Supplementary Information

Fredston et al.

2022

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1 Supplementary methods

1.1 Trawl data preparation

To compare biomass across surveys with different methods, it must be converted into an index of catch per unit effort (CPUE; here, kg / km^2). To estimate the fish biomass from each sample, the minimum required information is: taxa specific weight or abundance at length data, swept area or information to estimate it from sampling duration, sampled distance and gear opening. When species weight needed to be estimated from abundance at length data for ICES surveys, length-weight relationships were retrieved from locally relevant areas from FishBase. Missing swept area information was estimated when relevant based on survey variables such as sampling ship, sampling depth, and haul duration. Reported taxonomy in the surveys was cleaned and homogenized with the World Register of Marine Species for a semi-automated method, and information from taxonomic inconsistencies reported by surveys providers and experts was used to correct taxonomic names. We omitted survey-years with very few samples, a change in the area sampled, or other methodological inconsistencies, and only analyzed surveys that were conducted annually or biennially for at least ten consecutive survey-years (methods detailed below). A total of 18 surveys were incorporated, with a total of 202,819 hauls covering 2088 taxa before spatio-temporal standardization of each survey region. 80% of those taxa were identified to species, 12% to genus, and the remaining 8% to higher taxonomic levels. We used all of the taxa for biomass analyses but only the species-level records for community analyses.

Data cleaning scripts from the are summarized below:

The marine heatwave analysis began with the harmonized FISHGLOB v1.1 public dataset, and additional data trimming measures are summarized below and contained in prep_trawl_data.R:

- Omit surveys in FISHGLOBv1.1 that show very inconsistent sampling patterns in the summary PDFs
- Calculate CPUE for the one region for which it is not calculated in FISHGLOB already: the Northeast US. This region does not report swept area, but staff at the survey agency (NOAA) use a fixed value for the swept area for all hauls, regardless of haul duration (the fixed value is standardized to a 30-minute

haul). To make this a more reasonable assumption, we omit hauls more than 5 minutes shorter or longer than the target haul duration, and then calculate CPUE

- Manually trim out years for which, based on the summary PDFs, our expert opinion is that survey methods were not consistent (e.g., far fewer hauls than usual). This step most frequently omits the early years of a survey, when methods and sampling intensity were not yet standardized; these years may also be too early to match to temperature data, and thus would have been omitted later in the analysis anyway
- Remove surveys that have fewer than 10 years of data, as our focus is temporal dynamics. This step removes three small surveys in Canada
- Trim each survey to one season, i.e., the most consistently or frequently sampled three-month interval
- Standardize spatial footprints over time for each survey by creating hexagonal cells covering the Earth's surface, pairing each haul with a cell, and retaining only hauls in the cells that were sampled every year. Cells were created using the dggridR package[1]. We used a cell resolution of 8, corresponding to a cell area of 7,774 km^2, for all regions except the Norway survey. Norway conducts an extremely large-scale scientific trawl survey that has operated in the Norwegian and Barents Seas for decades. Because this survey is larger-scale than all of the others, we used a cell resolution of 7 (cell area of 23,323 km^2) to standardize the footprint of this survey
- Impute zeros for true absences in every instance where a species ever observed in a survey was *not* encountered in a given haul
- Calculate species-specific mean CPUE as the mean of every CPUE for that species in a given survey and year (i.e., average over hauls)
- Calculate species-specific mean depth as the mean of depths where hauls occurred in a given survey and year, weighted by the species' CPUE in each haul

1.2 Power analysis

We simulated data to assess whether our study had sufficient power to detect MHW-driven biomass changes (see power_analysis.R). We fitted an autoregressive linear model of log biomass over time (Gompertz model) to each region's biomass data, including MHW presence/absence as a predictor. We extracted the coefficient ρ, intercept α, and conditional standard deviation σ of this model, and used them to simulate data from the same Gompertz model

$$log(B_t) = \alpha + \rho \times log(B_{t-1}) + \gamma \times MHW_t + \sigma'$$

where B represents biomass, MHW is a binary variable for MHW presence/absence, and γ represents the "true" MHW effect that we vary to explore power. This simulation also includes an error term σ' calculated as a random draw from a normal distribution with mean 0 and standard deviation σ. We (1) varied the number of years the simulation was run (assuming that each region was sampled for the same number of years) from 10 to 200 in 10-year intervals (plus 24- and 25-year runs, since the mean survey duration in our actual dataset is 24.4) with a fixed value of $\gamma = ln(0.94)$, corresponding to the 6% loss of biomass predicted by,[2] and (2) varied γ to represent biomass losses ranging from 1% to 30% (in 1% intervals up to 10%, and then in 5% intervals; this included a $\gamma = ln(0.94)$ trial to correspond to[2]) given the actual number of years of data we have ($n = 435$). For both of these tests, simulations were run for each region individually, converted into log ratio units (used in the main text), and pooled across regions. Each set of simulations was run 1000 times for each condition (region and either number of years or γ).

With these two simulated datasets—annual, regional biomass with a true MHW effect on biomass of -6% and variable numbers of years, and annual, regional biomass with a fixed number of years from the real dataset and a variable effect of MHW on biomass—we conducted the same statistical tests as we did in the main text to look for an effect. For every simulation iteration, we split the biomass log ratio data into MHW and non-MHW years and compared the two with a t-test. We then calculated what proportion of those tests were significant ($p <= 0.05$). These results are shown in Fig. 33 and Fig. 34.

1.3 Additional predictors

In addition to the geographical shifts that may lead to changes in biomass and community composition in a fixed area, marine fishes may shift deeper in response to warming[3 4]. We tested for this by calculating depth log ratios that describe whether assemblages have gotten deeper or shallower from one survey to the next. Depth log ratio was quantified by: 1. Taking an average of depths at which a species was found in each survey and year, using the depth records for each haul, and weighted by biomass in the haul. 2. Taking a weighted mean of all these species-level depth values for the entire survey, again weighted by species biomass. 3. Calculating the log ratio of these survey-level, biomass-weighted depth values from one year to the next. We find no relationship between MHW duration and depth log ratio (Fig. 5) and no difference between depth changes that do and do not follow a MHW (Fig. 6).

Marine communities across latitudes have responded differently to climate change, with some declines in species richness recorded in the tropics and at equatorward range edges[5 6] and some increases in species richness recorded in colder oceans and at poleward range edges[6 7]. We also tested for latitudinal trends in biomass log ratios, finding that the direction or magnitude of biomass change was not related to the latitude of the region 7.

Species frequently exhibit individualistic responses to global change.[8] We explored whether species taxonomy, species traits, and regional identity help to predict species-level biomass change at all and in the context of marine heatwaves. All fish species traits were obtained from the database in.[9] Of the 1752 taxa used in the analysis, 1599 had trophic level data (used in Fig. 10), 1571 had feeding mode data (used in Fig. 11), and 1592 had feeding mode data (used in Fig. 12). The pattern of no relationship between MHW duration and biomass log ratio persists when data are grouped by trophic level (Fig. 10), feeding mode (Fig. 11), or habitat (Fig. 12).

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

```
## Random effect variances not available. Returned R2 does not account for random effects.

## Random effect variances not available. Returned R2 does not account for random effects.

## Random effect variances not available. Returned R2 does not account for random effects.

## Random effect variances not available. Returned R2 does not account for random effects.
```

Table 2: Models of biomass change. All models were fitted to biomass log ratio values (scaled and centered within surveys) using MHW duration in days (scaled and centered within surveys). Model names correspond to: linear model, linear mixed-effects model with survey identity as a random effect, generalized additive model (GAM), and GAM with survey as a random effect. Values in parentheses are standard errors. Stars, if present, correspond to: + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	LM	LME	GAM	GAM + RE
(Intercept)	0.000 (0.048)	0.000 (0.048)	0.000 (0.048)	0.000 (0.048)
anom_days_scale	−0.008 (0.049)			
SD (Intercept survey)		0.000		
SD (anom_days_scale survey)		0.000		
SD (Observations)		0.980		
Num.Obs.	422	422	422	422
R2	0.000		−0.002	−0.002
R2 Adj.	−0.002			
R2 Marg.		0.000		
R2 Cond.				
AIC	1185.2	1193.4	1185.2	1186.0
BIC	1197.3	1213.7	1197.4	1198.1
F	0.029			
RMSE	0.98	0.98	0.98	0.98
df.error	420.000	417.000	420.000	420.000

Table 3: This table is identical to the previous one, except rather than centering and scaling MHW duration within regions, it is centered and scaled among regions. The approach used in most of these models (centering and scaling MHW duration 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 duration matters regardless of the oceangraphic history of each region (centering and scaling MHW duration among regions). Values in parentheses are standard errors. Stars, if present, correspond to: + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	LM	LME	GAM	GAM + RE
(Intercept)	0.000 (0.048)	0.000 (0.048)	0.000 (0.048)	0.000 (0.048)
anom_days_scale_alt	−0.024 (0.048)			
SD (Intercept survey)		0.000		
SD (anom_days_scale_alt survey)		0.000		
SD (Observations)		0.980		
Num.Obs.	422	422	422	422
R2	0.001		−0.002	−0.002
R2 Adj.	−0.002			
R2 Marg.		0.000		
R2 Cond.				
AIC	1184.9	1193.4	1185.0	1185.8
BIC	1197.1	1213.7	1197.1	1197.9
F	0.262			
RMSE	0.98	0.98	0.98	0.98
df.error	420.000	417.000	420.000	420.000

Table 4: Models of biomass change. All models were fitted to biomass log ratio values (scaled and centered within surveys) using MHW duration in days (scaled and centered within surveys). Model names correspond to: GAM with a matrix of predictors including MHW data from 2-5 years prior to the survey in addition to the year prior to the survey. Values in parentheses are standard errors. Stars, if present, correspond to: + p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001.

	GAM Lag 1	GAM Lag 2	GAM Lag 3	GAM Lag 4
(Intercept)	−0.044 (0.061)	−0.010 (0.067)	−0.025 (0.075)	0.009 (0.083)
Num.Obs.	404	386	368	350
R2	−0.001	−0.003	−0.002	−0.003
AIC	1125.1	1073.0	1023.8	981.2
BIC	1137.1	1084.9	1035.5	992.8
RMSE	0.97	0.96	0.96	0.97
df.error	402.000	384.000	366.000	348.000

Table 5: Model of biomass change as a function of MHW duration and lagged biomass (i.e., Gompertz models). All models were fitted to biomass log ratio values using MHW duration in days (scaled and centered within surveys) and used the previous year's log biomass as a predictor. Rather than centering and scaling biomass values, these models allow slopes and intercepts to vary by survey. Values in parentheses are standard errors. Stars, if present, correspond to: + p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001.

	Gompertz LM	Gompertz LME	Gompertz GAM
(Intercept)	0.302 (0.555)	0.013 (0.072)	0.033 (0.031)
factor(survey)DFO-QCS	−9.814 (13.870)		
factor(survey)EBS	1.226 (1.026)		
factor(survey)EVHOE	1.574 (0.753)*		
factor(survey)FR-CGFS	−0.171 (0.569)		
factor(survey)GMEX	−0.286 (0.558)		
factor(survey)GOA	0.723 (3.462)		
factor(survey)GSL-S	0.441 (0.586)		
factor(survey)IE-IGFS	1.033 (0.907)		
factor(survey)NEUS	0.138 (0.598)		
factor(survey)NIGFS	2.886 (2.194)		
factor(survey)Nor-BTS	−0.169 (0.559)		
factor(survey)NS-IBTS	0.580 (0.654)		
factor(survey)PT-IBTS	1.272 (0.661)+		
factor(survey)SCS	0.153 (0.570)		
factor(survey)SEUS	0.413 (0.600)		
factor(survey)SWC-IBTS	0.685 (0.630)		
factor(survey)WCANN	0.223 (1.737)		
anom_days_scale	0.000 (0.016)	0.001 (0.016)	
factor(survey)BITS × wt_mt_lag	−0.163 (0.323)		
factor(survey)DFO-QCS × wt_mt_lag	−0.359 (0.521)		
factor(survey)EBS × wt_mt_lag	−0.510 (0.285)+		
factor(survey)EVHOE × wt_mt_lag	−0.997 (0.271)***		
factor(survey)FR-CGFS × wt_mt_lag	−0.054 (0.113)		
factor(survey)GMEX × wt_mt_lag	−0.492 (0.214)*		
factor(survey)GOA × wt_mt_lag	−0.331 (1.072)		
factor(survey)GSL-S × wt_mt_lag	−0.563 (0.128)***		
factor(survey)IE-IGFS × wt_mt_lag	−0.734 (0.401)+		
factor(survey)NEUS × wt_mt_lag	−0.262 (0.132)*		
factor(survey)NIGFS × wt_mt_lag	−1.504 (1.007)		
factor(survey)Nor-BTS × wt_mt_lag	−0.557 (0.081)***		
factor(survey)NS-IBTS × wt_mt_lag	−0.643 (0.250)*		
factor(survey)PT-IBTS × wt_mt_lag	−1.302 (0.284)***		
factor(survey)SCS × wt_mt_lag	−0.864 (0.224)***		
factor(survey)SEUS × wt_mt_lag	−0.433 (0.136)**		
factor(survey)SWC-IBTS × wt_mt_lag	−0.454 (0.133)***		
factor(survey)WCANN × wt_mt_lag	−0.195 (0.611)		
wt_mt_lag			−0.011 (0.006)+
SD (Intercept survey)		0.055	
SD (1.wt_mt_lag survey)		0.404	
Cor (Intercept~1.wt_mt_lag survey)		−0.912	
SD (Intercept survey.1)		0.583	
SD (Observations)		0.318	
Num.Obs.	404	404	350
R2	0.313		0.005
R2 Adj.	0.246		
R2 Marg.		0.000	
R2 Cond.		0.029	
AIC	247.7	329.0	290.0
BIC	399.7	357.0	305.5
ICC		0.0	
F	4.644		
RMSE	0.30	0.31	0.36
df.error	367.000	397.000	347.000

Table 6: Linear mixed-effect models of overall biomass as predicted by single-species biomass, with survey identity included as a random intercept. All models were fitted to scaled and centered biomass values. Model names correspond to the number of species used as predictors. Species were ranked by from highest overall biomass in the survey to lowest. Values in parentheses are standard errors. Stars, if present, correspond to: + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	LME-1	LME-2	LME-3	LME-4	LME-5
(Intercept)	−0.581 (0.062)***	−0.611 (0.051)***	−0.512 (0.047)***	−0.276 (0.033)***	−0.010 (0.037)
spp1	0.558 (0.027)***	0.507 (0.022)***	0.505 (0.019)***	0.507 (0.015)***	0.510 (0.014)***
spp2		0.474 (0.033)***	0.448 (0.028)***	0.449 (0.023)***	0.443 (0.020)***
spp3			0.511 (0.041)***	0.532 (0.033)***	0.529 (0.030)***
spp4				0.534 (0.035)***	0.444 (0.032)***
spp5					0.505 (0.050)***
SD (Intercept survey)	0.184	0.151	0.145	0.055	0.000
SD (Observations)	0.690	0.567	0.486	0.399	0.362
Num.Obs.	435	435	435	435	435
R2 Marg.	0.505	0.657	0.742	0.832	0.863
R2 Cond.	0.538	0.680	0.763	0.835	
AIC	944.1	780.0	655.6	477.8	394.4
BIC	960.4	800.4	680.1	506.3	427.0
ICC	0.1	0.1	0.1	0.0	
RMSE	0.68	0.56	0.48	0.39	0.36
df.error	431.000	430.000	429.000	428.000	427.000

Table 7: Models of CTI change. All models were fitted to scaled and centered CTI log ratio values using MHW duration in days (scaled and centered). Model names correspond to: linear model, linear mixed-effects model with survey identity as a random effect, generalized additive model (GAM), GAM with survey as a random effect, and GAM with a matrix of predictors including MHW data from 1-4 years prior to the survey in addition to the year prior to the survey. Values in parentheses are standard errors. Stars, if present, correspond to: + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	LM	LME
(Intercept)	0.000 (0.048)	0.000 (0.048)
anom_days_scale	0.019 (0.049)	
SD (Intercept survey)		0.000
SD (anom_days_scale survey)		0.054
SD (Observations)		0.978
Num.Obs.	422	422
R2	0.000	
R2 Adj.	−0.002	
R2 Marg.		0.000
R2 Cond.		
AIC	1185.0	1193.4
BIC	1197.2	1213.6
F	0.158	
RMSE	0.98	0.98
df.error	420.000	417.000

Table 8: Model of depth change. Depth log ratio and MHW duration variables were scaled and centered. Values in parentheses are standard errors. Stars, if present, correspond to: + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	Model 1
(Intercept)	0.000 (0.050)
anom_days_scale	−0.022 (0.051)
Num.Obs.	389
R2	0.001
R2 Adj.	−0.002
AIC	1092.4
BIC	1104.2
F	0.196
RMSE	0.98
df.error	387.000

