Exploring MHW effects on fish abundance in trawl surveys

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Exploring marine heatwaves

North America

Characterizing MHWs in North America

How frequent and severe have heatwaves been in North America since 1982 (the start of the MHW data)?
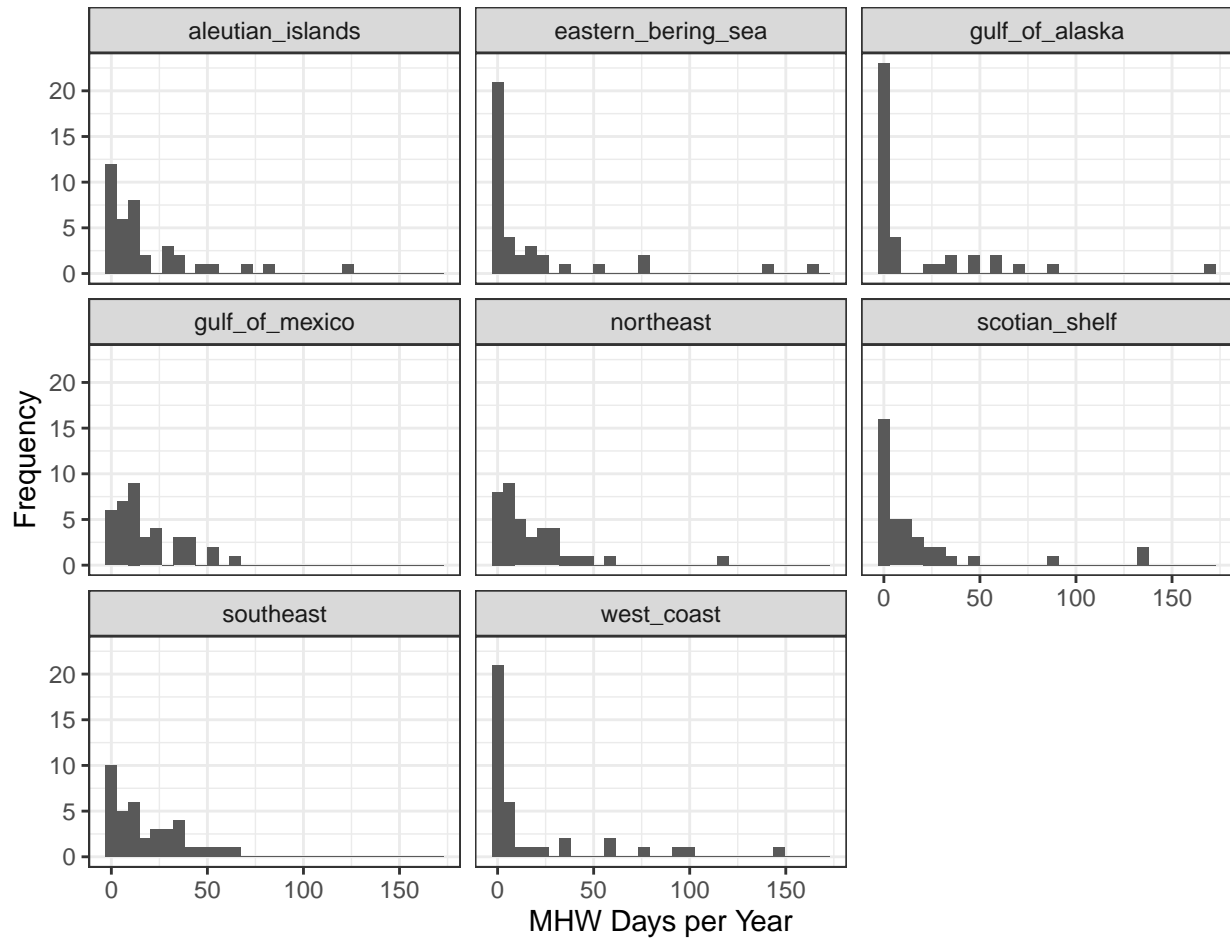

