Supplementary Information

Fredston et al.

2022

Contents

1 Software

Code and data for this analysis can be found on GitHub at https://github.com/afredston/marine_heatwaves_trawl. The statistical analysis used the following packages: glmmTMB[1] to fit generalized linear models, mgcv[2] to fit generalized additive models, dggridR[3] for spatial standardization of data, and ncdf4[4] for processing marine heatwave data.

2 Supplementary tables

Table 1: Survey names used in this analysis, and corresponding codes used in figures and tables in this Supplement.

Code	Survey
BITS	Baltic Sea
DFO-QCS	British Columbia
EBS	Eastern Bering Sea
EVHOE	France
FR-CGFS	English Channel
GMEX	Gulf of Mexico
GOA	Gulf of Alaska
GSL-S	Gulf of Saint Lawrence
IE-IGFS	Ireland
NEUS	Northeast US
NIGFS	Northern Ireland
Nor-BTS	Norway
NS-IBTS	North Sea
PT-IBTS	Portugal
SCS	Scotian Shelf
SEUS	Southeast US
SWC-IBTS	Scotland
WCANN	West Coast US

Table 2: Models of biomass response to MHWs. All models were fitted to biomass log ratio values (scaled and centered within surveys) using MHW severity in °C days (scaled and centered within surveys, calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text). Model names correspond to: null (intercept-only) model, linear model, linear model including survey as a fixed effect, generalized additive model (GAM), and GAM including survey as a random effect.

	Null	LM	LM Survey	GAM	GAM Survey
Intercept	0.00 ± 0.051	0.00 ± 0.052	0.00 ± 0.236	0.00 ± 0.051	0.00 ± 0.051
MHW coefficient	NA	0.008 ± 0.053	0.008 ± 02	NA	NA
Coefficient p-value	NA	0.88	0.883	0.593	0.593
R^2	NA	0.000	0.000	0.004	0.004
AIC	1007	1009	1043	1009	1009
Degrees of freedom	359	358	341	356	356

Table 3: Linear models of biomass response to MHWs fitted individually within each region. All models were fitted to biomass log ratio values (scaled and centered within surveys) using MHW severity in °C days (scaled and centered within surveys, calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text).

	Intercept	MHW coefficient	Coefficient p-value	R^2	AIC	Degrees of freedom
Baltic Sea	0.00 ± 0.243	-0.012 ± 0.25	0.962	0.00	56	16
British Columbia	0.00 ± 0.338	0.316 ± 0.359	0.408	0.10	30	7
Eastern Bering Sea	0.00 ± 0.187	-0.358 ± 0.191	0.073	0.128	75	24
France	0.00 ± 0.221	0.164 ± 0.226	0.478	0.027	64	19
English Channel	0.00 ± 0.221	0.15 ± 0.227	0.516	0.022	64	19
Gulf of Mexico	0.00 ± 0.192	-0.287 ± 0.196	0.155	0.082	77	24
Gulf of Alaska	0.00 ± 0.283	-0.535 ± 0.299	0.111	0.286	30	8
Gulf of Saint Lawrence	0.00 ± 0.193	0.332 ± 0.197	0.105	0.11	73	23
Ireland	0.00 ± 0.258	-0.059 ± 0.267	0.828	0.003	50	14
Northeast US	0.00 ± 0.187	0.352 ± 0.191	0.078	0.124	75	24
Northern Ireland	0.00 ± 0.335	-0.02 ± 0.353	0.957	0.00	33	8
Norway	0.00 ± 0.209	0.015 ± 0.213	0.944	0.00	73	22
North Sea	0.00 ± 0.20	-0.066 ± 0.204	0.75	0.004	79	24
Portugal	0.00 ± 0.299	-0.342 ± 0.313	0.303	0.117	35	9
Scotian Shelf	0.00 ± 0.209	0.009 ± 0.213	0.968	0.00	73	22
Southeast US	0.00 ± 0.20	-0.011 ± 0.204	0.956	0.00	79	24
Scotland	0.00 ± 0.20	0.076 ± 0.204	0.712	0.006	79	24
West Coast US	0.00 ± 0.264	0.163 ± 0.274	0.562	0.027	47	13

Table 4: Models of biomass response to MHWs. This table is identical to Supp. Tab. 2, except rather than centering and scaling MHW severity within regions, it is centered and scaled among regions. The approach used in most of these models (centering and scaling MHW severity within regions) assumes that history matters in ecological responses to MHW responses, i.e., that biomass change should be compared to how anomalous a MHW is relative to other MHWs that occurred in the region. Here, we test the hypothesis that absolute MHW severity matters regardless of the oceanographic history of each region (centering and scaling MHW severity among regions). All models were fitted to biomass log ratio values (scaled and centered within surveys) using MHW severity in days (scaled and centered within surveys, calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text). Model names correspond to: null (intercept-only) model, linear model, linear model including survey as a fixed effect, generalized additive model (GAM), and GAM including survey as a random effect.

	Null	LM	LM Survey	GAM	GAM Survey
Intercept	0.00 ± 0.051	0.00 ± 0.052	0.002 ± 0.236	0.00 ± 0.051	0.00 ± 0.051
MHW coefficient	NA	0.009 ± 0.052	0.009 ± 02	NA	NA
Coefficient p-value	NA	0.867	0.865	0.185	0.18
R^2	NA	0.000	0.000	0.019	0.019
AIC	1007	1009	1043	1008	1008
Degrees of freedom	359	358	341	352	352

Table 5: Models of biomass response to lagged MHW effects. All models were fitted to biomass log ratio values (scaled and centered within surveys) using MHW severity in °C days (scaled and centered within surveys, calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text). All models are generalized additive models (GAMs) that use a smoothed predictor matrix containing lagged MHW data for up to five years into the past.

	1-2 Years	1-3 Years	1-4 Years	1-5 Years
p-value	0.531	0.552	0.164	0.559
R^2	-0.002	0.001	0.003	-0.002
AIC	955	902	841	797
Degrees of freedom	340	321	304	286

Table 6: Null (intercept-only) model and generalized linear model (GLM) of biomass as a function of MHWs and biomass from the previous time step. This Gompertz model accounts for autoregressive properties of the biomass time-series. It predicts biomass log ratios with MHW severity in °C days (scaled and centered within surveys, calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text) and lagged biomass (not scaled and centered). To account for variability and heteroskedasticity among surveys, we included survey identity as a fixed effect and allowed dispersion to vary among surveys.

	Null model	Gompertz GLM
Intercept	0.01 ± 0.013	0.317 ± 0.241
MHW coefficient	NA	-0.009 ± 0.012
Coefficient p-value	NA	0.444
R^2	NA	0.335
AIC	180	99
Degrees of freedom	341	287

Table 7: Null model (latitude-only) and model of biomass response to MHWs and latitude. Linear model was fitted to biomass log ratio values (scaled and centered within surveys) using MHW severity in °C days (scaled and centered within surveys, calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text) and median latitude of each survey (scaled and centered within surveys) as predictors.

	Null model	Linear model
Intercept	0.00 ± 0.052	0.00 ± 0.052
MHW coefficient	NA	0.008 ± 0.053
Latitude coefficient	NA	0.00 ± 0.052
MHW coefficient p-value	NA	0.88
R^2	NA	0.00
AIC	1009	1011
Degrees of freedom	358	357

Table 8: Null (intercept-only) model and model of depth response to MHWs. Linear model was fitted to the weighted mean depth of the fish assemblage (scaled and centered within surveys, calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text) using MHW severity in °C days (scaled and centered within surveys).

	Null model	Linear model
Intercept	0.00 ± 0.053	0.00 ± 0.053
MHW coefficient	NA	-0.016 ± 0.055
Coefficient p-value	NA	0.775
R^2	NA	0.00
AIC	937	939
Degrees of freedom	334	333

Table 9: Models of Community Temperature Index (CTI) response to MHWs. All models were fitted to CTI year-over-year difference values (scaled and centered within surveys) using MHW severity in °C days (scaled and centered within surveys, calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text). Model names correspond to: null (intercept-only) model, linear model, linear model including survey as a fixed effect, generalized additive model (GAM), and GAM including survey as a random effect.

	Null	LM	LM Survey	GAM	GAM Survey
Intercept	0.00 ± 0.051	0.00 ± 0.051	0.00 ± 0.236	0.00 ± 0.051	0.00 ± 0.051
MHW coefficient	NA	0.051 ± 0.053	0.051 ± 02	NA	NA
Coefficient p-value	NA	0.332	0.344	0.311	0.311
R^2	NA	0.003	0.003	0.004	0.004
AIC	1007.170	1008.223	1042.223	1007.244	1007.244
Degrees of freedom	359.000	358.000	341.000	357.311	357.311

3 Supplementary figures: sensitivity of main results to metrics and methods

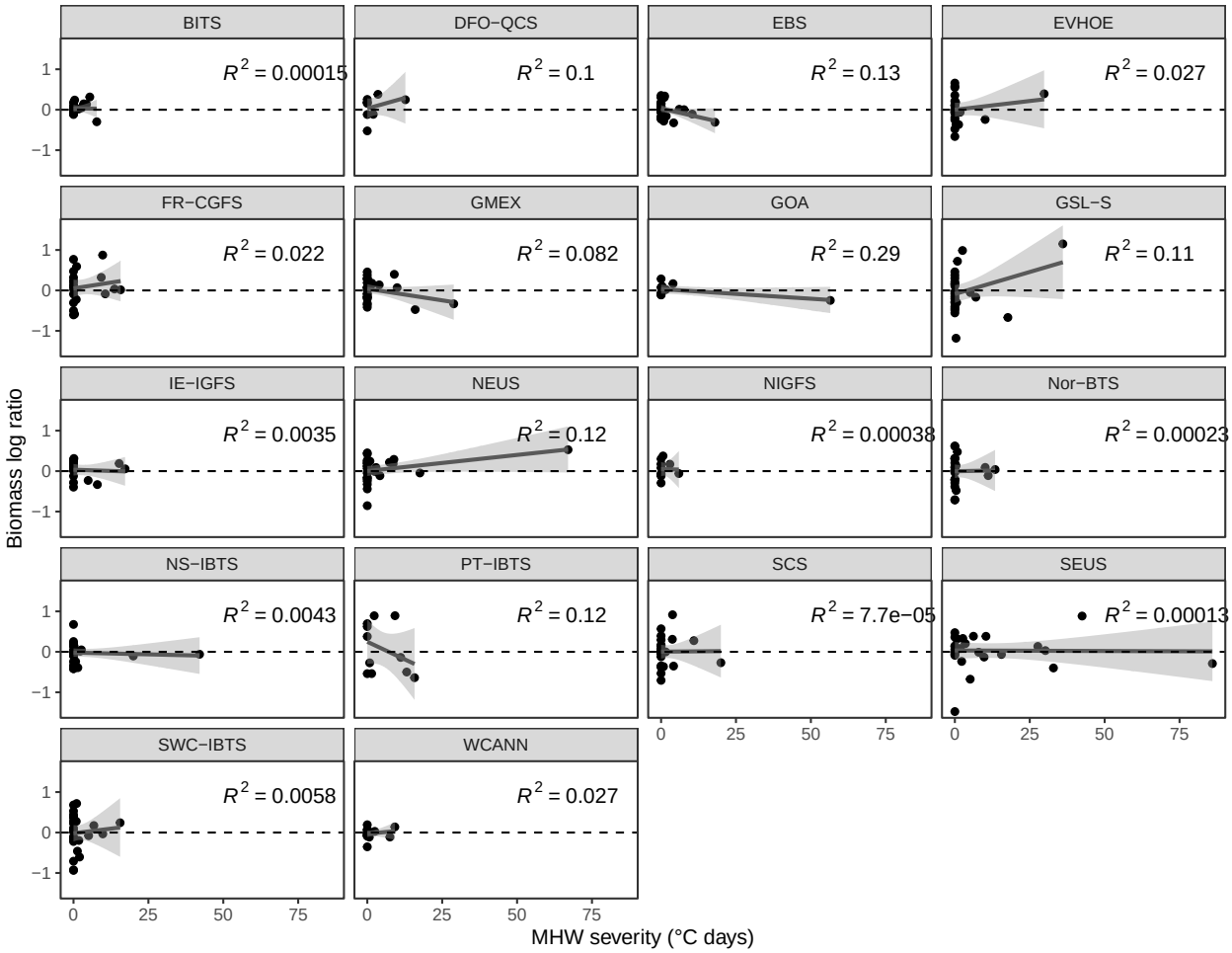


Figure 1: Alternate version of Fig. 2 from the main text, showing results by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. Points represent log ratios of mean biomass in a survey from one year to the next. The fitted lines are linear regressions. The shaded areas are 95% confidence intervals. Survey names are listed in Supp. Tab. 1.

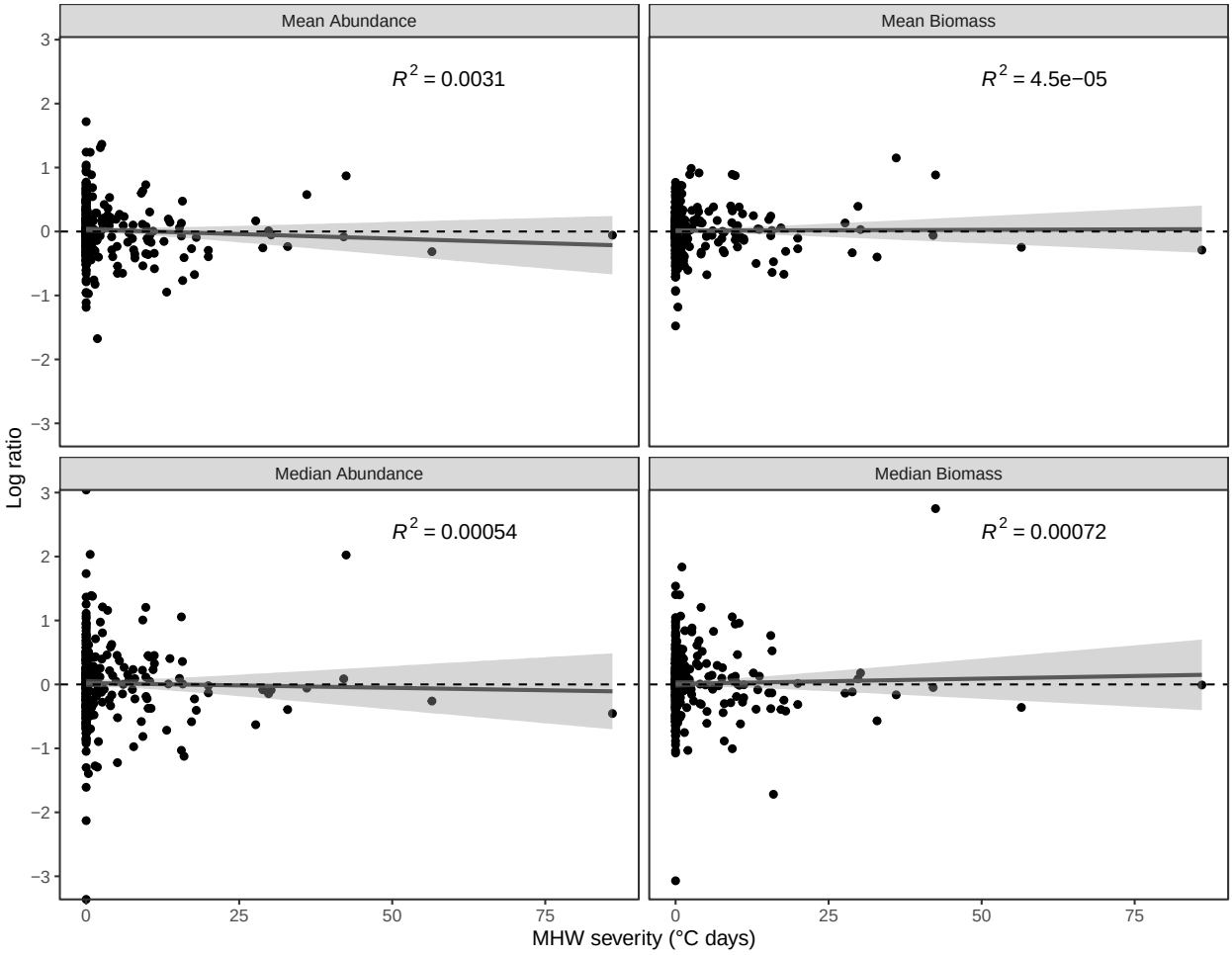


Figure 2: Alternate version of Fig. 2 from the main text using different metrics of biomass change: mean biomass (used in the main text), median biomass, mean abundance, and median abundance. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. Points represent log ratios of each metric in a survey from one year to the next. The fitted lines are linear regressions. The shaded areas are 95% confidence intervals. The Northeast US survey is omitted because it does not have abundance data recorded.

