Appendix S1: Reviewed experimental studies used to extract effects of seaweeds on seagrasses

Seaweed-column: *taxonomy* = Green, Red, Mixed/Multiple; *attachment* = Rooted, Drift, Epiphyte, Mixed/Multiple; *morphology* = Clonal, Coarsely-branched, Sheet-form, Filamentous, Encrusting-calcareous, Articulated-calcareous. Species names that are underlined are non-natives. Seagrass-column: Number in brackets = ranked 'size'. Experimental-design column: '×' = orthogonal test-factor. Data-column: show the figures and tables from where data was extracted for the meta-analysis.

Study, region	**Seaweed (taxonomy, attachment, morphology)**	**Seagrass**	**Experimental design**	**Data**
[1]: Italy, Mediterranean sea	*Caulerpa taxifolia* (G,R,Clo)	*Cymodocea nodosa* (2)	2 seaweed treatments × 2 neighbours [=competition] × 2 nutrients × 8 sites	Fig. 3
[2]: Italy, Mediterranean sea	*Caulerpa racemosa* (G,R,Clo)	*Zostera noltii* (2), *Cymodocea nodosa* (2)	2 seaweed treatments × 2 sites	Fig. 1, 2, 3
[3]: Italy, Mediterranean sea	*Caulerpa taxifolia* (G,R,Clo)	*Cymodocea nodosa* (2)	2 seaweed treatments × 2 neighbours [=competition] × 2 nutrients × 8 sites	Fig. 2
[4]: USA, NW Atlantic	*Caulerpa prolifera* (G,R,Clo)	*Halodule wrigthii* (1)	2 seaweed treatments × 2 neighbours [=competition] × 2 depth	Fig. 3, 2
[5]: Tanzania, West Indian Ocean	*Eucheuma dentticulatum* (R,D,Coa)	*Enhalus acoroides* (3), *Thalassia hemprichii* (3)	3 seaweed treatments [including cage-artefact]	Fig. 1, 2, 3, 4
[6]: USA, Caribbean	*Laurencia poiteaui* (R,D,Coa)	*Thalassia testudinum* (3) (w/*Halodule wrightii, Syringodium filiforme*)	2 seaweed treatments	Fig. 1-5
[7]: USA, NE Pacific	*Ulvaria obscura* (G,D,S)	*Zostera marina* (3)	3 seaweed treatments [impact *vs.* two non-impacted controls]	Fig. 1, Table 1
[8]: USA, NW Atlantic	Mixed (*Laurencia, Dictyota*) (M,D,M)	*Thalassia testudinum* (3)	3 seaweed treatments [including cage-artefact] × 3 grazers	Fig. 1
[9]: Australia, SW Pacific	*Enteromorpha intestinalis*	Mixed (*Halophila ovalis* 60%, *Zostera capricorni* (20%), *Ruppia megacarpa* (20%)	3 seaweed treatments [including cage-artefacts] × 2 sites	Fig. 3, 4, Tabl 1
[10]: Denmark, NE Atlantic	Mixed (*Ceramium, Chaetomorpha*) (M,D,Fil)	*Zostera marina* (3)	3 seaweed abundances	Fig. 3, 4, Table 2

[11]: USA, NW Atlantic	*Laurencia* (R,D,Coa)	*Thalassia testudinum* (3)	2 seaweed treatments × 6 times [=incubation length = experiment 1]	Fig. 3
[11]: USA, NW Atlantic	*Laurencia* (R,D,Coa)	*Thalassia testudinum* (3)	2 seaweed treatments × 2 experiments [=time, methods = experiment 2)	txt p87
[11]: USA, NW Atlantic	Epiphytes – encrusting (M,E,Enc-cal)	*Thalassia testudinum* (3)	2 seaweed treatments [=experiment 3)	txt p87
[11]: USA, NW Atlantic	*Laurencia vs.* Encrusting epiphytes)	*Thalassia testudinum* (3)	3 seaweed attachment types [=epiphytes *vs.* drift = experiment 4]	txt p87
[12]: USA, Gulf of Mexico	Mixed drift (M,D,M)	*Thalassia testudinum* (3)	2 seaweed treatments [also test for effect of abiotic light reduction and follow recovery after drift removal]	Fig. 1, 3, 4, 5
[13]: USA, NE Pacific	*Gracilariopsis* sp. (R,D,Coa)	*Zostera marina* (3)	4 seaweed abundance [including cage-artefact]	Fig. 4, 5
[14]: USA, NW Atlantic	Mixed (*Gracilaria tikvahia, Cladophora vagabunda*) (M,D,M)	*Zostera marina* (3)	5-6 seaweed abundance [including cage-artefact] × 2 sites	Fig. 2, 5, 6
[15]: Denmark, NE Atlantic	<u>*Gracilaria vermiculophylla*</u> (R,D,Coa)	*Zostera marina* (3)	3 seaweed abundance × 4 temperature	Fig. 1-3
[16]: Portugal, NE Atlantic	*Ulva rigida* (G,D,She)	*Zostera noltii* (2)	4 seaweed abundance	Fig. 1
[17]: Portugal, NE Atlantic	*Ulva rigida* (G,D,She)	*Zostera noltii* (2)	4 seaweed abundance × 3 experiments [=lab, field1, field2]	Fig. 1-3
[18]: Australia, East Indian Ocean	Epiphytes (mixed) (M,E,fil)	*Amphibolis* sp. (3)	2 seaweed treatments × 2 seagraass abundance	Fig. 1
[19]: USA, NW Atlantic.	*Halimeda incrasata* (G,R,Ere-cal)	*Thalassia testudinum* (3)	3 seaweed abundance × 2 neighbours [=competition]	Fig. 3-5
[20]: Denmark, NE Atlantic	Epiphytes (diatoms) (M,E,fil)	*Zostera marina* (3)	2 seaweed treatments × 6 HCO3	Fig. 1
[20]: Denmark, NE Atlantic	Epiphytes (diatoms) (M,E,fil)	*Zostera marina* (3)	2 seaweed treatments × 7 light	Fig. 4
[21]: Australia, East Indian Ocean	*Gracilaria comosa* (R,D,Coa)	*Halophila ovalis* (1)	3 seaweed abundance × 3 temperature	Fig. 1-3
[22]. Denmark, NE Atlantic	<u>*Gracilaria vermiculophylla*</u> (R,D,Coa)	*Zostera marina* (3)	3 seaweed abundance × 3 experiments [=temperature]	Fig. 5-6

