Supplements

Table S1: Environmental variables in river water, river plume, estuarine surface, mid- and bottom boundary layer (BBL) waters of the Öre and Vistula estuaries in spring and summer. Values are the average and standard deviation for of each water layer. The number of replicates is shown in parentheses. Mid-water data are averages from distinct sampled water depths within the given water depth range.

Site	Season	Water layer	Sample depth/ BBL thickness (m)	S	T (°C)	DO (μM)	NO_3^-+NO_2^- (μM)	NH_4^+ (μM)	Chl.*a* (μg L^{-1})
Öre estuary	Spring	River	0	0	3	-	6	0.7	-
		River plume	0-1	1.7 ± 1.2 (12)	4.7 ± 1.0 (12)	316.2 ± 46.7 (7)	5.1 ± 2.7 (12)	0.3 ± 0.2 (12)	3.2 ± 1.6 (8)
		Surface	0-1	4.3 ± 0.8 (19)	4.1 ± 0.6 (19)	328.1 ± 32.6 (9)	0.6 ± 0.5 (14)	0.1 ± 0.1 (17)	4.5 ± 1.4 (9)
		Mid	3-20	4.6 ± 0.6 (18)	3.5 ± 0.4 (18)	377.3 ± 21.6 (11)	0.7 ± 0.6 (16)	0.2 ± 0.2 (16)	6.8 ± 0.9 (10)
		BBL	2-3.9	5.0 ± 0.4 (12)	2.8 ± 0.1 (12)	389.3 ± 19 (4)	2.4 ± 1.2 (11)	0.3 ± 0.3 (13)	3.7 ± 1.4 (5)
	Summer	River	0	0	17.5	-	0.6	0.3	-
		River plume	0-1	1.4 ± 0.6 (7)	17.0 ± 0.4 (7)	292.7 ± 2.6 (8)	0.7 ± 1.3 (9)	0.2 ± 0.1 (11)	3.5 ± 0.6 (8)
		Surface	0-1	2.8 ± 0.2 (18)	16.5 ± 0.5 (18)	302.6 ± 5.2 (18)	0.1 ± 0.1 (5)	0.1 ± 0.0 (17)	2.7 ± 1.3 (18)
		Mid	4-15	3.2 ± 0.5 (22)	14.3 ± 1.2 (22)	280.0 ± 10.1 (23)	0.3 ± 0.2 (9)	0.2 ± 0.1 (22)	1.6 ± 0.9 (23)
		BBL	1.2-2.6	4.5 ± 0.6 (6)	7.4 ± 0.8 (7)	237.63 ± 14.0 (7)	2.3 ± 0.6 (9)	1.1 ± 0.6 (9)	0.2 ± 0.1 (3)
Vistula estuary[a]	Spring	River	0	0.2	3.9	-	286.96	6.67	3.48
		River plume	0-2	3.6 ± 1.7 (6)	4.1 ± 0.3 (6)	387.9 ± 9.9 (6)	152.2 ± 80.4 (8)	3.5 ± 2.5 (8)	8.1 ± 3.6 (8)
		Surface	0-2.5	6.9 ± 0.4 (6)	4.2 ± 0.2 (6)	405.1 ± 21.2 (6)	21.7 ± 13.8 (6)	0.3 ± 0.2 (6)	8.4 ± 2.7 (6)
		Mid	10-20	7.6 ± 0.1 (18)	4.2 ± 0.1 (18)	376.1 ± 13.7 (18)	5.0 ± 1.6 (9)	0.3 ± 0.1 (8)	3.5 ± 1.9 (18)
		BBL	3.2-6.9	7.7 ± 0.3 (19)	4.1 ± 0.2 (9)	355.8 ± 11.0 (17)	5.9 ± 1.5 (19)	0.6 ± 0.3 (18)	2.0 ± 1.3 (19)
	Summer	River	0	-	-	-	-	-	-
		River plume	1.25	6	20.8	398	-	0.5	3.1
		Surface	0-2	6.9 ± 0.2 (7)	16.7 ± 1.3 (7)	312.2 ± 27.9 (7)	-	0.2 ± 0.1 (7)	4.6 ± 2.2 (7)
		Mid	10-20	7.3 ± 0.1 (14)	14.3 ± 0.7 (14)	276.8 ± 18.9 (14)	0.4 ± 0.4 (5)	0.4 ± 0.3 (14)	2.6 ± 1.5 (15)
		BBL	1.4-6.7	7.7 ± 0.2 (7)	8.2 ± 3.4 (7)	263.2 ± 17.9 (7)	1.0 ± 0.8 (13)	3.5 ± 2.0 (13)	0.8 ± 0.6 (7)

S = salinity, T = temperature, DO = dissolved oxygen, NO_3^-+NO_2^-= nitrate + nitrite, NH_4^+ = ammonia, Chl.*a* = chlorophyll-a.
[a] Including data from Bartl et al. (2018).