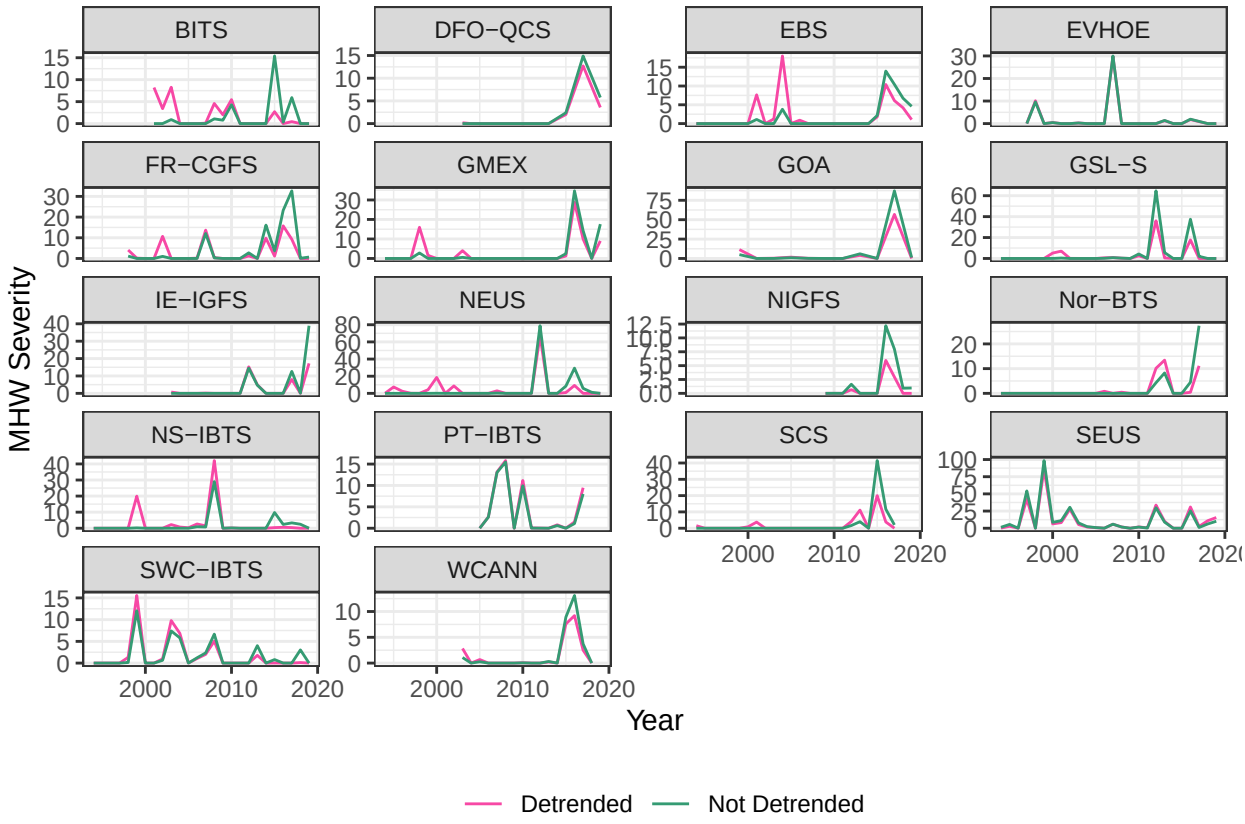


Figure 3: MHW severity (total anomaly in °C days) in each survey region with and without detrending the temperature data to remove the signal of secular warming. The main text results are detrended. Here, we plot MHW severity based on all SBT anomalies from GLORYS, rather than applying the five-day threshold that was used the main text, to more clearly show the differences between the two methods.

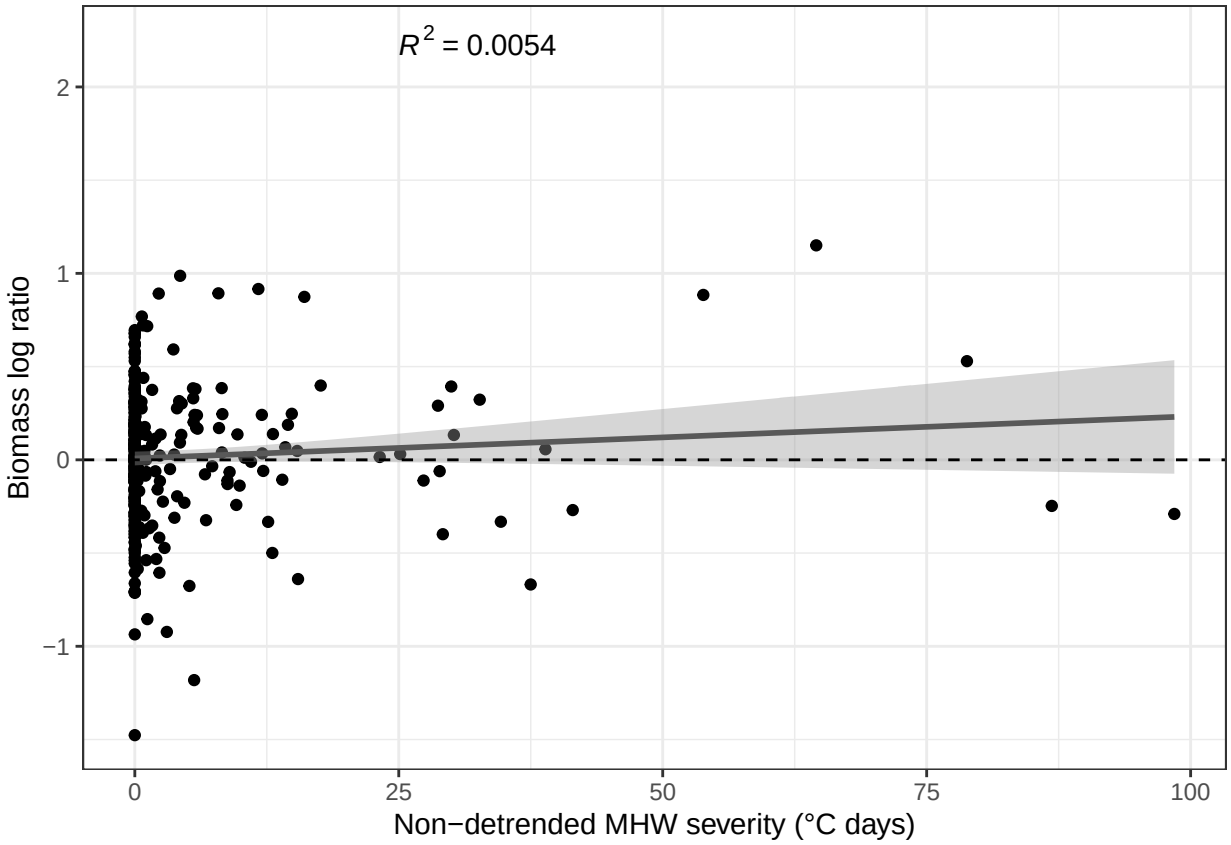


Figure 4: Alternate version of Fig. 2 from the main text, showing biomass change (log ratio) and MHW severity (total anomaly in °C days, using GLORYS data with the five-day MHW threshold) calculated from non-detrended data. The fitted lines are linear regressions. The shaded areas are 95% confidence intervals.

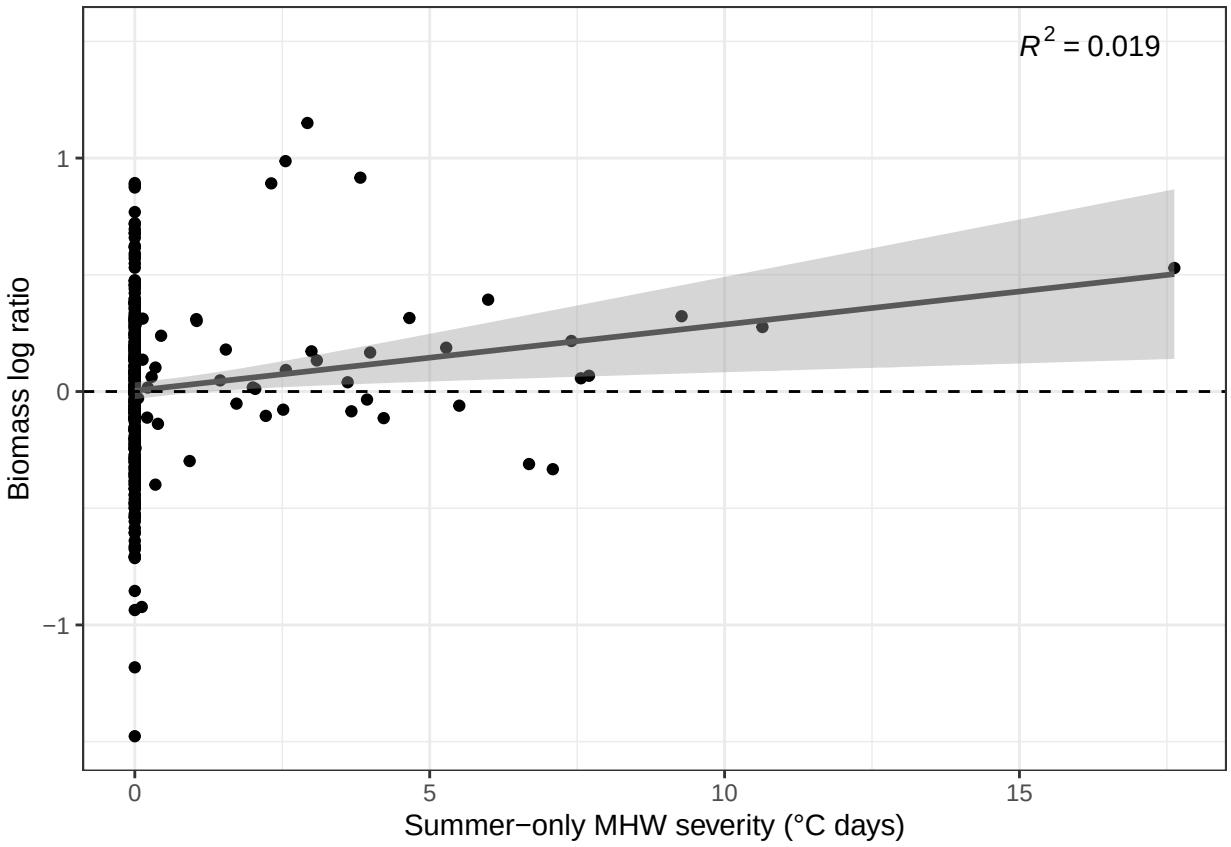


Figure 5: Alternate version of Fig. 2 from the main text, showing biomass change (log ratio) and MHW severity (total anomaly in °C days, using GLORYS data without the five-day MHW threshold) based on only summer temperature anomalies (June, July, and August in the Northern Hemisphere). The fitted lines are linear regressions. The shaded areas are 95% confidence intervals.

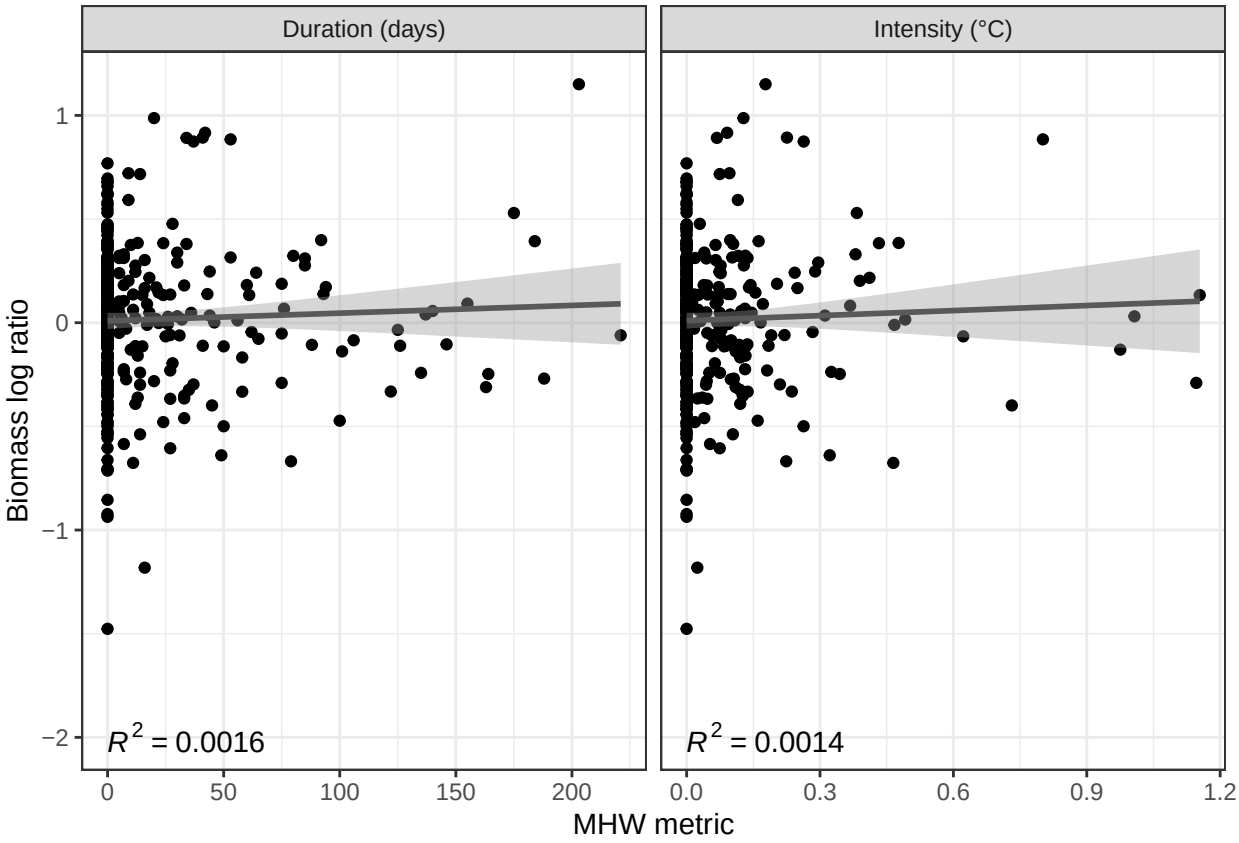


Figure 6: Biomass change (log ratio) and two alternative metrics of MHW impacts: duration (total number of MHW-days), and intensity (severity divided by duration, i.e., the average anomaly over the course of the MHW in °C) calculated from the detrended GLORYS sea bottom temperature data with a minimum MHW duration of five days. The fitted lines are linear regressions. The shaded areas are 95% confidence intervals.

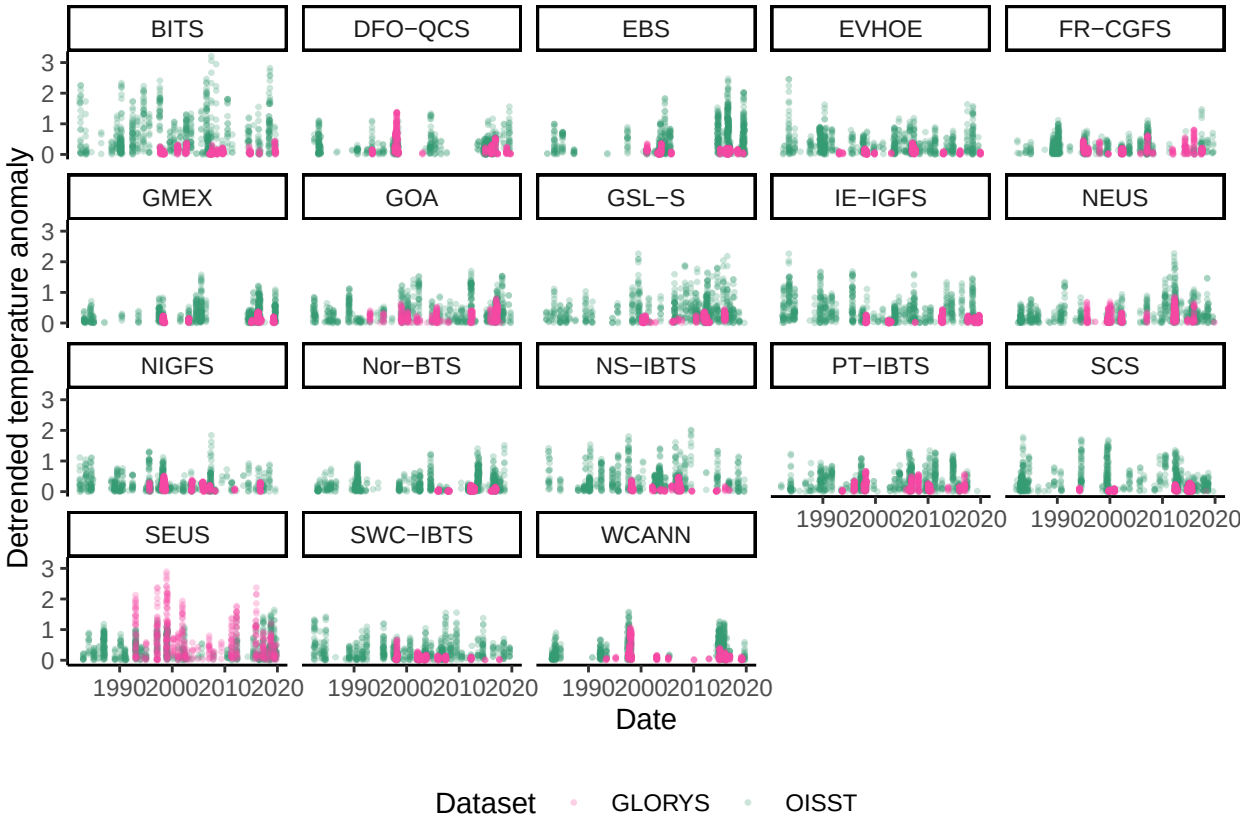


Figure 7: Daily 95th percentile anomalies in the two MHW data sources: sea surface temperature from OISST and sea bottom temperature from GLORYS (both detrended). To simplify comparison we plot all anomalies, not just those MHWs that exceeded a five-day threshold. Note that the OISST time-series began in 1982 and GLORYS began in 1993. Region names are listed in Supp. Tab. 1.

