Appendices:

Appendix 1: Sources of supplemental data sets

Variable	Temporal availability of data	Data source	Data acquisition method or reference for methods details	Location of sampling
Total and Organic Particulate Carbon (TPC and POC) concentrations	2009-2013	WCO time series	Thermoquest Flash EA 1112 elemental analyser	L4
Total and Organic Particulate Nitrogen (TPN and PON) concentrations	2009-2013	WCO time series	Thermoquest Flash EA 1112 elemental analyser	L4
CDOM concentration	2009-2013	WCO time series	L4 buoy in-situ sensor	L4
Suspended particulate matter concentration	2009-2013	WCO time series	L4 buoy in-situ sensor	L4
Oxygen concentration	2009-2017	WCO time series	L4 buoy in-situ sensor and CTD measurements	L4
Phytoplankton abundance	2009-2014	WCO time series	(Widdicombe *et al.*, 2010)	L4
Phytoplankton biomass	2009-2014	WCO time series	(Widdicombe *et al.*, 2010)	L4
Zooplankton abundance	2009-2016	WCO time series	(Eloire *et al.*, 2010)	L4
Benthic macrofauna abundance and biomass	2009-2013	WCO time series benthic survey	Box coring Sediment and sieving out	L4 benthic station
Benthic fluorescence and chlorophyll	2010-2016	WCO time series	CTD measurement	L4
Solar radiation	2009-2013	PML MET station	Weather station stationary sensor	PML (see figure 1)
Photosynthetically active radiation	2009-2013	PML MET station	Weather station stationary sensor	PML (see figure 1)
Air pressure	2011-2013	Rame Head MET station	Weather station stationary sensor	Rame Head (see figure 1)
Rain	2011-2013	Rame Head MET station	Weather station stationary sensor	Rame Head (see figure 1)
Wave height	2009-2017	Looe buoy	In-situ buoy sensor	Looe (see figure 1)
Benthic temperature	2010-2016	WCO time series	CTD measurement	L4

Benthic photosynthetically active radiation (PAR)	2010-2016	WCO time series	CTD measurement	L4
Sediment grain size	2009-2012	WCO time series benthic survey	Particle Size Analysis	L4 benthic station
River flow	2009-2016	National River Flow Archive	Flow check gauge	Gunnislake, Tamar (see figure 1)
Tidal state	2009-2017	Permanent Service for Mean Sea Level	Tidal gauge	Devonport Tidal station (see figure 1)

Appendix 2: Sampling campaign of data collection throughout 2017 and 2018

Variable	Field sampling method	08 / 2017	11 / 2017	12 / 2017	01 / 2018	02 / 2018	03 / 2018	04 / 2018	05-06 / 2018
Resuspension / erosion thresholds	Box corer	✓	✓					✓	✓
Bioturbation	Box corer	✓	✓	✓	✓	✓	✓	✓	✓
Water column SPM and POC	Rosette sampler	✓	✓	✓	✓	✓	✓	✓	✓
Nepheloid SPM and POC	Multi-corer	✓	✓	✓	✓	✓	✓	✓	✓
Sediment grain size	Box corer	✓	✓	✓	✓	✓	✓	✓	✓
Sediment density	Box corer	✓	✓	✓	✓	✓	✓	✓	✓
Sediment OC content	Box corer	✓	✓	✓	✓	✓	✓	✓	✓
Water column temperature	CTD	✓	✓	✓	✓	✓	✓	✓	✓
Water column fluorescence	CTD	✓	✓	✓	✓	✓	✓	✓	✓
Water column density	CTD	✓	✓	✓	✓	✓	✓	✓	✓

Water column salinity	CTD	✓	✓	✓	✓	✓	✓	✓	✓

Appendix 3: Flume programmes

K-index	Dwell time in minutes	Velocity in m/s	Shear stress in Pa
0	10	0.000128103	0.017409884
1	10	0.001195501	1.516262444
2	10	0.002013365	4.300506215
3	10	0.002856191	8.654637122
4	10	0.003718308	14.66780767
5	10	0.00470084	23.44365984
6	10	0.005713836	34.63618521
7	10	0.006607689	46.32054397
8	10	0.007540815	60.32690907
9	10	0.008451207	75.77255817
10	10	0.009468514	95.11260725
11	10	0.010376729	114.2339979

Appendix 4: Details on Predictors and Responses of ANOSIM tests carried out throughout this study

Test number	Predictors	Response
1	5 periods (for inclusion of months in each period, see Table I)	Full data set, including all variables
2	5 periods (for inclusion of months in each period, see Table I)	DIN concentration throughout the water column (0-50 m)
3	5 periods (for inclusion of months in each period, see Table I)	Shear-stress driven DIN flux and DIN concentration at 50 m depth
4	5 periods (for inclusion of months in each period, see Table I)	POC concentration throughout the water column (0-50 m)
5	5 periods (for inclusion of months in each period, see Table I)	POC concentration throughout the sediment (0-5 cm)
6	5 periods (for inclusion of months in each period, see Table I)	Shear-stress driven POC flux, POC concentration at the sediment surface (0-1 cm) and POC concentration at 50 m depth
7	5 periods (for inclusion of months in each period, see Table I)	Variables of influence for DM flux driven by biological particle mixing (see Table II)

