Appendix S1 for:

A marine heatwave changes the stabilizing effects of biodiversity in kelp forests

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in *Ecology*

This appendix includes:

Figs. S1 to S13
Tables S1 to S12

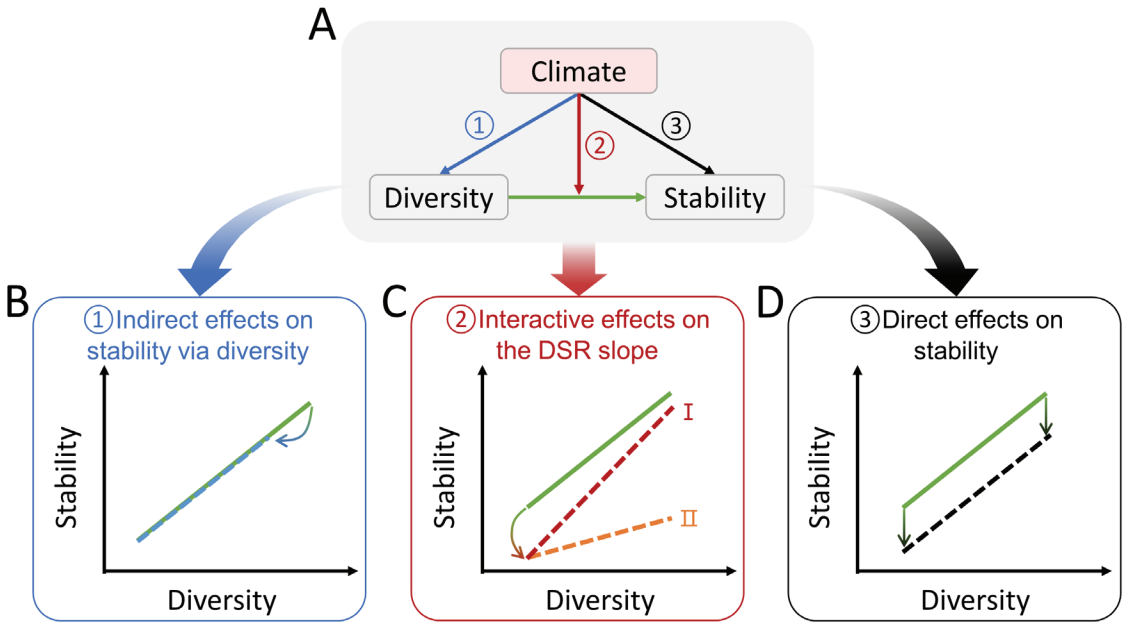

Fig. S1. Conceptual diagrams of the effects of climate extremes on the diversity-stability relationships (DSRs). Climate extremes can decrease ecosystem stability and change the magnitude of the DSRs following three proposed hypotheses (**A**). Climate extremes indirectly reduce ecosystem stability by: (**B**) reducing the maximum level of biodiversity without changing the DSR slope; (**C**) through interactions with the effects of biodiversity, climate extremes can either amplify (case I, the systems or organisms are resistant to climate extremes) or dampen (case II, the systems or organisms are subject to climate extremes) the DSR slope resulting in changing ecosystem stability; (**D**) climate extremes can directly reduce ecosystem stability without altering biodiversity and have no effects on the DSR slopes (**D**). Adapted from Benkwitt et al. 2020.

Reference

Benkwitt, C. E., S. K. Wilson, and N. A. J. Graham. 2020. "Biodiversity increases ecosystem functions despite multiple stressors on coral reefs." Nature Ecology & Evolution 4:919-926.

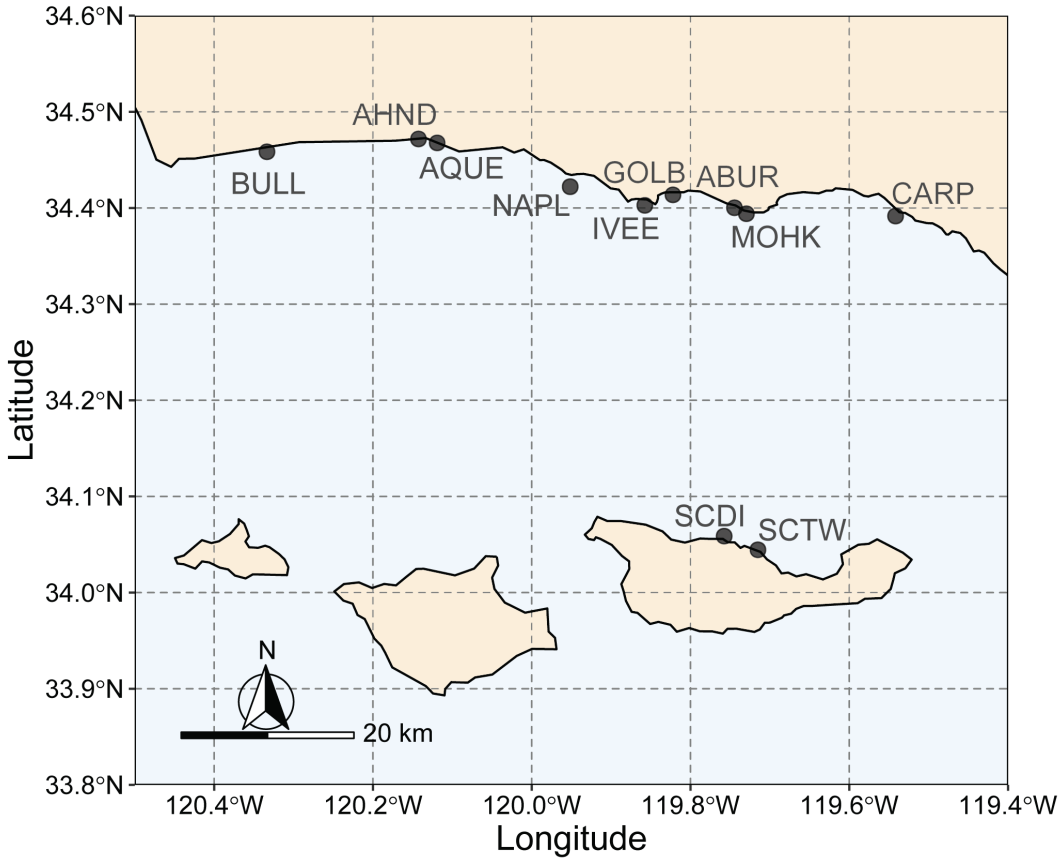

Fig. S2. Geographic locations of study sites in the Santa Barbara Channel, California, USA. ABUR: Arroyo Burro reef; AHND: Arroyo Hondo reef; AQUE: Arroyo Quemado reef; BULL: Bulito; CARP: Carpinteria Reef; GOLB: Goleta Bay; IVEE: Isla Vista Reef; MOHK: Mohawk Reef; NAPL: Naples Reef; SCDI: Santa Cruz Island, Diablo; SCTW: Santa Cruz Island, Twin Harbor West.

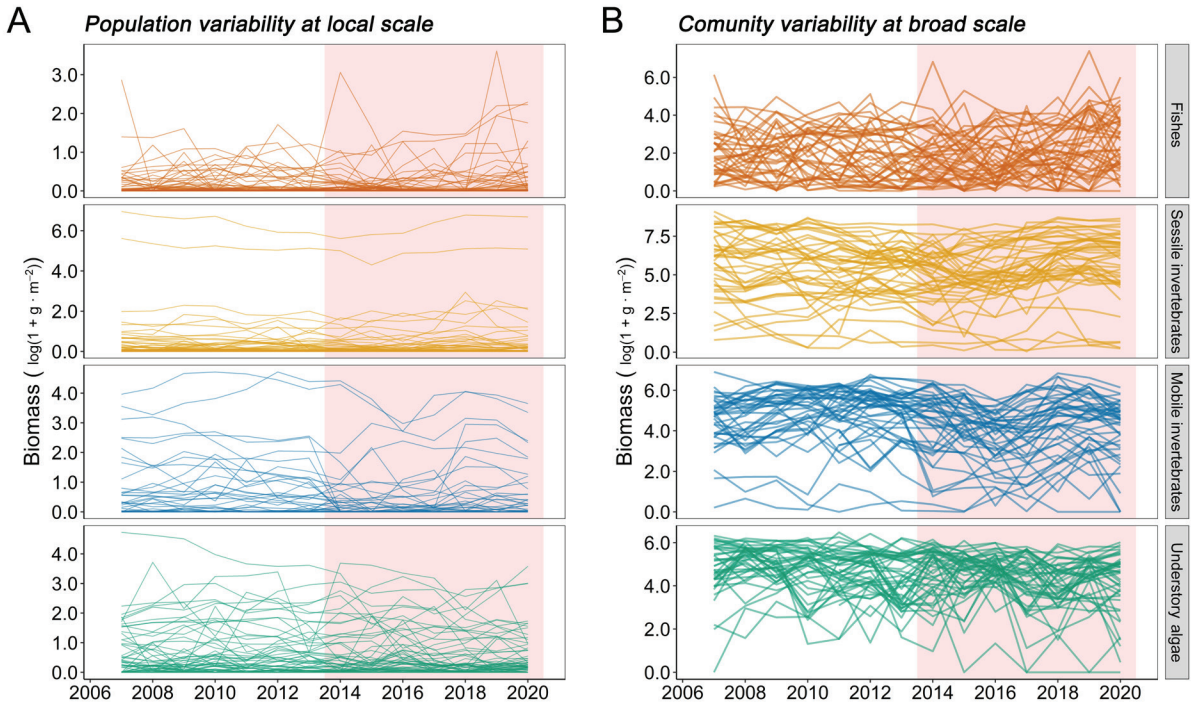

Fig. S3. Long-term functional group biomass dynamics at Santa Barbara Coastal Long Term Ecological Research sites. Plot shows the natural log of long-term biomass (*log*[1 + biomass]) for functional groups at the levels of (**A**) populations and (**B**) communities. In panel A, each line represents the mean biomass dynamics for an individual taxon (fishes: N = 66; sessile invertebrates: N = 69; mobile invertebrates: N = 33; understory algae: N = 58), averaged over 44 transects. In panel B, each line represents the mean community biomass dynamics for an individual transect ($N_{transect}$ = 44 for all functional groups). Red shading shows the during/after heatwave period (2014−2020).

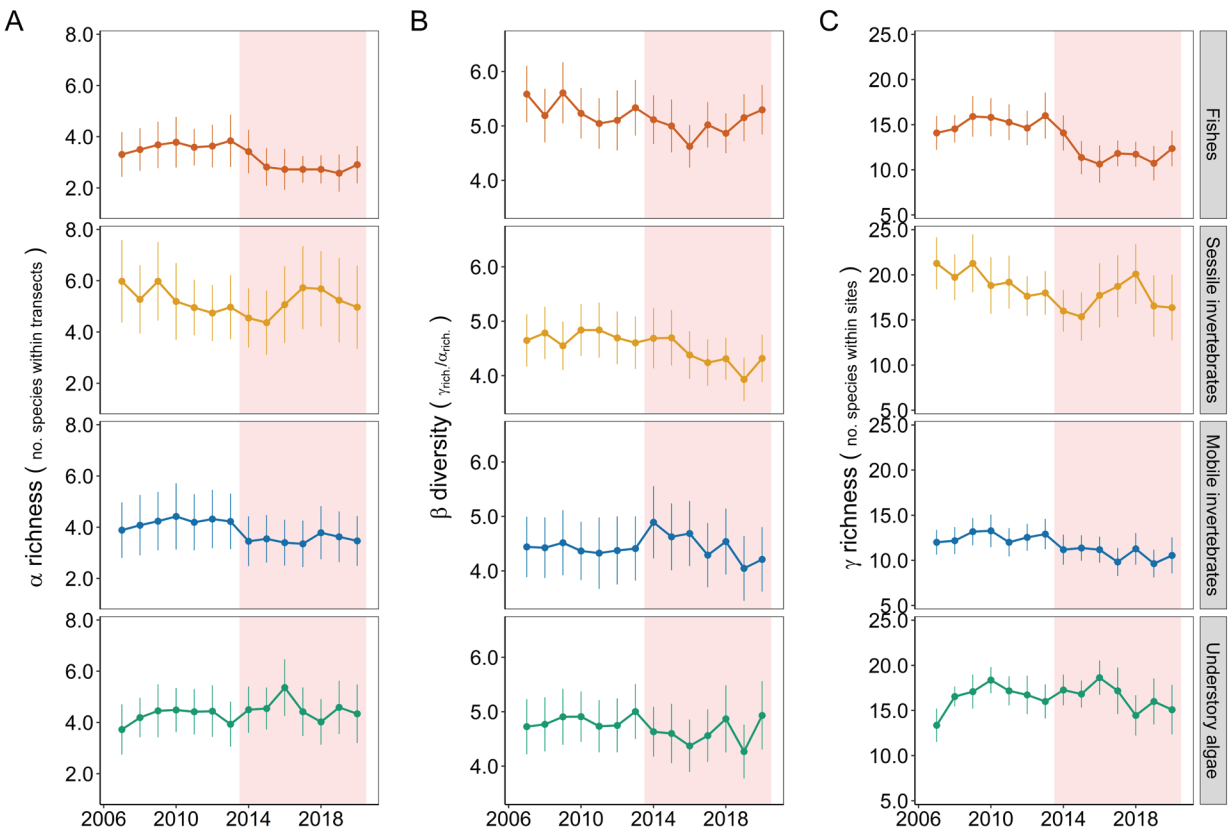

Fig. S4. Long-term dynamics of functional group species richness at multiple scales. Points and error bars are the mean and standard error of species richness (number of species), respectively, for each functional group at the (**A**) transect scale (i.e., richness per transect, averaged across 44 transects) and (**C**) site scale (i.e., richness per site, averaged across 11 sites). Panel (**B**) shows mean β diversity, calculated as values in (**C**) divided by corresponding values in (**A**) (i.e., $\beta = \gamma/\alpha$). Red shading shows the during/after heatwave period (2014−2020).