Table 9: Models of biomass change as a function of MHW duration and median survey latitude. All variables were scaled and centered. Values in parentheses are standard errors. Stars, if present, correspond to: + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	Model 1
(Intercept)	0.000 (0.048)
anom_days_scale	−0.008 (0.049)
med_lat_scale	0.000 (0.048)
Num.Obs.	422
R2	0.000
R2 Adj.	−0.005
AIC	1187.2
BIC	1203.3
F	0.014
RMSE	0.98
df.error	419.000

3 Supplementary figures

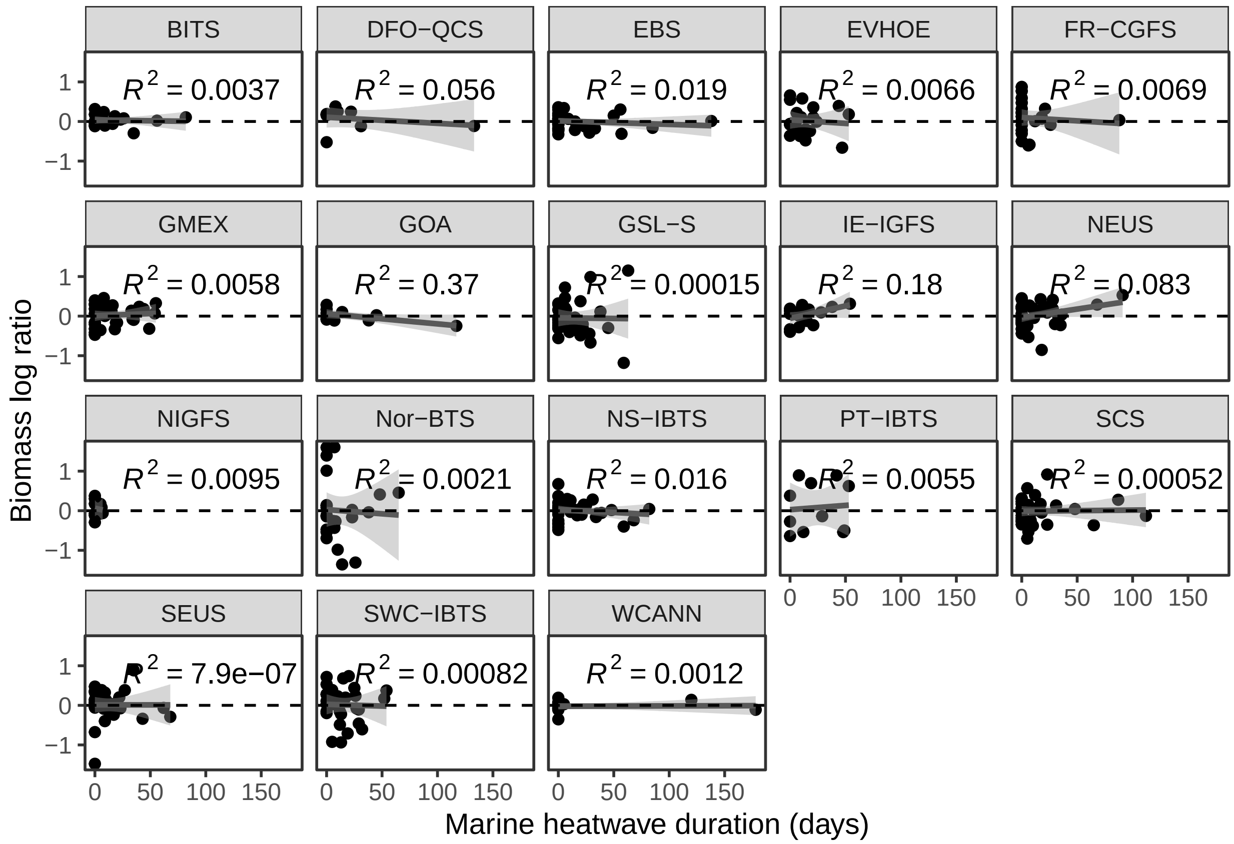

Figure 1: Alternate version of Fig. 2 from the main text, showing results by region. Longer MHWs are not associated with a decline in temperate fish biomass, and biomass is approximately as likely to increase as it is to decrease from one year to the next, regardless of whether a marine heatwave occurred. Points represent log ratios of mean biomass in a survey from one year to the next.

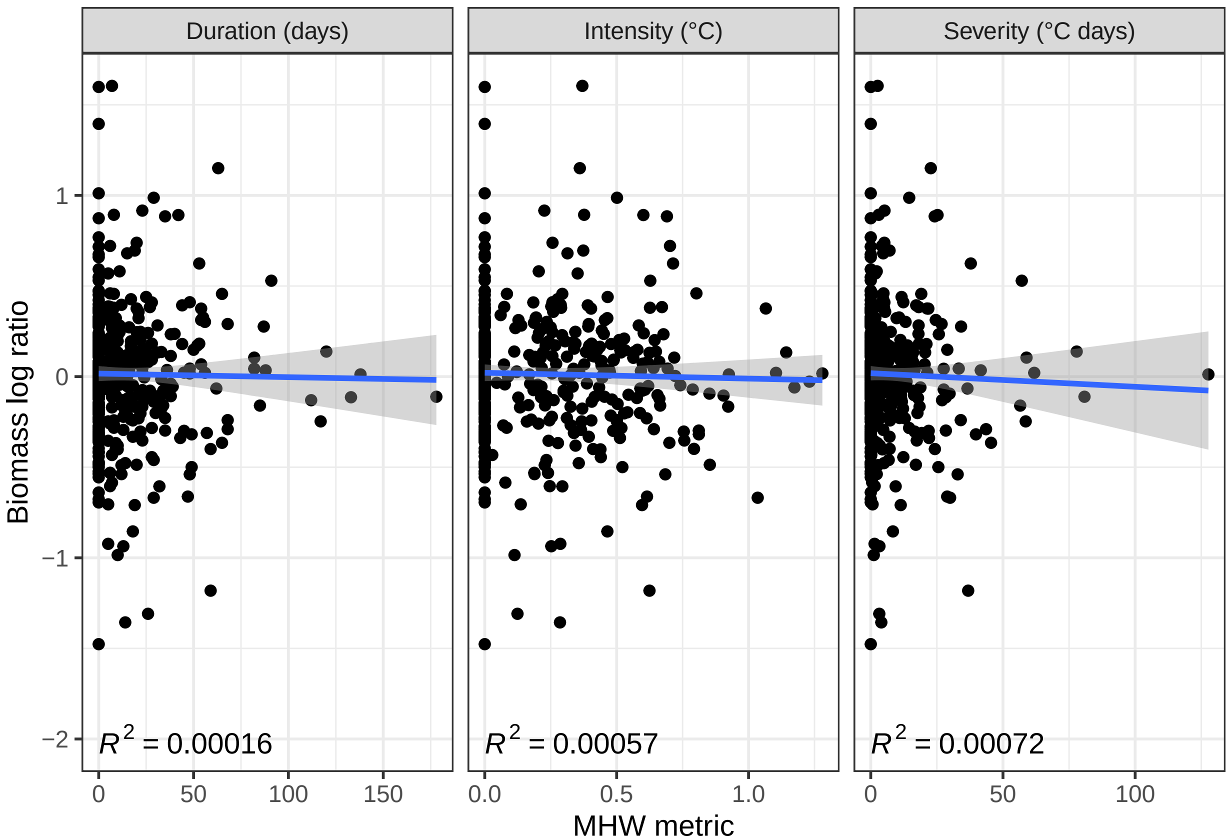

Figure 2: Biomass change (log ratio) and three metrics of measuring MHW impacts: severity (total anomaly in °C days), duration (number of days), and intensity (severity divided by duration, i.e., the average anomaly over the course of the MHW in °C).

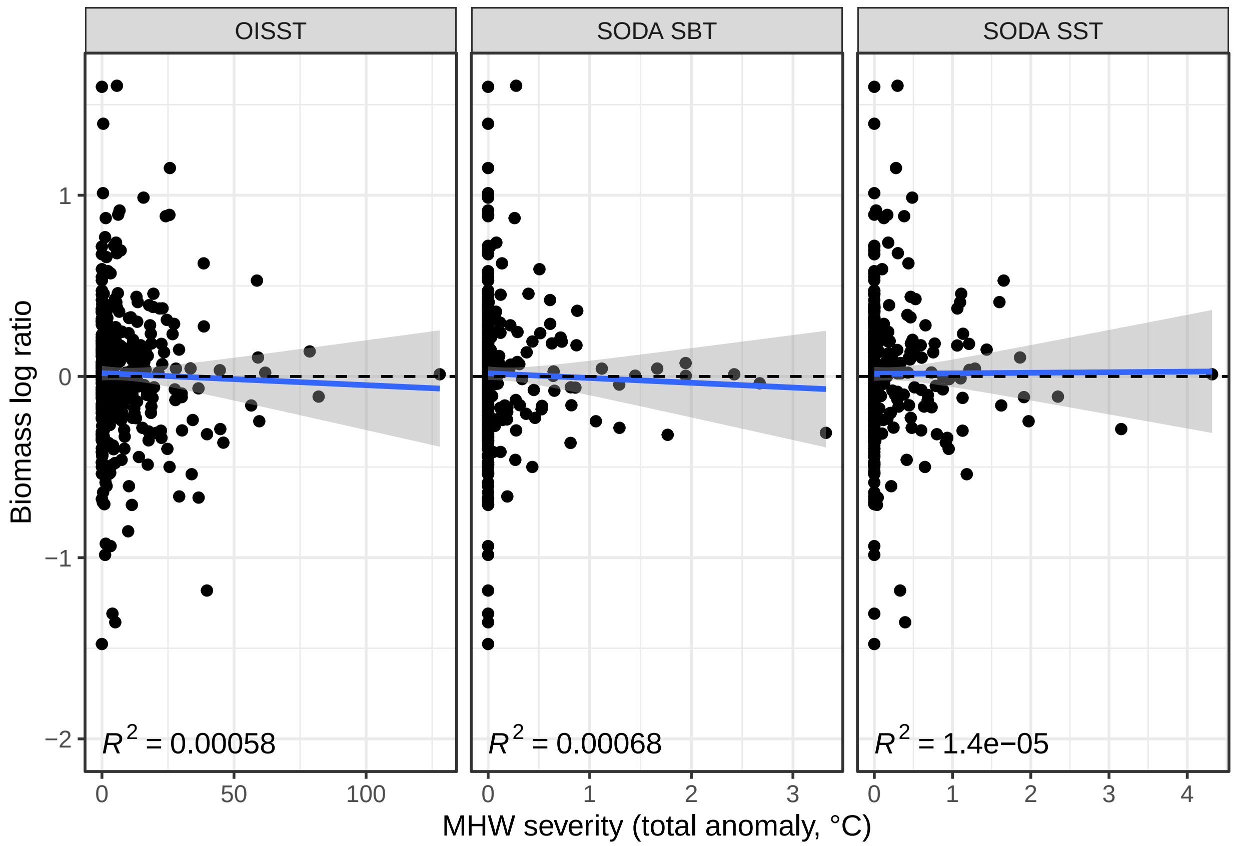

Figure 3: Biomass change (log ratio) and MHW severity from three data products. Here, we consider all anomaly-days in OISST to be MHWs, regardless of MHW duration (i.e., no 5-day cutoff). Severity is calculated as the total anomaly (°C) over the 12-month interval to which each biomass log ratio is paired. Note that the greater magnitude of severity values in OISST (see x-axis) are due to its higher (daily) temporal resolution revealing greater temperature anomalies than those that appear in the monthly SODA datasets.

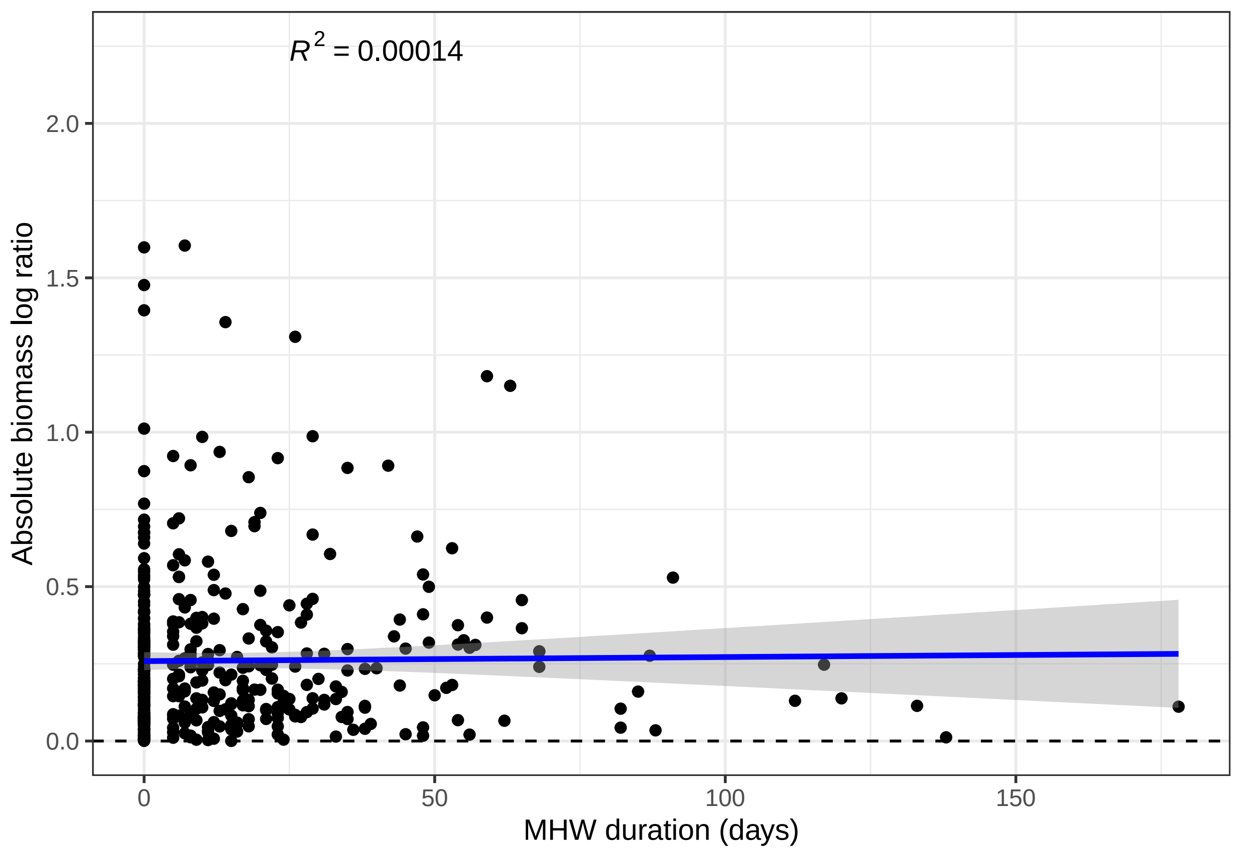

Figure 4: MHW duration and absolute value of biomass log ratio.

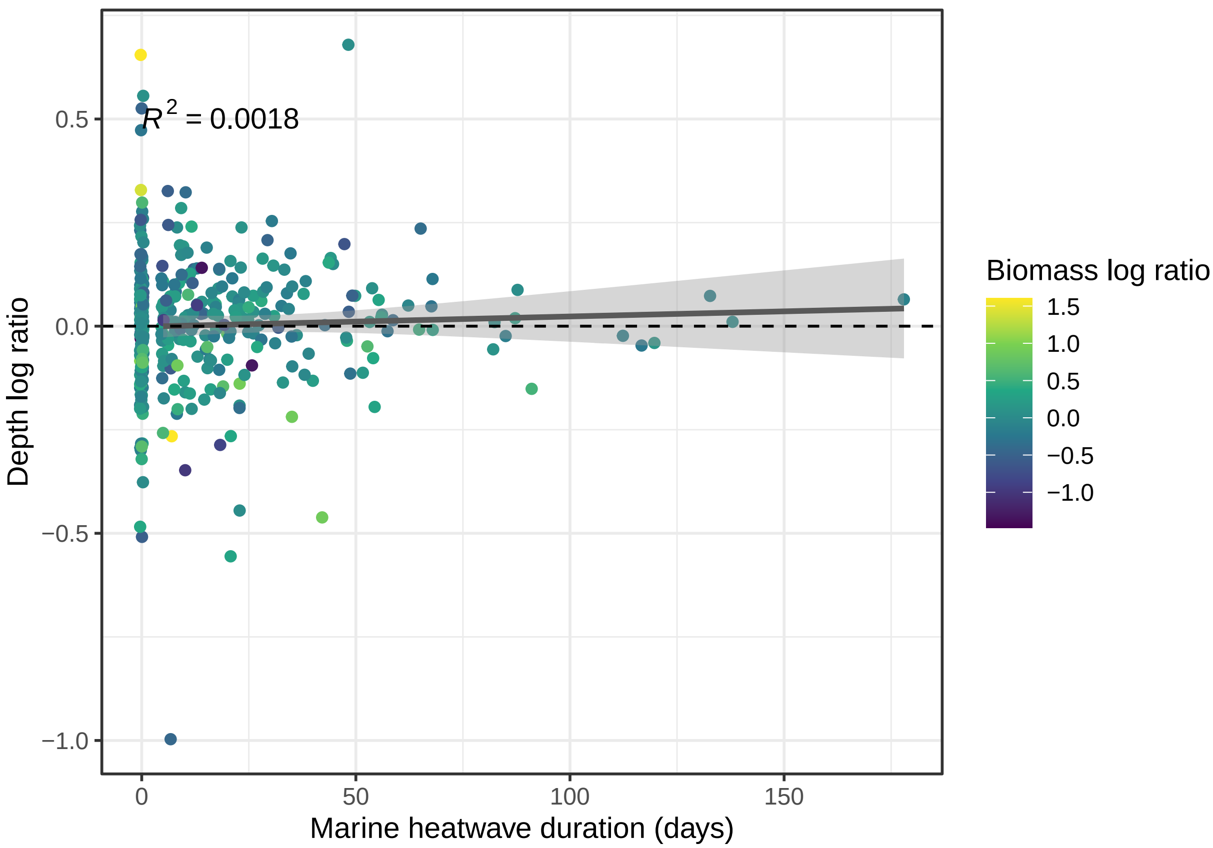

Figure 5: Fish assemblage depth change (log ratio) and MHW duration.