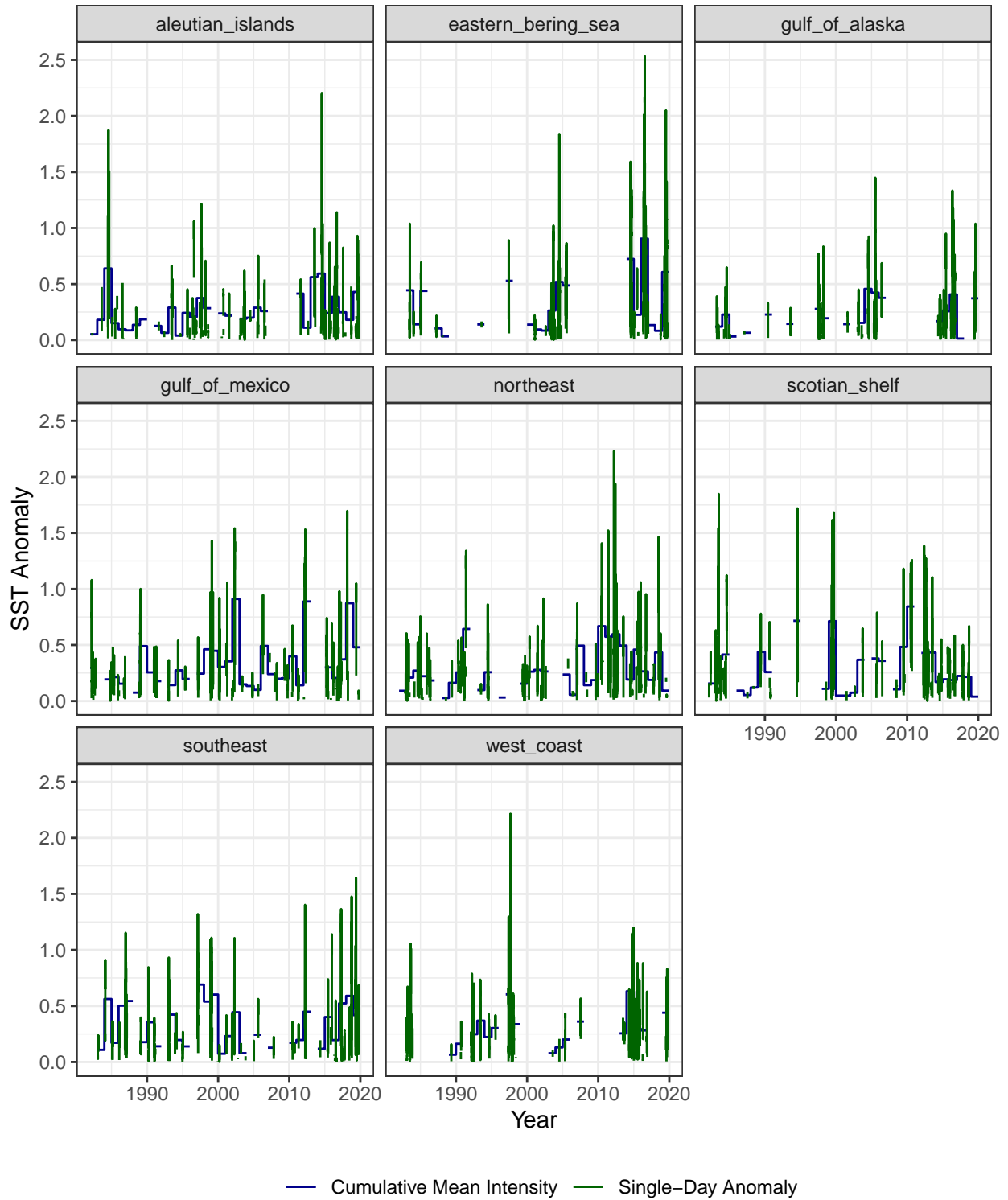Figure 1: Frequency of MHW Events in North America

Figure 2: Anomaly of MHW Events in North America

MHWs vs. CPUE

Let's look at annual cumulative mean intensity (sum of SST anomalies in the calendar year / number of MHW-days in the calendar year) vs. trends in aggregate abundance (total CPUE across all species) for the

whole region. The two metrics of CPUE change used are proportion change CPUE vs. last year ((cpueThisYear - cpueLastYear)/cpueLastYear), and proportion change CPUE relative to the long-term mean ((cpueThisYear - cpueSeriesMean)/cpueSeriesMean).
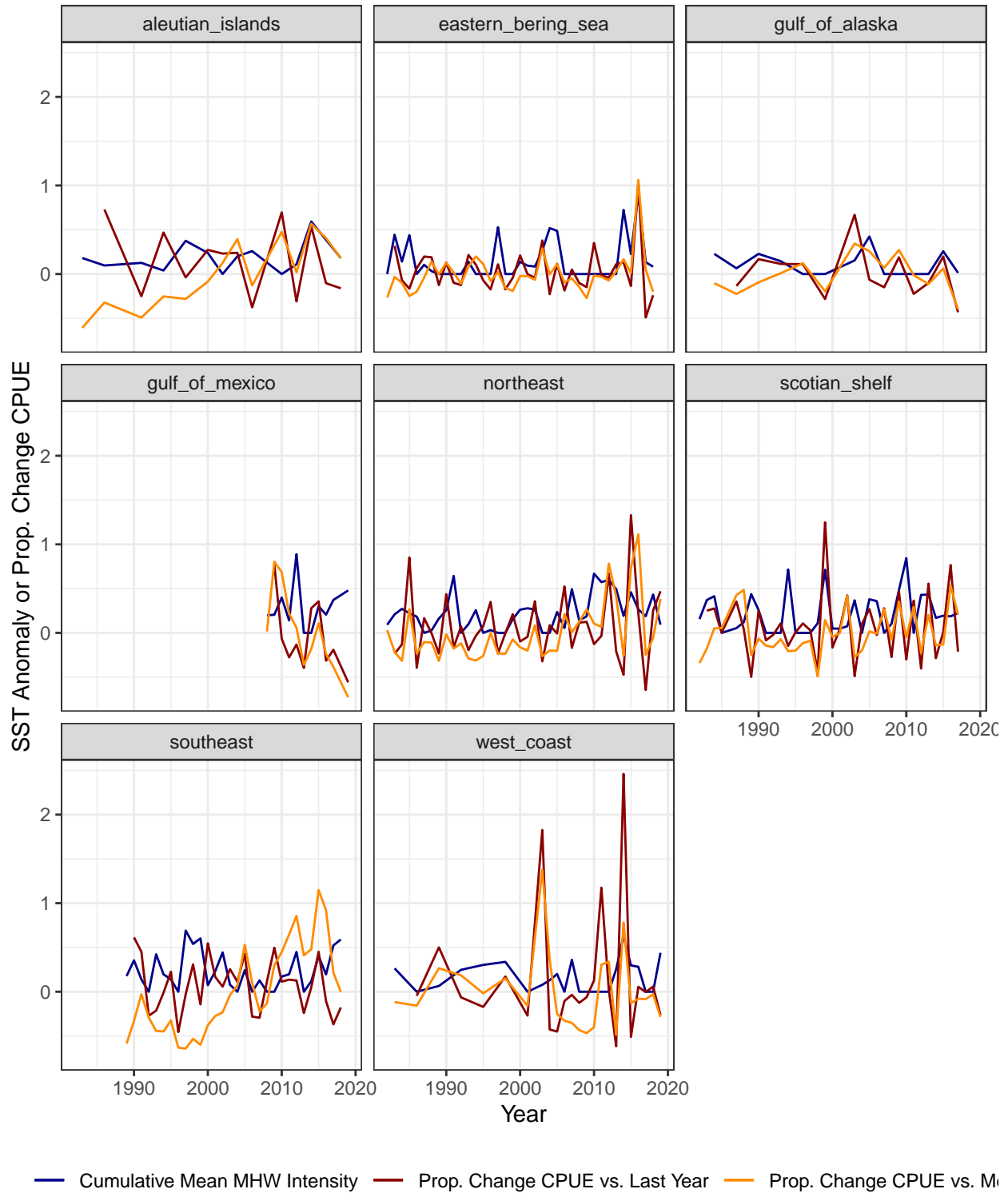

