

Supplementary Material for:

Marked spatial heterogeneity of macro-benthic communities along a shallow-mesophotic depth gradient in Reunion Island

Ludovic Hoarau^{1,2,3*}, François Guilhaumon¹, Sophie Bureau^{1,3}, Perrine Mangion¹, Priscille Labarrère², Lionel Bigot^{1,3}, Pascale Chabanet^{1,3}, Lucie Penin^{1,3}, Mehdi Adjeroūd^{3,4,5}

¹ UMR ENTROPIE (IRD, Université de La Réunion, CNRS, IFREMER, Université de Nouvelle-Calédonie), Saint-Denis, La Réunion, France

² Grand Port Maritime De La Réunion, Le Port, La Réunion, France

³ Laboratoire d'Excellence CORAIL, Paris, France

⁴ UMR ENTROPIE (IRD, Université de La Réunion, CNRS, IFREMER, Université de Nouvelle-Calédonie), Perpignan, France

⁵ PSL Université Paris, UAR 3278 CRILOBE - EPHE-UPVD-CNRS, 66860 Perpignan, France

*Corresponding author: Email: ludovic.remy.hoarau@gmail.com

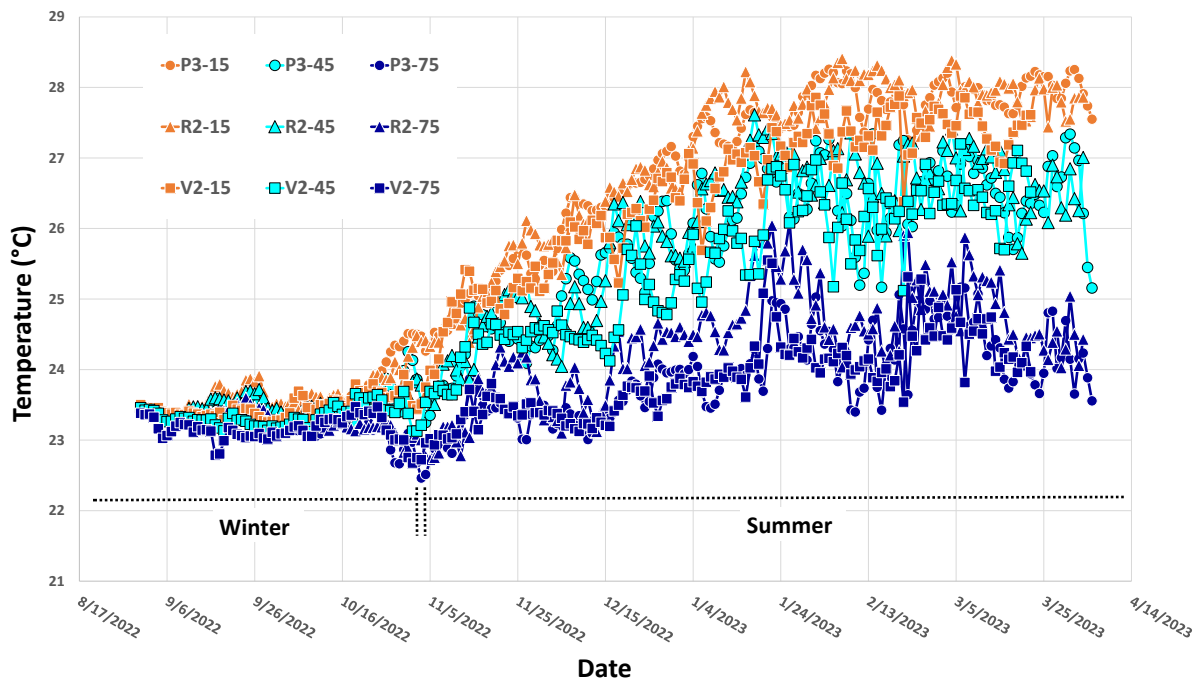


Figure S1. Temporal variation of temperature from September 2022 to April 2023 at three depths (15, 45 and 75 m) across three locations (coral reef R2, port P3 and volcanic lava flow V2).

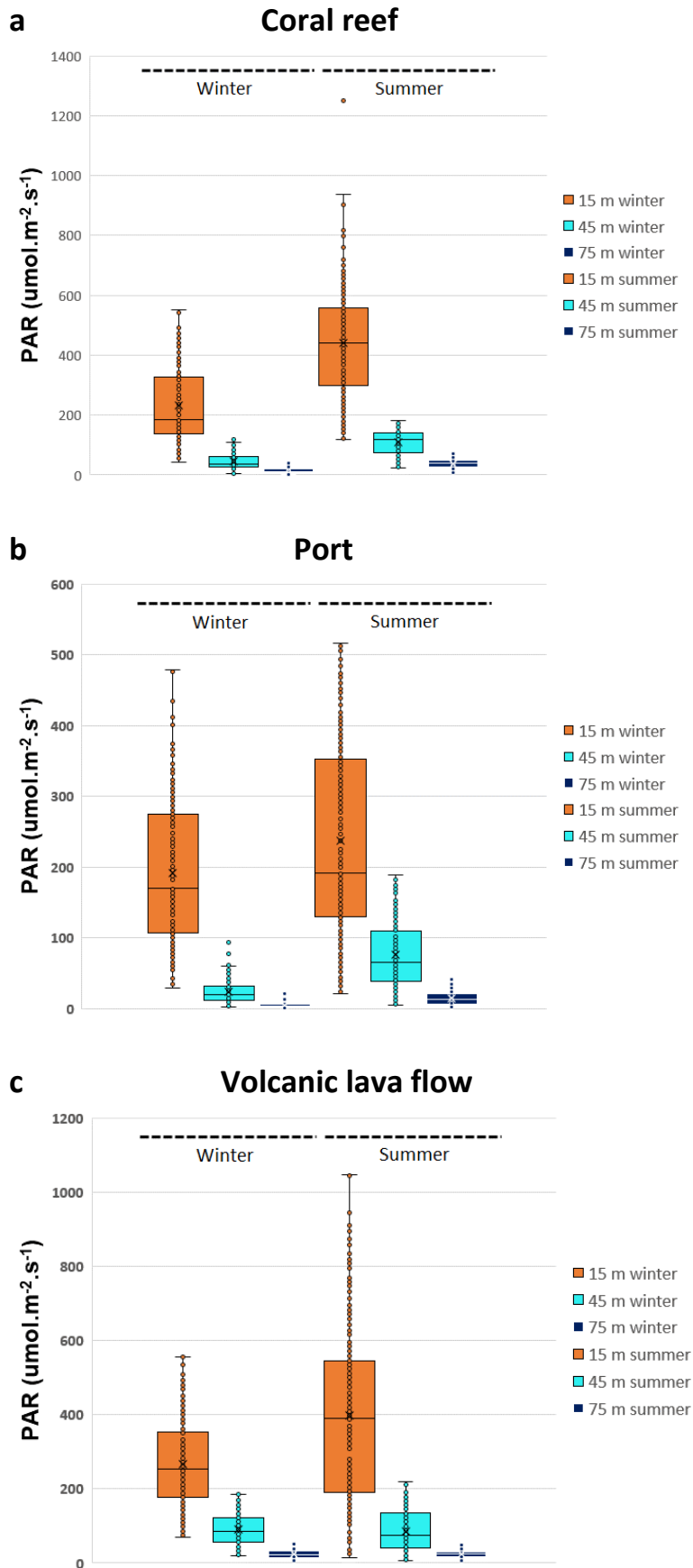


Figure S2. Distribution of photosynthetically available radiation (PAR) measured every 15 minutes for 15 consecutive days between 10 am and 3 pm during winter and summer at 3 depths (15, 45 and 75 m) across three locations: **a.** coral reef, **b.** port and **c.** volcanic lava flow.