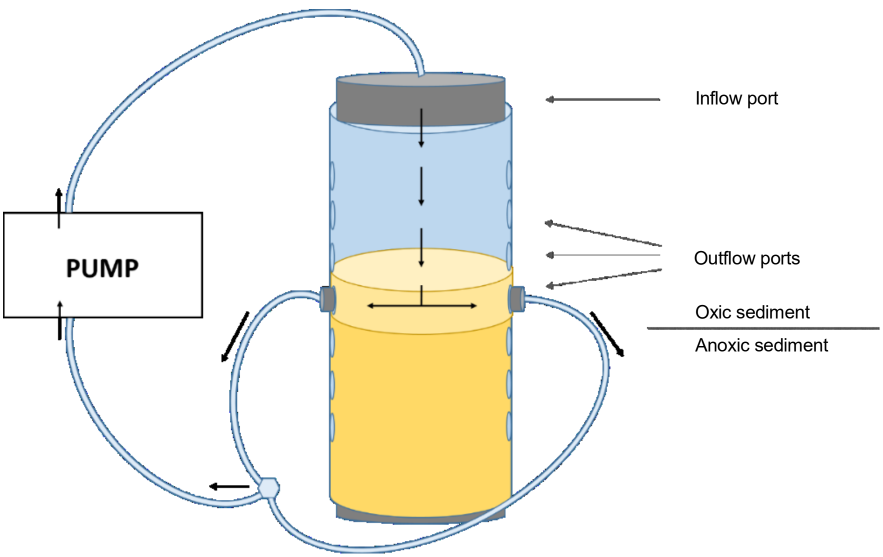

Figure S1: A schematic of the incubation design used to measure sediment denitrification with advective pore-water flow. Site-water spiked with ^{15}N tracer is pumped into the core from the top and drawn out from two sides of the oxic sediment layer (light yellow), as an approximation of the layer affected by advective flow. The outflow ports have a resolution of 5 mm, chosen according to the previously determined oxygen penetration depth.

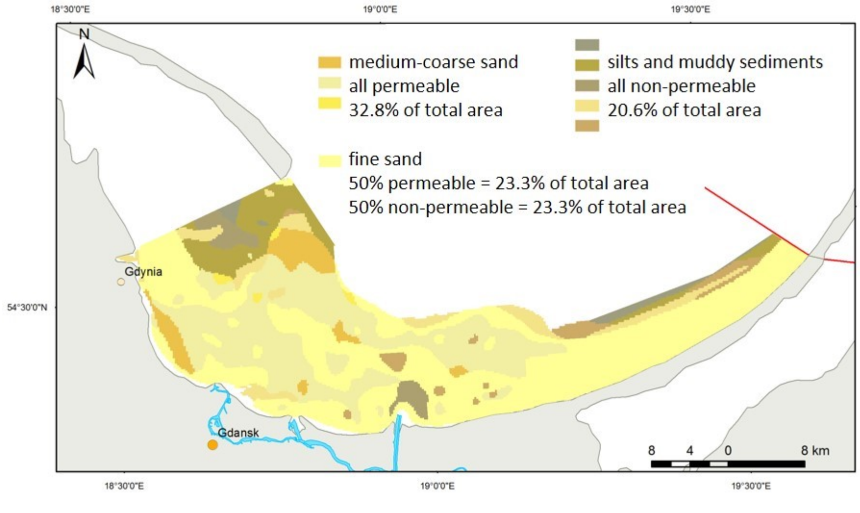

Figure S2: Sediment types of the Vistula estuary. For the fine sands, permeable and non-permeable sediments were used in a 1:1 ratio, as roughly half of the sampled cores with this sediment type were permeable. Sediment map provided by Halina Kendierska (University of Gdansk). Total estuarine area (825 km²) and areal proportions of the sediment types were calculated by Mayya Gogina (IOW).

Estimation of the absence / presence of advective pore water flow in the permeable sediment of the Vistula estuary

Theoretical pressure gradients at the sediment surface, established based on the interaction of near-bottom flow with sediment topography, were estimated for the sampling period (05.–11.07.2014) using the model-derived near-bottom flow velocity (average and maximum, Table 2) and a theoretical topographical object (sediment mound) with a height of 3 cm, as given in Huettel et al. (1996, Figure 4). Model simulations were carried out using the General Estuarine Transport Model (GETM; for further details see Holtermann et al., 2014), which has been thoroughly tested for applications in the Baltic Sea (e.g. Burchard et al., 2009, 2005). The bottom flow velocity was derived from 50 cm above the sediment; hence, the actual near-bottom flow velocity is probably lower, as friction increases with decreasing distance to the sediment.

The theoretical horizontal pore-water flow over a distance of 1 cm was calculated after Bear (1972), using the estimated pressure gradients and equations derived from Darcy´s Law together with the average measured hydraulic conductivity, water density and porosity. The Peclet number, an indicator of the dominating transport mechanism in the sediment, was calculated by dividing the pore-water flow velocity by the diffusive transport velocity. We used oxygen as example element to be transported over 1 cm distance by molecular diffusion in the sediment (calculated after Schulz ([2005]), with period-specific salinity and porosity at 20°C to allow comparisons with hydraulic conductivity measurements). A Peclet number ≥ 5 indicates the dominance of advective processes over diffusive processes (Bear, 1972 and references therein).

Table S2: Estimation of the pressure gradient at the sediment surface, the resulting pore-water (PW) flow velocity, and the Peclet number (output variables) in the permeable sediment of the Vistula estuary, based on a modeled bottom-water (BW) flow velocity 50 cm above the sediment surface, the height of a representative topographic object, and the molecular diffusion of oxygen, as an example element (input variables). Averages and the maximum values (in parentheses) are shown.

	--------------------------Input variables--------------------------			------------------------Output variables----------------------		
Period	**BW flow velocity** ($cm\ s^{-1}$)	**Object height** (cm)	**Molecular diffusion** ($10^{-6}\ cm\ s^{-1}$)	**Pressure gradient** (Pa)	**PW flow velocity** ($10^{-6}\ cm\ s^{-1}$)	**Peclet Nb**
05.–11.07.2014	1.4 ± 0.2 (2.5)	3.0	7.27	< 0.10 (0.15)	15.20 (22.81)	2.1 (3.1)