

Supplementary information for
When depth fails to prevent bleaching but limits coral death: insights from the 2019 heatwave in Mo'orea

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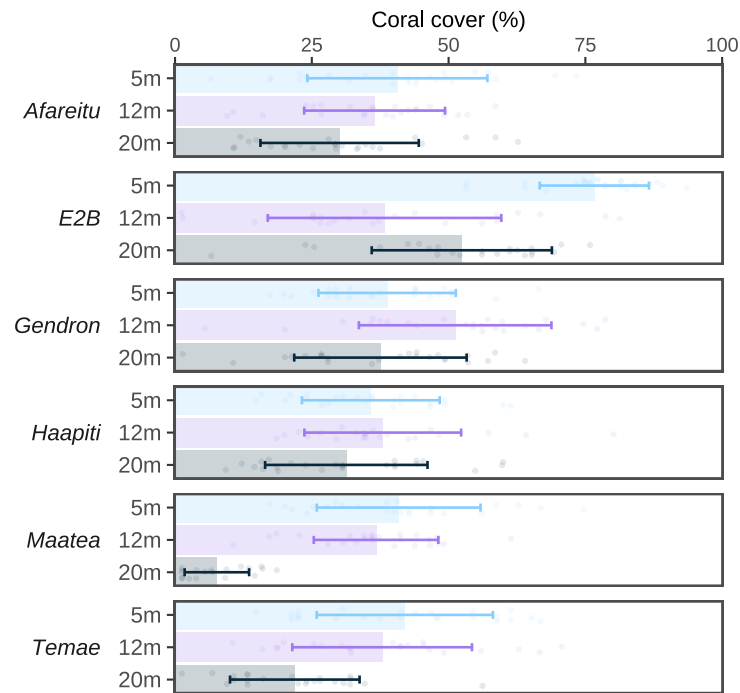
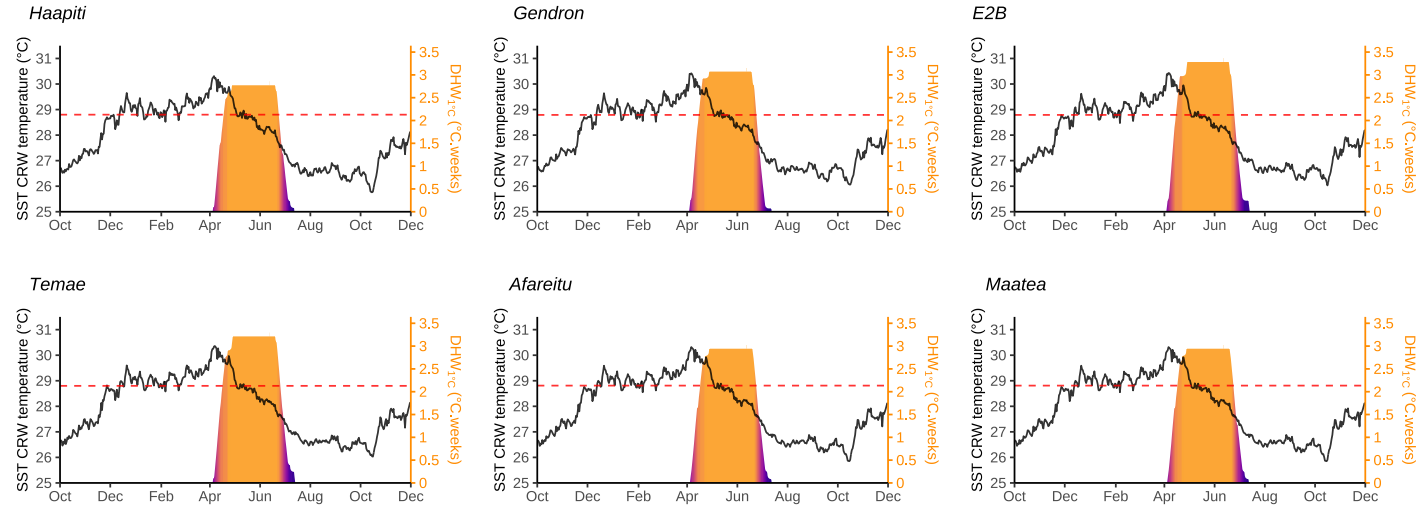


Fig. S1 Coral cover around Mo'orea at 5, 12 and 20 meters deep before the bleaching event of 2019. Sites were in good health with a strong coral cover. Bar and errorbars are mean \pm standard deviation and points are raw data