Figure 3: MHW Cumulative Mean Intensity and Change in Total CPUE Over Time

Rather than comparing both MHW intensity and CPUE trends over time, we can just plot cumulative mean intensity against the CPUE trend in that year:
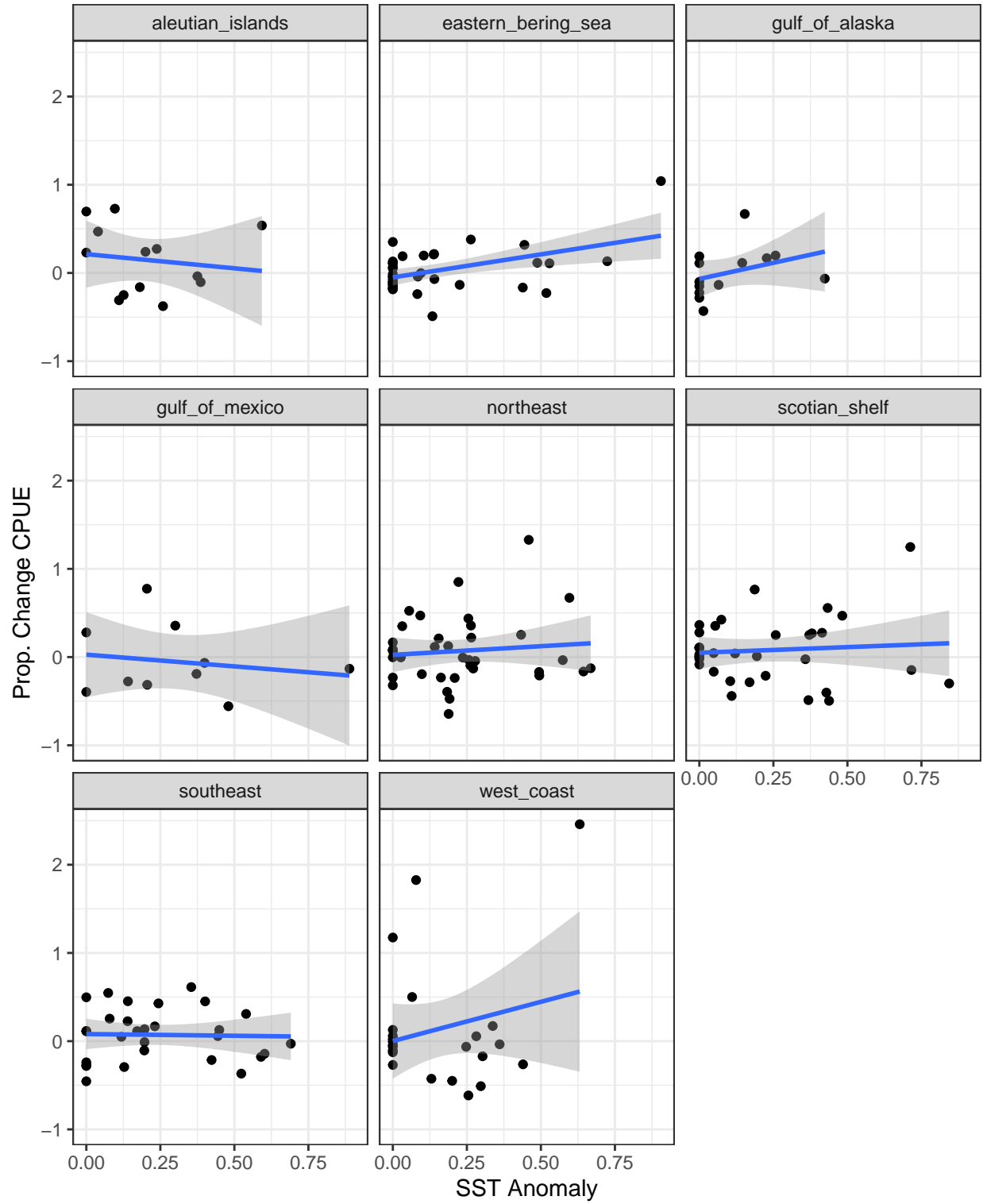