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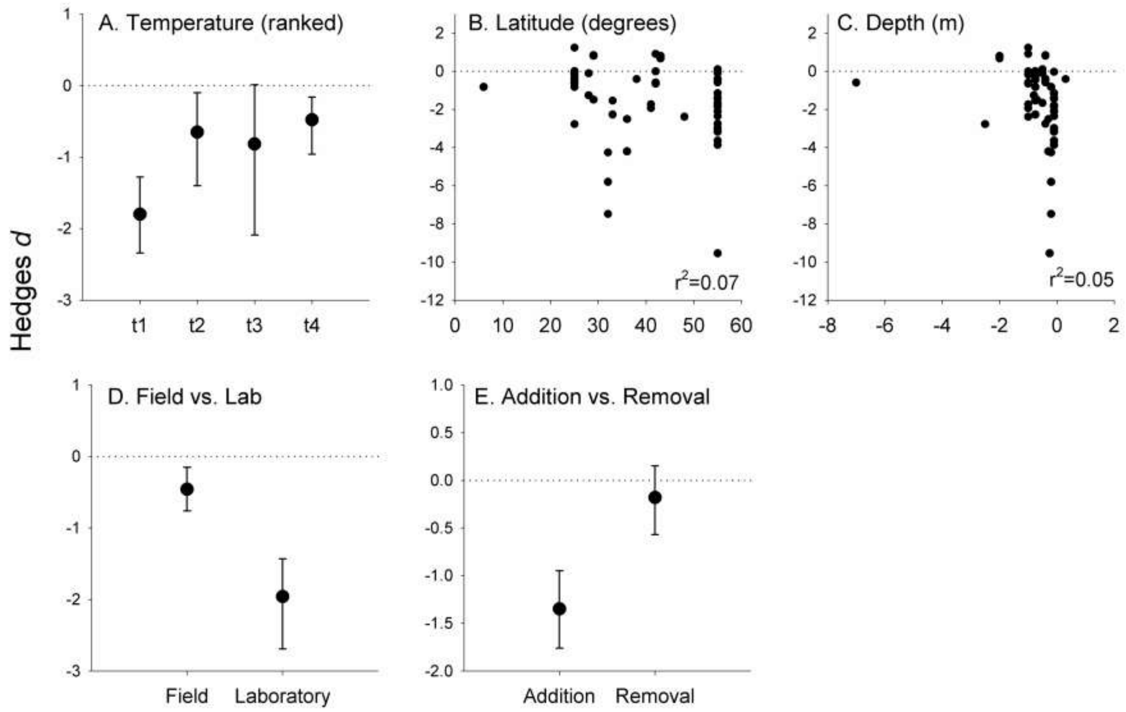
Appendix S2. Modifying effects of habitat and methodology on seaweed impact on seagrasses

Introduction. Seaweed-seagrass attributes may be modified by habitat-attributes and depend on the methods used to detect impact.

Method. To test if the habitat and the experimental context modify impact, we extracted data on the 'latitude' where the experiment was conducted (a proxy for temperature and day-length combined), 'temperature' (<18º, 18-22º, 23-27º, >27ºC), 'depth', field *vs*., laboratory conditions, and if the experiment was based on seaweed 'removal' or 'addition' methods.

Results and discussion. We found no effects of latitude (Fig. S1A) or depth (Fig. S1C), but impact at low temperatures were significantly larger than at high temperatures (Fig. S1B). Laboratory and addition-type experiments had significantly larger negative effects than field and removal-type experiments, respectively (Fig. S1D-E, see also discussion in manuscript). We were only able to extract crude data to test if habitat attributes modify impact. We expected that impact increases with increasing temperatures (and latitude) because Q_{10} values are higher for seaweeds than seagrasses, resulting in more stressful levels of anoxia and sulphides [1,2]. However, we found no effect of latitude but highest negative impacts at low temperatures. This result may be caused by co-varying attributes; for example, many 'warm' studies were conducted using attached and coenocytic seaweeds with relatively low impacts (see discussion in the paper). Of the few studies that specifically tested for effects of temperature, impacts were generally highest at high temperatures [1,2,3]. We did not find any effect of depth. However, depth co-varies with desiccation, wave regimes, disturbance levels, light levels, sedimentation, and sediment properties, and it is therefore not surprising that this result is non-significant. Only a single experiment has specifically tested if depth modified seaweed impacts, documenting a minor difference between impact recorded on 0.5 and 0.8 m depth. A few other habitat-attributes have been tested in the reviewed papers, but too few for formal meta-analysis. For example, grazing pressure can modify impact of unattached seaweeds [4] and bicarbonate and irradiance levels can modify impacts of epiphytes [5]. By contrast, nutrient addition seems not to modify impact of *Caulerpa* [6,7]. In short, many more studies are needed to better understand how local habitat conditions modify impact of seaweeds on seagrasses.



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Appendix S3. Meta-analytical test results and sample sizes

All analyses were conducted in Metawin 2.0. Figure numbers refers to the graphs as shown in the paper.

Analysis of all 59 experiments

Weighted analysis

Heterogeneity		df	Prob(Chi-Square)
Qtotal	83.3410	58	0.01628

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.9566	-1.2667 to -0.6465	-1.2850 to -0.6580	-1.2834 to -0.6520

Sqrt Pooled Variance = 0.9107
Mean Study Variance = 0.9132 Ratio = 0.9973

Un-weighted analysis

Heterogeneity		df	Prob(Chi-Square)
Qtotal	58.0000	58	0.47530

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-1.4423	-1.9618 to -0.9229	-1.9792 to -0.9539	-1.9770 to -0.9500

Sqrt Pooled Variance = 1.7241
Mean Study Variance = 1.0000 Ratio = 1.7241

Figure 1a Seaweed abundance gDWm2

Note: Not all experiments reported seaweed abundance; 17 experiments included multiple seaweed abundance levels (these were represented with >1 $d_{\text{experiment}}$).

Weighted analysis

Estimate of pooled variance: 0.7614

Predictor	Value	SE	Prob(Norm)	Prob(Rand)
Intercept	-0.2640	0.2525	0.29588	0.004
Slope	-0.0024	0.0009	0.01224	0.982

Model	df	Q	Prob(Chi-Square)
Regression	1	6.2760	0.01224
Residual	44	70.4063	0.00694

Total	45	76.6823	0.00225

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	76.6823	45	0.00225

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.7341	-1.0745 to -0.3936	-1.1049 to -0.4293	-1.1232 to -0.4316

Sqrt Pooled Variance = 0.8726, Mean Study Variance = 0.8867 Ratio = 0.9841

Unweighted analysis

Estimate of pooled variance: 3.6215

Predictor	Value	SE	Prob(Norm)	Prob(Rand)
Intercept	-0.2751	0.5087	0.58867	0.017
Slope	-0.0040	0.0017	0.01800	0.984

Model	df	Q	Prob(Chi-Square)
Regression	1	5.5964	0.01800
Residual	44	44.0000	0.47164
Total	45	49.5964	0.29505

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	49.5964	45	0.29505

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-1.2164	-1.8549 to -0.5780	-1.9001 to -0.5990	-2.0238 to -0.6613

Sqrt Pooled Variance = 1.9030, Mean Study Variance = 1.0000 Ratio = 1.9030

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Figure 1b Seaweed abundance

Note; This analysis is based on 17 experiments that tested explicitly for impact of seaweed abundance. This test does not suffer from problems with environmental co-variation. An un-structured meta-analysis was conducted on =Δd values (=Δd $d_{High} - d_{Low}$, V = variance of d).

Table: Data-set used for paired seaweed abundances.

