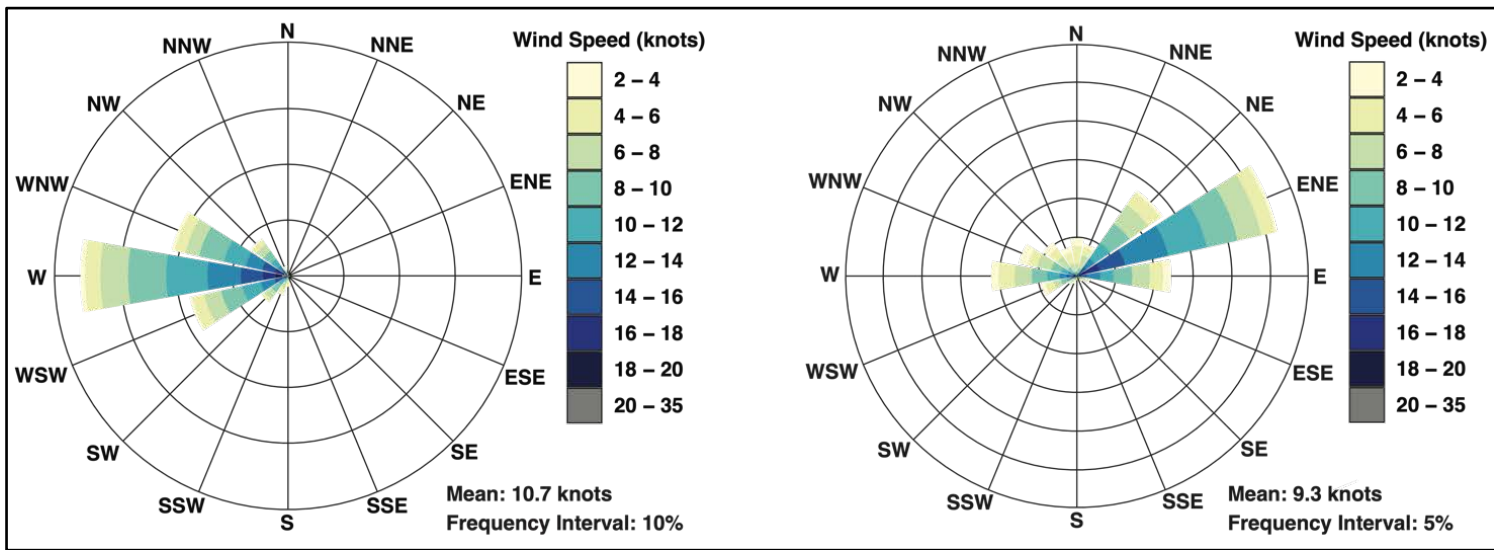


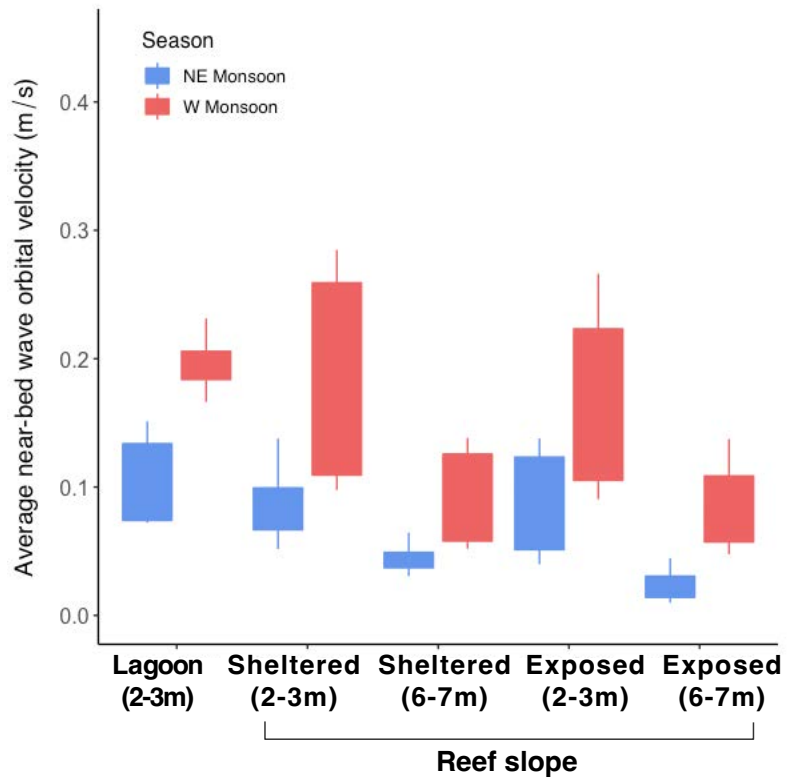
1 Supplementary Material



2
3 Figure S1 Rubble bases used in the wave flume for (a) ‘free’ not interlocked rubble pieces; and (b) interlocked rubble.



2 Figure S2 Windrose of mean wind speed (knots) and wind direction data measured at Hulhumale ranging 1985-2018 for western monsoon, showing monsoonal mean wind speed
 3 (left); and (right) north-eastern monsoon, showing monsoonal mean wind speed (Source: Maldives Meteorological Service, Government of Maldives).



1

2 Figure S3 Boxplots representing the range of the nine (one per day for three days, across 3 sites) average peak velocity values (the average of all peak velocities across each day, as
 3 opposed to the absolute peak within each day period, shown in Figure 4 of the manuscript), estimated for each habitat in each monsoonal observation period.

4

1 **Table S1 The min, max and median recorded peak near-bed wave orbital velocities in each habitat and monsoon season.**

Monsoon season	Habitat	Peak near-bed wave orbital velocity (m/s)		
		Min	Median	Max
North-eastern	Lagoon	0.086	0.164	0.218
	Sheltered Shallow	0.084	0.100	0.229
	Sheltered Deep	0.048	0.056	0.092
	Exposed Shallow	0.059	0.160	0.252
	Exposed Deep	0.017	0.035	0.061
Western	Lagoon	0.214	0.245	0.297
	Sheltered Shallow	0.114	0.295	0.402
	Sheltered Deep	0.061	0.136	0.192
	Exposed Shallow	0.117	0.188	0.552
	Exposed Deep	0.064	0.102	0.287

2 **Table S2 Anova table of model “fl.r.global” describing the effect of velocity, rubble size, branchiness and underlying substrate on the probability of rocking motions of rubble pieces.**

Model term	LR χ^2	df	p-value ($>\chi^2$)
calculated.velocity_corrected	1012.400	1	<0.001
size	8.692	3	0.034
substrate	0.732	1	0.392
branched	191.305	1	<0.001
calculated.velocity_corrected:size	92.921	3	<0.001
calculated.velocity_corrected:substrate	33.668	1	<0.001

Model term	LR χ^2	df	p-value ($>\chi^2$)
calculated.velocity_corrected:branched	0.684	1	0.408
size:substrate	20.401	3	<0.001
size:branched	90.655	3	<0.001
substrate:branched	33.544	1	<0.001
calculated.velocity_corrected:size:branched	55.330	3	<0.001
calculated.velocity_corrected:size:substrate	17.765	3	<0.001

1

1 Table S3 Pairwise comparisons between branched and unbranched rubble for 4 rubble size categories and 4 levels of continuous variable ‘velocity’ (0.01 m/s, 0.2 m/s (mean), 0.3 m/s,
 2 0.4 m/s) for model described in Table S2.