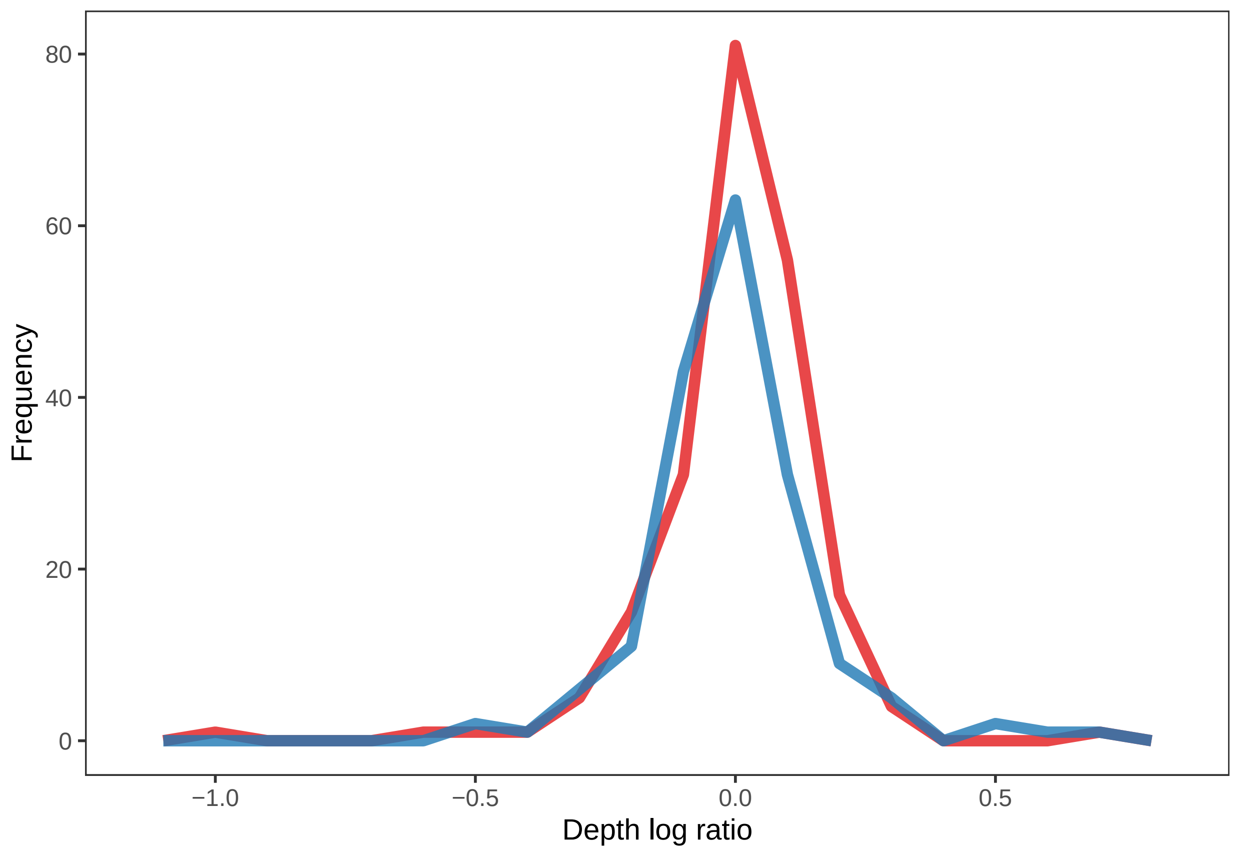

Figure 6: Fish assemblage depth change (log ratio) and MHW occurrence.

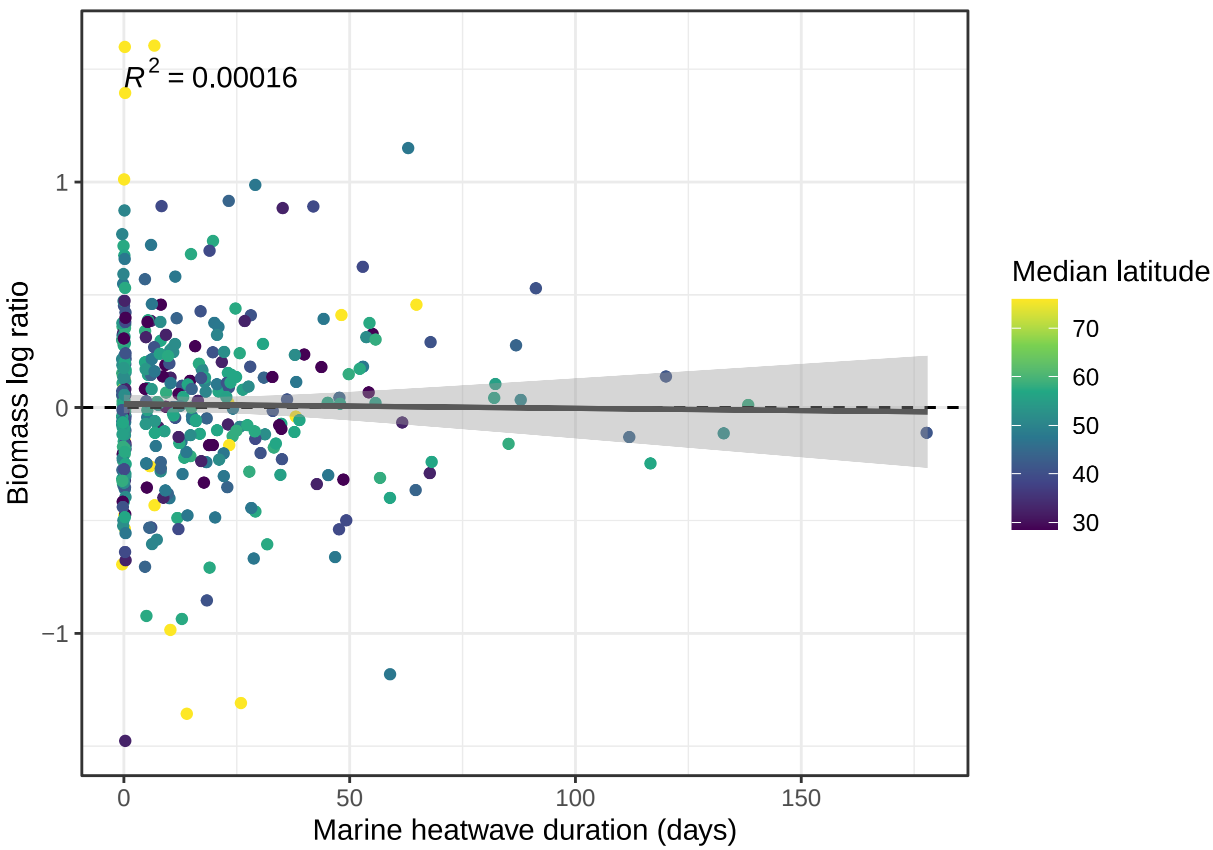

Figure 7: Biomass change (log ratio) and MHW duration, color-coded by median latitude of each survey region.

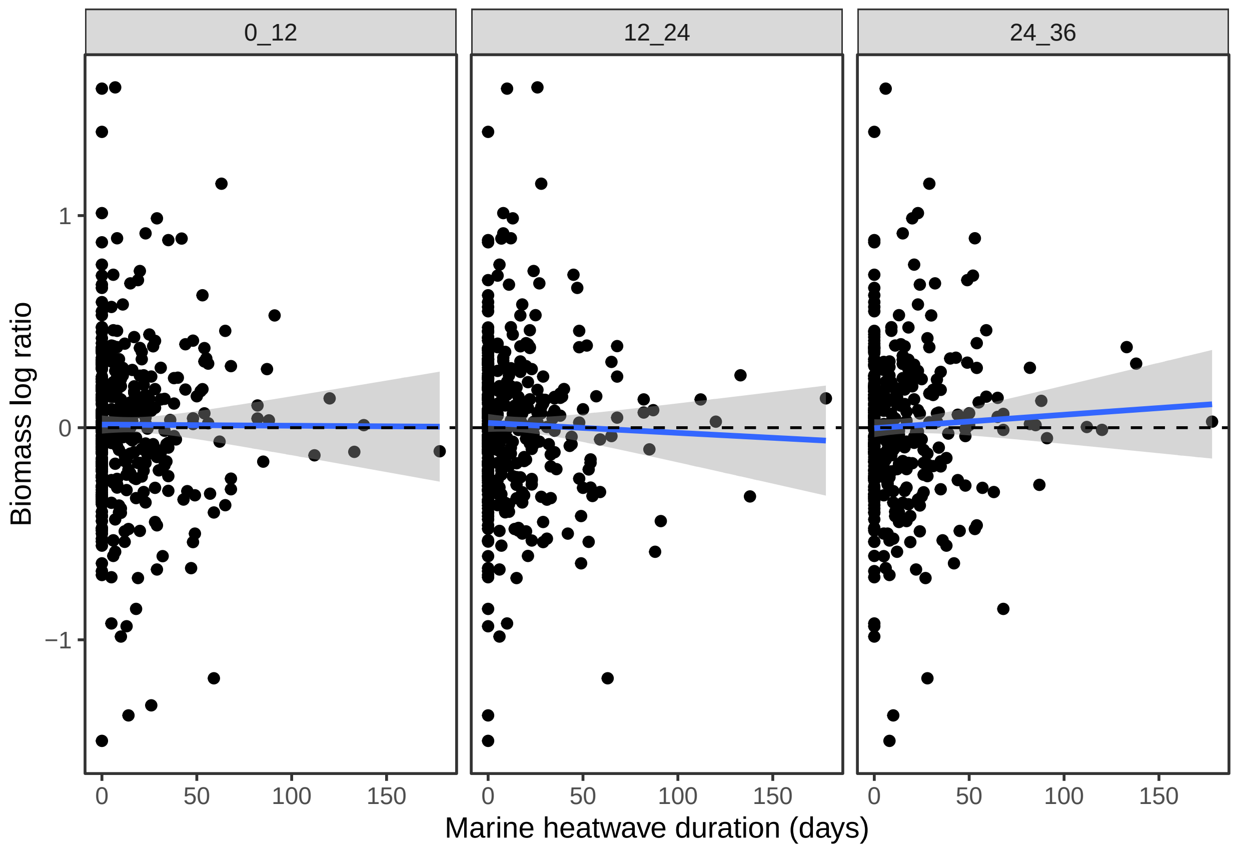

Figure 8: Biomass change (log ratio) and MHW duration calculated the preceding year as in the main text (0-12 months), a one-year lag (12-24 months), and a two-year lag (24-36 months).

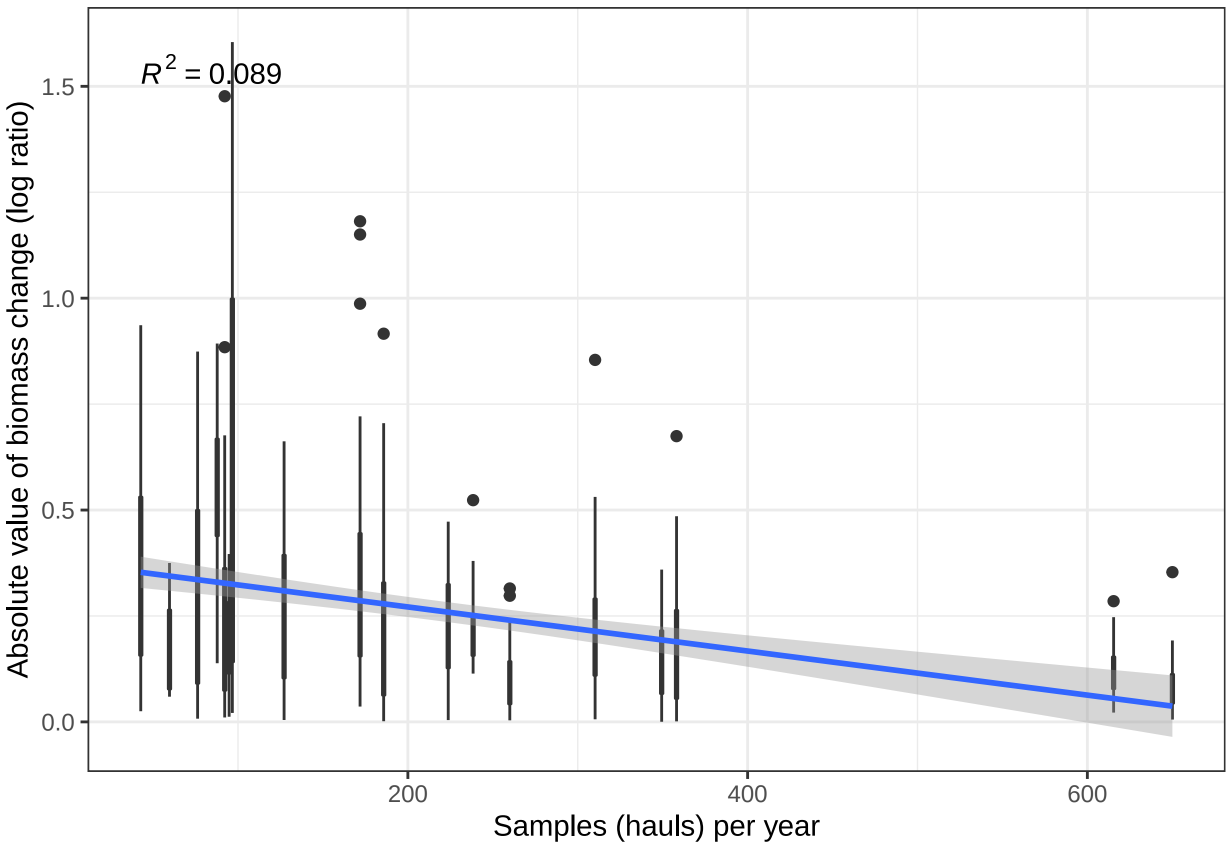

Figure 9: Absolute value of biomass log ratios vs. sampling intensity, defined as the average number of samples (hauls) per year in each region. The relationship between biomass log ratio magnitude and sampling is highly significant (p < 0.001).