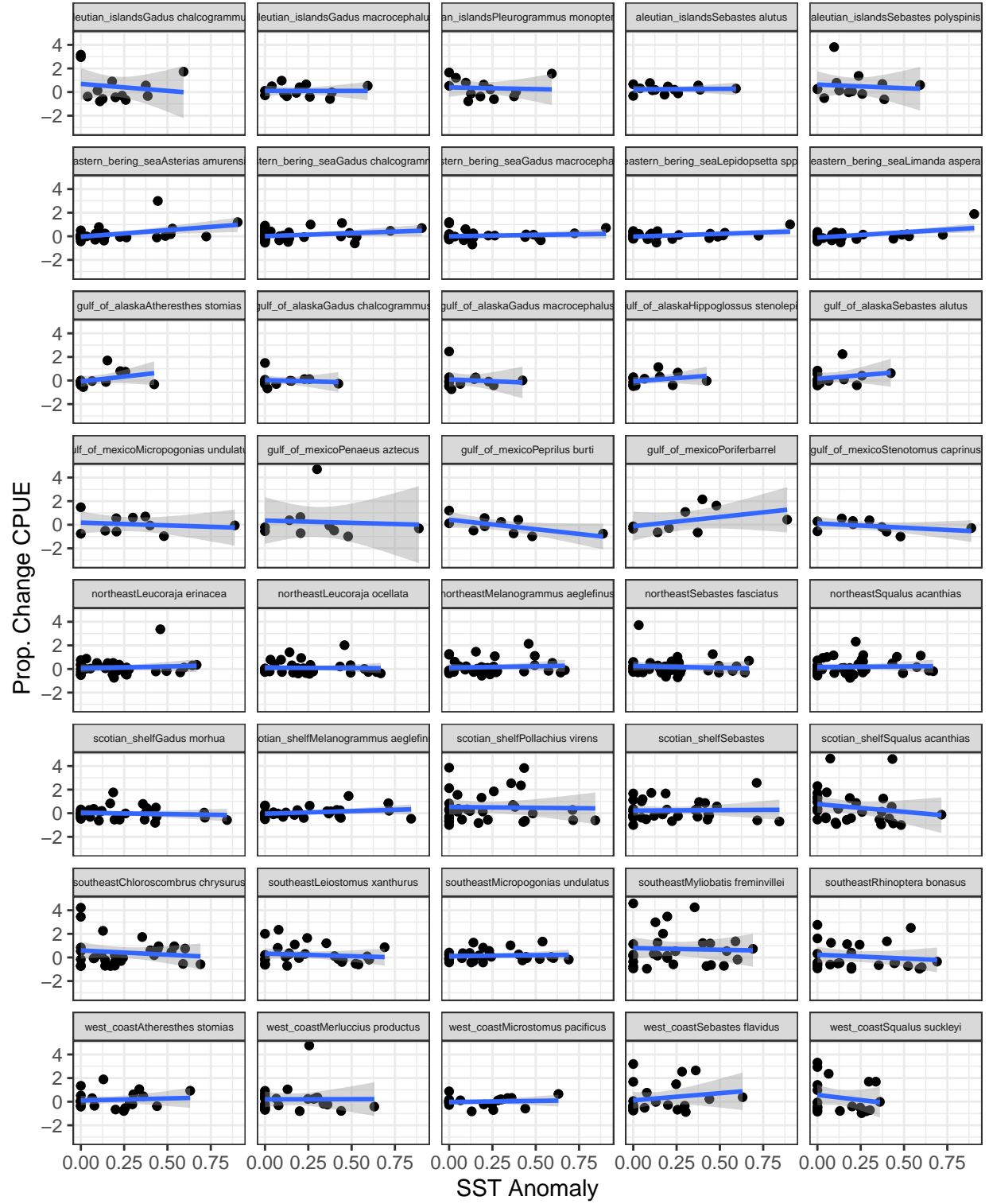Figure 4: MHW Cumulative Mean Intensity vs. Change in Total CPUE

Figure 5: MHW Cumulative Mean Intensity vs. Single-Species Change in Total CPUE

Evaluating a yearly MHW index

At Thomas's suggestion, let's try using a yearly definition of MHWs rather than a daily one, to match the time scale of the trawl data. In the histograms below I've imputed zeros for NA values (no MHW) just to see the data distribution.