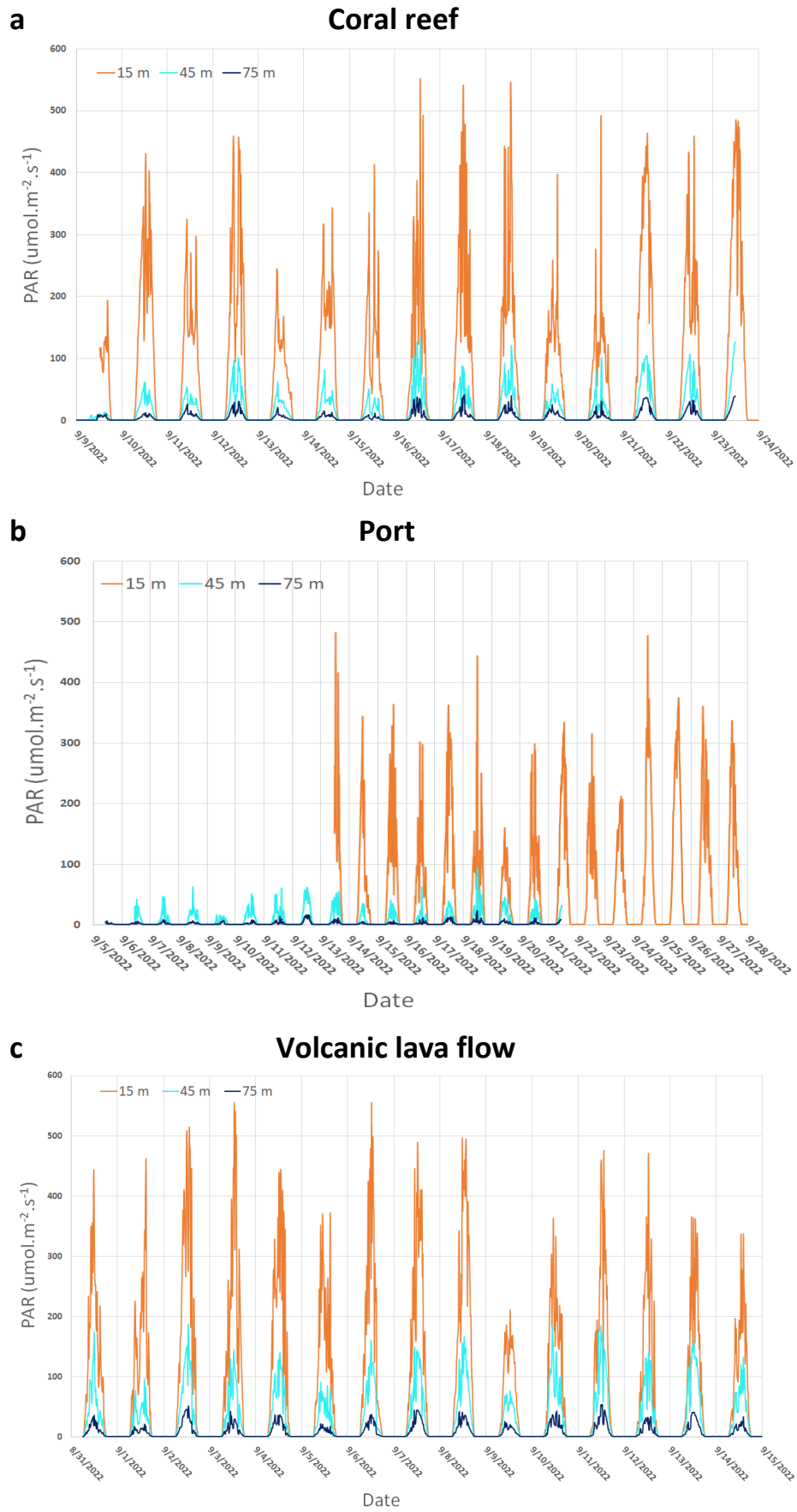


Figure S3. Photosynthetically available radiation (PAR) measured every 15 min for 15 consecutive days during winter at 3 depths (15, 45 and 75 m) at **a.** coral reef, **b.** port and **c.** volcanic lava flow.

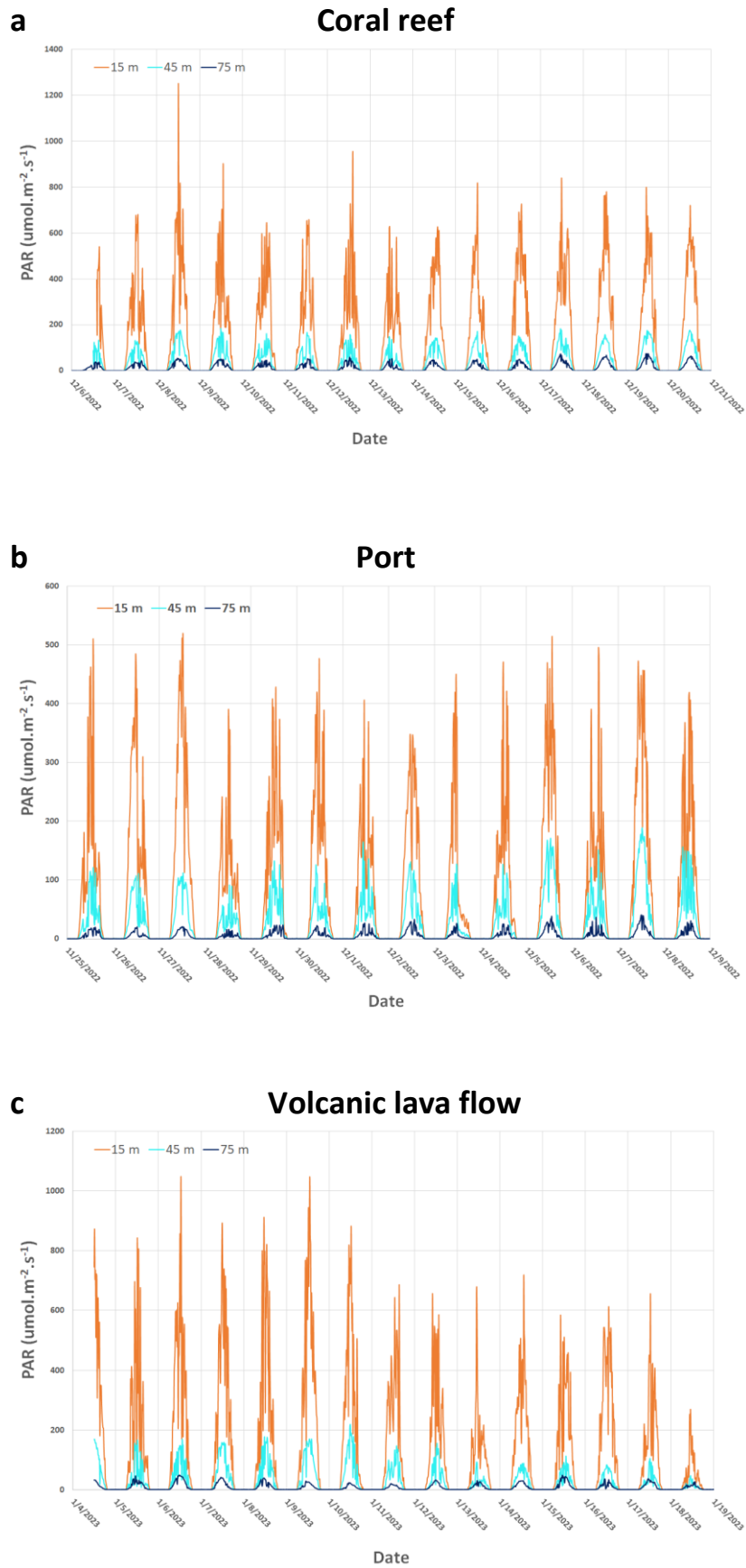


Figure S4. Photosynthetically available radiation (PAR) measured every 15 min for 15 consecutive days during summer at 3 depths (15, 45 and 75 m) at **a.** coral reef, **b.** port and **c.** volcanic lava flow. Note that PAR at volcanic lava flow at 75 m were recorded from 3 October to 18 October 2022.