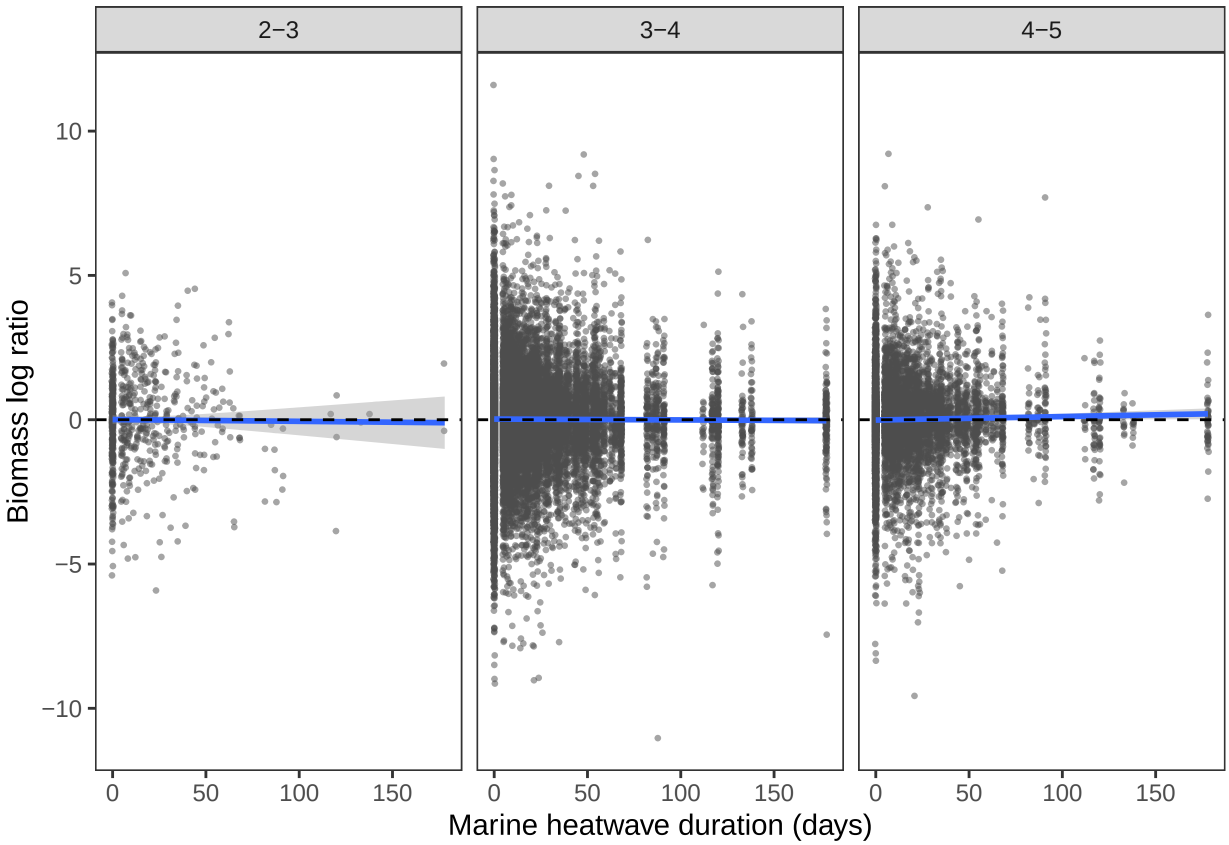

Figure 10: Biomass log ratio and MHW duration grouped by trophic level of each taxon.

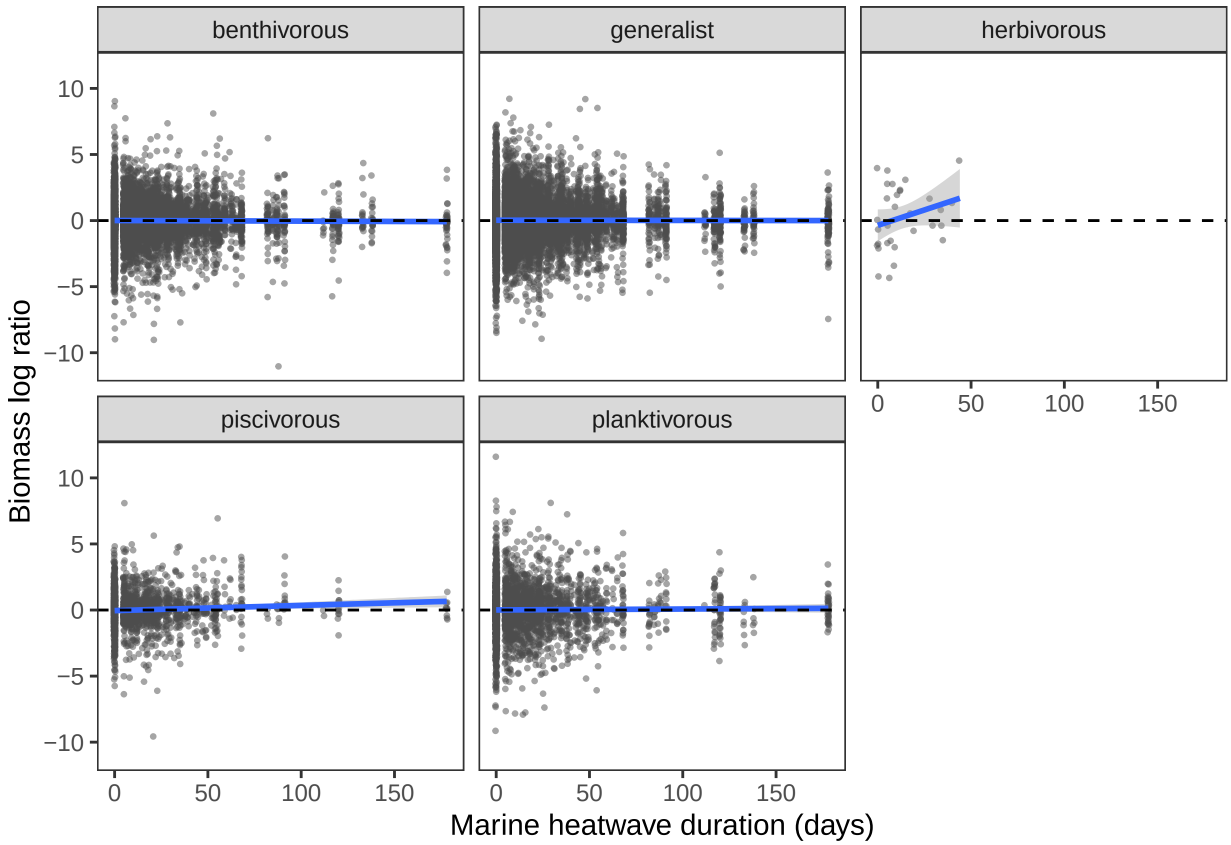

Figure 11: Biomass log ratio and MHW duration grouped by feeding mode of each taxon.

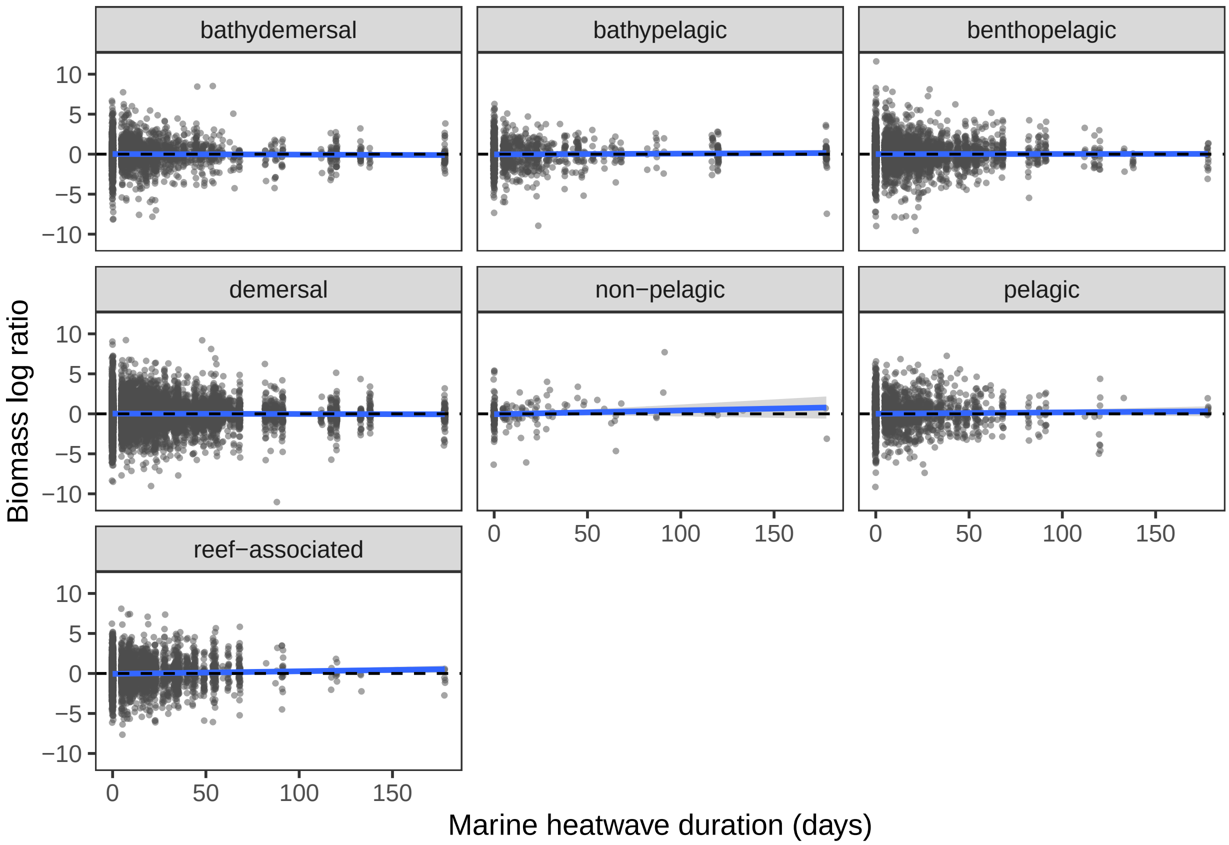

Figure 12: Biomass log ratio and MHW duration grouped by habitat preference of each taxon.

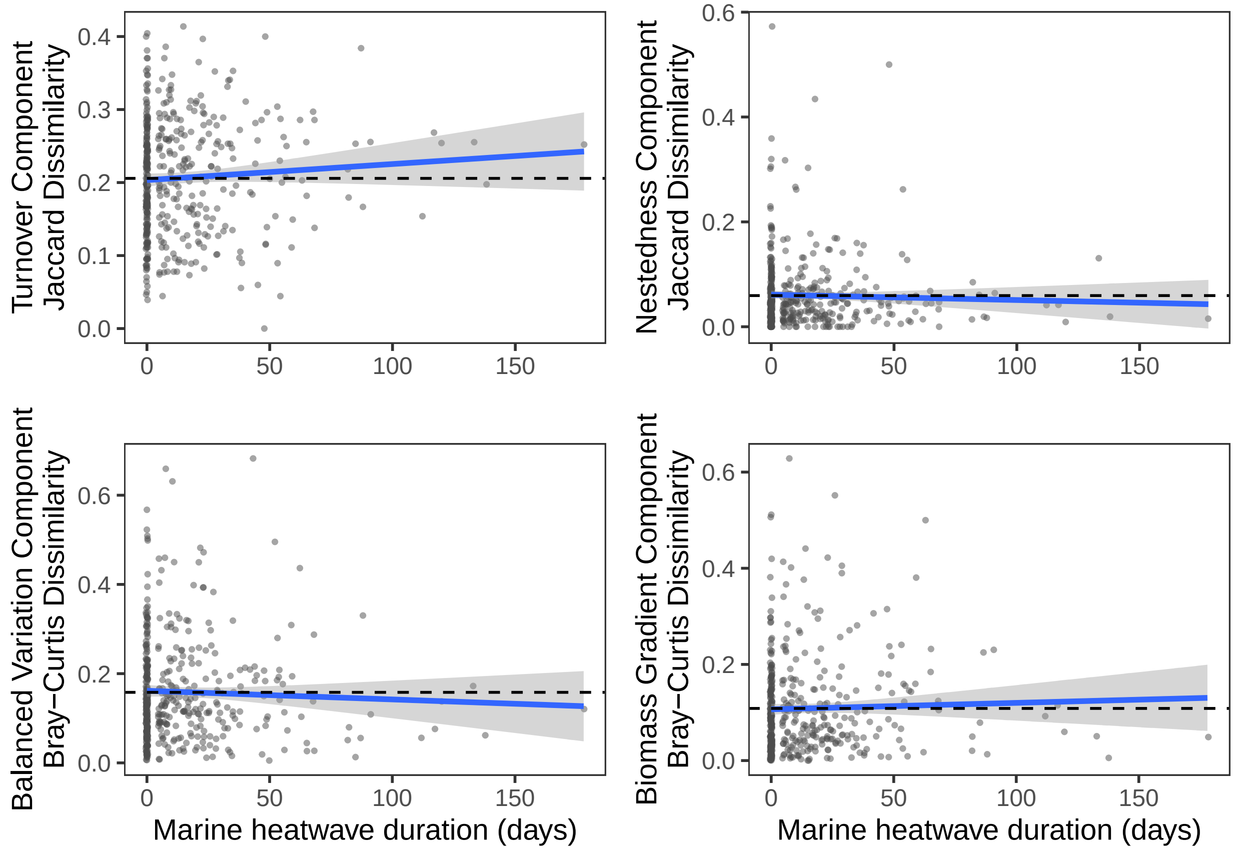

Figure 13: Temporal Community Dissimilarity and MHW duration for partitioned occurence based beta diversity metrics (Jaccard turnover and nestedness; top) and partitioned biomass based beta diversity metrics (Bray-Curtis balanced variation and biomass gradient; bottom).

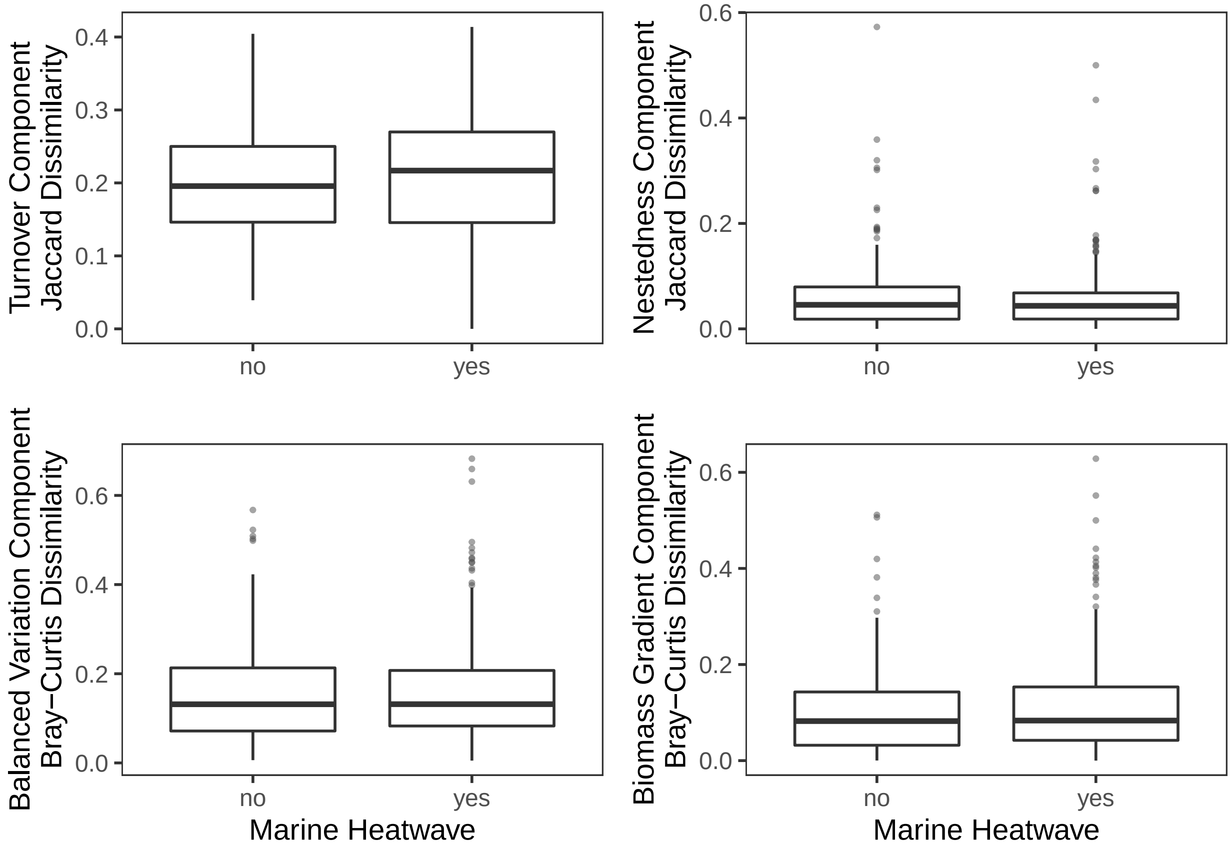

Figure 14: Temporal Community Dissimilarity and MHW event for partitioned occurence based beta diversity metrics (Jaccard turnover and nestedness; top) and partitioned biomass based beta diversity metrics (Bray-Curtis balanced variation and biomass gradient; bottom).