Rubble size	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
4-8 cm	0.1	6.916	1.668	Inf	8.019	<0.001
9-15 cm	0.1	1.795	0.435	Inf	2.414	0.016
16-23 cm	0.1	3.134	0.778	Inf	4.605	<0.001
24-39 cm	0.1	4.378	0.989	Inf	6.534	<0.001
4-8 cm	0.2	6.875	1.254	Inf	10.568	<0.001
9-15 cm	0.2	4.462	0.977	Inf	6.829	<0.001
16-23 cm	0.2	1.236	0.202	Inf	1.292	0.196
24-39 cm	0.2	9.042	1.708	Inf	11.659	<0.001
4-8 cm	0.3	6.834	2.396	Inf	5.483	<0.001
9-15 cm	0.3	11.093	4.560	Inf	5.855	<0.001
16-23 cm	0.3	0.487	0.115	Inf	-3.058	0.002
24-39 cm	0.3	18.676	6.167	Inf	8.864	<0.001
4-8 cm	0.4	6.794	3.885	Inf	3.351	0.001
9-15 cm	0.4	27.577	17.907	Inf	5.108	<0.001
16-23 cm	0.4	0.192	0.074	Inf	-4.303	<0.001
24-39 cm	0.4	38.572	20.088	Inf	7.014	<0.001
4-8 cm	0.1	6.916	1.668	Inf	8.019	<0.001
9-15 cm	0.1	1.795	0.435	Inf	2.414	0.016
16-23 cm	0.1	3.134	0.778	Inf	4.605	<0.001
24-39 cm	0.1	4.378	0.989	Inf	6.534	<0.001
4-8 cm	0.2	6.875	1.254	Inf	10.568	<0.001
9-15 cm	0.2	4.462	0.977	Inf	6.829	<0.001

Rubble size	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
16-23 cm	0.2	1.236	0.202	Inf	1.292	0.196
24-39 cm	0.2	9.042	1.708	Inf	11.659	<0.001
4-8 cm	0.3	6.834	2.396	Inf	5.483	<0.001
9-15 cm	0.3	11.093	4.560	Inf	5.855	<0.001
16-23 cm	0.3	0.487	0.115	Inf	-3.058	0.002
24-39 cm	0.3	18.676	6.167	Inf	8.864	<0.001
4-8 cm	0.4	6.794	3.885	Inf	3.351	0.001
9-15 cm	0.4	27.577	17.907	Inf	5.108	<0.001
16-23 cm	0.4	0.192	0.074	Inf	-4.303	<0.001
24-39 cm	0.4	38.572	20.088	Inf	7.014	<0.001

1 Table S4 Pairwise comparisons between rubble and sand substrate for 4 rubble size categories and 4 levels of continuous variable 'velocity' (0.01 m/s, 0.2 m/s (mean), 0.3 m/s, 0.4 m/s)
2 for model described in Table S2

Rubble size	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
4-8 cm	0.1	2.354	0.609	Inf	3.313	0.001
9-15 cm	0.1	1.130	0.286	Inf	0.482	0.630
16-23 cm	0.1	1.441	0.392	Inf	1.343	0.179
24-39 cm	0.1	2.062	0.556	Inf	2.686	0.007
4-8 cm	0.2	0.429	0.092	Inf	-3.967	<0.001
9-15 cm	0.2	0.613	0.106	Inf	-2.839	0.005
16-23 cm	0.2	1.033	0.174	Inf	0.190	0.849
24-39 cm	0.2	1.386	0.232	Inf	1.952	0.051
4-8 cm	0.3	0.078	0.038	Inf	-5.227	<0.001
9-15 cm	0.3	0.333	0.076	Inf	-4.800	<0.001
16-23 cm	0.3	0.740	0.165	Inf	-1.355	0.176

Rubble size	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
24-39 cm	0.3	0.931	0.177	Inf	-0.375	0.708
4-8 cm	0.4	0.014	0.011	Inf	-5.299	<0.001
9-15 cm	0.4	0.181	0.066	Inf	-4.701	<0.001
16-23 cm	0.4	0.530	0.196	Inf	-1.715	0.086
24-39 cm	0.4	0.626	0.196	Inf	-1.500	0.134
4-8 cm	0.1	2.354	0.609	Inf	3.313	0.001
9-15 cm	0.1	1.130	0.286	Inf	0.482	0.630
16-23 cm	0.1	1.441	0.392	Inf	1.343	0.179
24-39 cm	0.1	2.062	0.556	Inf	2.686	0.007
4-8 cm	0.2	0.429	0.092	Inf	-3.967	<0.001
9-15 cm	0.2	0.613	0.106	Inf	-2.839	0.005
16-23 cm	0.2	1.033	0.174	Inf	0.190	0.849
24-39 cm	0.2	1.386	0.232	Inf	1.952	0.051
4-8 cm	0.3	0.078	0.038	Inf	-5.227	<0.001
9-15 cm	0.3	0.333	0.076	Inf	-4.800	<0.001
16-23 cm	0.3	0.740	0.165	Inf	-1.355	0.176
24-39 cm	0.3	0.931	0.177	Inf	-0.375	0.708
4-8 cm	0.4	0.014	0.011	Inf	-5.299	<0.001
9-15 cm	0.4	0.181	0.066	Inf	-4.701	<0.001
16-23 cm	0.4	0.530	0.196	Inf	-1.715	0.086
24-39 cm	0.4	0.626	0.196	Inf	-1.500	0.134

1 **Table S5** Pairwise comparisons between four different rubble size categories for each level of branchiness and 4 levels of continuous variable ‘velocity’ (0.01 m/s, 0.2 m/s (mean), 0.3
 2 m/s, 0.4 m/s) for model described in Table S2.

Size comparison	Rubble branchiness	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
4-8 cm / 9-15 cm	Unbranched	0.1	0.7948	2.03E-01	Inf	-0.901	0.8043
4-8 cm / 16-23 cm	Unbranched	0.1	0.7549	1.73E-01	Inf	-1.23	0.6078
4-8 cm / 24-39 cm	Unbranched	0.1	0.6975	1.56E-01	Inf	-1.612	0.3715
9-15 cm / 16-23 cm	Unbranched	0.1	0.9498	2.68E-01	Inf	-0.182	0.9979
9-15 cm / 24-39 cm	Unbranched	0.1	0.8777	2.44E-01	Inf	-0.47	0.9657
16-23 cm / 24-39 cm	Unbranched	0.1	0.9241	2.36E-01	Inf	-0.309	0.9898
4-8 cm / 9-15 cm	Branched	0.1	0.2063	5.38E-02	Inf	-6.057	<.0001
4-8 cm / 16-23 cm	Branched	0.1	0.3421	9.55E-02	Inf	-3.843	0.0007
4-8 cm / 24-39 cm	Branched	0.1	0.4416	1.21E-01	Inf	-2.984	0.0151
9-15 cm / 16-23 cm	Branched	0.1	1.6584	3.72E-01	Inf	2.253	0.1093
9-15 cm / 24-39 cm	Branched	0.1	2.1406	4.70E-01	Inf	3.463	0.003
16-23 cm / 24-39 cm	Branched	0.1	1.2908	3.13E-01	Inf	1.053	0.7181
4-8 cm / 9-15 cm	Unbranched	0.2	1.8795	4.74E-01	Inf	2.502	0.0596
4-8 cm / 16-23 cm	Unbranched	0.2	6.5106	1.31E+00	Inf	9.294	<.0001
4-8 cm / 24-39 cm	Unbranched	0.2	1.5403	3.47E-01	Inf	1.916	0.2214
9-15 cm / 16-23 cm	Unbranched	0.2	3.4641	8.42E-01	Inf	5.113	<.0001
9-15 cm / 24-39 cm	Unbranched	0.2	0.8196	2.16E-01	Inf	-0.755	0.8744
16-23 cm / 24-39 cm	Unbranched	0.2	0.2366	4.98E-02	Inf	-6.849	<.0001
4-8 cm / 9-15 cm	Branched	0.2	1.2199	1.86E-01	Inf	1.301	0.5625
4-8 cm / 16-23 cm	Branched	0.2	1.1702	1.89E-01	Inf	0.973	0.7651
4-8 cm / 24-39 cm	Branched	0.2	2.026	3.25E-01	Inf	4.395	0.0001
9-15 cm / 16-23 cm	Branched	0.2	0.9593	1.28E-01	Inf	-0.311	0.9896
9-15 cm / 24-39 cm	Branched	0.2	1.6607	2.20E-01	Inf	3.821	0.0008

