The following supplements accompany the article

Mechanisms of stability of rhodolith beds: sedimentological aspects

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Marine Ecology Progress Series 594: 65–83 (2018)

Supplement 1. Comparison of water flow between shallow and deep stations

Mean water flow speed for the deep (20 m) station was available for two blocks of 15 min in each of August, September, October, and November, 2014, for a total of eight blocks. The mean flow speed from each time block at the deep station was paired with the mean flow speed at the shallow station from the 15-min block that (1) preceded the moving of the current meter from shallow to deep, hereafter termed "pre-deep" pairing; and (2) followed the moving of the current meter from deep to shallow, hereafter termed "post-deep" pairing. In doing so, less than three hours separated two time blocks in any given pair, limiting differences in hydrodynamic conditions resulting from regime shifts in broad scale phenomena such as tides and wind-generated waves. Pre-deep and post-deep pairings were both investigated instead of simply one or the other to assess the strength of the conclusions about the difference, or lack thereof, in flow speed between stations. Simple linear regression analysis was used to measure the fit between pre-deep and post-deep flow speed pairings. Both analyses were applied to the raw data (n=8 in each analysis). Two (one for each type of pairing) one-tailed t-tests (two-sample assuming equal variances) were also used to determine if flow speed significantly differed between stations (n=16 in each analysis).

Simple linear regression analysis indicated that flow speeds at the two stations were unrelated in both the pre- and post-deep comparisons (Table S1.1). Moreover, mean flow speed in the pre-deep comparison did not differ significantly between the shallow (0.036±0.011 m s^{-1}) and deep (0.022±0.003 m s^{-1}) stations ($t_{0.05(1),14}$=1.32, p=0.270). These results alone suggest that the hydrodynamic environment did not differ between stations. However, mean flow speed in the post-deep comparison was significantly higher at the shallow (0.046±0.009 m s^{-1}) station ($t_{0.05(1),14}$=7.07, p=0.019), suggesting greater water turbulence there. Sequential moving of the current meter between stations was consistently initiated around 11:00 am to accommodate other subtidal work at the study site. As is typical for that time of day, wind speed and wave action generally increased over the time window needed to complete the first (shallow to deep) and second (deep to shallow) moving. The higher mean flow speed at the shallow station in the post-deep comparison could reflect higher wave-induced water flows at the shallow station after the second moving. Yet, such higher water flows were likely still small enough not to influence the outcome of the regression analysis (Table S1.1). Given (1) the poor fit between mean water flow speeds at the two stations [both pre- and post-deep comparisons]; (2) contradictory conclusions from comparing mean flow velocities [significantly different for the post-deep comparison only]; and (3) relatively small sample size [comparisons based on eight days for which flow data were available for both stations], water flow at both stations was deemed similar.

Table S1.1. Results of simple linear regression analyses (applied to raw data) examining relationships between mean water flow speed at the deep (20 m) station and mean water flow speed at the shallow (12 m) station before the moving of the current meter from shallow to deep (pre-deep) and after the moving of the current meter from deep to shallow (post-deep) on eight occasions from August to November, 2014. Models' coefficients are shown with corresponding 95% confidence limits (CL).

Data	**Intercept (95% CL)**	**Slope (95% CL)**	**r^2**	**$F_{(df)}$**	***p***
Pre-deep	0.025 (0.014, 0.035)	0.065 (-0.030, 0.170)	0.08	$0.458_{(1,6)}$	0.52
Post-deep	0.018 (0.002, 0.034)	0.094 (-0.211, 0.399)	0.06	$0.568_{(1,6)}$	0.48

