Supporting Information

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SI Text

Further Details of the HURDAT Dataset. The Atlantic Basin Hurricane Database (HURDAT), available at http://www.aoml.noaa. gov/hrd/hurdat/Data_Storm.html, contains tropical cyclone tracks in the North Atlantic since 1851. Several authors have noted that this record is not spatiotemporally homogeneous: Until 1943, it is based on ship logbooks and landfall observations, with changes over time in the ship tracks affecting the record (1). The ship and landfall record was complemented by aircraft reconnaissance flights from 1944 and satellite observations have been used since they became available in 1966. Various corrections have been proposed to address the storm undercounts which are likely to have occurred before 1944 (1, 2). However, these corrections are of no use for the purpose of our paper because they aim at correcting the basin-wide yearly numbers of tropical cyclones, whereas our methodology requires the actual tracks. To partially address this issue, following Villarini et al. (3), we only consider HURDAT tracks lasting for more than 2 d. In the figures below, we compare the results obtained by taking all HURDAT tracks versus the results (presented in the main text) which use only tropical cyclones with duration of at least 2 d: There is virtually no change and the same holds for the dispersion of the hurricane tracks. Indeed, only 21 tracks are removed by the 2-d filtering procedure (Fig. S1).

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Fig. S1. Comparison of yearly transit rates (*A*), dispersion for all cyclones (*C*), and dispersion for hurricanes only (*D*) using all HURDAT tracks (*Left*) versus only HURDAT tracks that last more than 2 d (*Right*). Subpanel lettering (*A*, *C*, *D*) matches that provided in Fig. 1 of the main text to aid comparison. The circles in A have equal radius of 300 km with distances measured along a great circle.

Table S1. Contents of individual cells (0.25 m²) within the model

Substratum	Range, cm ²
Brooding coral 1 (e.g., <i>Porites, Agaricia</i>) (BC1)	1 ≤ BC1 ≤ 2,500
Brooding coral 2 (e.g., <i>Mycetophyllia</i>) (BC2)	$1 \le BC2 \le 2,500$
Spawning coral 1 (e.g., <i>Montastraea cavernosa, Meandrina</i>) (SC1)	$1 \le SC1 \le 2,500$
Spawning coral 2 (e.g., <i>Montastraea annularis</i>) (SC2)	$1 \le SC2 \le 2,500$
Cropped algae [filamentous, coralline red algae, and short turfs (<5 mm height)], 0–6 mo (A_6)	$0 \le A_6 \le 2,500$
Dictyota pulchella (D)	$0 \le D \le 2,500$
Lobophora variegata (L)	$0 \le L \le 2,500$
Ungrazeable substratum (e.g., sand), U	U = 0 or U = 2,500

All substrata represented as area (cm²).

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Table S2. Basic parameterization of simulation model for midshelf reefs without significant sediment input and sparisomid-dominated grazing