Size comparison	Rubble branchiness	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
16-23 cm / 24-39 cm	Branched	0.2	1.7312	2.47E-01	Inf	3.847	0.0007
4-8 cm / 9-15 cm	Unbranched	0.3	4.4445	2.29E+00	Inf	2.895	0.0198
4-8 cm / 16-23 cm	Unbranched	0.3	56.1546	2.20E+01	Inf	10.288	<.0001
4-8 cm / 24-39 cm	Unbranched	0.3	3.4014	1.58E+00	Inf	2.638	0.0415
9-15 cm / 16-23 cm	Unbranched	0.3	12.6346	5.66E+00	Inf	5.666	<.0001
9-15 cm / 24-39 cm	Unbranched	0.3	0.7653	3.92E-01	Inf	-0.522	0.9537
16-23 cm / 24-39 cm	Unbranched	0.3	0.0606	2.27E-02	Inf	-7.481	<.0001
4-8 cm / 9-15 cm	Branched	0.3	7.2143	2.06E+00	Inf	6.92	<.0001
4-8 cm / 16-23 cm	Branched	0.3	4.003	1.18E+00	Inf	4.718	<.0001
4-8 cm / 24-39 cm	Branched	0.3	9.2948	2.61E+00	Inf	7.941	<.0001
9-15 cm / 16-23 cm	Branched	0.3	0.5549	9.15E-02	Inf	-3.572	0.002
9-15 cm / 24-39 cm	Branched	0.3	1.2884	1.81E-01	Inf	1.806	0.2704
16-23 cm / 24-39 cm	Branched	0.3	2.3219	3.62E-01	Inf	5.4	<.0001
4-8 cm / 9-15 cm	Unbranched	0.4	10.5103	8.61E+00	Inf	2.872	0.0212
4-8 cm / 16-23 cm	Unbranched	0.4	484.336	3.03E+02	Inf	9.897	<.0001
4-8 cm / 24-39 cm	Unbranched	0.4	7.511	5.54E+00	Inf	2.736	0.0316
9-15 cm / 16-23 cm	Unbranched	0.4	46.0819	3.27E+01	Inf	5.396	<.0001
9-15 cm / 24-39 cm	Unbranched	0.4	0.7146	5.79E-01	Inf	-0.415	0.9759
16-23 cm / 24-39 cm	Unbranched	0.4	0.0155	9.22E-03	Inf	-7.004	<.0001
4-8 cm / 9-15 cm	Branched	0.4	42.6628	2.10E+01	Inf	7.623	<.0001
4-8 cm / 16-23 cm	Branched	0.4	13.6931	6.97E+00	Inf	5.144	<.0001
4-8 cm / 24-39 cm	Branched	0.4	42.6438	2.06E+01	Inf	7.756	<.0001
9-15 cm / 16-23 cm	Branched	0.4	0.321	8.98E-02	Inf	-4.06	0.0003
9-15 cm / 24-39 cm	Branched	0.4	0.9996	2.33E-01	Inf	-0.002	1
16-23 cm / 24-39 cm	Branched	0.4	3.1143	8.28E-01	Inf	4.272	0.0001

1 **Table S6 Anova table of model “fl.t.global” describing the effect of velocity, rubble size, branchiness and underlying substrate on the probability of transport of rubble pieces.**

Model term	LR χ^2	df	p-value ($>\chi^2$)
calculated.velocity_corrected	2188.332	1	<0.001
size	175.957	3	<0.001
substrate	2.292	1	0.130
branched	289.922	1	<0.001
calculated.velocity_corrected:size	50.249	3	<0.001
calculated.velocity_corrected:substrate	8.485	1	0.004
calculated.velocity_corrected:branched	0.285	1	0.593
size:substrate	25.755	3	<0.001
size:branched	21.922	3	<0.001
substrate:branched	0.762	1	0.383
calculated.velocity_corrected:size:branched	17.569	3	0.001
calculated.velocity_corrected:size:substrate	8.940	3	0.030

2

3 **Table S7 Pairwise comparisons between two levels of branchiness for 4 rubble size classes and 4 levels of continuous variable ‘velocity’ (0.01 m/s, 0.2 m/s (mean), 0.3 m/s, 0.4 m/s) for**
 4 **model described in Table S6.**

Branchiness comparison	Rubble size	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
Unbranched / Branched	4-8 cm	0.1	8.263	3.257	Inf	5.358	<0.001
Unbranched / Branched	9-15 cm	0.1	2.340	0.860	Inf	2.312	0.021
Unbranched / Branched	16-23 cm	0.1	3.677	1.390	Inf	3.445	0.001
Unbranched / Branched	24-39 cm	0.1	6.284	2.737	Inf	4.219	<0.001
Unbranched / Branched	4-8 cm	0.196	4.437	0.900	Inf	7.345	<0.001
Unbranched / Branched	9-15 cm	0.196	4.335	0.906	Inf	7.015	<0.001

Branchiness comparison	Rubble size	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
Unbranched / Branched	16-23 cm	0.196	2.860	0.619	Inf	4.853	<0.001
Unbranched / Branched	24-39 cm	0.196	5.898	1.505	Inf	6.956	<0.001
Unbranched / Branched	4-8 cm	0.3	2.268	0.474	Inf	3.918	<0.001
Unbranched / Branched	9-15 cm	0.3	8.433	1.916	Inf	9.383	<0.001
Unbranched / Branched	16-23 cm	0.3	2.181	0.366	Inf	4.654	<0.001
Unbranched / Branched	24-39 cm	0.3	5.508	0.967	Inf	9.722	<0.001
Unbranched / Branched	4-8 cm	0.4	1.188	0.489	Inf	0.419	0.675
Unbranched / Branched	9-15 cm	0.4	16.010	6.482	Inf	6.850	<0.001
Unbranched / Branched	16-23 cm	0.4	1.680	0.513	Inf	1.700	0.089
Unbranched / Branched	24-39 cm	0.4	5.156	1.599	Inf	5.289	<0.001

1

2 Table S8 Pairwise comparisons between four categories of rubble ‘length’ for each level of morphology and 4 levels of continuous variable ‘velocity’ (0.1 m/s, 0.2 m/s (mean), 0.3 m/s,
3 and 0.4 m/s) for model described in Table S6.

