Ecological and ontogenetic responses of groundfish species to climate-induced changes in the Northern California Current Ecosystem

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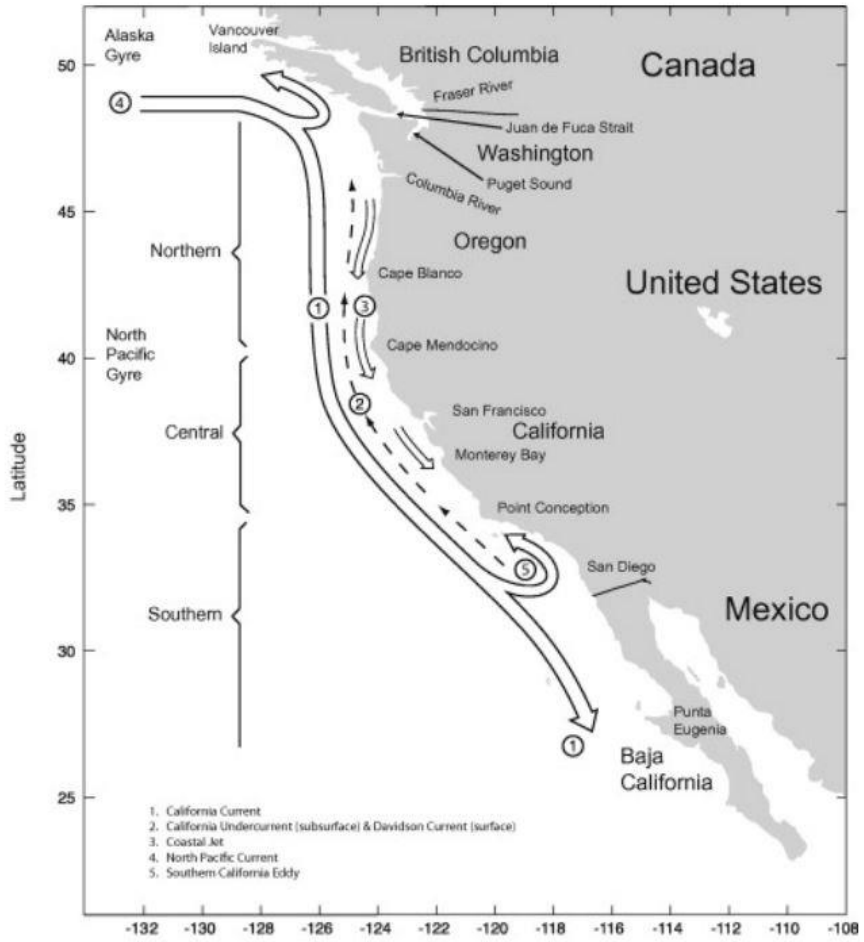
Study Area



(Checkley and Barth, 2009)

- The California Currrent System extends from British Columbia (~50°N) to off Baja California, Mexico (~15–25°N) with a major discontinuity at Point Conception (34.5°N) (Checkley and Barth, 2009).
- It is a highly productive, dynamic, diverse upwelling current system extraordinarily rich in marine biodiversity.
- Research suggests that global warming has unprecedented effects on these large marine ecosystem through increased water temperature, changes in DO, salinity, pH and other biogeochemical properties, and possibly have effects on the species that populate them.
- **Recent studies have shown that deep ocean temperatures in the Pacific Ocean, including the Northwest Pacific, have been rising over years (Johnson et al., 20).**
- Response of marine fishes to climate induced oceanographic changes vary according to different stages of life cycle (physiological or distributional) (Bernhardt and Leslie., 2013; Deutsch et.al., 2015).
- It is hypothesized that there exists differential response in life stage specific response of fishes to varying habitat conditions including water temperature and depth.
- Focus of the study is representative species from the groundfish fishery management plan (FMP) functional groups in the Northern California Current region, with size information, having management interest and significance and greatest conservation need.

Research Questions

- How Climate Change affects the ontogenetic distributional shifts of selected ground fish species of Northern California Current Ecosystem?

- Are there changes in spatial overlap among life history stages over years?