Exp	d_{Low}	V_{Low}	d_{High}	V_{High}	Δd	$V_{average}$
1	-6.07157	3.738667	-13.0371	14.8306	-6.96557	9.284634
2	0.151861	0.335137	-0.9814	0.385462	-1.13326	0.360299
3	-0.33885	0.677534	-2.58581	1.415648	-2.24696	1.046591
4	-1.74517	0.974244	-2.4691	1.268491	-0.72393	1.121368
5	-0.32973	0.679154	-0.47656	0.686145	-0.14683	0.682649
6	-0.56127	0.701693	-0.36209	0.707672	0.199186	0.704682
7	-2.00938	1.310679	-3.50647	3.012515	-1.49709	2.161597
8	-0.32893	0.686914	-0.85388	0.760655	-0.52495	0.723784
9	-4.02364	1.739739	-5.16306	2.487421	-1.13942	2.11358
10	-2.42444	1.928442	-2.86816	3.400996	-0.44372	2.664719
11	-0.5187	0.690352	-0.68442	0.707045	-0.16573	0.698698
12	-4.70881	1.799899	-10.2698	8.526666	-5.56103	5.163283
13	-5.1354	2.012049	-6.4758	2.769054	-1.34039	2.390551
14	-3.11458	1.038012	-5.41374	2.161311	-2.29916	1.599662
15	-0.06773	0.766706	-0.12453	1.072448	-0.05681	0.919577
16	-0.01017	0.688762	0.22056	0.724468	0.230733	0.706615
17	-1.24832	0.82086	-2.08888	1.041969	-0.84056	0.931415

Weighted analysis

Estimate of pooled variance: 0.0965

SUMMARY RESULTS

Heterogeneity df Prob(Chi-Square)

Qtotal 16.4525 16 0.42185

Mean Effect Size 95% CI Bootstrap CI Bias CI

E++ -0.7820 -1.3359 to -0.2280 -1.2506 to -0.4196 -1.2775 to -0.4248

Sqrt Pooled Variance = 0.3106 Mean Study Variance = 1.9573 Ratio = 0.1587

Unweighted analysis

Estimate of pooled variance: 2.9056

SUMMARY RESULTS

Heterogeneity df Prob(Chi-Square)

Qtotal 16.0000 16 0.45296

Mean Effect Size 95% CI Bootstrap CI Bias CI

E++ -1.4503 -2.4663 to -0.4343 -2.5055 to -0.6688 -2.5748 to -0.7028

Sqrt Pooled Variance = 1.7046 Mean Study Variance = 1.0000 Ratio = 1.7046

Figure 1c Run time (Seaweed duration)

Note: One study contributed with multiple independent $d_{experiment}$ (tested explicitly for impact of sample time with independent time treatments).

Weighted analysis

Estimate of pooled variance: 0.7397

Predictor	Value	SE	Prob(Norm)	Prob(Rand)
Intercept	-1.2758	0.1804	0.00000	0.001
Slope	0.1143	0.0358	0.00143	0.001

Model	df	Q	Prob(Chi-Square)
Regression	1	10.1636	0.00143
Residual	65	87.4591	0.03311
Total	66	97.6227	0.00692

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	97.6227	66	0.00692

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.9158	-1.1967 to -0.6350	-1.2299 to -0.6301	-1.2071 to -0.6158

Sqrt Pooled Variance = 0.8601, Mean Study Variance = 0.9264 Ratio = 0.9284

Unweighted analysis

Estimate of pooled variance: 2.5013

Predictor	Value	SE	Prob(Norm)	Prob(Rand)
Intercept	-1.8772	0.2827	0.00000	0.002
Slope	0.1647	0.0590	0.00524	0.002

Model	df	Q	Prob(Chi-Square)

Regression	1	7.7947	0.00524
Residual	65	65.0000	0.47667
Total	66	72.7947	0.26440

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	72.7947	66	0.26440

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-1.4127	-1.8692 to -0.9563	-1.9105 to -0.9924	-1.9212 to -0.9914

Sqrt Pooled Variance = 1.5815, Mean Study Variance = 1.0000 Ratio = 1.5815

Figure 1d Plot size (Seaweed extent)

Weighted analysis

Estimate of pooled variance: 0.8883

Predictor	Value	SE	Prob(Norm)	Prob(Rand)
Intercept	-1.0784	0.1819	0.00000	0.068
Slope	0.2561	0.2174	0.23870	0.001

Model	df	Q	Prob(Chi-Square)
Regression	1	1.3882	0.23870
Residual	58	81.7506	0.02167
Total	59	83.1388	0.02091

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	83.1388	59	0.02091

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.9715	-1.2870 to -0.6560	-1.2998 to -0.6837	-1.2802 to -0.6694

Sqrt Pooled Variance = 0.9425 , Mean Study Variance = 0.9539 Ratio = 0.9881

Unweighted analysis

Estimate of pooled variance: 3.0087

Predictor	Value	SE	Prob(Norm)	Prob(Rand)
Intercept	-1.7054	0.2952	0.00000	0.022
Slope	0.6375	0.3936	0.10527	0.022

Model	df	Q	Prob(Chi-Square)
Regression	1	2.6238	0.10527
Residual	58	58.0000	0.47530
Total	59	60.6238	0.41706

SUMMARY RESULTS

Heterogeneity	df	Prob(Chi-Square)
Qtotal 60.6238	59	0.41706

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-1.4745	-1.9918 to -0.9573	-2.0189 to -1.0438	-2.0311 to -1.0545

Sqrt Pooled Variance = 1.7346 Mean Study Variance = 1.0000 Ratio = 1.7346

Figure 1e Seaweed origin

Weighted analysis

Estimate of pooled variance: 0.8206

--Heterogeneity--

Class	#Studies	PooledVar
0	45	1.0370
1	14	0.1384

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	1	6.1180	0.01338	0.021
Within	57	77.6207	0.03604	
Total	58	83.7386	0.01514	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
0	45	-1.1746	44	-1.5335 to -0.8157	-1.6048 to -0.8162	-1.5960 to -0.8052
1	14	-0.2910	13	-0.9600 to 0.3780	-0.6702 to 0.0899	-0.6780 to 0.0876

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	83.7386	58	0.01514

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.9551	-1.2641 to -0.6460	-1.2894 to -0.6500	-1.2797 to -0.6390

Sqrt Pooled Variance = 0.9058 Mean Study Variance = 0.9132 Ratio = 0.9920

Unweighted analysis

Estimate of pooled variance: 2.6916

--Heterogeneity--

Class	#Studies	PooledVar
0	45	3.5029
1	14	-0.0540

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	1	5.4144	0.01997	0.025
Within	57	57.0000	0.47509	
Total	58	62.4144	0.32223	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
0	45	-1.7670	44	-2.3442 to -1.1897	-2.4038 to -1.2079	-2.4240 to -1.2170
1	14	-0.3988	13	-1.5081 to 0.7105	-0.9358 to 0.0748	-0.9593 to 0.0559

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	62.4144	58	0.32223

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-1.4423	-1.9430 to -0.9416	-2.0006 to -0.9705	-2.0401 to -0.9842