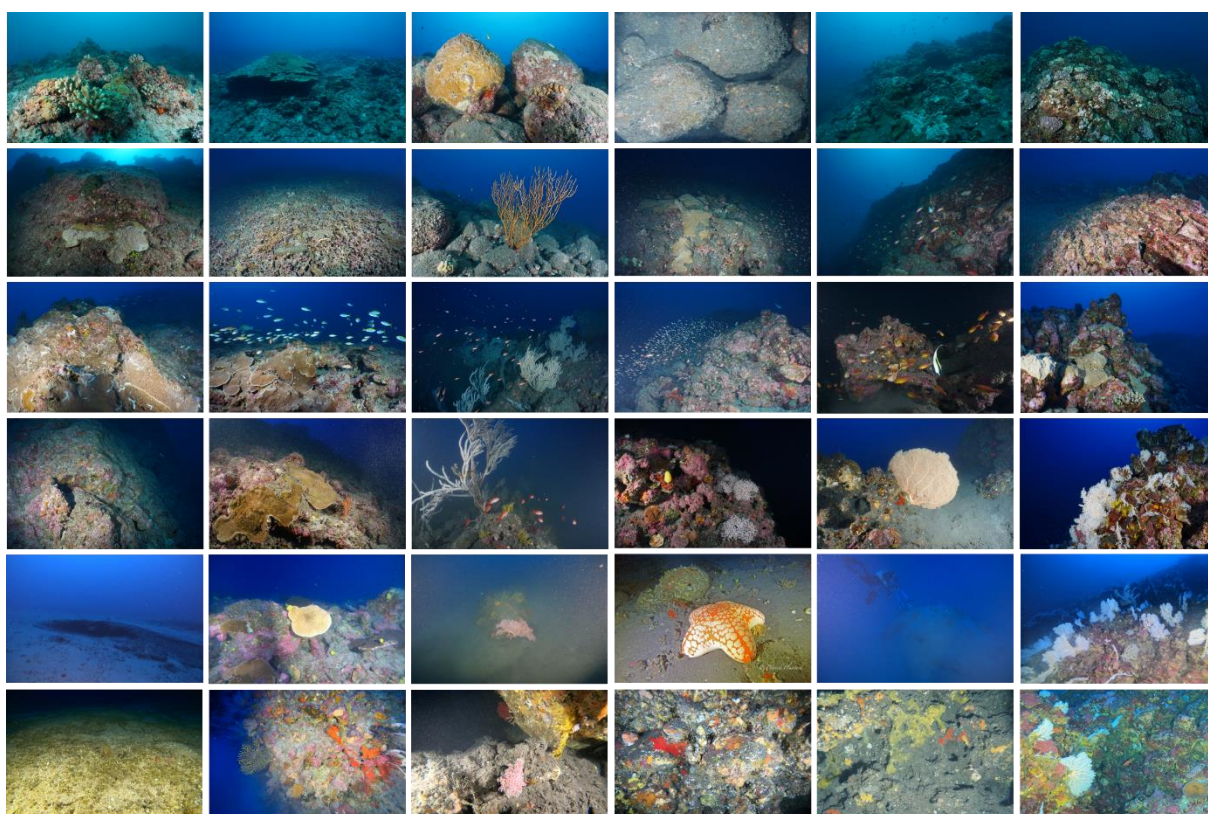


Figure S5. Representative photos of benthic communities at six sites (from left to right: R1, R2, P1, P3, V1 and V2) across three locations (coral reef, port and volcanic lava flow respectively) at 15, 30, 45, 60, 75 and 95 m depths (top to bottom).

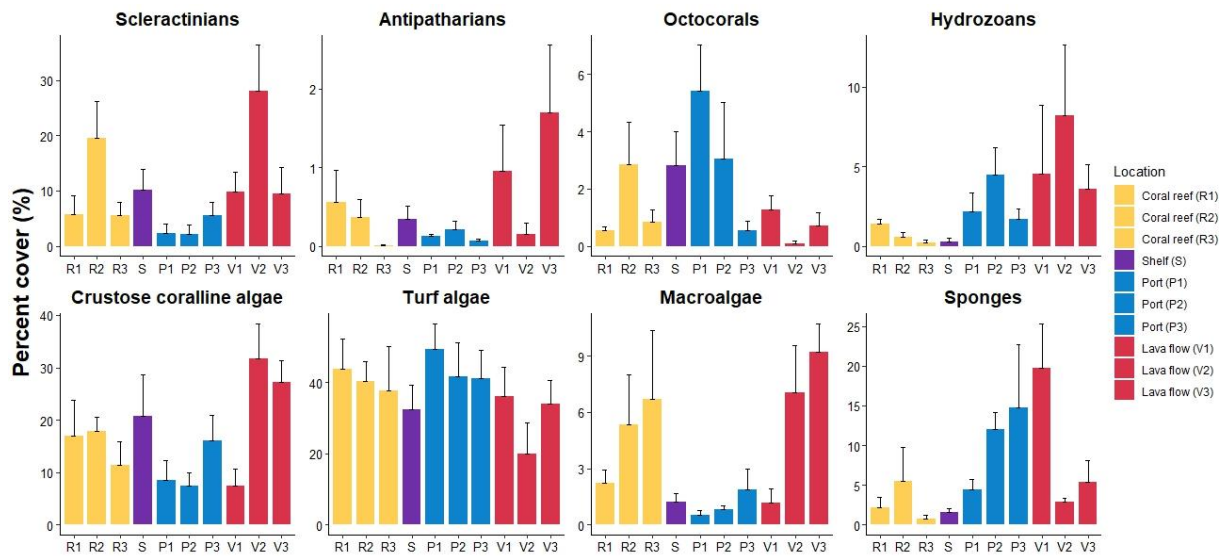


Figure S6. Mean percent cover of eight sessile macro-benthic categories across studied sites with scleractinians, octocorals, antipatharians, hydrozoans, crustose coralline algae, turf algae, macroalgae and sponges. Different colors represent different locations: coral reef (in yellow), shelf (in purple), port (in blue) and volcanic lava flow (in red). Error bars indicate +S.E.

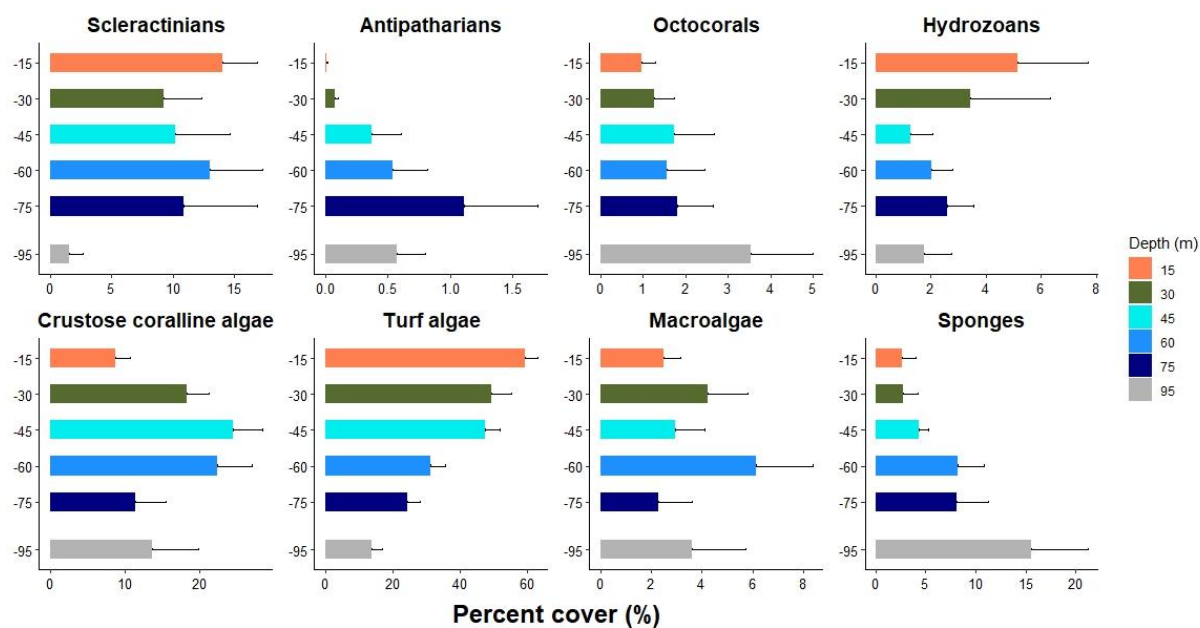


Figure S7. Mean percent cover of sessile macro-benthic across depths (all sites pooled) with scleractinians, octocorals, antipatharian, hydrozoan, crustose coralline algae, turf algae, macroalgae and sponges. Error bars indicate +S.E.