Methodology

Response variables

Abundance data (CPUE)
Presence- Absence

NWFSC (WCGBTS)
2003-2022

Sable fish
Dover sole
Petrale sole
Longspine Thorny head
Short spine Thorny head


Large


Medium


Small

Predictors

Temperature
Depth
Latitude
Longitude
Year

SDM-BRT

Abundance - BRT

Pr/Ab - BRT

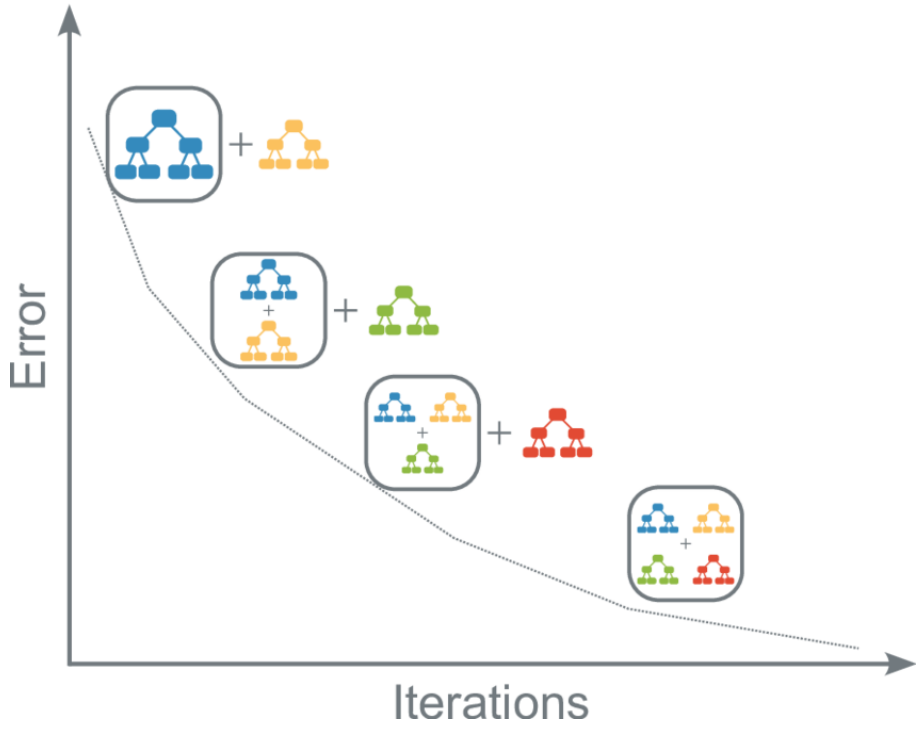
Spatial Prediction

Predicted species distributions

Ecological indices - Overlap metrics
(Area Overlap
Biomass Overlap)