Sqrt Pooled Variance = 1.6406 Mean Study Variance = 1.0000 Ratio = 1.6406

Figure 1f Seaweed attachment

Weighted analysis

Estimate of pooled variance: 0.8523

--Heterogeneity--

Class	#Studies	PooledVar
Drift	34	0.8839
Epiphyte	17	1.4006
Root	9	0.2642

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	2	6.9911	0.03033	0.049
Within	57	77.0573	0.03959	
Total	59	84.0485	0.01779	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
Drift	34	-1.0278	33	-1.4523 to -0.6033	-1.4738 to -0.6482	-1.4694 to -0.6416
Epiphyte	17	-1.3476	16	-1.9824 to -0.7128	-2.1030 to -0.6777	-2.0592 to -0.6443
Root	9	-0.1399	8	-0.9680 to 0.6882	-0.5815 to 0.3456	-0.5924 to 0.2935

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	84.0485	59	0.01779

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.9485	-1.2578 to -0.6393	-1.2926 to -0.6570	-1.2785 to -0.6442

Sqrt Pooled Variance = 0.9232 Mean Study Variance = 0.9017 Ratio = 1.0239

Unweighted analysis

Estimate of pooled variance: 2.7571

--Heterogeneity--

Class	#Studies	PooledVar
Drift	34	4.2581
Epiphyte	17	1.2532
Root	9	-0.4264

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	2	4.9987	0.08214	0.089
Within	57	57.0000	0.47509	
Total	59	61.9987	0.36969	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
Drift	34	-1.6768	33	-2.3531 to -1.0004	-2.4887 to -0.9691	-2.5513 to -1.0013
Epiphyte	17	-1.6284	16	-2.6249 to -0.6319	-2.3090 to -0.9428	-2.2484 to -0.8931
Root	9	-0.0949	8	-1.5849 to 1.3951	-0.5685 to 0.3813	-0.5564 to 0.3856

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	61.9987	59	0.36969

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-1.4258	-1.9265 to -0.9250	-1.9091 to -0.9734	-1.9784 to -0.9901

Sqrt Pooled Variance = 1.6605 Mean Study Variance = 1.0000 Ratio = 1.6605

Figure 1g Seaweed morphology

Weighted analysis

Note; morphologies that only were tested in a single experiment (Articulated calcareous, Encrusting) could not be analysed.

Estimate of pooled variance: 0.7998

--Heterogeneity--

Class	#Studies	PooledVar
Clo	8	0.3077
Coa	12	1.2344
Fil	26	1.0010
Mix	6	0.7559
She	5	-0.1802

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	4	12.8388	0.01209	0.024
Within	52	71.7520	0.03606	
Total	56	84.5907	0.00810	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
Clo	8	-0.1012	7	-0.9667 to 0.7644	-0.6002 to 0.3969	-0.6469 to 0.3758
Coa	12	-1.2788	11	-2.1102 to -0.4474	-2.3504 to -0.6493	-2.3792 to -0.6512
Fil	26	-1.0281	25	-1.4955 to -0.5607	-1.5539 to -0.5915	-1.5563 to -0.5911
Mix	6	-0.6207	5	-1.8896 to 0.6483	-1.5497 to 0.2431	-1.4955 to 0.3708
She	5	-2.3858	4	-3.9941 to -0.7776	-3.1163 to -1.8395	-3.1394 to -1.8656

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	84.5907	56	0.00810

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.9601	-1.2731 to -0.6471	-1.2895 to -0.6587	-1.2565 to -0.6467

Sqrt Pooled Variance = 0.8943   Mean Study Variance = 0.9298   Ratio = 0.9618

Unweighted analysis

Excluded Groups from "Test factor": Artic, Enc , Estimate of pooled variance: 2.8331

--Heterogeneity--

Class	#Studies	PooledVar
Clo	8	-0.3857
Coa	12	5.2940

Fil	26	3.5892
Mix	6	0.4433
She	5	-0.0401

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	4	7.8195	0.09842	0.116
Within	52	52.0000	0.47392	
Total	56	59.8195	0.33881	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
Clo	8	-0.0316	7	-1.6684 to 1.6052	-0.5565 to 0.4608	-0.5213 to 0.5059
Coa	12	-2.0562	11	-3.3001 to -0.8124	-3.5810 to -0.8806	-3.6223 to -0.8919
Fil	26	-1.5804	25	-2.3713 to -0.7896	-2.3957 to -0.8823	-2.4944 to -0.9763
Mix	6	-0.7886	5	-2.8430 to 1.2659	-1.5785 to 0.1621	-1.6457 to 0.1209
She	5	-2.5830	4	-5.0140 to -0.1520	-3.4768 to -1.8814	-3.4768 to -1.9050

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	59.8195	56	0.33881

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-1.4678	-1.9873 to -0.9483	-1.9914 to -1.0084	-1.9881 to -1.0051

Sqrt Pooled Variance = 1.6832 Mean Study Variance = 1.0000 Ratio = 1.6832

Figure 1h Seaweed taxonomy (genus)

Weighted analysis

Note; genera that only were tested in a single experiment (*Ceramium, Eucheuma, Halimeda*) could not be analyzed.

Estimate of pooled variance: 0.7658

--Heterogeneity--

Class	#Studies	PooledVar
Caulerpa	8	0.3077

Gracilaria	11	1.9573
Laurencia	10	0.4170
Mixed	23	1.3411
Ulva	5	-0.1802

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	4	16.7972	0.00212	0.005
Within	52	69.2772	0.05480	
Total	56	86.0744	0.00603	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
Caulerpa	8	-0.1034	7	-0.9549 to 0.7482	-0.6132 to 0.4295	-0.6606 to 0.3711
Gracilaria	11	-1.3530	10	-2.2594 to -0.4465	-2.5655 to -0.6253	-2.7247 to -0.6805
Laurencia	10	-0.4909	9	-1.2034 to 0.2215	-1.0136 to -0.1052	-1.1343 to -0.1110
Mixed	23	-1.3069	22	-1.8400 to -0.7738	-1.8779 to -0.7656	-1.8765 to -0.7543
Ulva	5	-2.3827	4	-3.9722 to -0.7932	-3.2862 to -1.8659	-3.2862 to -1.8659

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	86.0744	56	0.00603

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.9750	-1.2840 to -0.6659	-1.3143 to -0.6813	-1.3204 to -0.6857

Sqrt Pooled Variance = 0.8751 Mean Study Variance = 0.9313 Ratio = 0.9397

Unweighted analysis

Estimate of pooled variance: 2.6117

--Heterogeneity--

Class	#Studies	PooledVar
Caulerpa	8	-0.3857
Gracilaria	11	5.7586
Laurencia	10	-0.2143
Mixed	23	3.7732

Ulva	5	-0.0401

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	4	11.2003	0.02440	0.034
Within	52	52.0000	0.47392	
Total	56	63.2003	0.23711	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
Caulerpa	8	-0.0316	7	-1.6204 to 1.5572	-0.5314 to 0.4783	-0.5484 to 0.4569
Gracilaria	11	-2.1680	10	-3.4446 to -0.8913	-3.8743 to -0.8242	-3.8683 to -0.8011
Laurencia	10	-0.5135	9	-1.8731 to 0.8461	-1.1524 to -0.1083	-1.2419 to -0.1207
Mixed	23	-1.8435	22	-2.6654 to -1.0216	-2.7263 to -0.9870	-2.8994 to -1.0747
Ulva	5	-2.5830	4	-4.9427 to -0.2232	-3.4525 to -1.9171	-3.4768 to -2.0033

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	63.2003	56	0.23711

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-1.4834	-1.9876 to -0.9791	-1.9991 to -0.9730	-2.0319 to -0.9789

Sqrt Pooled Variance = 1.6161 Mean Study Variance = 1.0000 Ratio = 1.6161

Figure 2a Seagrass abundance (gDW/m2)

Note: Not all experiments reported seagrass abundance.