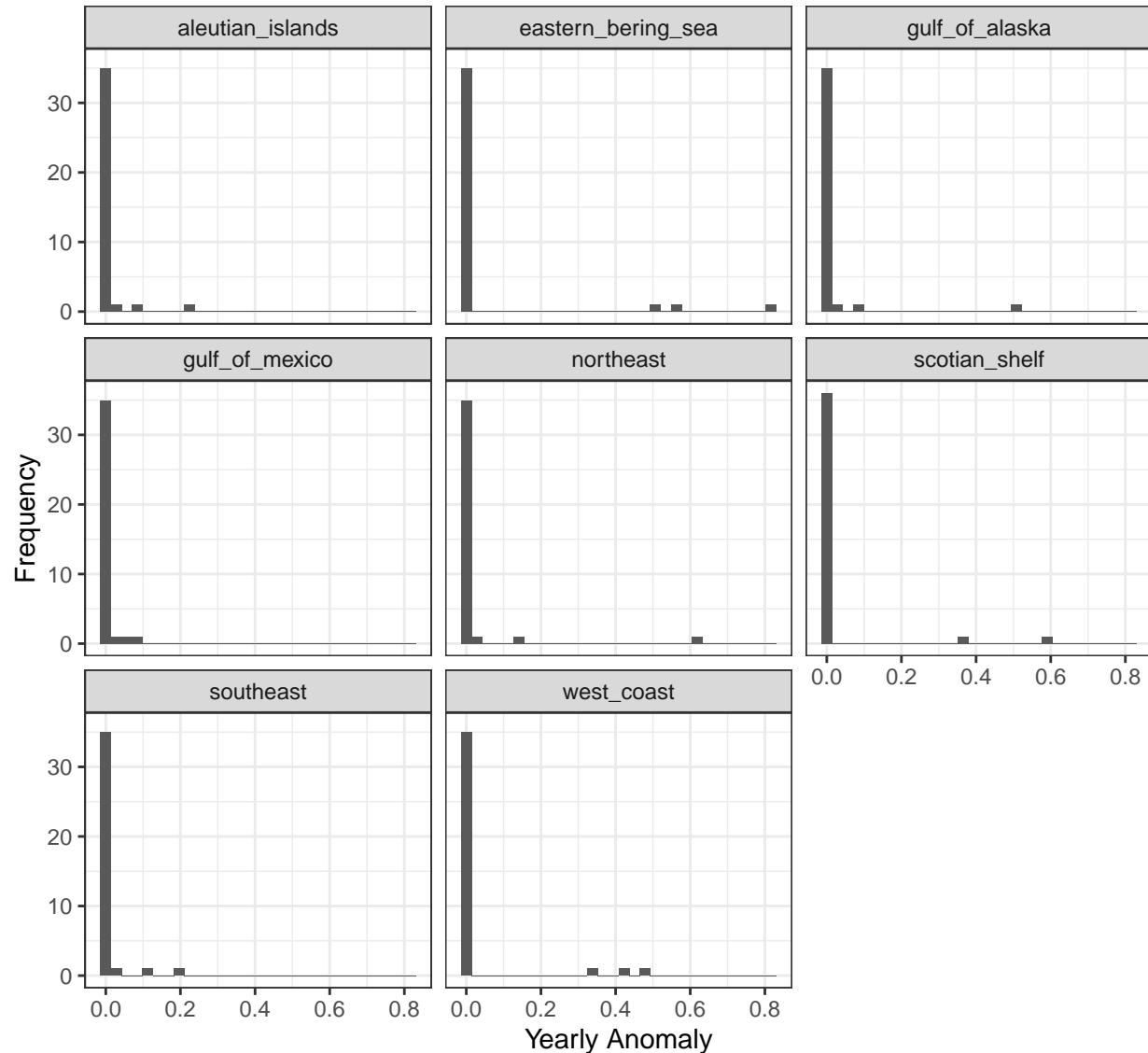Figure 6: Distributions of Yearly MHW Estimates Across Regions

This approach calculated exactly 3 MHW-years per region, I think because we took the 90th percentile of the same number of years:

```
## # A tibble: 18 x 2
##    region            mhw_years
##    <chr>                 <int>
##  1 aleutian_islands          3
##  2 bits                      3
##  3 eastern_bering_sea        3
##  4 evhoe                     3
```

```
##  5 fr_cgfs               3
##  6 gulf_of_alaska        3
##  7 gulf_of_mexico        3
##  8 ie_igfs               3
##  9 nigfs                 3
## 10 norbts                3
## 11 northeast             3
## 12 ns_ibts               3
## 13 pt_ibts               3
## 14 rockall               3
## 15 scotian_shelf         3
## 16 southeast             3
## 17 swc_ibts              3
## 18 west_coast            3
```

