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Appendix S2. Descriptions of regional environmental variables.

This supplementary information provides details of the environmental variables collated for the three large marine regions: the Australia's Great Barrier Reef shelf (GBR), the deep Gulf of Mexico (DGoMx) and the temperate Gulf of Maine area (GoMA). The environmental variables included the various attributes of bathymetry, sediments, chemistry, and ocean colour (see Table S2-1). These datasets were derived from research and governmental databases, public ocean data portals, and online marine environmental databases (see references and data sources).

Details of data processing for the GBR region are described in Pitcher et al (2007) and for the GoMA region in Greenlaw *et al.* (2010); data processing for the DGoMx region followed similar procedures (C-L Wei, unpublished). Environmental data types originally acquired during surveys at sea (e.g. bathymetry, sediments, chemistry) did not provide full coverage so were interpolated using GIS software to obtain full coverage grids. Temporally varying environmental data (e.g. chemistry, SST and ocean colour) were summarized as a climatic mean and variation. Where possible, these climatologies were constructed to coincide with broad periods when the biological surveys occurred to minimize temporal mismatch. For example, separate oceanographic water chemistry datasets were collated to correspond with the different time periods of the GoMA historical benthic grab and more recent trawl surveys (see Appendix S1). To further minimize oceanographic differences, the SST and ocean colour datasets constructed for the pre-satellite era sediment-infauna grab surveys were selected from a modern oceanographic regime consistent with that when the grab sampling was conducted.

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$$B\_IRR = \cos((LAT\text{-}offsetN) / 180 * \pi) * \exp(K490\_monthN * BATHY)$$
where K490_monthN are the mean monthly values of the NASA SeaWiFS attenuation coefficient at 490 nm, BATHY is Depth (m), LAT is the latitude of the site, and offsetN is the latitude position of the sun for monthN so that (LAT-offsetN) is the angle between the site position and the sun. The annual average B_Irr_av is the average of the monthly estimates and the seasonal range B_Irr_sr is the max-min of the monthly values.

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Table S2-1: Description of environmental variables by region, with ranges at sampled sites. Superscripts in regional columns indicate data sources.