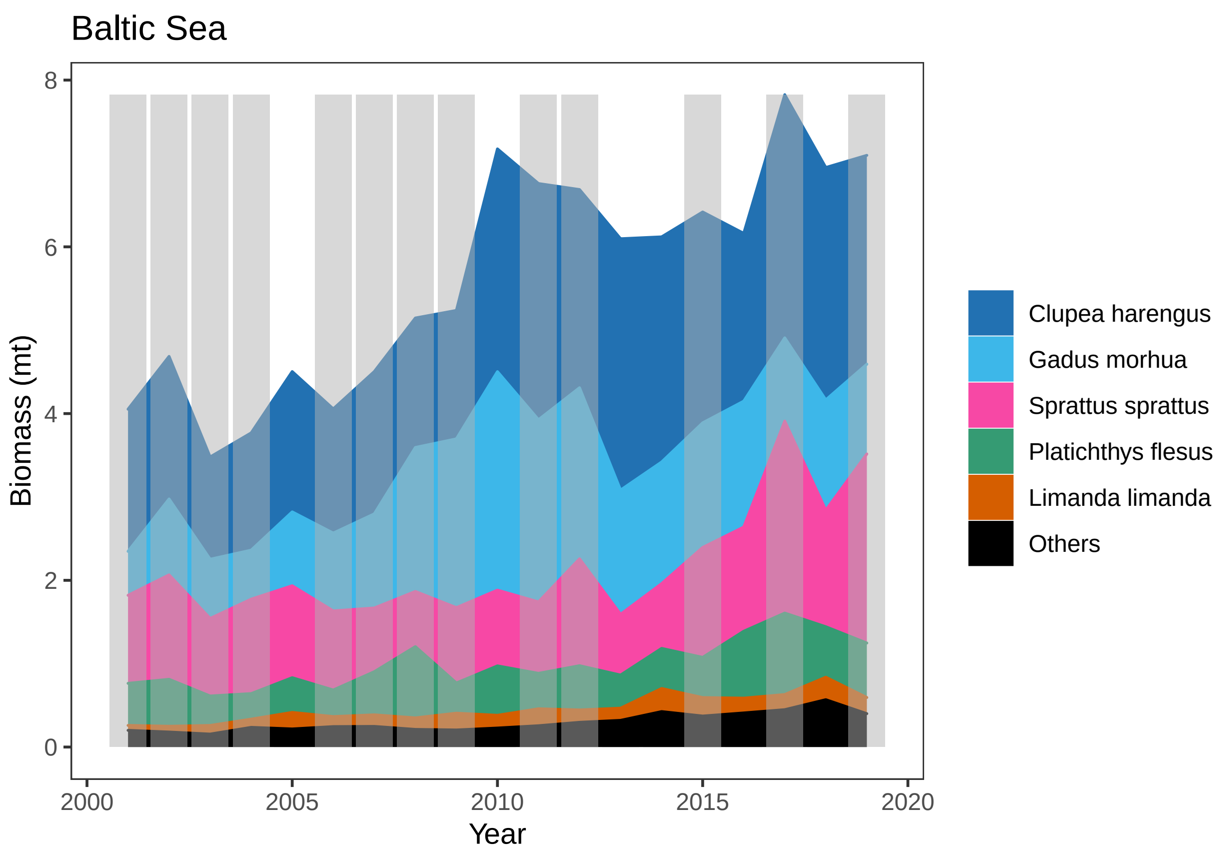

Figure 15: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

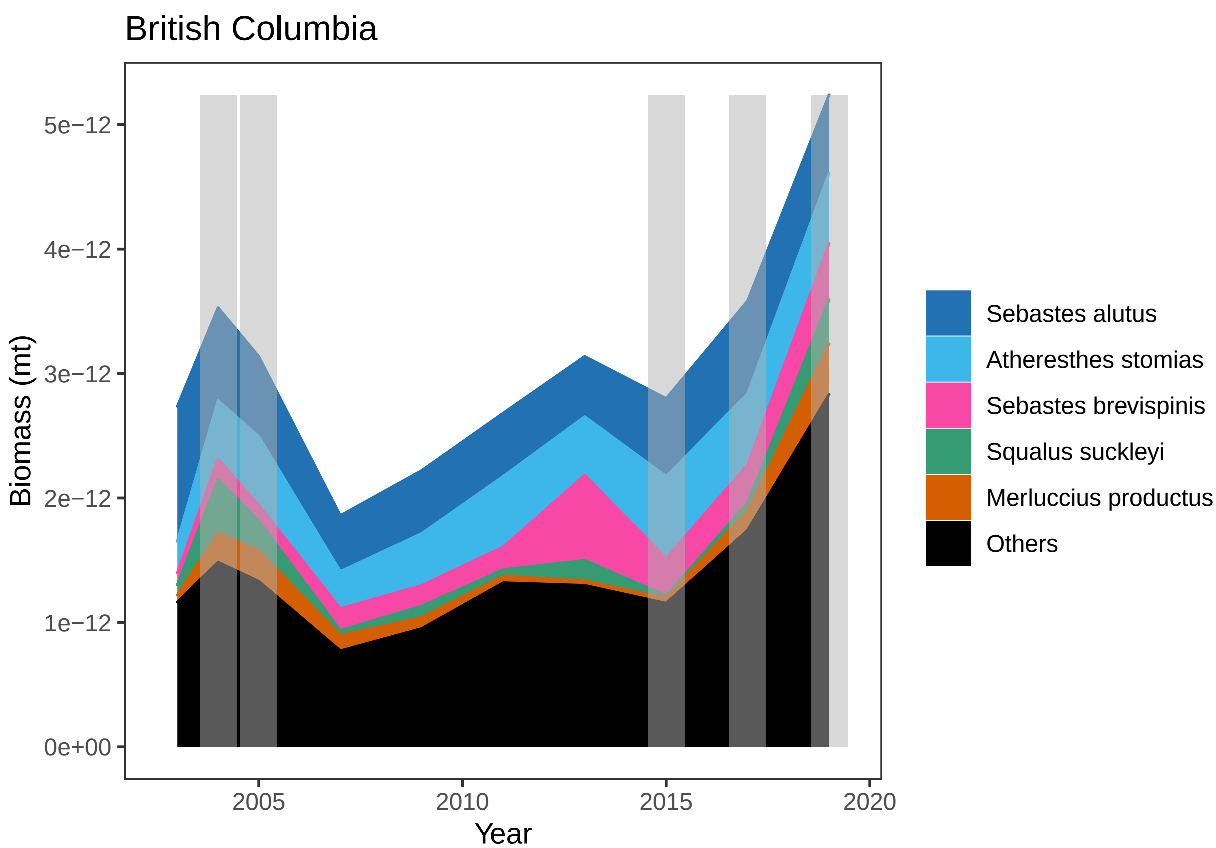

Figure 16: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

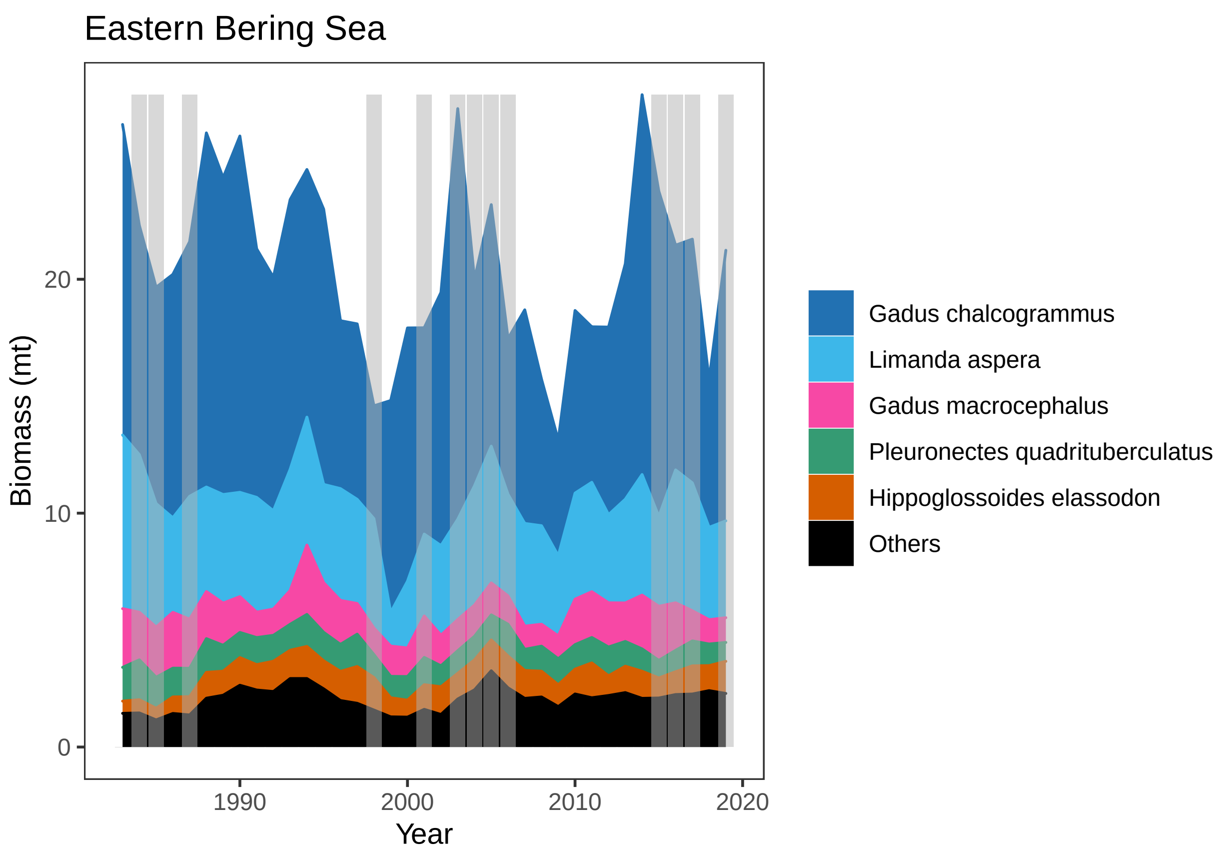

Figure 17: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

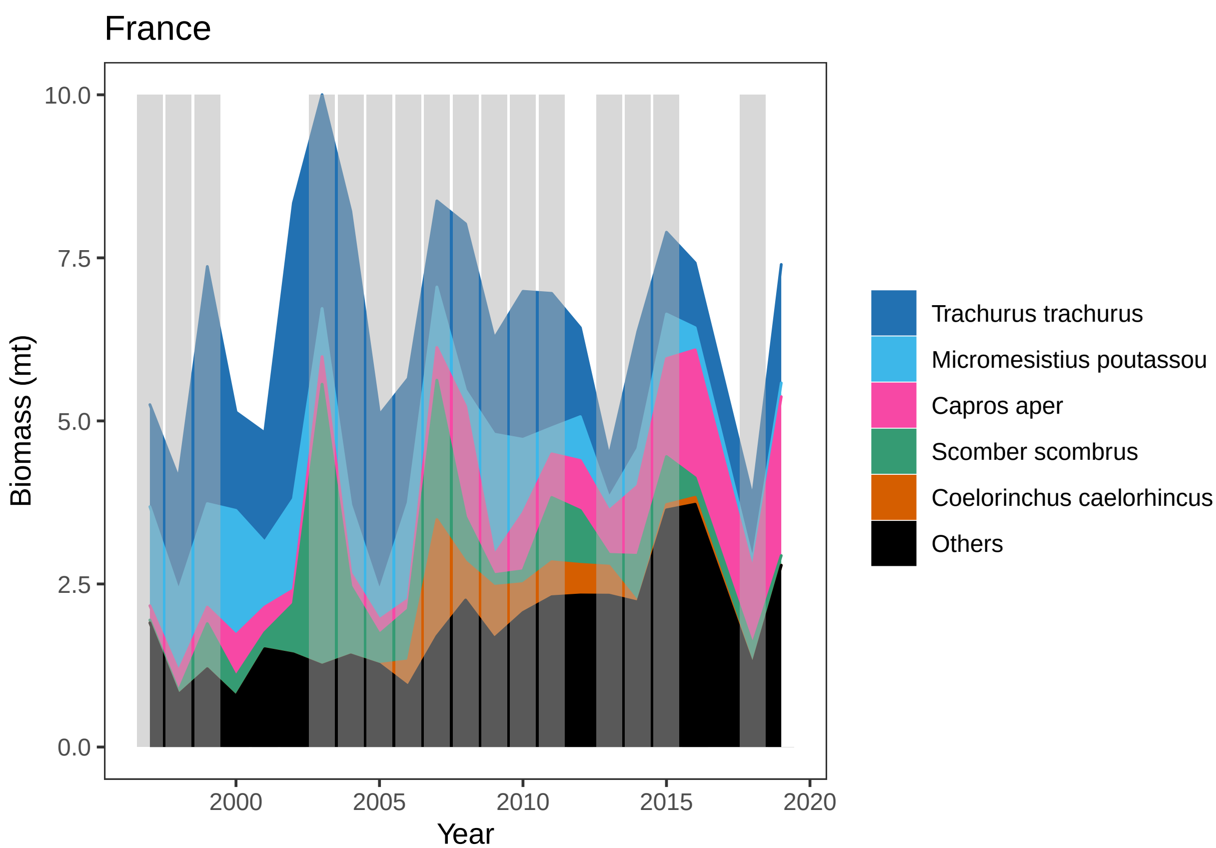

Figure 18: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

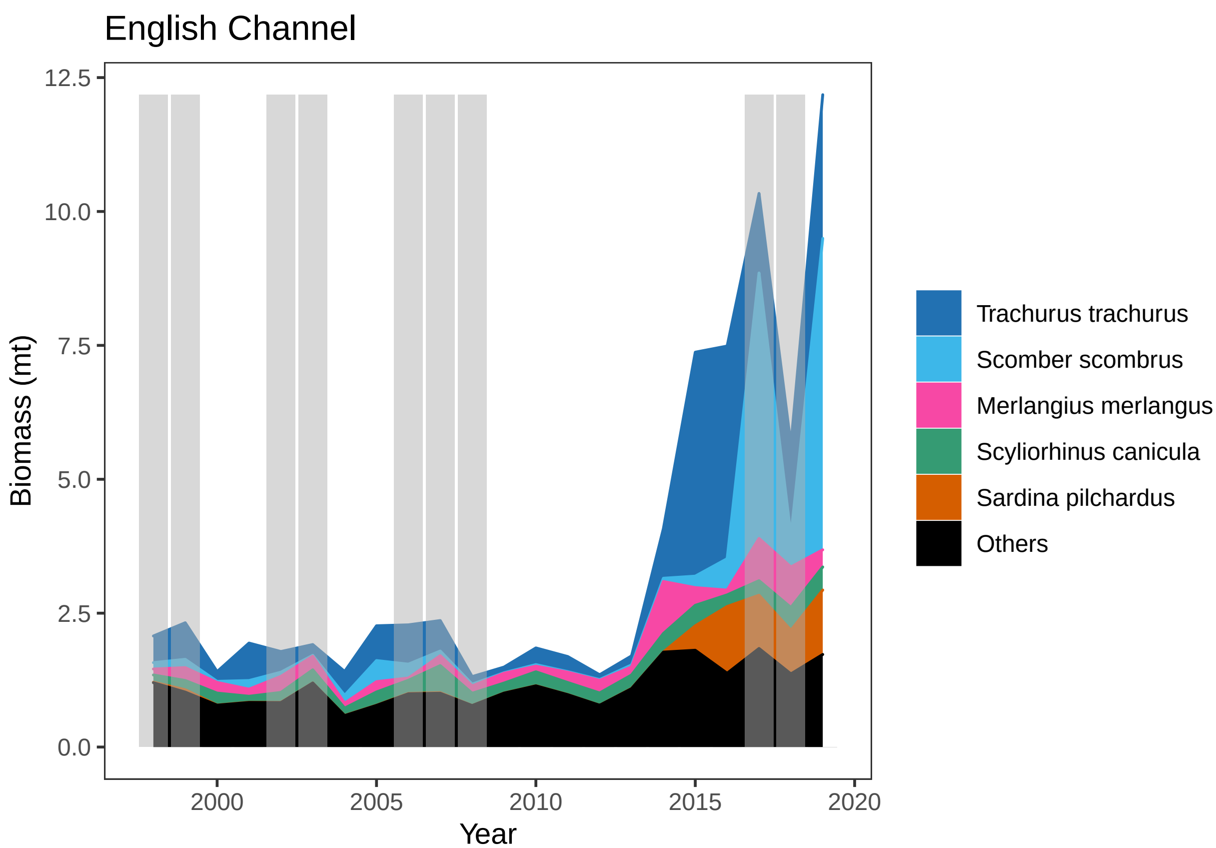

Figure 19: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

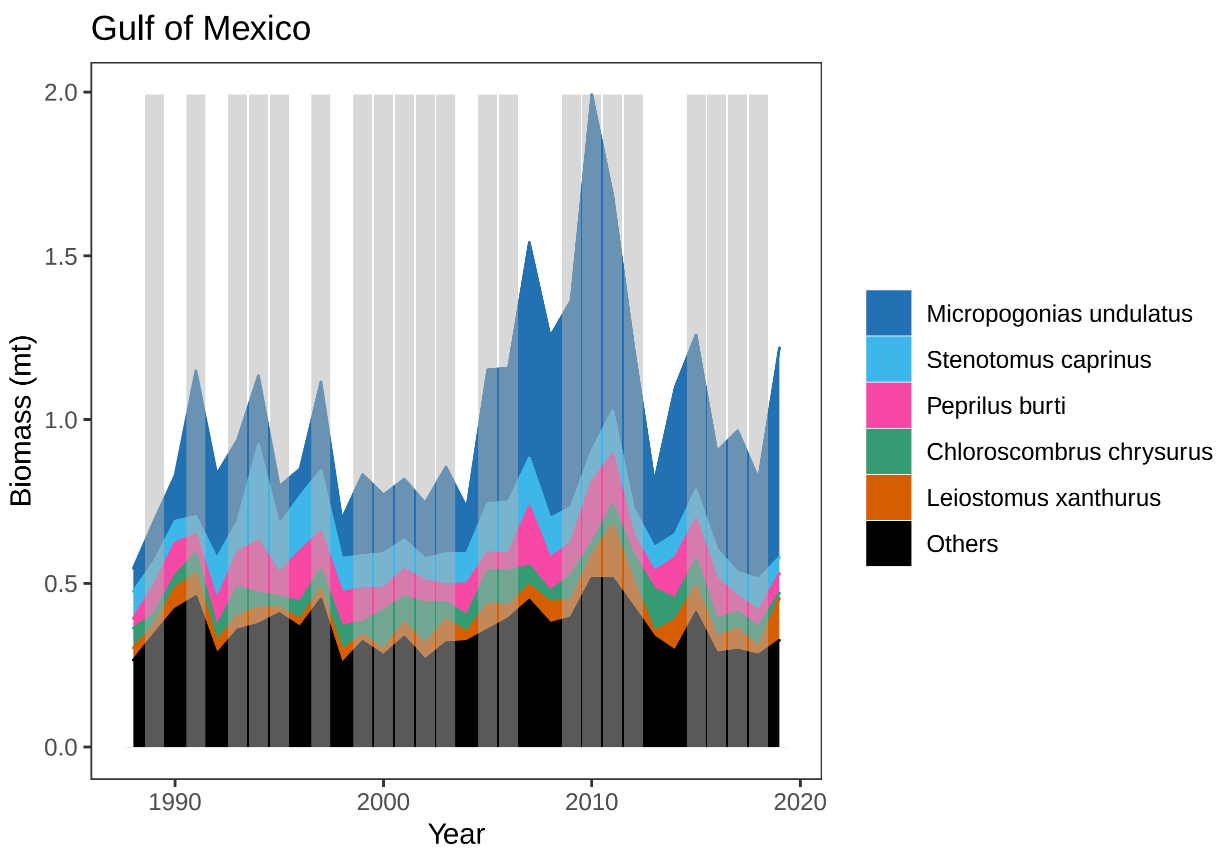

Figure 20: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

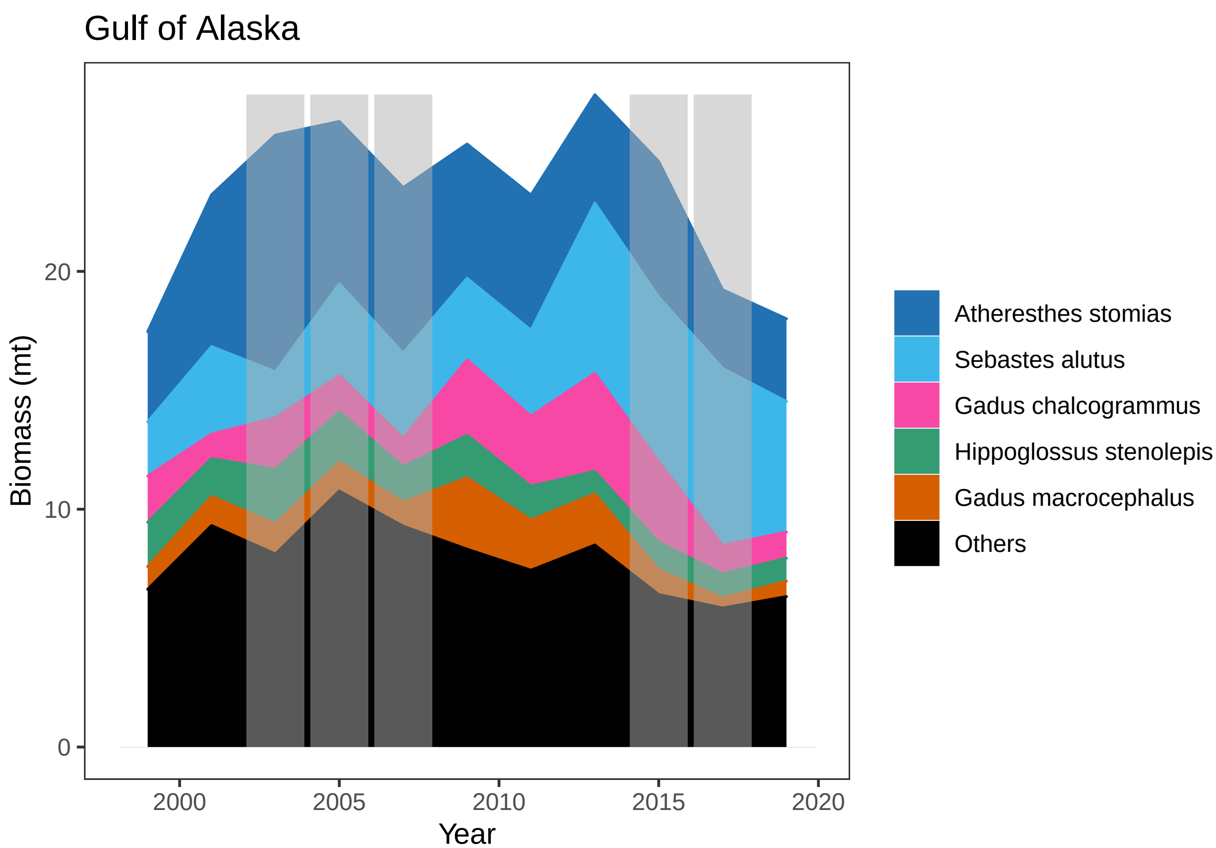

Figure 21: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

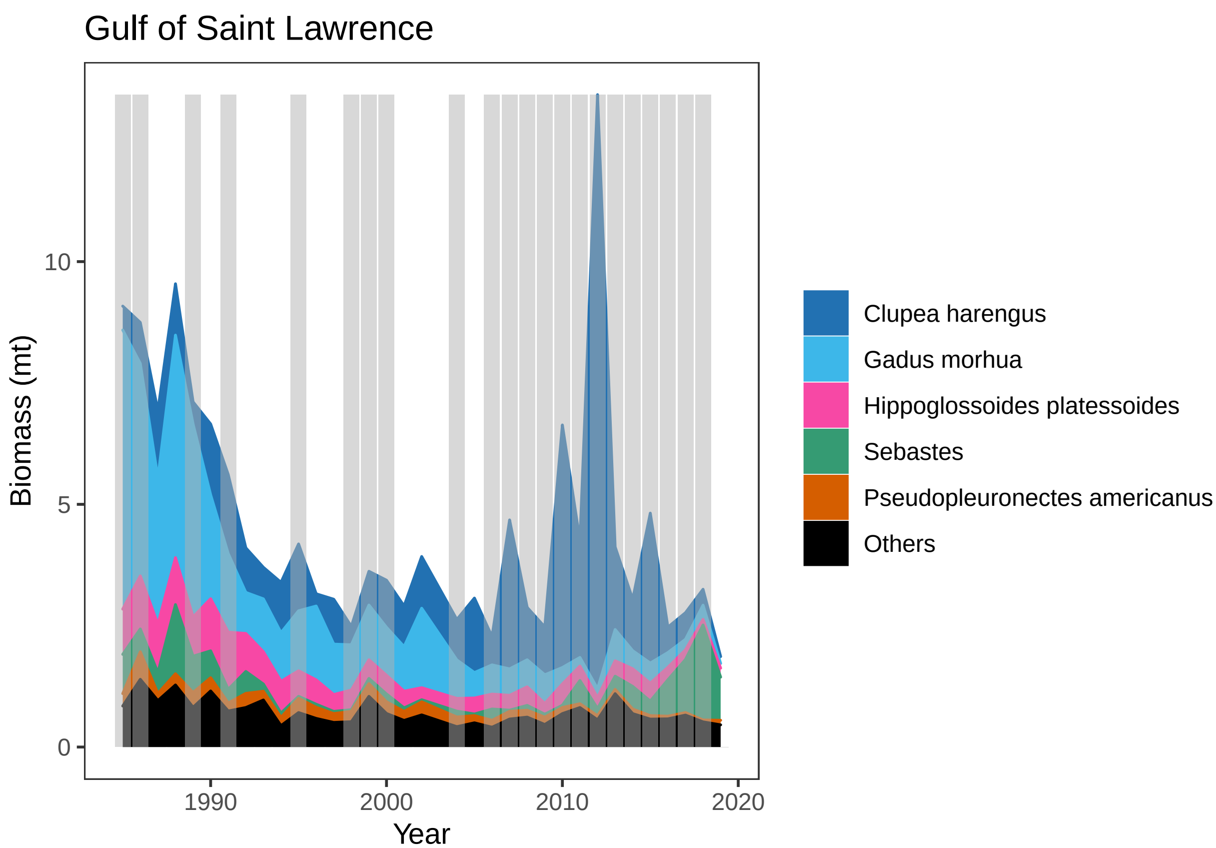