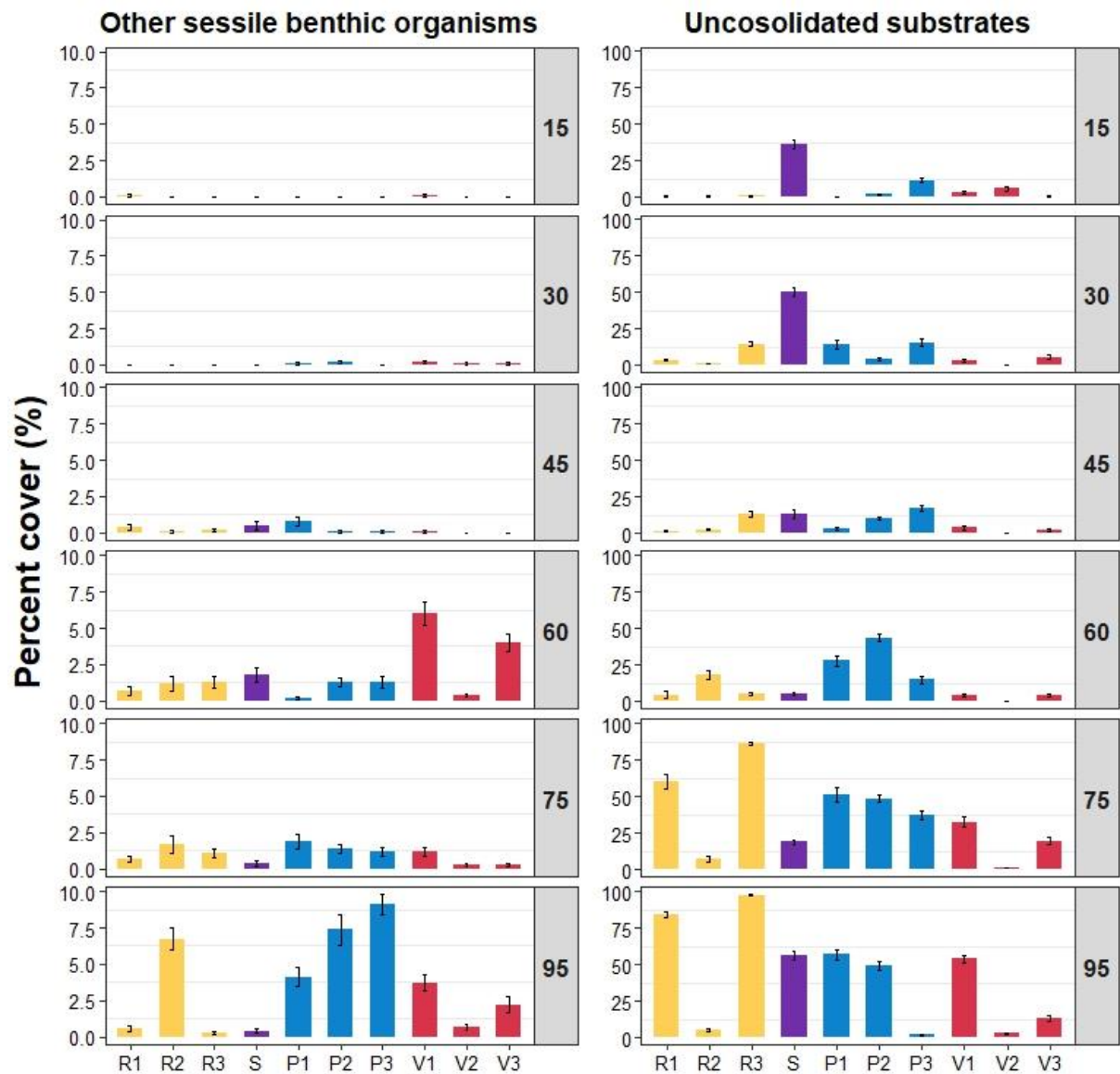


Figure S8. Mean percent cover of other sessile macro-benthic invertebrates and unconsolidated substrates at the 60 stations, disposed across the 10 sites (with coral reef sites in yellow, shelf in purple, port in blue, and volcanic lava flow in red) and the 6 depths (15, 30, 45, 60, 75, and 95 m). Error bars indicate $\pm$ S.E.

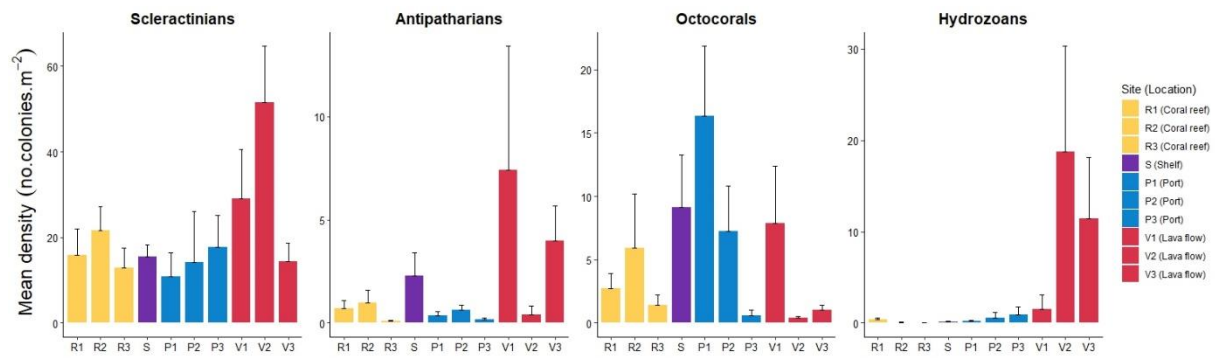


Figure S9. Mean density (number of colonies.m⁻²) of cnidarians across studied sites with scleractinians, octocorals, antipatharians and calcareous hydrozoans. Different colors in the barplots represent different locations: coral reef in yellow, shelf in purple, port in blue and volcanic lava flow in red. Error bars indicate +S.E.

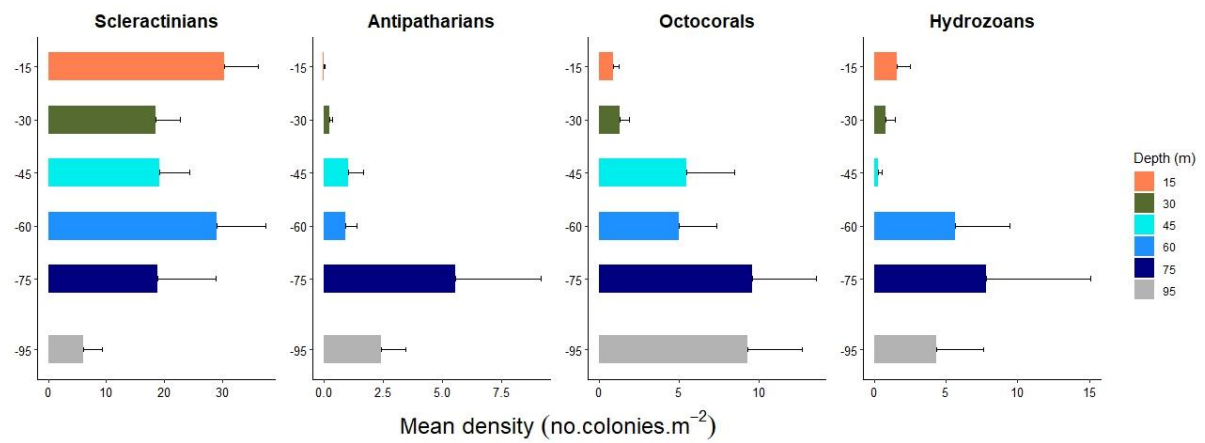


Figure S10. Mean density (number of colonies.m⁻²) of cnidarians across depths (all sites pooled) with scleractinians, octocorals, antipatharians and calcareous hydrozoans. Error bars indicate +S.E.

Table S1. PERMANOVA testing for differences in macro-benthic and cnidarian community assemblages between different locations (coral reef: R, shelf: S, port: P and volcanic lava flow: V) and depths (15, 30, 45, 60, 75 and 95 m) and the interactions between them. Model was of the form: sessile macro-benthic community matrix ~ depth × location.

	Sessile macro-benthic assemblages						Cnidarian assemblages				
	<i>df</i>	<i>SS</i>	<i>R</i> ²	<i>Pseudo-F</i>	<i>p</i>	<i>p-adj.</i>	<i>SS</i>	<i>R</i> ²	<i>Pseudo-F</i>	<i>p</i>	<i>p-adj.</i>
A. Main factors											
Depth	1	1.7189	0.2130	18.7814	0.0001	-	1.9883	0.1472	11.1945	0.0001	-
Location	3	1.0286	0.1275	3.7464	0.0001	-	1.4599	0.1080	2.7399	0.0022	-
Depth:Location	3	0.5617	0.0696	2.0460	0.0151	-	0.8282	0.0613	1.5544	0.0587	-
Residual	52	4.7590	0.5899			-	9.2358	0.6835			-
Total	59	8.0682	1.0000			-	13.5122	1.0000			-
B. Depth pairwise comparison											
15 m vs. 30 m	1	0.0898	0.08260	1.6204	0.192	0.2400	0.2050	0.0988	1.9723	0.127	0.2381
15 m vs. 45 m	1	0.1861	0.1866	4.1286	0.005	0.0125	0.3066	0.1068	2.1512	0.099	0.2121
15 m vs. 60 m	1	0.4314	0.2684	6.6025	0.003	0.0090	0.2315	0.0760	1.4807	0.172	0.2790
15 m vs. 75 m	1	0.5873	0.2458	5.8663	0.001	0.0038	0.9645	0.2161	4.9617	0.001	0.0075
15 m vs. 95 m	1	1.3216	0.3468	9.5551	0.001	0.0038	1.5107	0.2971	7.6068	0.001	0.0075
30 m vs. 45 m	1	0.0206	0.0180	0.3293	0.829	0.8290	0.0949	0.0325	0.6047	0.628	0.7246
30 m vs. 60 m	1	0.1930	0.1146	2.3290	0.074	0.1110	0.2541	0.0763	1.4878	0.186	0.2790
30 m vs. 75 m	1	0.4059	0.1609	3.4510	0.011	0.0206	0.6996	0.1569	3.3497	0.011	0.0413
30 m vs. 95 m	1	0.9387	0.2508	6.0244	0.001	0.0038	1.0378	0.2130	4.8710	0.002	0.0100
45 m vs. 60 m	1	0.1333	0.0921	1.8265	0.136	0.1855	0.0943	0.0244	0.4501	0.815	0.8732
45 m vs. 75 m	1	0.3797	0.1637	3.5228	0.010	0.0206	0.2781	0.0588	1.1237	0.289	0.3941
45 m vs. 95 m	1	0.8900	0.2530	6.0967	0.001	0.0038	0.5597	0.1100	2.2239	0.078	0.1950
60 m vs. 75 m	1	0.1421	0.0581	1.1098	0.308	0.3300	0.2756	0.0554	1.0550	0.384	0.4800
60 m vs. 95 m	1	0.4787	0.1379	2.8796	0.014	0.0233	0.5848	0.1090	2.2028	0.057	0.1710
75 m vs. 95 m	1	0.2448	0.0634	1.2180	0.280	0.3231	0.1278	0.0229	0.4210	0.903	0.9030
C. Location pairwise comparison											
R vs. V	1	0.3509	0.0667	2.4281	0.030	0.0450	0.6076	0.0811	3.0022	0.023	0.0690
R vs. S	1	0.0448	0.0145	0.3238	0.940	0.9400	0.1550	0.0403	0.9248	0.410	0.4220
R vs. P	1	0.3551	0.0795	2.9377	0.015	0.0450	0.3949	0.0479	1.7120	0.133	0.1995
V vs. S	1	0.2046	0.0653	1.5363	0.198	0.2376	0.4086	0.0885	2.1353	0.090	0.1800
V vs. P	1	0.6611	0.1420	5.6263	0.001	0.0060	0.9102	0.0981	3.6997	0.008	0.0480
S vs. P	1	0.2714	0.1132	2.8081	0.027	0.0450	0.2171	0.0403	0.9237	0.422	0.4220