Supplement 2. Effect of paint on contact of macrofauna with marked rhodoliths

A preliminary experiment was conducted to determine whether the paint used to mark the rhodoliths influenced the frequency at which the two predominant macrofaunal species in the rhodolith bed, the green sea urchin, *Strongylocentrotus droebachiensis*, and common sea star, *Asterias rubens*, contacted rhodoliths. Trials were conducted at the OSC in a shallow (43 cm deep), 31 x 31-cm glass tank filled with seawater. Sixteen (16) rhodoliths were placed in a circle (28 cm in diameter) on the bottom of the tank. One contiguous half of the circle was composed of dried, unpainted rhodoliths, and the other contiguous half of rhodoliths dried and spray painted bright orange like marked rhodoliths used in Field survey 2. Each trial began with the placement of one urchin (4-5 cm in test diameter [t.d.]) or one sea star (10-15 cm in body diameter [b.d.]) in the centre of the circle of rhodoliths, and ended when the urchin or sea star had contacted one of the rhodoliths, whose identity (painted or not) was then noted. Twenty (20) trials were run for each species, each with new seawater and a new urchin or sea star. The position of unpainted and painted rhodoliths within each contiguous half of the circle, as well as the placement of each half within the circle (e.g. top versus bottom or left versus right portions of the circle), were systematically alternated from one trial to the next. There was no difference between the proportion of urchins that contacted unpainted (55%) and painted (45%) rhodoliths (χ^2=0.2, p=0.65). There was also no difference between the proportion of sea stars that contacted unpainted (50%) and painted (50%) rhodoliths (χ^2=0, p=1). Rhodolith painting was therefore deemed to have no influence on the frequency of contacts by dominant macrofauna in the bed, and hence unlikely to bias rhodolith movement in the field as measured with the approach described above.

Supplement 3. Breakdown of number of observations used to model rhodolith sediment load

Table S3.1. Number of observations for each of the nine variables measured at the shallow (12 m) and deep (20 m) stations in the seven months (June to December, 2014) that rhodolith sediment load was monitored. SFS = significant flow speed; SR = sedimentation rate; DSU = density of adult sea urchins on rhodoliths; DSS = density of adult sea stars on rhodoliths; BBS = biomass of cryptic brittle stars; BRC = biomass of cryptic mottled red chitons; BSU = biomass of cryptic sea urchins; BSS = biomass of cryptic sea stars; RSL = Rhodolith sediment load.

		Month							
Variable	Station	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
SFS*	Shallow	-	-	-	292	277	212	239	1020
SR*	Shallow	2	4	4	4	4	4	4	26
	Deep	4	4	4	4	3	4	4	27
DSU	Shallow	21	24	21	24	20	24	29	163
	Deep	26	27	22	24	24	25	22	170
DSS	Shallow	21	24	21	24	20	24	29	163
	Deep	26	27	22	24	24	25	22	170
BBS	Shallow	12	12	12	10	12	9	12	79
	Deep	12	11	9	12	12	12	12	80
BRC	Shallow	12	12	12	10	12	9	12	79
	Deep	12	11	9	12	12	12	12	80
BSU	Shallow	12	12	12	10	12	9	12	79
	Deep	12	11	9	12	12	12	12	80
BSS	Shallow	12	12	12	10	12	9	12	79
	Deep	12	11	9	12	12	12	12	80
RSL	Shallow	12	12	12	10	12	9	12	79
	Deep	12	11	9	12	12	12	12	80

*Variables eliminated from the best-fitting model presented in the results section.

Supplement 4. Explanatory power of water flow and selection of best-fitting model

Two stepwise regression analyses, one with backward and one with forward selection of model terms, were used to assess the explanatory power of significant flow speed (SFS) on rhodolith sediment load at the shallow (12 m) site for the period during which SFS data was available (September to December, 2014). The removal of SFS from the full model with all candidate variables yielded a substantially more powerful model, as indicated by a drop of 35 in AIC (Table S4.1). The addition of SFS to the most basic model containing month as the only candidate variable yielded a substantially less powerful model, with a rise of 160 in AIC (Table S4.1). SFS was also highly non-significant in the backward and forward selection models in which it had been included (Table S4.2). Accordingly, SFS was deemed unimportant to rhodolith sediment load and was excluded from further analyses of rhodolith sediment load at both sites throughout the entire survey.

The best-fitting model, as identified with stepwise regression analysis of rhodolith sediment load based on data from both sites (12 and 20 m) throughout the entire survey, included the terms DSU, DSS, BBS, BRC, BSU, BSS, S, M, and the interaction between S and M (model 4 in Table S4.3). This model presented a much lower AIC (189, with an ΔAIC of 3) than that of the next less powerful model (model 5 in Table S4.3 with an AIC of 608 and ΔAIC of 422). It was chosen over three models with comparable AICs (models 1 to 3 in Table S4.3) because it was the most conservative of these models, presenting the highest number of candidate variables. Interestingly, elimination of sedimentation rate (SR) dramatically improved model performance, as shown by a change in ΔAIC from 422 to 3 in respectively the best- and next less-fitting models (models 4 and 5 in Table S4.3). Accordingly, the model that best explained variation in rhodolith sediment load was:

DSU+DSS+BBS+BRC+BSU+BSS+S+M+S*M

Table S4.1. Results of stepwise regression analysis of rhodolith sediment load examining the Akaike Information Criterion (AIC) and variation in AIC (ΔAIC) from one model to the next, in backward and forward model terms selection modes, based on data collected at the shallow (12 m) site for the period during which significant flow speed data was available (September to December, 2014). SFS = significant flow speed; SR = sedimentation rate; DSU = density of adult sea urchins on rhodoliths; DSS = density of adult sea stars on rhodoliths; BBS = biomass of cryptic brittle stars; BRC = biomass of cryptic mottled red chitons; BSU = biomass of cryptic sea urchins; BSS = biomass of cryptic sea stars; M = sampling month.

Elimination mode	**Model**	**AIC**	**ΔAIC**
Backward	1. **SFS**+SR+DSU+DSS+BBS+BRC+BSU+BSS+M	96	35
	2. SR+DSU+DSS+BBS+BRC+BSU+BSS+M	61	0
Forward	1. M	176	0
	2. **SFS**+M	336	160

Table S4.2. Model terms significance for the least two performant models including significant flow speed presented in Table S4.1 (n=1445 [backward] and 1063 [forward]). SFS = significant flow speed; SR = sedimentation rate; DSU = density of adult sea urchins on rhodoliths; DSS = density of adult sea stars on rhodoliths; BBS = biomass of cryptic brittle stars; BRC = biomass of cryptic mottled red chitons; BSU = biomass of cryptic sea urchins; BSS = biomass of cryptic sea stars; M = sampling month.

Elimination mode	Source of variation	*df*	MS	F-value	*p*
Backward	**SFS**	1	0.33	0.16	0.71
	SR	1	0.46	0.22	0.66
	DSU	1	1.13	0.54	0.50
	DSS	1	3.78	1.83	0.25
	BBS	1	0.02	0.01	0.93
	BRC	1	2.40	1.16	0.34
	BSU	1	1.16	0.56	0.50
	BSS	1	5.71	2.76	0.17
	M	3	6.52	3.15	0.15
	Error	4	2.07		
	Total	15			
Forward	**SFS**	1	0.20	0.10	0.75
	M	3	25.21	12.59	<0.001
	Error	43	2.00		
	Total	47			

Table S4.3. Results of stepwise regression analysis of rhodolith sediment load examining the Akaike Information Criterion (AIC) and variation in AIC (ΔAIC) from one model to the next, in backward model terms selection mode, based on data collected at the shallow (12 m) and deep (20 m) sites for the entire duration of the survey (6 June to 7 December, 2014). SR = sedimentation rate; DSU = density of adult sea urchins on rhodoliths; DSS = density of adult sea stars on rhodoliths; BBS = biomass of cryptic brittle stars; BRC = biomass of cryptic mottled red chitons; BSU = biomass of cryptic sea urchins; BSS = biomass of cryptic sea stars; S = sampling station; M = sampling month.

Model	AIC	ΔAIC
1. DSU+ BBS+ BSU+BSS+S+M+S*M	186	0
2. DSU+ BBS+ BRC+BSU+BSS+S+M+S*M	187	1
3. DSU+DSS+BBS+ BRC+ BSS+S+M+S*M	188	2
4. DSU+DSS+BBS+ BRC+BSU+BSS+S+M+S*M	189	3
5. SR+DSU+DSS+BBS+ BRC+BSS+S+M+S*M	608	422
6. SR+DSU+DSS+BBS+BRC+BSU+BSS+S+M+S*M	610	424
7. SR+DSU+DSS+BBS+ BSU+BSS+S+M+S*M	612	426

Supplement 5. Field Survey 1. Outcome of statistical analyses for Fig. 3

Table S5.1. Summary of two-way ANOVA (applied to raw data) examining the effect of Depth (12 and 20 m), Month (June to December, 2014), and their interaction on rhodolith sediment load in Field survey 1.

Source of variation	*df*	MS	F-value	*p*
Depth	1	46.985	19.361	<0.001
Month	6	32.574	13.423	<0.001
Depth x Month	6	6.052	2.494	0.025
Error	154	2.427		
Corrected total	167			

Table S5.2. Summary of two-way ANOVA (applied to raw data) examining the effect of Depth (12 and 20 m), Month (June to December, 2014), and their interaction on sedimentation rate in Field survey 1.