Elith et al., 2007, Carroll et al., 2018

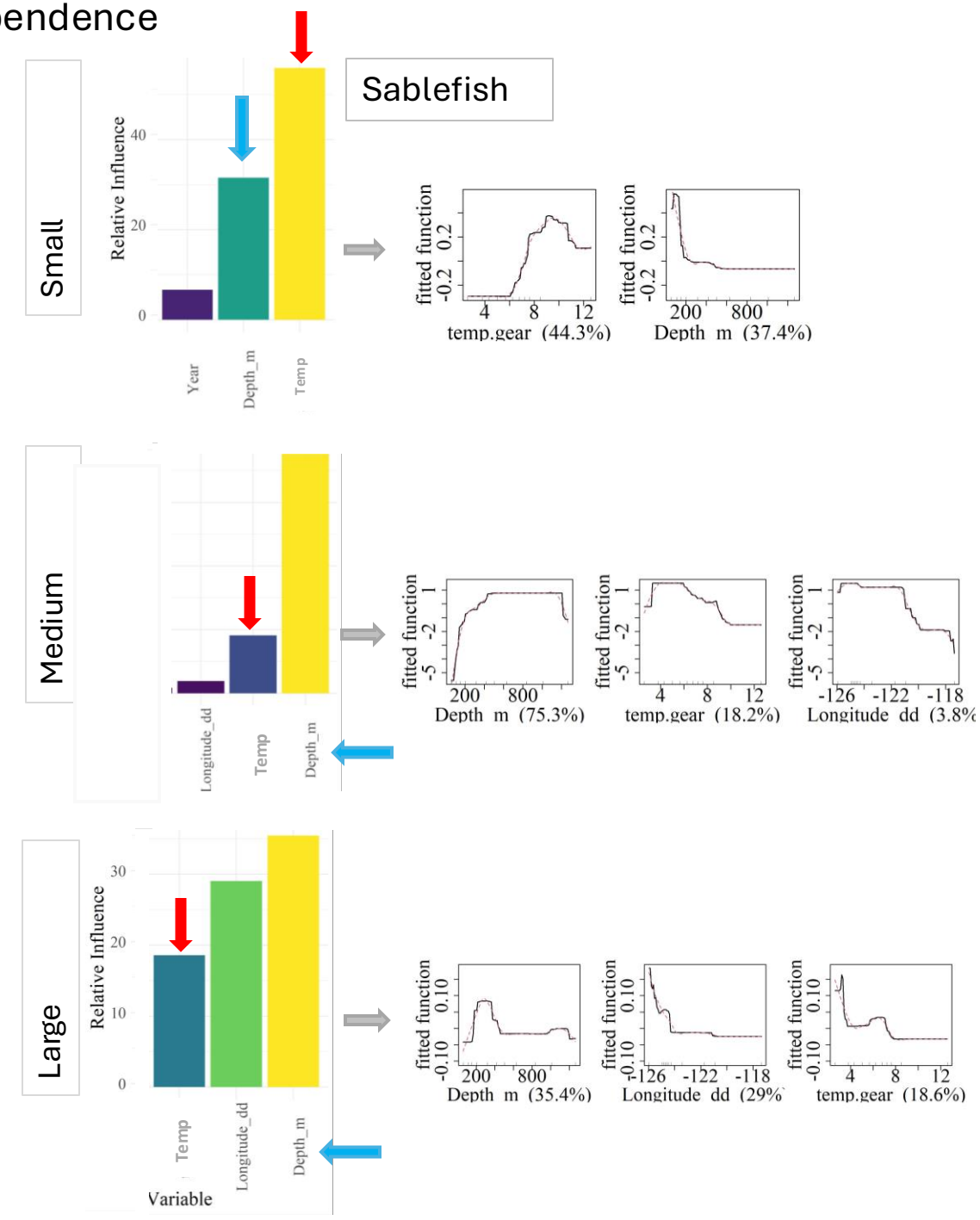
Boosted Regression Trees

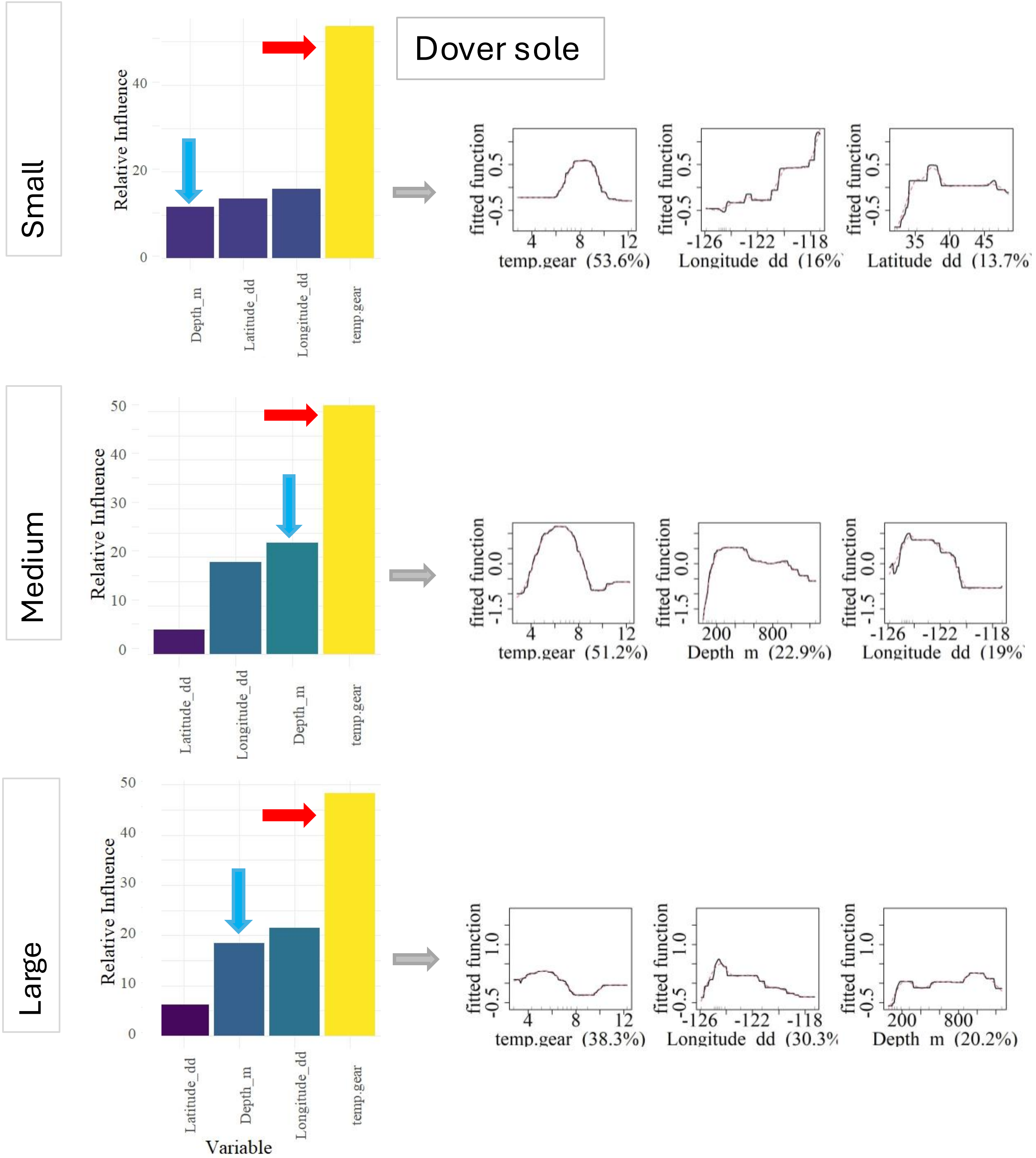


- Boosted Regression Trees (BRT) specifically work by improving predictions step-by-step through randomly selecting data.
- After each tree is added, the residuals, the differences between the observed and predicted values are recalculated for the new ensemble.
- The model performs better by controlling gradient descent through the 'learning rate' ('lr' or 'shrinkage factor'), which determines the contribution of each tree, and tree complexity ('tc'), which accommodates all interactions.
- The 'gbm.step' function of 'dismo' package which builds upon the "gbm" library (Ridgeway, 2007) in R software (R Development Core Team, 2005).
- (1) model deviance (minimized loss function for regression trees) (2) Correlation Coefficient (3) Root Mean Squared Error.

Preliminary results
and
Discussion

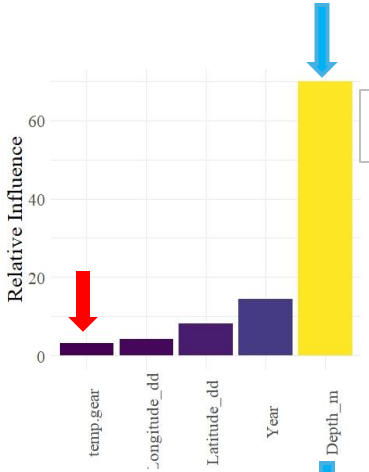
Relative influence and Partial dependence