Size comparison	Rubble branchiness	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
4-8 cm / 9-15 cm	Unbranched	0.1	0.734	0.277	Inf	-0.819	0.846
4-8 cm / 16-23 cm	Unbranched	0.1	0.713	0.255	Inf	-0.946	0.780
4-8 cm / 24-39 cm	Unbranched	0.1	0.871	0.313	Inf	-0.385	0.981
9-15 cm / 16-23 cm	Unbranched	0.1	0.972	0.417	Inf	-0.066	0.999
9-15 cm / 24-39 cm	Unbranched	0.1	1.186	0.511	Inf	0.396	0.979
16-23 cm / 24-39 cm	Unbranched	0.1	1.221	0.504	Inf	0.482	0.963
4-8 cm / 9-15 cm	Branched	0.1	0.208	0.090	Inf	-3.622	0.002
4-8 cm / 16-23 cm	Branched	0.1	0.317	0.149	Inf	-2.453	0.068
4-8 cm / 24-39 cm	Branched	0.1	0.662	0.336	Inf	-0.812	0.849

Size comparison	Rubble branchiness	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
9-15 cm / 16-23 cm	Branched	0.1	1.528	0.588	Inf	1.101	0.689
9-15 cm / 24-39 cm	Branched	0.1	3.186	1.380	Inf	2.675	0.038
16-23 cm / 24-39 cm	Branched	0.1	2.086	0.975	Inf	1.573	0.394
4-8 cm / 9-15 cm	Unbranched	0.196	0.995	0.205	Inf	-0.025	0.999
4-8 cm / 16-23 cm	Unbranched	0.196	1.684	0.330	Inf	2.659	0.039
4-8 cm / 24-39 cm	Unbranched	0.196	1.983	0.394	Inf	3.442	0.003
9-15 cm / 16-23 cm	Unbranched	0.196	1.693	0.406	Inf	2.197	0.124
9-15 cm / 24-39 cm	Unbranched	0.196	1.993	0.485	Inf	2.835	0.024
16-23 cm / 24-39 cm	Unbranched	0.196	1.177	0.276	Inf	0.694	0.900
4-8 cm / 9-15 cm	Branched	0.196	0.972	0.221	Inf	-0.125	0.999
4-8 cm / 16-23 cm	Branched	0.196	1.086	0.267	Inf	0.336	0.987
4-8 cm / 24-39 cm	Branched	0.196	2.635	0.735	Inf	3.474	0.003
9-15 cm / 16-23 cm	Branched	0.196	1.117	0.245	Inf	0.507	0.958
9-15 cm / 24-39 cm	Branched	0.196	2.711	0.695	Inf	3.893	0.001
16-23 cm / 24-39 cm	Branched	0.196	2.427	0.662	Inf	3.249	0.006
4-8 cm / 9-15 cm	Unbranched	0.3	1.381	0.368	Inf	1.211	0.620
4-8 cm / 16-23 cm	Unbranched	0.3	4.257	0.916	Inf	6.734	<0.001
4-8 cm / 24-39 cm	Unbranched	0.3	4.818	1.066	Inf	7.109	<0.001
9-15 cm / 16-23 cm	Unbranched	0.3	3.082	0.776	Inf	4.470	<0.001
9-15 cm / 24-39 cm	Unbranched	0.3	3.488	0.898	Inf	4.852	<0.001
16-23 cm / 24-39 cm	Unbranched	0.3	1.132	0.226	Inf	0.618	0.926
4-8 cm / 9-15 cm	Branched	0.3	5.136	0.899	Inf	9.348	<0.001
4-8 cm / 16-23 cm	Branched	0.3	4.094	0.734	Inf	7.866	<0.001
4-8 cm / 24-39 cm	Branched	0.3	11.699	2.159	Inf	13.329	<0.001
9-15 cm / 16-23 cm	Branched	0.3	0.797	0.103	Inf	-1.753	0.297

Size comparison	Rubble branchiness	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
9-15 cm / 24-39 cm	Branched	0.3	2.278	0.311	Inf	6.022	<0.001
16-23 cm / 24-39 cm	Branched	0.3	2.857	0.406	Inf	7.389	<0.001
4-8 cm / 9-15 cm	Unbranched	0.4	1.895	0.916	Inf	1.322	0.549
4-8 cm / 16-23 cm	Unbranched	0.4	10.400	4.104	Inf	5.935	<0.001
4-8 cm / 24-39 cm	Unbranched	0.4	11.333	4.562	Inf	6.031	<0.001
9-15 cm / 16-23 cm	Unbranched	0.4	5.489	2.509	Inf	3.724	0.001
9-15 cm / 24-39 cm	Unbranched	0.4	5.981	2.768	Inf	3.864	0.001
16-23 cm / 24-39 cm	Unbranched	0.4	1.090	0.397	Inf	0.235	0.995
4-8 cm / 9-15 cm	Branched	0.4	25.529	9.372	Inf	8.825	<0.001
4-8 cm / 16-23 cm	Branched	0.4	14.704	5.606	Inf	7.051	<0.001
4-8 cm / 24-39 cm	Branched	0.4	49.175	18.392	Inf	10.415	<0.001
9-15 cm / 16-23 cm	Branched	0.4	0.576	0.144	Inf	-2.214	0.120
9-15 cm / 24-39 cm	Branched	0.4	1.926	0.458	Inf	2.755	0.030
16-23 cm / 24-39 cm	Branched	0.4	3.344	0.867	Inf	4.659	<0.001

1

2 **Table S9** Pairwise comparisons between sand and rubble substrate for each level of ‘size’ and 4 levels of continuous variable ‘velocity’ (0.1 m/s, 0.2 m/s (mean), 0.3 m/s and 0.4 m/s) for
3 **model described in Table S6.**

Substrate comparison	Rubble size	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
Rubble / Sand	4-8 cm	0.1	2.011	0.764	Inf	1.840	0.066
Rubble / Sand	9-15 cm	0.1	1.092	0.447	Inf	0.215	0.830
Rubble / Sand	16-23 cm	0.1	1.728	0.787	Inf	1.200	0.230
Rubble / Sand	24-39 cm	0.1	1.305	0.630	Inf	0.552	0.581
Rubble / Sand	4-8 cm	0.196	0.879	0.168	Inf	-0.678	0.498
Rubble / Sand	9-15 cm	0.196	0.909	0.216	Inf	-0.402	0.688

Substrate comparison	Rubble size	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
Rubble / Sand	16-23 cm	0.196	1.100	0.281	Inf	0.372	0.710
Rubble / Sand	24-39 cm	0.196	1.452	0.410	Inf	1.321	0.187
Rubble / Sand	4-8 cm	0.3	0.359	0.087	Inf	-4.224	<0.001
Rubble / Sand	9-15 cm	0.3	0.746	0.130	Inf	-1.688	0.091
Rubble / Sand	16-23 cm	0.3	0.675	0.110	Inf	-2.419	0.016
Rubble / Sand	24-39 cm	0.3	1.629	0.270	Inf	2.949	0.003
Rubble / Sand	4-8 cm	0.4	0.152	0.071	Inf	-4.051	<0.001
Rubble / Sand	9-15 cm	0.4	0.616	0.192	Inf	-1.553	0.121
Rubble / Sand	16-23 cm	0.4	0.422	0.135	Inf	-2.705	0.007
Rubble / Sand	24-39 cm	0.4	1.820	0.539	Inf	2.021	0.043
Rubble / Sand	4-8 cm	0.1	2.011	0.764	Inf	1.840	0.066
Rubble / Sand	9-15 cm	0.1	1.092	0.447	Inf	0.215	0.830
Rubble / Sand	16-23 cm	0.1	1.728	0.787	Inf	1.200	0.230
Rubble / Sand	24-39 cm	0.1	1.305	0.630	Inf	0.552	0.581
Rubble / Sand	4-8 cm	0.196	0.879	0.168	Inf	-0.678	0.498
Rubble / Sand	9-15 cm	0.196	0.909	0.216	Inf	-0.402	0.688
Rubble / Sand	16-23 cm	0.196	1.100	0.281	Inf	0.372	0.710
Rubble / Sand	24-39 cm	0.196	1.452	0.410	Inf	1.321	0.187
Rubble / Sand	4-8 cm	0.3	0.359	0.087	Inf	-4.224	<0.001
Rubble / Sand	9-15 cm	0.3	0.746	0.130	Inf	-1.688	0.091
Rubble / Sand	16-23 cm	0.3	0.675	0.110	Inf	-2.419	0.016
Rubble / Sand	24-39 cm	0.3	1.629	0.270	Inf	2.949	0.003
Rubble / Sand	4-8 cm	0.4	0.152	0.071	Inf	-4.051	<0.001
Rubble / Sand	9-15 cm	0.4	0.616	0.192	Inf	-1.553	0.121
Rubble / Sand	16-23 cm	0.4	0.422	0.135	Inf	-2.705	0.007