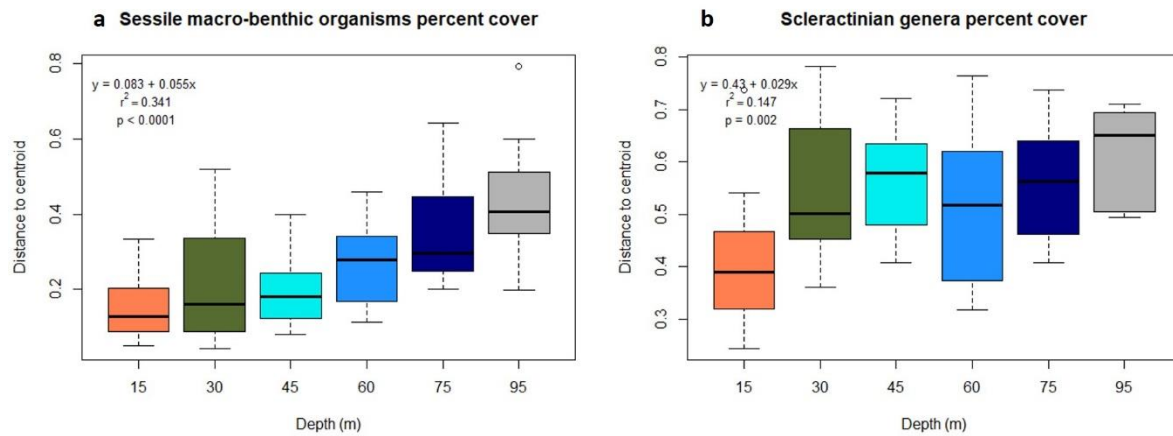


Figure S11. Distance to centroid of Bray-Curtis dissimilarity as a function of depth for **a.** sessile macro-benthic percent cover and **b.** scleractinian genera percent cover. The equation of the linear model is displayed with r^2 and p-value showing significant increase of beta-diversity for both macro-benthic and scleractinians with increasing depth.

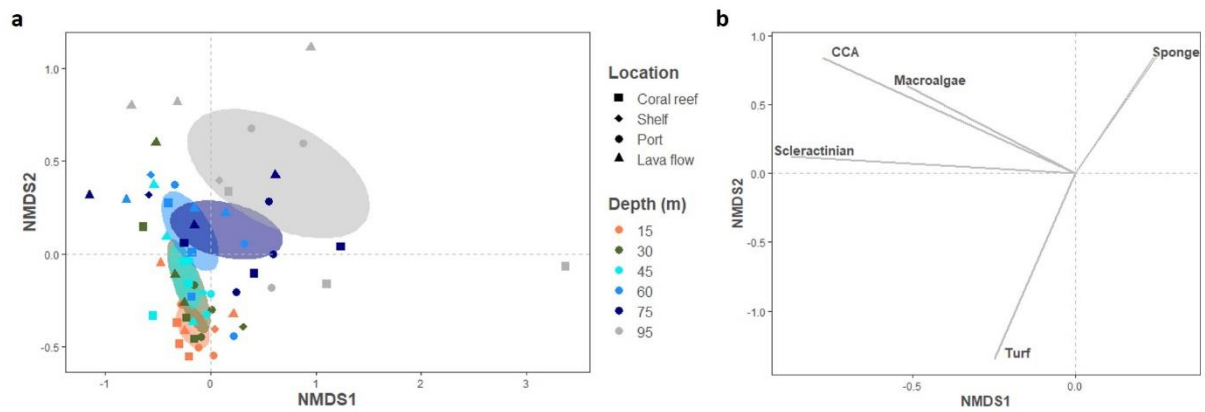


Figure S12. Non-metric multidimensional scaling (NMDS) of percent cover of sessile macrobenthic communities (**a** and **b**) based on untransformed Bray-Curtis dissimilarity distance matrix, **b.** with significant vectors ($p < 0.05$) explaining the overall depth patterns in assemblage structure. Different symbols represent locations and ellipses the standard error with 95 % confidence limit of depth centroid. Stress value = 0.13.

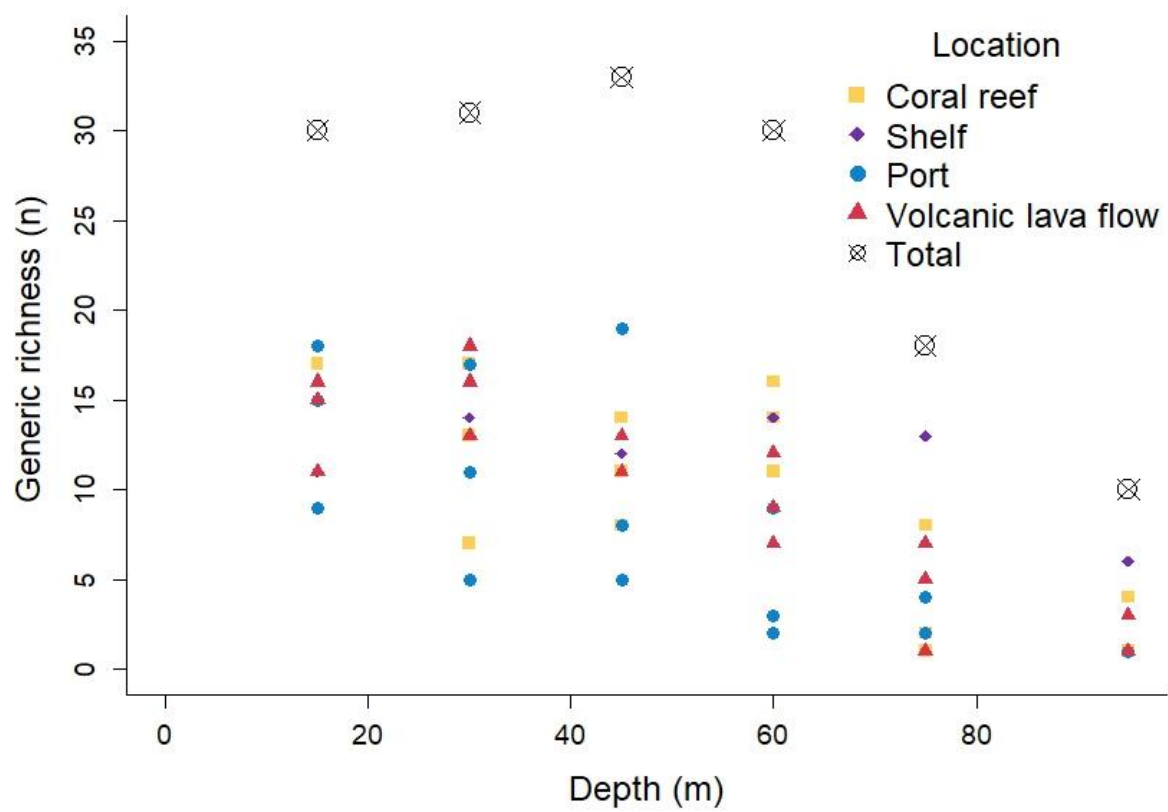


Figure S13. Generic richness of scleractinians as function of depth at the four locations and all locations pooled (total).

Table S2. PERMANOVA testing for differences in the composition of scleractinian assemblages between different locations (coral reef: R, shelf: S, port: P and volcanic lava flow: V) and depths (15, 30, 45, 60, 75 and 95 m) and the interactions between them. Model was of the form: scleractinian genera community matrix ~ depth × location.