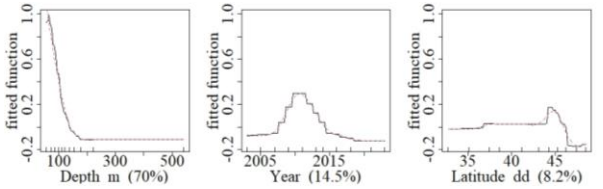


temp.gear - Temperature

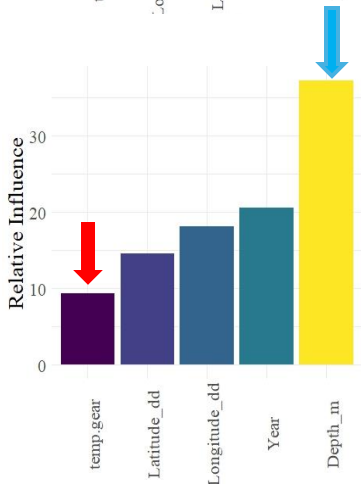
Small

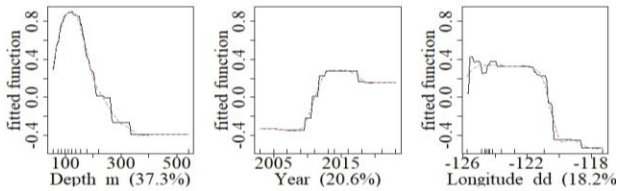


Petrale sole

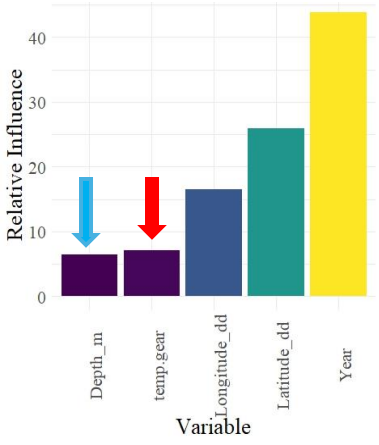