4 Supplementary figures: exploring additional predictors

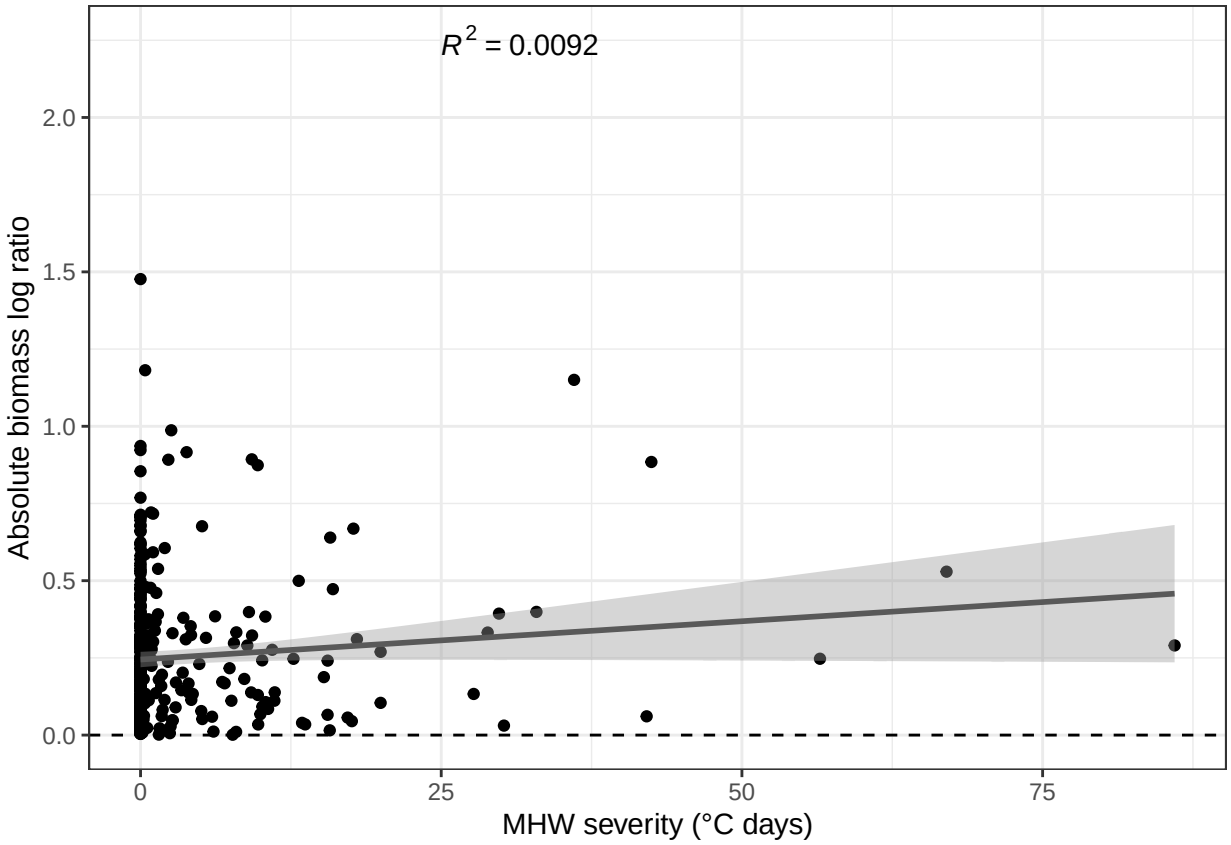


Figure 8: MHW severity (total anomaly in °C days) and absolute value of biomass log ratio. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The fitted line is a linear regression. The shaded area is its 95% confidence interval.

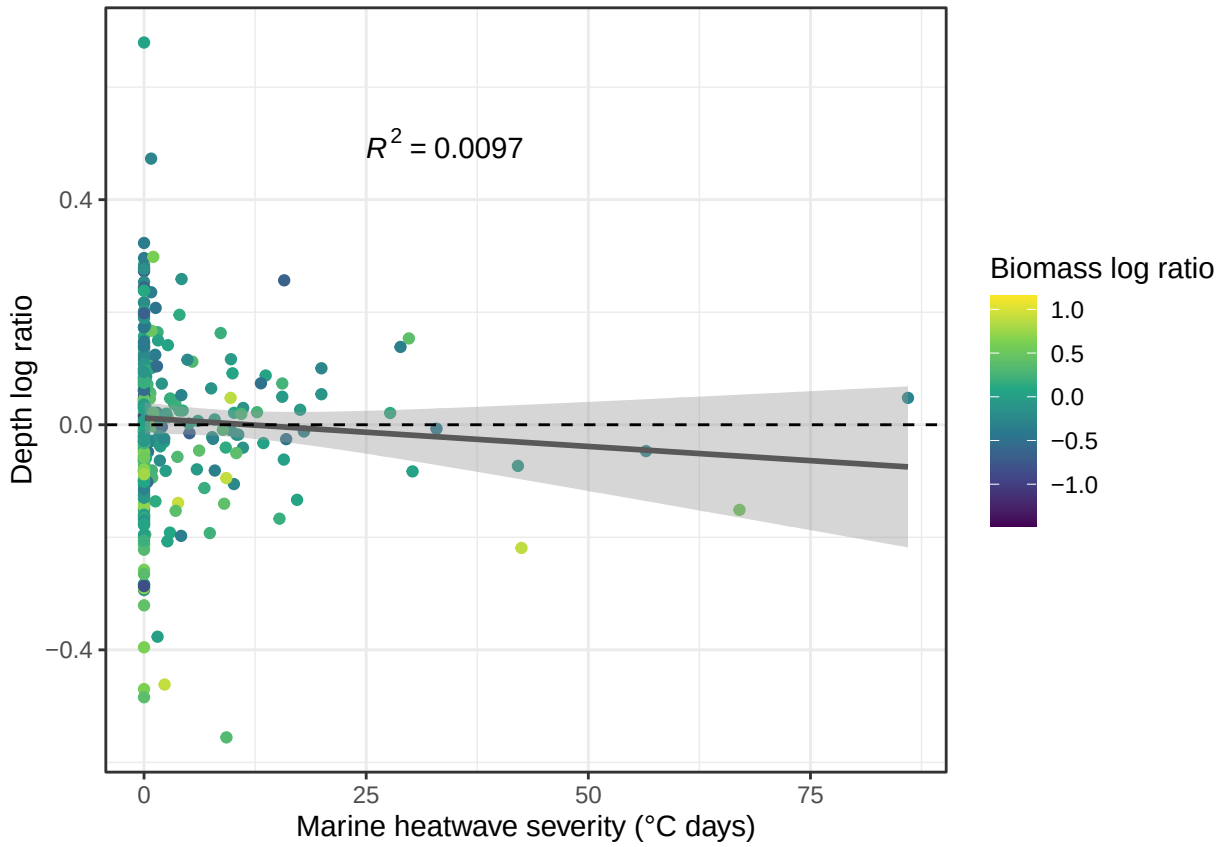


Figure 9: Fish assemblage depth change (log ratio) and MHW severity (total anomaly in °C days). MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The fitted line is a linear regression. The shaded area is its 95% confidence interval.

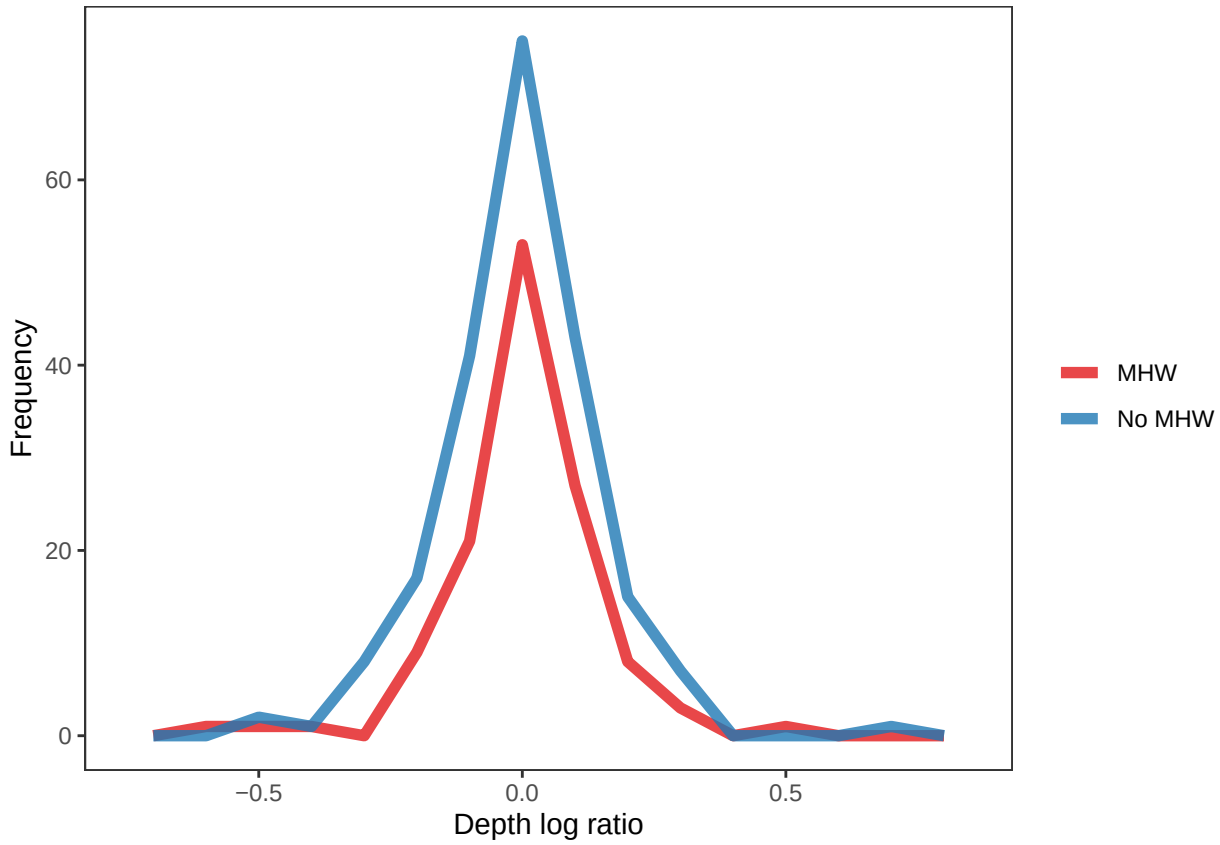


Figure 10: Fish assemblage depth change (log ratio) and MHW occurrence. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text.

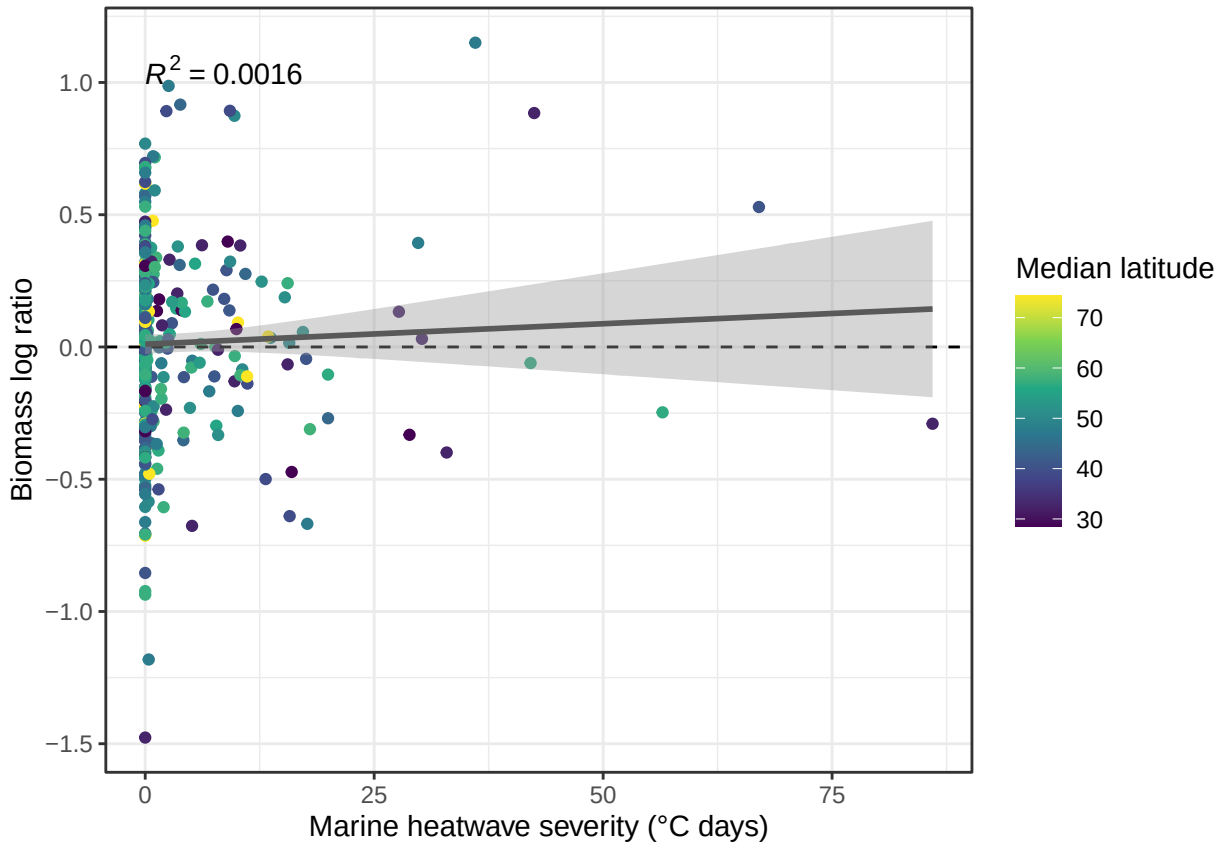


Figure 11: Biomass change (log ratio) and MHW severity (total anomaly in °C days), color-coded by median latitude of each survey region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The fitted line is a linear regression. The shaded area is its 95% confidence interval.

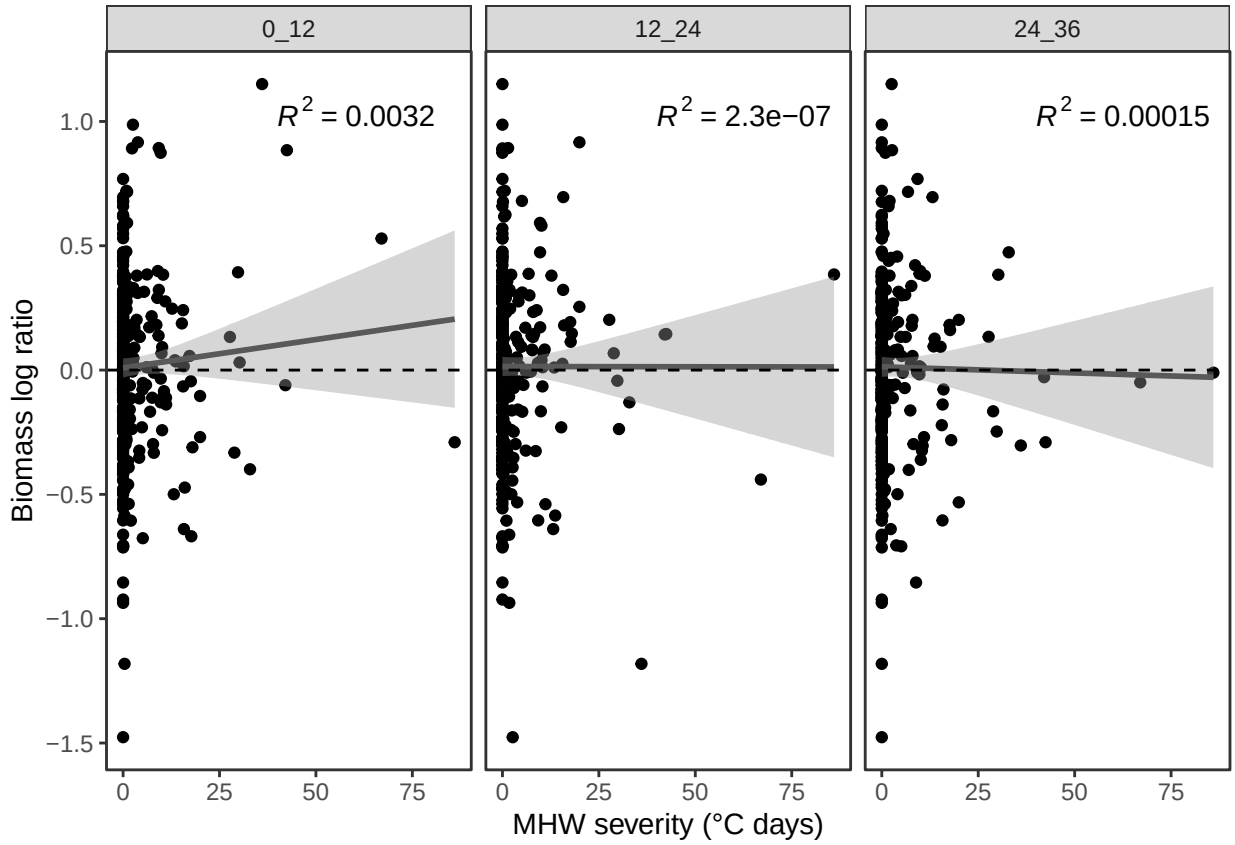


Figure 12: Biomass change (log ratio) and MHW severity (total anomaly in °C days) calculated the preceding year as in the main text (0-12 months), a one-year lag (12-24 months), and a two-year lag (24-36 months). MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. Fitted lines are linear regressions. Shaded areas are 95% confidence intervals.