Figure 22: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

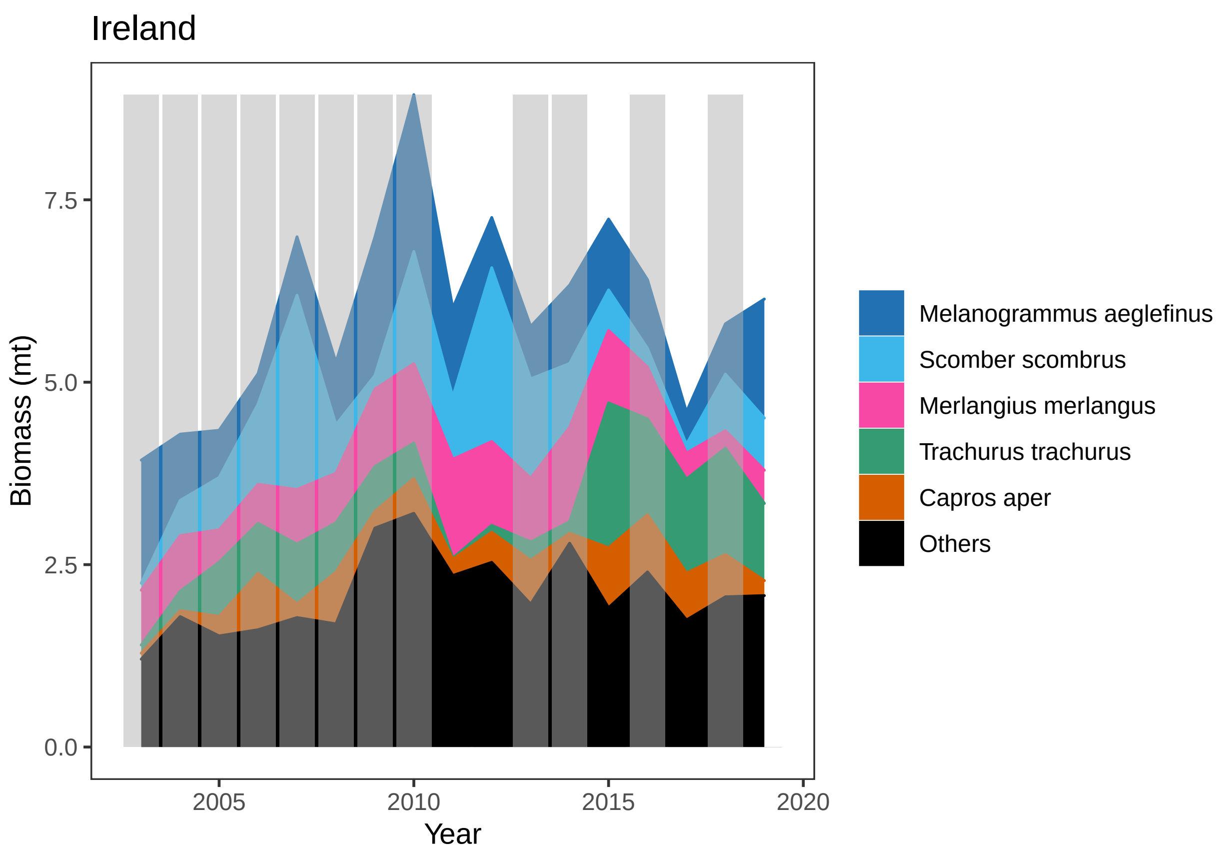

Figure 23: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

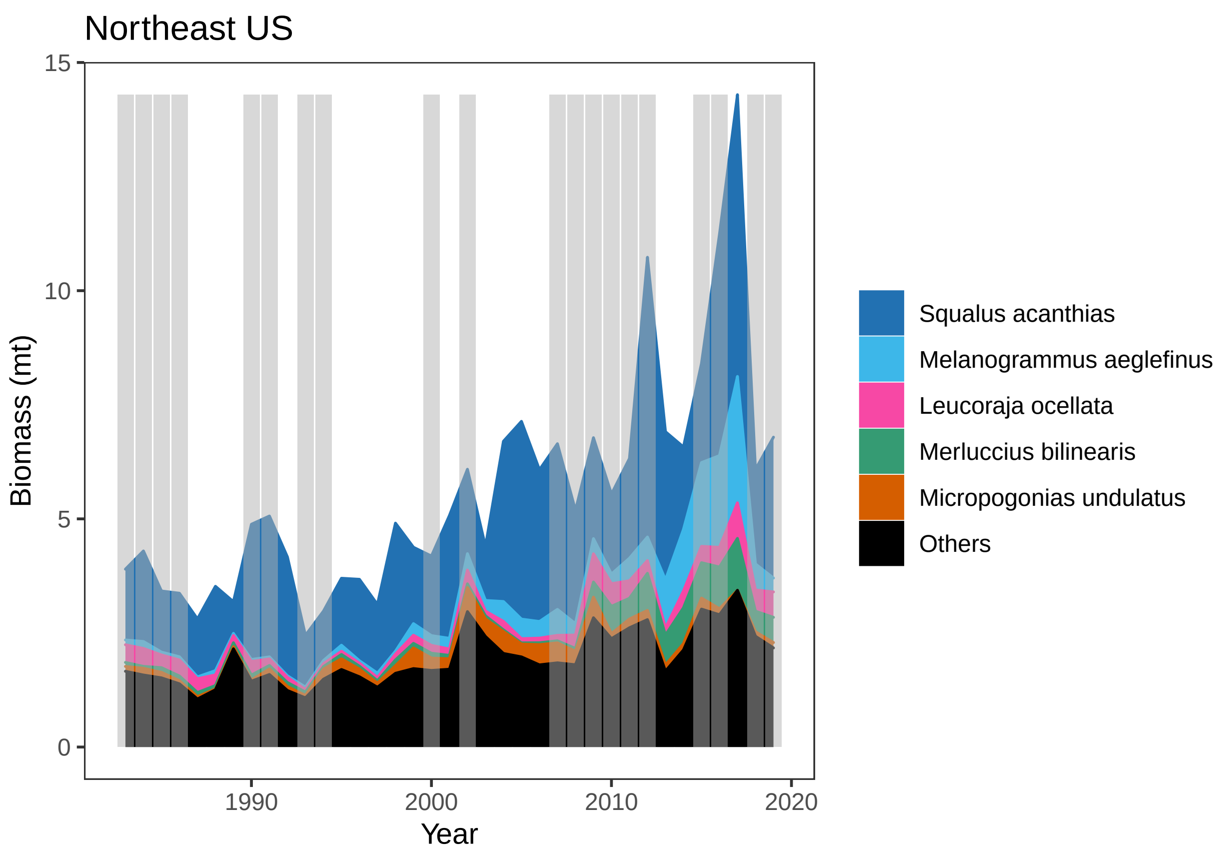

Figure 24: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

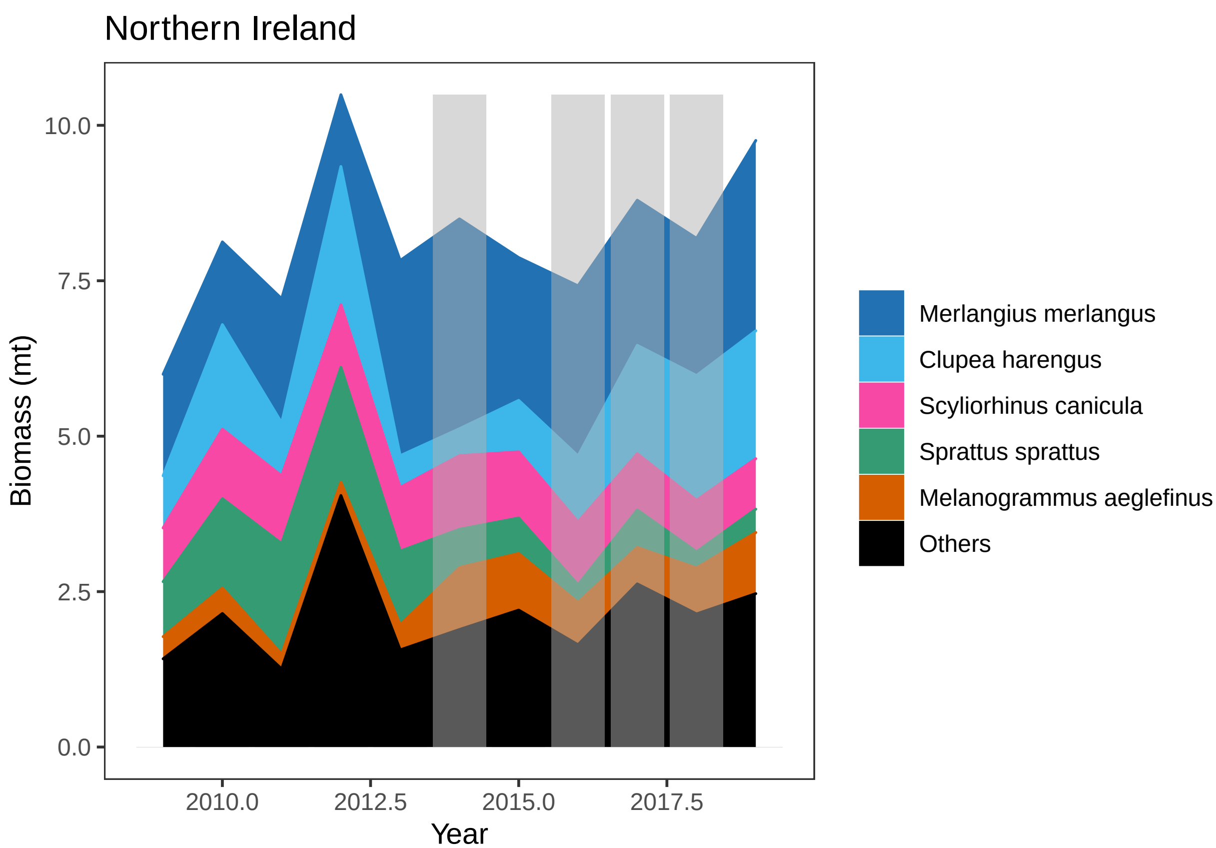

Figure 25: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

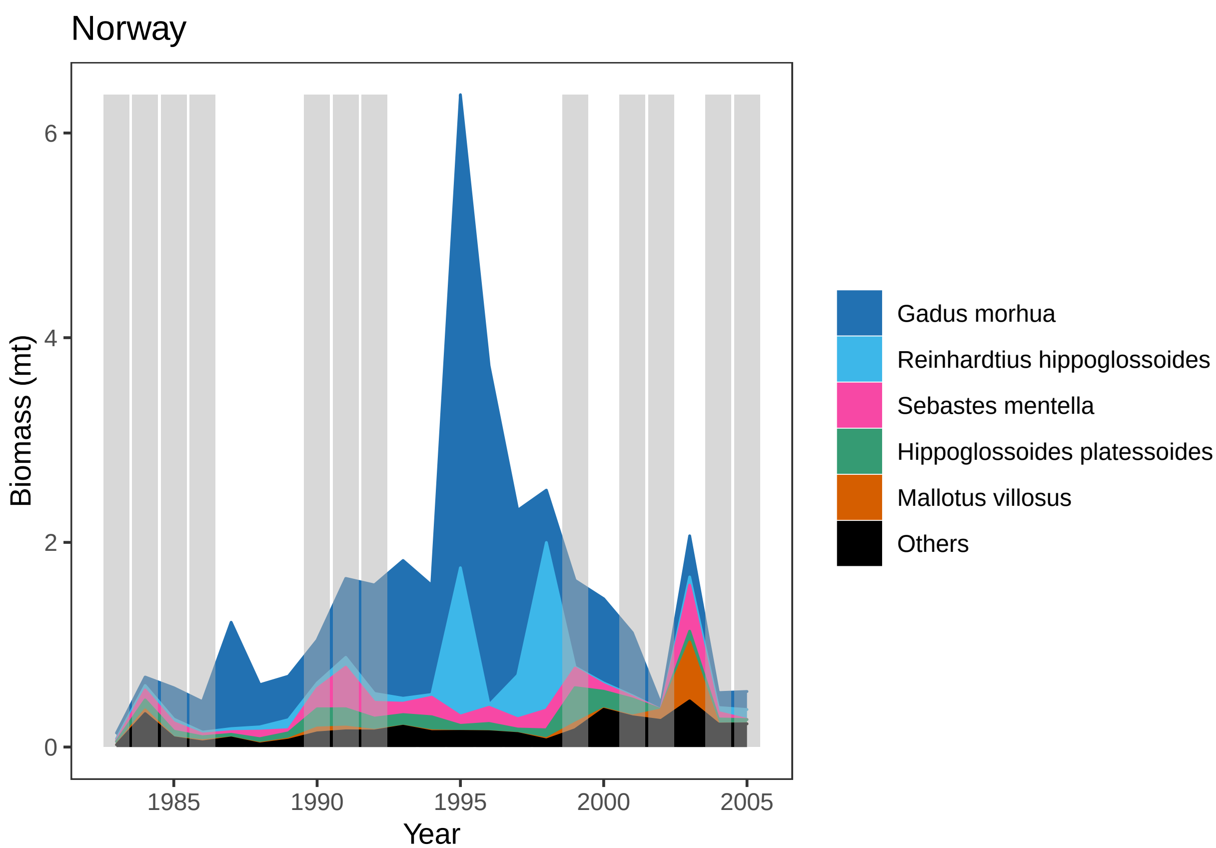

Figure 26: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

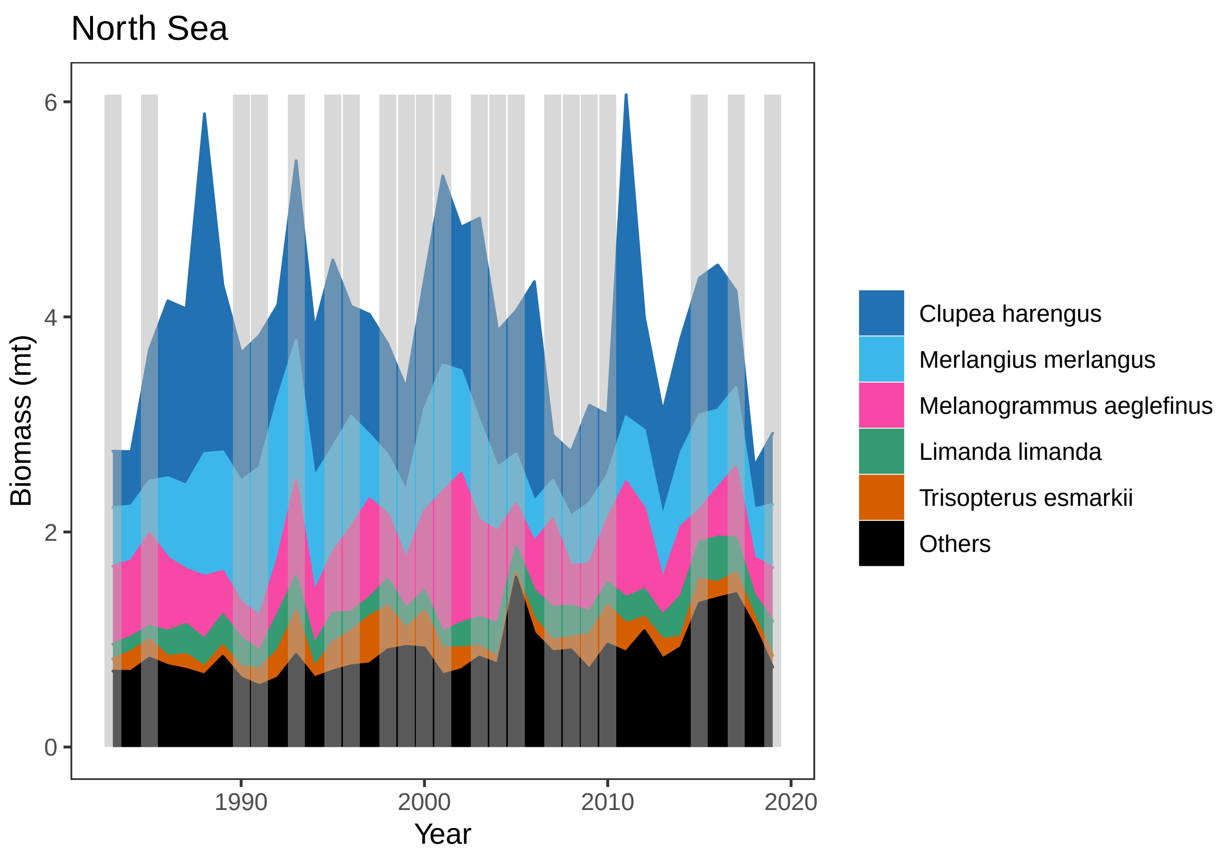

Figure 27: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

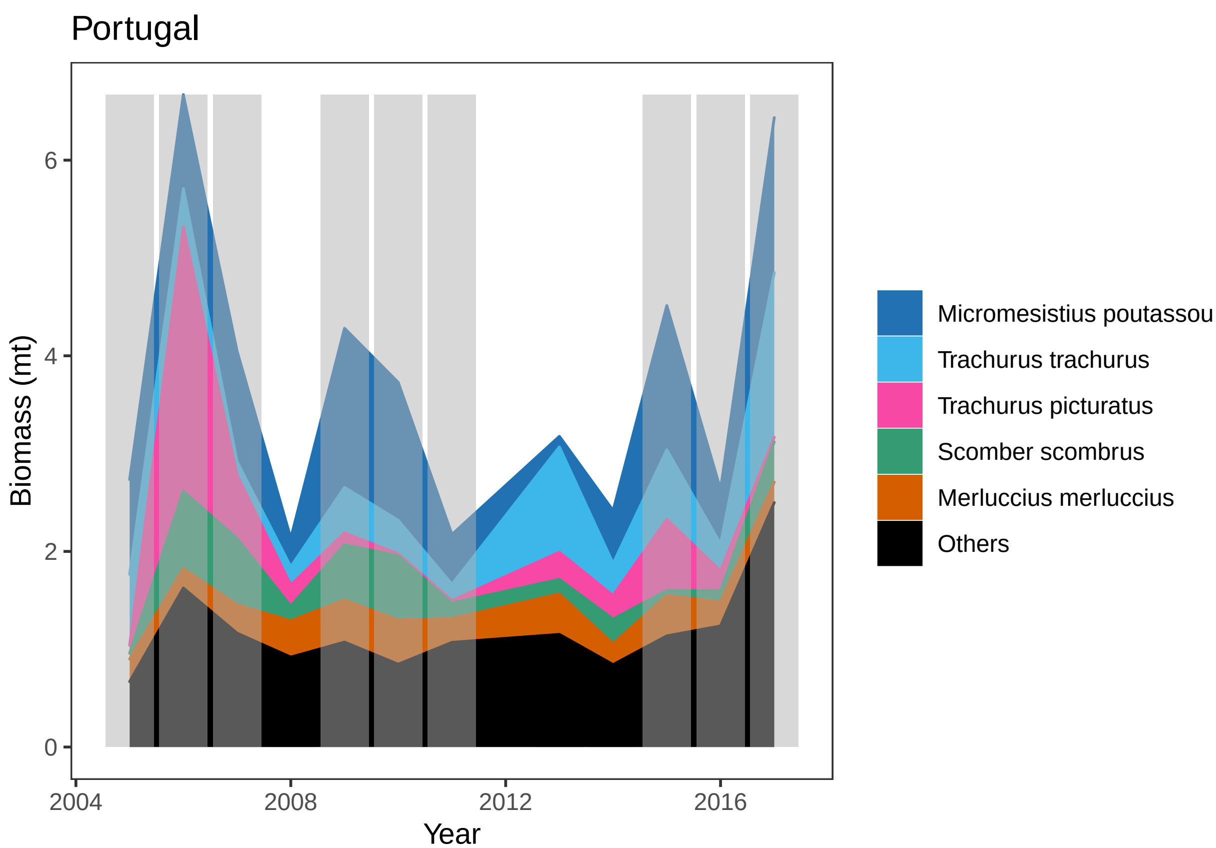

Figure 28: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

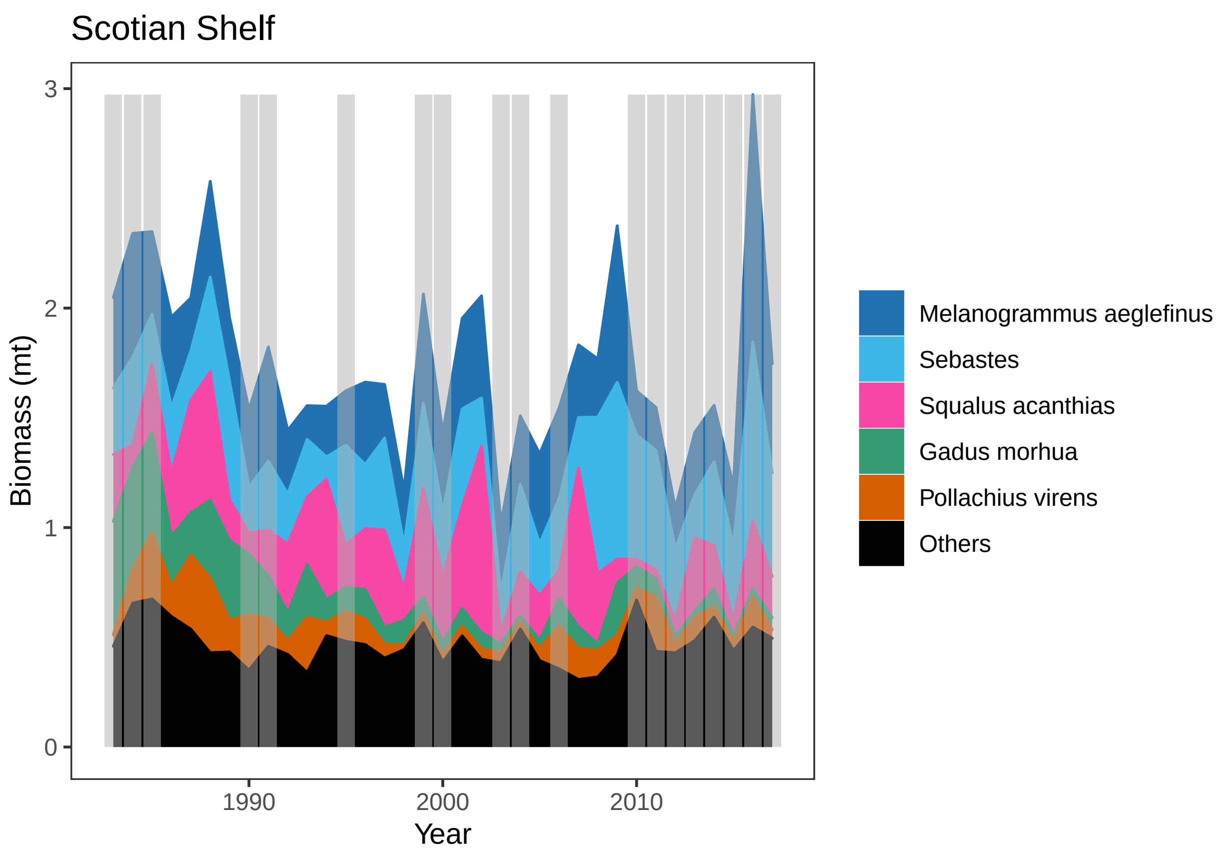

Figure 29: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

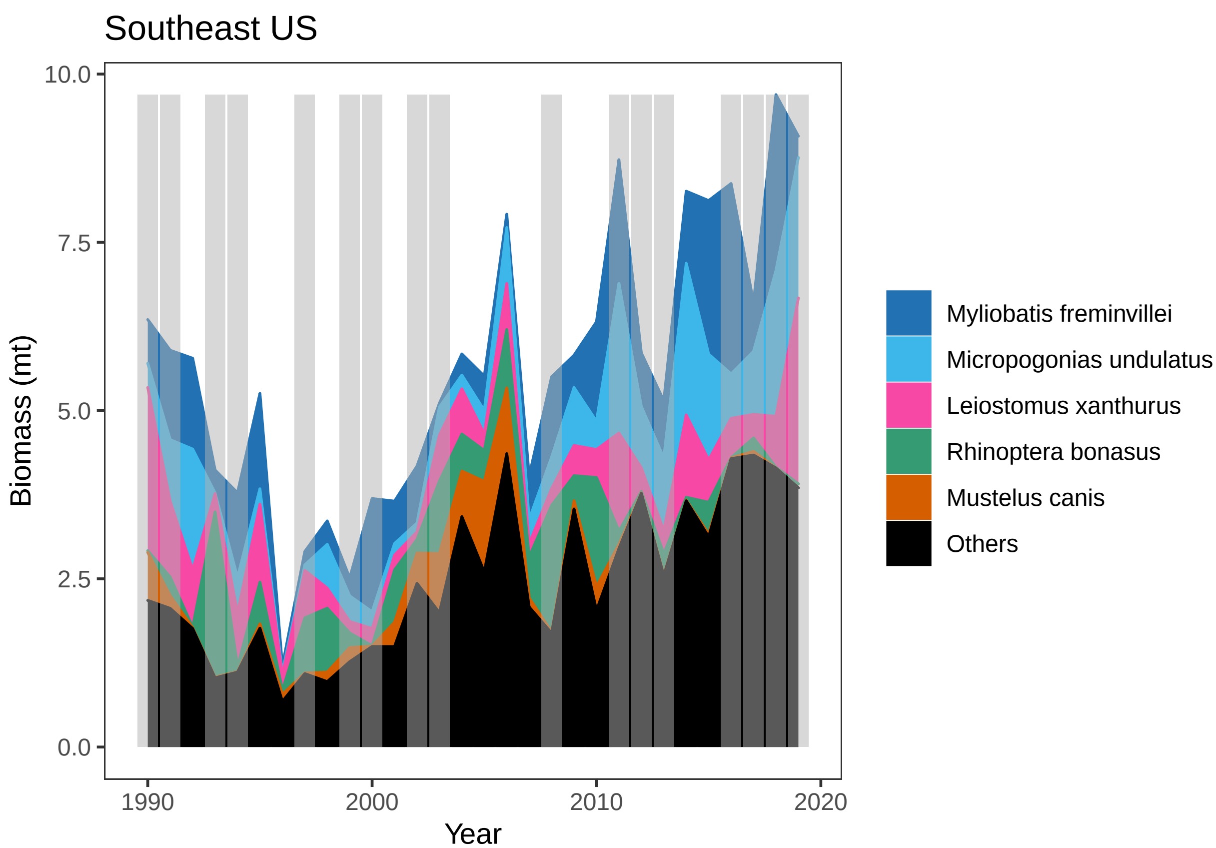

