The following supplements accompany the article

Positive feedback between large-scale disturbance and density-dependent grazing decreases resilience of a kelp bed ecosystem

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Supplement 1: Additional Tables and Figures

Fig. S1. Illustration of the dimensions of circular experimental plots from the kelp-thinning experiment at Duncan's Cove Protected in June/July 2013 consisting of a sub-plot within a larger one. The spatial arrangement of kelp thalli within thinned and control plots is shown. Dark brown thalli indicate individuals that were identified at the start of the experiment and on which grazing damage was measured at the end. Light brown thalli indicate unmarked individuals in control plots.

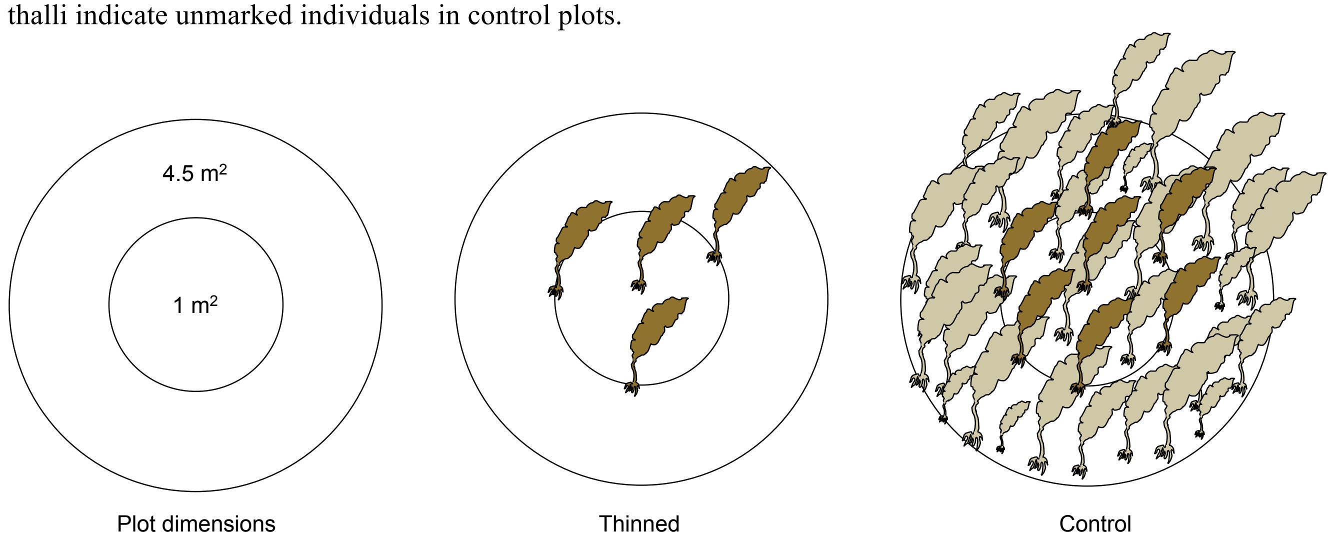

Table S1. Estimated parameters from linear regressions of dry weight against wet weight of blade and stipe (including holdfast) tissue of *Saccharina latissima* and *Laminaria digitata* from 6 sites (Cranberry Cove- CC, Duncan's Cove Exposed- DE, Duncan's Cove Protected- DP, The Lodge- TL, Splitnose Point- SP, Paddy's Head- PH) and 5 sampling periods. na: not available; parameters taken from Mann 1972.