	Scleractinian assemblages					
	<i>df</i>	<i>SS</i>	<i>R</i> ²	<i>Pseudo-F</i>	<i>p</i>	<i>p-adjusted</i>
A. Main factors						
Depth	1	3.0719	0.1299	9.1916	0.0001	-
Location	3	1.8459	0.0780	1.8410	0.0031	-
Depth:Location	3	1.3594	0.0575	1.3559	0.0740	-
Residual	52	17.3787	0.7347			-
Total	59	23.6559	1.0000			-
B. Depth pairwise comparison						
15 m vs. 30 m	1	0.7379	0.1316	2.7268	0.004	0.0075
15 m vs. 45 m	1	1.5102	0.2263	5.2641	0.001	0.0025
15 m vs. 60 m	1	2.1621	0.3126	8.1842	0.001	0.0025
15 m vs. 75 m	1	2.3094	0.3102	8.0940	0.001	0.0025
15 m vs. 95 m	1	2.0799	0.2663	6.5333	0.001	0.0025
30 m vs. 45 m	1	0.5286	0.0781	1.5258	0.077	0.0888
30 m vs. 60 m	1	1.1742	0.1677	3.6268	0.002	0.0043
30 m vs. 75 m	1	1.4115	0.1853	4.0926	0.001	0.0025
30 m vs. 95 m	1	1.3125	0.1617	3.4729	0.001	0.0025
45 m vs. 60 m	1	0.4316	0.0659	1.2694	0.240	0.2571
45 m vs. 75 m	1	0.7112	0.0987	1.9693	0.034	0.0464
45 m vs. 95 m	1	0.7638	0.0972	1.9376	0.021	0.0315
60 m vs. 75 m	1	0.6136	0.0915	1.8129	0.077	0.0888
60 m vs. 95 m	1	0.8810	0.1164	2.3717	0.016	0.0267
75 m vs. 95 m	1	0.1641	0.0227	0.4179	0.905	0.9050
C. Location pairwise comparison						
R vs. V	1	0.4500	0.0319	1.1216	0.294	0.3528
R vs. S	1	0.3615	0.0395	0.9048	0.558	0.5580
R vs. P	1	0.6573	0.0467	1.6661	0.067	0.1340
V vs. S	1	0.4869	0.0548	1.2756	0.233	0.3495
V vs. P	1	0.8918	0.0641	2.3285	0.008	0.0480
S vs. P	1	0.7677	0.0859	2.0676	0.032	0.0960

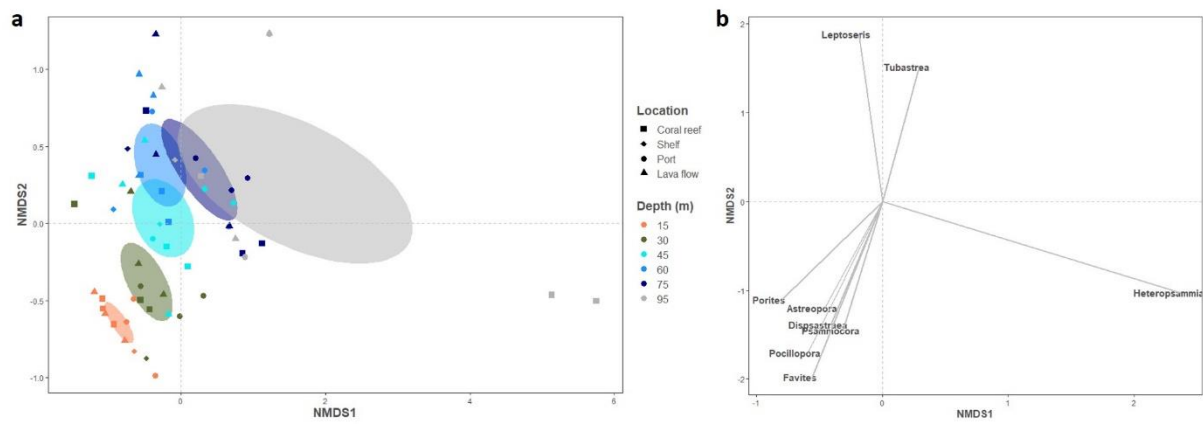


Figure S14. Non-metric multidimensional scaling (NMDS) of percent cover of scleractinian genera communities (**a** and **b**) based on untransformed Bray-Curtis dissimilarity distance matrix **b.** with significant vectors ($p < 0.05$) explaining the overall depth patterns in assemblage structure. Different symbols represent locations and ellipses the standard error with 95 % confidence limit of depth centroid. Stress value = 0.11.

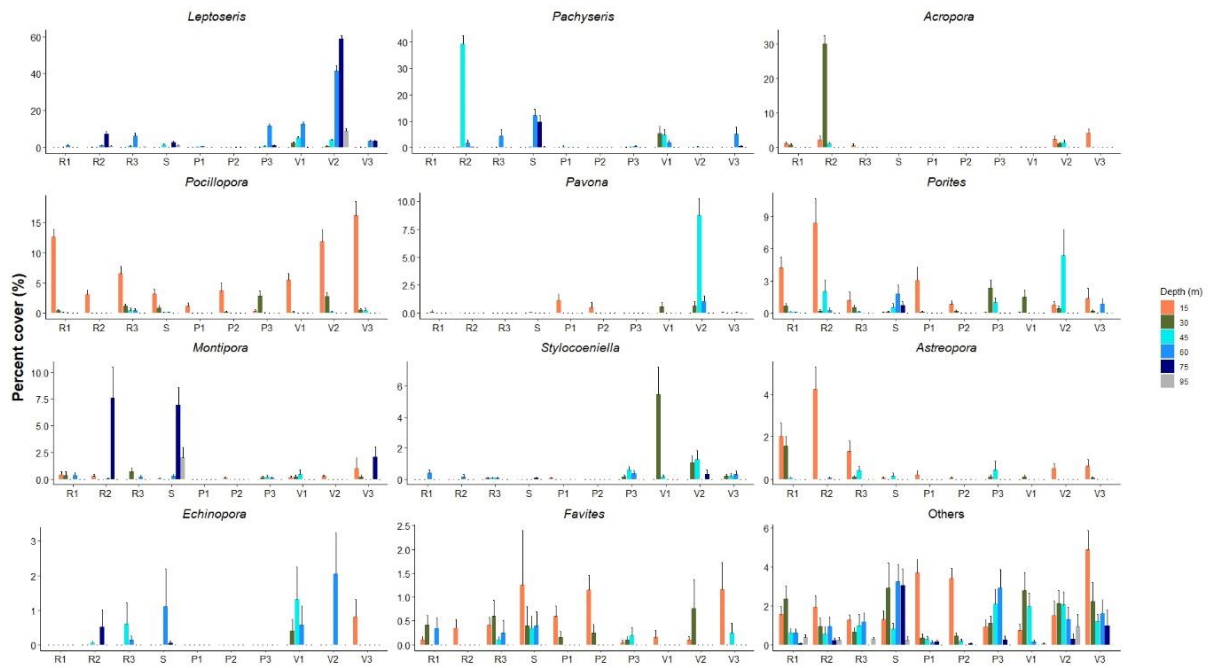


Figure S15. Mean percent cover of the 11 dominant scleractinian coral genera (+ others) at each studied site at 15 m in orange, 30 m in green, 45 m in cyan, 60 m in sky blue, 75 m in dark blue and 95 m in grey. Error bars indicate +S.E.

