Benthic phosphorus cycling affects pelagic nutrient stoichiometry in the northern Benguela upwelling system

Supplementary Information

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S1. Dissolved oxygen micro-profiling at the sediment-water interface

For O_2 micro-profiling with micro-sensors, the readings of the microamperometer were converted to % air saturation using a temperature calibration at 100 % saturation (seawater bubbled with air for 20 min and then rested under very gentle stirring to avoid oversaturation):

Table S1. Temperature calibration of oxygen micro-sensor in seawater at 100% air saturation and atmospheric pressure.

Temp (°C)	Signal (pA)		
	1	*2*	*mean*
5	275	276	275.5
13	246	247	246.5
22	207	208	207.5

From this, we obtained: $nA_{100\%\ air\ sat} = -4.0069 * temp_{°C} + 296.6$ ($R^2 = 0.9974$). Taking the bottom-water temperature from the CTD measurements at each station, we calculated the maximum sensor response. Further, using standard relationships between O_2 concentration, temperature and salinity, we calculated the maximum bottom-water O_2 concentration in µmol L^{-1} for each station. Assuming a linear relationship between $[O_2]$ and sensor signal, we then obtained the O_2 micro-profiles in μmol L^{-1}. Using the O2 gradient in the diffusive boundary layer, we then calculated the diffusive sediment O_2 uptake (Jørgensen et al., 2022):

$$DBL\,flux = D \times \frac{dC}{dz}$$

where *D* is the molecular diffusion coefficient of O_2 at the relevant temperature and salinity (calculated with the *marelac* package in Rstudio) and *dC/dz* is the vertical O_2 gradient.

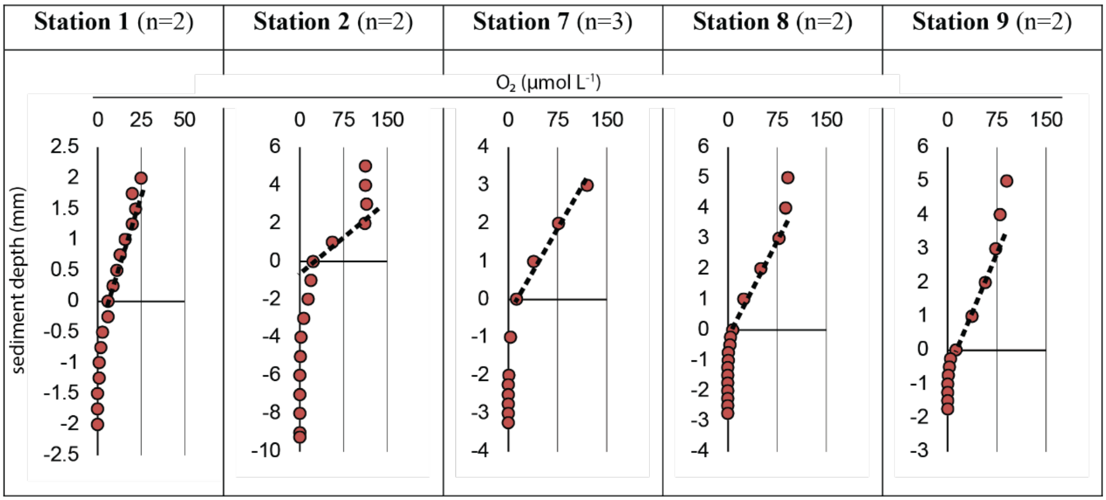

Figure S1: Dissolved O_2 micro-profiling around the sediment-water interface. No robust data could be collected for the stations on the oxygen-depleted shelf, likely due to intrusion of atmospheric oxygen. The thick black dashed line indicates the O_2 gradient around the SWI from which the diffusive O2 uptake was calculated. Note that the unit of the y-axis, sediment depth, is in mm.

S2. Visual observation of white, filamentous sulphur-oxidizing bacteria

Figure S2: Images of white filamentous microbes, likely sulphur-oxidizing bacteria, observed in core tops from stations 4, 5 and 6 on the oxygen-depleted shelf (~ 100 – 105 mbss). The middle image shows occurrence up to a few centimetres into the sediment.

