

Online supplement S1: The devil in the detail: harmful seaweeds are not harmful to everyone

*Mads S. Thomsen, Thomas Wernberg

*mads.solgaard.thomsen@gmail.com

Table S1. Hedge's g effect sizes used in the analyses for functional matching and density dependency [extracted from Fig. S3.5 in 1]. To ensure causality between seaweeds and responses, only manipulative experiments were included. Effect sizes (ES#) 1-18 and 19-27 were classified as samples collected 'below the seaweed' or 'including the seaweed structure itself', respectively. Meta-analyses were conducted in Meta-win 2.0 following the procedures of Thomsen et al. [2]; i.e., we interpreted factorial and nested experiments as multiple independent experiments, compared the most extreme contrast from multiple-density experiments, calculated bias-corrected confidence limits, and ran un-weighted analyses. See footnotes for further details.

Experiment	Hedge's	
	ES#	g
Franz & Friedman 2002 Addition [3]	1	-1.03
Franz & Friedman 2002 Removal [3]	2	-0.56
Gamenick et al. 1996 [4]	3	-3.69
Lewis et al. 2003 [5]	4	-1.90
Norkko & Bonsdorff 1996 [6]	5	-0.39
Österling & Pihl 2001 Exp 1 [7]	6	-0.74
Österling & Pihl 2001 Exp 2 [7]	7	-2.29
Rossi 2006 Site 1 [8]	8	-2.32
Rossi 2006 Site 2 [8]	9	0.32
Rossi 2006 Site 3 [8]	10	-2.13
Sundbäck et al 1996 Exp a [9]	11	-0.78
Sundbäck et al 1996 Exp b [9]	12	-0.90
Sundbäck et al 1996 Exp c [9]	13	-1.55
Sundbäck et al 1996 Exp e [9]	14	-0.40
Thomsen & McGlathery 2006 Currents [10]	15	-0.33*
Thomsen & McGlathery 2006 Protected [10]	16	-1.51*
Thomsen & McGlathery 2006 Waves [10]	17	-2.68*
Wetzel et al. 2002 [11]	18	-0.23
Aarnio & Mattilda 2000 Exp 1 [12]	19	7.49
Aarnio & Mattilda 2000 Exp 2 [12]	20	2.09
Bolam et al. 2000 [13]	21	3.38

Bolam & Fernandez 2002 [14]	22	4.49
Deegan et al 2002 [15] Max	23	1.40*
Holmquist 1997 [16]	24	10.10
Thomsen 2010 Deep Max [17]	25	1.60*
Thomsen 2010 Shallow Max [17]	26	0.61*
Thomsen et al. 12 Max [18]	27	2.44*

Footnotes

1. Hedge's g effect sizes marked with * varied slightly from Lyons et al 2014 because we used slightly different data pooling procedures (see below for details).
2. Experiments marked '**Max**' included multiple seaweed-densities (and reported standard errors) and were used to test the density hypothesis. These experiments reported the following percent difference in invertebrate abundances between low vs. high seaweed treatments: (1) Deegan et al. 2002 **Max** = 213% (extracted from their Fig. 3, Ambient = 7.52, High = 16.07), (2) Thomsen 2010 Deep **Max** = 189% (from Fig. 1a, Low = 18.9, High = 35.9), Thomsen 2010 Shallow **Max** = 165% (from Fig. 1a, Low = 20.8, High = 34.6), and Thomsen et al. 2012 **Max** = 138% (from Fig. 3a, Low = 6533, High = 9026) (cf. footnotes #23 and #25-27 below for details).
3. We excluded two experimental studies included in Lyon et al. 2014 Fig. S3.5; Lavery et al. 1999 and Cummins et al. 2004. Lavery et al. 1999 was excluded because *more* (not less) seaweed were quantified *in the seaweed-removal treatments* compared to the controls at the final sampling event (Fig. 2; Recovery Treatment) making interpretations of habitat-associated effects problematic. This experiment provided qualitative support for the functional-matching hypothesis because high epifaunal densities were reported in the presence of seaweed mats (After' treatment) as concluded in the study ("the trend in epifaunal density mirrored the trends in macrophyte biomass"). Cummins et al. 2004 was excluded because this study, in contrast to the other analyzed studies, did not report impact on community abundances, but instead reported impact on 9 specific species. Summing abundances of these 9 species showed more invertebrates in the seaweed addition treatments than the controls (Cummins et al 2004, Fig. 4), providing additional support to the functional matching hypothesis (largely caused by strong facilitation of the gastropod *Potamopyrgus antipodarum*).
4. ES#1-2. Effects were reported on an infaunal copepod community. The addition experiment included a density tests with two addition levels - but we could not identify standard errors on any impacts and could therefore not re-calculate effect sizes. Seaweed-associated copepods were also sampled (separately) providing additional qualitative support to both the functional matching and density-dependency hypotheses (e.g. Fig. 4D show increasing abundances of specific copepod species at increasing seaweed levels).
5. ES#3. Fauna was quantified from sediment cores. We also note that (i) *Fucus* normally is considered a slow-growing canopy-former that provide habitat for a rich flora and fauna, (ii) that this particular decomposing mat was created by special hydrodynamic conditions, and (iii) that none of the abundant fauna normally associated with *Fucus* (isopods, snails, amphipods) were reported (supporting our classification that only infauna was sampled).
6. ES#4. Infauna was sampled using a 10 cm diameter core.
7. ES#5. Fauna was quantified as changes in zoobenthic community structure under the seaweed. It was explicitly stated that seaweed mats were removed prior to sampling.