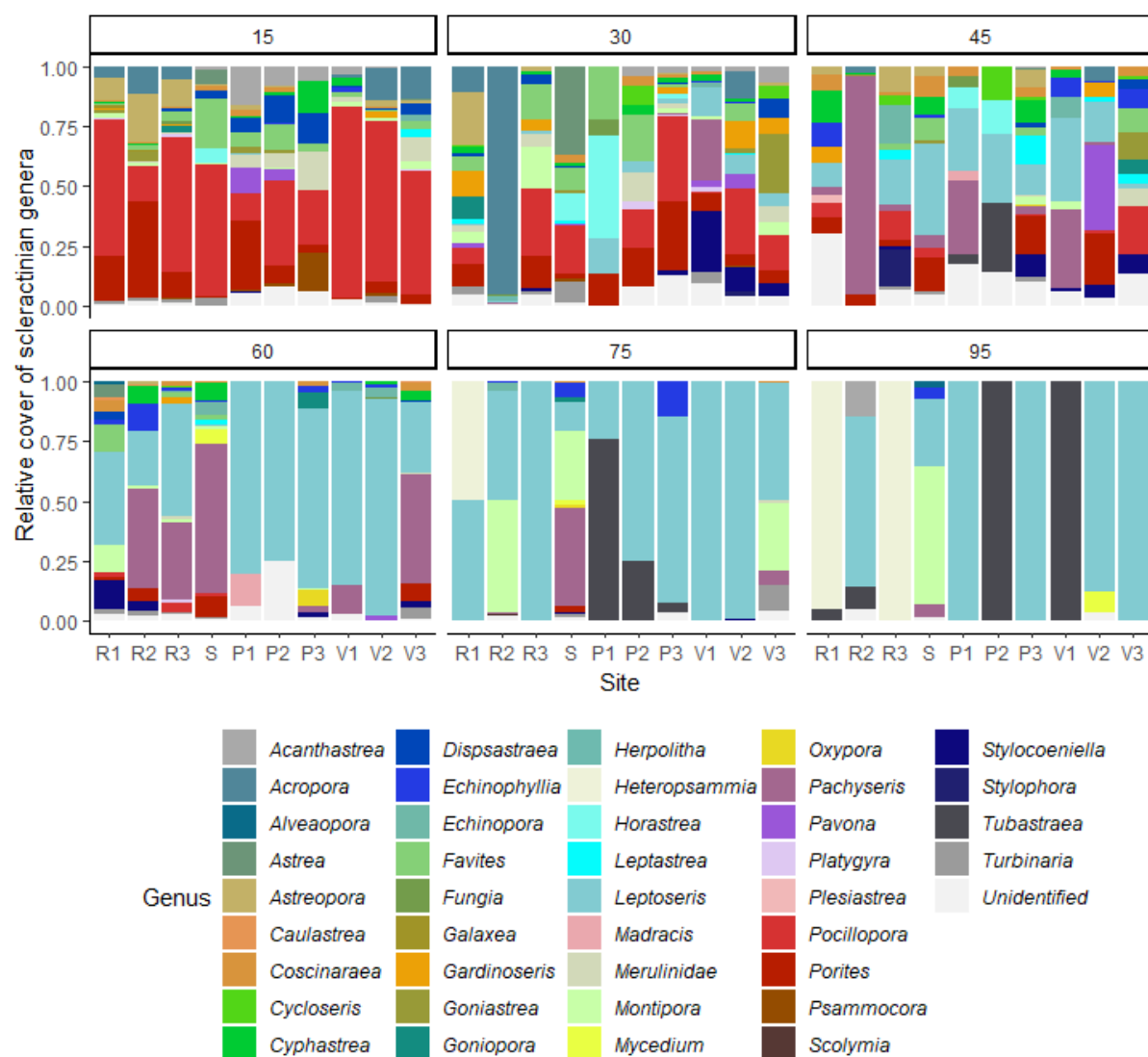


Figure S16. Relative proportion of scleractinian genera across sites and depths.

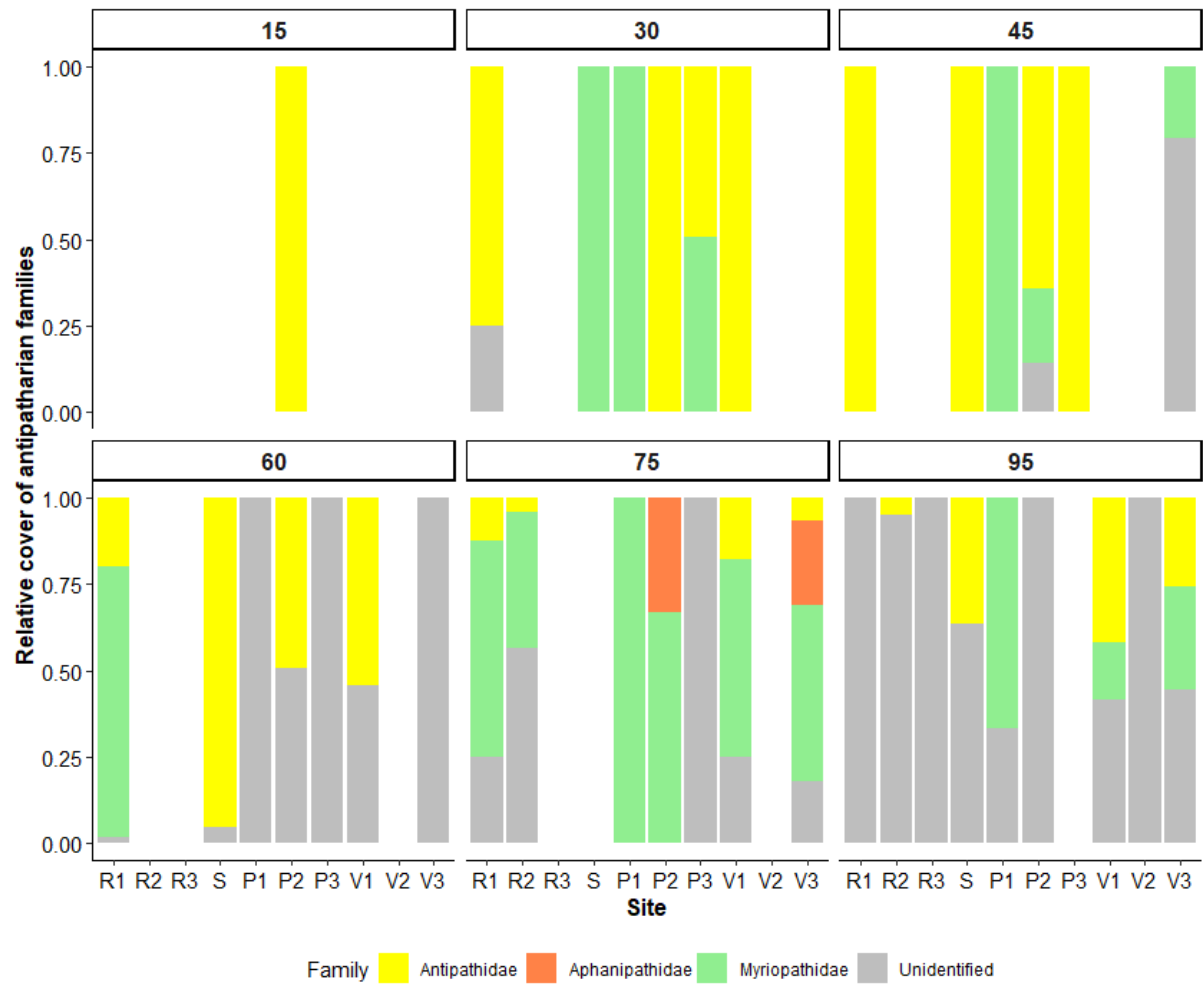


Figure S17. Relative proportion of antipatharian families across sites and depths.

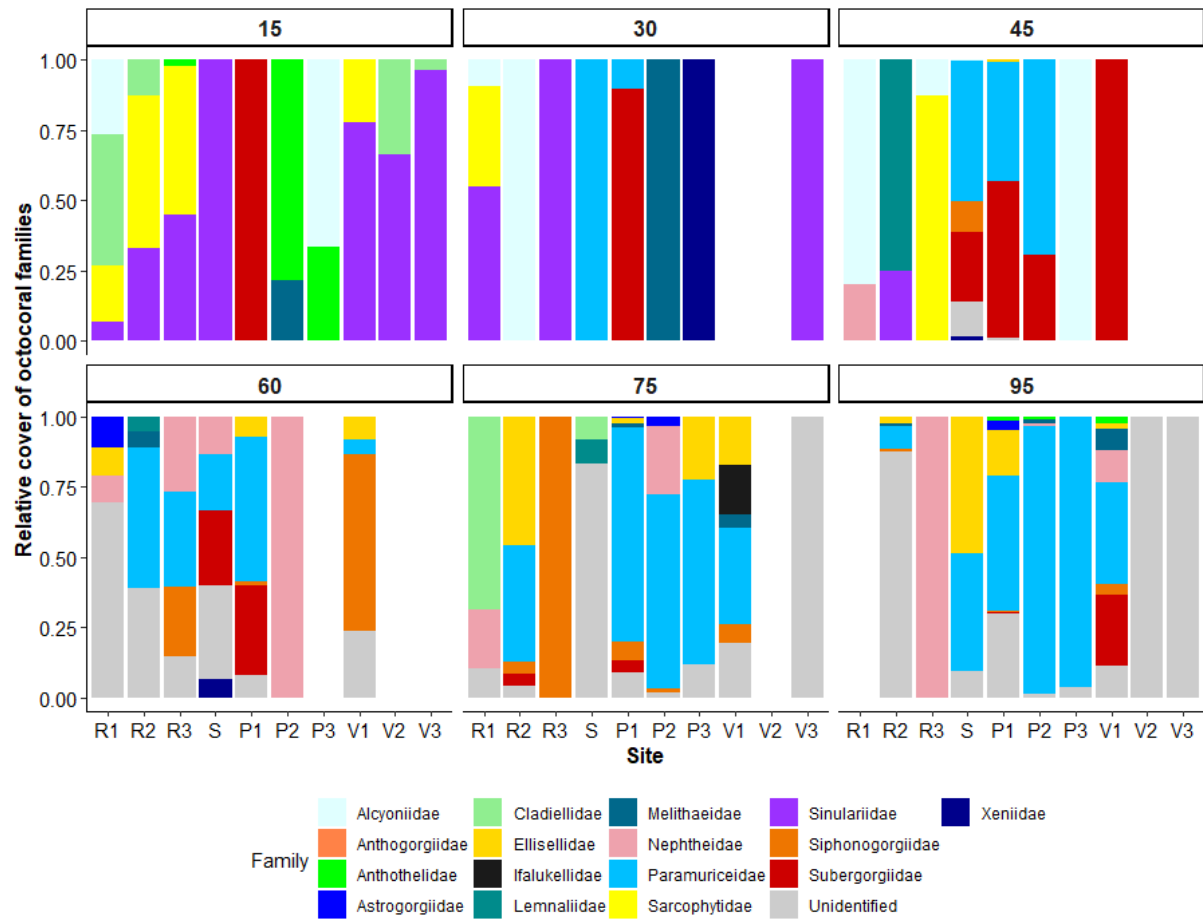


Figure S18. Relative proportion of octocoral families across sites and depths.