S3. Correlations between benthic fluxes

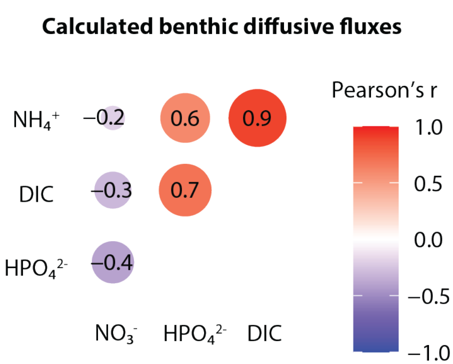

Figure S3: Correlation matrix for calculated diffusive benthic fluxes of C, N and P.

S4. Whole-core incubations

S4.1 Time series of C, N and P in the overlying water

The consumption or accumulation of key dissolved species over time in whole-core incubations was determined by taking discrete, filtered samples of the overlying water over time. Low-quality data was already pruned from this dataset prior to further processing. For flux calculations, subsequently a threshold R^2 of (–)0.3 was applied to discard time series that did not show a robust increasing or decreasing trend.

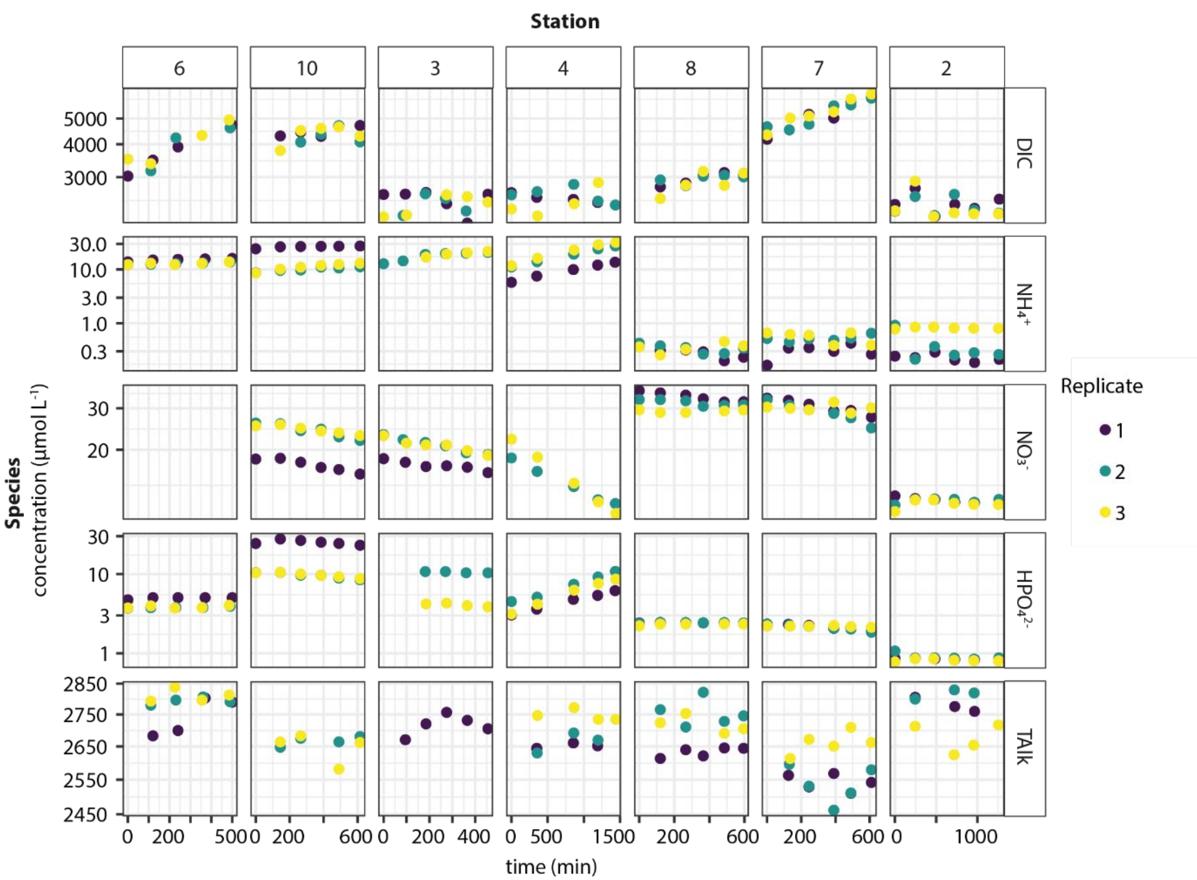

Figure S4: Time series of concentrations of key species in overlying water during whole-core incubations.

