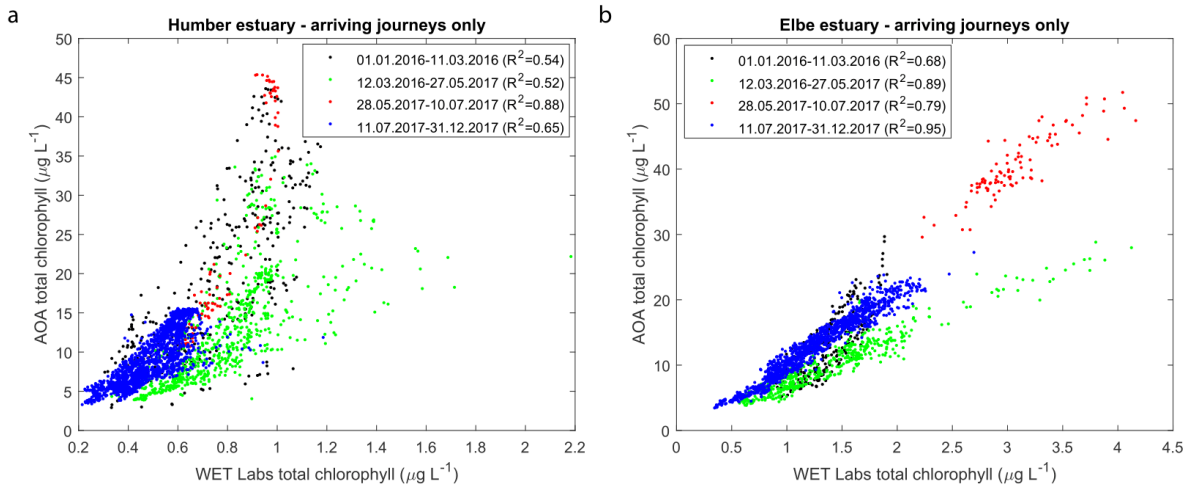

Fig. S2 The linear relationships between the total chlorophyll-a measurements provided by the AOA and WET Labs sensors in the Humber and Elbe Outer Estuaries, respectively, used as one of the steps in the final data correction.

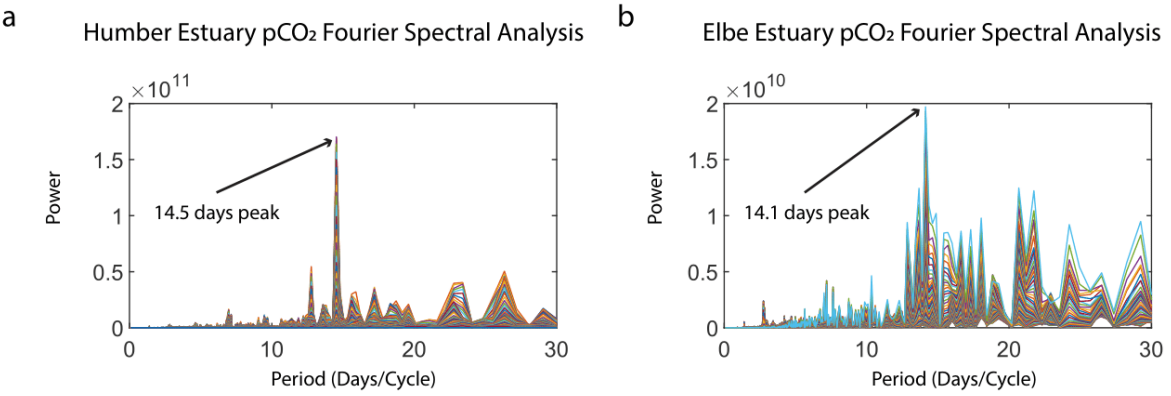

Fig. S3 The power versus period (inverse of frequency) plots resulting from a fast Fourier transform analysis on pCO_2 data in the two studied estuaries.

