River radii: a comparative national framework for remote monitoring of environmental change at river mouths

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Supplementary Material

Table S1. Topographical adjustments to REC2[†] river end points from calibration with recent aerial imagery. [†]River Environment Classification [1].

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Table S1. Topographical adjustments to REC2[†] river end points from calibration with recent aerial imagery.

Name	Region	nzsegment	Order	X[‡]	Y[‡]	Comments
Waiapu River	Gisborne	5069486	6	2080697	5803514	moved seaward
Porangahau River	Hawke's Bay	8237479	6	1913072	5535248	moved seaward
Hinds River	Canterbury	13158795	6	1492928	5114968	repositioned to existing REC2 vertex near north end of lagoon
Rakaia River	Canterbury	13300007	6	1538565	5139848	repositioned to existing REC2 vertex near north end of lagoon
Hollyford River/Whakatipu kā Tuka	Southland	15178863	6	1201717	5077750	located between new and old mouths
Okuru River	West Coast	12151763	6	1269874	5130215	located between direct outlet and northward outlet positions
Taiari River	Otago	14295077	6	1383515	4896058	located between the two outlet positions

[†] River Environment Classification [1]

[‡] NZTM2000 (EPSG:2193) projection

Table S2. Pairwise comparisons of 10-year light attenuation (K_d) mean values at coastal river mouths within sampling units of increasing radii. See main text for details of sampling units and data sources.

a) KdPAR SCENZ 500m dataset

Radius (km)	Kd mean	SD	SE	Pairwise comparisons†							
				1	2	3	4	5	10	15	20
1	0.47	0.26	0.02								
2	0.47	0.29	0.02	ns							
3	0.44	0.30	0.02	**	ns						
4	0.41	0.30	0.02	***	***	ns					
5	0.39	0.30	0.02	***	***	**	ns				
10	0.29	0.22	0.02	***	***	***	***	***			
15	0.22	0.14	0.01	***	***	***	***	***	***		
20	0.18	0.10	0.01	***	***	***	***	***	***	***	

b) ESA Kd490 4km dataset

Radius (km)	Kd mean	SD	SE	Pairwise comparisons†				
				5	10	15	20	25
5	0.22	0.13	0.01					
10	0.19	0.12	0.01	**				
15	0.18	0.12	0.01	***	**			
20	0.16	0.10	0.01	***	***	**		
25	0.14	0.07	0.01	***	***	***	**	

† significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, ns - not significantly different at $\alpha = 0.05$

