

## Direct and indirect effects of climate change squeeze the local distribution of a habitat-forming seaweed

G. M. Martins\*, C. D. G. Harley, J. Faria, M. Vale, S. J. Hawkins, A. I. Neto, F. Arenas

\*Corresponding author: gustavomartins@aquazor.eu

Marine Ecology Progress Series - 626: 43–52 (2019)

**Table S1.** ANOVA comparing maximum frond length of *F. guiryi* among treatments (transplants, translocation and control) at two shores on each sampling time. \*  $P < 0.05$ , \*\*  $P < 0.01$ , \*\*\*  $P < 0.001$

Source	df	July		August		September		December	
		MS	<i>F</i>	MS	<i>F</i>	MS	<i>F</i>	MS	<i>F</i>
Treatment = T	2	16.86	0.06	7618.6	42.90*	9688.2	3.38	7811.1	2.20
Location = L	1	1190.25	2.63	23104.0	37.99***	11377.8	60.50***	14002.8	26.16***
T × L	2	279.25	0.61	177.6	0.29	2863.2	15.23***	3552.8	6.64**
Residual	30	453.13		608.1		188.1		535.3	
Cochran's		<i>C</i> = 0.30		<i>C</i> = 0.37		<i>C</i> = 0.48*		<i>C</i> = 0.66***	
Transformation		none		none		None		none	
SNK tests				T < PC = C		Santa Clara: T < PC = C Forno da Cal: T < PC = C		Santa Clara: T = PC = C Forno da Cal: T < PC = C	

**Table S2.** Proportion of *F. guiryi* individuals with signs of bleaching across the two locations (n = 50) at both the upper and lower shore.

Year	Month	High shore	Low shore
2013	10	0.00	0.00
	11	0.00	0.00
	12	0.00	0.00
2014	03	0.02	0.00
	04	1.00	0.00
	05	0.04	0.02
	06	0.00	0.00
	07	0.92	0.00
	08	0.00	0.00
	10	0.00	0.00
	11	0.00	0.00
2015	12	0.00	0.00
	01	0.00	0.00
	02	0.50	0.00
	03	0.50	0.00
	04	1.00	0.00
	06	1.00	0.00
	10	0.50	0.00

**Table S3.** PERMANOVA comparing maximum frond length of *F. guiryi* at different levels of the shore at two locations over 20 sampling dates.

Source	df	MS	F	P
Height = H	1	16811.0	29.54	<0.001
Location = L	1	461.6	21.35	<0.001
Time = T	19	58.4	2.70	0.021
H × L	1	435.8	16.74	0.002
H × T	19	134.1	5.15	<0.001
L × T	19	21.6	6.66	<0.001
H × L × T	19	26.0	8.02	<0.001
Residual	1924	3.2		

Pairwise comparisons among heights in each location and sampling time

	Santa Clara	Forno da Cal
Oct 13	lower shore < upper shore	lower shore < upper shore
Nov 13	lower shore < upper shore	lower shore < upper shore
Dez 13	lower shore < upper shore	lower shore < upper shore
Jan 14	lower shore < upper shore	lower shore < upper shore
Fev 14	lower shore < upper shore	lower shore < upper shore
Mar 14	lower shore < upper shore	lower shore < upper shore
Apr 14	lower shore < upper shore	lower shore < upper shore
May 14	Lower shore > upper shore	lower shore < upper shore
Jun 14	lower shore < upper shore	lower shore < upper shore
Jul 14	lower shore < upper shore	lower shore < upper shore
Aug 14	lower shore < upper shore	lower shore < upper shore
Oct 14	lower shore < upper shore	lower shore < upper shore
Nov 14	lower shore < upper shore	lower shore < upper shore
Dez 14	lower shore < upper shore	lower shore < upper shore
Jan 15	lower shore < upper shore	lower shore < upper shore
Fev 15	lower shore < upper shore	lower shore < upper shore
Mar 15	lower shore < upper shore	lower shore < upper shore
Apr 15	lower shore < upper shore	lower shore < upper shore
Jun 15	lower shore < upper shore	lower shore < upper shore
Oct 15	lower shore < upper shore	lower shore < upper shore

**Table S4.** ANOVA comparing (a) percentage cover, (b) number of reproductive structures per plot and (c) maximum frond length in *F. guiryi* among treatments (C – control, P – Procedural control, E – Exclusion). P-values as \* P < 0.05, \*\* P < 0.01, \*\*\* P < 0.001. § - Pooled term (P > 0.25, Underwood 1997). L – stands for location.

<b>(a) % cover</b>											
Source	df	April		June		July		August		September	
		MS	F	MS	F	MS	F	MS	F	MS	F
Location = L	2	870.56	5.74**	875.00	6.11**	1532.07	5.48**	1969.62	7.62**	1919.08	11.06***
Treatment = T	2	41.49	0.24	592.47	9.08 *	1245.27	4.45*	10852.69	23.45**	14868.36	27.57**
L × T	4	169.56	1.12	65.27	0.46	377.23	1.35§	462.86	1.79	539.29	3.11*
Residual	36	151.56		143.13		268.92		258.43		173.48	
Cochran's		C = 0.31		C = 0.24		C = 0.20		C = 0.30		C = 0.30	
Transformation		none		none		none		none		none	
SNK tests				C = P < E		C = P < E		C = P < E		Sta Clara: C = P < E Lagoa: C = P < E R. Taínhas: C = P < E	

  

<b>(b) Reproductive structures</b>											
Source	df	April		June		July		August		September	
		MS	F	MS	F	MS	F	MS	F	MS	F
Location = L	2	484.29	6.69**	866.87	12.68***	575.76	8.30**	341.69	7.10**	0.22	2.56
Treatment = T	2	25.09	0.61	117.80	1.18	984.69	21.62**	2969.09	7.44*	42.17	84.37***
L × T	4	41.46	0.57	99.67	1.46	45.56	0.66	399.16	8.29***	0.50	5.90***
Residual	36	72.34		68.37		69.36		48.12		0.08	
Cochran's		C = 0.21		C = 0.25		C = 0.34		C = 0.89**		C = 0.19	
Transformation		none		none		none		none		Ln (x + 1)	
SNK tests						C = P < E		Sta Clara: C = P < E Lagoa: C = P < E R. Taínhas: C = P < E		Sta Clara: C = P < E Lagoa: C = P < E R. Taínhas: C = P < E	

  

<b>(c) Maximum length</b>											
Source	df	April		June		July		August		September	
		MS	F	MS	F	MS	F	MS	F	MS	F
Location = L	2	5.60	2.71	0.02	0.01	19.36	8.18**	14.96	7.53**	8.82	6.73**
Treatment = T	2	3.80	1.90	19.09	7.88*	104.29	31.08**	150.24	491.69***	202.69	521.20***
L × T	4	2.00	0.97	2.42	1.18	3.36	1.42	0.31	0.15	0.39	0.30
Residual	36	2.07		2.06		2.37		1.99		1.31	
Cochran's		C = 0.19		C = 0.25		C = 0.26		C = 0.32		C = 0.31	
Transformation		none		none		none		none		none	
SNK tests				C = E		C = P < E		C = P < E		C = P < E	
				C = P		E > P					