Substrate comparison	Rubble size	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
Rubble / Sand	24-39 cm	0.4	1.820	0.539	Inf	2.021	0.043

1

2 **Table S10 Anova table of model “fl.f.global2” describing the effect of velocity, rubble size, branchiness and underlying substrate on the probability of flipping of rubble pieces.**

Model term	LR χ^2	Df	Pr(> χ^2)
calculated.velocity_corrected	1550.877	1	<0.001
size	323.197	3	<0.001
substrate	7.253	1	0.007
branched	533.511	1	<0.001
calculated.velocity_corrected:size	59.299	3	<0.001
calculated.velocity_corrected:substrate	1.919	1	0.166
calculated.velocity_corrected:branched	1.003	1	0.317
size:substrate	21.392	3	<0.001
size:branched	34.631	3	<0.001
substrate:branched	19.138	1	<0.001
calculated.velocity_corrected:size:branched	18.363	3	<0.001
calculated.velocity_corrected:size:substrate	10.738	3	0.013

3

4

1 **Table S11 Pairwise comparisons branched and unbranched rubble for each level of ‘size’ and 3 levels of continuous variable ‘velocity’ (0.1 m/s, 0.2 m/s (mean) and 0.4 m/s) for model**
 2 **described in Table S10.**

Branchiness comparison	Rubble size	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
Unbranched / Branched	4-8 cm	0.1	10.977	4.530	Inf	5.805	<0.001
Unbranched / Branched	9-15 cm	0.1	3.241	1.273	Inf	2.995	0.003
Unbranched / Branched	16-23 cm	0.1	5.403	2.237	Inf	4.074	<0.001
Unbranched / Branched	24-39 cm	0.1	42.522	32.482	Inf	4.909	<0.001
Unbranched / Branched	4-8 cm	0.196	7.006	1.541	Inf	8.852	<0.001
Unbranched / Branched	9-15 cm	0.196	7.459	1.676	Inf	8.943	<0.001
Unbranched / Branched	16-23 cm	0.196	5.656	1.373	Inf	7.136	<0.001
Unbranched / Branched	24-39 cm	0.196	33.922	16.101	Inf	7.425	<0.001
Unbranched / Branched	4-8 cm	0.4	2.706	1.073	Inf	2.512	0.012
Unbranched / Branched	9-15 cm	0.4	43.609	17.966	Inf	9.164	<0.001
Unbranched / Branched	16-23 cm	0.4	6.233	1.965	Inf	5.805	<0.001
Unbranched / Branched	24-39 cm	0.4	21.016	8.938	Inf	7.161	<0.001
Unbranched / Branched	4-8 cm	0.1	10.977	4.530	Inf	5.805	<0.001
Unbranched / Branched	9-15 cm	0.1	3.241	1.273	Inf	2.995	0.003
Unbranched / Branched	16-23 cm	0.1	5.403	2.237	Inf	4.074	<0.001
Unbranched / Branched	24-39 cm	0.1	42.522	32.482	Inf	4.909	<0.001
Unbranched / Branched	4-8 cm	0.196	7.006	1.541	Inf	8.852	<0.001
Unbranched / Branched	9-15 cm	0.196	7.459	1.676	Inf	8.943	<0.001
Unbranched / Branched	16-23 cm	0.196	5.656	1.373	Inf	7.136	<0.001
Unbranched / Branched	24-39 cm	0.196	33.922	16.101	Inf	7.425	<0.001
Unbranched / Branched	4-8 cm	0.4	2.706	1.073	Inf	2.512	0.012
Unbranched / Branched	9-15 cm	0.4	43.609	17.966	Inf	9.164	<0.001
Unbranched / Branched	16-23 cm	0.4	6.233	1.965	Inf	5.805	<0.001

Branchiness comparison	Rubble size	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
Unbranched / Branched	24-39 cm	0.4	21.016	8.938	Inf	7.161	<0.001

1

2 **Table S12 Pairwise comparisons between rubble size categories for each level of ‘morphology’ and 3 levels of continuous variable ‘velocity’ (0.1 m/s, 0.2 m/s (mean) and 0.4 m/s) for**
3 **model described in Table S10.**

Size comparison	Rubble branchiness	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
4-8 cm / 9-15 cm	Unbranched	0.1	0.741	0.279	Inf	-0.796	0.857
4-8 cm / 16-23 cm	Unbranched	0.1	0.662	0.228	Inf	-1.198	0.628
4-8 cm / 24-39 cm	Unbranched	0.1	0.965	0.366	Inf	-0.094	0.999
9-15 cm / 16-23 cm	Unbranched	0.1	0.893	0.377	Inf	-0.268	0.993
9-15 cm / 24-39 cm	Unbranched	0.1	1.301	0.588	Inf	0.583	0.937
16-23 cm / 24-39 cm	Unbranched	0.1	1.458	0.622	Inf	0.884	0.813
4-8 cm / 9-15 cm	Branched	0.1	0.219	0.103	Inf	-3.213	0.007
4-8 cm / 16-23 cm	Branched	0.1	0.326	0.168	Inf	-2.181	0.128
4-8 cm / 24-39 cm	Branched	0.1	3.738	3.130	Inf	1.575	0.393
9-15 cm / 16-23 cm	Branched	0.1	1.488	0.670	Inf	0.883	0.814
9-15 cm / 24-39 cm	Branched	0.1	17.072	13.667	Inf	3.544	0.002
16-23 cm / 24-39 cm	Branched	0.1	11.473	9.473	Inf	2.955	0.017
4-8 cm / 9-15 cm	Unbranched	0.196	1.021	0.210	Inf	0.102	0.999
4-8 cm / 16-23 cm	Unbranched	0.196	1.712	0.329	Inf	2.799	0.026
4-8 cm / 24-39 cm	Unbranched	0.196	2.772	0.599	Inf	4.717	<0.001
9-15 cm / 16-23 cm	Unbranched	0.196	1.676	0.400	Inf	2.166	0.133
9-15 cm / 24-39 cm	Unbranched	0.196	2.714	0.703	Inf	3.854	0.001
16-23 cm / 24-39 cm	Unbranched	0.196	1.619	0.401	Inf	1.949	0.208
4-8 cm / 9-15 cm	Branched	0.196	1.087	0.280	Inf	0.325	0.988

Size comparison	Rubble branchiness	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
4-8 cm / 16-23 cm	Branched	0.196	1.382	0.389	Inf	1.148	0.659
4-8 cm / 24-39 cm	Branched	0.196	13.421	6.755	Inf	5.159	<0.001
9-15 cm / 16-23 cm	Branched	0.196	1.271	0.334	Inf	0.911	0.799
9-15 cm / 24-39 cm	Branched	0.196	12.343	6.099	Inf	5.086	<0.001
16-23 cm / 24-39 cm	Branched	0.196	9.712	4.924	Inf	4.484	<0.001
4-8 cm / 9-15 cm	Unbranched	0.4	2.013	0.955	Inf	1.474	0.453
4-8 cm / 16-23 cm	Unbranched	0.4	12.810	4.888	Inf	6.683	<0.001
4-8 cm / 24-39 cm	Unbranched	0.4	25.924	10.097	Inf	8.358	<0.001
9-15 cm / 16-23 cm	Unbranched	0.4	6.365	2.850	Inf	4.133	<0.001
9-15 cm / 24-39 cm	Unbranched	0.4	12.881	5.826	Inf	5.651	<0.001
16-23 cm / 24-39 cm	Unbranched	0.4	2.024	0.713	Inf	2.002	0.187
4-8 cm / 9-15 cm	Branched	0.4	32.430	11.517	Inf	9.796	<0.001
4-8 cm / 16-23 cm	Branched	0.4	29.505	10.896	Inf	9.165	<0.001
4-8 cm / 24-39 cm	Branched	0.4	201.319	91.599	Inf	11.659	<0.001
9-15 cm / 16-23 cm	Branched	0.4	0.910	0.265	Inf	-0.324	0.988
9-15 cm / 24-39 cm	Branched	0.4	6.208	2.438	Inf	4.650	<0.001
16-23 cm / 24-39 cm	Branched	0.4	6.823	2.766	Inf	4.737	<0.001