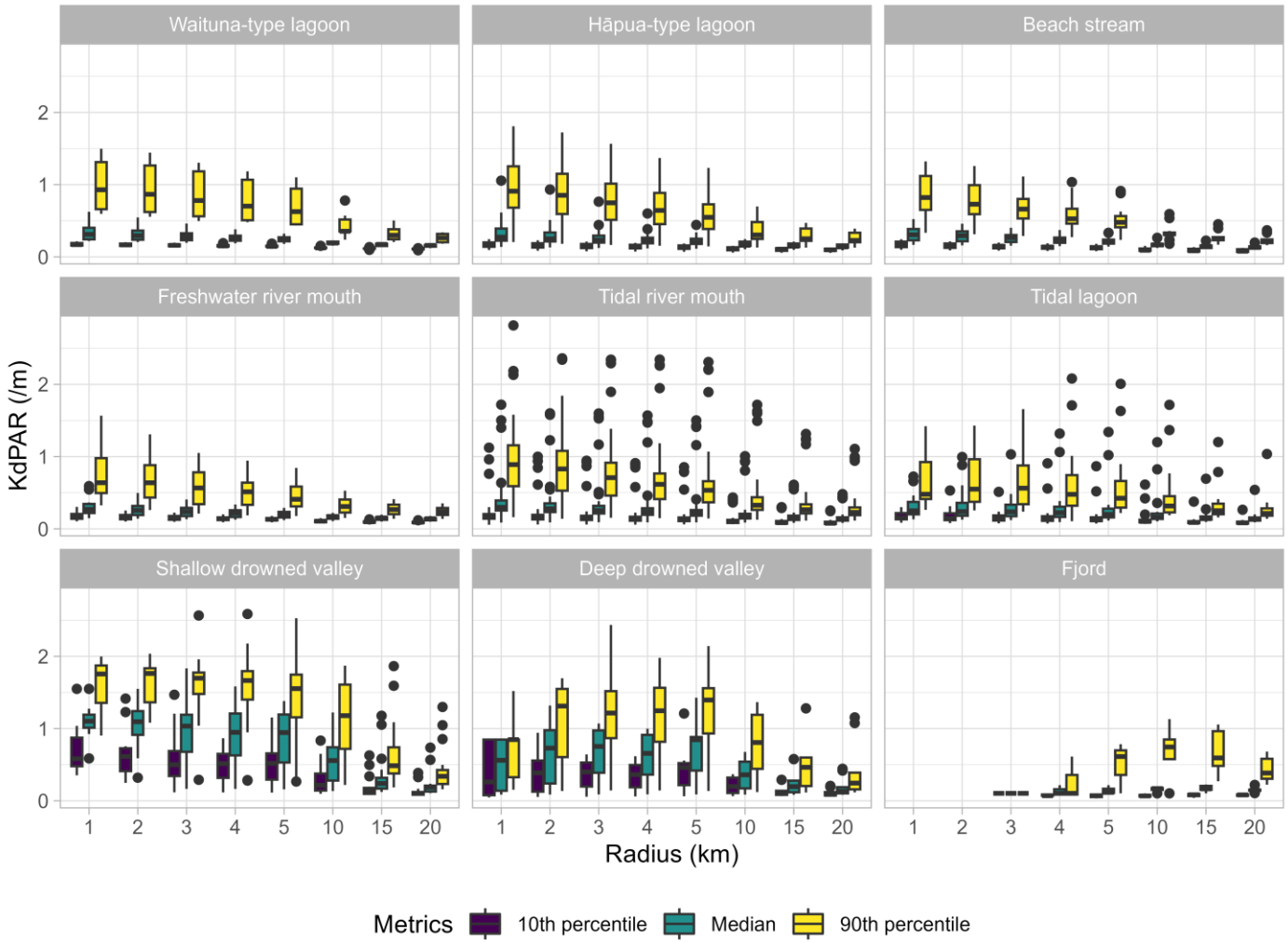


Figure S1. Relationships between coastal hydrosystem classes and satellite-derived estimates of light attenuation (K_d) at river mouths within sampling units of different radii (1–20km). Boxplots show the median and interquartile range for the 10th, 50th and 90th percentile K_d values in each sampling unit over the 10-year period 2013–2022 calculated from the SCENZ 500 m K_dPAR product [2]. The analysis covers the 226 highest-order river catchments in Aotearoa New Zealand that discharge to the coast (orders 5 – 8). Coastal hydrosystem classes are detailed in Appendix A. K_dPAR is the diffuse attenuation coefficient for down-welling irradiance (K_d) in the Photosynthetically Active Radiation (PAR) range (400–700 nm).