Variable	Description of environmental variable	GBR[17]	GoMA[9]	DGoMx
Lat	Latitude range	10.5S – 24.5S	39.92N – 44.99N	23.5N – 29.5N
Lon	Longitude range	142.5E – 153.5E	63.74W – 71.02W	96.0W – 85.5W
Depth	Depth from bathymetry DEM – metres	1 – 105 [1]	7.34 – 603.01 [23]	213 – 3,732 [21,22]
Slope	Slope derived from bathymetry DEM – degrees	0 – 2.17° [1]	0 – 7.44 [23]	0.12 – 14.73 [14]
Aspect	Aspect of slope derived from bathymetry DEM – degrees T	0 – 360° [1]	0 – 359.9 [23]	7.4 – 354.1 [14]
Complex	Complexity: maximum change in slope in the 9 surrounding grid cells	na	0 – 0.28 [23]	na
BPI	Benthic position index	na	-55 – 45 [23]	na
Mud	Sediment % mud grainsize fraction, (Ø < 63 μm)	0 – 100 [12]	0 – 100 [8,16]	5.7 – 99.2 [21,22]
Sand	Sediment % sand grainsize fraction, (63 μm < Ø < 2 mm)	1 – 99 [12]	0 – 100 [8,16]	0.8 – 94.2 [21,22]
Gravel	Sediment % gravel grainsize fraction, (Ø > 2 mm)	0 – 96 [12]	0 – 100 [8,16]	na
Carbonate	Sediment % carbonate ($CaCO_3$) composition, percent	2 – 98 [12]	na	na
Stress_T	Seabed tidal current stress, RMS mean – Nm^{-2}	~0 – 4.5 [7]	0.01 – 3.04 [55]	na
Stress_tW	Seabed current stress with tide and Wind – Nm^{-2}	na	0 – 33.16 [4]	na
Nitr_av	Nitrate bottom water annual average NO_3 – μM	~0 – 11.5 [3]	0.06 – 16.32 [19]	na
Nitr_sr	Nitrate Seasonal Range	0.03 – 3.7 [3]	na	na
Phos_av	Phosphate bottom water annual average PO_4 – μM	0.07 – 0.82 [3]	0.11 – 1.49 [19,10]	na
Phos_sr	Phosphate Seasonal Range	0.01 – 0.28 [3]	na	na
Oxyg_av	Oxygen bottom water annual average O_2 – ml L^{-1}	3.59 – 4.84 [3]	4.13 – 7.92 [10]	2.44 – 5.53 [21,22]
Oxyg_sr	Oxygen Seasonal Range	0.03 – 1.57 [3]	na	na
Salin_av	Salinity bottom water annual average S – ‰ (ppt)	34.7 – 36.7 [3]	31.52 – 35.26 [10,13,11]	34.9 – 36.0 [21,22]
Salin_sr	Salinity Seasonal Range	0.07 – 4.70 [3]	0.03 – 2.33 [10,13,11]	0 – 0.33 [3]
Temp_av	Temperature bottom water annual average T – °C	16.8 – 29.0 [3]	3.68 – 12.18 [13,11]	4.0 – 15.2 [21,22]
Temp_sr	Temperature Seasonal Range	0.33 – 7.49 [3]	0.08 – 14.35 [13,11]	0 – 1.7 [3]
Silic_av	Silicate bottom water annual average Si – μM	0.62 – 4.42 [3]	0.03 – 18.05 [19]	na
Silic_sr	Silicate Seasonal Range	0.13 – 6.95 [3]	na	na
Stratif_av	Surface Stratification, density difference between the surface and 50 m	na	-0.02 – 0.44 [11]	na
Strat_sum	Surface Stratification from May to September	na	-0.01 – 0.47 [11]	na
Chlor_av	Chlorophyll annual average from SeaWiFS – mg m^{-3}	0.11 – 9.70 [2]	0.44 – 4.69 [2]	0.13 – 2.29 [2, 6]
Chlor_sr	Chlorophyll Seasonal Range	0.02 – 6.76 [2]	0.37 – 4.67 [2]	0.15 – 9.36 [2, 6]
K490_av	Attenuation coefficient at wavelength 490nm annual average from SeaWiFS – m^{-1}	0.03 – 1.10 [2]	0.08 – 0.59 [2]	0.04 – 0.13 [2]
K490_sr	Attenuation coefficient Seasonal Range	~0 – 0.37 [2]	0.02 – 1.54 [2]	0.02 – 0.31 [2]
SST_av	Sea Surface Temperature annual average from Modis – °C	23.6 – 27.2 [2]	6.86 – 14.58 [2]	25.2 – 27.6 [2, 6]
SST_sr	Sea Surface Temperature Seasonal Range	3.55 – 10.6 [2]	8.68 – 18.94 [2]	5.8 – 19.6 [2, 6]
NPP_av	Net Primary Production annual average from SeaWiFS – mg C m^{-2} d^{-1}	na	na	301 – 3053 [15, 6]
NPP_sr	Net Primary Production seasonal range	na	na	337 – 6138 [15, 6]
E.POC_av	Export Particulate Organic Carbon flux annual average from SeaWiFS – mg C m^{-2} d^{-1}	na	na	2.7 – 77.7 [6]
E.POC_sr	Export Particulate Organic Carbon seasonal range	na	na	3.1 – 275.7 [6]
B_Irr_av	Benthic Irradiance relative to sea surface at equator, annual average	~0 – 0.86 [20]	0 – 0.21 [20]	na
B_Irr_sr	Benthic Irradiance Seasonal Range	~0 – 0.55 [20]	0 – 0.28 [20]	na
Trawl_Eff	Trawl Effort, weighted annual average – hours per 0.01° cell	0.00 – 109 [18]	na	na