The following supplement accompanies the article

Model to manage and reduce crown-of-thorns starfish outbreaks

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SUPPLEMENT

This supplement summarises the results of sensitivity analyses carried out to (1) test the robustness of model results to alternative model configurations, and (2) investigate the impact of using different values of COTS mortality (M) and different approaches to its estimation. Thus, the model was run under the following conditions:

(1) The base-case, estimating 7 parameters, including COTS natural mortality, M^{Cots};

(2) Including the estimation of extra parameters: the effect of fast- growing coral on COTS parameter 2 (Eq. 6a, Table 1), and separately estimating the effect of slow- growing coral on COTS parameter 2 (Eq. 6b, Table 1) (Table S1);

(3) Testing the sensitivity of the model to different values for M^{Cots}: a fixed value of $M^{\text{Cots}} = 2.1\ \text{yr}^{-1}$, and one with a fixed value of $M^{\text{Cots}} = 1.1\ \text{yr}^{-1}$ (Table S1);

(4) Testing the effect of assuming mortality is age-dependent, using a functional form where mortality at age a, M_a, is calculated from the mortality estimated by fitting the model (parameter ω) and scaled by a parameter (λ) that controls the difference between the mortality rates of younger and older animals (Eq. 10, Table 1). Parameter λ was fixed to values of 0.2 and 0.3, as well as estimated (Table S2)

Table S1. Comparison of negative log-likelihood (–nlL) and AIC model scores for 5 model configurations: (1) the base case model, (2) the estimation of extra parameters (p_2^f and p_2^m, separately), (3) fixed COTS natural mortality (M = 2.1 yr^{-1}, M = 1.1 yr^{-1})

	1. Base-case			2. Estimation of extra parameters						3. Fixing M					
Case				Estimating par p_2^f			Estimating par p_2^m			M = 2.1			M = 1.1		
Estimated parameters	Value	SD	CV	Value	SD	CV	Value	SD	CV	Value	SD	CV	Value	SD	CV
Initial number of 2+ COTS	0.505	0.119	0.24	0.495	0.189	0.382	0.441	0.129	0.292	1.000	0.056	0.06	1.000	0.057	0.06
Stock-recruitment residual for year 1994	4.307	0.378	0.09	4.198	0.475	0.113	4.299	0.403	0.094	4.275	0.550	0.13	4.084	0.554	0.55
Immigration for year 1996	4.292	0.352	0.08	4.176	0.456	0.109	4.284	0.376	0.088	4.568	0.552	0.12	4.610	0.623	0.55
Natural mortality (M)	2.560	0.146	0.06	2.519	0.250	0.099	2.631	0.169	0.064	2.100	fixed		1.100	fixed	
Effect of COTS on fast-growing coral par 1, p_1^f	0.129	0.041	0.32	0.117	0.042	0.360	0.131	0.046	0.352	0.132	0.126	0.96	0.045	0.029	0.55
Effect of COTS on fast-growing coral par 2, p_2^f				2.920	3.263	1.117									
Effect of fast-growing coral on COTS, $\tilde{\tilde{p}}$	0.258	0.167	0.65	0.232	0.186	0.802	0.277	0.172	0.620	0.083	0.299	3.58	0.000	0.000	0.55
Effect of COTS on slow-growing coral par 1, p_1^m	0.268	0.106	0.40	0.316	0.141	0.446	0.219	0.249	1.137	0.054	0.061	1.13	0.019	0.017	0.55
Effect of COTS on slow-growing coral par 2, p_2^m							3.078	20.248	6.579						
Likelihoods															
No. parameters estimated	7			8			8			6			6		
-lnL(total)	-19.704			-19.746			-19.715			-16.990			-15.721		
AIC	-25.408			-23.492			-23.431			-21.980			-19.443		
-lnL(COTS)	8.374			8.317			8.366			8.210			9.682		
-lnL(fast-growing coral)	-14.039			-14.031			-14.041			-12.600			-12.702		
-lnL(slow-growing coral)	-14.039			-14.031			-14.041			-12.600			-12.702		
σ(COTS)	1.096			1.092			1.095			1.084			1.196		
σ(fast-growing coral)	0.246			0.246			0.246			0.271			0.269		
σ(slow-growing coral)	0.246			0.246			0.246			0.271			0.269		

Table S2. Comparison of negative log-likelihood (–nlL) and AIC model scores for 4 model configurations: (1) the base case model, (2) assuming age-dependent COTS natural mortality under different configurations (λ= 0.2, λ= 0.3, λ estimated). *Calculated using Eq. (11) (Table 1 in the main article)

Model	1. Base-case			2. Calculating *M* at age								
Case				λ = 0.2			λ = 0.3			λ estimated		
Estimated parameters	Value	SD	CV	Value	SD	CV	Value	SD	CV	Value	SD	CV
Initial number of 2+ COTS	0.505	0.119	0.24	0.278	0.025	0.09	0.132	0.004	0.03	0.144	0.061	0.43
Stock-recruitment residual for year 1994	4.307	0.378	0.09	3.021	0.551	0.18	3.102	0.121	0.04	4.341	0.483	0.11
Immigration for year 1996	4.292	0.352	0.08	3.350	0.067	0.02	3.370	0.096	0.03	4.337	0.470	0.11
Natural mortality (M)	2.560	0.146	0.06	2.036	0.000	0.00	2.276	0.000	0.00	2.733	0.052	0.02
Effect of COTS on fast-growing coral par 1, p_1^{f}	0.129	0.041	0.32	0.221	0.039	0.18	0.322	0.005	0.02	0.176	0.091	0.52
Effect of fast-growing coral on COTS, $\tilde{\tilde{p}}$	0.258	0.167	0.65	0.416	0.045	0.11	0.375	0.009	0.02	0.334	0.172	0.51
Effect of COTS on slow-growing coral par 1, p_1^{m}	0.268	0.106	0.40	0.653	0.017	0.03	0.987	0.013	0.01	0.265	0.246	0.93
Lambda, λ										0.539	0.283	0.53
Likelihoods												
No. parameters estimated	7			7			7			8		
-lnL(total)	-19.704			-8.306			-8.477			-19.705		
AIC	-25.408			-2.611			-2.953			-23.410		
-lnL(COTS)	8.374			8.760			8.734			8.384		
-lnL(fast-growing coral)	-14.039			-8.533			-8.606			-14.045		
-lnL(slow-growing coral)	-14.039			-8.533			-8.606			-14.045		
σ(COTS)	1.096			1.124			1.123			1.097		
σ(fast-growing coral)	0.246			0.355			0.353			0.246		
σ(slow-growing coral)	0.246			0.355			0.353			0.246		
M at age*				Age	M		Age	M		Age	M	
				0	2.236		0	2.576		0	3.272	
				1	2.136		1	2.426		1	3.002	
				2	2.102		2	2.376		2	2.913	
				3	2.086		3	2.351		3	2.868	
				4	2.076		4	2.336		4	2.841	
				5	2.069		5	2.326		5	2.823	
				6	2.064		6	2.319		6	2.810	
				7	2.061		7	2.314		7	2.800	
				8	2.058		8	2.310		8	2.793	