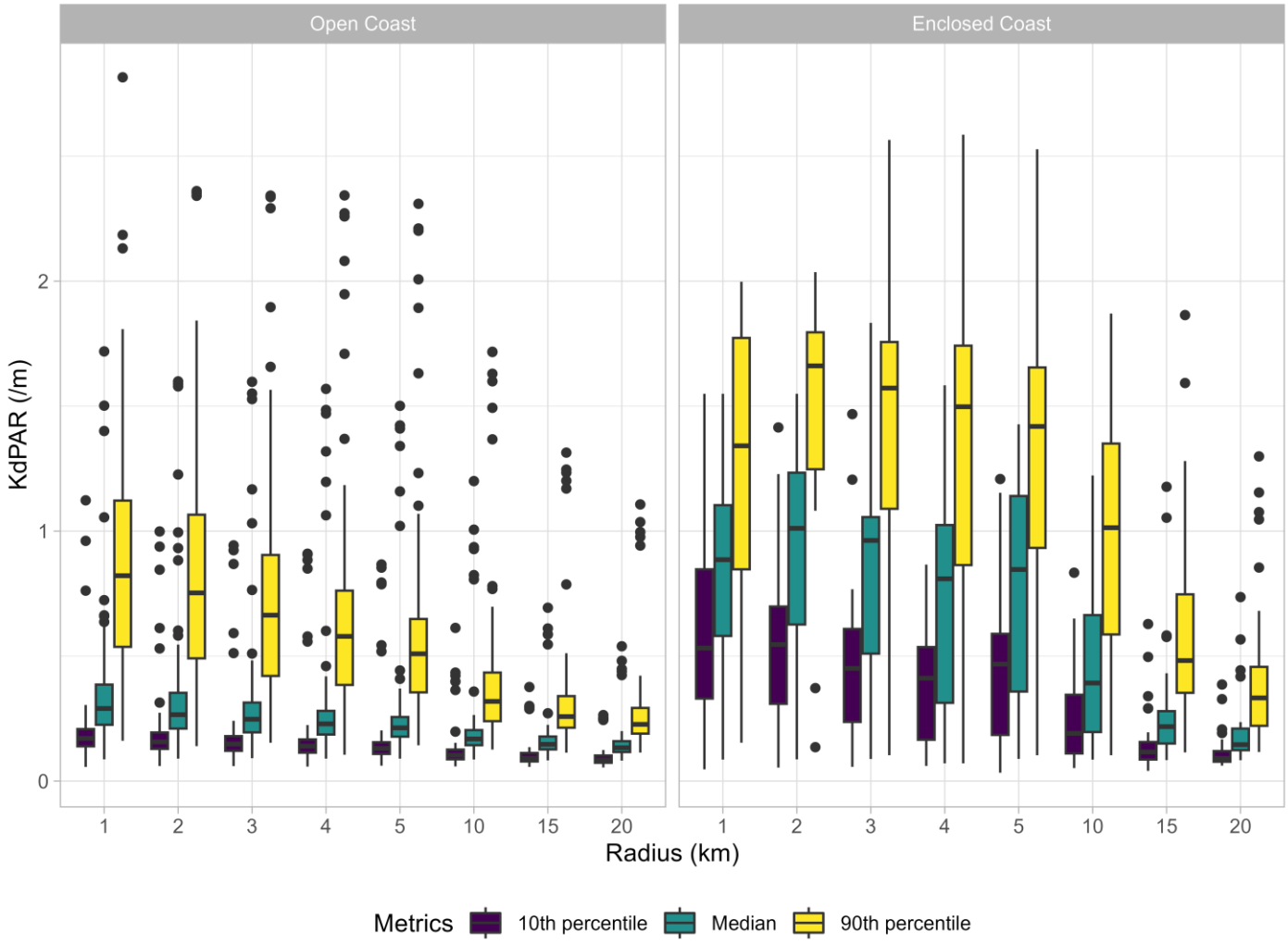


Figure S2. Relationships between coastline geometry classes and satellite-derived estimates of light attenuation (K_d) at river mouths within sampling units of different radii (1–20km). Boxplots show the median and interquartile range for the 10th, 50th and 90th percentile Kd values in coastal waters within a 10 km radius of the river mouth over the 10-year period 2013–2022 calculated from the SCENZ 500 m K_dPAR product (Gall et al., 2022). Coastline geometry classes are detailed in Appendix A. KdPAR is the diffuse attenuation coefficient for downwelling irradiance (K_d) in the Photosynthetically Active Radiation (PAR) range (400–700 nm).