S4.2 Time series of dissolved O_2 in the overlying water

Dissolved O_2 in the overlying water during whole-core incubation at selected stations was monitored at high temporal resolution (every 2 minutes) using a Presens fiber optic system. Limited reliable data were gathered from the triplicate cores, particularly for shelf stations where bottom-water oxygen was (very) low. Below, we show data for station with more or less oxygenated bottom waters. In light of the issues encountered during O_2 measurements, the O_2 consumption data are therefore only used in combination with the calculated diffusive fluxes to show the overall transition from aerobic respiration to anaerobic metabolism (particularly sulphate reduction) from the oxygenated slope to the severely oxygen-depleted shelf.

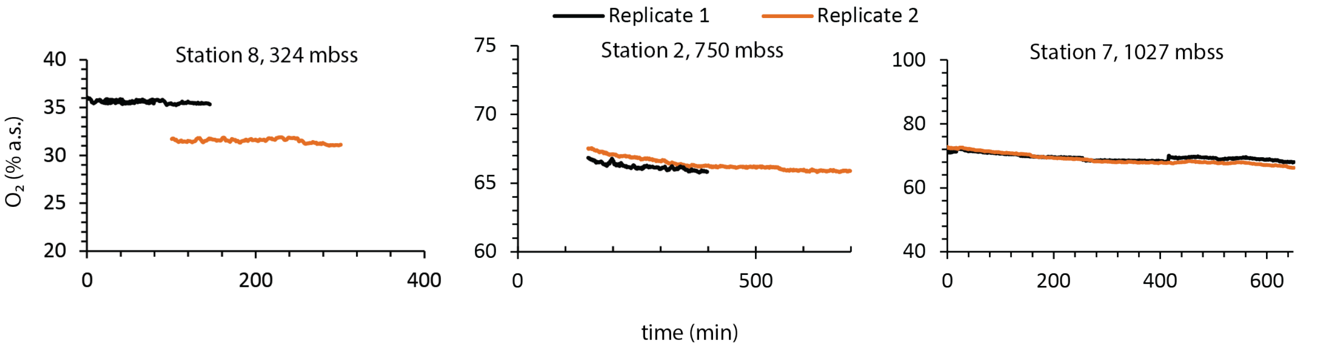

Figure S5: Time series of dissolved O_2 in overlying water during whole-core incubations.

S5. Bottom-water chemistry

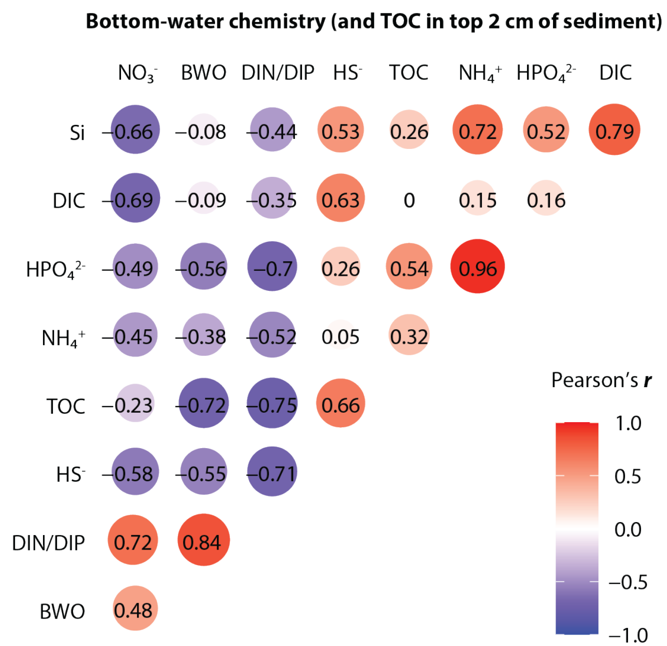

Figure S6: Correlation plot for bottom-water parameters and TOC content in the top 2 cm of the sediment.

References

Jørgensen, B. B., Wenzhöfer, F., Egger, M., and Glud, R. N.: Sediment oxygen consumption: Role in the global marine carbon cycle, Earth-Sci. Rev., 228, 103987, https://doi.org/10.1016/j.earscirev.2022.103987, 2022.