Source of variation	*df*	MS	F-value	*p*
Depth	1	1.647×10^{-6}	41.92	<0.001
Month	6	2.800×10^{-6}	71.24	<0.001
Depth x Month	6	1.548×10^{-7}	3.94	0.004
Error	39	3.931×10^{-8}		
Corrected total	52			

Supplement 6. Outcome of statistical analyses for panels A to I in Fig. 5

Table S6.1. Summary of two-way ANOVA (applied to raw data) examining the effect of Depth (shallow [12 m] and deep [20 m] stations) and Month (the seven months in which rhodolith sediment load was measured; June to December, 2014) on the density of large green sea urchins (*Strongylocentrotus droebachiensis*) on rhodoliths in Field survey 1 (see “Mobile invertebrate macrofauna” for sampling details).

Source of variation	*df*	MS	F-value	*p*
Depth	1	1.618×10^{-4}	26.48	<0.001
Month	6	8.235×10^{-6}	1.35	0.236
Depth x Month	6	1.004×10^{-5}	1.64	0.135
Error	319	6.112×10^{-6}		
Corrected total	332			

Table S6.2. Summary of two-way ANOVA (applied to raw data) examining the effect of Depth (shallow [12 m] and deep [20 m] stations) and Month (the seven months in which rhodolith sediment load was measured; June to December, 2014) on the density of large common sea stars (*Asterias rubens*) on rhodoliths in Field survey 1 (see "Mobile invertebrate macrofauna" for sampling details).

Source of variation	*df*	MS	F-value	*p*
Depth	1	2.200×10^{-6}	4.96	0.027
Month	6	2.854×10^{-7}	0.64	0.695
Depth x Month	6	8.195×10^{-7}	1.85	0.089
Error	319	4.432×10^{-7}		
Corrected total	332			

Table S6.3. Summary of two-way ANOVA (applied to raw data) examining the effect of Depth (shallow [12 m] and deep [20 m] stations) and Month (the seven months in which rhodolith sediment load was measured; June to December, 2014) on the wet weight of daisy brittle stars (*Ophiopholis aculeata*) within rhodoliths interstices in Field survey 1 (see "Rhodolith cryptofauna" for sampling details).

Source of variation	*df*	MS	F-value	*p*
Depth	1	92.806	68.90	<0.001
Month	6	4.690	3.48	0.003
Depth x Month	6	2.423	1.80	0.103
Error	145	1.347		
Corrected total	158			

Table S6.4. Summary of two-way ANOVA (applied to raw data) examining the effect of Depth (shallow [12 m] and deep [20 m] stations) and Month (the seven months in which rhodolith sediment load was measured; June to December, 2014) on the wet weight of mottled red chitons (*Tonicella marmorea*) within rhodoliths interstices in Field survey 1 (see "Rhodolith cryptofauna" for sampling details).

Source of variation	*df*	MS	F-value	*p*
Depth	1	0.155	11.87	<0.001
Month	6	0.038	2.91	0.010
Depth x Month	6	0.015	1.13	0.346
Error	145	0.013		
Corrected total	158			

Table S6.5. Summary of two-way ANOVA (applied to raw data) examining the effect of Depth (shallow [12 m] and deep [20 m] stations) and Month (the seven months in which rhodolith sediment load was measured; June to December, 2014) on the wet weight of small green sea urchins (*Strongylocentrotus droebachiensis*) within rhodoliths interstices in Field survey 1 (see "Rhodolith cryptofauna" for sampling details).

Source of variation	*df*	MS	F-value	*p*
Depth	1	2.349	16.43	<0.001
Month	6	0.352	2.46	0.027
Depth x Month	6	0.076	0.53	0.782
Error	145	0.143		
Corrected total	158			

Table S6.6. Summary of two-way ANOVA (applied to raw data) examining the effect of Depth (shallow [12 m] and deep [20 m] stations) and Month (the seven months in which rhodolith sediment load was measured; June to December, 2014) on the wet weight of small common sea stars (*Asterias rubens*) within rhodoliths interstices in Field survey 1 (see "Rhodolith cryptofauna" for sampling details).

Source of variation	*df*	MS	F-value	*p*
Depth	1	0.020	1.38	0.242
Month	6	0.022	1.51	0.179
Depth x Month	6	0.028	1.94	0.079
Error	145	1.347		
Corrected total	158			