a. DHW cutoff 1°C



b. DHW cutoff 0°C

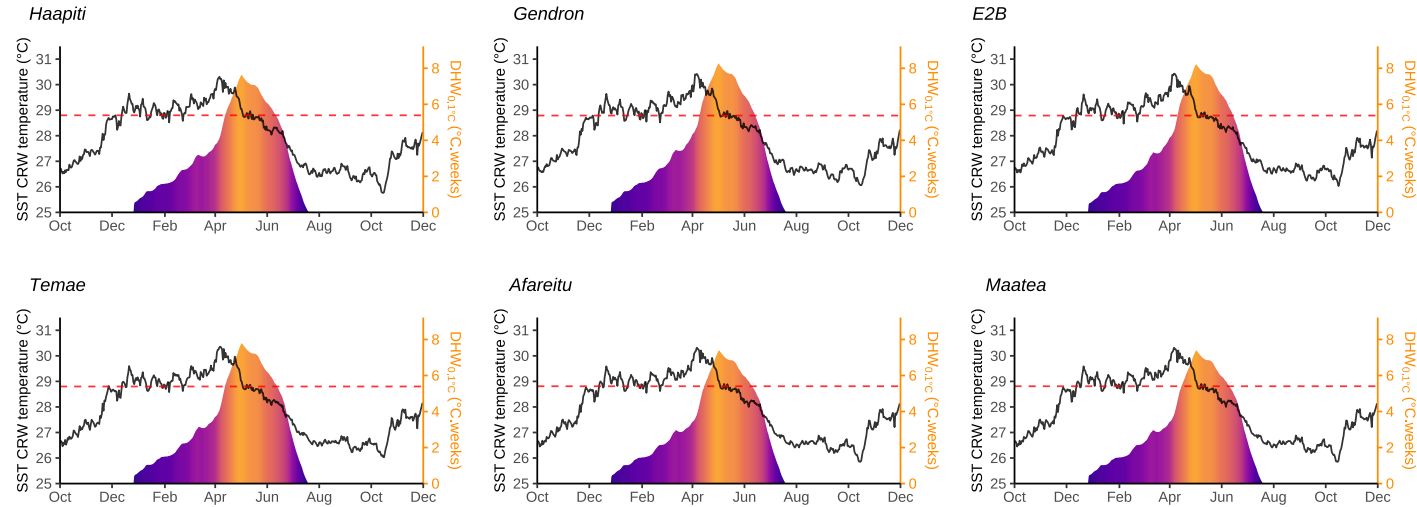


Fig. S2 Daily sea surface temperature (SST) and (A) degree heating weeks (DHW) (common 1°C threshold) and (B) DHW at 0.1°C threshold (low magnitude stress). Extracted from Coral Reef Watch NOAA 5-km resolution. Horizontal red dashed line represents the MMM extracted from NOAA climatologies at each site

Table S1 Site- and depth-specific *in-situ* maximum monthly means (MMM). MMM are averages of the warmest month over the period 2005-2003. *In-situ* temperature data were extracted from Moorea Coral Reef LTER et al. (2025).

| Depth | E2B | Temae | Afareitu | Haapiti | Gendron |
|--------------|------------|--------------|-----------------|----------------|----------------|
| 10m | 28.94 | 28.79 | 28.83 | 28.87 | 28.90 |
| 20m | 28.87 | 28.75 | 28.75 | 28.89 | 28.81 |
| 30m | 28.83 | 28.73 | 28.76 | 28.85 | 28.83 |
| 40m | 28.68 | 28.56 | 28.56 | 28.62 | 28.75 |

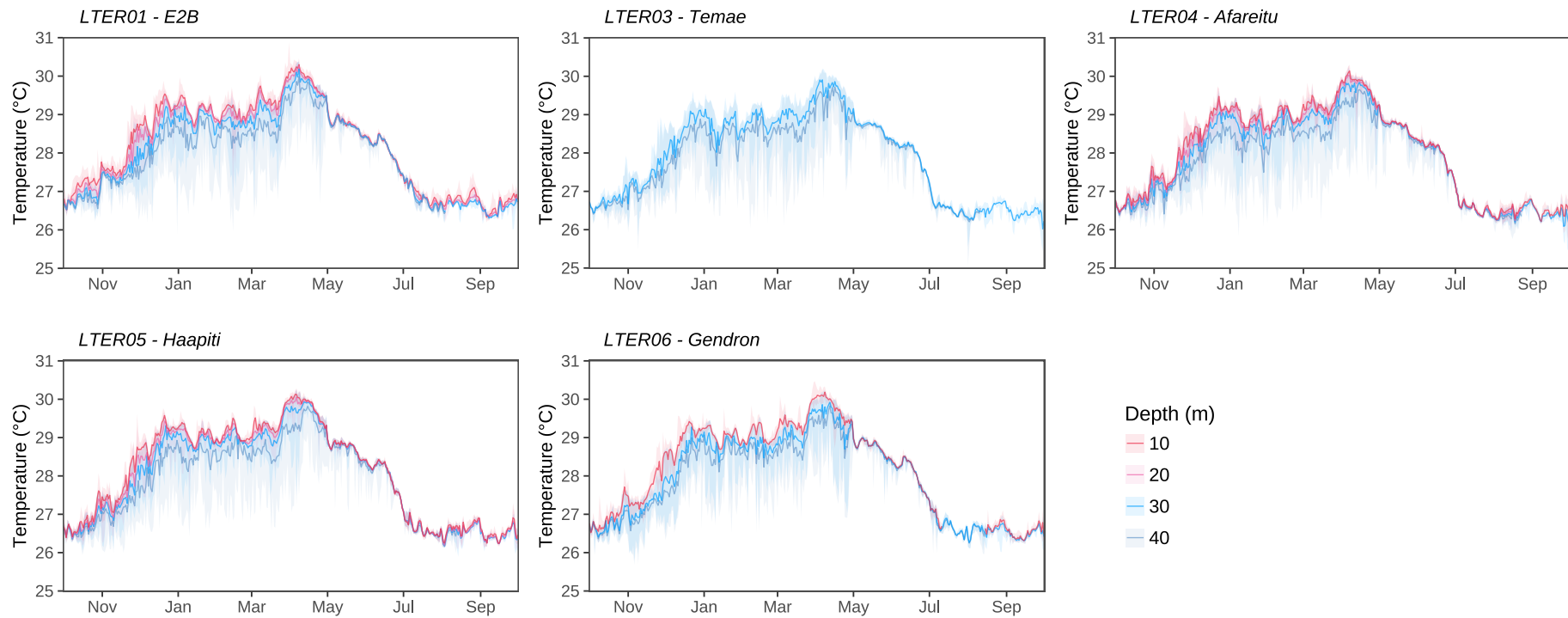


Fig. S3 Daily mean (line) and range (ribbon) temperatures around along the outer slope at 10, 20, 30 and 40 meters from October 1, 2018 to October 1, 2019. Temperature data were extracted from Moorea Coral Reef LTER et al. (2025). Dashed horizontal line represent MMM (extracted from NOAA climatologies) at each site

Table S2 Pairwise post-hoc Dunn tests on accumulated heat stress (AHS) and mean daily temperature fluctuations (MDTF) along the depth gradient

| | Contrasts | Z | p-value | |
|--|-----------|--------|---------|-----|
| <i>Accumulated heat stress</i> | 10 - 20 | 0.302 | 0.3811 | |
| | 10 - 30 | 2.450 | 0.0214 | * |
| | 20 - 30 | 1.934 | 0.0398 | * |
| | 10 - 40 | 2.863 | 0.0126 | * |
| | 20 - 40 | 2.314 | 0.0207 | * |
| | 30 - 40 | 0.438 | 0.3967 | |
| <i>Mean daily temperature fluctuations</i> | 10 - 20 | -0.454 | 0.3250 | |
| | 10 - 30 | -1.993 | 0.0463 | * |
| | 20 - 30 | -1.356 | 0.1051 | |
| | 10 - 40 | -3.469 | 0.0016 | *** |
| | 20 - 40 | -2.712 | 0.0100 | * |
| | 30 - 40 | -1.566 | 0.0881 | |