Weighted analysis

Estimate of pooled variance: 0.9992

Predictor	Value	SE	Prob(Norm)	Prob(Rand)
Intercept	-0.5090	0.2453	0.03796	0.425
Slope	0.0000	0.0002	0.83878	0.241

Model	df	Q	Prob(Chi-Square)

Model	df	Q	Prob(Chi-Square)
Regression	1	0.0414	0.83878
Residual	46	80.2681	0.00131
Total	47	80.3094	0.00177

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	80.3094	47	0.00177

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.4747	-0.8328 to -0.1166	-0.8648 to -0.1070	-0.8619 to -0.1061

Sqrt Pooled Variance = 0.9996   Mean Study Variance = 0.8893   Ratio = 1.1240

Unweighted analysis

Estimate of pooled variance: 4.5973

Predictor	Value	SE	Prob(Norm)	Prob(Rand)
Intercept	-1.0364	0.4700	0.02744	0.388
Slope	0.0001	0.0004	0.71668	0.388

Model	df	Q	Prob(Chi-Square)
Regression	1	0.1317	0.71668
Residual	46	46.0000	0.47227
Total	47	46.1317	0.50845

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	46.1317	47	0.50845

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.9192	-1.6062 to -0.2322	-1.5794 to -0.3106	-1.6342 to -0.3347

Sqrt Pooled Variance = 2.1441   Mean Study Variance = 1.0000   Ratio = 2.1441

Figure 2b Seagrass size

Note: Experiments reporting effects on mixed seagrass species assemblages were not included.

Weighted analysis

Estimate of pooled variance: 0.8275

--Heterogeneity--

Class	#Studies	PooledVar
1	7	2.1296
2	8	0.7143
3	44	0.6846

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	2	7.8377	0.01986	0.035
Within	56	75.5897	0.04162	
Total	58	83.4274	0.01602	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
1	7	-2.0374	6	-3.2104 to -0.8644	-3.7886 to -1.1049	-3.7217 to -1.0576
2	8	-0.2744	7	-1.2493 to 0.7006	-1.3231 to 0.3558	-1.3315 to 0.3552
3	44	-0.9342	43	-1.2936 to -0.5749	-1.3167 to -0.6232	-1.3001 to -0.6129

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	83.4274	58	0.01602

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.9563	-1.2661 to -0.6464	-1.3122 to -0.6764	-1.3070 to -0.6648

Sqrt Pooled Variance = 0.9097, Mean Study Variance = 0.9132 Ratio = 0.9961

Unweighted analysis

Estimate of pooled variance: 2.6094

--Heterogeneity--

Class	#Studies	PooledVar
1	7	6.2048

2	8	2.2487
3	44	2.1664

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	2	7.8371	0.01987	0.032
Within	56	56.0000	0.47486	
Total	58	63.8371	0.27886	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
1	7	-3.2490	6	-5.0062 to -1.4918	-5.0948 to -1.4888	-5.1727 to -1.5055
2	8	-0.6992	7	-2.2875 to 0.8891	-1.9903 to 0.3566	-2.0079 to 0.3400
3	44	-1.2900	43	-1.8676 to -0.7124	-1.8808 to -0.7950	-1.9780 to -0.8566

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	63.8371	58	0.27886

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-1.4423	-1.9374 to -0.9472	-1.9615 to -0.9828	-1.9658 to -0.9837

Sqrt Pooled Variance = 1.6153   Mean Study Variance = 1.0000   Ratio = 1.6153

Figure 2c Seagrass taxonomy (genus)

Note; genera that only were tested in a single experiment (*Enhalus*) could not be analysed.

Weighted analysis

Estimate of pooled variance: 0.7826

--Heterogeneity--

Class	#Studies	PooledVar
Amp	2	-0.4560
Cym	6	-0.0139
Halod	3	2.3315
Halop	3	-0.4094

Mix	3	0.0557
Tha	17	0.2256
Zos	29	2.0644

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	6	35.0837	0.00000	0.001
Within	56	72.9239	0.06385	
Total	62	108.0076	0.00027	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
Amp	2	0.4188	1	-9.1759 to 10.8135	-0.8019 to 0.1371	-0.8019 to 0.1371
Cym	6	-0.1631	5	-1.2615 to 0.9353	-0.5027 to 0.2653	-0.5078 to 0.2653
Halod	3	-1.3897	2	-4.1661 to 1.3867	-7.4313 to -0.1085	-3.2611 to -0.1085
Halop	3	-5.3983	2	-9.9312 to -0.8654	-7.4915 to -4.2642	-6.6708 to -4.2642
Mix	3	-1.5014	2	-4.1859 to 1.1831	-2.2721 to -0.9931	-2.2721 to -0.9931
Tha	17	-0.3971	16	-0.9295 to 0.1354	-0.7886 to -0.0829	-0.8297 to -0.1041
Zos	29	-1.3531	28	-1.8430 to -0.8632	-1.9481 to -0.7901	-1.9198 to -0.7655

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	108.0076	62	0.00027

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.8981	-1.1919 to -0.6043	-1.2352 to -0.5770	-1.2207 to -0.5579

Sqrt Pooled Variance = 0.8847, Mean Study Variance = 0.9217 Ratio = 0.9598

Unweighted analysis

Estimate of pooled variance: 2.1851

--Heterogeneity--

Class	#Studies	PooledVar
Amp	2	-0.9994
Cym	6	-0.6811

Halod	3	14.5023
Halop	3	1.6056
Mix	3	-0.5882
Tha	17	-0.3430
Zos	29	3.6150

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	6	33.9548	0.00001	0.002
Within	56	56.0000	0.47486	
Total	62	89.9548	0.01169	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
Amp	2	0.4195	1	-15.2152 to 16.8542	-0.8019 to 1.371	- 0.8019 to 1.3371
Cym	6	-0.1244	5	-1.9971 to 1.7484	-0.4835 to 0.3506	-0.4640 to 0.3865
Halod	3	-2.9340	2	-7.3674 to 1.4995	-7.4313 to -0.1085	-7.4313 to -0.1085
Halop	3	-5.8537	2	-10.2872 to -1.4203	-7.4915 to -4.2642	-6.9295 to -4.2642
Mix	3	-1.6021	2	-6.0356 to 2.8313	-2.2721 to -0.9931	-2.2721 to -1.1758
Tha	17	-0.4178	16	-1.3354 to 0.4997	-0.8173 to -0.0750	-0.8395 to -0.1052
Zos	29	-1.8371	28	-2.5160 to -1.1582	-2.5940 to -1.1430	-2.6029 to -1.1429