Fourier analysis for time series spectral analysis in environmental science is usually applied for fixed-point observation stations with continuous data. In our case, the ship was moving through the estuaries and there were data gaps when the ship was not sailing through. We therefore created interpolated products similar to those used to create the Hovmöller diagrams in the main manuscript Figures 4 and 5. The data were interpolated every 1 hour and 0.01 degrees of longitude. We then used these pseudo-fixed and pseudo-continuous time series to investigate the dominant driver period in the pCO_2 variability. The maximum peak was found at a period of 14.5 days in the Humber and 14.1 days in the Elbe, similar to the usual periodicity of the spring-neap tidal cycles.

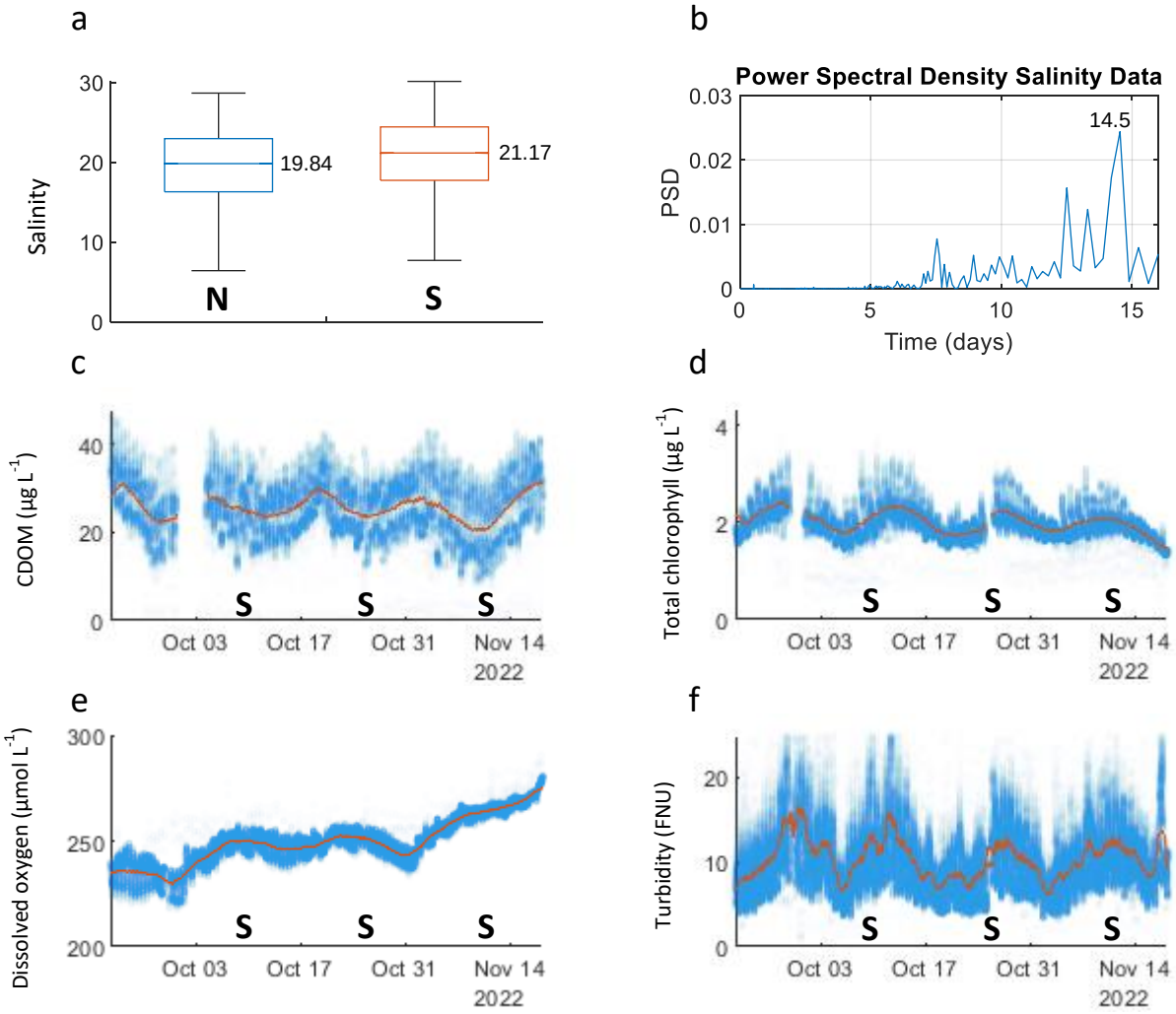

Fig. S4 (**a**) Box plot of seawater salinity observations at the Cuxhaven fixed-point observing station in the outer Elbe Estuary, comparing the neap (blue) and spring (orange) tide measurements in 2020 and 2021. Outliers more than 1.5 times the interquartile range away from the top and bottom of the box were visually removed and the values of the medians are indicated. (**b**) A Fourier analysis of the