Parameter	Details
Coral recruitment	Corals recruit to cropped algae, A_6 and A_{12} , because algal turfs are not heavily sediment laden. Recruit at size 1 cm ² . Recruitment rate of brooders and spawners (respectively): 2 and 0.2 per 0.25 m ² of cropped algae per time interval. Recruitment rate was adjusted for rugosity (<i>ca.</i> 2) and the cover of cropped algae at Glovers Reef (1)
Coral growth	Coral size is quantified as the cross-sectional, basal area of a hemispherical colony (cm ²). BC have a lateral extension rate of 0.8 cm y ⁻¹ and SC grow slightly faster at 0.9 cm y ⁻¹ (based on median rates for <i>Porites astreoides, Porites porites, Siderastrea siderea, Montastraea annularis, Colpophyllia natans, and Agaricia agaricites</i>) (2–6)
Coral reproduction	Excluded, assume constant rate of coral recruitment from outside reef (i.e., no stock- recruitment dynamics)
Colonization of cropped algae	Cropped algae arises (<i>i</i>) when macroalgae is grazed and (<i>ii</i>) after all coral mortality events (7) except those due to macroalgal overgrowth (see coral–algal competition below).
Colonization of macroalgae	Macroalgae have a 70% chance of becoming established if cropped algae are not grazed for 6 mo (mostly <i>Dictyota</i>) and this increases to 100% probability after 12 mo of no grazing (mostly <i>Lobophora</i>). Rates acquired from detailed centimeter-resolution observations of algal dynamics with and without grazing (8).
Macroalgal growth over dead coral (cropped algae)	In addition to arising from cropped algae that are not grazed (above), established macroalgae also spread vegetatively over cropped algae (mostly <i>Lobophora</i> because <i>Dictyota</i> spread shows little pattern with grazing). The probability that macroalgae will encroach onto the algal turf within a cell, $P_{A \rightarrow M}$, is given by $P_{A \rightarrow M} = M_4$ cells, where M_4 cells is the percent cover of macroalgae within the von Neumann (four-cell) neighborhood (9). This is a key method of algal expansion and represents the opportunistic overgrowth of coral that was extirpated by disturbance.
Competition between corals	If corals fill the cell (2,500 cm ²), the larger coral overtops smaller corals (chosen at random if more than one smaller coral share the cell). If corals have equal size, the winner is chosen at random (10)
Competition between corals and cropped algae Competition between corals and macroalgae 1: Effect of macroalgae on corals	Corals always overgrow cropped algae (7) (<i>i</i>) Growth rate of juvenile corals (area <60 cm ²) set to zero if $M_{4 \text{ cells}} > 80\%$, and reduced by 70% if $60\% < M_{4 \text{ cells}} \le 80\%$. Parameters based on both <i>Dictyota</i> and <i>Lobophora</i> (11) (<i>ii</i>) Growth rate of juvenile and adult corals (area $\ge 60 \text{ cm}^2$) reduced by 50% if $M_{4 \text{ cells}} < 60\%$ (7, 12).
	(iii) Limited direct overgrowth of coral by macroalgae can occur (13, 14). Nugues and Bak (15) found that the upper 95% CL of the mean area of overgrowth ranged from 0–18 cm ² pa across an approximately 7-cm length of coral edge, with an overall mean of 8 cm ² pa. This translates to 4 cm ² in each 6-mo time step of the model. Overgrowth (cm ²), $O_{C\rightarrow M}$, was scaled to entire colonies using $O_{C\rightarrow M} = M_{4 \text{ cells}} \times P_i/7 \times 4$, where $M_{4 \text{ cells}}$ is the proportion of macroalgae in the von Neumann four-cell neighborhood and P_i is the perimeter of the coral. Note that Nugues and Bak (15) did not find significant effects of <i>Lobophora</i> on all coral species studied. Although this was the correct interpretation of their data, the published results strongly suggest that an effect does exist and that a larger sample size may well have resulted in significant differences. Other studies have found negative effects of macroalgae on both massive (13) and branching corals (16).
Competition between corals and macroalgae 2: Effect of corals on macroalgae	The vegetative growth rate of macroalgae, $P_{A \to M}$, is reduced by 25% when at least 50% of the local von Neumann neighborhood includes coral (7, 17): proportion of coral, $C = \frac{(BC+SC)}{2,500}$ $P_{A \to M} = 0.75 \times M_{4 \text{ cells}}$ if $C \ge 0.5$
Grazing by fishes and impact of fishing	An unfished community of parrot fishes grazes a maximum of 40% of the seabed per 6-mo time interval. During a given time interval, cells are visited in a random order and all algae consumed until the total grazing impact is reached. All turf and macroalgae are consumed (and converted to A_6) until the constraint is reached. Fishing can reduce the instantaneous grazing intensity of parrot fish communities by at least sixfold (18) to 5% 6 mo ⁻¹ .

Parameter	Details
Partial-colony mortality of corals	Size-dependent, following empirical observations from Curaçao before major bleaching or hurricane disturbances (19). State variables reported in literature converted to dynamic variables using least squares optimization until equilibrial state in model matched observed data. Implementation uses $P_{pm} = (100 - \{88.9 + [-11.2 \ln(\chi)]\})/100$ and $Ln[(A_{pm} \times 100) + 1] = -0.5 + [1.1 \ln(\chi)]$, where P_{pm} is the probability of a partial mortality event, A_{pm} is the area of tissue lost in a single event, and χ is the size of the coral in squared centimeters.
Whole-colony mortality of juvenile and adult corals	Incidence of mortality in juvenile corals (60–250 cm ²), 2% per time interval (<i>ca.</i> 4% pa). Halved to 1% (2% pa) for mature colonies (>250 cm ²) (20). These levels of mortality occur in addition to macroalgal overgrowth. Algal overgrowth and predation affects juvenile corals (see above and below).
Predation on coral recruits	Instantaneous whole-colony mortality occurs from parrot fish predation at a rate of 15% each 6-mo iteration of the model (11). Predation is confined to small corals of area ≤5 cm ² , based on Meesters et al. (19), where between 60% and 95% of bite-type lesions were of this size
Hurricane impact on juvenile and mature corals (>60 cm ²): Whole-colony mortality	Whole-colony mortality of larger corals is represented using a quadratic function (5) where x is the cross-sectional basal area of colony (20, 21). Small colonies avoid dislodgement due to their low drag, intermediate-sized corals have greater drag and are light enough to be dislodged, whereas large colonies are heavy enough to prevent dislodgement $P_{hur} = -0.000003x^2 + 0.0007x + 0.0551$.
Hurricane impact on mature corals (>250 cm ²): Partial-colony mortality	The extent of partial mortality, M_{hur} , is modeled using a Gaussian distribution with mean of 0.30 and standard deviation of 0.20. Each value of M_{hur} represents the percentage of original colony tissue that is lost due to the hurricane. If $M_{hur} \leq 0$, there is no mortality. If $M_{hur} \geq 1$, the entire colony is lost (though this is a rare event) (22).
Hurricane impact on juvenile corals (1–60 cm ²)	Scouring by sand during a hurricane may cause 80% whole-colony mortality in juvenile corals (1).
Hurricane impact on macroalgae	Hurricanes reduce the cover of macroalgae to 10% of its prehurricane level (23).

BC, brooding coral; SC, spawning coral; pa, per annum; CL, confidence level.

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