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	89.9548	62	0.01169

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-1.4390	-1.8885 to -0.9895	-1.9502 to -0.9418	-1.9717 to -0.9444

Sqrt Pooled Variance = 1.4782, Mean Study Variance = 1.0000 Ratio = 1.4782

Figure S1a Temperature ranking

Weighted analysis

Estimate of pooled variance: 0.6755

--Heterogeneity--

Class	#Studies	PooledVar
1	20	0.7350
2	13	0.9986
3	8	1.3656
4	18	0.3547

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	3	14.1761	0.00268	0.007
Within	55	76.8129	0.02764	
Total	58	90.9890	0.00367	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
1	20	-1.8019	19	-2.3837 to -1.2201	-2.3418 to -1.2910	-2.3414 to -1.2887
2	13	-0.6586	12	-1.3417 to 0.0246	-1.3953 to -0.0980	-1.4091 to -0.1023
3	8	-0.8235	7	-1.7770 to 0.1299	-2.0362 to 0.0544	-2.0961 to 0.0093
4	18	-0.4897	17	-0.9850 to 0.0056	-0.9285 to -0.1397	-0.9608 to -0.1603

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	90.9890	58	0.00367

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.9276	-1.2183 to -0.6368	-1.2603 to -0.6207	-1.2546 to -0.6185

Sqrt Pooled Variance = 0.8219; Mean Study Variance = 0.9132 Ratio = 0.9000

Unweighted analysis

Estimate of pooled variance: 2.7243

--Heterogeneity--

Class	#Studies	PooledVar
1	20	3.3103
2	13	4.5306
3	8	3.6950

4	18	0.3947

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	3	6.8667	0.07627	0.088
Within	55	55.0000	0.47464	
Total	58	61.8667	0.33982	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
1	20	-2.2470	19	-3.1503 to -1.3437	-3.2112 to -1.5068	-3.4025 to -1.5736
2	13	-1.3671	12	-2.5333 to -0.2010	-2.7354 to -0.3330	-2.9219 to -0.4297
3	8	-1.4314	7	-3.0448 to 0.1820	-2.9836 to -0.1340	-3.1272 to -0.2157
4	18	-0.6073	17	-1.5670 to 0.3523	-1.1949 to -0.1052	-1.2764 to -0.1384

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	61.8667	58	0.33982

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-1.4423	-1.9453 to -0.9394	-1.9570 to -0.9465	-2.0090 to -0.9870

Sqrt Pooled Variance = 1.6505; Mean Study Variance = 1.0000 Ratio = 1.6505

Figure S1b continuous Latitude

Weighted analysis

Estimate of pooled variance: 0.7690

Predictor	Value	SE	Prob(Norm)	Prob(Rand)
Intercept	0.2230	0.4470	0.61798	0.001
Slope	-0.0314	0.0113	0.00547	0.005

Model	df	Q	Prob(Chi-Square)
Regression	1	7.7174	0.00547

Residual	57	78.4326	0.03141
Total	58	86.1500	0.00962

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	86.1500	58	0.00962

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.9458	-1.2484 to -0.6431	-1.2680 to -0.6370	-1.2707 to -0.6414

Sqrt Pooled Variance = 0.8769; Mean Study Variance = 0.9132 Ratio = 0.9603

Unweighted analysis

Estimate of pooled variance: 2.7663

Predictor	Value	SE	Prob(Norm)	Prob(Rand)
Intercept	0.0978	0.7949	0.90203	0.023
Slope	-0.0389	0.0191	0.04099	0.023

Model	df	Q	Prob(Chi-Square)
Regression	1	4.1764	0.04099
Residual	57	57.0000	0.47509
Total	58	61.1764	0.36265

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	61.1764	58	0.36265

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-1.4423	-1.9481 to -0.9365	-1.9751 to -0.9787	-2.0158 to -1.0168

Sqrt Pooled Variance = 1.6632; Mean Study Variance = 1.0000 Ratio = 1.6632

Figure S1c Depth

Weighted analysis

Estimate of pooled variance: 0.8369

Predictor	Value	SE	Prob(Norm)	Prob(Rand)
Intercept	-1.1581	0.1991	0.00000	0.020
Slope	-0.2650	0.1650	0.10818	0.001

Model	df	Q	Prob(Chi-Square)
Regression	1	2.5807	0.10818
Residual	57	80.4264	0.02219
Total	58	83.0070	0.01730

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	83.0070	58	0.01730

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.9579	-1.2689 to -0.6469	-1.3146 to -0.6666	-1.3159 to -0.6658

Sqrt Pooled Variance = 0.9148, Mean Study Variance = 0.9132 Ratio = 1.0018

Unweighted analysis

Estimate of pooled variance: 2.8337

Predictor	Value	SE	Prob(Norm)	Prob(Rand)
Intercept	-1.7654	0.3141	0.00000	0.012
Slope	-0.4643	0.2637	0.07823	0.012

Model	df	Q	Prob(Chi-Square)
Regression	1	3.1014	0.07823
Residual	57	57.0000	0.47509
Total	58	60.1014	0.39953

SUMMARY RESULTS

Heterogeneity	df	Prob(Chi-Square)
Qtotal 60.1014	58	0.39953

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-1.4423	-1.9526 to -0.9320	-1.9393 to -0.9659	-1.9446 to -0.9748

Sqrt Pooled Variance = 1.6834, Mean Study Variance = 1.0000 Ratio = 1.6834

Figure S1d Experiment design; field *vs.* laboratory

Weighted analysis

Estimate of pooled variance: 0.5898

--Heterogeneity--

Class	#Studies	PooledVar
field	34	0.3937
lab	26	1.4774

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	1	24.6911	0.00000	0.001
Within	58	73.8247	0.07865	
Total	59	98.5158	0.00096	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
field	34	-0.4601	33	-0.7982 to -0.1221	-0.7820 to -0.1764	-0.7639 to -0.1568
lab	26	-1.9646	25	-2.4859 to -1.4432	-2.6307 to -1.4161	-2.6904 to -1.4325

SUMMARY RESULTS

Heterogeneity	df	Prob(Chi-Square)
Qtotal 98.5158	59	0.00096

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.9131	-1.1910 to -0.6352	-1.2528 to -0.6163	-1.2470 to -0.6115

Sqrt Pooled Variance = 0.7680, Mean Study Variance = 0.9539 Ratio = 0.8051

Unweighted analysis

Estimate of pooled variance: 1.9253

--Heterogeneity--

Class	#Studies	PooledVar
field	34	-0.0381
lab	26	4.5170

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	1	25.0767	0.00000	0.001
Within	58	58.0000	0.47530	
Total	59	83.0767	0.02114	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
field	34	-0.5076	33	-1.1044 to 0.0892	-0.8573 to -0.1795	-0.8529 to -0.1671
lab	26	-2.7389	25	-3.4298 to -2.0481	-3.6541 to -1.9025	-3.7727 to -1.9532

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	83.0767	59	0.02114

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-1.4745	-1.9164 to -1.0327	-2.0153 to -0.9872	-1.9651 to -0.9580

Sqrt Pooled Variance = 1.3875, Mean Study Variance = 1.0000 Ratio = 1.3875

Figure S1e Experiment design; addition *vs.* removal

Note: A few experiments included both an addition or removal treatment (contributing with >1 $d_{experiment}$). A = compare additions to plots without seagrass, R = compare removals to plots with seagrass, AR = compare addition plots to removal plots.