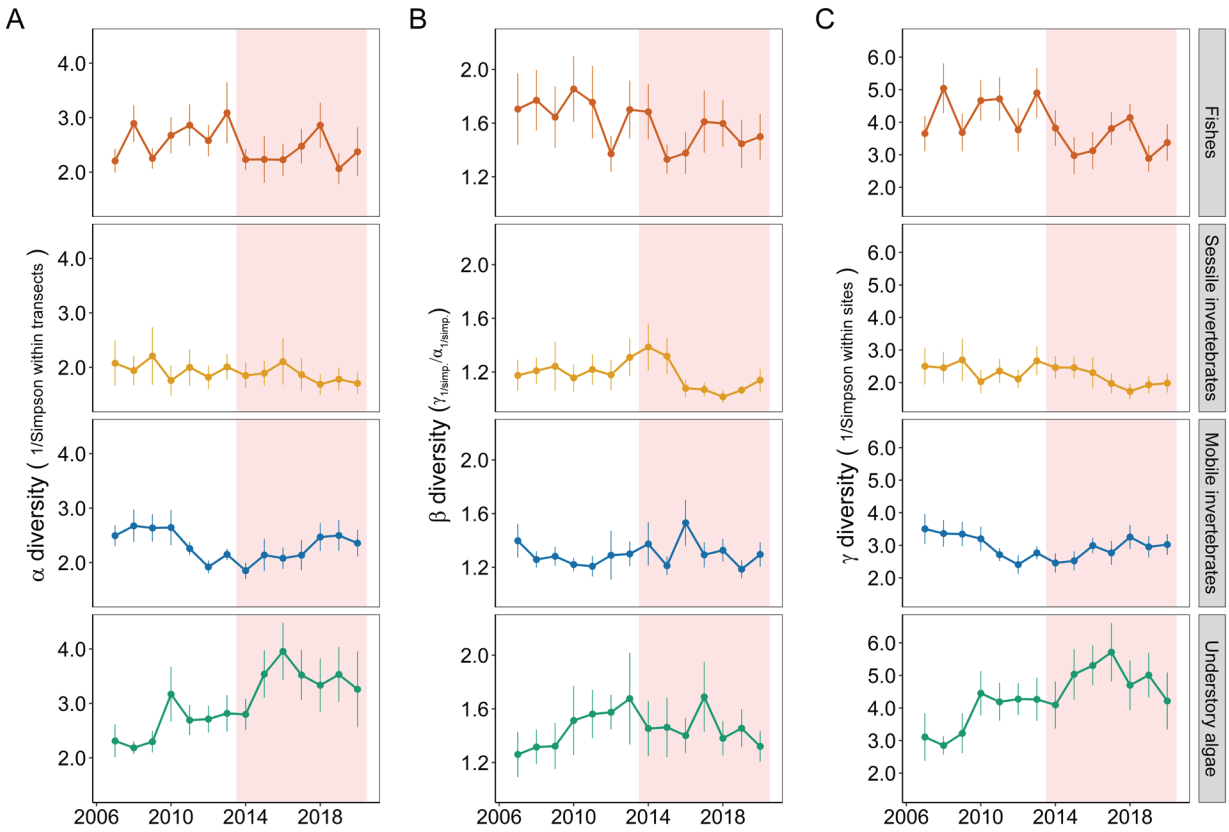

Fig. S5. Long-term dynamics of functional group diversity (1/Simpson) at multiple scales. Points and error bars show the mean and standard error of species diversity (1/Simpson), respectively, for each functional group at the (**A**) transect scale (i.e., averaged across 44 transects) and (**C**) site scale (i.e., averaged across 11 sites). Panel (**B**) shows mean β diversity, calculated as values in (**C**) divided by corresponding values in (**A**) (i.e., $\beta = \gamma/\alpha$). Red shading shows the during/after heatwave period (2014−2020).

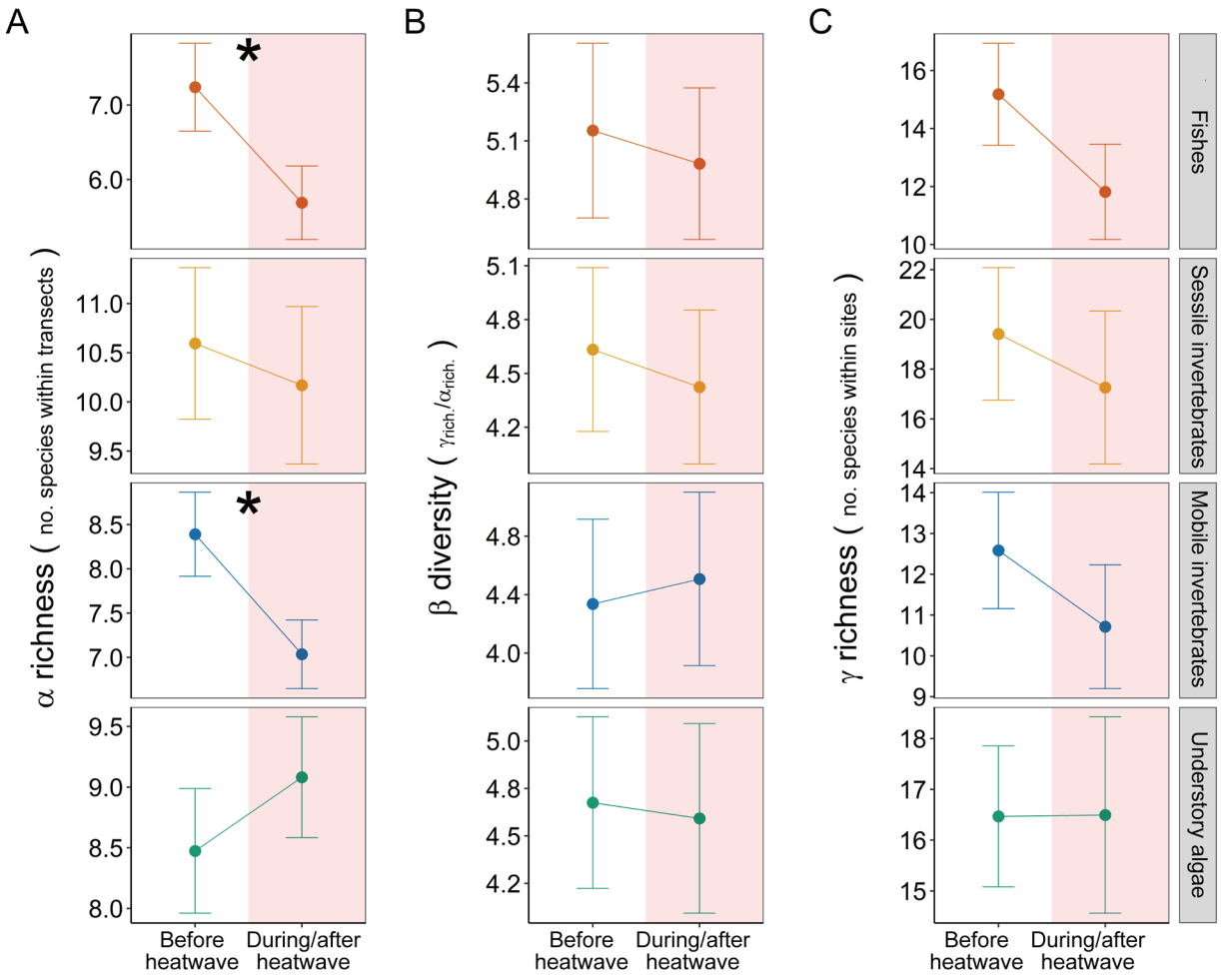

Fig. S6. Changes in functional group richness at multiple scales before vs. during/after the heatwave. Points and error bars show mean species richness metrics and standard error, respectively, for fishes, sessile invertebrates, mobile invertebrates, and understory algae at (**A**) within-transect, (**B**) among-transect, and (**C**) site levels before (2007−2013) and during/after (2014−2020) the heatwave. Sample sizes were 44 for indices at local scales (i.e., $\boldsymbol{\alpha_{rich}}$) and 44 for indices at the broader spatial scales (i.e., $\boldsymbol{\beta_{rich}}$ and $\boldsymbol{\gamma_{rich}}$). Red shading shows the during/after heatwave period (2014−2020). Asterisks denote $P \leq 0.05$. Information about the model fit is provided in Table S1.

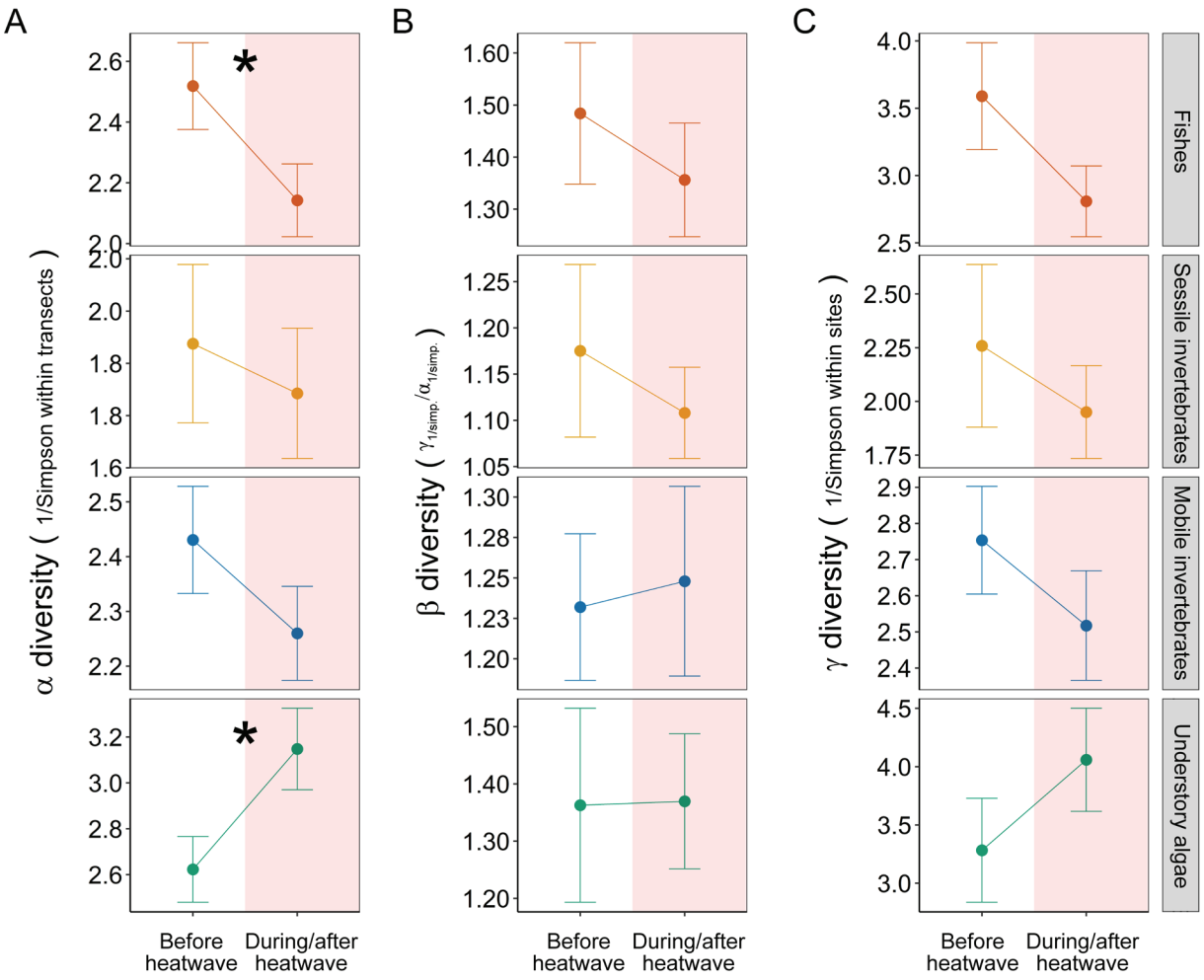

Fig. S7. Changes in functional group diversity (1/Simpson) at multiple scales before vs. during/after the heatwave. Points and error bars show mean species diversity metrics and standard error, respectively, for fishes, sessile invertebrates, mobile invertebrates, and understory algae at (**A**) within-transect, (**B**) among-transect, and (**C**) site levels before (2007−2013) and during/after (2014−2020) the heatwave. Sample sizes were 44 for indices at local scales (i.e., $\boldsymbol{\alpha_{1/simp}}$) and 11 for indices at the broader spatial scales (i.e., $\boldsymbol{\beta_{1/simp}}$ and $\boldsymbol{\gamma_{1/simp}}$). Red shading shows the during/after heatwave period (2014−2020). Asterisks denote $P \leq 0.05$. Information about the model fit is provided in Table S1.