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2

1 **Table S13 Pairwise comparisons between rubble and sand substrate for each level of ‘morphology’ and 3 levels of continuous variable ‘velocity’ (0.1 m/s, 0.2 m/s (mean) and 0.4 m/s)**
 2 **for model described in Table S10.**

Substrate comparison	Rubble size	Near-bed wave orbital velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
Rubble / Sand	Unbranched	0.1	1.091	0.267	Inf	0.354	0.723
Rubble / Sand	Branched	0.1	2.710	0.840	Inf	3.216	0.001
Rubble / Sand	Unbranched	0.196	0.949	0.148	Inf	-0.334	0.738
Rubble / Sand	Branched	0.196	2.358	0.481	Inf	4.208	<0.001
Rubble / Sand	Unbranched	0.4	0.708	0.176	Inf	-1.388	0.165
Rubble / Sand	Branched	0.4	1.758	0.352	Inf	2.815	0.005
Rubble / Sand	Unbranched	0.1	1.091	0.267	Inf	0.354	0.723
Rubble / Sand	Branched	0.1	2.710	0.840	Inf	3.216	0.001
Rubble / Sand	Unbranched	0.196	0.949	0.148	Inf	-0.334	0.738
Rubble / Sand	Branched	0.196	2.358	0.481	Inf	4.208	<0.001
Rubble / Sand	Unbranched	0.4	0.708	0.176	Inf	-1.388	0.165
Rubble / Sand	Branched	0.4	1.758	0.352	Inf	2.815	0.005

3
 4 **Table S14 The 10%, 50% and 90% thresholds for transport, averaged across sizes 4-23 cm and both morphologies and substrates, for model “fl.t.threshold”.**

Probability	Velocity (m/s)	SE	lower	upper
0.1	0.172	0.004	0.165	0.179
0.5	0.303	0.003	0.298	0.309
0.9	0.435	0.006	0.423	0.446

5
 6

1 **Table S15 The 10%, 50% and 90% thresholds for flipping, averaged across sizes 4-23 cm and both morphologies and substrates, for model “fl.f.threshNOXL”.**

Probability	Velocity (m/s)	SE	lower	upper
0.1	0.181	0.004	0.173	0.189
0.5	0.336	0.004	0.329	0.344
0.9	0.491	0.009	0.474	0.508

2

3 **Table S16 Anova table of model “lockmove2” and Anova table of model “lockflip”..**

	LR χ^2	Df	Pr(> χ^2)
Transport			
calculated.velocity_corrected	1.036	1	0.309
size	2.571	1	0.109
calculated.velocity_corrected:size	2.146	1	0.143
Flipping			
calculated.velocity_corrected	1.626	1	0.202
size	2.152	1	0.142
calculated.velocity_corrected:size	9.3E-09	1	0.999

4

5

1 **Table S17 Anova table of model “gamma1”.**

Model term	χ^2	Df	Pr(> χ^2)
aspectDepth	533.069	4	<0.001
season	18.961	1	<0.001
aspectDepth:season	54.206	4	<0.001

2

3 **Table S18 Pairwise comparisons between two monsoon seasons (W and NE monsoon) for 5 levels of ‘habitat’ (i.e, Lagoon shallow, Sheltered Shallow, Sheltered Deep, Exposed Shallow,**
 4 **Exposed Deep) for model described in Table S17.**

Monsoon comparison	Habitat	Odds Ratio	SE	df	z-ratio	p-value
NE Monsoon / W Monsoon	Lag_Shal	0.604	0.212	4019	-1.433	0.152
NE Monsoon / W Monsoon	Shelt_Shal	0.434	0.110	4019	-3.297	0.001
NE Monsoon / W Monsoon	Shelt_Deep	0.480	0.121	4019	-2.903	0.004
NE Monsoon / W Monsoon	Exp_Shal	0.663	0.191	4019	-1.424	0.155
NE Monsoon / W Monsoon	Exp_Deep	0.322	0.093	4019	-3.918	<0.001
NE Monsoon / W Monsoon	Lag_Shal	0.604	0.212	4019	-1.433	0.152
NE Monsoon / W Monsoon	Shelt_Shal	0.434	0.110	4019	-3.297	0.001
NE Monsoon / W Monsoon	Shelt_Deep	0.480	0.121	4019	-2.903	0.004
NE Monsoon / W Monsoon	Exp_Shal	0.663	0.191	4019	-1.424	0.155
NE Monsoon / W Monsoon	Exp_Deep	0.322	0.093	4019	-3.918	<0.001

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6

1 **Table S19 Pairwise comparisons for 5 levels of ‘habitat’ (i.e, Lagoon shallow, Sheltered Shallow, Sheltered Deep, Exposed Shallow, Exposed Deep) in each of two monsoon seasons (W**
 2 **and NE monsoon) for model described in Table S17.**

Habitat comparison	Monsoon	Odds Ratio	SE	df	z-ratio	p-value
Lag_Shal / Shelt_Shal	NE Monsoon	1.343	0.410	4019	0.966	0.871
Lag_Shal / Shelt_Deep	NE Monsoon	2.462	0.751	4019	2.953	0.026
Lag_Shal / Exp_Shal	NE Monsoon	1.102	0.354	4019	0.302	0.998
Lag_Shal / Exp_Deep	NE Monsoon	4.046	1.301	4019	4.345	<0.001
Shelt_Shal / Shelt_Deep	NE Monsoon	1.834	0.113	4019	9.866	<0.001
Shelt_Shal / Exp_Shal	NE Monsoon	0.821	0.222	4019	-0.730	0.950
Shelt_Shal / Exp_Deep	NE Monsoon	3.013	0.815	4019	4.079	<0.001
Shelt_Deep / Exp_Shal	NE Monsoon	0.448	0.121	4019	-2.973	0.025
Shelt_Deep / Exp_Deep	NE Monsoon	1.643	0.444	4019	1.837	0.352
Exp_Shal / Exp_Deep	NE Monsoon	3.671	0.257	4019	18.543	<0.001
Lag_Shal / Shelt_Shal	W Monsoon	0.965	0.296	4019	-0.117	0.999
Lag_Shal / Shelt_Deep	W Monsoon	1.954	0.600	4019	2.182	0.187
Lag_Shal / Exp_Shal	W Monsoon	1.208	0.389	4019	0.588	0.977
Lag_Shal / Exp_Deep	W Monsoon	2.158	0.694	4019	2.391	0.118
Shelt_Shal / Shelt_Deep	W Monsoon	2.026	0.171	4019	8.342	<0.001
Shelt_Shal / Exp_Shal	W Monsoon	1.253	0.342	4019	0.825	0.923
Shelt_Shal / Exp_Deep	W Monsoon	2.237	0.610	4019	2.951	0.026
Shelt_Deep / Exp_Shal	W Monsoon	0.618	0.169	4019	-1.763	0.396
Shelt_Deep / Exp_Deep	W Monsoon	1.104	0.301	4019	0.363	0.996
Exp_Shal / Exp_Deep	W Monsoon	1.786	0.125	4019	8.270	<0.001

3

4

1 **Table S20 Anova table for model “wmod2”.**

Model term	χ^2	Df	Pr(>χ^2)
pt_peak_u	19.562	1	<0.001
day2	116.096	2	<0.001

2 **Table S21 Model predictions for probability of transport on each day in the western monsoon, and pairwise comparisons between each level of day, at the average velocity (0.2 m/s)**
 3 **for model described in Table S20.**