8. ES#6-7. Effects were reported on nematode communities on sediment core samples (0.01 m²) taken under each net-bag (net-bag contained seaweeds). Furthermore it was stated that “meiofauna was extracted from the sediment“
9. ES#8-10. These effect sizes represent a decomposition impact experiment, i.e. it was the only experiment that tested for impact of buried dead seaweed. Only infauna was sampled (e.g., it was stated that “*Ulva* was buried in the sediment”, “freezing could ensure that *Ulva* was dead”, and “cores of sediment was taken”).
10. ES#11-14. Meiofaunal communities were sampled from cores. Furthermore in Exp a, the seaweed was physically separated from the sediment by a PVC tube, whereas in Exp b-d, green seaweeds were kept afloat by bubbling (i.e. the seaweed was separated from the sediment).
11. ES#15-17. Effects were reported on sessile species recruiting onto settlement plates beneath (not including) the seaweeds. Lyons et al. 2014 reported a single effect size (-0.76) that was in the same direction as the three independent effect sizes we here report from this (2×3 factorial) experiment.
12. ES#18. Quantitative sampling of meiofauna was extracted from the sediment. Samples were taken separately from the seaweed mat, but abundances of these seaweed-associated meiofauna were not quantified.
13. ES#19-20. Seaweed-associated animals were probably sampled because Aarni & Mattilda stated that “all animals in the algae was counted”, noting that “*Hydrobia* moved into alga“.
14. ES#21. It is less clear if seaweed-associated animals were sampled in this experiment, but Bolam et al. conclude that “epibenthic gammarids increased“ (if only in-fauna was sampled this could not have been concluded). Still, if we re-classified this particular effect size, only the magnitude, not direction or significance, changed [re-tests; below-seaweed fauna = -1.04, Df. = 18, 95% 95% CL = -1.59 to -0.29 vs. fauna included in seaweeds = 3.77, Df = 7, 95% CL = 1.99 to 6.35].
15. ES#22. Seaweed-associated fauna were sampled because it was impossible to sample the sediments without the seaweed (“the fine filaments of *V. subsimplx* are found in close association with the sediment and so could not be removed when sampling the macrofauna“).
16. ES#23. Effects was reported on macro-epifauna (no infauna was sampled in this study). We quantified effects by comparing the highest ('High' = addition treatment) vs. the lowest seaweed density ('Low' = removals) to document a positive effect of seaweeds (Fig. 3, top-right plot). This effect size differed in direction to Lyons et al. (-0.27). We also note that the medium seaweed levels ('controls' = ambient levels) contained more epifauna than the lowest seaweed levels, thereby also documenting a positive effect of seaweeds.
17. ES#24. Holmquist 1997 stated that “animals associated with both seagrass and algae were sampled“.
18. ES#25-26. Thomsen 2010 stated that “algae, seagrass and macro-invertebrates above the sediment surface (i.e. not including the infauna) were collected“. Lyons et al. 2014 reported a single effect size (0.72) from this factorial density-experiment, but in the same direction (positive effects). We calculated effect sizes by comparing the highest ('High') vs. the lowest seaweed density ('Control'), for each Depth-experiment.
19. ES#27. Effects were reported on “seagrass associated“ fauna and was discussed in a density-dependency context for fauna that mainly inhabited the seaweed, the seagrass, the sediment surface, or the sediment, respectively. We calculated effect sizes by comparing the highest

('High') vs. the lowest seaweed density ('Control') (Lyons et al.'s 2014 single reported effect size was very similar; = 2.2).