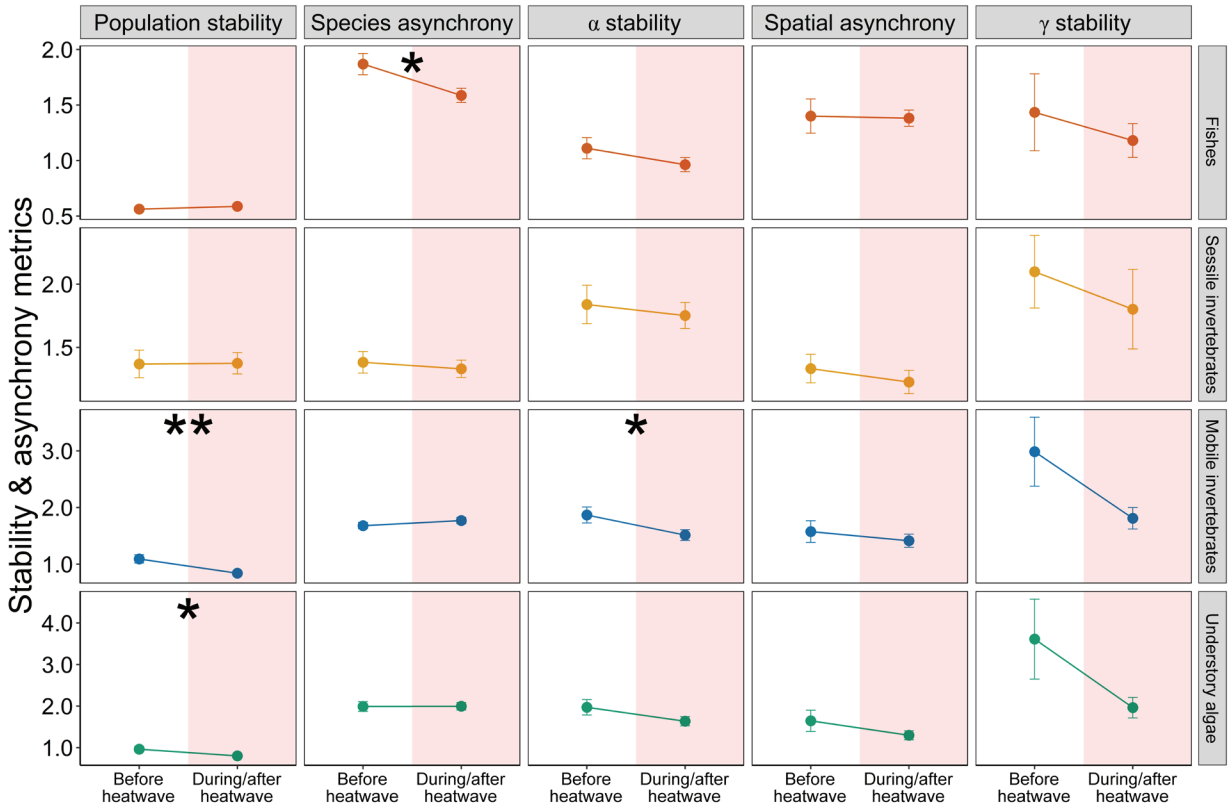

Fig. S8. Changes in functional group stability and asynchrony at multiple scales before vs. during/after the heatwave. Points and error bars show mean stability and asynchrony metrics and standard error, respectively, for fishes, sessile invertebrates, mobile invertebrates, and understory algae at within-transect (population stability, species asynchrony, $\boldsymbol{\alpha}$ stability), among-transect (spatial asynchrony), and site levels ($\boldsymbol{\gamma}$ stability) before (2007−2013) and during/after (2014−2020) the heatwave. Sample sizes were 44 for indices at local scales (i.e., population-level stability, species asynchrony, and $\boldsymbol{\alpha}$ stability) and 11 for indices at the broader spatial scales (i.e., spatial asynchrony and $\boldsymbol{\gamma}$ stability). Red shading shows the during/after heatwave period (2014−2020). Asterisks denote significance levels: *: $P \leq 0.05$; and **: $P \leq 0.001$. Information about the model fit is provided in Table S2.

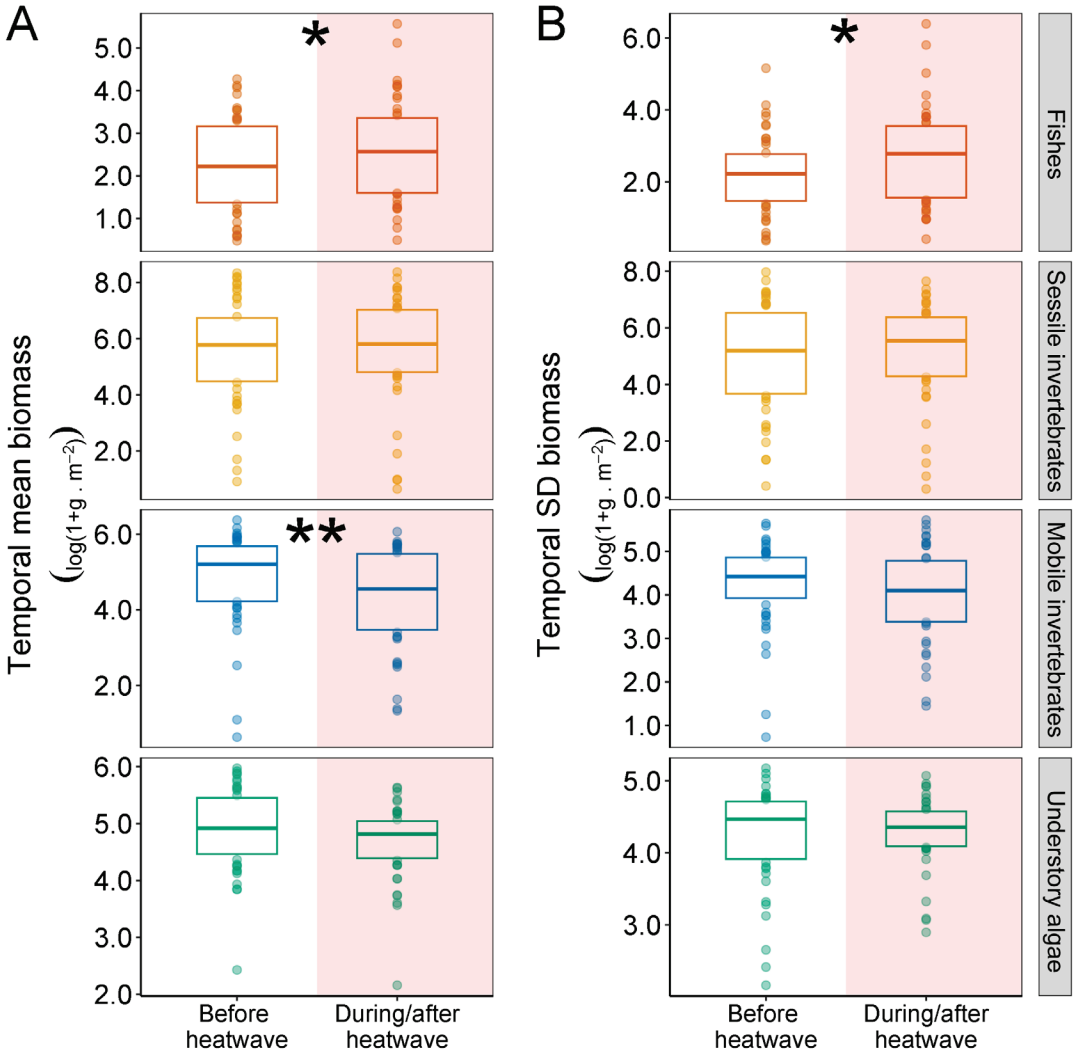

Fig. S9. Changes in the temporal mean (**A**) and standard deviation (**B**) of biomass among functional groups before (2007−2013) vs. during/after (2014−2020) the heatwave ($N_{transect}$ = 44). Red shading shows the during/after heatwave period (2014−2020). Asterisks denote significance levels: *: $P \leq 0.05$; and **: $P \leq 0.001$; Information about the model fit is provided in Table S3.

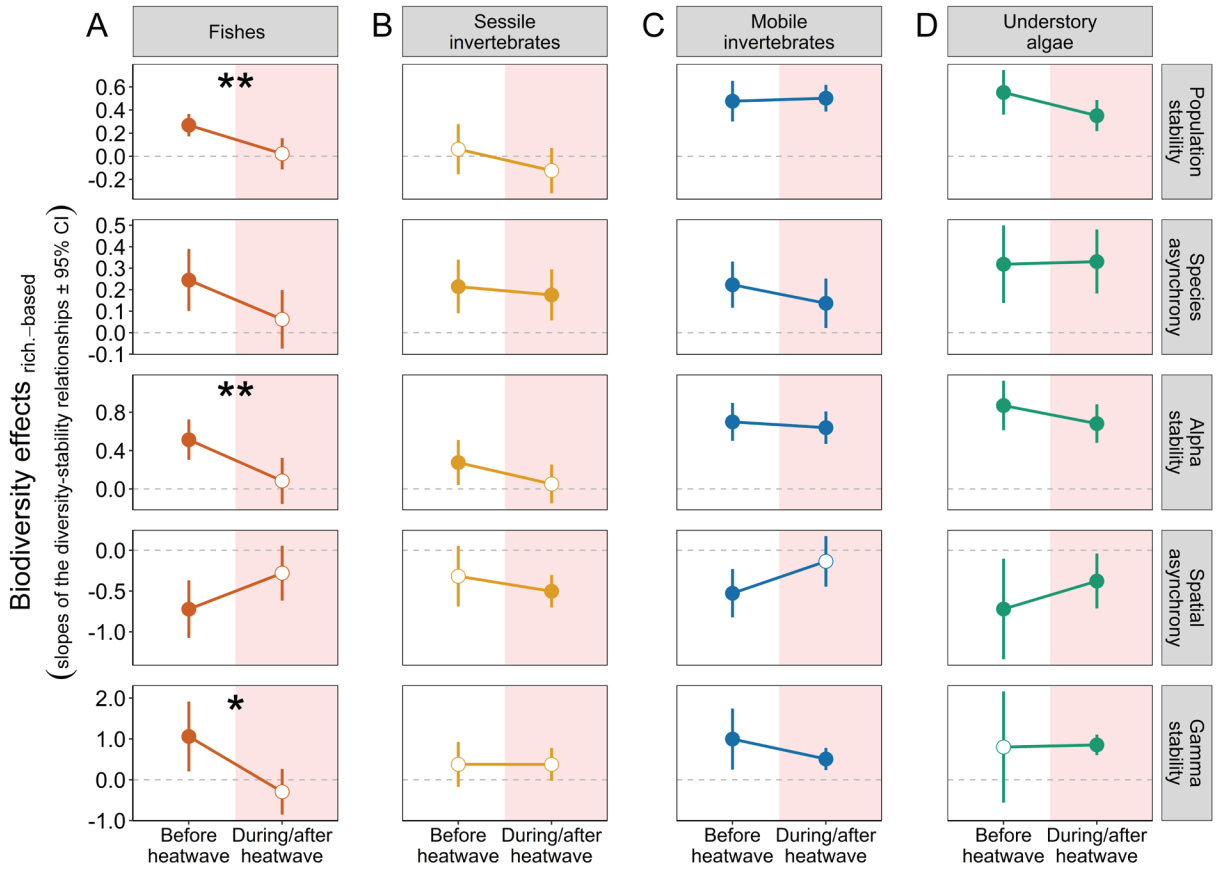

Fig. S10. Changes in functional group diversity-stability relationships based on species richness across multiple scales before vs. during/after the heatwave. Data show the standardized strength of the diversity-stability relationships (DSRs) (i.e., slopes from the linear models) for fishes (**A**), sessile invertebrates (**B**), mobile invertebrates (**C**), and understory algae (**D**) before (2007−2013) and during/after (2014−2020) the marine heatwave. In the models, $\boldsymbol{\alpha}$ diversity is the explanatory variable for analyzing $\boldsymbol{\alpha}$ stability, population stability, and species asynchrony at the local scale ($N_{transect}$ = 44); $\boldsymbol{\beta}$ diversity was used for analyzing $\boldsymbol{\beta}$ stability (spatial asynchrony); $\boldsymbol{\gamma}$ diversity was employed for explaining changes in $\boldsymbol{\gamma}$ stability at the broader spatial scales (N_{site} = 11). Points and error bars are the standardized effect sizes of DSRs and 95% confidential intervals, respectively. Filled points indicate slopes greater than zero ($P \leq 0.05$). Red shading shows the during/after heatwave period (2014−2020). Asterisks denote the significance of pairwise differences between slopes before vs. during/after: *$P \leq 0.05$ and **$P \leq 0.001$. Information about the model fit and the DSR relationships of each functional group are provided in Tables S4 to S11.