Let's see what happened to CPUE in those regions in those years; these are the same plots as above but now MHW years are indicated with an asterisk. In plots with fewer than three asterisks, there aren't trawl data available in the MHW year.
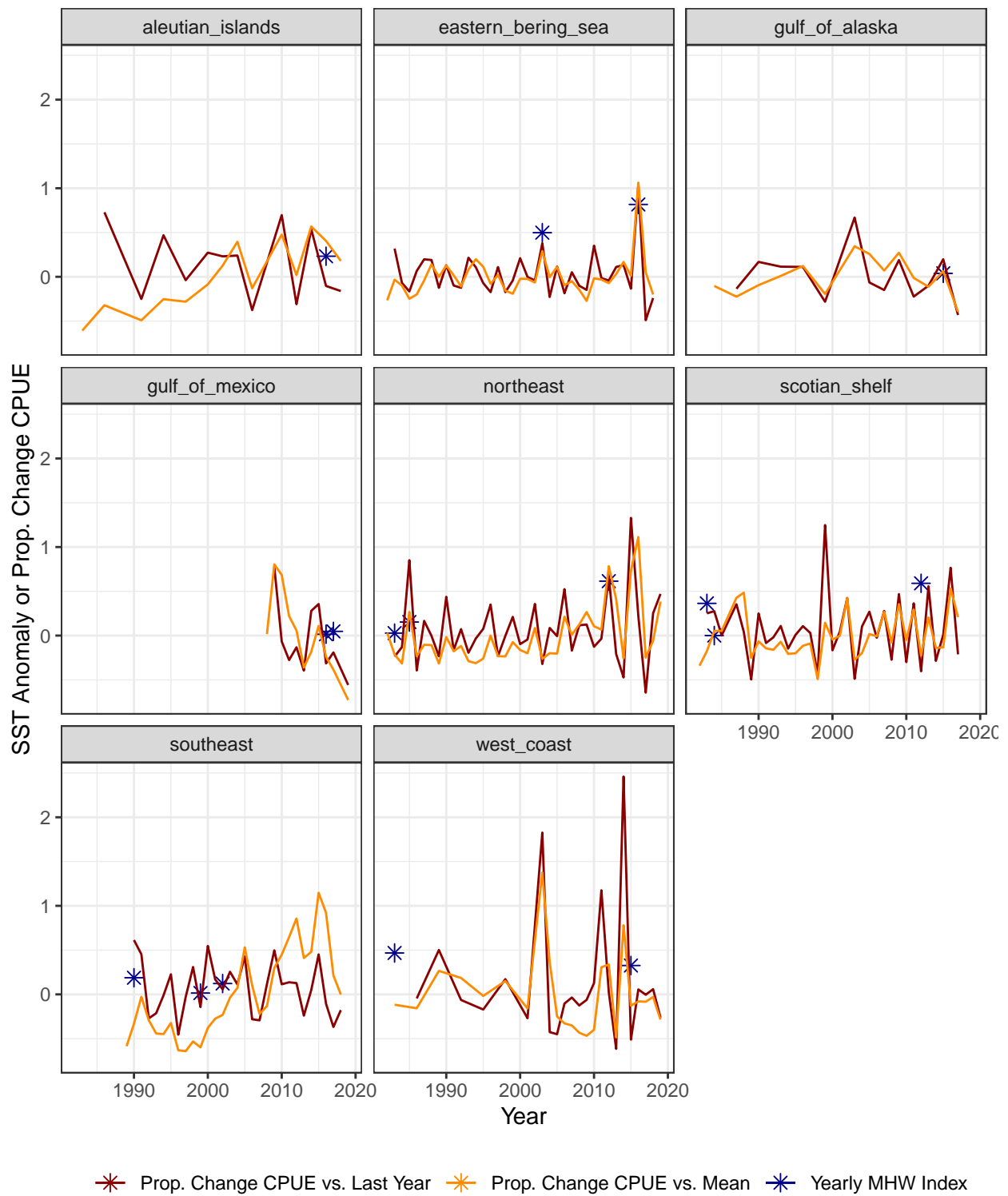
Figure 7: Yearly MHWs and Change in Total CPUE Over Time
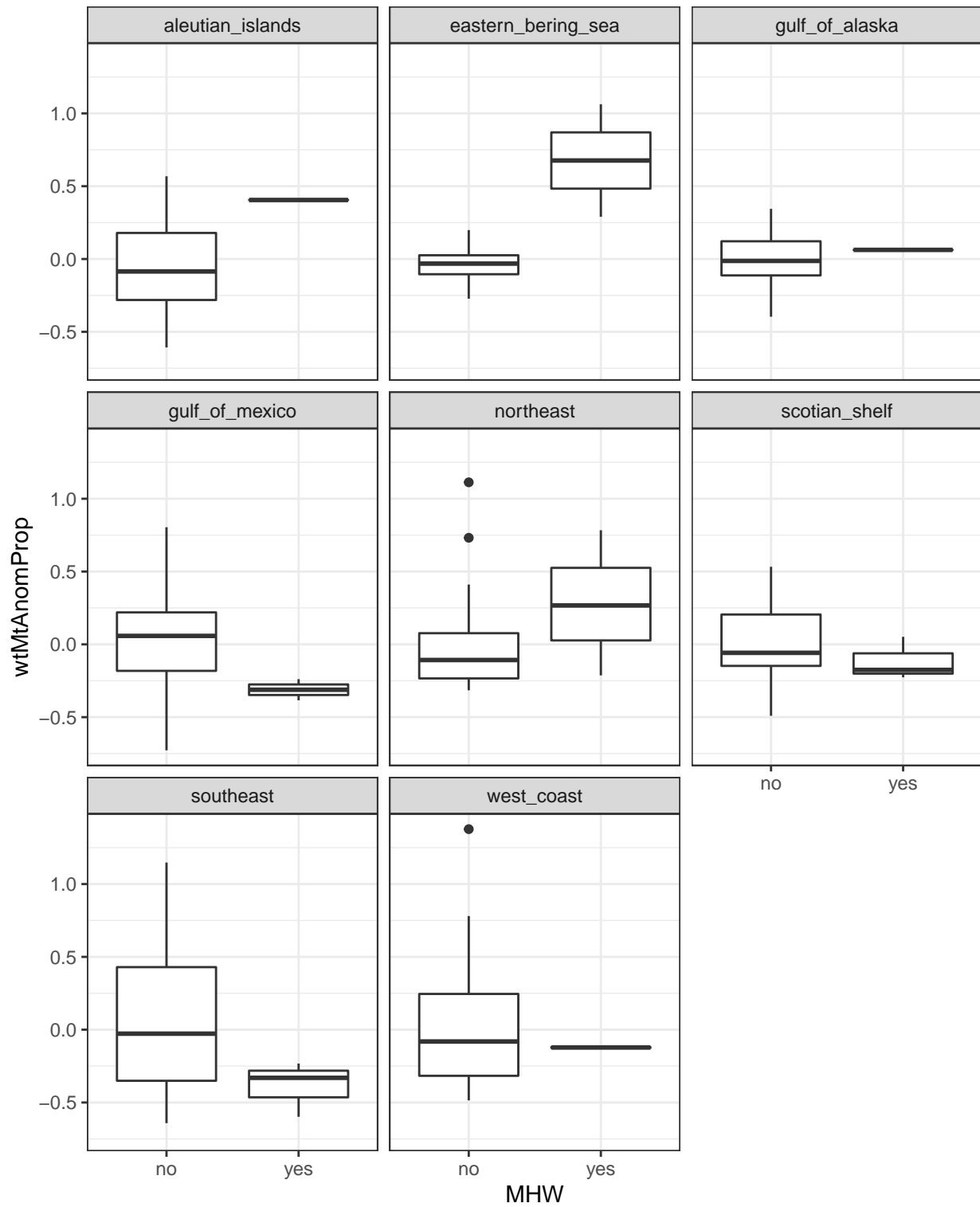
How does catch vary in MHW years vs. non-MHW years?