8	5 periods (for inclusion of months in each period, see Table I)	Variables of influence for DM flux driven by advective flushing (see Table II)
9	5 periods (for inclusion of months in each period, see Table I)	Variables of influence for DM flux driven by bioirrigation (see Table II)
10	5 periods (for inclusion of months in each period, see Table I)	Variables of influence for DM flux driven by diffusion (see Table II)
11	5 periods (for inclusion of months in each period, see Table I)	Variables of influence for DM flux driven by physical resuspension (see Table II)
12	5 periods (for inclusion of months in each period, see Table I)	Variables driving upward-transport and resuspension of PM (see Table II)
13	5 periods (for inclusion of months in each period, see Table I)	Variables driving downward-transport and deposition of PM (see Table II)
14	5 periods (for inclusion of months in each period, see Table I)	Variables of influence for DM flux driven by biological particle mixing (see Table II), excluding those variables that are not affected by PM exchange processes
15	5 periods (for inclusion of months in each period, see Table I)	Variables of influence for DM flux driven by physical resuspension (see Table II), excluding those variables that are not affected by PM exchange processes
16	5 periods (for inclusion of months in each period, see Table I)	Variables of influence for DM flux driven by bioirrigation (see Table II), excluding those variables that are not affected by PM exchange processes
17	5 periods (for inclusion of months in each period, see Table I)	Variables of influence for DM flux driven by diffusion (see Table II), excluding those variables that are not affected by PM exchange processes
18	5 periods (for inclusion of months in each period, see Table I)	Variables of influence for DM flux driven by advection (see Table II), excluding those variables that are not affected by PM exchange processes
19	5 periods (for inclusion of months in each period, see Table I)	Variables driving upward-transport and resuspension of PM (see Table II), excluding those variables that are not affected by DM exchange processes
20	5 periods (for inclusion of months in each period, see Table I)	Variables driving downward-transport and deposition of PM (see Table II), excluding those variables that are not affected by DM exchange processes

Appendix 5: VIP scores of the OPLS models

OPLS model	Driver	VIP score

Model 1; Responses: Full data set with all variables; Predictors: Five time periods as specified in Table I	PAR at 50 m	1.0065
	Salinity at 50 m	1.0272
	Wave height	1.7049
	Wave peak period	1.3445
	Wave peak duration	1.6255
	River flow	1.6560
	τ_0	1.1906
	Tidal flow	1.2797
	Phytoplankton abundance	1.5386
	Phytoplankton biomass	1.3547
	Fluorescence at 50 m	1.2176
	SPM at 0 m	1.4934
	SPM at 10 m	1.1250
	Sediment [OC] (1-2 cm)	1.1556
	Sediment [OC] (2-3 cm)	1.1881
	Sediment density (3-5 cm)	1.0465
	Macrofauna biomass	1.0794
	Overall Nitrite/Nitrate ratio	1.5283
	Nitrite/Nitrate ratio at 50 m	1.3568
	Overall [Ammonia]	1.5250
	[Ammonia] at 50 m	1.4055
	Overall [Silicate]	1.7070
	[Silicate] at 50 m	1.6048
	Overall [Phosphate]	1.5311
	[Phosphate] at 50 m	1.3186
Model 2; Responses: Variables affecting the biological mixing-driven B/P exchange of DIN; Predictors: Five time periods as specified in Table I	Water temperature at 50 m	1.5024
	D50 (0-1 cm depth)	1.3281
	D50 (1-2 cm depth)	1.5478
	BPc	1.576
	Bioturbation activity	1.0365
Model 3; Responses: Variables affecting advection-driven B/P exchange of DIN; Predictors: Five time periods as specified in Table I	Wave height	1.5092
	Wave peak period	1.6552
	Wave peak duration	1.5910
	Sediment density (1-2 cm)	1.2024
Model 4; Responses: Variables affecting the bioirrigation-driven B/P exchange of DIN; Predictors: Five time periods as specified in Table I	Water temperature at 50 m	1.524
Model 5; Responses: Variables affecting the diffusion-driven B/P exchange of DIN; Predictors: Five time periods as specified in Table I	Sediment density (0-1cm)	1.6774
	Sediment density (1-2 cm)	1.0986
	[Nitrite] at 50 m	2.3159
	[O$_2$] at 50 m	1.6200
Model 6; Responses: Variables affecting the physical resuspension-driven B/P exchange of DIN; Predictors:	Wave peak period	1.4890
	Wave peak duration	1.7244
	T0	1.3518
	Tidal flow	1.0494

Five time periods as specified in Table I		
Model 7; Responses: Variables affecting the upward exchange and resuspension of POC; Predictors: Five time periods as specified in Table I	Wave height	1.6738
	Wave peak period	1.5877
	Wave peak duration	1.7352
	T0	1.5206
	Sediment [OC] (2-3 cm)	1.0534
	Sediment density (2-3 cm)	1.4673
	Bioturbation depth	1.2217
	[POC] at 50 m	1.1074
Model 8; Responses: Variables affecting the downward exchange and deposition of POC, including SPM; Predictors: Five time periods as specified in Table I	Water temperature at 50 m	1.2550
	Tidal flow	2.0048
	River flow	1.0944
	[SPM] at 0 m	1.6994
	[SPM] at 10 m	1.3421
	[SPM] at 20 m	1.2413
	[SPM] at 30 m	1.6096
	[SPM] at 40 m	1.2767
	[POC] at 10 m	1.7630
	[POC] at 20 m	1.7489
	[POC] at 30 m	1.8626
	[POC] at 40 m	1.9624
Model 8a; Responses: Variables affecting the downward exchange and deposition of POC, excluding SPM; Predictors: Five time periods as specified in Table I	Zooplankton abundance	1.1891
	Wave height	1.1263
	River flow	1.4385
	Chlorophyll at 10 m	1.3620
	Tidal flow	1.5175
	POC at 0 m	1.2785
	POC at 20 m	1.7559
	POC at 30 m	1.1427
	POC at 40 m	1.4492