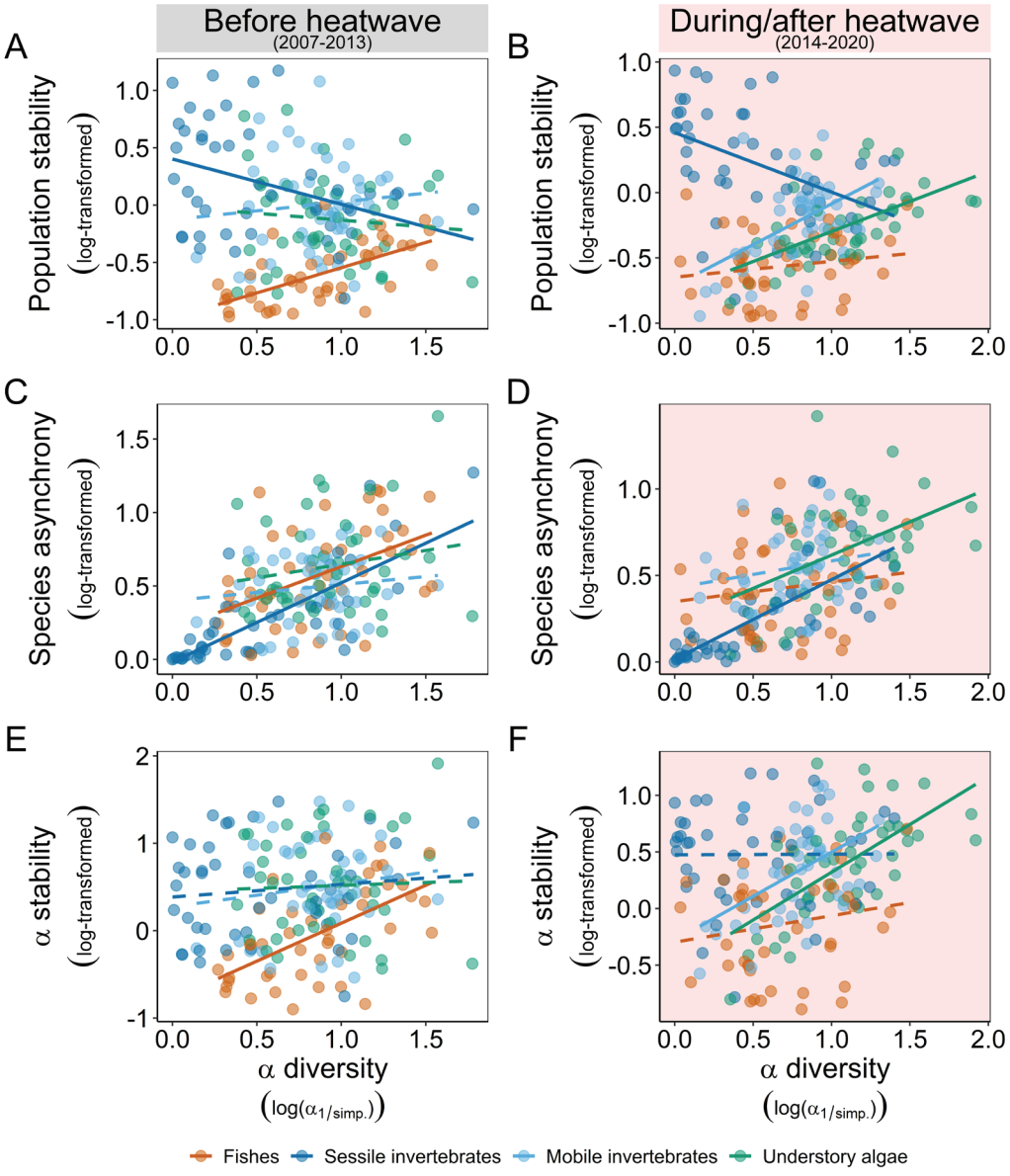

Fig. S11. Changes in functional group diversity-stability relationships at local transect scales before (2007−2013) versus during/after (2014−2020) the heatwave. Data show diversity-stability relationships (DSRs) from linear models (LMs) for fishes, sessile invertebrates, mobile invertebrates, and understory algae. Points represent values of diversity and stability for a given functional group at an individual transect ($N_{transect}$ = 44). Dashed lines indicate non-significant trends ($P > 0.05$). Solid lines indicate significant trends ($P \leq 0.05$). Red shading shows the during/after heatwave period (2014−2020). The diversity indices used here are based on the inverse of the Simpson index. Information about the model fit is provided in Tables S4 to S11.

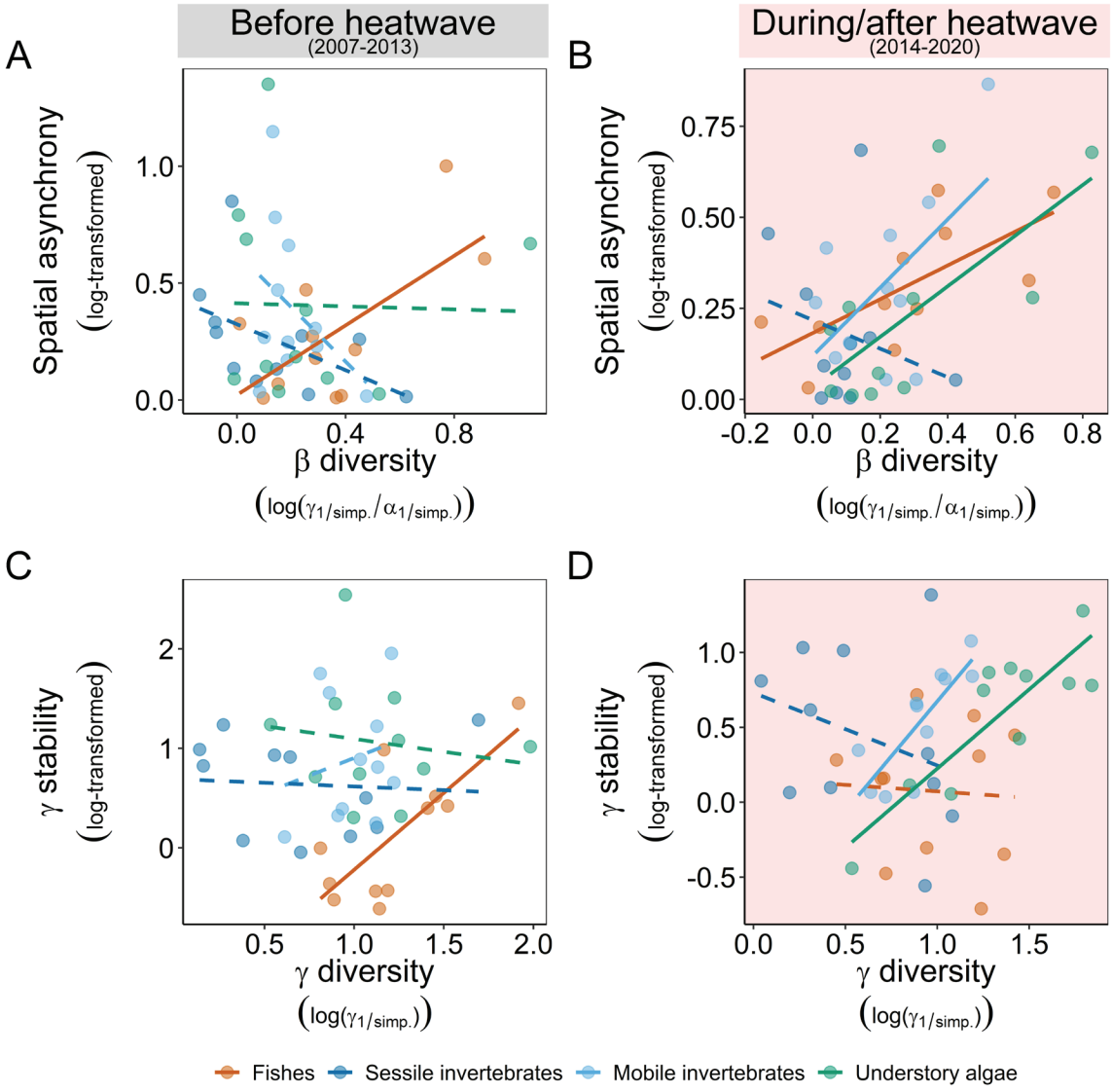

Fig. S12. Changes in functional group diversity-stability relationships at site scales before (2007−2013) versus during/after (2014−2020) the heatwave. Data show diversity-stability relationships (DSRs) from the linear models (LMs) for fishes, sessile invertebrates, mobile invertebrates, and understory algae. Points represent values of diversity and stability for a given functional group at an individual site (N_{site} = 11). Dashed lines indicate non-significant trends ($P > 0.05$). Solid lines indicate significant trends ($P \leq 0.05$). Red shading shows the during/after heatwave period (2014−2020). The diversity indices used here are based on the inverse of the Simpson index. Information about the model fit is provided in Tables S4 to S11.