Table S3 Summary of all final models fitted. Models were chosen based on likelihood-ratio tests: random structure always included sites, fixed effects always included depth (factorial), taxa and its interaction with taxa was also considered. Explained variability is expressed through marginal R^2 (R^2_m ; variability explained by the fixed effects) and conditional R^2 (R^2_c ; variability explained by both fixed and random effects) when random effects were retained.

| | Model chosen | Family distribution | Explained variability |
|---|--|---------------------|------------------------------------|
| <i>Bleaching prevalence</i> <i>global (assemblage)</i> | Bleached [1 if pale or bleached ; 0 if healthy] ~ Depth + (1 Site) + (1 Genus) | Binomial | $R^2_m = 1\%$; $R^2_c = 53\%$ |
| <i>taxa level</i> | Bleached [1 if pale or bleached ; 0 if healthy] ~ Depth*Genus + (1 Site) for genus: <i>Acropora</i> , <i>Pocillopora</i> , <i>Astrea</i> , <i>Montipora</i> , <i>Leptastrea</i> , <i>Millepora</i> , <i>Pavona</i> , <i>Porites</i> | Binomial | $R^2_m = 61\%$; $R^2_c = 62\%$ |
| <i>Bleaching severity</i> <i>taxa level</i> | Severity [1 if severely bleached ; 0 if partially] ~ Depth*Genus + (1 Site) for genus: <i>Acropora</i> , <i>Pocillopora</i> , <i>Astrea</i> , <i>Montipora</i> , <i>Leptastrea</i> , <i>Millepora</i> , <i>Pavona</i> , <i>Porites</i> , <i>Filtered to bleached colony only</i> | Binomial | $R^2_m = 86\%$; $R^2_c = 87\%$ |
| <i>Live coral cover</i> <i>global</i> | (Live coral, Total points - live coral) ~ Time*Depth + (1 Site) | Binomial | $R^2_m = 4\%$; $R^2_c = 7\%$ |
| <i>taxa level</i> | (Live coral, Total points - live coral) ~ Time*Depth*Genus + (1 Site) | Binomial | $R^2_m = 26\%$; $R^2_c = 27\%$ |
| <i>Relative coral cover</i> <i>loss global</i> | Relative cover loss ~ Depth + (1 Site) | Beta | $R^2_m = 41\%$; $R^2_c = 43\%$ |
| <i>taxa level</i> | Relative cover loss ~ Depth*Genus + (1 Site) for genus: <i>Pocillopora</i> and <i>Acropora</i> only | Beta | $R^2_m = 38\%$; $R^2_c = 45\%$ |
| <i>Shift in composition</i> <i>distance in nMDS space</i> | Distance ~ Depth | Gamma Log link | $R^2 = 21\%$ |

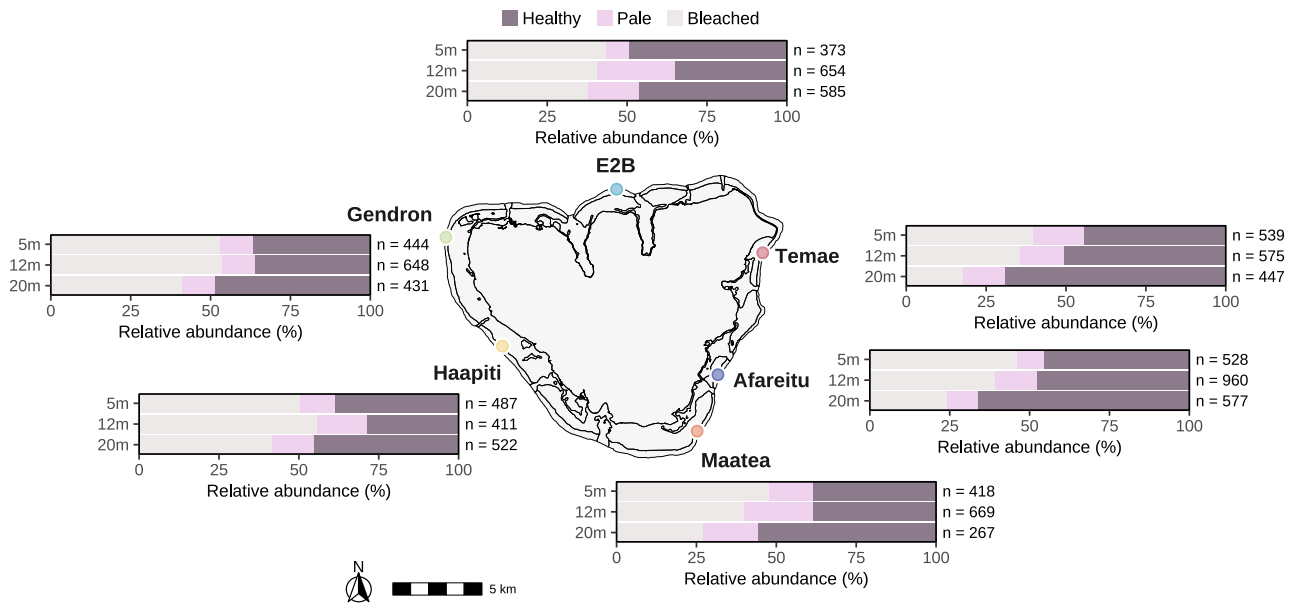


Fig. S4 Patterns of coral bleaching around Mo'orea island. Proportion of colonies that were healthy (brown), pale (rose) and bleached (grey) in mid-April 2019 at the 6 different surveyed sites from shallow to intermediate depths. Numbers of colonies surveyed are indicated for each site and depth (n)