Day	Probability of transport	SE	df	Lower confidence interval	Upper confidence interval
One	0.368	0.036	2168	0.278	0.468
Two	0.213	0.027	2168	0.150	0.294
Three	0.110	0.018	2168	0.071	0.167
Day comparison	Odds Ratio	SE	df	z-ratio	p-value
One - Two	2.15	0.272	2168	6.064	<0.001
One - Three	4.69	0.683	2168	10.62	<0.001
Two - Three	2.18	0.323	2168	5.273	<0.001

4 **Table S22 Anova table for model “nemod2”.**

	χ^2	Df	Pr(>χ^2)
pt_peak_u	3.073	1	0.080
day2	7.602	2	0.022

5

1 **Table S23 Pairwise comparisons between each level of day, at the average velocity (0.2 m/s) for model “nemod2”.**

Day	Probability of transport	SE	df	Lower confidence interval	Upper confidence interval
One	0.218	0.021	1769	0.168	0.277
Two	0.201	0.020	1769	0.154	0.259
Three	0.157	0.018	1769	0.116	0.209
Day comparison	Odds Ratio	SE	df	z-ratio	p-value
One - Two	1.10	0.161	1769	0.678	0.776
One - Three	1.50	0.227	1769	2.672	0.021
Two - Three	1.36	0.206	1769	2.008	0.111

2

3 **Table S24 Anova table for model “wmod.fl”.**

Model term	X2	Df	Pr(>X2)
pt_peak_u	15.503	1	<0.001
day2	50.415	2	<0.001
pt_peak_u:day2	5.818	2	0.054

4 **Table S25 Pairwise comparisons between each level of day, at three levels of velocity for model “wmod.fl”.**

Day comparison	Velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
One - Two	0.1	1.35	0.305	2166	1.313	0.388
One - Three	0.1	3.13	0.884	2166	4.035	0.000
Two - Three	0.1	2.32	0.691	2166	2.834	0.013
One - Two	0.2	2.08	0.346	2166	4.378	<0.001
One - Three	0.2	3.6	0.678	2166	6.804	<0.001

Day comparison	Velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
Two - Three	0.2	1.73	0.349	2166	2.738	0.017
One - Two	0.3	3.2	0.843	2166	4.419	<0.001
One - Three	0.3	4.14	1.138	2166	5.176	<0.001
Two - Three	0.3	1.29	0.434	2166	0.769	0.722

1 Table S26 Anova table for model “nemod.fl2”.

Model term	X2	Df	Pr(>X2)
pt_peak_u	3.547	1	0.060
day2	28.667	2	<0.001

2 Table S27 Model predictions for probability of flipping on each day in the north-eastern monsoon, and pairwise comparisons between each level of day, at the average velocity for
3 model described in Table S26.

Day	Probability of transport	SE	df	Lower confidence interval	Upper confidence interval
One	0.132	0.018	1769	0.091	0.189
Two	0.063	0.012	1769	0.038	0.101
Three	0.060	0.011	1769	0.036	0.098

Day comparison	Odds Ratio	SE	df	z-ratio	p-value
One - Two	2.29	0.431	1769	4.384	<0.001
One - Three	2.38	0.453	1769	4.55	<0.001
Two - Three	1.04	0.217	1769	0.19	0.9803

4

1 **Table S28 Anova table for model “wmod.dist2”.**

Model term	X2	Df	Pr(>X2)
pt_peak_u	8.412	1	0.004
day2	12.612	2	0.002

2 **Table S29 Model predictions for distance of transport, and pairwise comparisons between each level of day, at the average velocity in the western monsoon for model described in**

3 **Table S28.**

Day	Distance transported	SE	df	Lower confidence interval	Upper confidence interval
One	5.283	0.392	14	4.208	6.632
Two	3.937	0.340	14	3.020	5.132
Three	4.668	0.483	14	3.399	6.412
Day comparison	Odds Ratio	SE	df	z-ratio	p-value
One - Two	1.342	0.111	526	3.538	0.0013
One - Three	1.132	0.114	526	1.232	0.4347
Two - Three	0.843	0.089	526	1.616	0.2396

4 **Table S30 Anova table for model “nemod.dist2”.**

Model term	X2	Df	Pr(>X2)
pt_peak_u	6.008	1	0.014
day2	17.284	2	<0.001

5

1 **Table S31 Model predictions and pairwise comparisons between each level of day for the average velocity for model described in Table S28.**

Day	Distance transported	SE	df	Lower confidence interval	Upper confidence interval
One	4.793	0.317	14	3.912	5.871
Two	4.026	0.271	14	3.275	4.948
Three	3.427	0.247	14	2.747	4.276
Day comparison	Odds Ratio	SE	df	z-ratio	p-value
One - Two	1.191	0.092	397	2.255	0.064
One - Three	1.398	0.114	397	4.117	0.0001
Two - Three	1.175	0.097	397	1.947	0.127

2 **Table S32 Anova table of model “fi.m.senglob6”.**

Model term	X2	Df	Pr(>X2)
pt_peak_u	36.135	1	<0.001
size_cat_adjusted_to_flume_exp	36.018	2	<0.001
branched	17.741	1	<0.001
starting_substrate_new	0.438	2	0.803
pt_peak_u:size_cat_adjusted_to_flume_exp	8.080	2	0.018

3

1 Table S33 Pairwise comparisons between three different rubble size categories and 8 levels of continuous variable ‘velocity’ (0.03 m/s, 0.1 m/s, 0.17 m/s (mean), 0.19 m/s, 0.25 m/s, 0.3
 2 m/s, 0.4 m/s, 0.55 for model described in Table S32.

Size comparison	Velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
4-8cm / 9-15cm	0.025	2.370	0.509	1307	4.017	<0.001
4-8cm / 16-23cm	0.025	6.038	2.024	1307	5.363	<0.001
9-15cm / 16-23cm	0.025	2.548	0.845	1307	2.819	0.014
4-8cm / 9-15cm	0.1	2.071	0.326	1307	4.620	<0.001
4-8cm / 16-23cm	0.1	4.345	1.086	1307	5.879	<0.001
9-15cm / 16-23cm	0.1	2.098	0.520	1307	2.992	0.008
4-8cm / 9-15cm	0.172	1.819	0.243	1307	4.482	<0.001
4-8cm / 16-23cm	0.172	3.168	0.639	1307	5.719	<0.001
9-15cm / 16-23cm	0.172	1.741	0.347	1307	2.786	0.015
4-8cm / 9-15cm	0.19	1.760	0.237	1307	4.198	<0.001
4-8cm / 16-23cm	0.19	2.923	0.579	1307	5.417	<0.001
9-15cm / 16-23cm	0.19	1.660	0.324	1307	2.600	0.026
4-8cm / 9-15cm	0.25	1.580	0.251	1307	2.879	0.011
4-8cm / 16-23cm	0.25	2.244	0.482	1307	3.761	0.001
9-15cm / 16-23cm	0.25	1.421	0.298	1307	1.674	0.216
4-8cm / 9-15cm	0.3	1.443	0.282	1307	1.878	0.145
4-8cm / 16-23cm	0.3	1.801	0.462	1307	2.294	0.057
9-15cm / 16-23cm	0.3	1.248	0.311	1307	0.887	0.648
4-8cm / 9-15cm	0.4	1.205	0.348	1307	0.646	0.794
4-8cm / 16-23cm	0.4	1.159	0.437	1307	0.392	0.919
9-15cm / 16-23cm	0.4	0.962	0.352	1307	-0.106	0.994
4-8cm / 9-15cm	0.552	0.916	0.410	1307	-0.196	0.979

Size comparison	Velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
4-8cm / 16-23cm	0.552	0.594	0.353	1307	-0.876	0.656
9-15cm / 16-23cm	0.552	0.648	0.375	1307	-0.749	0.734