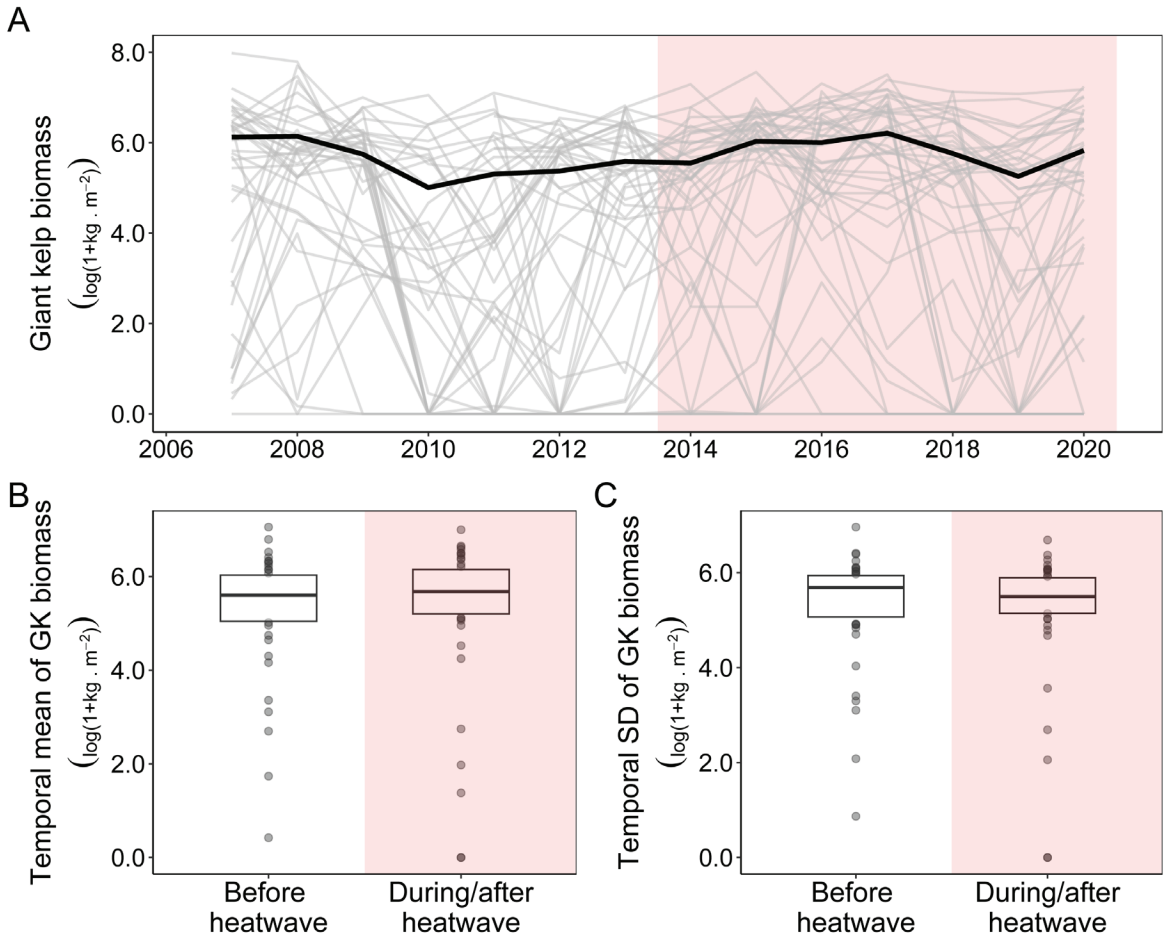

Fig. S13. Long-term biomass dynamics of giant kelp (*Macrocystis pyrifera*) at Santa Barbara Coastal Long Term Ecological Research sites. Panel (**A**) shows the natural log of long-term dynamics of giant kelp biomass (*log*[1 + biomass]) for each transect (gray lines) and the mean among all transects (black line). Panel (**B**) shows boxplots representing the temporal mean of giant kelp biomass ($F_{1,76} = 0.342$, $P = 0.561$) before (2007−2013) versus during/after (2014−2020) the heatwave ($N_{transect} = 44$). Panel (**C**) shows boxplots representing the standard deviation of giant kelp biomass ($F_{1,76} = 0.187$, $P = 0.667$) before (2007−2013) versus during/after (2014−2020) the heatwave ($N_{transect} = 44$). Results are based on the mixed-effects models with "*sites*" as a random factor. Red shading shows the during/after heatwave period (2014−2020).

Table S1. Results for the effects of heatwave on functional group biodiversity at multiple spatial scales. Mixed effects models were used at the local scale with time period as fixed factor and site as a random factor ($N_{transect}$ = 44, $\boldsymbol{\alpha_{rich}}$ and $\boldsymbol{\alpha_{1/simp}}$). Ordinary least squares linear models were used at the broader landscape scale (N_{site} = 11, $\boldsymbol{\gamma_{rich}}$ and $\boldsymbol{\gamma_{1/simp}}$, $\boldsymbol{\beta_{rich}}$ and $\boldsymbol{\beta_{1/simp}}$). Bold face denotes $P \leq 0.05$. SE denotes standard error. Note that diversity metrics have been natural log-transformed.

Variables	Fishes			Sessile invertebrates			Mobile invertebrates			Understory algae		
	Estimate	SE	*P*	Estimate	SE	*P*	Estimate	SE	*P*	Estimate	SE	*P*
α_{rich}	**-0.230**	**0.070**	**0.0016**	-0.038	0.082	0.6476	**-0.163**	**0.063**	**0.0123**	0.079	0.080	0.3281
β_{rich}	-0.023	0.136	0.8671	-0.046	0.156	0.7711	0.041	0.211	0.8492	-0.031	0.160	0.8499
γ_{rich}	-0.289	0.197	0.1583	-0.236	0.291	0.4271	-0.212	0.210	0.3244	-0.063	0.179	0.7303
$\alpha_{1/simp}$	**-0.157**	**0.054**	**0.0051**	-0.033	0.064	0.6038	-0.071	0.045	0.1126	**0.176**	**0.068**	**0.0112**
$\beta_{1/simp}$	-0.085	0.114	0.4615	-0.040	0.084	0.6386	0.009	0.057	0.8820	0.028	0.121	0.8203
$\gamma_{1/simp}$	-0.238	0.139	0.1014	-0.098	0.185	0.6018	-0.092	0.084	0.2829	0.216	0.166	0.2069

Table S2. Results for the effects of heatwave on functional group stability at multiple scales. Temporal stability metrics were calculated based on different temporal intervals, including 3-year (2010−2013 vs. 2014−2016), 4-year (2009−2013 vs. 2014−2017), 5-year (2009−2013 vs. 2014−2018), 6-year (2008−2013 vs. 2014−2019), and 7-year (2007−2013 vs. 2014−2020) before versus during/after the extreme heatwave. Mixed effects models were used at the local scale with time period as fixed factor and site as a random factor ($N_{transect}$ = 44, population stability, species asynchrony, and $\boldsymbol{\alpha}$ stability). Ordinary least squares linear models were used at the broader landscape scale (N_{site} = 11, spatial asynchrony and $\boldsymbol{\gamma}$ stability). Bold face denotes $P \leq 0.05$. SE denotes standard error. Note that stability metrics have been natural log-transformed.

Variables	Intervals	Fishes			Sessile invertebrates			Mobile invertebrates			Understory algae		
		Estimate	SE	*P*	Estimate	SE	*P*	Estimate	SE	*P*	Estimate	SE	*P*
Population stability	3-year	-0.074	0.047	0.1246	**-0.313**	**0.107**	**0.0045**	**-0.285**	**0.071**	**0.0001**	**-0.156**	**0.068**	**0.0241**
	4-year	-0.006	0.040	0.8818	-0.166	0.093	0.0784	**-0.287**	**0.058**	**<0.0001**	**-0.141**	**0.068**	**0.0413**
	5-year	0.049	0.041	0.2331	-0.105	0.083	0.2089	**-0.309**	**0.059**	**<0.0001**	**-0.136**	**0.065**	**0.0391**
	6-year	0.000	0.043	0.9961	-0.041	0.080	0.6123	**-0.260**	**0.058**	**<0.0001**	**-0.120**	**0.059**	**0.0468**
	7-year	0.047	0.045	0.3048	0.040	0.078	0.6073	**-0.226**	**0.056**	**0.0001**	**-0.138**	**0.057**	**0.0178**
Species asynchrony	3-year	**-0.249**	**0.093**	**0.0089**	0.001	0.095	0.9879	-0.003	0.079	0.9718	-0.078	0.090	0.3914
	4-year	**-0.213**	**0.067**	**0.0022**	0.011	0.068	0.8676	0.037	0.064	0.5606	0.006	0.061	0.9271
	5-year	-0.045	0.059	0.4444	-0.046	0.055	0.4054	0.068	0.055	0.2199	-0.037	0.058	0.5278
	6-year	-0.128	0.066	0.0557	-0.059	0.049	0.2401	0.058	0.045	0.2082	-0.029	0.064	0.6485
	7-year	**-0.142**	**0.059**	**0.0192**	-0.024	0.052	0.6429	0.056	0.042	0.1826	0.019	0.060	0.7513
α stability	3-year	**-0.322**	**0.113**	**0.0057**	-0.311	0.152	0.0438	**-0.288**	**0.119**	**0.0181**	-0.234	0.122	0.0593
	4-year	**-0.219**	**0.090**	**0.0168**	-0.155	0.115	0.1821	**-0.250**	**0.095**	**0.0104**	-0.135	0.104	0.1964
	5-year	0.004	0.081	0.9593	-0.151	0.104	0.1481	**-0.242**	**0.088**	**0.0077**	-0.173	0.098	0.0804
	6-year	-0.127	0.095	0.1834	-0.099	0.091	0.2769	**-0.203**	**0.082**	**0.0163**	-0.149	0.099	0.1351
	7-year	-0.095	0.093	0.3090	0.016	0.095	0.8637	**-0.170**	**0.077**	**0.0298**	-0.119	0.095	0.2160
Spatial asynchrony	3-year	0.118	0.092	0.2134	0.088	0.138	0.5281	-0.369	0.159	0.0311	-0.415	0.255	0.1198
	4-year	**0.065**	**0.095**	**0.5027**	0.240	0.149	0.1219	-0.214	0.175	0.2357	-0.234	0.177	0.2006
	5-year	0.072	0.104	0.4948	-0.087	0.106	0.4233	-0.255	0.146	0.0967	-0.214	0.147	0.1614
	6-year	-0.011	0.089	0.9068	-0.107	0.101	0.2996	-0.192	0.150	0.2150	-0.187	0.153	0.2354
	7-year	0.021	0.106	0.8481	-0.077	0.097	0.4362	-0.076	0.127	0.5553	-0.175	0.148	0.2502
γ stability	3-year	-0.007	0.185	0.9691	-0.020	0.260	0.9396	**-0.753**	**0.228**	**0.0035**	-0.597	0.340	0.0942
	4-year	-0.156	0.188	0.4167	0.175	0.280	0.5381	**-0.561**	**0.273**	**0.0528**	-0.418	0.252	0.1123
	5-year	0.024	0.189	0.9014	-0.361	0.246	0.1578	**-0.617**	**0.251**	**0.0232**	**-0.487**	**0.228**	**0.0452**
	6-year	-0.289	0.204	0.1717	-0.339	0.243	0.1784	**-0.551**	**0.255**	**0.0427**	-0.473	0.235	0.0579
	7-year	-0.055	0.249	0.8288	-0.201	0.229	0.3896	-0.367	0.222	0.1136	-0.487	0.241	0.0574

Table S3. Results for the effects of heatwave on functional group biomass. Temporal mean and standard deviation (SD) of community biomass and giant kelp biomass were calculated based on different temporal intervals, including 3-year (2010−2013 vs. 2014−2016), 4-year (2009−2013 vs. 2014−2017), 5-year (2009−2013 vs. 2014−2018), 6-year (2008−2013 vs. 2014−2019), and 7-year (2007−2013 vs. 2014−2020) before versus during/after the extreme heatwave. Mixed effects models were used at the local scale with time period as fixed factor and site as a random factor ($N_{transect}$ = 44). Bold face denotes $P \leq 0.05$. SE denotes standard error. Note that community biomass and giant kelp biomass metrics have been natural log-transformed ($\mathbf{1} + \boldsymbol{g} \cdot \boldsymbol{m^{-2}}$).

Variables	Intervals	Fishes			Sessile invertebrates			Mobile invertebrates			Understory algae			Giant kelp		
		Estimate	SE	*P*	Estimate	SE	*P*	Estimate	SE	*P*	Estimate	SE	*P*	Estimate	SE	*P*
Temporal mean	3-year	-0.005	0.177	0.9783	-0.347	0.207	0.0972	**-0.722**	**0.178**	**0.0001**	0.170	0.134	0.2100	**0.985**	**0.348**	**0.0060**
	4-year	0.028	0.166	0.8691	-0.195	0.198	0.3279	**-0.802**	**0.171**	**0.0000**	0.055	0.130	0.6735	**0.551**	**0.277**	**0.0501**
	5-year	-0.033	0.156	0.8321	-0.053	0.195	0.7844	**-0.675**	**0.158**	**0.0001**	-0.106	0.115	0.3602	**0.564**	**0.270**	**0.0398**
	6-year	0.240	0.162	0.1433	0.032	0.195	0.8693	**-0.546**	**0.144**	**0.0003**	-0.198	0.112	0.0796	0.284	0.271	0.2968
	7-year	**0.332**	**0.164**	**0.0464**	-0.026	0.192	0.8945	**-0.532**	**0.137**	**0.0002**	-0.212	0.111	0.0612	0.153	0.262	0.5607
Temporal SD	3-year	0.243	0.208	0.2469	-0.024	0.255	0.9262	**-0.413**	**0.193**	**0.0355**	**0.394**	**0.144**	**0.0078**	**0.747**	**0.352**	**0.0369**
	4-year	0.245	0.192	0.2048	0.118	0.235	0.6164	**-0.478**	**0.186**	**0.0120**	**0.270**	**0.129**	**0.0404**	0.309	0.266	0.2487
	5-year	0.021	0.184	0.9097	0.291	0.234	0.2187	-0.330	0.167	0.0517	0.175	0.115	0.1327	0.365	0.260	0.1650
	6-year	0.415	0.209	0.0511	0.340	0.226	0.1368	-0.237	0.139	0.0914	0.076	0.117	0.5169	0.246	0.257	0.3422
	7-year	**0.492**	**0.212**	**0.0231**	0.173	0.229	0.4530	-0.243	0.131	0.0669	0.046	0.114	0.6837	0.106	0.245	0.6668

Table S4. Results for the relationship between biodiversity and stability of fishes at the local scale ($N_{transect}$ = 44) based on ordinary least squares linear regression models (LMs) before vs. during/after the heatwave. The temporal intervals include 3-year (2010−2013 vs. 2014−2016), 4-year (2009−2013 vs. 2014−2017), 5-year (2009−2013 vs. 2014−2018), 6-year (2008−2013 vs. 2014−2019), and 7-year (2007−2013 vs. 2014−2020). The explanatory variables are $\boldsymbol{\alpha_{1/simp}}$ and $\boldsymbol{\alpha_{rich}}$. R^2 is the explained variance in LMs. Bold face denotes $P \leq 0.05$. SE denotes standard error. Note that diversity and stability metrics have been natural log-transformed.