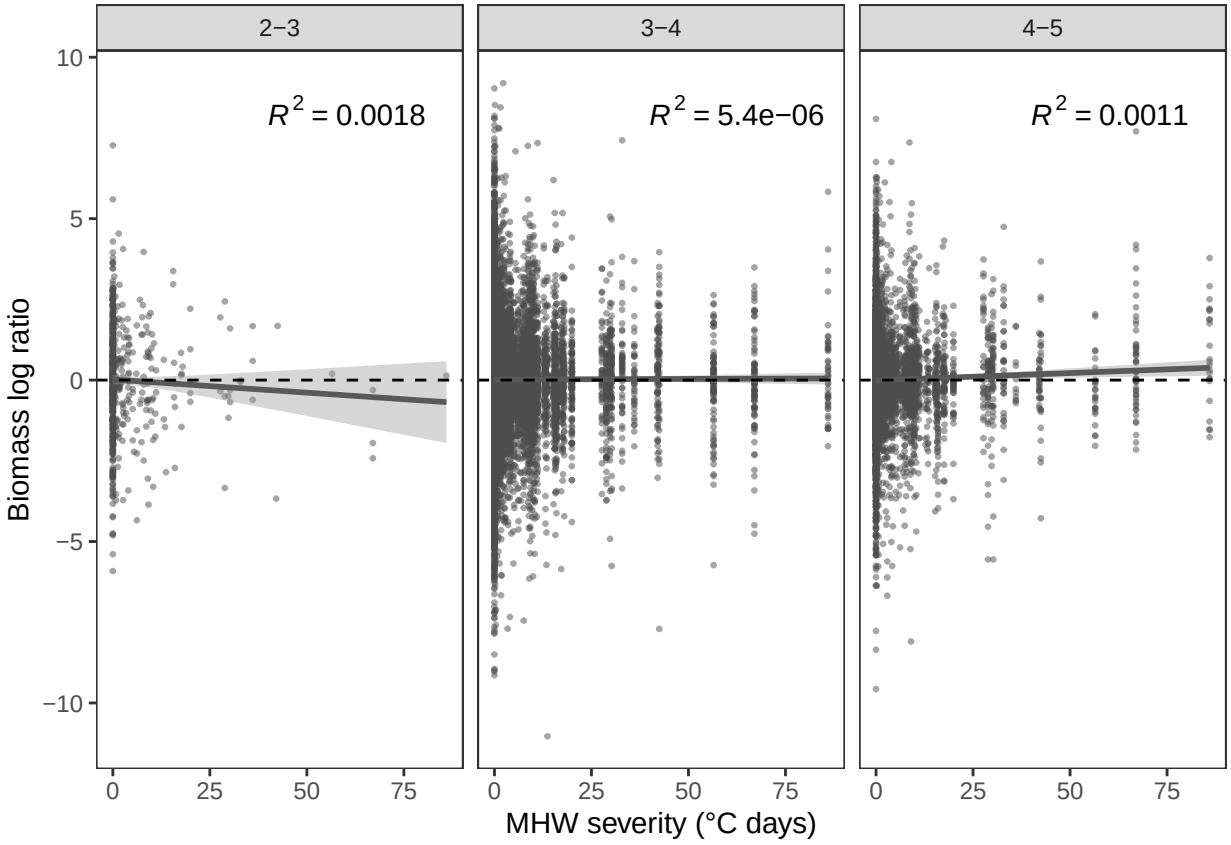


Figure 13: Biomass log ratio and MHW severity (total anomaly in °C days) grouped by trophic level of each taxon. Trophic levels are binned (2-3, 3-4, and 4-5). MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. Fitted lines are linear regressions. Shaded areas are 95% confidence intervals.

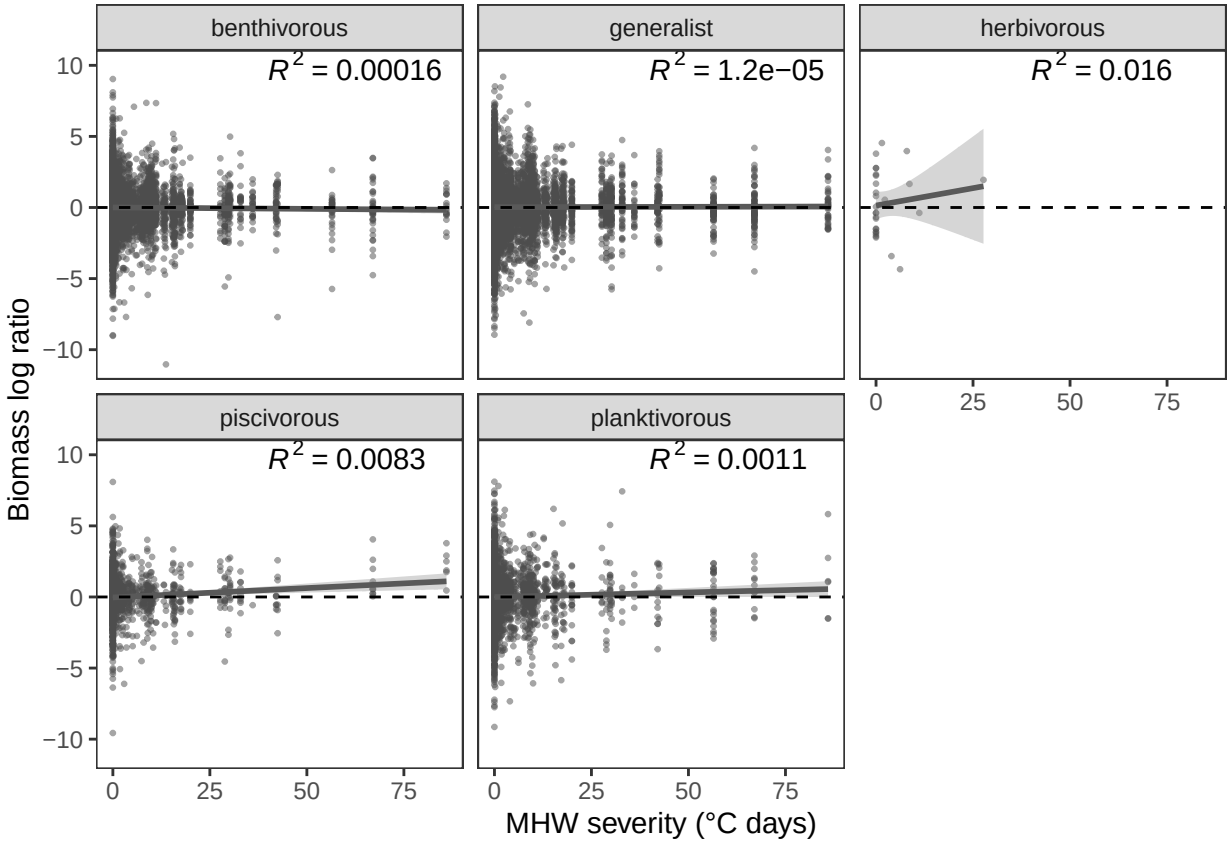


Figure 14: Biomass log ratio and MHW severity (total anomaly in °C days) grouped by feeding mode of each taxon. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. Fitted lines are linear regressions. Shaded areas are 95% confidence intervals.

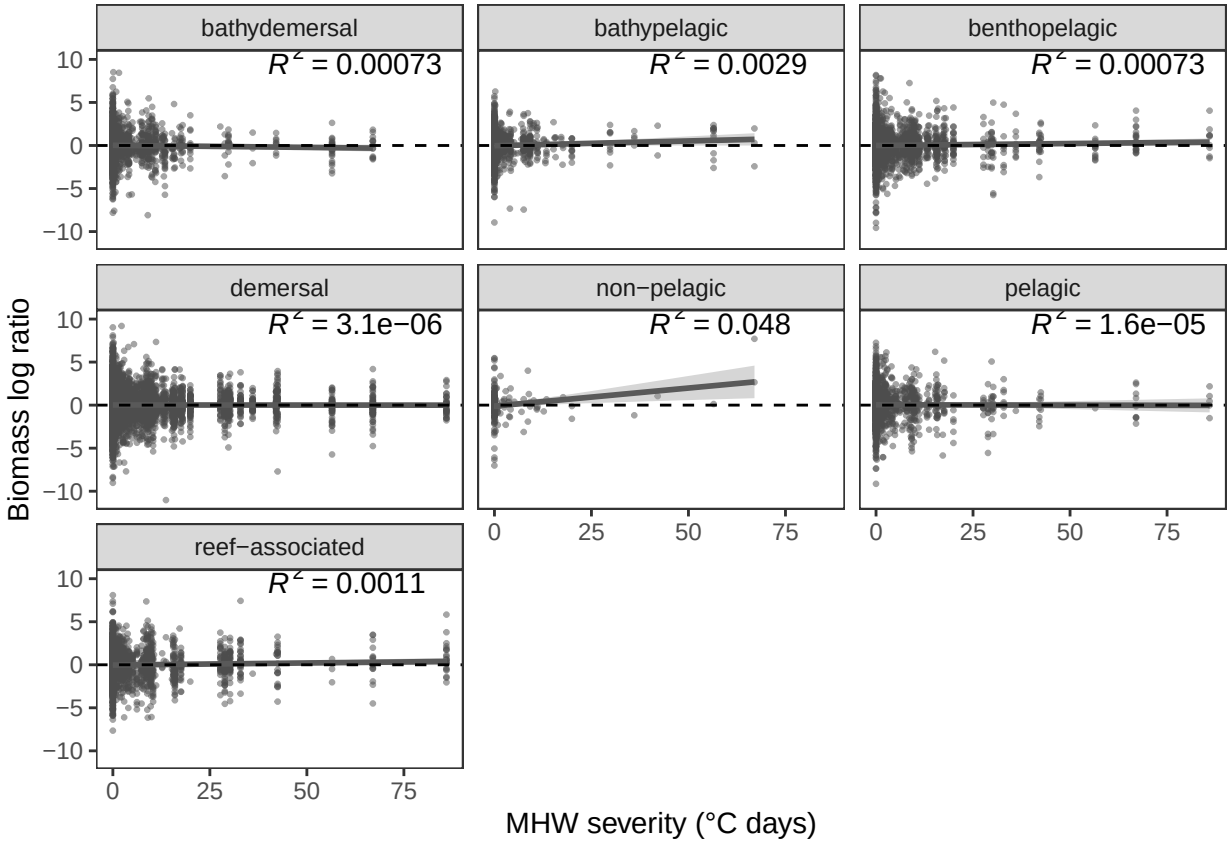


Figure 15: Biomass log ratio and MHW severity (total anomaly in °C days) grouped by habitat preference of each taxon. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. Fitted lines are linear regressions. Shaded areas are 95% confidence intervals.

5 Supplementary figures: community dissimilarity

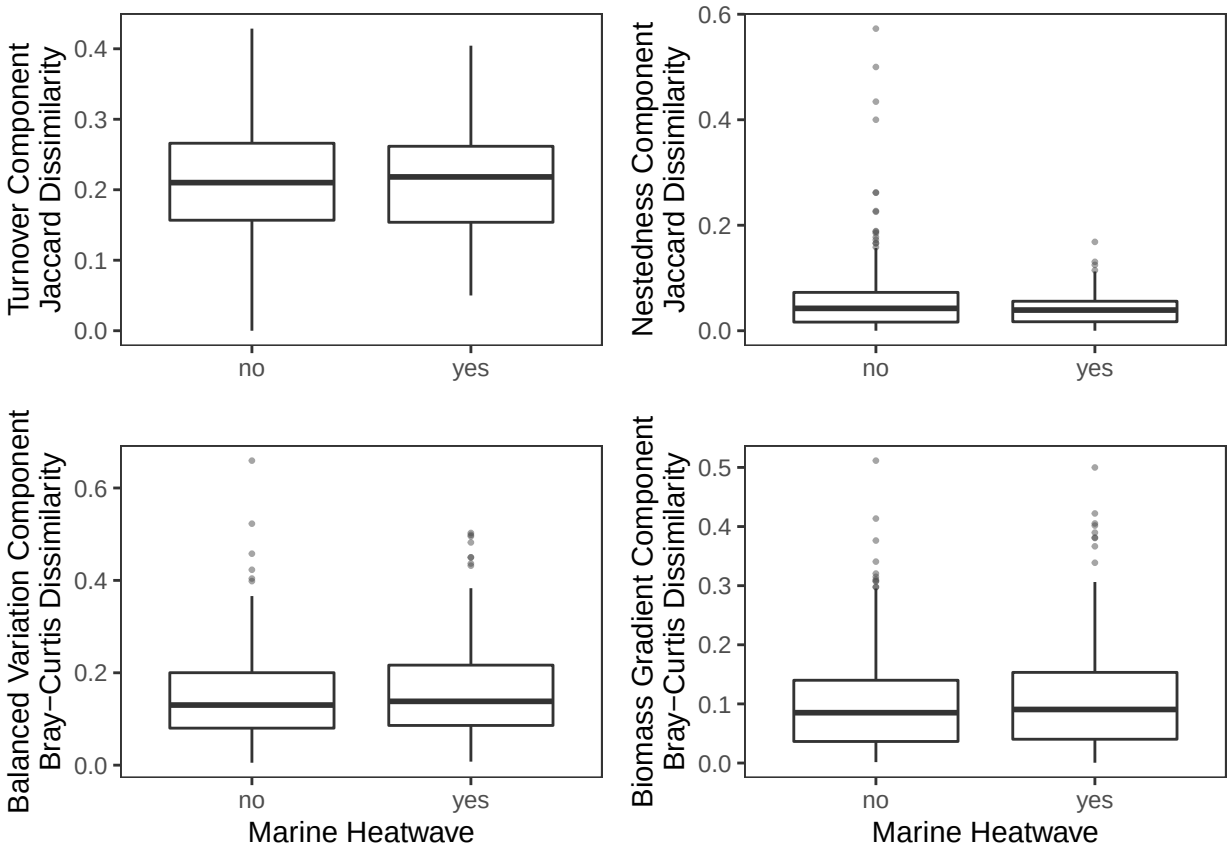


Figure 16: Box-and-whisker plots of temporal community dissimilarity and MHW incidence for partitioned occurence-based beta diversity metrics (Jaccard turnover and nestedness; top) and partitioned biomass-based beta diversity metrics (Bray-Curtis balanced variation and biomass gradient; bottom). MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text.

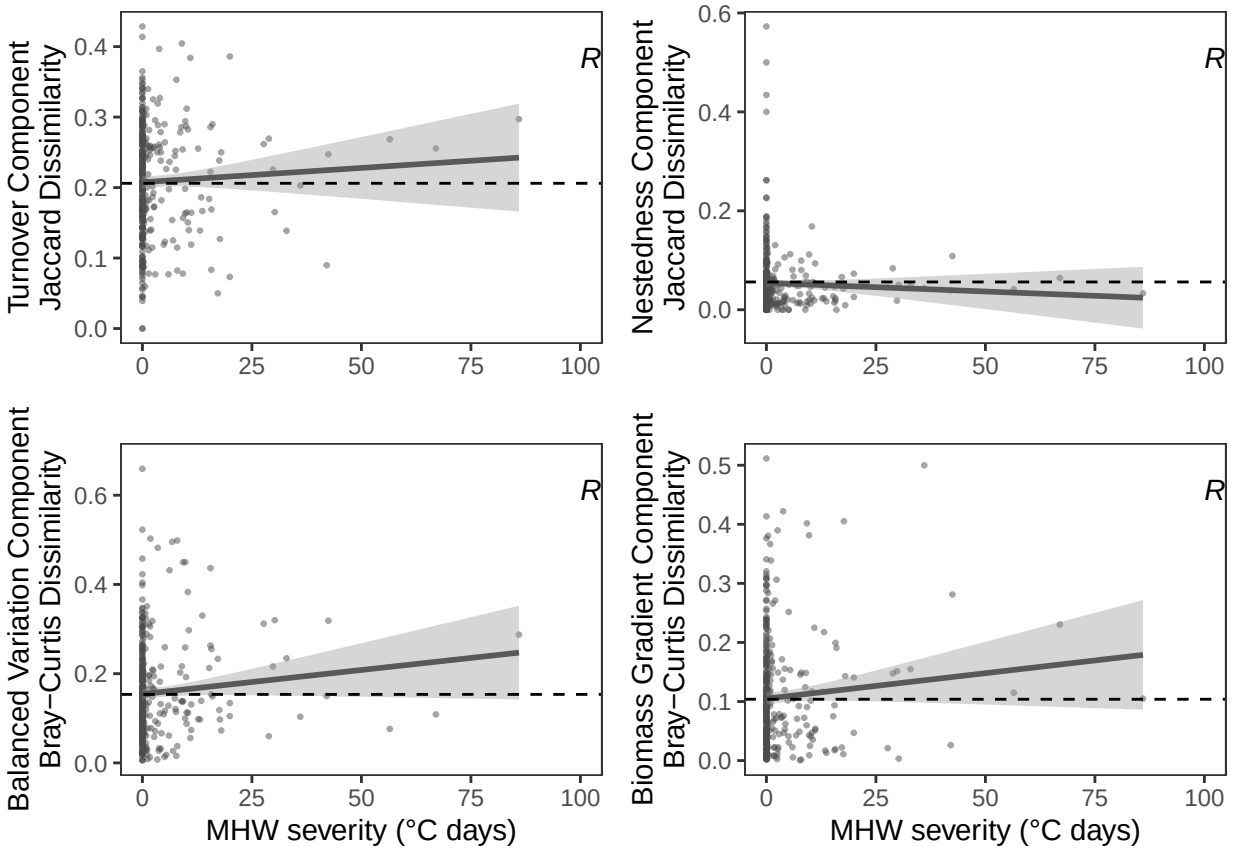


Figure 17: Temporal community dissimilarity and MHW severity (total anomaly in °C days) for partitioned occurrence-based beta diversity metrics (Jaccard turnover and nestedness; top) and partitioned biomass-based beta diversity metrics (Bray-Curtis balanced variation and biomass gradient; bottom). MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. Fitted lines are linear regressions. Shaded areas are 95% confidence intervals.