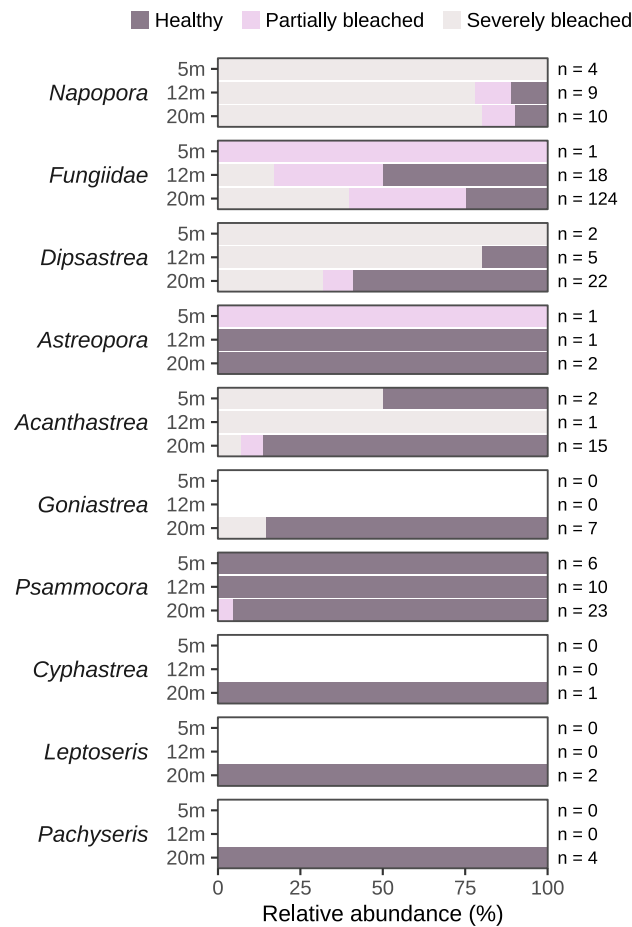


Fig. S5 Bleaching susceptibility of rare coral taxa (< 10 observations per depth) across depths, classified from most (top) to less (bottom) sensitive. Stacked barplot represent relative abundance of corals in the different health status from healthy to severely bleached. Number of observations at each depth is annotated for each taxa.

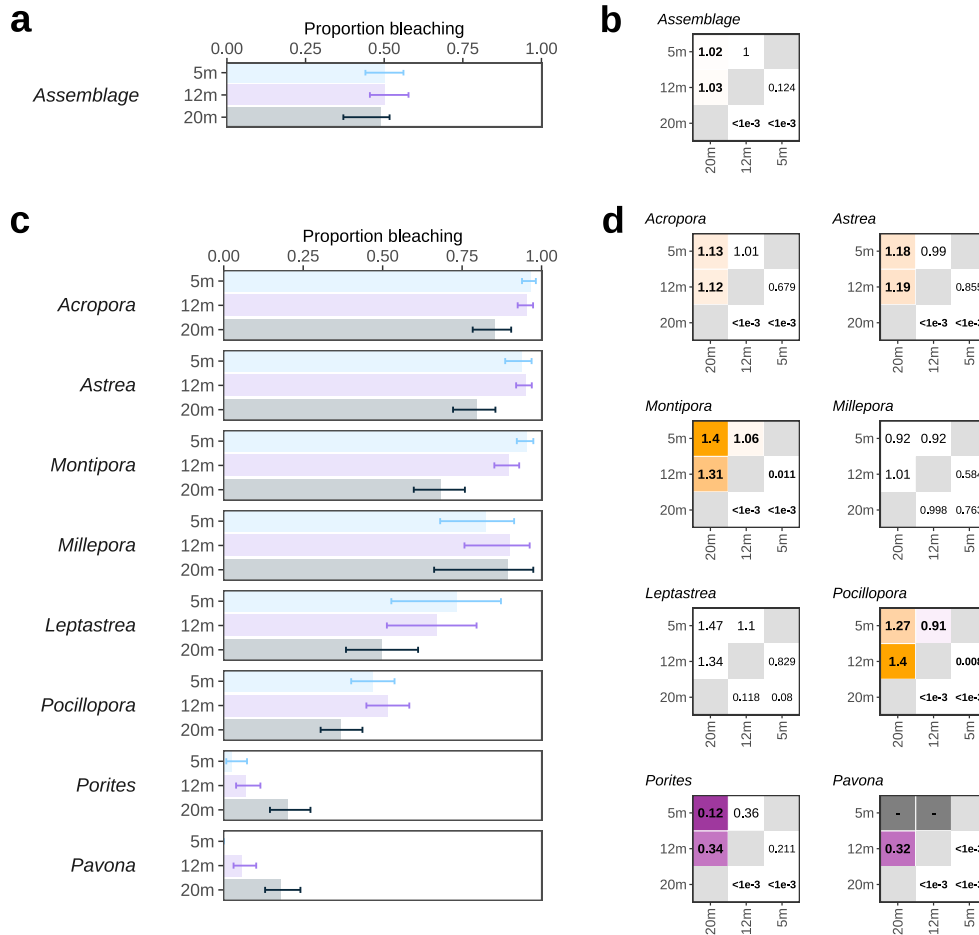


Fig. S6 Bleaching susceptibility over depths of the (a)(b) coral assemblages and (c)(d) the most abundant coral taxa (with > 10 observations for each depth). (a)(c) Barplot and errorbars are predicted probabilities (\pm 95% confidence intervals) from the best fitted model, (b)(d) significant pairwise differences are in bold – upper left triangles are ratios of emmeans, and lower right triangles are the associated contrast p-values. Ratios should be read as Y axis/X axis. Significant differences are in bold and colored according to their importance (ratios > 1 in shades of orange and < 1 in shades of purple); e.g. for *Acropora* estimate_{5m/20m} = 1.13, p-value = < 0.001. To account for Jensen's inequality, bias-adjustment were applied based on sigma = 1.9426 for the assemblage as the variation associated with taxa was important (variance = 3.62; sd = 1.9); and sigma = 0.3230 for taxa-specific responses.