Weighted analysis

Estimate of pooled variance: 0.7239

--Heterogeneity--

Class	#Studies	PooledVar
A	40	0.9883

AR	3	-0.2385
R	20	0.4083

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	2	16.1460	0.00031	0.005
Within	60	75.0879	0.09077	
Total	62	91.2338	0.00922	

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
A	40	-1.3577	39	-1.7381 to -0.9774	-1.8209 to -0.9876	-1.7669 to -0.9530
AR	3	-1.5223	2	-4.7604 to 1.7158	-2.1539 to -0.6844	-2.0990 to -0.6844
R	20	-0.1815	19	-0.6682 to 0.3052	-0.5379 to 0.1744	-0.5787 to 0.1537

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	91.2338	62	0.00922

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-0.9155	-1.2025 to -0.6286	-1.2157 to -0.6372	-1.2140 to -0.6335

Sqrt Pooled Variance = 0.8508, Mean Study Variance = 0.8947 Ratio = 0.9510

Unweighted analysis

Estimate of pooled variance: 2.1680

--Heterogeneity--

Class	#Studies	PooledVar
A	40	3.4522
AR	3	-0.3531
R	20	-0.2026

Model	df	Q	Prob(Chi-Square)	Prob(Rand)
Between	2	14.3930	0.00075	0.007
Within	60	60.0000	0.47572	

Total	62	74.3930	0.13450

--Mean Effect Sizes--

Class	#Studies	E+	df	95% CI	Bootstrap CI	Bias CI
A	40	-1.9989	39	-2.5681 to -1.4296	-2.6736 to -1.4105	-2.7236 to -1.4262
AR	3	-1.6080	2	-6.0296 to 2.8135	-2.1539 to -0.6844	-2.1539 to -0.6844
R	20	-0.1525	19	-0.9856 to 0.6805	-0.5257 to 0.1976	-0.5455 to 0.1941

SUMMARY RESULTS

Heterogeneity		df	Prob(Chi-Square)
Qtotal	74.3930	62	0.13450

Mean Effect Size		95% CI	Bootstrap CI	Bias CI
E++	-1.3941	-1.8424 to -0.9458	-1.9155 to -0.9507	-1.9177 to -0.9527

Sqrt Pooled Variance = 1.4724, Mean Study Variance = 1.0000 Ratio = 1.4724

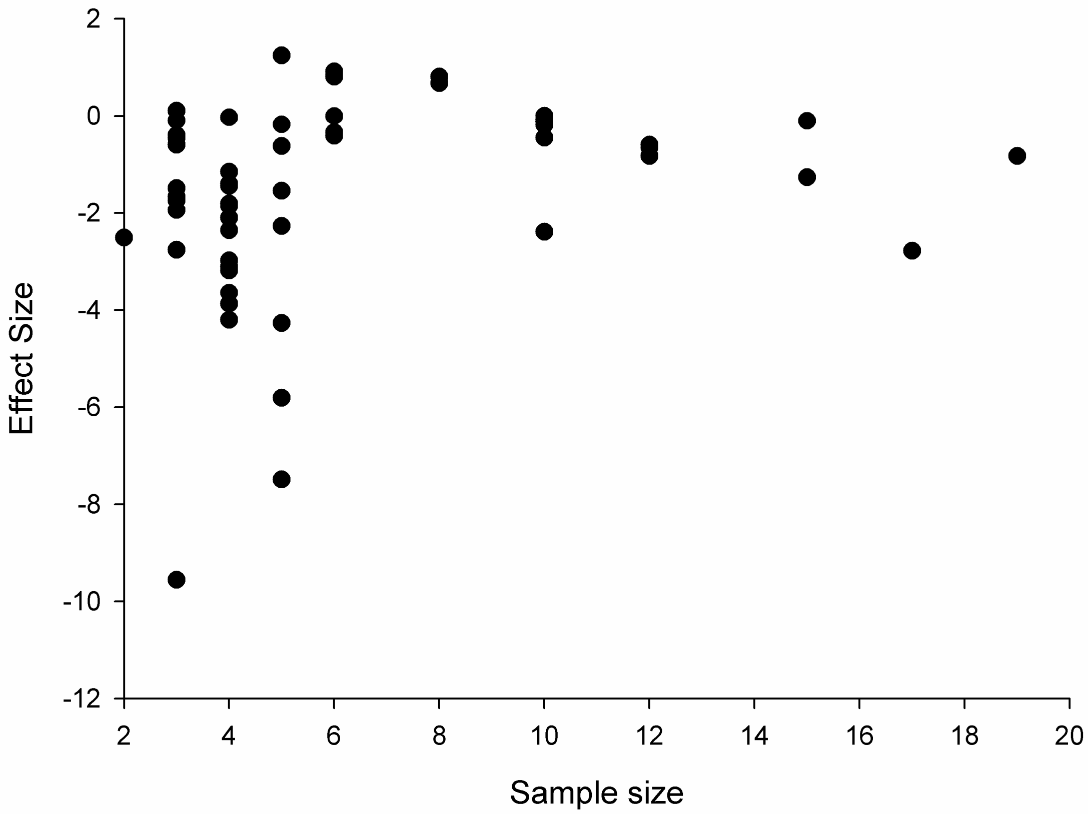
Appendix S4. Publication bias

Methods

We examined publication bias from funnel and normal quantile plots and tested for robustness of our results against potential publication bias by calculating weighted Rosenthal's fail-safe number [1]. Bias analysis was conducted in MetaWin 2.0 [1] on the average Hedges *d* effect size per experiment (n = 59 experiments).

Results and Discussion

The funnel plot indicated a weak tendency for smaller sample sizes to be associated with stronger negative effects (Fig. S2). Experiment with small samples sizes had highest data variability. A normal quantile plot showed that standardized effect sizes followed normal-assumptions with no major deviations from linearity or 'major data jumps' suggesting that publication bias is minor. However, the rank correlation tests suggested minor publication bias (Kendall tau = 0.183, Z = 2.046, p = 0.045, Spearman Rank r^2 = 0.323, p = 0.019). The weighted fail-safe numbers showed that 2360 non-significant studies would have to be added to the analysis to change the statistical significance of the observed main effect. This indicates that even if the publication bias against small and non-significant effects occurs, the results of our main meta-analyses is reasonable robust and unlikely to be influenced by publication bias. Also, these results suggest that studies with small sample sizes are more likely to produce extreme results than studies with larger sample sizes. We see no particular reason why some seagrass/seaweed tests attributes (see manuscript) should have a higher proportion of bias than any other, i.e., even if minor publication bias exist, this will likely be relatively similar between test attributes (and thereby not change differences between effect sizes for different test-attributes).