Response variables	Periods	Intervals	$\alpha_{1/simp}$				α_{rich}			
			Estimate	SE	*P*	R^2	Estimate	SE	*P*	R^2
Population stability	Before heatwave	3-year	**0.217**	**0.080**	**0.0095**	**0.147**	**0.172**	**0.055**	**0.0035**	**0.183**
		4-year	**0.359**	**0.072**	**<0.0001**	**0.367**	**0.274**	**0.049**	**<0.0001**	**0.416**
		5-year	**0.442**	**0.071**	**<0.0001**	**0.476**	**0.288**	**0.049**	**<0.0001**	**0.445**
		6-year	**0.457**	**0.075**	**<0.0001**	**0.461**	**0.298**	**0.047**	**<0.0001**	**0.489**
		7-year	**0.440**	**0.084**	**<0.0001**	**0.391**	**0.269**	**0.050**	**<0.0001**	**0.407**
	During/ after heatwave	3-year	0.062	0.085	0.4708	0.012	0.030	0.056	0.6038	0.006
		4-year	0.080	0.078	0.3113	0.024	0.066	0.053	0.2208	0.035
		5-year	0.057	0.079	0.4716	0.012	0.040	0.052	0.4529	0.013
		6-year	0.091	0.095	0.3443	0.021	0.029	0.059	0.6321	0.005
		7-year	0.121	0.108	0.2700	0.028	0.022	0.069	0.7551	0.002
Species asynchrony	Before heatwave	3-year	**0.532**	**0.211**	**0.0156**	**0.129**	0.193	0.158	0.2292	0.033
		4-year	**0.714**	**0.147**	**<0.0001**	**0.355**	**0.465**	**0.111**	**0.0001**	**0.292**
		5-year	**0.512**	**0.131**	**0.0003**	**0.263**	**0.360**	**0.087**	**0.0002**	**0.286**
		6-year	**0.477**	**0.128**	**0.0006**	**0.243**	**0.301**	**0.082**	**0.0006**	**0.241**
		7-year	**0.428**	**0.121**	**0.0010**	**0.224**	**0.245**	**0.074**	**0.0018**	**0.205**
	During/ after heatwave	3-year	-0.047	0.124	0.7045	0.003	-0.043	0.082	0.6029	0.006
		4-year	0.192	0.105	0.0752	0.072	**0.150**	**0.071**	**0.0402**	**0.094**
		5-year	0.223	0.110	0.0489	0.087	**0.173**	**0.072**	**0.0200**	**0.120**
		6-year	0.081	0.130	0.5337	0.009	0.051	0.080	0.5313	0.009
		7-year	0.113	0.110	0.3125	0.024	0.062	0.069	0.3769	0.018
α stability	Before heatwave	3-year	**0.749**	**0.245**	**0.0039**	**0.178**	**0.365**	**0.184**	**0.0541**	**0.084**
		4-year	**1.073**	**0.185**	**<0.0001**	**0.438**	**0.739**	**0.137**	**<0.0001**	**0.403**
		5-year	**0.954**	**0.167**	**<0.0001**	**0.432**	**0.649**	**0.112**	**<0.0001**	**0.439**
		6-year	**0.935**	**0.169**	**<0.0001**	**0.416**	**0.600**	**0.106**	**<0.0001**	**0.426**
		7-year	**0.868**	**0.178**	**<0.0001**	**0.355**	**0.514**	**0.108**	**<0.0001**	**0.346**
	During/ after heatwave	3-year	0.015	0.163	0.9291	0.000	-0.013	0.108	0.9023	0.000
		4-year	0.271	0.146	0.0709	0.074	**0.216**	**0.099**	**0.0343**	**0.100**
		5-year	0.281	0.154	0.0748	0.072	**0.213**	**0.101**	**0.0403**	**0.094**
		6-year	0.172	0.198	0.3901	0.017	0.079	0.124	0.5237	0.010
		7-year	0.234	0.193	0.2331	0.033	0.084	0.123	0.4991	0.011

Table S5. Results for the relationship between biodiversity and stability of fishes at the broad landscape scale (N_{site} = 11) based on ordinary least squares linear regression models (LMs) before vs. during/after the heatwave. The temporal intervals include 3-year (2010−2013 vs. 2014−2016), 4-year (2009−2013 vs. 2014−2017), 5-year (2009−2013 vs. 2014−2018), 6-year (2008−2013 vs. 2014−2019), and 7-year (2007−2013 vs. 2014−2020). The explanatory variables are $\boldsymbol{\beta_{1/simp}}$ and $\boldsymbol{\beta_{rich}}$, and $\boldsymbol{\gamma_{1/simp}}$ and $\boldsymbol{\gamma_{rich}}$ for spatial asynchrony and $\boldsymbol{\gamma}$ stability, respectively. The R^2 is the explained variance in the LMs. Bold face denotes $P \leq 0.05$. SE denotes standard error. Note that diversity and stability metrics have been natural log-transformed.

Response variables	Periods	Intervals	$\beta_{1/simp}$				β_{rich}			
			Estimate	SE	*P*	R^2	Estimate	SE	*P*	R^2
Spatial asynchrony	Before heatwave	3-year	0.306	0.192	0.1449	0.203	**-0.374**	**0.135**	**0.0218**	**0.434**
		4-year	0.267	0.201	0.2164	0.150	-0.348	0.160	0.0574	0.322
		5-year	**0.581**	**0.153**	**0.0042**	**0.592**	**-0.620**	**0.115**	**0.0004**	**0.743**
		6-year	**0.581**	**0.153**	**0.0042**	**0.592**	**-0.620**	**0.115**	**0.0004**	**0.743**
		7-year	**0.744**	**0.282**	**0.0270**	**0.410**	**-0.721**	**0.180**	**0.0031**	**0.616**
	During/after heatwave	3-year	0.207	0.262	0.4491	0.059	-0.224	0.234	0.3636	0.084
		4-year	0.322	0.252	0.2341	0.140	-0.453	0.209	0.0587	0.319
		5-year	0.488	0.236	0.0685	0.300	**-0.497**	**0.217**	**0.0476**	**0.345**
		6-year	0.331	0.166	0.0775	0.284	-0.213	0.173	0.2497	0.131
		7-year	**0.464**	**0.157**	**0.0159**	**0.467**	-0.280	0.172	0.1372	0.210
			$\gamma_{1/simp}$				γ_{rich}			
γ stability	Before heatwave	3-year	**0.768**	**0.219**	**0.0067**	**0.551**	**0.670**	**0.184**	**0.0054**	**0.570**
		4-year	**1.037**	**0.207**	**0.0007**	**0.716**	**0.771**	**0.258**	**0.0154**	**0.471**
		5-year	**1.112**	**0.199**	**0.0003**	**0.758**	**0.911**	**0.261**	**0.0068**	**0.550**
		6-year	**1.112**	**0.199**	**0.0003**	**0.758**	**0.911**	**0.261**	**0.0068**	**0.550**
		7-year	**1.545**	**0.457**	**0.0081**	**0.533**	**1.060**	**0.437**	**0.0382**	**0.371**
	During/after heatwave	3-year	0.000	0.267	0.9995	0.000	-0.147	0.240	0.5553	0.036
		4-year	**0.501**	**0.213**	**0.0429**	**0.357**	0.394	0.206	0.0883	0.268
		5-year	**0.568**	**0.209**	**0.0238**	**0.424**	0.279	0.226	0.2479	0.132
		6-year	-0.016	0.437	0.9715	0.000	-0.220	0.278	0.4482	0.059
		7-year	-0.087	0.482	0.8605	0.003	-0.295	0.285	0.3274	0.097

Table S6. Results for the relationship between biodiversity and stability of sessile invertebrates at the local scale ($N_{transect}$ = 44) based on ordinary least squares linear regression models (LMs) before vs. during/after the heatwave. The temporal intervals include 3-year (2010−2013 vs. 2014−2016), 4-year (2009−2013 vs. 2014−2017), 5-year (2009−2013 vs. 2014−2018), 6-year (2008−2013 vs. 2014−2019), and 7-year (2007−2013 vs. 2014−2020). The explanatory variables are $\boldsymbol{\alpha_{1/simp}}$ and $\boldsymbol{\alpha_{rich}}$. R^2 is the explained variance in LMs. Bold face denotes $P \leq 0.05$. SE denotes standard error. Note that diversity and stability metrics have been natural log-transformed.

Response variables	Periods	Intervals	$\alpha_{1/simp}$				α_{rich}			
			Estimate	SE	*P*	R^2	Estimate	SE	*P*	R^2
Population stability	Before heatwave	3-year	**-0.539**	**0.187**	**0.0061**	**0.162**	-0.120	0.170	0.4853	0.011
		4-year	**-0.397**	**0.157**	**0.0156**	**0.129**	-0.015	0.128	0.9081	0.000
		5-year	**-0.417**	**0.151**	**0.0086**	**0.150**	0.016	0.117	0.8919	0.000
		6-year	**-0.424**	**0.150**	**0.0070**	**0.157**	0.032	0.115	0.7843	0.002
		7-year	**-0.394**	**0.156**	**0.0151**	**0.130**	0.061	0.110	0.5815	0.007
	During/ after heatwave	3-year	-0.186	0.142	0.1974	0.038	-0.148	0.097	0.1327	0.052
		4-year	-0.198	0.160	0.2243	0.034	-0.040	0.109	0.7133	0.003
		5-year	**-0.354**	**0.149**	**0.0219**	**0.116**	-0.160	0.105	0.1370	0.051
		6-year	**-0.421**	**0.147**	**0.0064**	**0.161**	-0.164	0.104	0.1217	0.055
		7-year	**-0.455**	**0.141**	**0.0024**	**0.195**	-0.124	0.100	0.2213	0.035
Species asynchrony	Before heatwave	3-year	**0.741**	**0.144**	**<0.0001**	**0.382**	**0.334**	**0.145**	**0.0264**	**0.110**
		4-year	**0.822**	**0.108**	**<0.0001**	**0.575**	**0.399**	**0.110**	**0.0008**	**0.233**
		5-year	**0.605**	**0.072**	**<0.0001**	**0.624**	**0.291**	**0.071**	**0.0002**	**0.281**
		6-year	**0.587**	**0.061**	**<0.0001**	**0.684**	**0.265**	**0.065**	**0.0002**	**0.278**
		7-year	**0.539**	**0.069**	**<0.0001**	**0.587**	**0.214**	**0.064**	**0.0016**	**0.209**
	During/ after heatwave	3-year	**0.632**	**0.112**	**<0.0001**	**0.426**	**0.284**	**0.092**	**0.0035**	**0.182**
		4-year	**0.609**	**0.090**	**<0.0001**	**0.516**	**0.303**	**0.073**	**0.0002**	**0.285**
		5-year	**0.447**	**0.077**	**<0.0001**	**0.437**	**0.172**	**0.066**	**0.0123**	**0.137**
		6-year	**0.406**	**0.067**	**<0.0001**	**0.458**	**0.154**	**0.057**	**0.0095**	**0.147**
		7-year	**0.460**	**0.074**	**<0.0001**	**0.474**	**0.176**	**0.061**	**0.0059**	**0.164**
α stability	Before heatwave	3-year	0.202	0.264	0.4493	0.013	0.214	0.221	0.3375	0.021
		4-year	**0.425**	**0.203**	**0.0427**	**0.092**	**0.384**	**0.151**	**0.0148**	**0.131**
		5-year	0.188	0.197	0.3456	0.021	**0.308**	**0.135**	**0.0274**	**0.108**
		6-year	0.163	0.175	0.3587	0.020	**0.297**	**0.116**	**0.0144**	**0.132**
		7-year	0.145	0.191	0.4520	0.013	**0.276**	**0.120**	**0.0267**	**0.109**
	During/ after heatwave	3-year	**0.446**	**0.197**	**0.0289**	**0.106**	0.136	0.141	0.3422	0.021
		4-year	0.411	0.214	0.0614	0.079	0.263	0.144	0.0739	0.072
		5-year	0.093	0.173	0.5941	0.007	0.012	0.118	0.9204	0.000
		6-year	-0.014	0.162	0.9304	0.000	-0.010	0.108	0.9254	0.000
		7-year	0.005	0.160	0.9732	0.000	0.052	0.103	0.6207	0.006

Table S7. Results for the relationship between biodiversity and stability of sessile invertebrates at the broad landscape scale (N_{site} = 11) based on ordinary least squares linear regression models (LMs) before vs. during/after the heatwave. The temporal intervals include 3-year (2010−2013 vs. 2014−2016), 4-year (2009−2013 vs. 2014−2017), 5-year (2009−2013 vs. 2014−2018), 6-year (2008−2013 vs. 2014−2019), and 7-year (2007−2013 vs. 2014−2020). The explanatory variables are $\boldsymbol{\beta_{1/simp}}$ and $\boldsymbol{\beta_{rich}}$, and $\boldsymbol{\gamma_{1/simp}}$ and $\boldsymbol{\gamma_{rich}}$ for spatial asynchrony and $\boldsymbol{\gamma}$ stability, respectively. The R^2 is the explained variance in the LMs. Bold face denotes $P \leq 0.05$. SE denotes standard error. Note that diversity and stability metrics have been natural log-transformed.