| | | | | | | | | |
|-------------|--------------|-------------|-------------|--------|-------------|-------------|--------------|--------------|
| Acropora | 13.01 | 2.08 | 1.03 | - | 1.07 | 1.07 | 1.47 | |
| Leptastrea | 8.85 | 1.42 | 1.43 | - | 0.73 | 0.73 | | <1e-3 |
| Millepora | 12.15 | 1.95 | 1.04 | - | 1 | | 0.006 | 0.404 |
| Montipora | 12.2 | 1.95 | 1.04 | - | | 1 | <1e-3 | 0.002 |
| Pavona | 0.02 | 0 | - | | <1e-3 | <1e-3 | <1e-3 | <1e-3 |
| Astrea | 12.65 | 2.03 | | <1e-3 | 0.507 | 0.962 | <1e-3 | 0.575 |
| Pocillopora | 6.24 | | <1e-3 | <1e-3 | <1e-3 | <1e-3 | 0.002 | <1e-3 |
| Porites | | <1e-3 | <1e-3 | <1e-3 | <1e-3 | <1e-3 | <1e-3 | <1e-3 |
| | Porites | Pocillopora | Astrea | Pavona | Montipora | Millepora | Leptastrea | Acropora |

Fig. S7 Bleaching susceptibilities of the most abundant taxa (> 10 observations per depth). Pairwise differences in the proportion of bleached corals between taxa (averaged depth). Upper left triangles are ratios of emmeans, and lower right triangles are the associated contrast p-values. Ratios should be read as Y axis/X axis. Significant differences are in bold and colored according to their importance (ratio > 1 in shades of orange and < 1 in shades of purple). A bias adjustment of 0.3230 was applied.

Table S4 Pairwise post-hoc Tukey t-tests of differences in estimated marginal means (emmeans) of probabilities to be severely bleached when colonies are bleaching-susceptible

| Genus | Contrast | Odds ratio | SE | z.ratio | p-value | |
|--------------------|-----------------|-------------------|-----------|----------------|----------------|-----|
| <i>Acropora</i> | 5m / 12m | 8e6 | 1e10 | 0.01 | 0.9999 | |
| | 5m / 20m | 1e7 | 2e10 | 0.01 | 0.9999 | |
| | 12m / 20m | 1.78 | 1.37 | 0.67 | 0.7817 | |
| <i>Astrea</i> | 5m / 12m | 1.21 | 0.25 | 0.63 | 0.8033 | |
| | 5m / 20m | 0.76 | 0.18 | -1.41 | 0.3344 | |
| | 12m / 20m | 0.66 | 0.13 | -2.46 | 0.0367 | ** |
| <i>Leptastrea</i> | 5m / 12m | 1.05 | 0.82 | -0.01 | 0.9999 | |
| | 5m / 20m | 0.54 | 0.38 | -0.95 | 0.6059 | |
| | 12m / 20m | 0.54 | 0.30 | -1.22 | 0.4405 | |
| <i>Millepora</i> | 5m / 12m | 1.06 | 0.52 | 0.01 | 1.0000 | |
| | 5m / 20m | 0.33 | 0.21 | -1.81 | 0.1678 | |
| | 12m / 20m | 0.33 | 0.21 | -1.82 | 0.1643 | |
| <i>Montipora</i> | 5m / 12m | 1.72 | 0.36 | 2.28 | 0.0587 | |
| | 5m / 20m | 1.66 | 0.43 | 1.71 | 0.2031 | |
| | 12m / 20m | 1.02 | 0.25 | -0.15 | 0.9879 | |
| <i>Pocillopora</i> | 5m / 12m | 1.59 | 0.18 | 3.63 | 0.0008 | *** |
| | 5m / 20m | 1.64 | 0.23 | 3.15 | 0.0046 | *** |
| | 12m / 20m | 1.09 | 0.14 | 0.25 | 0.9673 | |
| <i>Porites</i> | 5m / 12m | 0.73 | 0.98 | -0.27 | 0.9594 | |
| | 5m / 20m | 0.97 | 1.22 | -0.07 | 0.9972 | |
| | 12m / 20m | 1.40 | 0.84 | 0.46 | 0.8886 | |
| <i>Pavona</i> | 12m / 20m | 0.05 | 0.05 | -2.84 | 0.0045 | *** |

Table S5 Pairwise post-hoc Tukey t-tests of differences in estimated marginal means (emmeans) of live coral cover before and after bleaching across depths and taxa

| Genus | Before/After contrast | Odds ratio | SE | z.ratio | p-value | |
|-------------------|------------------------------|-------------------|-----------|----------------|----------------|-----|
| <i>Assemblage</i> | 5m | 3.041 | 0.091 | 35.684 | < 0.0001 | *** |
| | 12m | 1.852 | 0.054 | 19.312 | < 0.0001 | *** |
| | 20m | 1.338 | 0.041 | 7.860 | < 0.0001 | *** |
| <i>Acropora</i> | 5m | 4.525 | 0.568 | 11.747 | < 0.0001 | *** |
| | 12m | 2.178 | 0.197 | 8.204 | < 0.0001 | *** |
| | 20m | 1.547 | 0.179 | 3.456 | 0.0005 | *** |
| <i>Astrea</i> | 5m | 1.036 | 0.302 | 0.000 | 0.9999 | |
| | 12m | 1.036 | 0.203 | 0.000 | 0.9999 | |
| | 20m | 1.061 | 0.233 | 0.110 | 0.9127 | |
| <i>Montipora</i> | 5m | 1.042 | 0.081 | 0.078 | 0.9376 | |
| | 12m | 1.041 | 0.104 | 0.050 | 0.9600 | |
| | 20m | 1.077 | 0.135 | 0.313 | 0.7541 | |