Site	Sampling Period	Tissue	*S. latissima*	R^2	DF	*L. digitata*	R^2	DF
CC	Sep 2008	Blade	y = 0.200x	0.990	20	y = 0.214x	na	na
		Stipe	y = 0.297x	0.918	22	y = 0.124x	na	na
DE	Sep 2008	Blade	y = 0.149x	0.970	10	y = 0.159x	0.974	15
		Stipe	y = 0.155x	0.986	10	y = 0.211x - 0.288	0.996	12
DP	Sep 2008	Blade	y = 0.189x	0.987	9	y = 0.200x	0.994	14
		Stipe	y = 0.190x	0.970	9	y = 0.165x	0.992	15
TL	Sep 2008	Blade	y = 0.153x	0.988	15	y = 0.208x	0.996	13
		Stipe	y = 0.168x	0.972	15	y = 0.205x	0.996	12
SP	Sep 2008	Blade	y = 0.146x	0.973	12	y = 0.166x	0.981	15
		Stipe	y = 0.146x	0.991	11	y = 0.133x	0.847	14
CC	Sep 2009	Blade	y = 0.183x	0.985	18	y = 0.214x	na	na
		Stipe	y = 0.339x - 2.18	0.926	12	y = 0.124x	na	na
DE	Sep 2009	Blade	y = 0.160x	0.991	15	y = 0.175x	0.990	13
		Stipe	y = 0.214x	0.870	16	y = 0.181x	0.978	13
DP	Sep 2009	Blade	y = 0.192x	0.994	12	y = 0.176x	0.993	14
		Stipe	y = 0.172x	0.985	12	y = 0.152x	0.989	14
TL	Sep 2009	Blade	y = 0.174x	0.980	13	y = 0.189x	0.986	11
		Stipe	y = 0.168x	0.925	12	y = 0.218x	0.992	11
SP	Sep 2009	Blade	y = 0.131x	0.990	12	y = 0.180x	0.992	16
		Stipe	y = 0.157x	0.985	10	y = 0.161x	0.976	12
PH	Jul 2012	Blade	y = 0.230x	0.978	46	y = 0.230x	0.978	6
		Stipe	y = 0.160x	0.958	46	y = 0.217x	0.998	6
DP	Jun 2013	Blade	y = 0.156x	0.984	21	y = 0.125x	0.991	22
		Stipe	y = 0.129x	0.979	24	y = 0.165x	0.962	20
DP	Jul 2013	Blade	y = 0.250x - 0.283	0.948	29	y = 0.156x + 0.172	0.881	27
		Stipe	y = 0.165x	0.985	29	y = 0.177x	0.992	25

Literature cited

Mann KH (1972) Ecological energetics of the seaweed zone in a marine bay on the Atlantic Coast of Canada. I. Zonation and biomass of seaweeds. Mar Biol 12:1-10

Supplement 2: Description of methods for determining general shape of total response curves

Trexler et al. (1988) describe methods for determining the general shape of functional response data (i.e. type I, II, or III) based on analysis of predation rate using least squares regression following arcsine transformation or logistic regression if data are binary. This approach fits a phenomenological expression that characterizes the density dependence of the response expressed as a proportion rather than an amount consumed. In this form, the slope of the relationship near the origin is distinct between response types, and polynomial expressions (often quadratic or cubic) flexibly fit type II and III shapes (Juliano 2001). A model is selected by backward elimination starting with higher order expressions. A best-fitting model with a significant negative second-order term and positive first-order term indicates a region of positively density-dependent predation or grazing (i.e. type III response), while a negative first-order term indicates negative density dependence (i.e. type II response; Trexler et al. 1988, Juliano 2001). A non-significant slope indicates a density-independent response (i.e. type I; Trexler et al. 1988). Because this approach is phenomenological, serving only as a diagnostic tool for determining the general form of the response, it should be equally useful for determining the shape of total response curves, which also can be described as type I, II, or III.

To determine the shape of the total response of *Lacuna vincta* to kelp abundance, a cubic polynomial and all reduced models were fit to the proportion of blade area grazed (plot or site averages) against kelp biomass (within plot or site) for each data set using the lm function in R (R Core Team 2012) following arcsine transformation of proportion data. The biomass of both kelp species were combined for all analyses as there was no relationship between the abundance of each species across sites, and grazing intensity was positively correlated between species. The fit of higher-order polynomial models were compared to reduced models using partial F statistics. In all cases the best-fitting expression was a first-order model with negative slope, indicating that grazing was negatively density-dependent throughout all ranges of kelp biomass (type II total response; Tables S2 & S3).