Response variables	Periods	Intervals	$\beta_{1/simp}$				β_{rich}			
			Estimate	SE	*P*	R^2	Estimate	SE	*P*	R^2
Spatial asynchrony	Before heatwave	3-year	0.192	0.446	0.6770	0.018	**-0.623**	**0.258**	**0.0390**	**0.368**
		4-year	-0.189	0.242	0.4545	0.058	**-0.393**	**0.117**	**0.0083**	**0.531**
		5-year	-0.342	0.326	0.3209	0.099	**-0.620**	**0.130**	**0.0010**	**0.694**
		6-year	-0.342	0.326	0.3209	0.099	**-0.620**	**0.130**	**0.0010**	**0.694**
		7-year	-0.491	0.287	0.1218	0.226	-0.317	0.190	0.1296	0.218
	During/after heatwave	3-year	0.009	0.408	0.9825	0.000	**-0.446**	**0.151**	**0.0163**	**0.465**
		4-year	1.085	0.738	0.1754	0.178	-0.122	0.375	0.7523	0.010
		5-year	-0.589	0.467	0.2391	0.137	**-0.509**	**0.105**	**0.0009**	**0.702**
		6-year	-0.508	0.470	0.3081	0.105	**-0.453**	**0.090**	**0.0007**	**0.718**
		7-year	-0.393	0.506	0.4573	0.057	**-0.503**	**0.102**	**0.0008**	**0.709**
			$\gamma_{1/simp}$				γ_{rich}			
γ stability	Before heatwave	3-year	0.268	0.483	0.5924	0.030	0.471	0.405	0.2744	0.119
		4-year	0.114	0.389	0.7768	0.008	**0.624**	**0.250**	**0.0343**	**0.383**
		5-year	0.169	0.423	0.6982	0.016	**0.766**	**0.268**	**0.0188**	**0.450**
		6-year	0.169	0.423	0.6982	0.016	**0.766**	**0.268**	**0.0188**	**0.450**
		7-year	-0.075	0.336	0.8293	0.005	0.377	0.281	0.2120	0.153
	During/after heatwave	3-year	0.723	0.356	0.0730	0.292	0.298	0.247	0.2594	0.127
		4-year	0.866	0.540	0.1431	0.205	0.286	0.331	0.4101	0.069
		5-year	-0.411	0.492	0.4251	0.065	0.389	0.214	0.1024	0.248
		6-year	-0.462	0.464	0.3453	0.090	0.339	0.203	0.1291	0.218
		7-year	-0.486	0.482	0.3401	0.092	0.375	0.204	0.0993	0.252

Table S8. Results for the relationship between biodiversity and stability of mobile invertebrates at the local scale ($N_{transect}$ = 44) based on ordinary least squares linear regression models (LMs) before vs. during/after the heatwave. The temporal intervals include 3-year (2010−2013 vs. 2014−2016), 4-year (2009−2013 vs. 2014−2017), 5-year (2009−2013 vs. 2014−2018), 6-year (2008−2013 vs. 2014−2019), and 7-year (2007−2013 vs. 2014−2020). The explanatory variables are $\boldsymbol{\alpha_{1/simp}}$ and $\boldsymbol{\alpha_{rich}}$. R^2 is the explained variance in LMs. Bold face denotes $P \leq 0.05$. SE denotes standard error. Note that diversity and stability metrics have been natural log-transformed.

Response variables	Periods	Intervals	$\alpha_{1/simp}$				α_{rich}			
			Estimate	SE	*P*	R^2	Estimate	SE	*P*	R^2
Population stability	Before heatwave	3-year	-0.257	0.241	0.2919	0.026	**0.331**	**0.137**	**0.0202**	**0.119**
		4-year	-0.019	0.219	0.9316	0.000	**0.424**	**0.110**	**0.0004**	**0.258**
		5-year	0.001	0.237	0.9966	0.000	**0.474**	**0.110**	**0.0001**	**0.302**
		6-year	0.040	0.230	0.8613	0.001	**0.439**	**0.098**	**0.0001**	**0.316**
		7-year	0.154	0.235	0.5157	0.010	**0.477**	**0.090**	**<0.0001**	**0.396**
	During/after heatwave	3-year	0.089	0.182	0.6269	0.006	**0.338**	**0.081**	**0.0001**	**0.290**
		4-year	0.281	0.151	0.0701	0.074	**0.319**	**0.070**	**<0.0001**	**0.322**
		5-year	**0.408**	**0.169**	**0.0203**	**0.119**	**0.391**	**0.074**	**<0.0001**	**0.394**
		6-year	**0.514**	**0.169**	**0.0040**	**0.177**	**0.506**	**0.067**	**<0.0001**	**0.568**
		7-year	**0.625**	**0.156**	**0.0002**	**0.272**	**0.503**	**0.059**	**<0.0001**	**0.630**
Species asynchrony	Before heatwave	3-year	0.085	0.167	0.6110	0.006	0.188	0.096	0.0557	0.083
		4-year	0.101	0.149	0.5014	0.011	0.141	0.085	0.1044	0.060
		5-year	0.234	0.143	0.1087	0.059	**0.252**	**0.072**	**0.0012**	**0.220**
		6-year	0.164	0.139	0.2470	0.031	**0.241**	**0.064**	**0.0005**	**0.251**
		7-year	0.109	0.131	0.4118	0.016	**0.223**	**0.055**	**0.0002**	**0.277**
	During/after heatwave	3-year	0.291	0.225	0.2031	0.037	0.043	0.121	0.7257	0.003
		4-year	0.355	0.182	0.0579	0.081	0.134	0.102	0.1961	0.039
		5-year	0.099	0.159	0.5388	0.009	0.046	0.084	0.5878	0.007
		6-year	0.194	0.129	0.1403	0.050	**0.176**	**0.068**	**0.0130**	**0.135**
		7-year	0.156	0.115	0.1815	0.041	**0.137**	**0.059**	**0.0247**	**0.112**
α stability	Before heatwave	3-year	-0.172	0.295	0.5630	0.008	**0.519**	**0.158**	**0.0021**	**0.201**
		4-year	0.082	0.277	0.7679	0.002	**0.565**	**0.137**	**0.0002**	**0.285**
		5-year	0.235	0.306	0.4458	0.014	**0.725**	**0.130**	**<0.0001**	**0.422**
		6-year	0.204	0.301	0.5018	0.011	**0.680**	**0.117**	**<0.0001**	**0.438**
		7-year	0.263	0.298	0.3835	0.018	**0.700**	**0.101**	**<0.0001**	**0.528**
	During/after heatwave	3-year	0.380	0.320	0.2419	0.032	**0.381**	**0.161**	**0.0230**	**0.115**
		4-year	**0.636**	**0.268**	**0.0224**	**0.116**	**0.452**	**0.140**	**0.0023**	**0.196**
		5-year	**0.506**	**0.253**	**0.0517**	**0.085**	**0.437**	**0.123**	**0.0009**	**0.227**
		6-year	**0.709**	**0.248**	**0.0066**	**0.160**	**0.682**	**0.106**	**<0.0001**	**0.490**
		7-year	**0.781**	**0.216**	**0.0008**	**0.233**	**0.639**	**0.087**	**<0.0001**	**0.559**

Table S9. Results for the relationship between biodiversity and stability of mobile invertebrates at the broad landscape scale (N_{site} = 11) based on ordinary least squares linear regression models (LMs) before vs. during/after the heatwave. The temporal intervals include 3-year (2010−2013 vs. 2014−2016), 4-year (2009−2013 vs. 2014−2017), 5-year (2009−2013 vs. 2014−2018), 6-year (2008−2013 vs. 2014−2019), and 7-year (2007−2013 vs. 2014−2020). The explanatory variables are $\boldsymbol{\beta_{1/simp}}$ and $\boldsymbol{\beta_{rich}}$, and $\boldsymbol{\gamma_{1/simp}}$ and $\boldsymbol{\gamma_{rich}}$ for spatial asynchrony and $\boldsymbol{\gamma}$ stability, respectively. The R^2 is the explained variance in the LMs. Bold face denotes $P \leq 0.05$. SE denotes standard error. Note that diversity and stability metrics have been natural log-transformed.

Response variables	Periods	Intervals	$\beta_{1/simp}$				β_{rich}			
			Estimate	SE	*P*	R^2	Estimate	SE	*P*	R^2
Spatial asynchrony	Before heatwave	3-year	-0.429	0.748	0.5809	0.032	**-0.502**	**0.246**	**0.0719**	**0.294**
		4-year	-0.650	0.739	0.4020	0.072	**-0.693**	**0.144**	**0.0010**	**0.699**
		5-year	-1.043	0.836	0.2439	0.135	**-0.718**	**0.144**	**0.0008**	**0.713**
		6-year	-1.043	0.836	0.2439	0.135	**-0.718**	**0.144**	**0.0008**	**0.713**
		7-year	-1.164	0.937	0.2456	0.134	**-0.527**	**0.151**	**0.0069**	**0.548**
	During/after heatwave	3-year	0.169	0.294	0.5797	0.032	-0.235	0.165	0.1900	0.167
		4-year	1.172	0.536	0.0566	0.323	-0.012	0.279	0.9670	0.000
		5-year	0.384	0.415	0.3785	0.079	-0.246	0.141	0.1164	0.232
		6-year	0.926	0.447	0.0682	0.300	-0.156	0.170	0.3845	0.077
		7-year	0.938	0.438	0.0610	0.314	-0.135	0.158	0.4151	0.068
			$\gamma_{1/simp}$				γ_{rich}			
γ stability	Before heatwave	3-year	-0.221	1.108	0.8463	0.004	**0.971**	**0.384**	**0.0323**	**0.390**
		4-year	0.159	1.160	0.8940	0.002	**1.293**	**0.407**	**0.0113**	**0.502**
		5-year	0.119	1.180	0.9220	0.001	**1.311**	**0.401**	**0.0097**	**0.517**
		6-year	0.119	1.180	0.9220	0.001	**1.311**	**0.401**	**0.0097**	**0.517**
		7-year	0.709	1.097	0.5346	0.040	**0.997**	**0.381**	**0.0282**	**0.406**
	During/after heatwave	3-year	0.561	0.537	0.3229	0.099	-0.137	0.281	0.6377	0.023
		4-year	0.795	0.962	0.4298	0.064	-0.077	0.314	0.8113	0.006
		5-year	**1.733**	**0.414**	**0.0023**	**0.637**	**0.465**	**0.153**	**0.0139**	**0.481**
		6-year	**1.597**	**0.391**	**0.0027**	**0.626**	**0.507**	**0.156**	**0.0102**	**0.512**
		7-year	**1.467**	**0.343**	**0.0021**	**0.647**	**0.508**	**0.138**	**0.0050**	**0.576**

Table S10. Results for the relationship between biodiversity and stability of understory algae at the local scale ($N_{transect}$ = 44) based on ordinary least squares linear regression models (LMs) before vs. during/after the heatwave. The temporal intervals include 3-year (2010−2013 vs. 2014−2016), 4-year (2009−2013 vs. 2014−2017), 5-year (2009−2013 vs. 2014−2018), 6-year (2008−2013 vs. 2014−2019), and 7-year (2007−2013 vs. 2014−2020). The explanatory variables are $\boldsymbol{\alpha_{1/simp}}$ and $\boldsymbol{\alpha_{rich}}$. R^2 is the explained variance in LMs. Bold face denotes $P \leq 0.05$. SE denotes standard error. Note that diversity and stability metrics have been natural log-transformed.