| | | | | | | |
|--------------------|-----|-------|-------|--------|----------|-----|
| <i>Millepora</i> | 5m | 1.036 | 0.122 | 0.000 | 0.9999 | |
| | 12m | 1.036 | 0.317 | 0.000 | 0.9998 | |
| | 20m | 1.036 | 0.236 | 0.000 | 1.0000 | |
| <i>Leptastrea</i> | 12m | 1.036 | 0.493 | 0.000 | 1.0000 | |
| | 20m | 1.036 | 0.308 | 0.000 | 0.9999 | |
| <i>Pocillopora</i> | 5m | 3.051 | 0.099 | 33.119 | < 0.0001 | *** |
| | 12m | 1.775 | 0.058 | 16.510 | < 0.0001 | *** |
| | 20m | 1.317 | 0.047 | 6.704 | < 0.0001 | *** |
| <i>Porites</i> | 5m | 1.036 | 0.141 | 0.000 | 0.9998 | |
| | 12m | 1.036 | 0.087 | 0.000 | 1.0000 | |
| | 20m | 1.042 | 0.081 | 0.077 | 0.9385 | |
| <i>Pavona</i> | 5m | 1.036 | 0.348 | 0.000 | 0.9999 | |
| | 12m | 1.036 | 0.153 | 0.000 | 1.0000 | |
| | 20m | 1.046 | 0.149 | 0.071 | 0.9434 | |

Table S6 Pairwise post-hoc Tukey t-tests of differences in estimated marginal means (emmeans) of live coral cover between depth, before and after bleaching, across taxa. Contrasts are only presented before bleaching for taxa which did not significantly lose coral cover loss (Table S5).

| Genus | Time | Contrast | Odds ratio | SE | z.ratio | p-value | |
|-------------------|-------------|-----------------|-------------------|-----------|----------------|----------------|-----|
| <i>Assemblage</i> | Before | 5m / 12m | 1.356 | 0.037 | 9.228 | < 0.0001 | *** |
| | | 5m / 20m | 2.032 | 0.058 | 23.017 | < 0.0001 | *** |
| | | 12m / 20m | 1.576 | 0.046 | 13.955 | < 0.0001 | *** |
| | After | 5m / 12m | 0.825 | 0.026 | -7.710 | < 0.0001 | *** |
| | | 5m / 20m | 0.894 | 0.028 | -5.076 | < 0.0001 | *** |
| | | 12m / 20m | 1.139 | 0.035 | 2.584 | 0.0264 | * |
| <i>Acropora</i> | Before | 5m / 12m | 1.255 | 0.097 | 2.483 | 0.0348 | * |
| | | 5m / 20m | 1.716 | 0.160 | 5.404 | < 0.0001 | *** |
| | | 12m / 20m | 1.416 | 0.129 | 3.437 | 0.0017 | ** |
| | After | 5m / 12m | 0.604 | 0.081 | -4.020 | 0.0002 | *** |
| | | 5m / 20m | 0.586 | 0.084 | -3.971 | 0.0002 | *** |
| | | 12m / 20m | 1.006 | 0.116 | -0.255 | 0.9647 | |
| <i>Astrea</i> | Before | 5m / 12m | 0.888 | 0.220 | -0.622 | 0.8079 | |
| | | 5m / 20m | 0.887 | 0.228 | -0.603 | 0.8184 | |
| | | 12m / 20m | 1.035 | 0.215 | -0.003 | 1.0000 | |
| <i>Montipora</i> | Before | 5m / 12m | 1.409 | 0.127 | 3.428 | 0.0018 | *** |
| | | 5m / 20m | 1.775 | 0.184 | 5.187 | < 0.0001 | *** |
| | | 12m / 20m | 1.304 | 0.147 | 2.044 | 0.1019 | |
| <i>Millepora</i> | Before | 5m / 12m | 5.217 | 1.209 | 6.979 | < 0.0001 | *** |
| | | 5m / 20m | 2.708 | 0.493 | 5.276 | < 0.0001 | *** |
| | | 12m / 20m | 0.538 | 0.145 | -2.429 | 0.0401 | * |
| <i>Leptastrea</i> | Before | 12m / 20m | 1.384 | 0.549 | 0.729 | 0.4662 | |

| | | | | | | | |
|--------------------|--------|-----------|-------|-------|--------|----------|-----|
| <i>Pocillopora</i> | Before | 5m / 12m | 1.462 | 0.043 | 11.795 | < 0.0001 | *** |
| | | 5m / 20m | 2.134 | 0.067 | 22.894 | < 0.0001 | *** |
| | | 12m / 20m | 1.511 | 0.049 | 11.612 | < 0.0001 | *** |
| | After | 5m / 12m | 0.851 | 0.030 | -5.514 | < 0.0001 | *** |
| | | 5m / 20m | 0.921 | 0.034 | -3.185 | 0.0041 | *** |
| | | 12m / 20m | 1.121 | 0.040 | 2.207 | 0.0700 | |
| <i>Porites</i> | Before | 5m / 12m | 0.534 | 0.060 | -5.864 | < 0.0001 | *** |
| | | 5m / 20m | 0.535 | 0.059 | -5.966 | < 0.0001 | *** |
| | | 12m / 20m | 1.038 | 0.084 | 0.027 | 0.9996 | |
| <i>Pavona</i> | Before | 5m / 12m | 0.653 | 0.169 | -1.778 | 0.1770 | |
| | | 5m / 20m | 0.593 | 0.153 | -2.163 | 0.0776 | |
| | | 12m / 20m | 0.941 | 0.136 | -0.668 | 0.7822 | |