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Appendix S5: List of research gaps in seaweed-seagrass interaction studies

Addressing gaps 1-12 will provide much-needed information to build conceptual frameworks and quantitative models to predict seaweed impact and counteract adverse effects. Gaps 1-6 reflect how seaweeds impact seagrasses (the main topic of this review), whereas gaps 7-12 address the important broader ecologic context of seaweed-seagrass interactions (which should be addressed in future reviews). It is important to limit co-variation issues and identify individual attributes used in any impact study (gaps 1-6).

Research gap	Reasoning and examples.
1. Data bias	Most studies have been conducted in the North Atlantic, at shallow depth, in small plots and on short time scales (Appendix S1). Such bias should be addressed to provide a representative and comprehensive understanding of seaweed impacts on seagrasses across biogeographical regions and between depth strata. For example, [1] is the only study to have tested for impact in the South West Pacific, [2] is the only to have conducted experiments deeper than 5 m, and [3] is the only to have conducted experiments in plots larger than 3 m^2.
2.Attribute types	Not a single impact attribute (Table 1) has yet been addressed adequately (cf. gaps 1, 3-6). Although tedious, this task is relatively straightforward to address. For example, impacts can be quantified between many different time periods [4] or many different plot sizes [5]. It is important to avoid seaweed loss in the long-term/large-plots, and ensure that the experiment does not enter seasons where impacts may be low due to co-varying attributes. It is also important to manipulate more seagrass attributes to understand how seagrasses respond to and persists under stress. For example, clonal integration and resource-sharing may modify impact, and it may therefore be vital to conserve large non-fragmented beds. Perhaps small and opportunistic seagrass species can adapt to localized seaweed stress by rapid re-colonization from adjacent clones whereas larger species simply may outlive the seaweed stress via translocation of resources. Experiments that manipulate resource sharing (e.g., by cutting seagrass rhizomes) should be useful to test these hypotheses.
3.Attribute levels	Many experiments have been conducted with binary designs comparing a single control to a single treatment. This design conflates and confuses impact attributes (see [6], for detailed discussion). A minimum of 3 test levels (control included) are needed to identify attributes and >3 levels are needed to identify thresholds, non-linearity and to compare impact-curve-shapes. Multi-level tests are vital to model impact. See the Appendix S1 (column; "experimental design") for list of treatment levels used in published papers. Only one study applied more >4 levels for any impact attribute [7] making it virtually impossible to compare and evaluate impact-curves.
4.Modifying habitat-attributes	Seaweed and seagrass impacts attributes are modified by seagrass-habitat attributes, such as resource levels (e.g. nutrients, light, CO_2, O_2, space), abiotic conditions (e.g. temperature, salinity, desiccation, hydrodynamic energy, sedimentation, substrate conditions, day-length) and resident animals living in or around the seagrass habitat (e.g. grazers, filter feeders, predators). Manipulations of seagrass and seaweed attributes should therefore be crossed with manipulations of seaweed and seagrass attributes to target separate and combined effects of seaweed and seagrass attributes (see also Gap 6). Experimental data were inadequate to address modifying habitat-attributes with meta-analysis. See [8,9] for published examples on modifying effects of temperature and Appendix S2 for preliminary meta-analytical examples of temperature, depth and latitude effects.

5.Attribute dynamics	Most impact attributes do not only depend on its ‘mean’ value (e.g. average seaweed abundance), but change over time. For example, the abundance of temperate seaweeds typically shows a strong seasonal pattern (a winter low), and even attributes like ‘attachment status’ can change, e.g., if an epiphyte dislodge and accumulate in the drift mat. Experiments should address these more realistic stress-scenarios by directly manipulating and controlling the dynamics of attributes (means, medians, minimums, maximums, and temporal changes) [10].
6.Attribute interactions	Attributes do not function in isolation, but interact in nature. Factorial experiments are needed to quantify such interactions between seaweed and seagrass attributes (Fig. 3), with modifying habitat-attributes, and with additional anthropogenic stressors. Only a few studies have tested for interactions between seaweed abundance and a second impact attribute (Appendix S1); for example, [11] tested if animals interact with seaweeds and [8] showed that seaweed impact depends on temperature.
7.Competition mechanisms	The easy-to-identify attributes (Table 1) are associated with potentially more complex underlying impact mechanisms. Novel manipulations are needed to test *how* light, nutrients, oxygen, CO_2, space, SH_2, NH_4, and allelochemicals (derived from the seaweed and seagrass) influence the competitive hierarchies. For example, seaweed associated SH_2 [12,13] and allelochemicals [14] can be underlying causes of seagrass inhibition. It may also be that in some cases mutualism, rather than competition, occur, e.g. in the high intertidal zone to reduce photo-inhibition and desiccation, to reduce sediments instability [15], by reducing grazing pressures or by facilitating dispersal ([16].
8.Recovery trajectories	It is important also to document if and how seagrass recover following release of the seaweed stress. For example, 1.5 year after seaweeds were removed, biomass and short shoots were still only half of the non-impacted control [17]. This information is of obvious importance for managers, as recovery mechanisms may be facilitated, e.g. via protecting seedlings or planting nursery species.
9.Reciprocal effects	Reciprocal impacts of the seagrass on the seaweed need to be documented. For example, seagrasses that have strong negative effects on seaweeds may only experience short-term impact before the seaweed is out-competed. Some seagrass species may also be strong seaweed facilitators by providing superior conditions for seaweed attachment or entanglement. A few studies have tested for reciprocal effects, so far documenting only minor negative effects on rooted seaweeds [2,18,19,20].
10.Ecosystem effect	To understand the full range of impacts of seaweeds, broader ecological effects should be documented. For example, seaweed may function as an alternative habitat for seagrass fauna that may be essential, substitutable, complimentary, antagonistic or inhibitory compared to the seagrass habitat [21,22]. Seaweeds impact not only seagrass performances, but also the suitability of the habitat for fauna, ecosystem metabolism and productivity; seaweeds likely affect energy and matter flows and modulate ecosystem subsidies to adjacent habitats.
11. Manipulative *vs.* mensurative experiments	Manipulative experiments (small scale, short time, mechanistic understanding, and simulating early blooming effects) should be compared to supplementary analysis of mensurative data (large scale, long time, pragmatic understanding, late blooming effects). For example, it may be useful to evaluate epiphyte effects that have been studied in much more detail with mensurative designs [23,24,25].
12. Broad ecological context	Additional insight may be gained by comparing seaweed effects on different habitat formers (e.g. salt marshes, [26], seaweed forests [27,28], oyster reefs [29] and coral reefs [30,31] or weed impacts in terrestrial systems [32,33] or impacts of invasive species [6]. For example, fast growing seaweeds, terrestrial weeds and invasive species all exhibit similar boom-and-burst population dynamics (indeed, 6 of reviewed studies tested for impact on invasive seaweeds, cf. Appendix S1).

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Appendix S6: Prisma Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3-4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4-5, Appendix S1
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	4-5, Appendix S1
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	4-5

Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	4-5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5-6
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	4-5, Appendix S1
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Appendix S4
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6-7
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	6-7

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	Appendix S4
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	6, Appendix S3
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	4, Appendix S1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Appendix S1
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Appendix

			S4
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Appendix S3
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	7-8
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Appendix S4
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	6 Appendix S3
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	8
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	8-11
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	12
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	13

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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