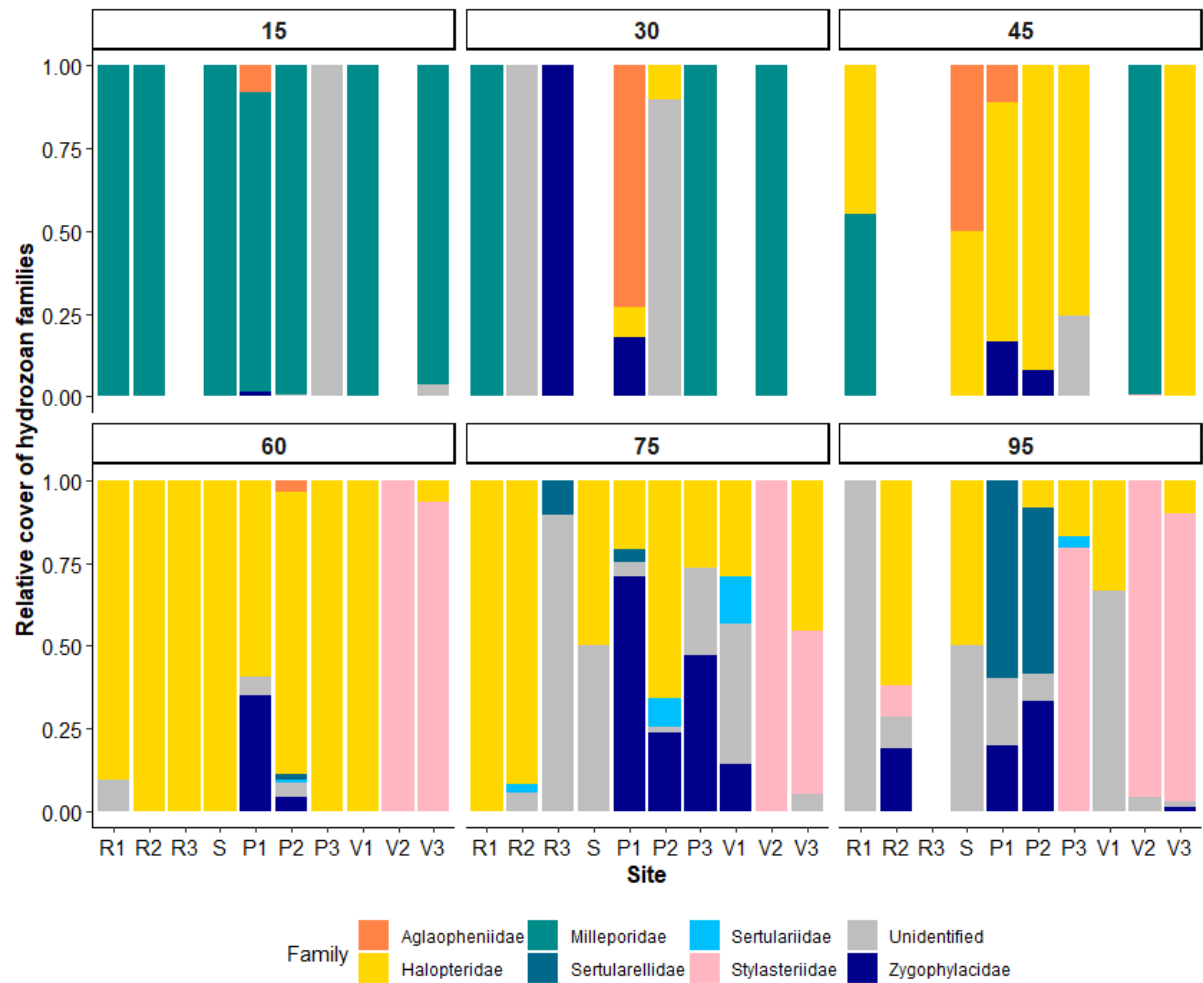


Figure S19. Relative proportion of hydrozoan families across sites and depths.

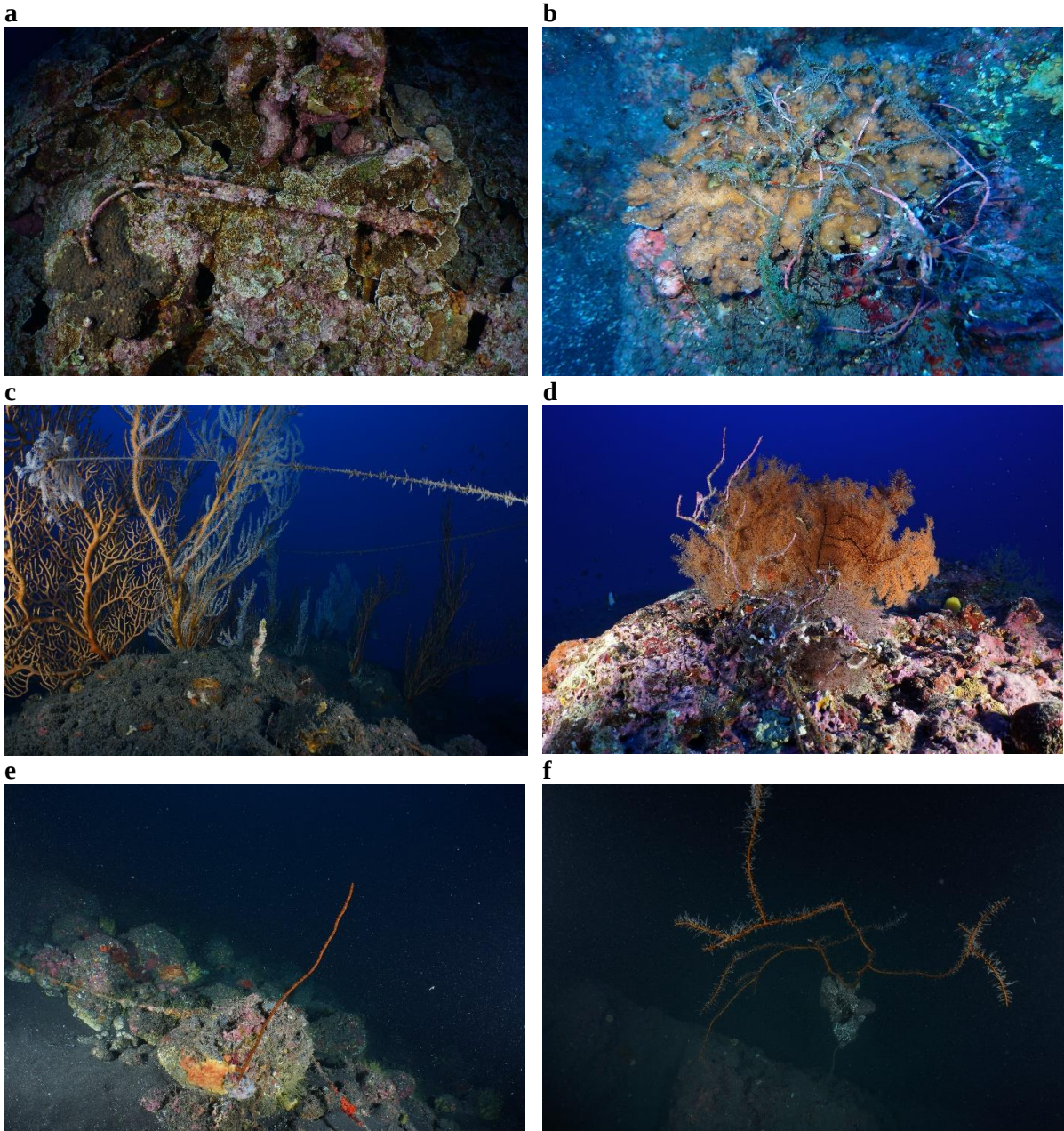


Figure S20. Mesophotic coral ecosystems across different locations with various anthropogenic debris on macro-benthic communities. **a.** Anchor on scleractinian corals at 60 m depth in volcanic lava flow **b.** Fishing lines entangled on *Pocillopora verrucosa* at 45 m depth in coral reef, **c.** on gorgonians at 60 m depth in port, **d.** on antipatharians at 65 m depth in shelf, and **e.** on sponge grounds at 60 m depth in port. **f.** Plastic bag entangled at the base of a large antipatharian at 50 m depth in volcanic lava flow.