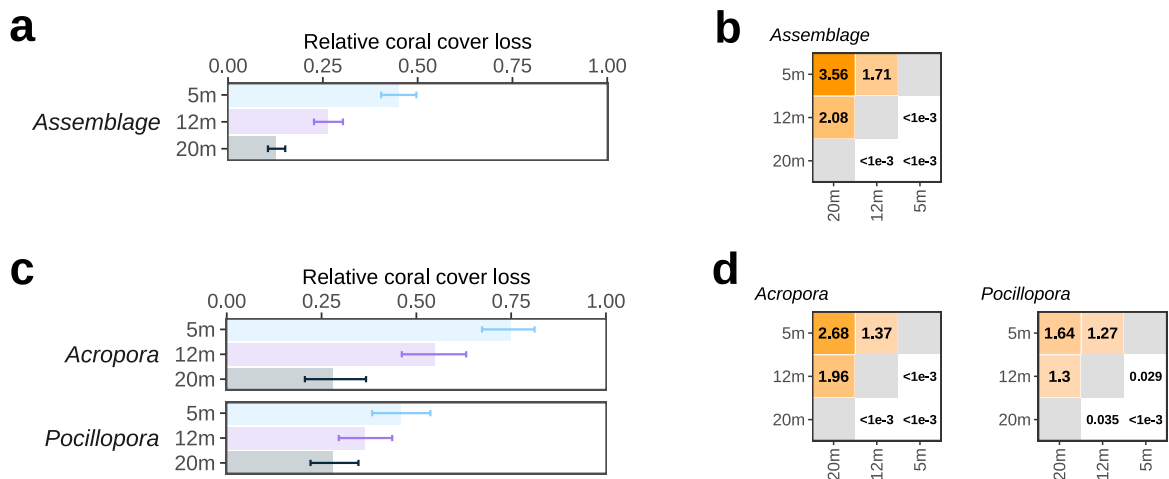


Fig. S8 Relative coral cover loss of (a)(b) the coral assemblages and (c)(d) the two dominant taxa *Acropora* and *Pocillopora* with depth. (a)(c) Predictions ± 95% confidence intervals and (c)(d) the pairwise differences in the relative proportion of coral cover lost between depths. Upper left triangles are ratios of emmeans, and lower right triangles are the associated contrast p-values. Ratios should be read as Y axis/X axis. Significant differences are in bold and colored according to their importance (ratios > 1 in shades of orange and < 1 in shades of purple). A bias-adjustment of 0.1449 and 0.2659 were applied to coral assemblages and the taxon-specific models.

Table S7 Pairwise post-hoc Tukey t-tests of differences in estimated marginal means of coral cover loss for *Acropora* and *Pocillopora* at the different depths

| Contrast | Depth | Odds ratio | SE | z.ratio | p-value | |
|--------------------------------------|-------|------------|------|---------|----------|-----|
| <i>Acropora</i> / <i>Pocillopora</i> | 5m | 3.44 | 0.64 | 6.41 | 1.43e-10 | *** |
| <i>Acropora</i> / <i>Pocillopora</i> | 12m | 2.29 | 0.39 | 4.61 | 3.96e-06 | *** |
| <i>Acropora</i> / <i>Pocillopora</i> | 20m | 1.13 | 0.22 | 0.42 | 0.677126 | |

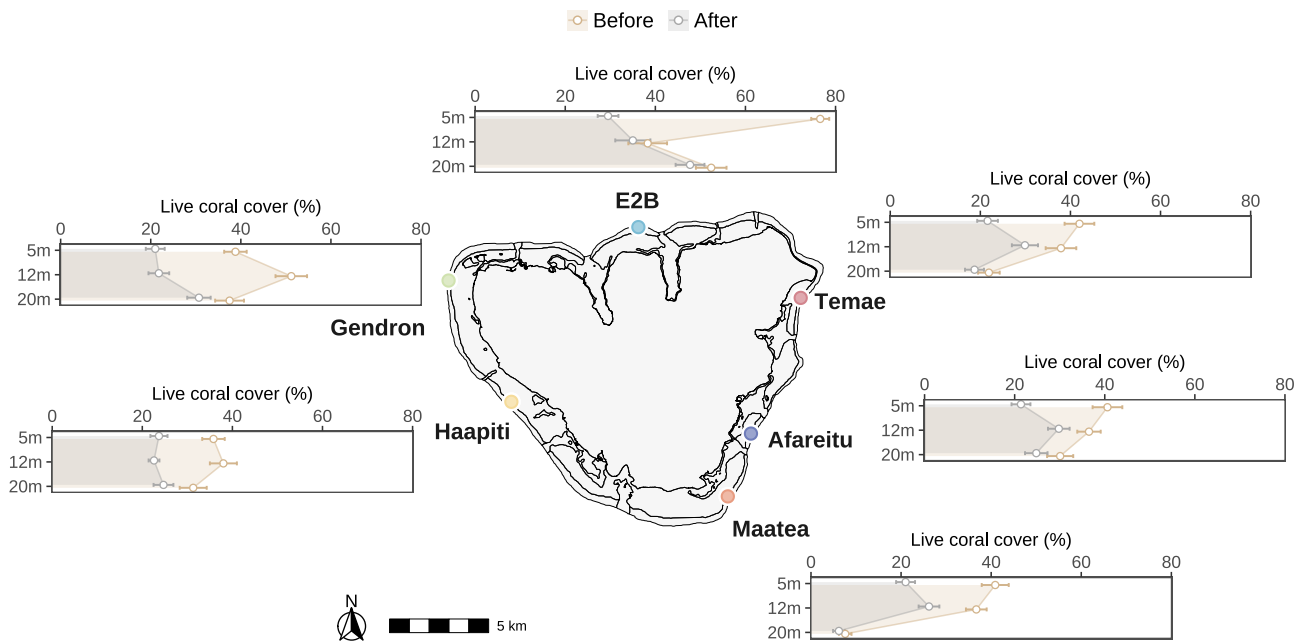


Fig. S9 Patterns of coral mortality around Mo'orea island following mass bleaching event. Relative coral cover loss observed in October 2019, is based on live coral cover before (living + recently dead corals) vs after the bleaching event, at the 6 different surveyed sites from shallow to intermediate depths (5 to 20m). Points are raw means and errorbars are standard errors.