Figure 30: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

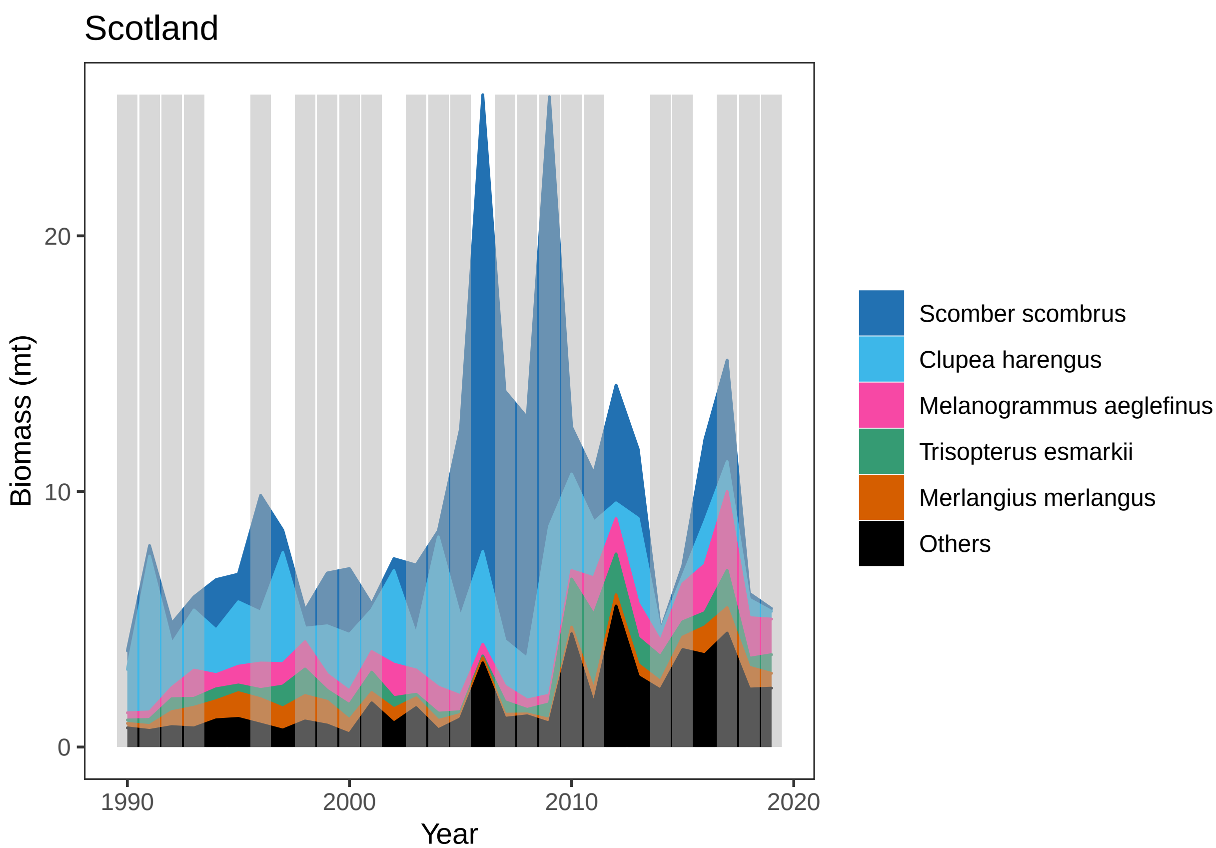

Figure 31: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

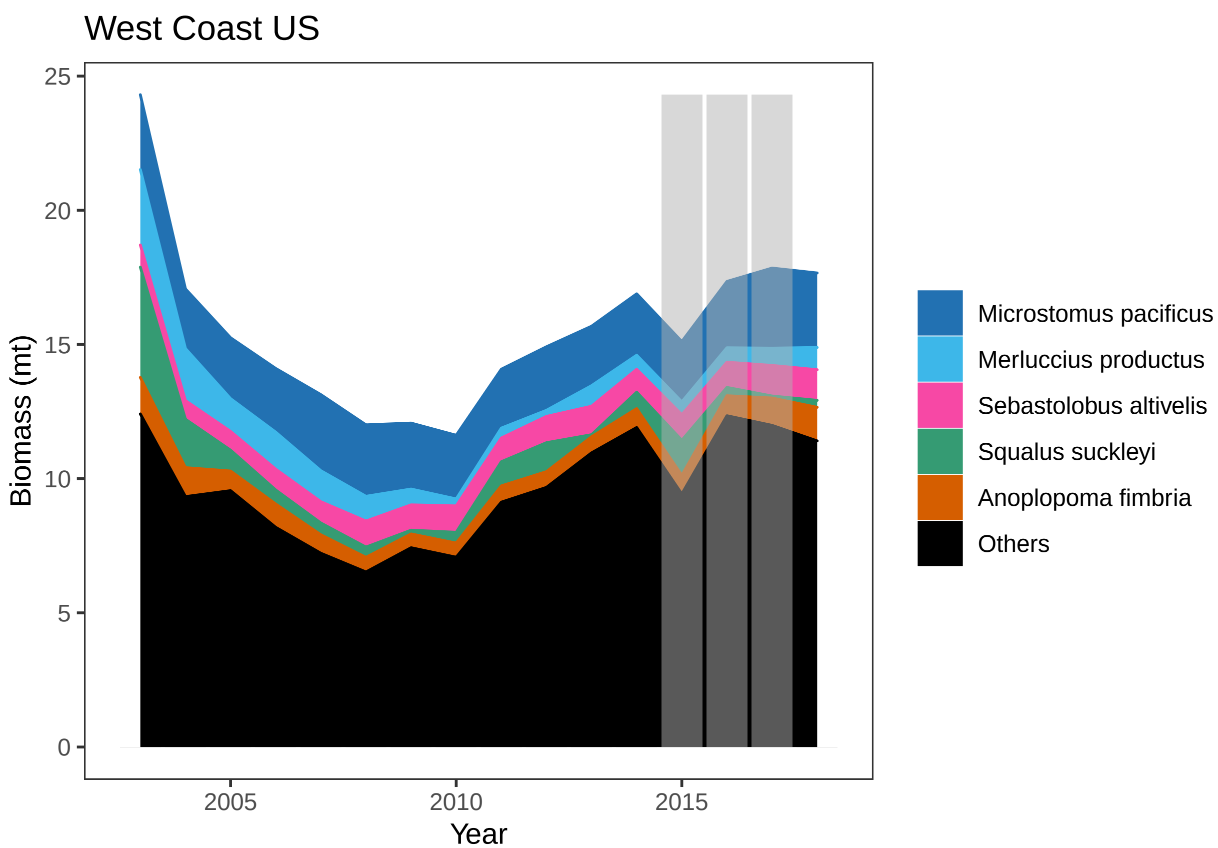

Figure 32: Biomass trends and historical MHWs by region. The top five taxa by biomass are highlighted. Shaded grey rectangles denote when any MHWs occurred in the preceding survey-year (e.g., 2015 in the Eastern Bering Sea time-series corresponds to the survey that began in June 2015, and MHW data from June 2014 - May 2015). British Columbia and the Gulf of Alaska are biennial surveys; all others are annual.

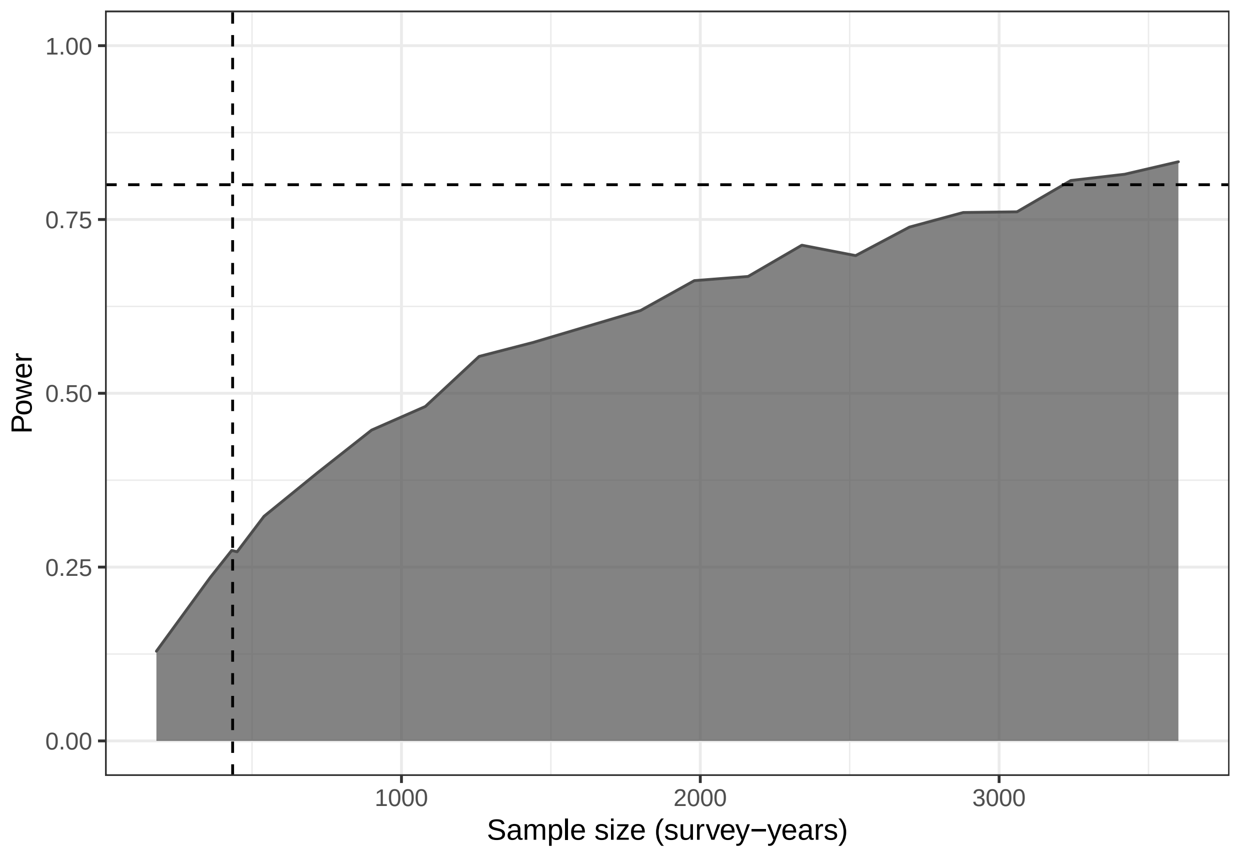

Figure 33: Results from a power analysis applying our methods to a simulated dataset in which MHWs reduce biomass by 6% and study duration is varied (described earlier in this Supplement). The sample sizes plotted are total survey-years across all regions. Dashed vertical line shows the sample size of our actual dataset. Dashed horizontal line denotes one conventionally accepted threshold for power (0.8).

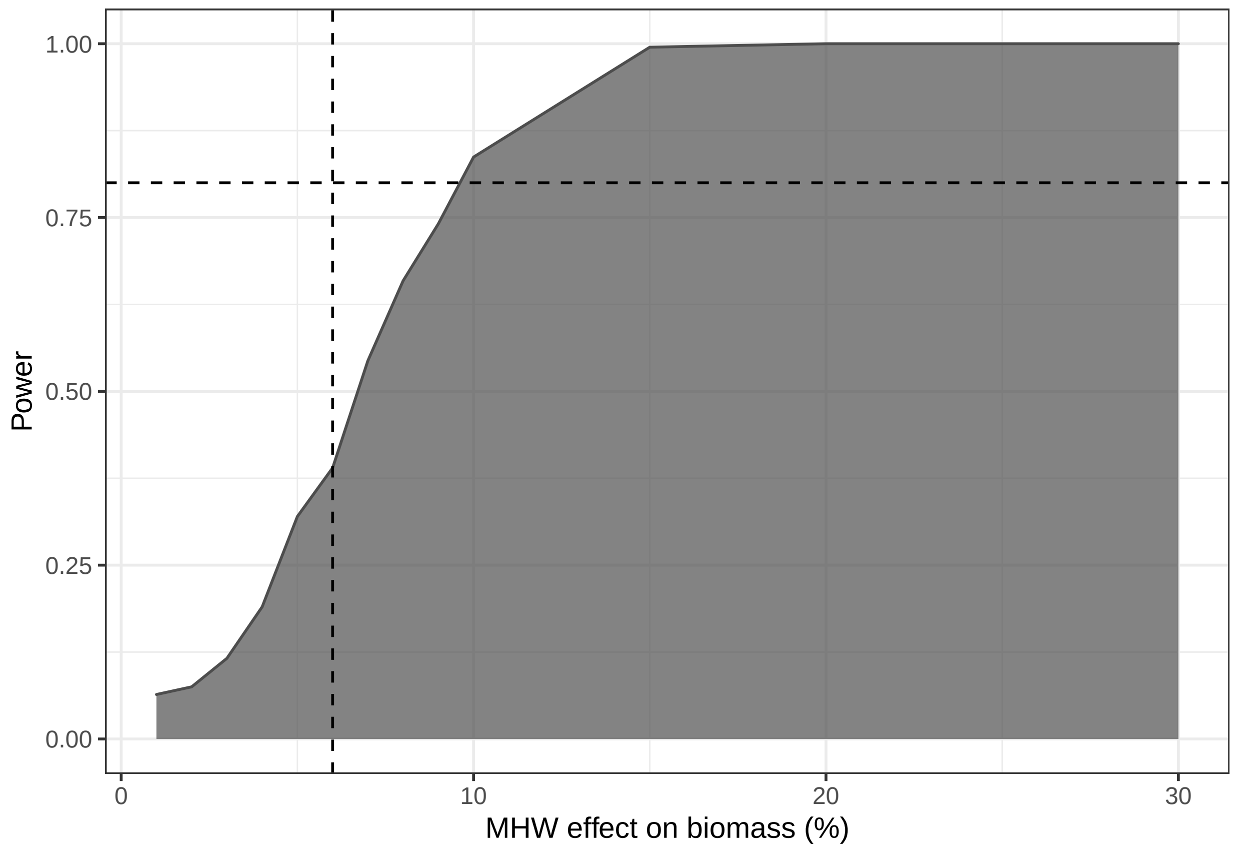

Figure 34: Results from a power analysis applying our methods to a simulated dataset that varied the MHW effect on biomass over the true number of survey-years for each region in our dataset (described earlier in this Supplement). The sample sizes plotted are total survey-years across all regions. Dashed vertical line shows the biomass decline simulated by Cheung *et al.* 2021. Dashed horizontal line denotes one conventionally accepted threshold for power (0.8).

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