Figure 8: CPUE Proportional Anomaly in MHW vs. non-MHW years

Here are the same plots using proportional difference from the last year instead of CPUE anomaly.
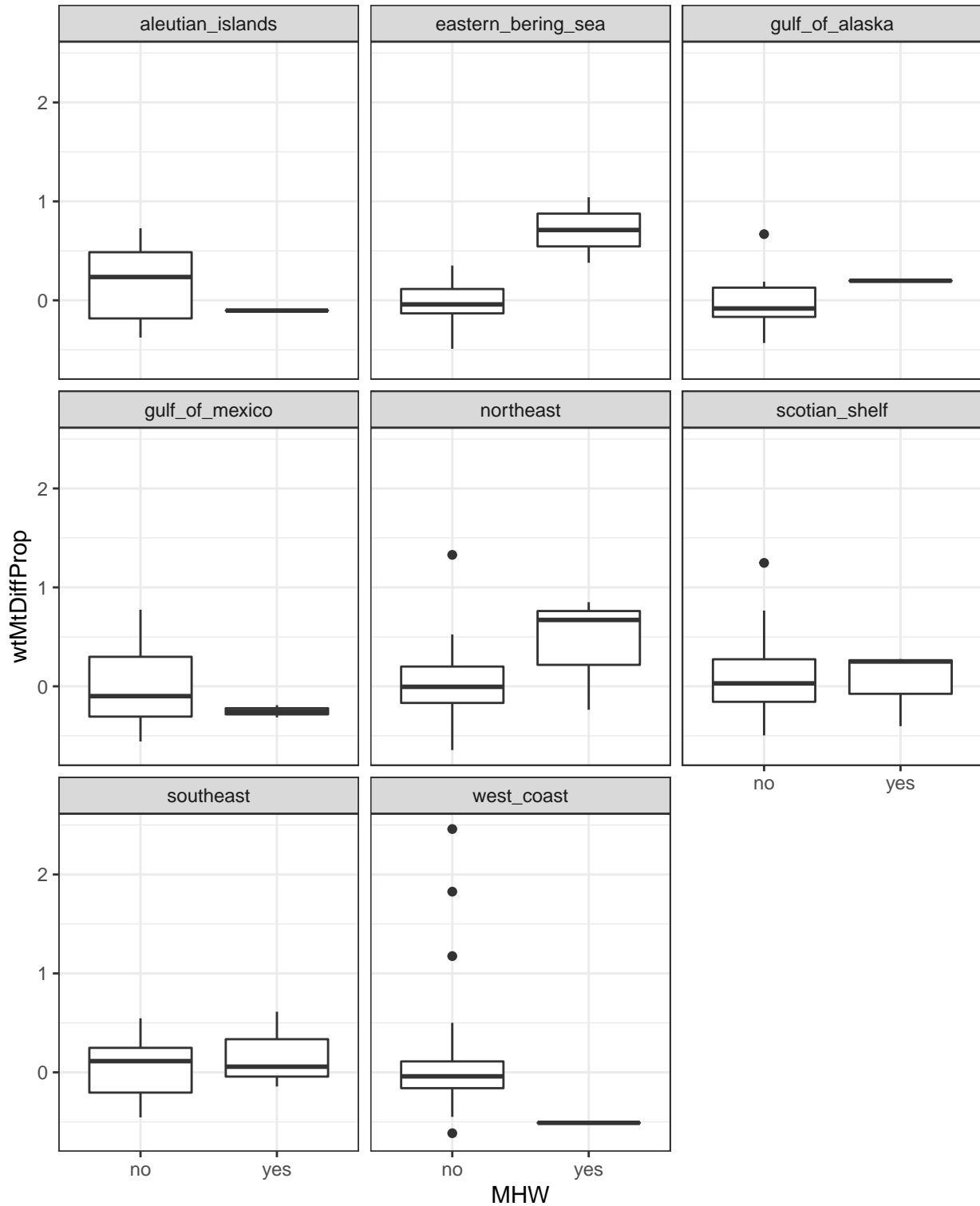
Figure 9: CPUE Proportional Year-Over-Year Difference in MHW vs. non-MHW years

Fitting a mixed-effects model to all the species-level data (not just top species) with random slopes and intercepts for species and region, `wtMtDiffPropAbs ~ sstYrAnom + (1 + sstYrAnom|spp) + (1 + sstYrAnom|region)` (note this is *absolute* change, so we are treating species that had increases or decreases

in biomass as equivalent):