same salinity data performed on a 3.5 day moving average to filter out the high frequencies, which would produce a strong 12.5 hour peak. The resulting power spectral density plot shows a peak at 14.5 days. We are also showing the cyclical biweekly biogeochemical variability at Cuxhaven by selecting observations from a two month period in fall 2022. The CDOM (**c**), chlorophyll-a (**d**), dissolved oxygen concentration (**e**) and turbidity (**f**) observations are shown in blue markers and a 3.5 day moving average is shown in orange. Spring tides are indicated on the time axes.

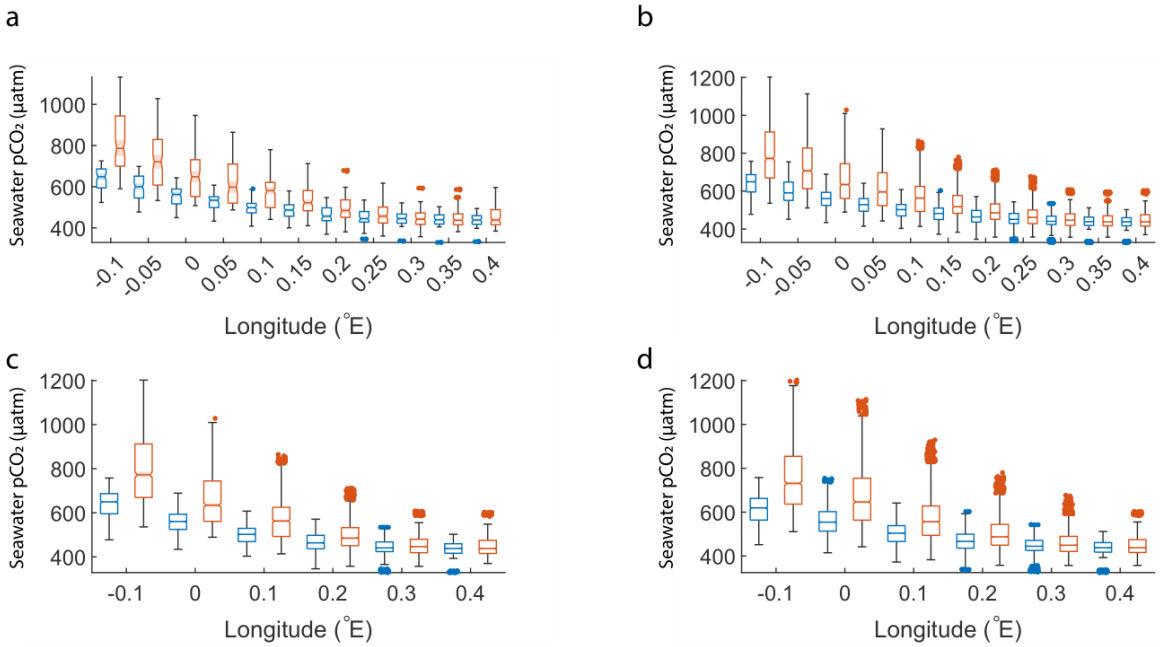

Fig. S5 Box plots of seawater pCO_2 observations in the outer Humber Estuary, comparing the neap (blue) and spring (red) tide measurements. The box plots display the median, interquartile range and outliers. When the notches of two box plots do not overlap, they have different medians at the 5% significance level. Compared to the plots in the main manuscript, which were produced selecting data every 0.1° with a ± 0.005° tolerance, here we use different selection criteria: every 0.05° ± 0.005° (**a**), every 0.05° ± 0.05° (**b**), every 0.1° ± 0.005° (**c**), and every 0.1° ± 0.1° (**d**).