Table S2. Partial F test results comparing the fit of polynomial expressions (third- to second-order; second- to first-order) describing the relationship of grazing intensity versus kelp biomass within a kelp bed for *Saccharina latissima* (Duncan's Cove Protected- DP) in 2013 and across sites for *S. latissima* and *Laminaria digitata* (Cranberry Cove- CC, Duncan's Cove Exposed- DE, DP, The Lodge- TL, Splitnose Point- SP) in 2008/2009. G: arcsine transformation of proportion of blade area grazed, B_k: combined kelp biomass of both species (g DW). SS_{extra} is the additional unexplained variation resulting from dropping a higher-order term from the model.

Data Source	Model	DF	RSS	SS_{extra}	F	P
DP 2013	*Saccharina latissima*					
	$G = \beta_0 + \beta_1(B_k) + \beta_2(B_k)^2 + \beta_3(B_k)^3$	8	7.35 x 10^{-3}			
	$G = \beta_0 + \beta_1(B_k) + \beta_2(B_k)^2$	9	7.97 x 10^{-3}	0.62 x 10^{-3}	0.674	0.436
	$G = \beta_0 + \beta_1(B_k)$	10	8.12 x 10^{-3}	0.15 x 10^{-3}	0.166	0.693
Site Averages 2008/2009	*Saccharina latissima*					
	$G = \beta_0 + \beta_1(B_k) + \beta_2(B_k)^2 + \beta_3(B_k)^3$	6	1.86 x 10^{-3}			
	$G = \beta_0 + \beta_1(B_k) + \beta_2(B_k)^2$	7	2.40 x 10^{-3}	0.54 x 10^{-3}	1.74	0.235
	$G = \beta_0 + \beta_1(B_k)$	8	2.46 x 10^{-3}	0.06 x 10^{-3}	0.186	0.679
Site Averages 2008/2009	*Laminaria digitata*					
	$G = \beta_0 + \beta_1(B_k) + \beta_2(B_k)^2 + \beta_3(B_k)^3$	4	2.48 x 10^{-3}			
	$G = \beta_0 + \beta_1(B_k) + \beta_2(B_k)^2$	5	4.29 x 10^{-3}	1.81 x 10^{-3}	2.92	0.163
	$G = \beta_0 + \beta_1(B_k)$	6	4.88 x 10^{-3}	0.59 x 10^{-3}	0.685	0.446

Table S3. Coefficient estimates and standard errors for best fitting polynomial expression describing the relationship of grazing intensity versus kelp biomass within a kelp bed for *Saccharina latissima* (DP) in 2013 and across sites for *S. latissima* and *Laminaria digitata* (CC, DE, DP, TL, SP; see Table S2 for site abbreviations) in 2008/2009. G: arcsine transformation of proportion of blade area grazed, B_k: combined kelp biomass of both species (g DW).

Data source	Species	Best fitting model	Estimate	SE	t	P
DP 2013	*S. latissima*	$G = \beta_0 + \beta_1(B_k)$	β_0 1.81 x 10^{-1} β_1 -6.83 x 10^{-5}	1.19 x 10^{-2} 2.58 x 10^{-5}	15.183 -2.649	< 0.001 < 0.05
Site Averages 2008/2009	*S. latissima*	$G = \beta_0 + \beta_1(B_k)$	β_0 9.86 x 10^{-2} β_1 -4.53 x 10^{-5}	1.03 x 10^{-2} 1.03 x 10^{-5}	9.564 -4.396	< 0.001 < 0.01
Site Averages 2008/2009	*L. digitata*	$G = \beta_0 + \beta_1(B_k)$	β_0 1.13 x 10^{-1} β_1 -4.73 x 10^{-5}	2.05 x 10^{-2} 1.86 x 10^{-5}	5.493 -2.542	< 0.01 < 0.05

Literature cited

Juliano SA (2001) Nonlinear curve fitting: predation and functional response curves. In: Scheiner SM, Gurevitch J (eds) Design and analysis of ecological experiments, 2nd ed. Oxford University Press, New York, p 178-196

R Core Team (2012) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/

Trexler JC, McCulloch CE, Travis J (1988) How can the functional response best be determined? Oecologia 76:206-214