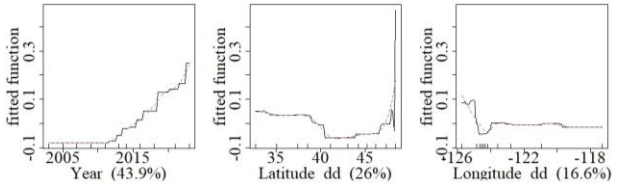
Medium



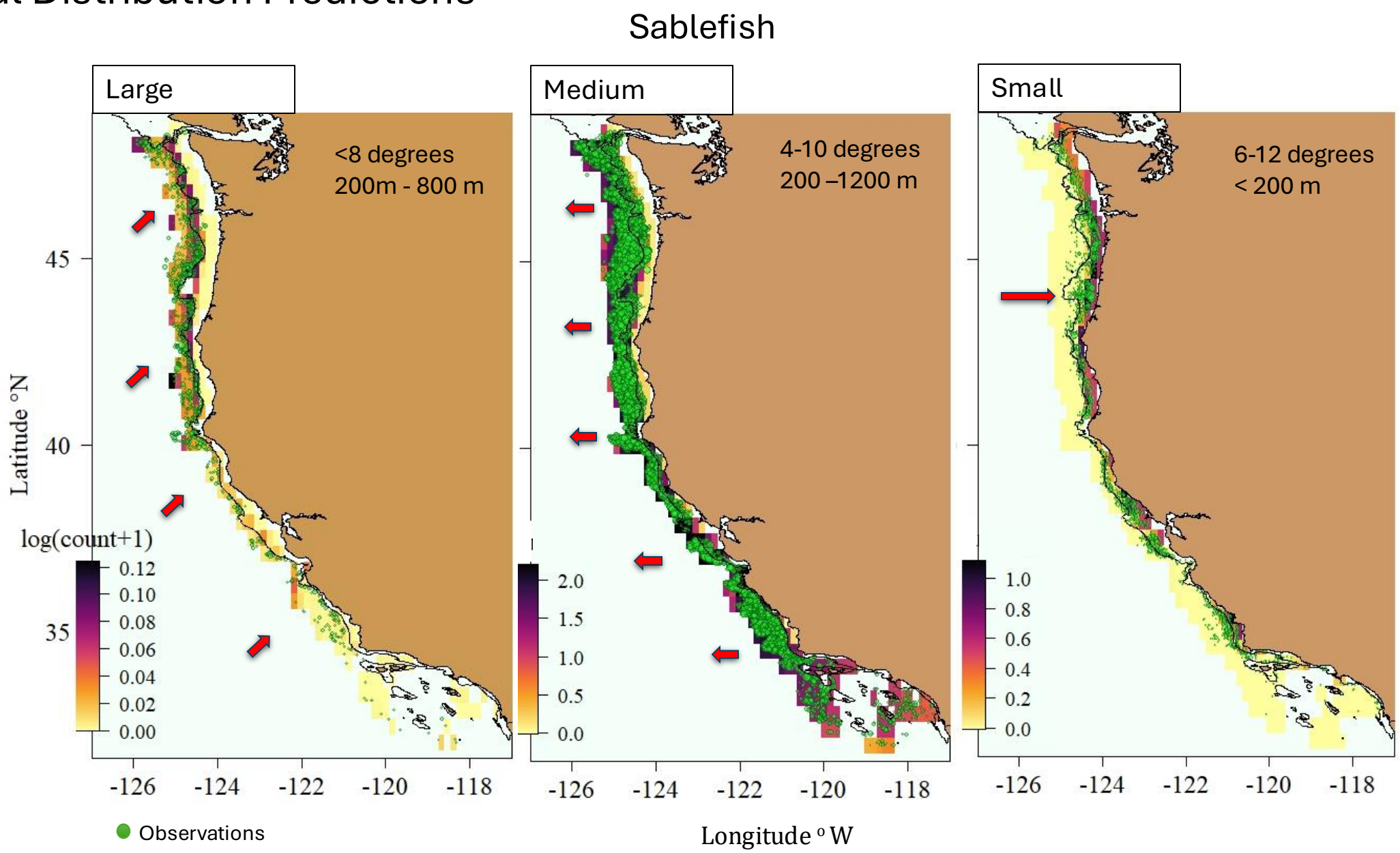


Large

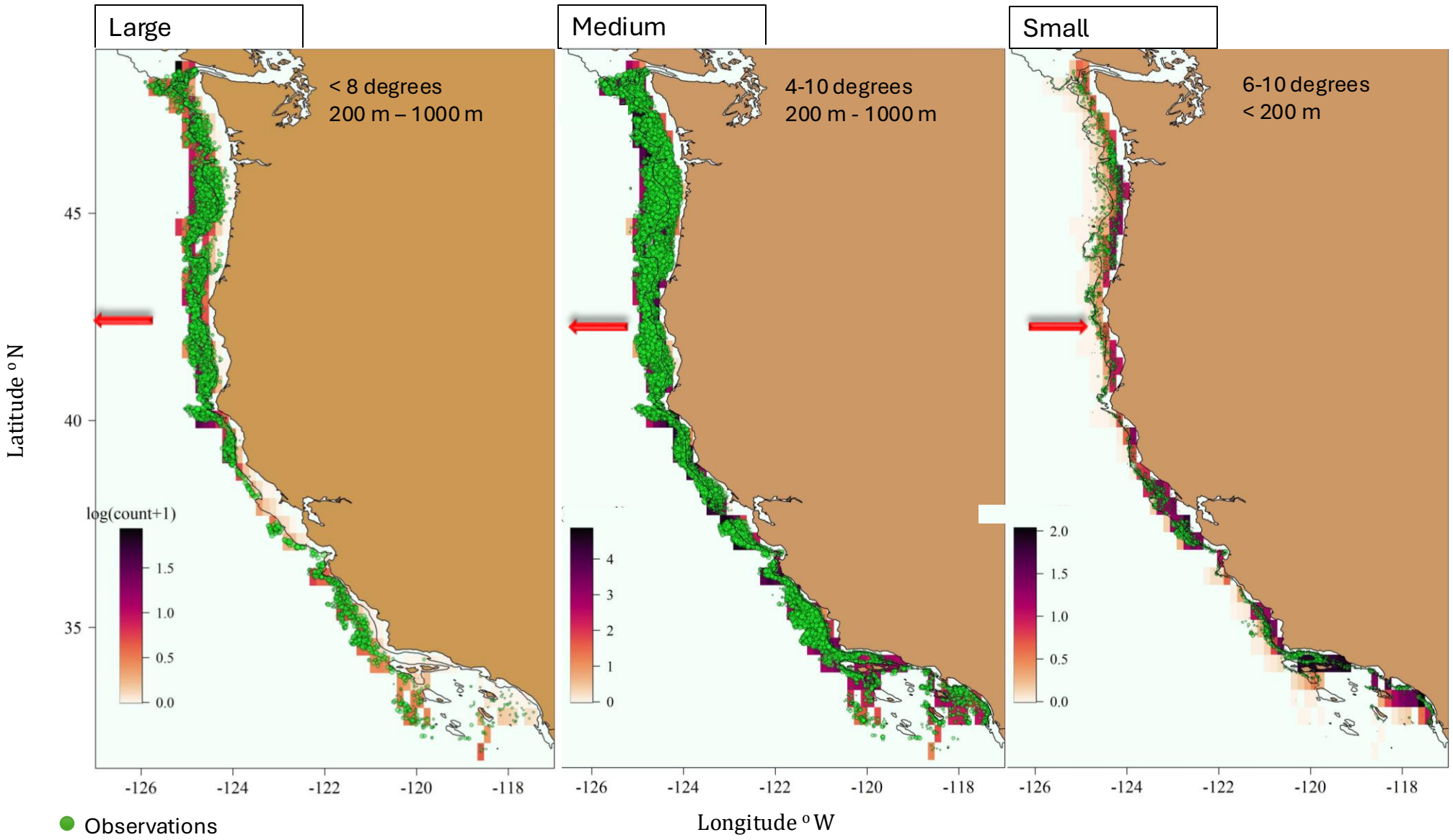




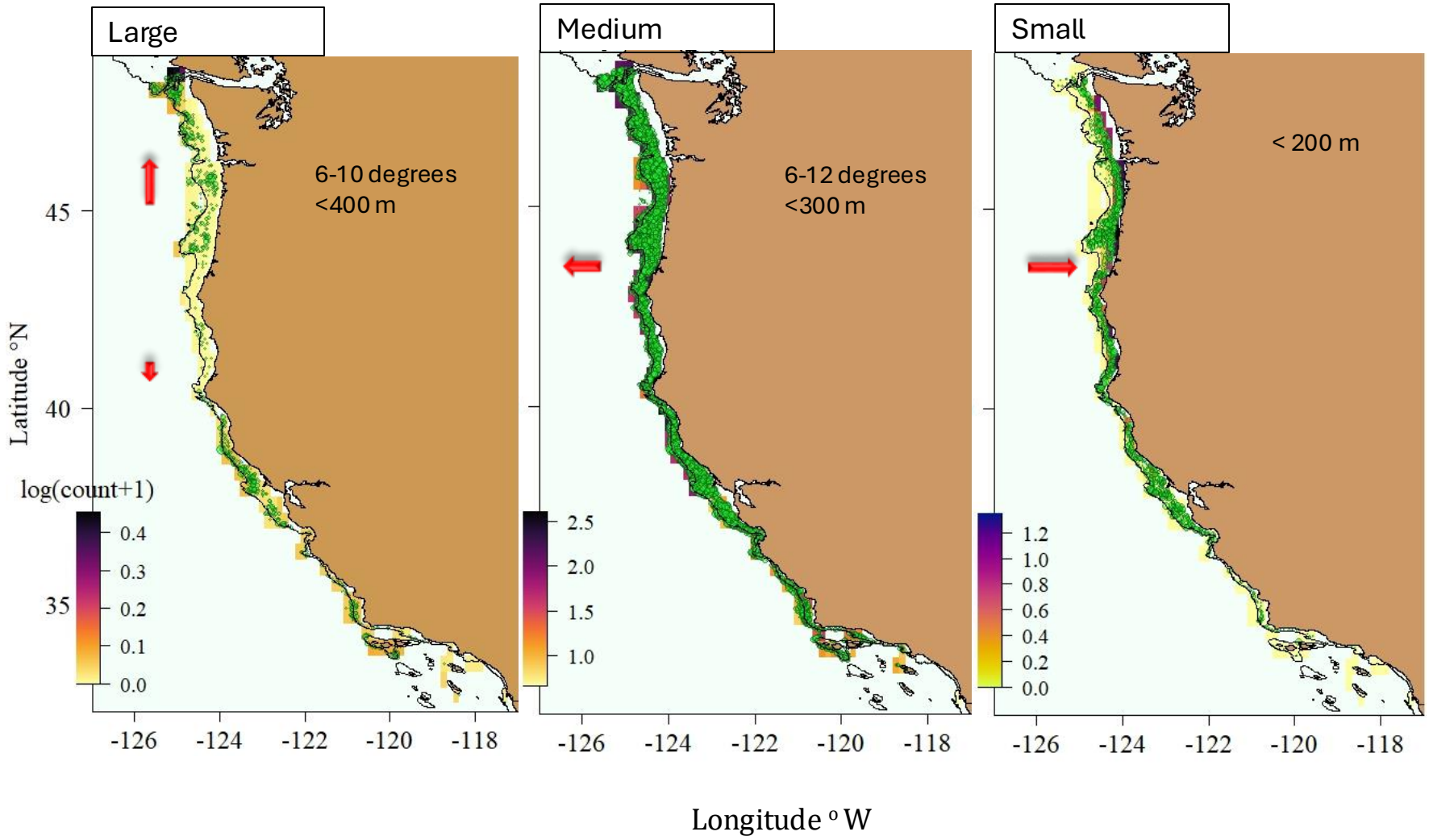
Spatial Distribution Predictions



Dover sole


Large
< 8 degrees
200 m – 1000 m
Medium
4-10 degrees
200 m - 1000 m
Small
6-10 degrees
< 200 m
Latitude º N
45
40
35
log(count+1)
1.5
1.0
0.5
0.0
4
3
2
1
0
2.0
1.5
1.0
0.5
0.0
-126
-124
-122
-120
-118
Observations
Longitude º W

