Appendix A: stability analysis of the coral-macroalgae model

To determine the stability structure of system (1) in the main text with different parameter combination, we determine whether coral dominance and macroalgae dominance are independently locally stable. Solving (1) for coral recruit and adult abundances when macroalgae is absent gives

$$\begin{aligned} R^* &= \frac{r_A A^* - r_A A^{*2}}{r_A A^* + a + d_R} \\ A^* &= \frac{a r_A + g a + g d_R - a d_A - d_A d_R}{a r_A + g A + g d_R + r_A d_A} \\ M^* &= 0. \end{aligned} \tag{A.1}$$

Solving (1) for macroalgae abundances when coral is absent gives

$$\begin{aligned} R^* &= 0 \\ A^* &= 0 \\ M^* &= \frac{r_M - h_b}{r_M}. \end{aligned} \tag{A.2}$$

Stability is calculated by deriving the Jacobian matrix J from (1) by finding the partial derivatives with respect to each state variable. For our system, the Jacobian

$$\begin{vmatrix} J_1 & J_2 & J_3 \\ J_4 & J_5 & J_6 \\ J_7 & J_8 & J_9 \end{vmatrix}$$

has entries

$$\begin{aligned} J_1 &= -r_A A^* - a - r_M M^* - d_R \\ J_2 &= r_A - r_A M^* - r_A R^* - 2 r_A A^* \\ J_3 &= -r_A A^* - r_M R^* \\ J_4 &= a - g A^* \\ J_5 &= g - g M^* - g R^* - 2 g A^* - \beta M^* - d_A \\ J_6 &= -g A^* - \beta A^* \\ J_7 &= 0 \\ J_8 &= -r_M M^* + \beta M^* - \frac{h_s \omega M^*}{(1 + \omega A^*)^2} \\ J_9 &= r_M - 2 r_M M^* - r_M A^* + \beta A^* - h_b - \frac{h_s \omega A^*}{1 + \omega A^*}. \end{aligned} \tag{A.3}$$

Coral dominance and macroalgae dominance are only locally stable if all the eigenvalues of the Jacobian are negative when evaluated at the equilibrium cover values (A.1) and (A.2), respectively. Thus, the stability structure is **a)** coral dominance when only coral is stable and macroalgae cannot invade, **b)** macroalgae dominance when macroalgae is stable and

coral cannot invade, **c)** alternative stable states when both are stable, and **d)** coexistence when neither is stable.

We determined the stability structure for each simulation by using the randomly-drawn parameter suites to calculate equilibrium abundances (A.1 and A.2) and local stability (A.3). Within the parameter ranges explored, 11.2% of simulated coral species traits resulted in coral dominance, 60.1% resulted in macroalgae dominance, 28.6% resulted in alternative stable states, and $< 1\%$ in stable coexistence of corals and macroalgae.