6 Supplementary figures: power analysis

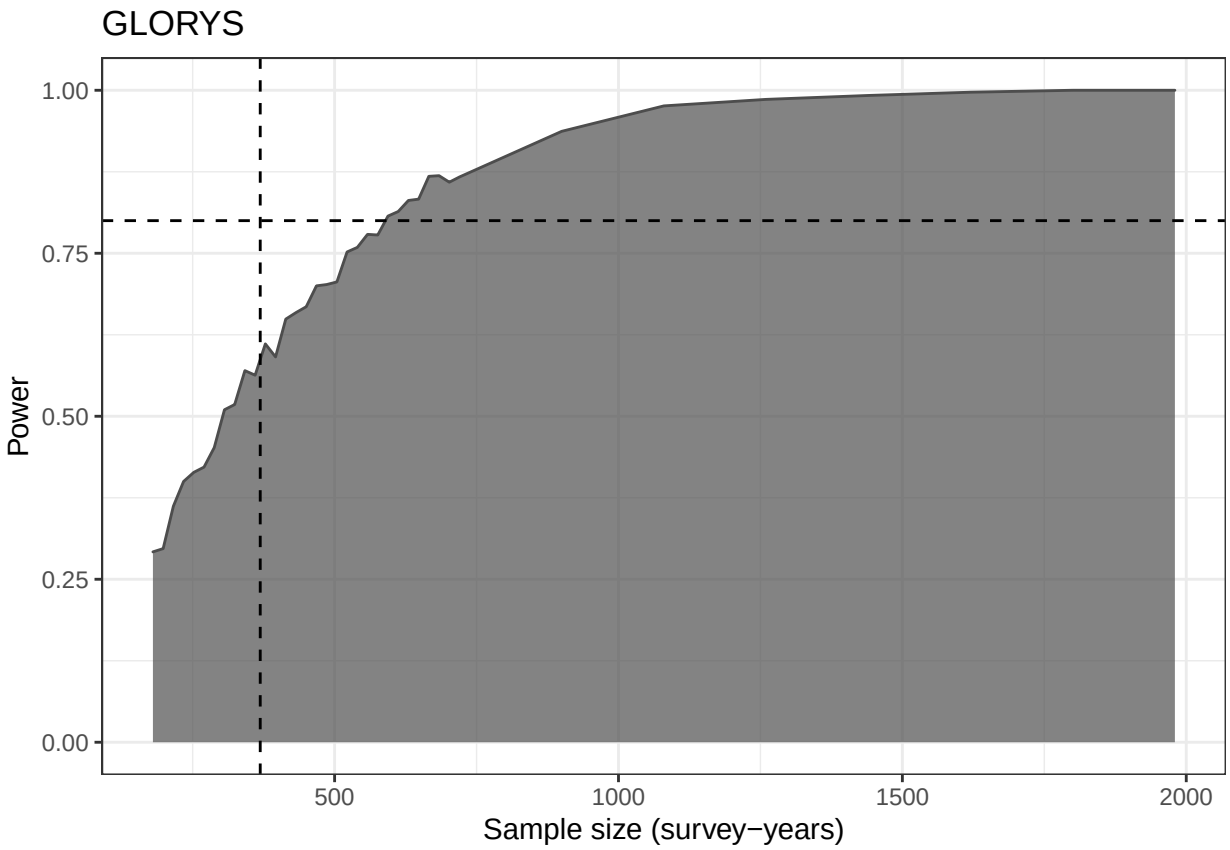


Figure 18: Results from a power analysis applying our methods to a simulated dataset in which MHWs reduce biomass by 6% and study duration is varied. The sample sizes plotted are total survey-years across all regions. Dashed vertical line shows the sample size of our actual dataset. Dashed horizontal line denotes one conventionally accepted threshold for power (0.8). MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. Simulations were run to 200 years per survey (3600 total survey-years across the 18 regions) but truncated in this figure after power saturated at 1.0.

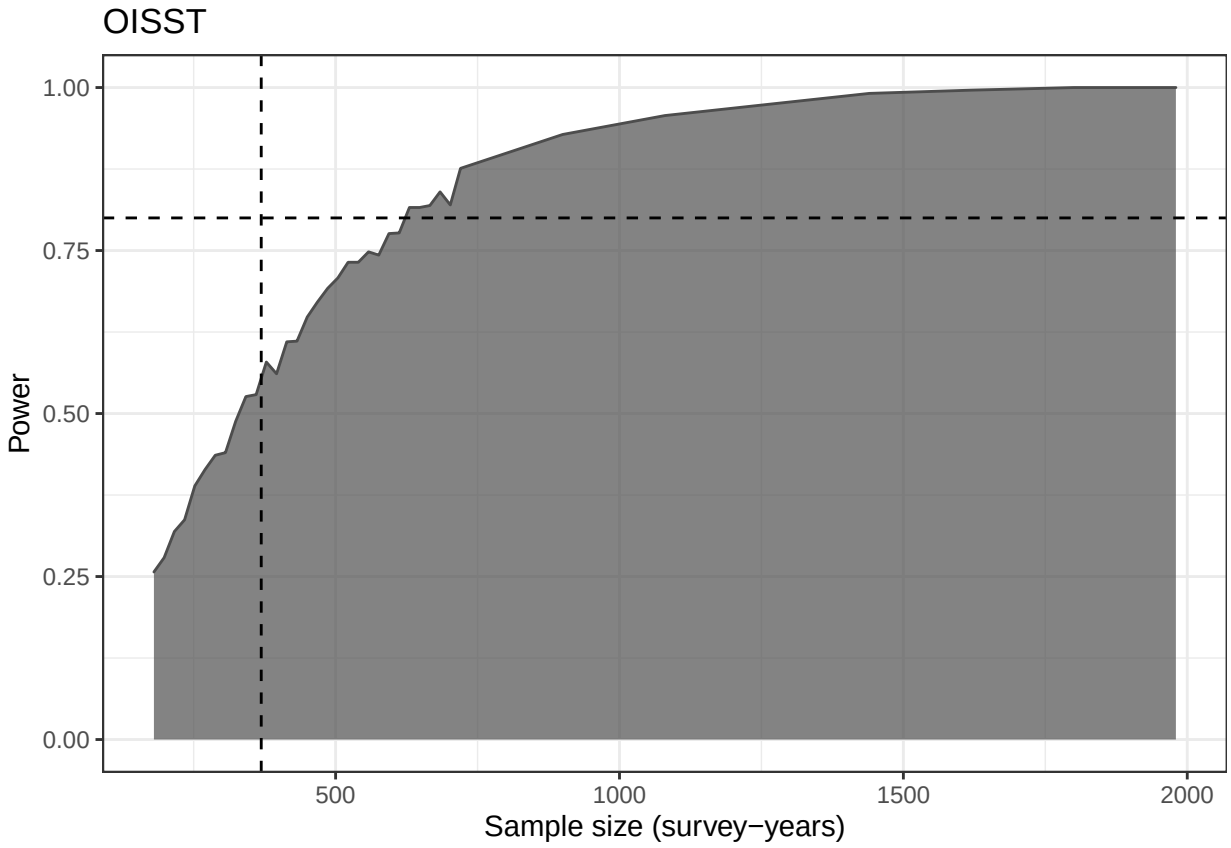


Figure 19: Results from a power analysis applying our methods to a simulated dataset in which MHWs reduce biomass by 6% and study duration is varied. The sample sizes plotted are total survey-years across all regions. Dashed vertical line shows the sample size of our actual dataset. Dashed horizontal line denotes one conventionally accepted threshold for power (0.8). MHWs were calculated from the detrended OISST sea surface temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. Simulations were run to 200 years per survey (3600 total survey-years across the 18 regions) but truncated in this figure after power saturated at 1.0.

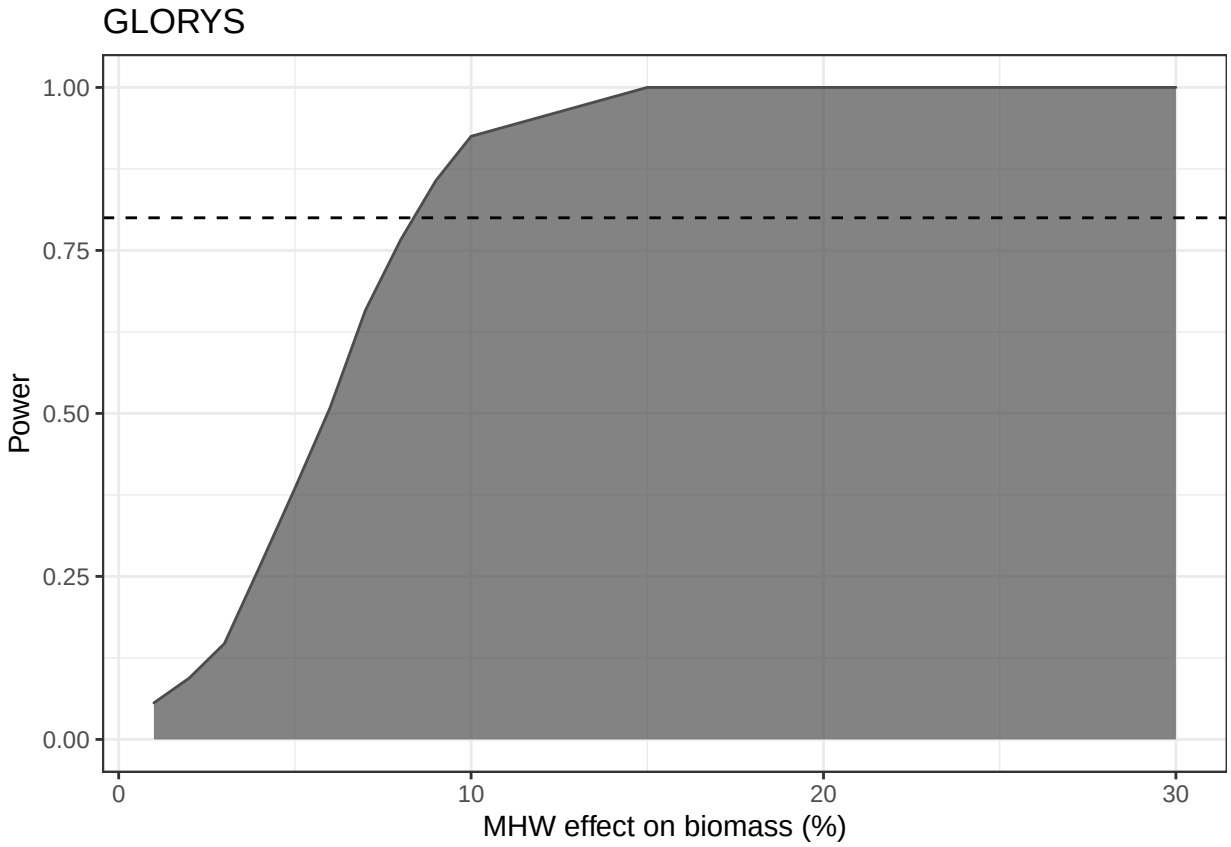
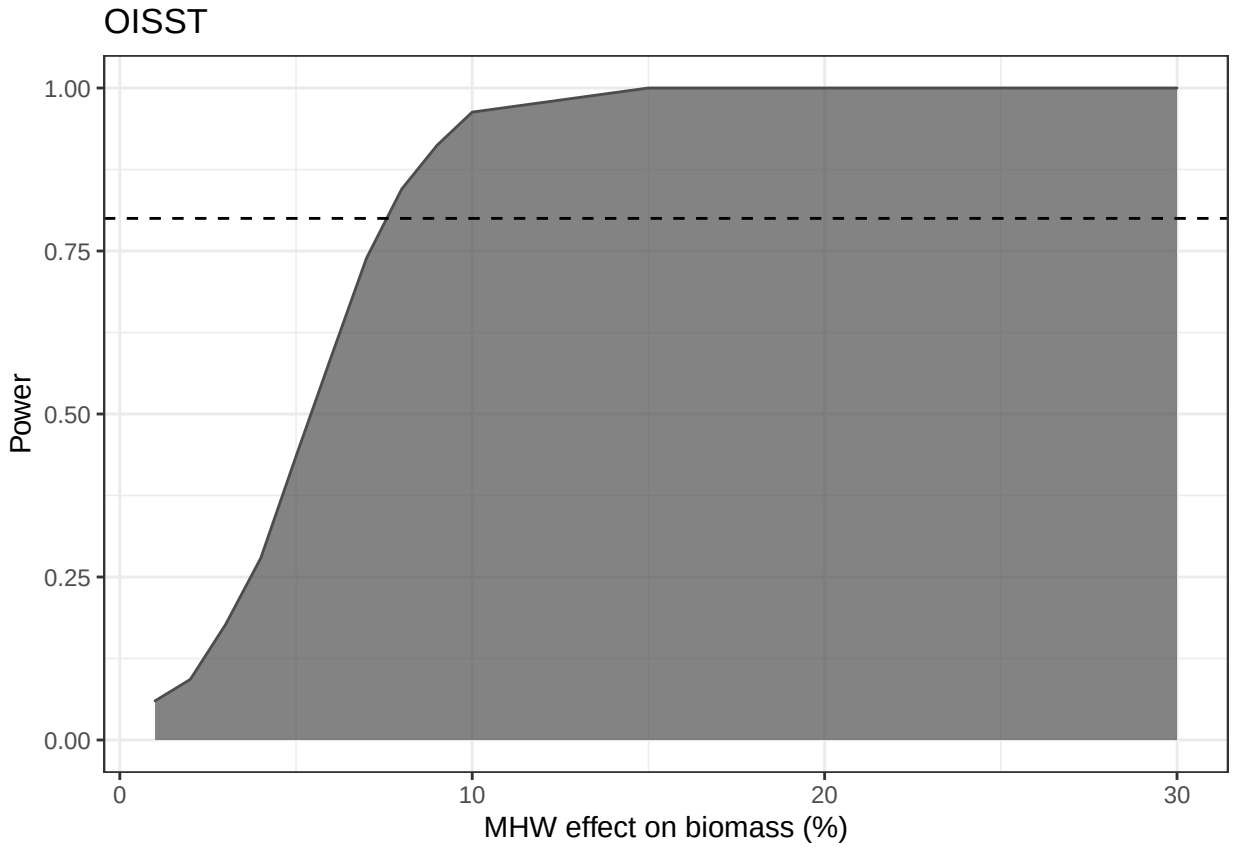


Figure 20: Results from a power analysis applying our methods to a simulated dataset that varied the MHW effect on biomass over the true number of survey-years for each region in our dataset. The sample sizes plotted are total survey-years across all regions. Dashed horizontal line denotes one conventionally accepted threshold for power (0.8). MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text.