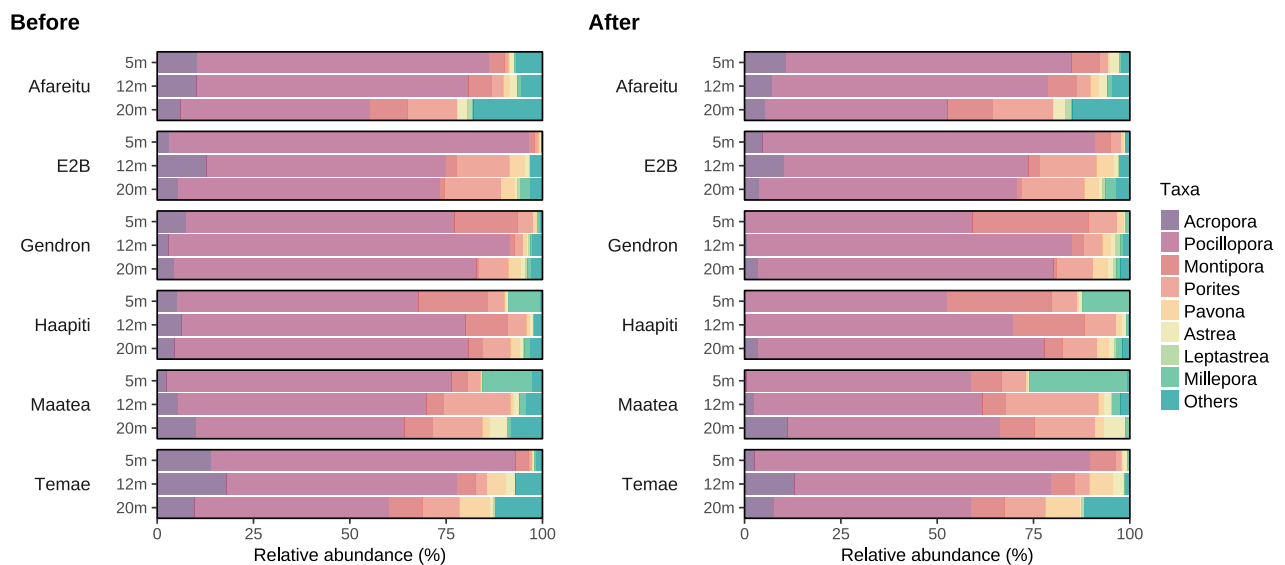


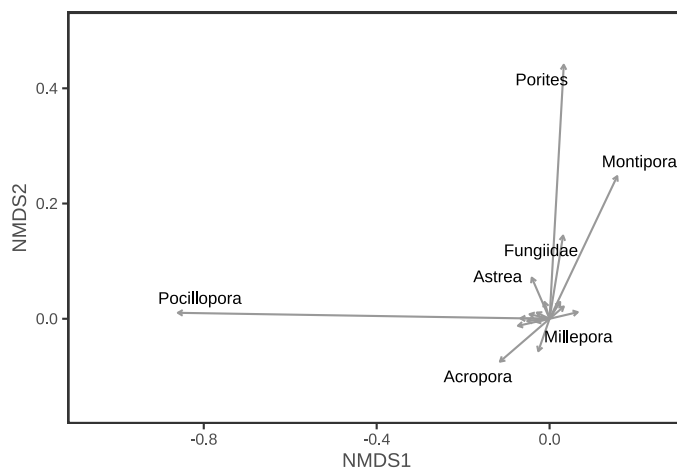
Fig. S10 Coral assemblages at each surveyed site over depth before (accounting for living and recently dead corals) and after (accounting for living corals only in October 2019) the bleaching event

Table S8 Pairwise PERMANOVA for coral assemblages before, after and their comparison. A Benjamini-Hochberg adjustment was applied for multiple comparisons.

| | Depth1 | Depth2 | SumsOfSqs | F.Model | R ² | p.value | |
|-----------------------|--------|--------|-----------|---------|----------------|---------|-----|
| <i>Before</i> | 5m | 12m | 0.84 | 6.97 | 0.023 | 0.001 | *** |
| | 5m | 20m | 3.26 | 20.12 | 0.066 | 0.001 | *** |
| | 12m | 20m | 1.45 | 8.78 | 0.030 | 0.001 | *** |
| <i>After</i> | 5m | 12m | 1.11 | 7.91 | 0.026 | 0.001 | *** |
| | 5m | 20m | 2.18 | 12.24 | 0.041 | 0.001 | *** |
| | 12m | 20m | 0.81 | 4.48 | 0.016 | 0.001 | *** |
| <i>After - Before</i> | 5m | 5m | 5.70 | 44.52 | 0.131 | 0.001 | *** |
| | 12m | 12m | 1.83 | 13.87 | 0.046 | 0.001 | *** |
| | 20m | 20m | 0.19 | 0.88 | 0.003 | 0.496 | |

Table S9 Pairwise post-hoc Tukey t-tests of differences in estimated marginal means of compositional shift (distance in nMDS space)

| Contrast | Ratio | SE | z.ratio | p-value | |
|-----------|-------|------|---------|---------|-----|
| 5m / 12m | 1.95 | 0.51 | 2.57 | 0.0275 | * |
| 5m / 20m | 3.46 | 0.86 | 4.98 | <0.0001 | *** |
| 12m / 20m | 1.77 | 0.45 | 2.26 | 0.0619 | |



| Species | R ² | p-value | |
|---------------------------|----------------|---------|-----|
| <i>Pocillopora</i> | 0.740 | 0.001 | *** |
| <i>Unidentified coral</i> | 0.001 | 0.544 | |
| <i>Acropora</i> | 0.019 | 0.002 | *** |
| <i>Montipora</i> | 0.086 | 0.001 | *** |
| <i>Porites</i> | 0.195 | 0.001 | *** |
| <i>Astrea</i> | 0.007 | 0.07 | |
| <i>Pavona</i> | 0.006 | 0.104 | |
| <i>Psammocora</i> | 0.004 | 0.152 | |
| <i>Millepora</i> | 0.004 | 0.171 | |
| <i>Fungiidae</i> | 0.022 | 0.001 | *** |
| <i>Napopora</i> | 0.001 | 0.64 | |
| <i>Acanthastrea</i> | 0.003 | 0.253 | |
| <i>Leptastrea</i> | 0.002 | 0.387 | |
| <i>Cyphastrea</i> | 0.005 | 0.146 | |
| <i>Dipsastrea</i> | 0.001 | 0.565 | |
| <i>Leptoseris</i> | 0.002 | 0.504 | |
| <i>Astreopora</i> | 0.001 | 0.638 | |

Fig. S11 Genera structuring coral assemblages in the nMDS (envfit results). Significant taxa are important drivers of the composition of communities (999 permutations).