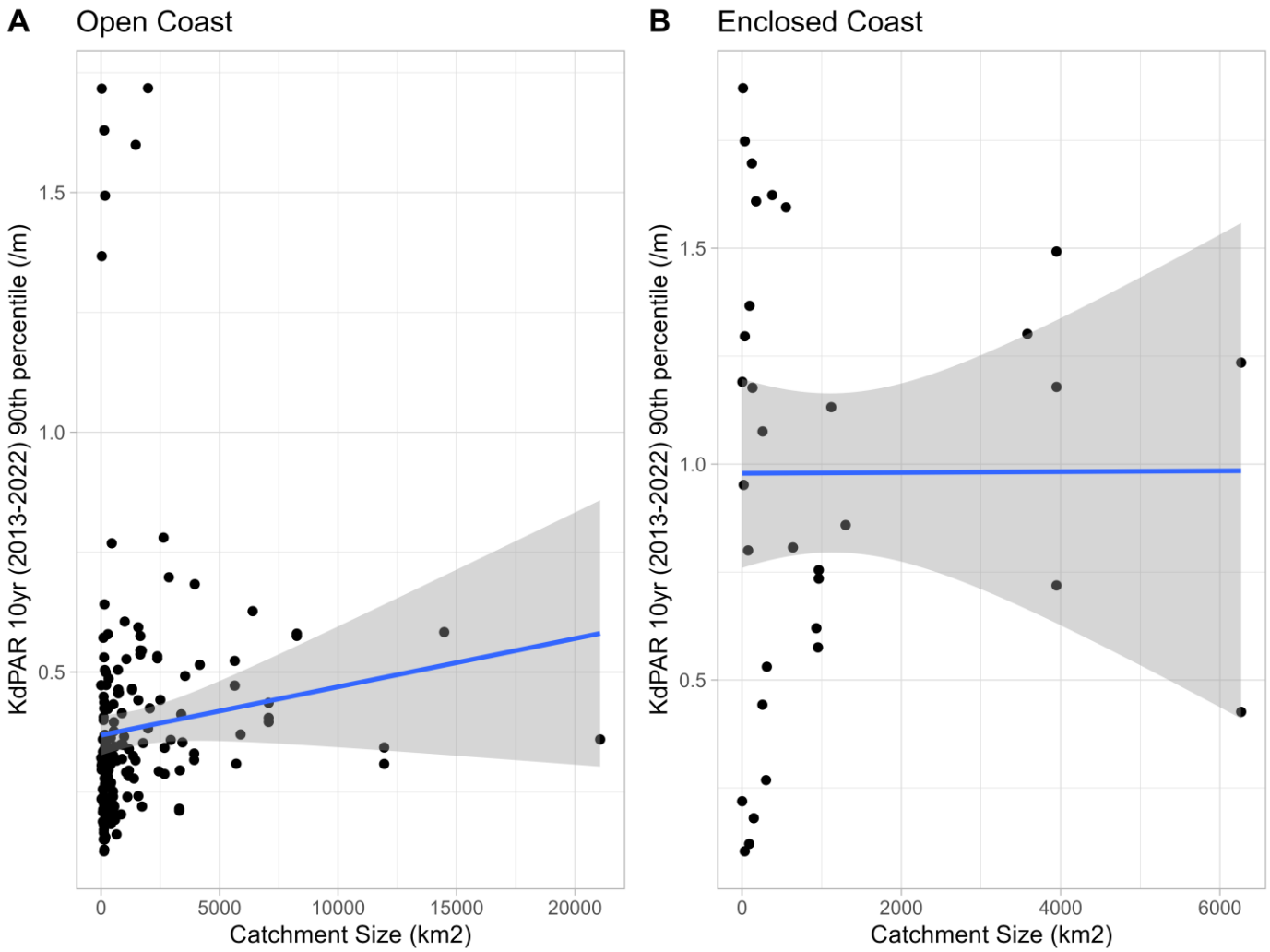


Figure S3. Relationship between catchment size and satellite-derived estimates of light attenuation (K_d) at the river mouths of the 226 highest-order river catchments in Aotearoa New Zealand. Scatterplots show the 90th percentile K_dPAR values in coastal waters within a 10 km radius of the river mouth over the 10-year period 2013–2022 calculated from the SCENZ 500 m K_dPAR product (Gall et al., 2022) for A) open coast environments, and B) enclosed coast environments. Note the outliers at small catchment sizes which are mostly generated by steep rivers in erodible terrain that lack appreciable coastal floodplains in which transported sediments may be trapped and deposited prior to reaching the coastline. K_dPAR = diffuse attenuation coefficient for downwelling irradiance (K_d) in the Photosynthetically Active Radiation (PAR) range (400–700 nm).