Response variables	Periods	Intervals	$\alpha_{1/simp}$				α_{rich}			
			Estimate	SE	*P*	R^2	Estimate	SE	*P*	R^2
Population stability	Before heatwave	3-year	0.139	0.146	0.3466	0.021	0.169	0.119	0.1626	0.045
		4-year	0.034	0.145	0.8157	0.001	**0.239**	**0.109**	**0.0339**	**0.101**
		5-year	-0.061	0.166	0.7154	0.003	**0.458**	**0.117**	**0.0003**	**0.262**
		6-year	-0.098	0.177	0.5838	0.007	**0.515**	**0.107**	**<0.0001**	**0.351**
		7-year	-0.119	0.187	0.5267	0.009	**0.553**	**0.098**	**<0.0001**	**0.423**
	During/after heatwave	3-year	**0.309**	**0.124**	**0.0166**	**0.126**	**0.356**	**0.114**	**0.0033**	**0.184**
		4-year	**0.415**	**0.124**	**0.0018**	**0.206**	**0.329**	**0.100**	**0.0021**	**0.201**
		5-year	**0.346**	**0.131**	**0.0118**	**0.139**	**0.338**	**0.095**	**0.0009**	**0.228**
		6-year	**0.356**	**0.116**	**0.0038**	**0.179**	**0.332**	**0.078**	**0.0001**	**0.296**
		7-year	**0.460**	**0.098**	**<0.0001**	**0.340**	**0.352**	**0.069**	**<0.0001**	**0.380**
Species asynchrony	Before heatwave	3-year	**0.460**	**0.157**	**0.0055**	**0.166**	**0.333**	**0.133**	**0.0161**	**0.128**
		4-year	**0.330**	**0.116**	**0.0068**	**0.159**	**0.319**	**0.087**	**0.0007**	**0.239**
		5-year	**0.265**	**0.120**	**0.0327**	**0.102**	**0.367**	**0.088**	**0.0001**	**0.290**
		6-year	0.171	0.159	0.2880	0.026	**0.352**	**0.108**	**0.0023**	**0.197**
		7-year	0.187	0.147	0.2126	0.036	**0.319**	**0.092**	**0.0013**	**0.218**
	During/after heatwave	3-year	0.170	0.142	0.2356	0.033	**0.368**	**0.125**	**0.0053**	**0.168**
		4-year	**0.376**	**0.104**	**0.0008**	**0.234**	**0.328**	**0.081**	**0.0002**	**0.277**
		5-year	**0.412**	**0.098**	**0.0001**	**0.292**	**0.327**	**0.073**	**0.0001**	**0.317**
		6-year	**0.381**	**0.102**	**0.0005**	**0.246**	**0.313**	**0.070**	**0.0001**	**0.314**
		7-year	**0.385**	**0.111**	**0.0013**	**0.217**	**0.331**	**0.076**	**0.0001**	**0.306**
α stability	Before heatwave	3-year	**0.599**	**0.224**	**0.0106**	**0.143**	**0.502**	**0.184**	**0.0094**	**0.147**
		4-year	0.364	0.203	0.0807	0.069	**0.558**	**0.143**	**0.0003**	**0.263**
		5-year	0.204	0.228	0.3769	0.018	**0.826**	**0.141**	**<0.0001**	**0.444**
		6-year	0.073	0.268	0.7853	0.002	**0.867**	**0.151**	**<0.0001**	**0.435**
		7-year	0.068	0.271	0.8040	0.001	**0.871**	**0.132**	**<0.0001**	**0.505**
	During/after heatwave	3-year	**0.480**	**0.196**	**0.0188**	**0.122**	**0.724**	**0.166**	**0.0001**	**0.306**
		4-year	**0.790**	**0.167**	**<0.0001**	**0.343**	**0.658**	**0.131**	**<0.0001**	**0.368**
		5-year	**0.758**	**0.164**	**<0.0001**	**0.332**	**0.665**	**0.114**	**<0.0001**	**0.440**
		6-year	**0.737**	**0.157**	**<0.0001**	**0.339**	**0.645**	**0.100**	**<0.0001**	**0.493**
		7-year	**0.845**	**0.155**	**<0.0001**	**0.408**	**0.683**	**0.102**	**<0.0001**	**0.508**

Table S11. Results for the relationship between biodiversity and stability of understory algae at the broad landscape scale (N_{site} = 11) based on ordinary least squares linear regression models (LMs) before vs. during/after the heatwave. The temporal intervals include 3-year (2010−2013 vs. 2014−2016), 4-year (2009−2013 vs. 2014−2017), 5-year (2009−2013 vs. 2014−2018), 6-year (2008−2013 vs. 2014−2019), and 7-year (2007−2013 vs. 2014−2020). The explanatory variables are $\boldsymbol{\beta_{1/simp}}$ and $\boldsymbol{\beta_{rich}}$, and $\boldsymbol{\gamma_{1/simp}}$ and $\boldsymbol{\gamma_{rich}}$ for spatial asynchrony and $\boldsymbol{\gamma}$ stability, respectively. The R^2 is the explained variance in the LMs. Bold face denotes $P \leq 0.05$. SE denotes standard error. Note that diversity and stability metrics have been natural log-transformed.

Response variables	Periods	Intervals	$\beta_{1/simp}$				β_{rich}			
			Estimate	SE	*P*	R^2	Estimate	SE	*P*	R^2
Spatial asynchrony	Before heatwave	3-year	-0.152	0.687	0.8296	0.005	-0.673	0.614	0.3015	0.107
		4-year	0.462	0.489	0.3697	0.082	**-1.023**	**0.372**	**0.0225**	**0.430**
		5-year	-0.114	0.423	0.7939	0.007	**-0.913**	**0.291**	**0.0120**	**0.496**
		6-year	-0.114	0.423	0.7939	0.007	**-0.913**	**0.291**	**0.0120**	**0.496**
		7-year	-0.033	0.447	0.9436	0.001	**-0.721**	**0.315**	**0.0479**	**0.344**
	During/after heatwave	3-year	0.373	0.462	0.4403	0.061	-0.464	0.361	0.2300	0.142
		4-year	0.194	0.230	0.4197	0.067	-0.155	0.192	0.4416	0.061
		5-year	**0.445**	**0.190**	**0.0434**	**0.355**	-0.180	0.164	0.3006	0.108
		6-year	**0.648**	**0.206**	**0.0117**	**0.498**	-0.309	0.181	0.1221	0.225
		7-year	**0.695**	**0.240**	**0.0178**	**0.455**	-0.377	0.172	0.0560	0.325
			$\gamma_{1/simp}$				γ_{rich}			
γ stability	Before heatwave	3-year	-0.296	0.826	0.7285	0.013	0.290	0.898	0.7541	0.010
		4-year	0.014	0.613	0.9817	0.000	1.088	0.733	0.1717	0.181
		5-year	-0.484	0.501	0.3599	0.085	0.713	0.678	0.3210	0.099
		6-year	-0.484	0.501	0.3599	0.085	0.713	0.678	0.3210	0.099
		7-year	-0.258	0.552	0.6510	0.021	0.801	0.695	0.2785	0.117
	During/after heatwave	3-year	-0.109	0.334	0.7511	0.011	0.729	0.404	0.1046	0.246
		4-year	0.372	0.296	0.2402	0.137	**0.694**	**0.251**	**0.0220**	**0.433**
		5-year	**0.602**	**0.244**	**0.0354**	**0.379**	**0.723**	**0.185**	**0.0035**	**0.606**
		6-year	**0.768**	**0.262**	**0.0168**	**0.462**	**0.799**	**0.152**	**0.0005**	**0.735**
		7-year	**1.057**	**0.207**	**0.0006**	**0.722**	**0.855**	**0.129**	**0.0001**	**0.816**

Table S12. Results for the relationship between the temporal mean/SD of community biomass and $\boldsymbol{\alpha}$ stability among functional groups at the local scale ($N_{transect}$ = 44) based on ordinary least squares linear regression models (LMs) before vs. during/after the heatwave. The temporal intervals include 3-year (2010−2013 vs. 2014−2016), 4-year (2009−2013 vs. 2014−2017), 5-year (2009−2013 vs. 2014−2018), 6-year (2008−2013 vs. 2014−2019), and 7-year (2007−2013 vs. 2014−2020). The explanatory variables are temporal mean and SD of community biomass. R^2 is the explained variance in LMs. Bold face denotes $P \leq 0.05$. SE denotes standard error. Note that both biomass and $\boldsymbol{\alpha}$ stability have been natural log-transformed.

Functional groups	Periods	Intervals	Temporal mean biomass				Temporal SD biomass			
			Estimate	SE	*P*	R^2	Estimate	SE	*P*	R^2
Fishes	Before heatwave	3-year	0.107	0.090	0.2435	0.03	-0.171	0.097	0.0847	0.07
		4-year	**0.222**	**0.079**	**0.0079**	**0.15**	-0.043	0.097	0.6587	0.01
		5-year	**0.214**	**0.072**	**0.0048**	**0.17**	0.008	0.087	0.9303	0.00
		6-year	**0.177**	**0.073**	**0.0201**	**0.12**	-0.018	0.085	0.8300	0.001
		7-year	0.123	0.073	0.1019	0.06	-0.062	0.077	0.4268	0.01
	During/after heatwave	3-year	-0.061	0.051	0.2407	0.03	**-0.122**	**0.047**	**0.0124**	**0.14**
		4-year	0.009	0.049	0.8590	0.001	-0.077	0.047	0.1079	0.06
		5-year	0.014	0.052	0.7948	0.002	-0.082	0.049	0.1028	0.06
		6-year	-0.081	0.057	0.1574	0.05	**-0.164**	**0.045**	**0.0007**	**0.24**
		7-year	-0.107	0.057	0.0670	0.08	**-0.183**	**0.043**	**0.0001**	**0.30**
Mobile invertebrates	Before heatwave	3-year	**0.229**	**0.054**	**0.0001**	**0.30**	0.079	0.076	0.3011	0.02
		4-year	**0.224**	**0.053**	**0.0001**	**0.29**	0.111	0.074	0.1440	0.05
		5-year	**0.281**	**0.054**	**<0.0001**	**0.39**	**0.195**	**0.081**	**0.0204**	**0.12**
		6-year	**0.251**	**0.056**	**<0.0001**	**0.32**	**0.176**	**0.078**	**0.0301**	**0.10**
		7-year	**0.239**	**0.054**	**<0.0001**	**0.31**	**0.195**	**0.074**	**0.0116**	**0.14**
	During/after heatwave	3-year	0.058	0.064	0.3753	0.02	-0.104	0.064	0.1101	0.06
		4-year	0.083	0.050	0.1057	0.06	-0.027	0.054	0.6245	0.01
		5-year	0.090	0.046	0.0583	0.08	-0.005	0.051	0.9191	0.00
		6-year	**0.211**	**0.044**	**<0.0001**	**0.35**	**0.126**	**0.061**	**0.0462**	**0.09**
		7-year	**0.213**	**0.039**	**<0.0001**	**0.41**	**0.153**	**0.057**	**0.0101**	**0.14**
Sessile invertebrates	Before heatwave	3-year	0.030	0.069	0.6693	0.004	**-0.152**	**0.064**	**0.0226**	**0.12**
		4-year	0.020	0.052	0.6932	0.004	-0.066	0.050	0.1945	0.04
		5-year	0.025	0.048	0.6068	0.01	-0.038	0.047	0.4223	0.02
		6-year	0.029	0.043	0.5036	0.01	-0.005	0.043	0.9149	0.00
		7-year	0.014	0.046	0.7689	0.002	-0.026	0.045	0.5745	0.01
	During/after heatwave	3-year	-0.032	0.051	0.5301	0.01	**-0.126**	**0.047**	**0.0101**	**0.14**
		4-year	0.022	0.052	0.6801	0.004	-0.087	0.051	0.0921	0.06
		5-year	0.015	0.040	0.7095	0.003	-0.046	0.040	0.2581	0.03
		6-year	0.043	0.036	0.2424	0.03	-0.008	0.039	0.8299	0.001
		7-year	0.071	0.033	0.0389	0.10	0.027	0.038	0.4852	0.01
Understory algae	Before heatwave	3-year	**0.263**	**0.117**	**0.0308**	**0.10**	**-0.343**	**0.108**	**0.0027**	**0.19**
		4-year	**0.346**	**0.089**	**0.0004**	**0.26**	-0.061	0.112	0.5897	0.01
		5-year	**0.445**	**0.096**	**<0.0001**	**0.33**	-0.013	0.127	0.9186	0.00
		6-year	**0.468**	**0.111**	**0.0001**	**0.29**	-0.058	0.130	0.6608	0.01
		7-year	**0.461**	**0.102**	**<0.0001**	**0.32**	0.053	0.127	0.6783	0.004
	During/after heatwave	3-year	**0.398**	**0.128**	**0.0034**	**0.18**	**-0.428**	**0.125**	**0.0014**	**0.21**
		4-year	**0.452**	**0.104**	**<0.0001**	**0.31**	-0.261	0.140	0.0681	0.08
		5-year	**0.461**	**0.089**	**<0.0001**	**0.39**	-0.121	0.143	0.4031	0.02
		6-year	**0.470**	**0.082**	**<0.0001**	**0.43**	-0.043	0.146	0.7690	0.002
		7-year	**0.477**	**0.082**	**<0.0001**	**0.44**	-0.043	0.147	0.7730	0.002