1 **Table S34 Model predictions and pairwise comparisons between branched and unbranched rubble (averaged across velocity because there was no interaction between velocity and**
2 **branchiness) for model described in Table S32.**

Branchiness	Distance transported	SE	df	Lower confidence interval	Upper confidence interval
Unbranched	0.374	0.037	1307	0.304	0.450
Branched	0.260	0.029	1307	0.207	0.320

Branchiness comparison	Odds Ratio	SE	df	z-ratio	p-value
Unbranched / Branched	1.704	0.216	1307	4.212	<0.001
Unbranched / Branched	1.704	0.216	1307	4.212	<0.001

3

4 **Table S35 Anova table for model “compnewSLOONLY”.**

Model term	X2	Df	Pr(>X2)
pt_peak_u	46.6492897	1	<0.001
avg_slope_angle_transect.1	11.1738946	1	<0.001
pt_peak_u:avg_slope_angle_transect.1	6.8624	1	<0.001

5

6

1 Table S36 Pairwise comparisons between three different slope categories and 4 levels of continuous variable ‘velocity’ (0.1 m/s, 0.2 m/s (mean), 0.3 m/s, 0.4 m/s, for model described in
 2 Table S35.

Slope angle	Velocity	Probability of transport	SE	df	Lower confidence interval	Upper confidence interval
3	0.1	0.160	0.026	1312	0.116	0.218
3	0.2	0.282	0.028	1312	0.230	0.339
3	0.3	0.446	0.046	1312	0.358	0.538
3	0.4	0.624	0.069	1312	0.482	0.747
13	0.1	0.238	0.019	1312	0.202	0.279
13	0.2	0.330	0.020	1312	0.292	0.371
13	0.3	0.438	0.027	1312	0.385	0.492
13	0.4	0.551	0.039	1312	0.475	0.625
22	0.1	0.328	0.025	1312	0.282	0.378
22	0.2	0.378	0.030	1312	0.320	0.439
22	0.3	0.430	0.049	1312	0.337	0.528
22	0.4	0.484	0.072	1312	0.348	0.622
Slope comparison	Velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
3 / 13	0.1	0.609	0.071	1312	-4.236	<0.001
3 / 22	0.1	0.390	0.087	1312	-4.236	<0.001
13 / 22	0.1	0.640	0.067	1312	-4.236	<0.001
3 / 13	0.2	0.794	0.082	1312	-2.225	0.067
3 / 22	0.2	0.646	0.127	1312	-2.225	0.067
13 / 22	0.2	0.813	0.076	1312	-2.225	0.067
3 / 13	0.3	1.035	0.174	1312	0.207	0.977
3 / 22	0.3	1.068	0.341	1312	0.207	0.977
13 / 22	0.3	1.032	0.156	1312	0.207	0.977

3 / 13	0.4	1.350	0.3473	1312	1.166	0.474
3 / 22	0.4	1.768	0.8645	1312	1.166	0.474
13 / 22	0.4	1.310	0.3034	1312	1.166	0.474

1

2 **Table S37 Anova table of model “fi.f.senglob5”.**

Model term	X2	Df	Pr(>X2)
pt_peak_u	8.084	1	0.004
size_cat_adjusted_to_flume_exp	40.801	2	<0.001
branched	28.139	1	<0.001
starting_substrate_new	4.928	2	0.085
pt_peak_u:size_cat_adjusted_to_flume_exp	5.786	2	0.055
size_cat_adjusted_to_flume_exp:branched	8.136	2	0.017

3

4

1 **Table S38 Pairwise comparisons between branched and unbranched rubble for each level of ‘size’ (4-8 cm, 9-15 cm, 16-23 cm) for model “fi.f.senglob5”.**

Branchiness contrast	Velocity (m/s)	Odds Ratio	SE	df	z-ratio	p-value
Unbranched / Branched	4-8cm	1.791	0.381	1305	2.739	0.006
Unbranched / Branched	9-15cm	3.805	0.949	1305	5.356	<0.001
Unbranched / Branched	16-23cm	1.164	0.481	1305	0.368	0.713
Unbranched / Branched	4-8cm	1.791	0.381	1305	2.739	0.006
Unbranched / Branched	9-15cm	3.805	0.949	1305	5.356	<0.001
Unbranched / Branched	16-23cm	1.164	0.481	1305	0.368	0.713

2 **Table S39 Pairwise comparisons between three different rubble size categories for each level of ‘branched’ (branched and unbranched) for model “fi.f.senglob5”.**

Size comparison	Branchiness	Odds Ratio	SE	df	z-ratio	p-value
4-8cm / 9-15cm	Unbranched	1.859	0.416	1305	2.767	0.016
4-8cm / 16-23cm	Unbranched	4.152	1.578	1305	3.744	0.001
9-15cm / 16-23cm	Unbranched	2.234	0.842	1305	2.133	0.084
4-8cm / 9-15cm	Branched	3.949	0.948	1305	5.720	<0.001
4-8cm / 16-23cm	Branched	2.700	0.782	1305	3.427	0.002
9-15cm / 16-23cm	Branched	0.684	0.220	1305	-1.184	0.463

3 **Table S40 Anova table of model “flip.compnewSLOONLY”.**

Model term	X2	Df	Pr(>X2)
pt_peak_u	7.088	1	0.008
avg_slope_angle_transect.1	0.147	1	0.702
pt_peak_u:avg_slope_angle_transect.1	0.779	1	0.377

4

1 **Table S41 Anova table of model “fi.d.add2”.**

Model term	X2	Df	Pr(>X2)
pt_peak_u	10.401	1	0.001
size_cat_adjusted_to_flume_exp	3.473	2	0.176
branched	0.523	1	0.470
starting_substrate_new	6.226	2	0.044

2 **Table S42 Pairwise comparisons between three different substrate categories (hard carbonate, rubble and sand) for model “fi.d.add2”.**

Substrate contrast	Odds Ratio	SE	df	t-ratio	p-value
Hard carbonate / Rubble	1.133	0.141	425	1.002	0.576
Hard carbonate / Sand	0.868	0.137	425	-0.896	0.643
Rubble / Sand	0.766	0.086	425	-2.364	0.048

3 **Table S43 Anova table of model “fi.d.sl2”.**

Model term	X2	Df	Pr(>X2)
pt_peak_u	20.577	1	<0.001
avg_slope_angle_transect.1	8.304	1	0.004
pt_peak_u:avg_slope_angle_transect.1	51.833	1	<0.001

4

5

1 **Table S44 Predictions for distance of transport for three examples of slope angle, very gentle (3 degrees), moderate (13 degrees) and very strong (22 degrees) for model in Table S43.**

Slope angle	Velocity	Distance transported	SE	df	Lower confidence interval	Upper confidence interval
3	0.1	2.86	0.186	440	2.51	3.25
3	0.2	4.26	0.254	440	3.79	4.78
3	0.3	7.38	0.733	440	6.07	8.97
3	0.4	15.76	3.413	440	10.29	24.12
13	0.1	3.82	0.170	440	3.50	4.17
13	0.2	4.42	0.169	440	4.11	4.77
13	0.3	5.21	0.233	440	4.77	5.69
13	0.4	6.25	0.420	440	5.48	7.14
22	0.1	5.30	0.270	440	4.80	5.86
22	0.2	4.59	0.169	440	4.13	5.10
22	0.3	4.02	0.309	440	3.45	4.67
22	0.4	3.56	0.361	440	2.92	4.34

2

3 **Table S45 Model (ldmod) used for predictions of velocity thresholds for transport (sliding/walking/flipping) of 10%, 50% and 90% of rubble pieces averaged across different sizes,**
 4 **branchiness and substrate categories.**

Model term	χ^2	Df	Pr(> χ^2)
pt_peak_u_cm	36.937	1	<0.001

5