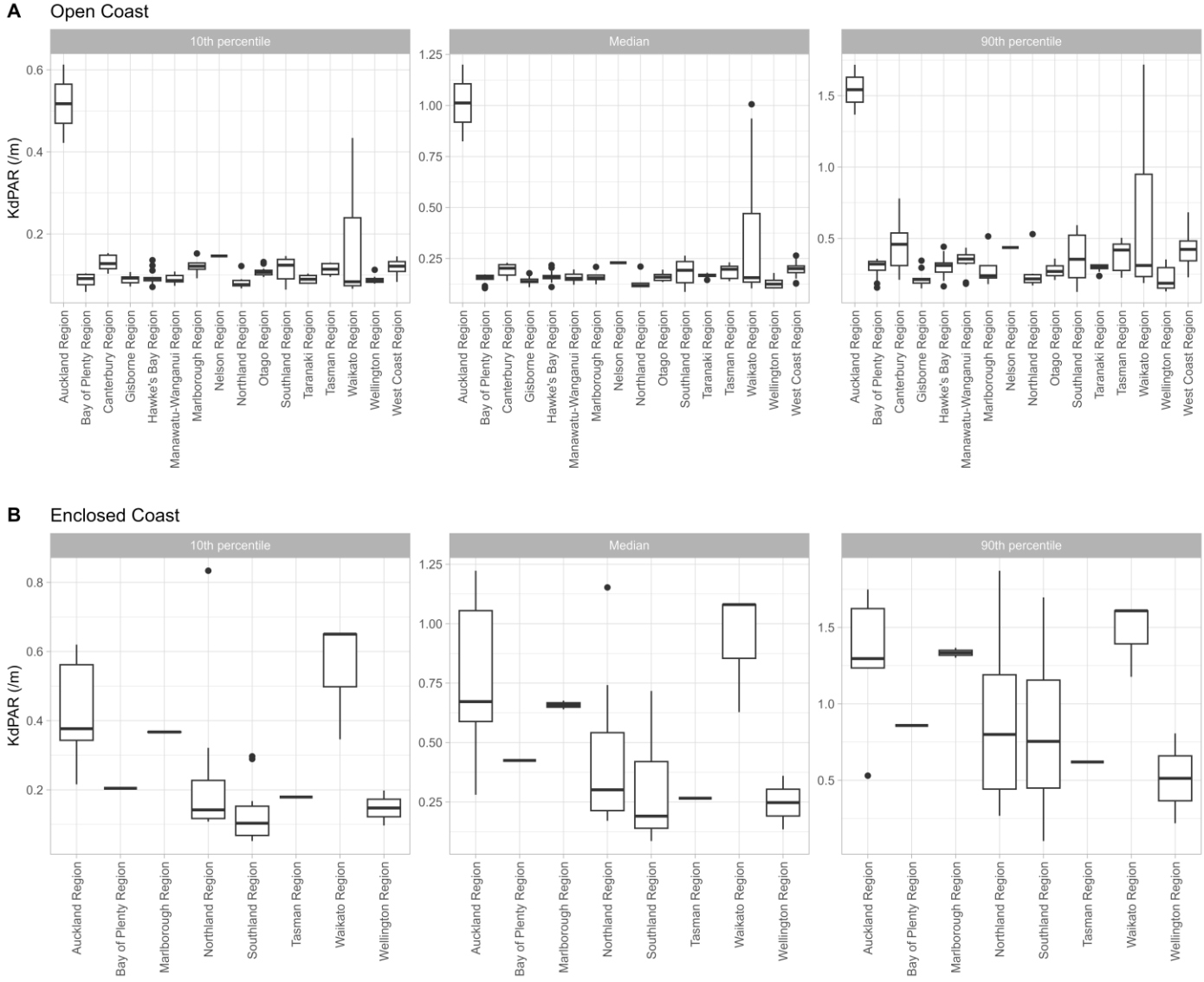


Figure S4. Differences across local government regions in satellite-derived estimates of light attenuation (K_d) at the river mouths of the 226 highest-order river catchments in Aotearoa New Zealand using a river radii framework. Boxplots summarise the median and interquartile range for the 10th, 50th and 90th percentile K_d values in coastal waters within a 10 km radius of the river mouth over the 10-year period 2013–2022 calculated from the SCENZ 500 m K_dPAR product (Gall et al., 2022). A) open coast environments. B) enclosed coast environments.