OISST
1.00
0.75
0.50
0.25
0.00
Power
0
10
20
30
MHW effect on biomass (%)

7 Supplementary figures: regional time-series

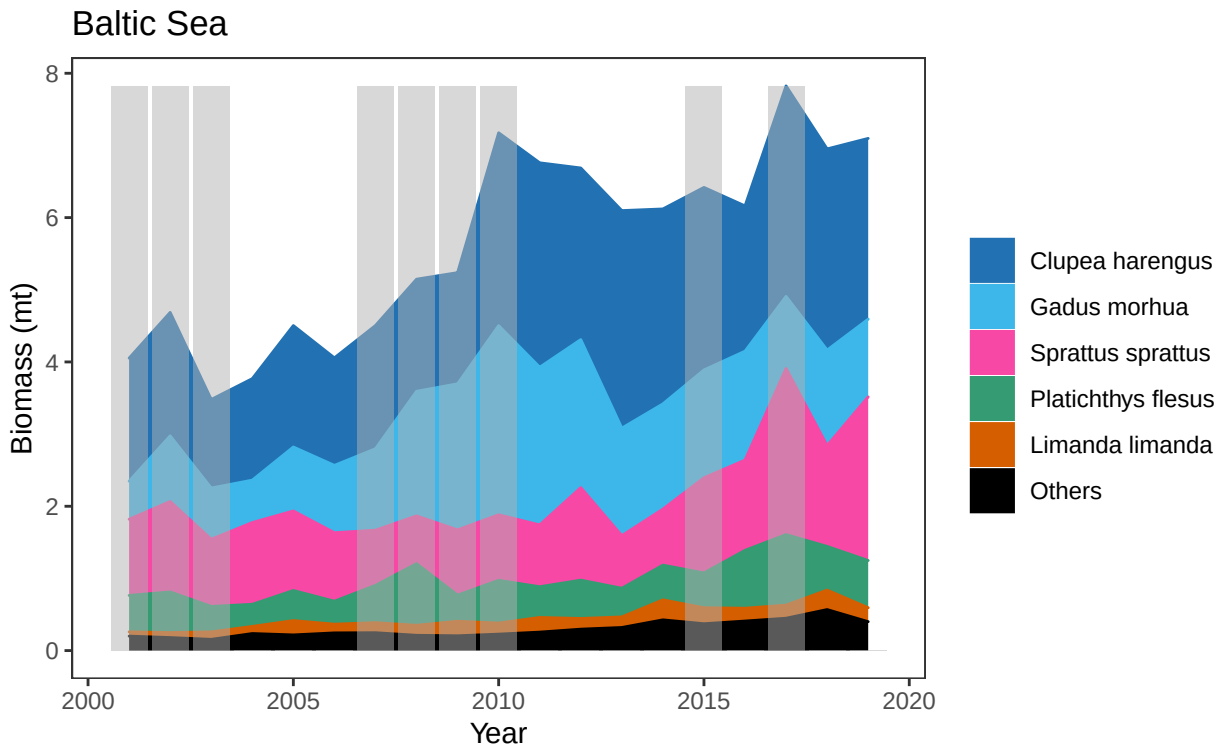


Figure 21: Biomass trends and historical MHWs by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

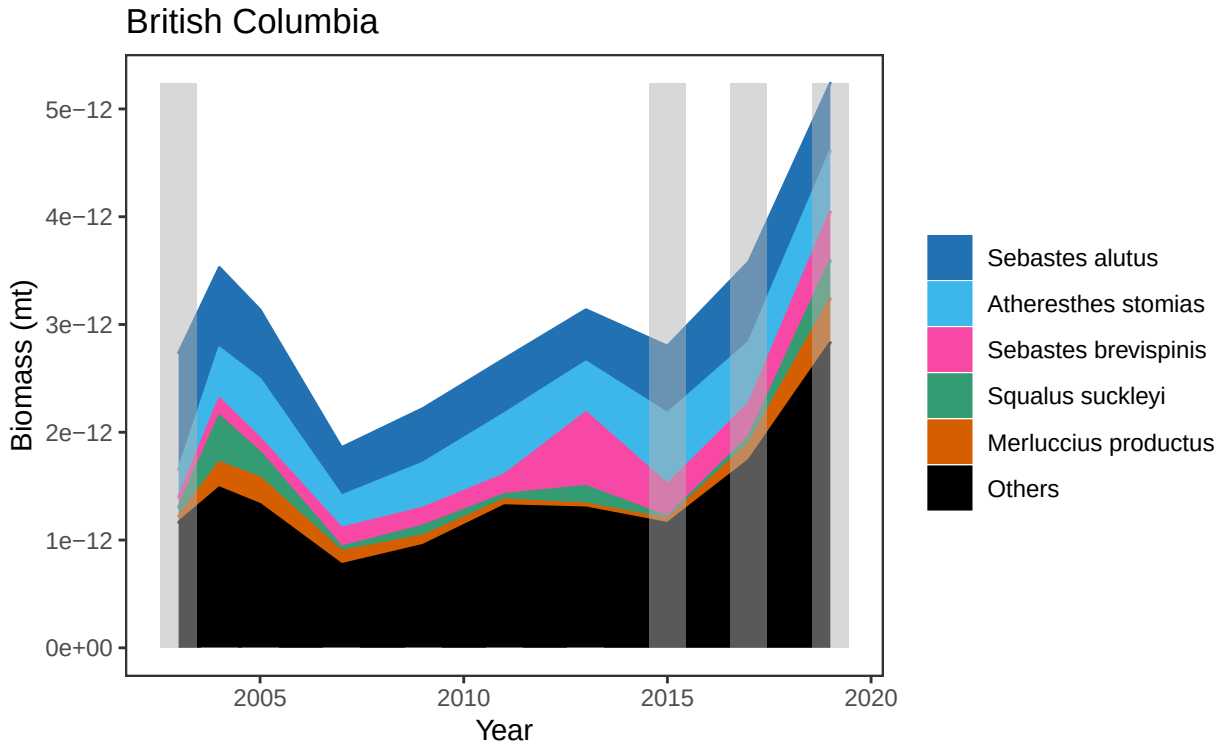


Figure 22: Biomass trends and historical MHWs by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

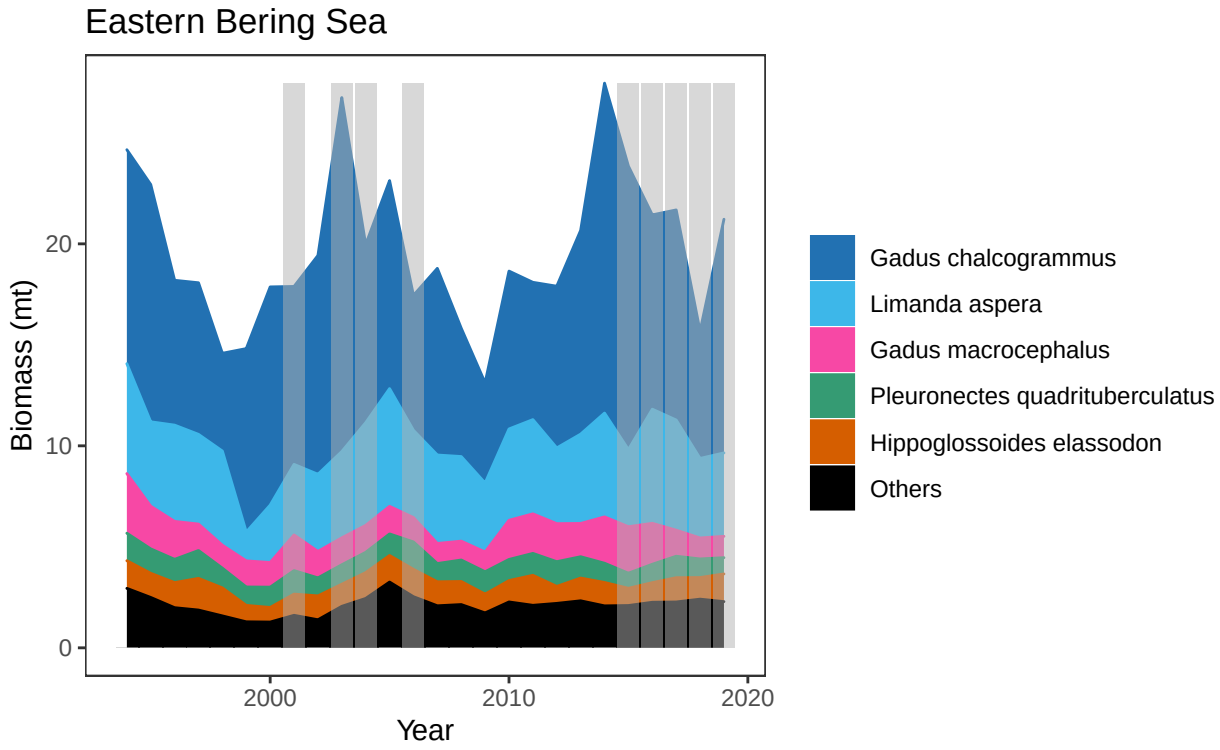


Figure 23: Biomass trends and historical MHWs by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

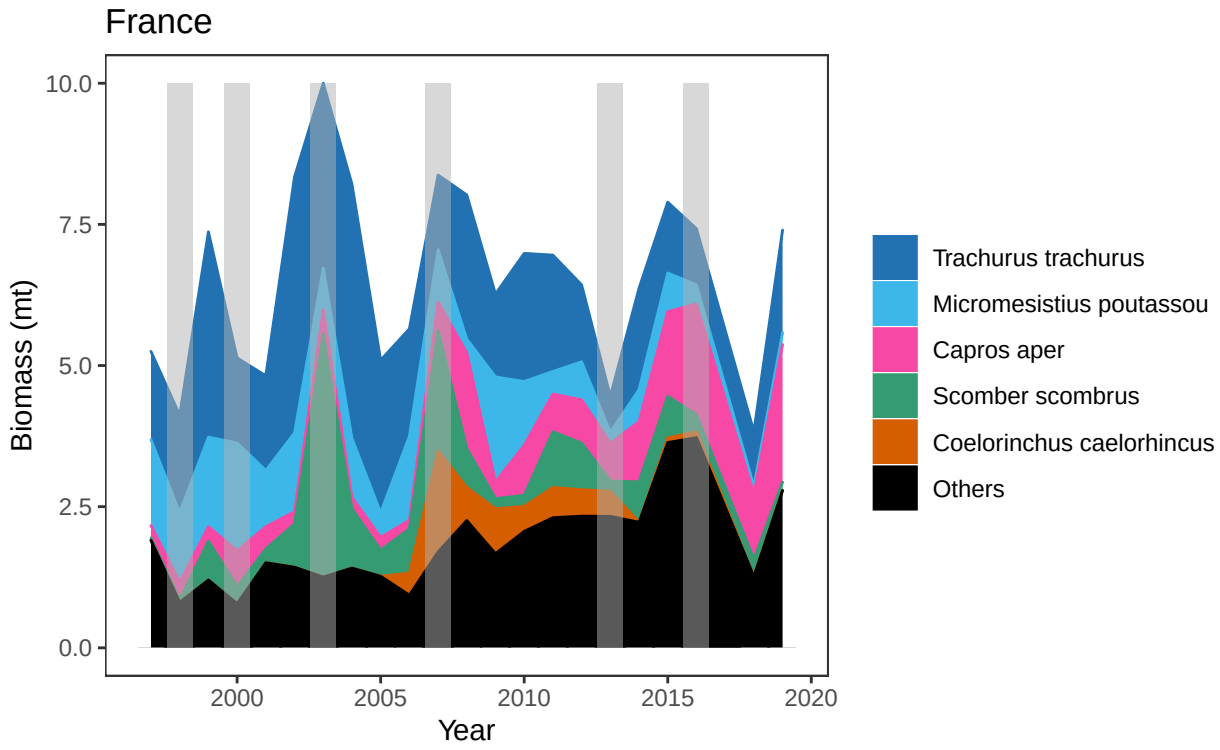


Figure 24: Biomass trends and historical MHWs by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

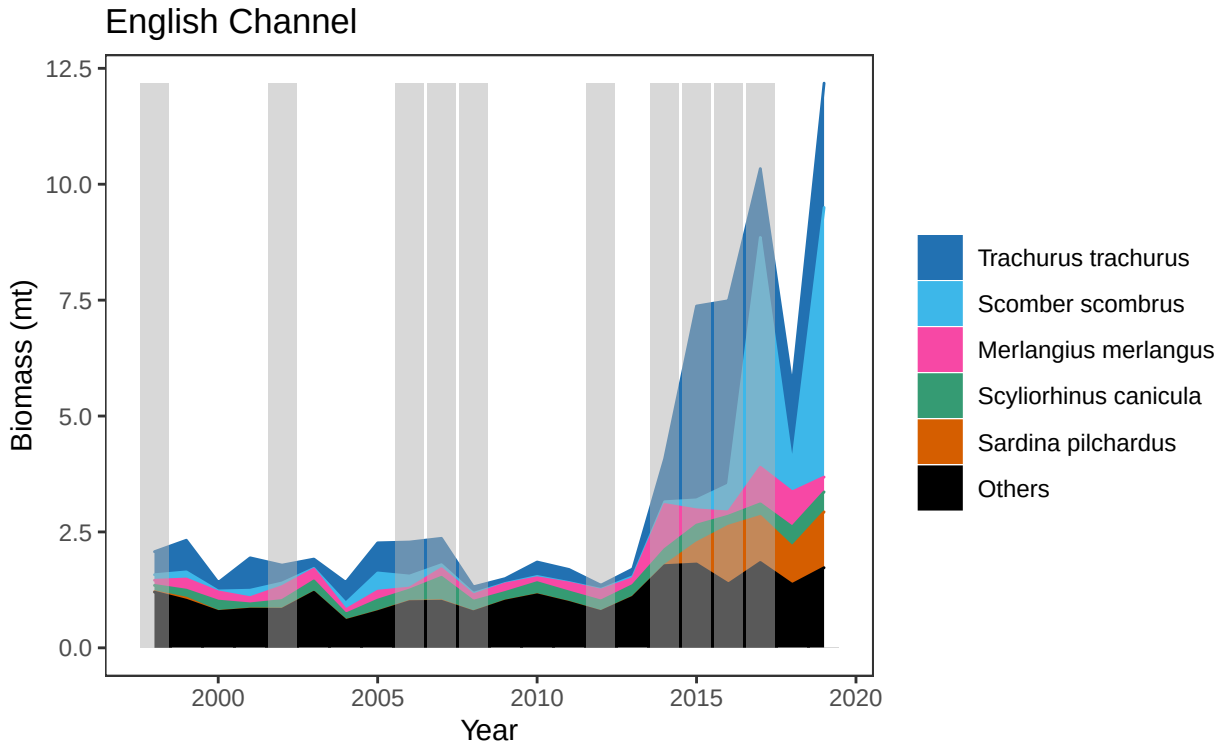


Figure 25: Biomass trends and historical MHWs by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

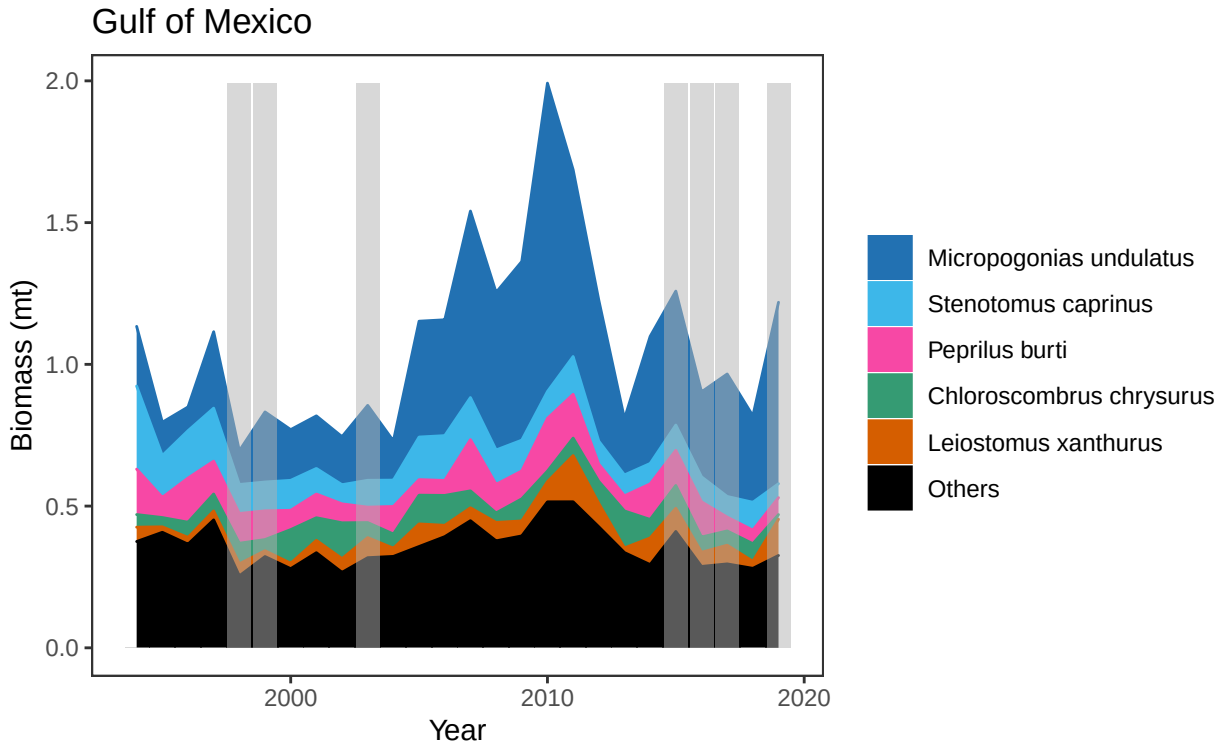


Figure 26: Biomass trends and historical MHWs by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