References

1. Lyons, D.A., et al., *Macroalgal blooms alter community structure and primary productivity in marine ecosystems*. *Global Change Biology*, 2014. **20**(9): p. 2712-2724.
2. Thomsen, M.S., et al., *Impacts of marine invaders on biodiversity depend on trophic position and functional similarity*. *Marine Ecology Progress Series*, 2014. **495**: p. 39-47.
3. Franz, D.R. and I. Friedman, *Effects of a macroalgal mat (Ulva lactuca) on estuarine sand flat copepods: an experimental study*. *Journal of Experimental Marine Biology and Ecology*, 2002. **271**: p. 209-226.
4. Gamenick, I., et al., *Hypoxia and sulphide as structuring factors in a macrozoobenthic community on the Baltic Sea shore: colonisation studies and tolerance experiments*. *Marine ecology progress series*, 1996. **14**(1): p. 73-85.
5. Lewis, L.J., J. Davenport, and T.C. Kelly, *Responses of benthic invertebrates and their avian predators to the experimental removal of macroalgal mats*. *Journal of the Marine Biological Association of the UK*, 2003. **83**(01): p. 31-36.
6. Norkko, A. and E. Bonsdorff, *Rapid zoobenthic community responses to accumulations of drifting algae*. *Marine Ecology Progress Series*, 1996. **131**(1-3): p. 143-157.
7. Osterling, M. and L. Pihl, *Effects of filamentous green algal mats on benthic macrofaunal functional feeding groups*. *Journal of Experimental Marine Biology and Ecology*, 2001. **263**: p. 159-183.
8. Rossi, F., *Small-scale burial of macroalgal detritus in marine sediments: Effects of Ulva spp. on the spatial distribution of macrofauna assemblages*. *Journal of Experimental Marine Biology and Ecology*, 2006. **332**(1): p. 84-95.
9. Sundbäck, K., et al., *Response of benthic microbial mats to drifting green algal mats*. *Aquatic Microbial Ecology*, 1996. **10**: p. 195-208.
10. Thomsen, M.S. and K. McGlathery, *Effects of accumulations of sediments and drift algae on recruitment of sessile organisms associated with oyster reefs*. *Journal of Experimental Marine Biology and Ecology*, 2006. **328**(1): p. 22-34.
11. Wetzel, M., A. Weber, and O. Giere, *Re-colonization of anoxic/sulfidic sediments by marine nematodes after experimental removal of macroalgal cover*. *Marine Biology*, 2002. **141**(4): p. 679-689.
12. Aarnio, K. and J. Mattila, *Predation by juvenile Platichthys flesus (L.) on shelled prey species in a bare sand and a drift algae habitat*, in *Island, Ocean and Deep-Sea Biology*. 2000, Springer. p. 347-355.
13. Bolam, S.G., et al., *Effects of macroalgal mats on intertidal sandflats: an experimental study*. *Journal of Experimental Marine Biology and Ecology*, 2000. **249**(1): p. 123-137.
14. Bolam, S. and T. Fernandes, *The effects of macroalgal cover on the spatial distribution of macrobenthic invertebrates: the effect of macroalgal morphology*. *Hydrobiologia*, 2002. **475/476**: p. 437-448.
15. Deegan, L.A., et al., *Nitrogen loading alters seagrass ecosystem structure and support of higher trophic levels*. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 2002. **12**: p. 193-212.

16. Holmquist, J.G., *Disturbance and gap formation in a marine benthic mosaic - influence of shifting macroalgal patches on seagrass structure and mobile invertebrates*. Marine Ecology Progress Series, 1997. **158**: p. 121-130.
17. Thomsen, M.S., *Experimental evidence for positive effects of invasive seaweed on native invertebrates via habitat-formation in a seagrass bed*. Aquatic Invasions, 2010. **5**: p. 341-346.
18. Thomsen, M.S., et al., *Harmful algae are not harmful to everyone*. Harmful Algae, 2012. **16**: p. 74-80.