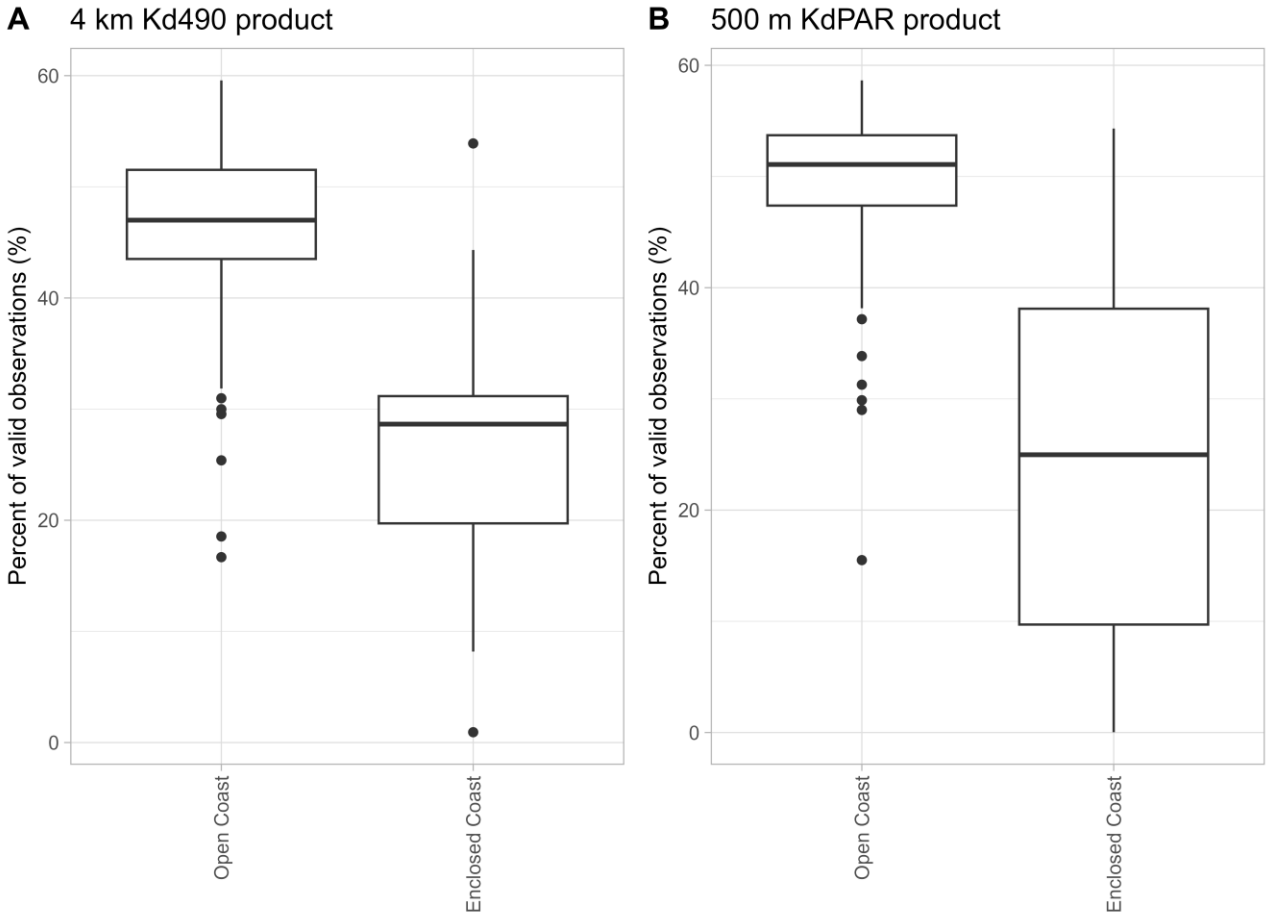


Figure S5. Differences in the percentage of valid observations for light attenuation (K_d) estimation between open and enclosed coast environments across the 226 highest-order river catchments in Aotearoa New Zealand. Boxplots summarise the median and inter-quartile range of the percentage of valid observations for (K_d) estimation within a 10 km radius of the river mouth. A) K_d490 results from ESA 4 km data (https://www.copernicus.eu/). B) K_dPAR results from SCENZ 500 m data (Gall et al., 2022). K_dPAR is the diffuse attenuation coefficient for downwelling irradiance (K_d) in the Photosynthetically Active Radiation (PAR) range (400–700 nm). K_d490 is the K_d at 490 nm.

References

1. Snelder, T.H.; Biggs, B.J.F. Multi-scale river environment classification for water resources management. *Journal of the American Water Resources Association* **2002**, *38*, 1225-1240.
2. Gall, M.P.; Pinkerton, M.H.; Steinmetz, T.; Wood, S. Satellite remote sensing of coastal water quality in New Zealand. *New Zealand Journal of Marine and Freshwater Research* **2022**, *56*, 585-616, doi:10.1080/00288330.2022.2113410.