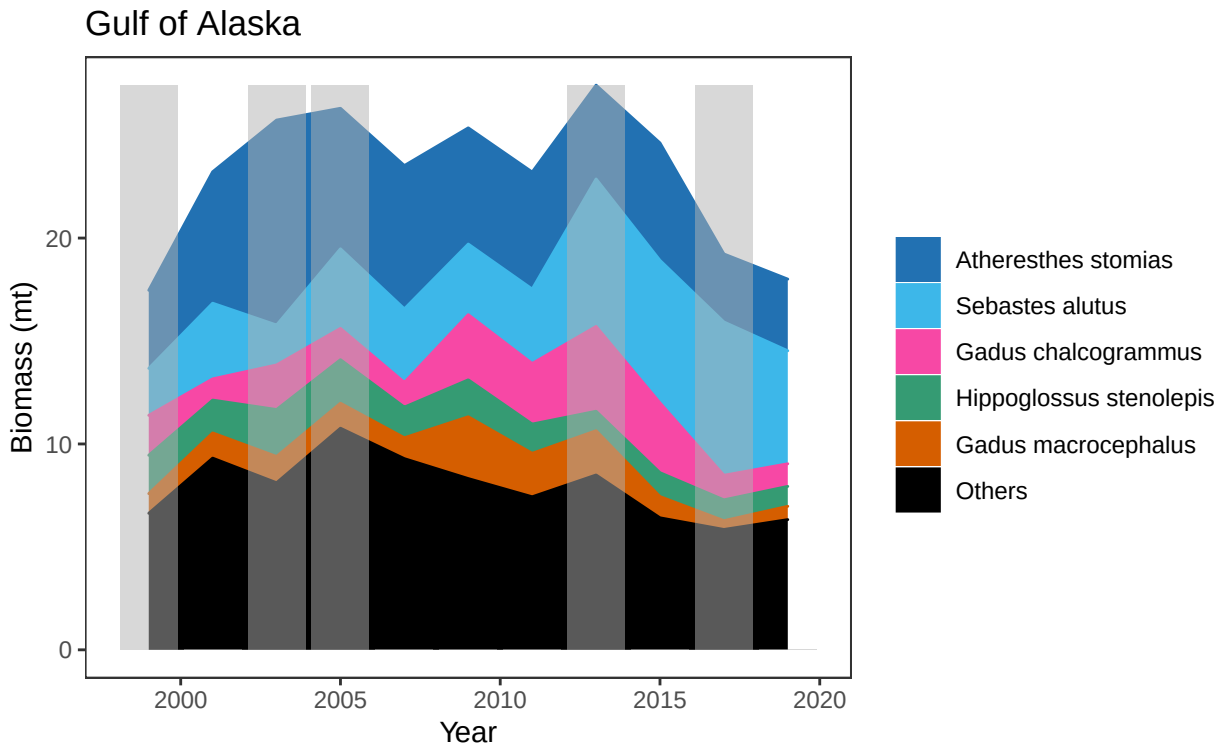


Figure 27: Biomass trends and historical MHWs by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

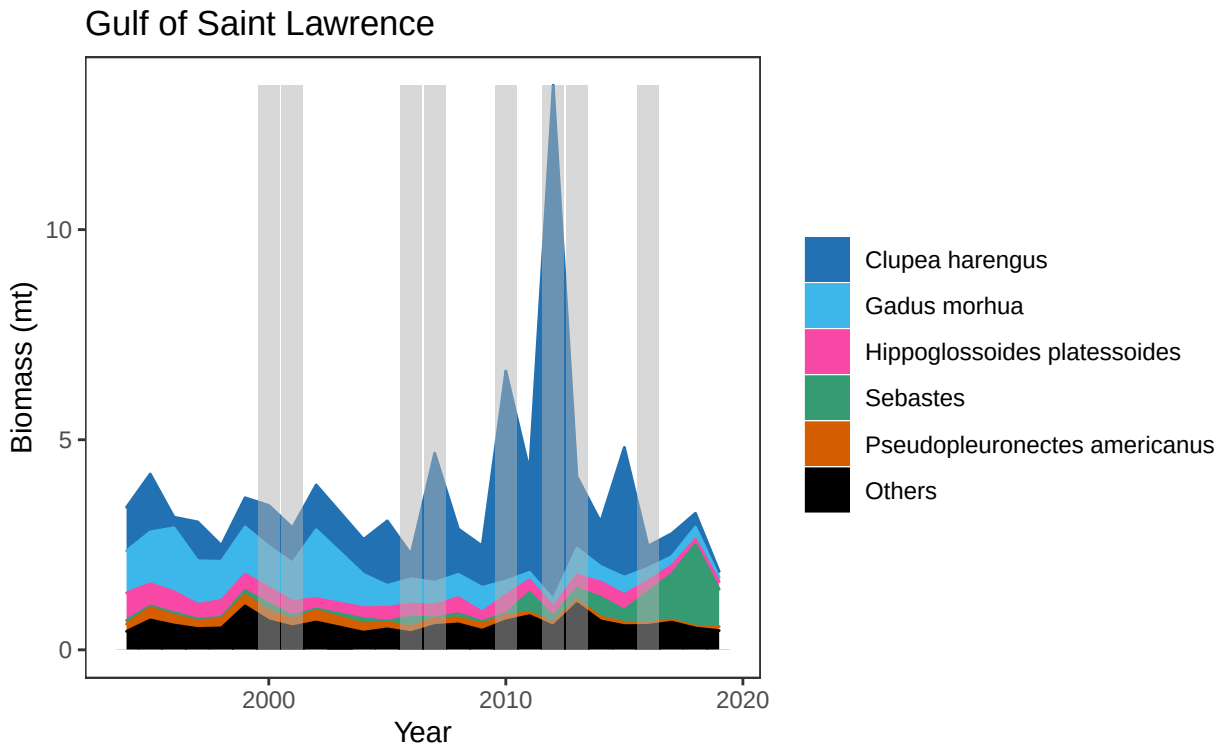
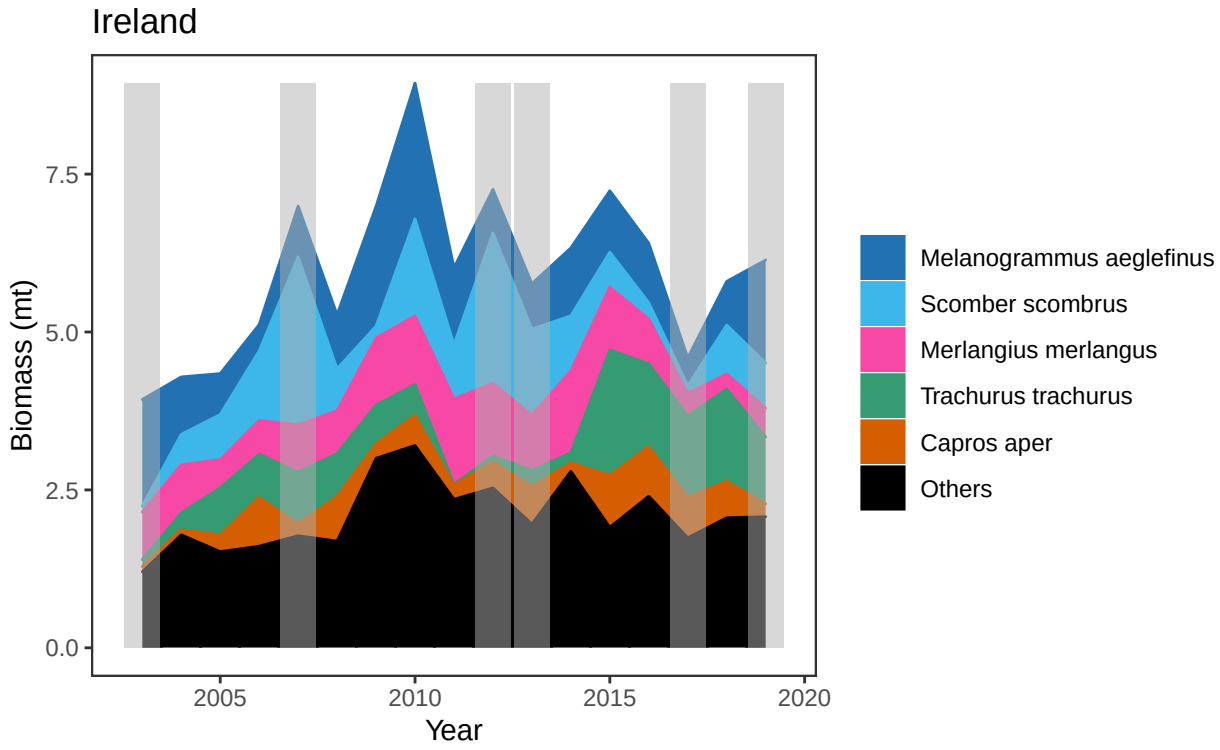


Figure 28: Biomass trends and historical MHWs by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.



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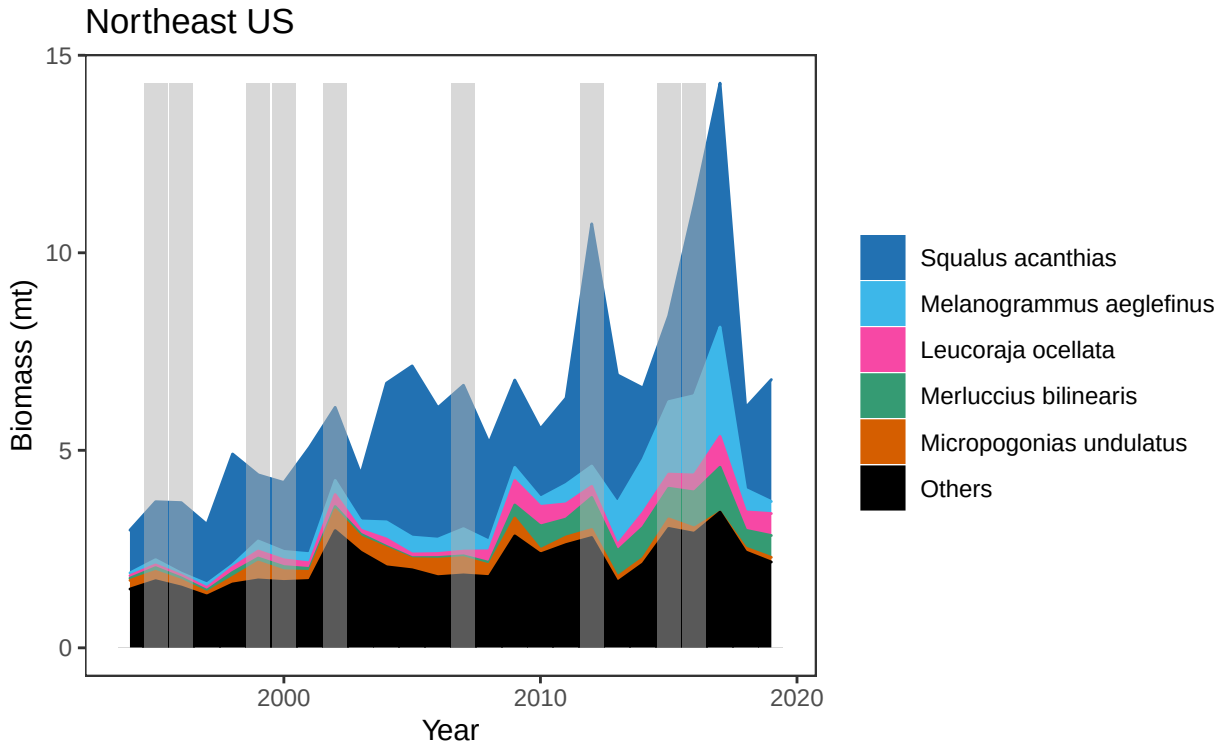


Figure 30: Biomass trends and historical MHWs by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

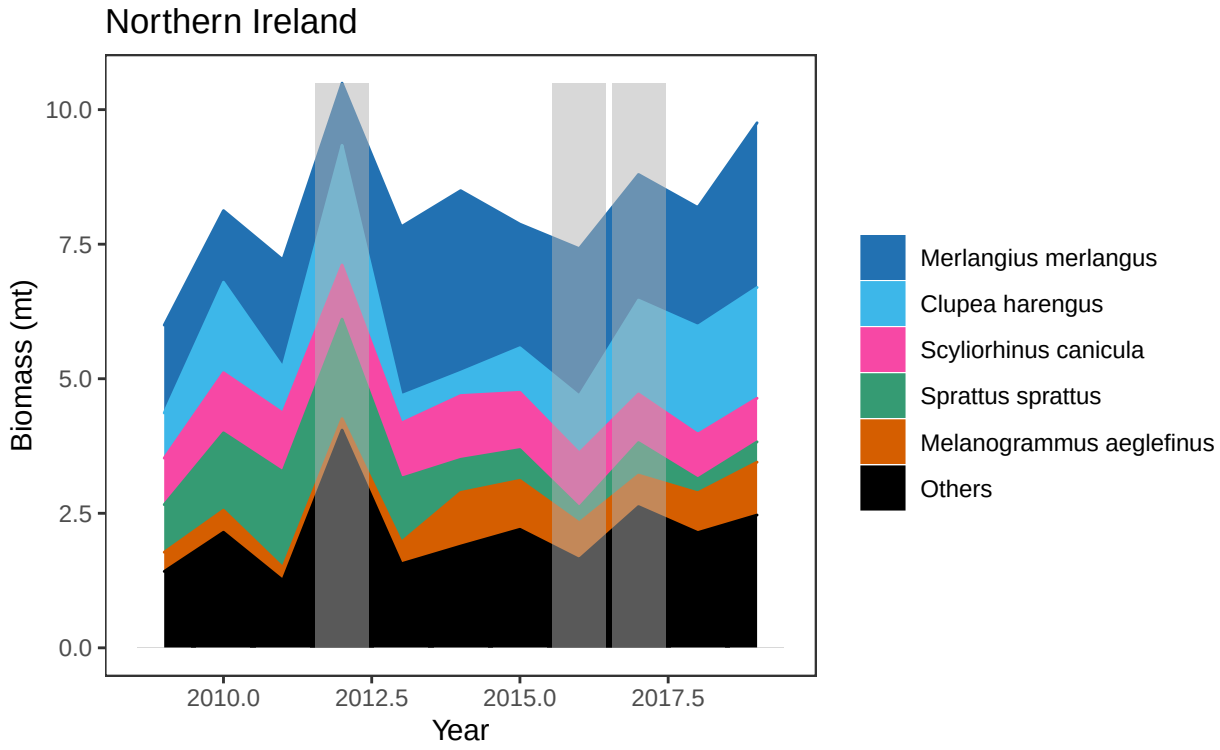


Figure 31: Biomass trends and historical MHWs by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

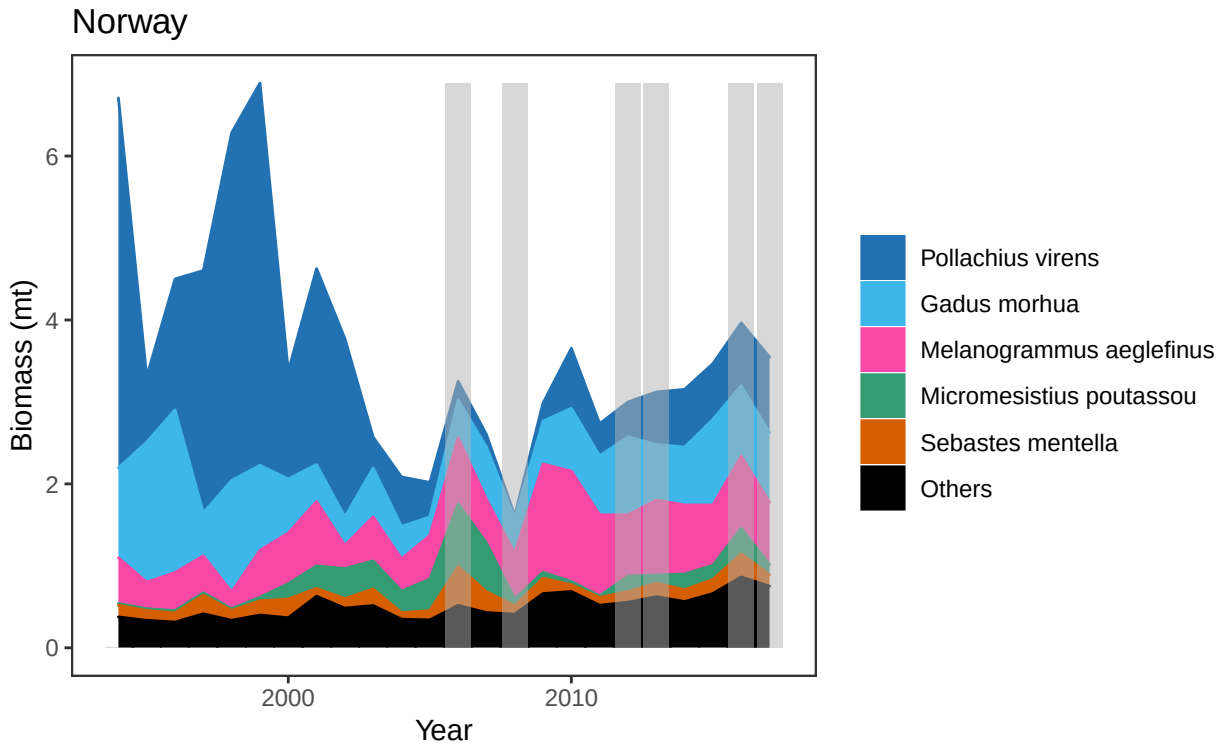


Figure 32: Biomass trends and historical MHWs by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