Note that the previous runs of this model had `NA` for years when there was no SST anomaly; replacing those values with 0 changed the results.

effect	group	term	estimate	std.error	statistic
fixed	NA	(Intercept)	8.2967243	2.320903	3.5747828
fixed	NA	sstYrAnom	-10.7937127	15.171198	-0.7114608
ran_pars	spp	sd___(Intercept)	21.3892968	NA	NA
ran_pars	spp	cor___(Intercept).sstYrAnom	-0.9999999	NA	NA
ran_pars	spp	sd___sstYrAnom	41.9714381	NA	NA
ran_pars	region	sd___(Intercept)	4.3841422	NA	NA
ran_pars	region	cor___(Intercept).sstYrAnom	-0.9997964	NA	NA
ran_pars	region	sd___sstYrAnom	3.4782437	NA	NA
ran_pars	Residual	sd___Observation	228.4465083	NA	NA

With the response variable on a log scale: `wtMtDiffPropAbsLog ~ sstYrAnom + (1 + sstYrAnom|spp) + (1 + sstYrAnom|region)`

effect	group	term	estimate	std.error	statistic
fixed	NA	(Intercept)	-0.4198672	0.0446527	-9.402956
fixed	NA	sstYrAnom	-0.0955101	0.1990283	-0.479882
ran_pars	spp	sd___(Intercept)	0.5021783	NA	NA
ran_pars	spp	cor___(Intercept).sstYrAnom	-1.0000000	NA	NA
ran_pars	spp	sd___sstYrAnom	0.1138408	NA	NA
ran_pars	region	sd___(Intercept)	0.1113150	NA	NA
ran_pars	region	cor___(Intercept).sstYrAnom	-0.9999997	NA	NA
ran_pars	region	sd___sstYrAnom	0.4694128	NA	NA
ran_pars	Residual	sd___Observation	1.4591519	NA	NA

Fitting a series of single-species models and plotting the results
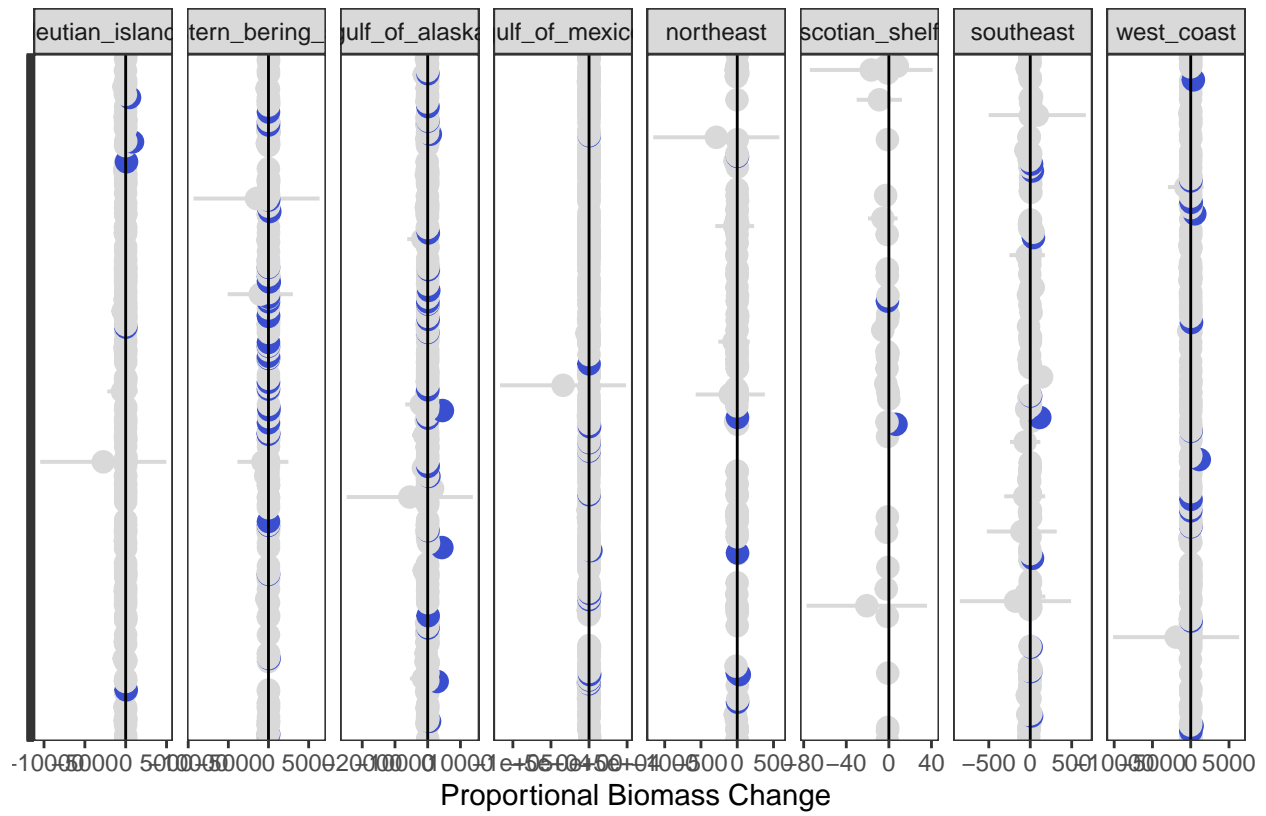
I already removed one major outlier, but it's still hard to see what's going on around the zero line. Let's zoom in:

Proportional Biomass Change