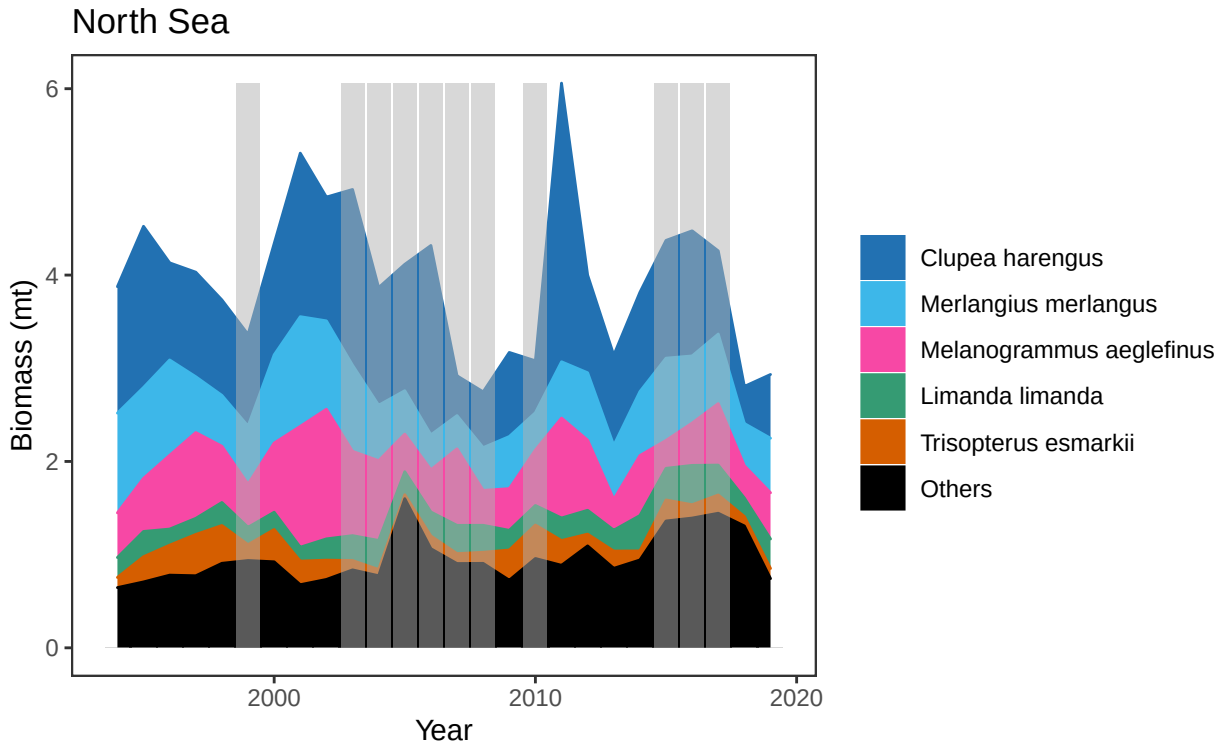


Figure 33: Biomass trends and historical MHWs by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

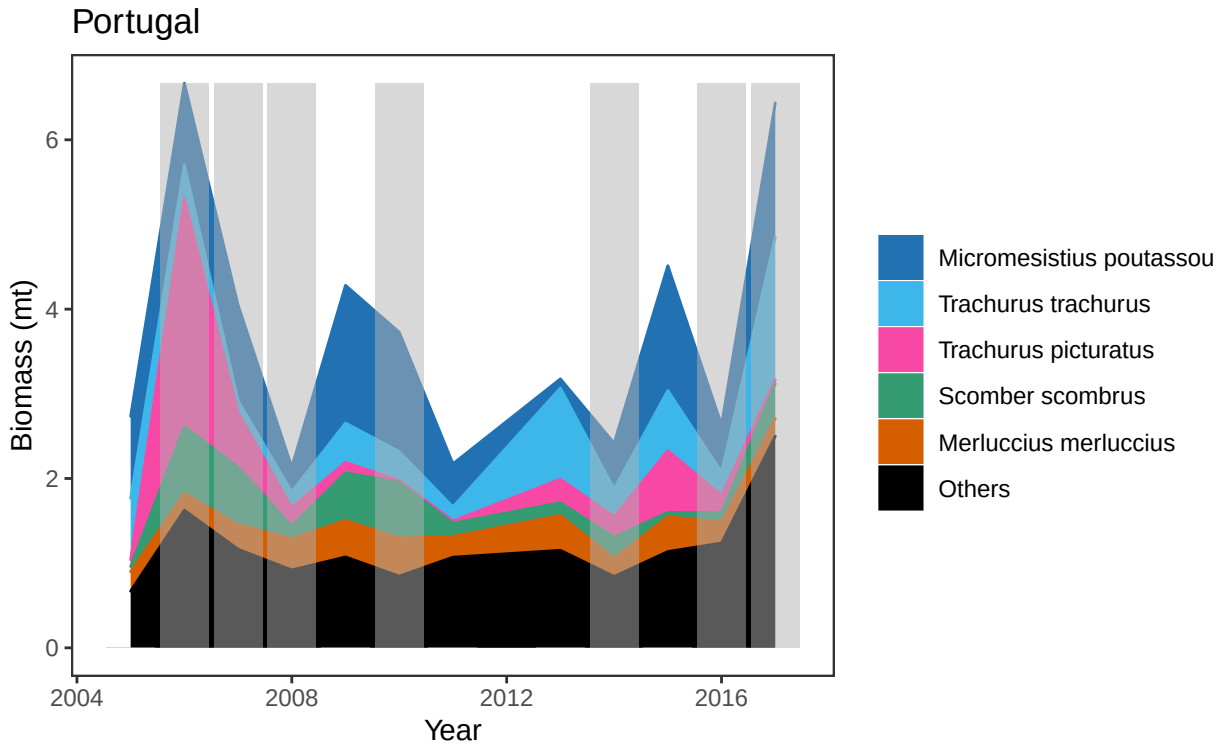


Figure 34: Biomass trends and historical MHWs by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

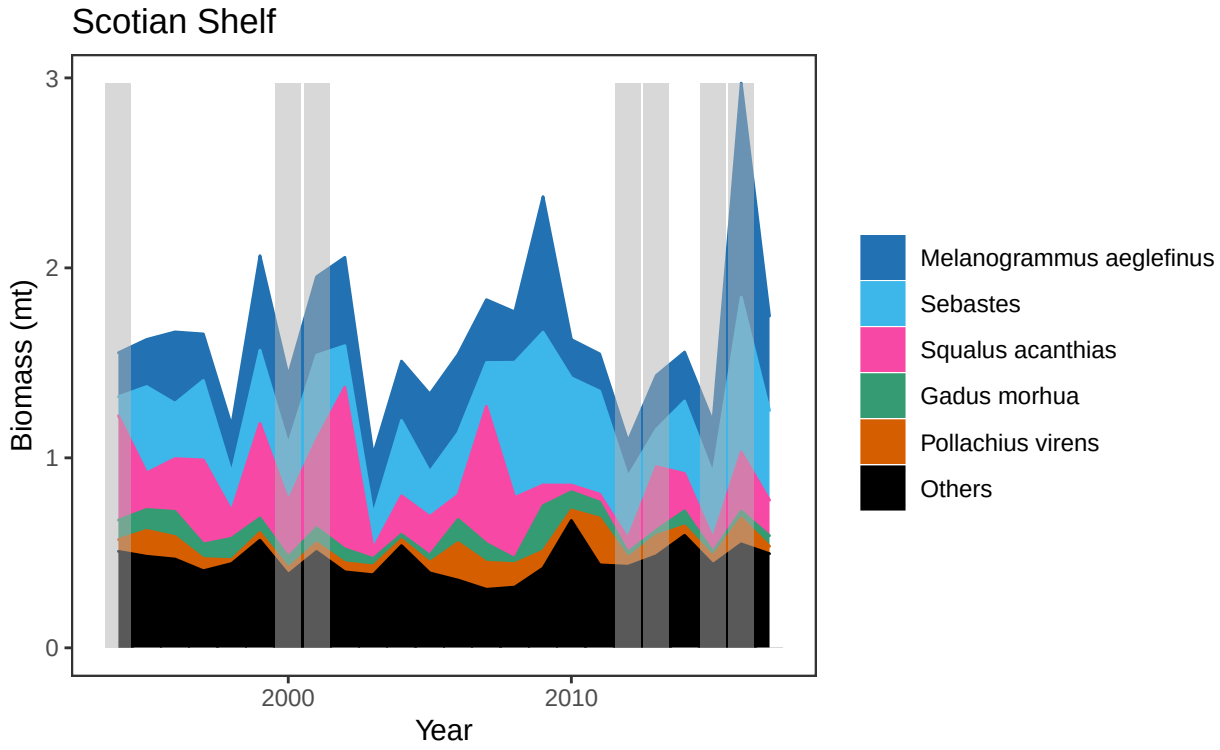
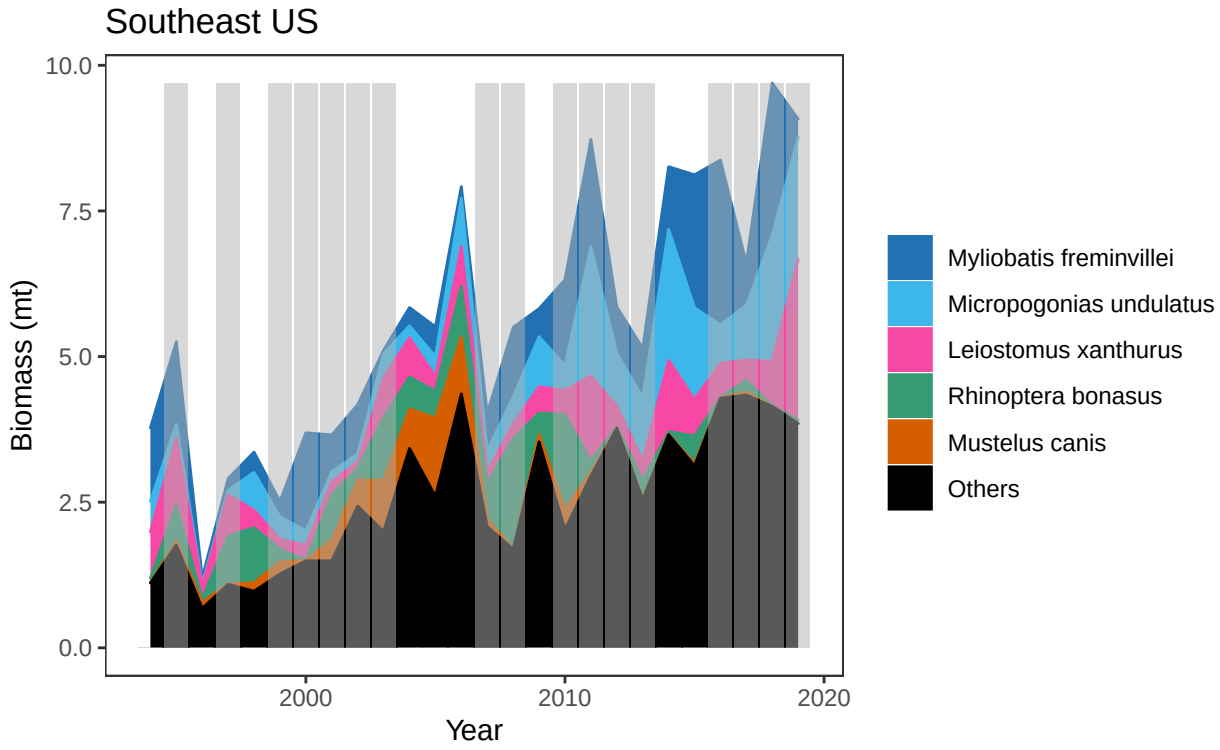


Figure 35: Biomass trends and historical MHWs by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.



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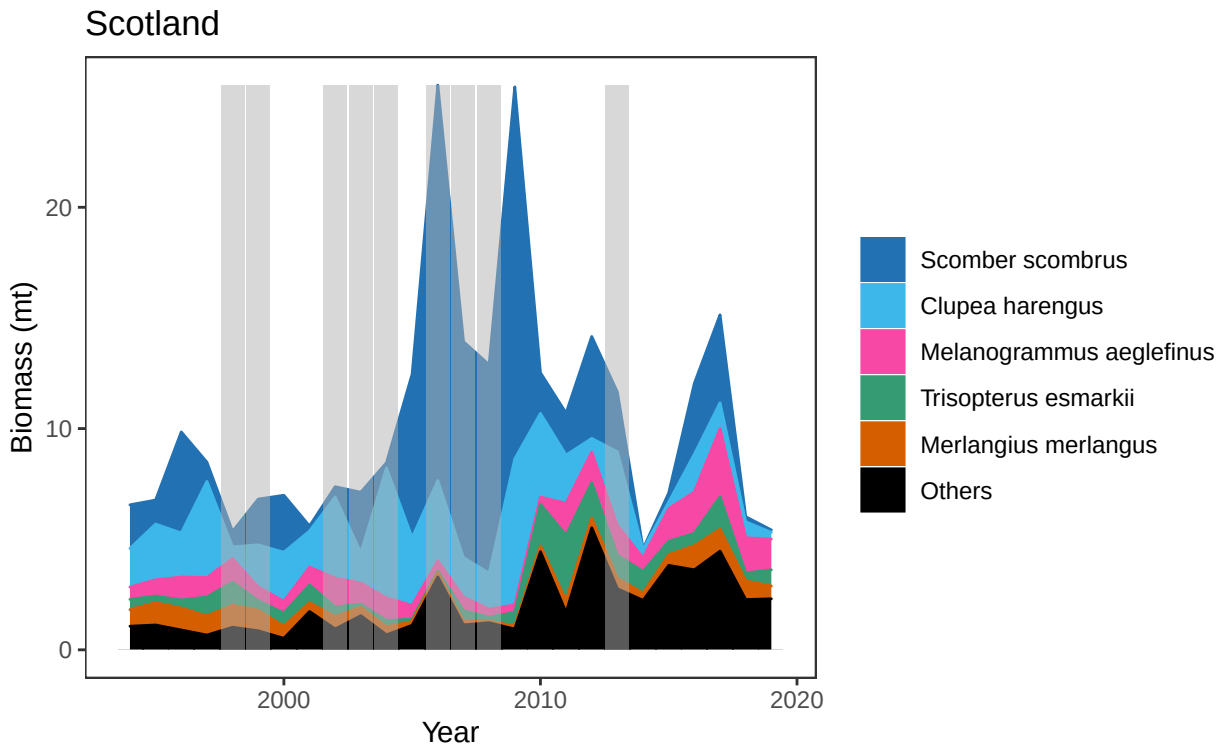
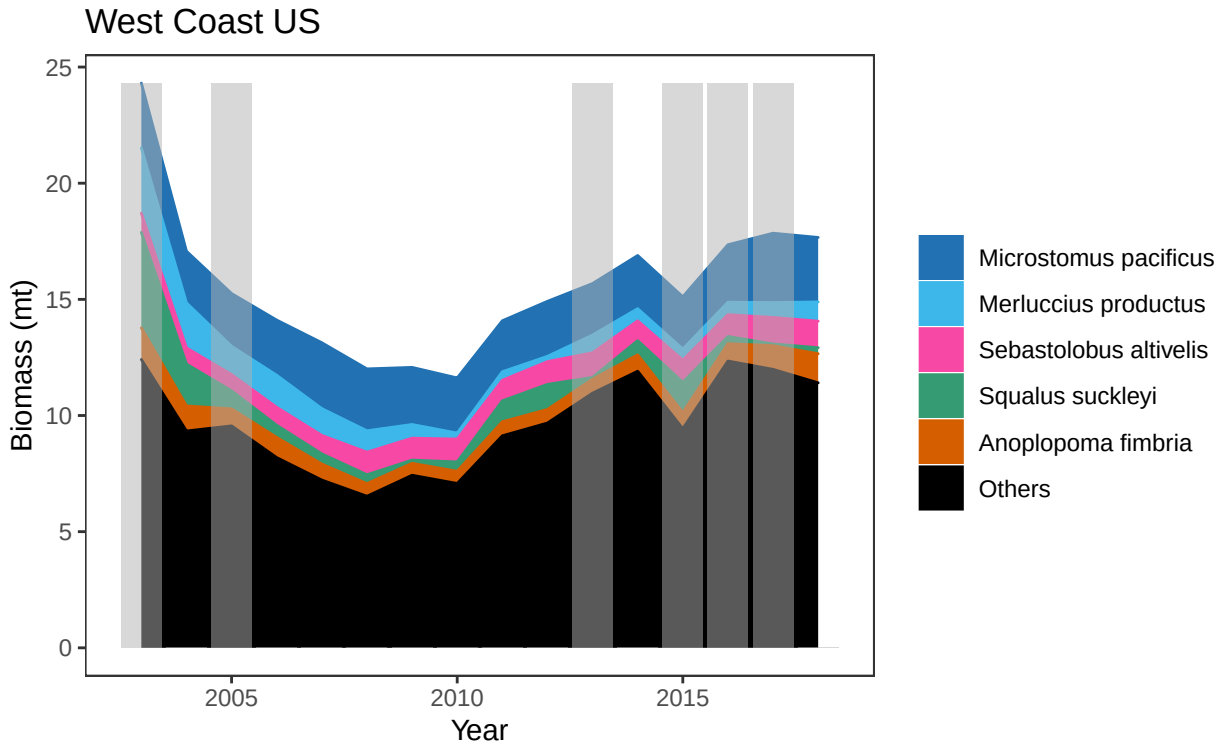


Figure 37: Biomass trends and historical MHWs by region. MHWs were calculated from the detrended GLORYS sea bottom temperature data with a five-day minimum duration threshold for MHWs, as used in the main text. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.



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