Petrale sole



Research Questions

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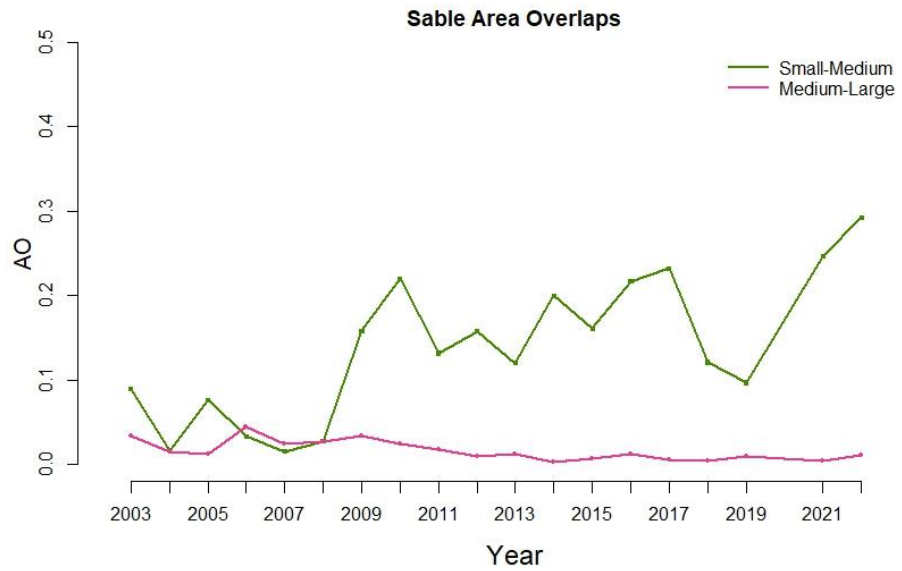
Ecological Indices

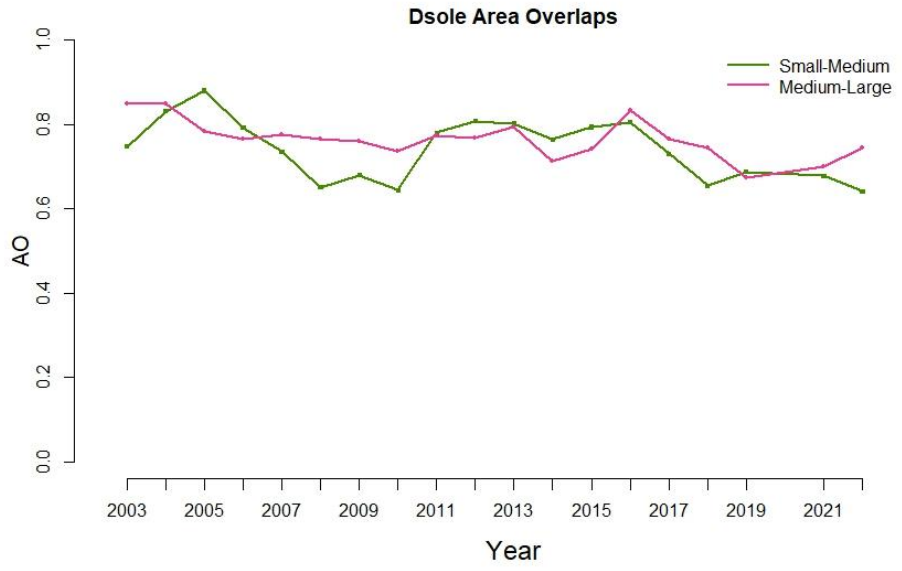
- Area overlap - Proportion of all sampled locations across a predefined area where species co-occur
- Biomass overlap - Amount of predator biomass interacting with prey (scaled to maximum prey density)

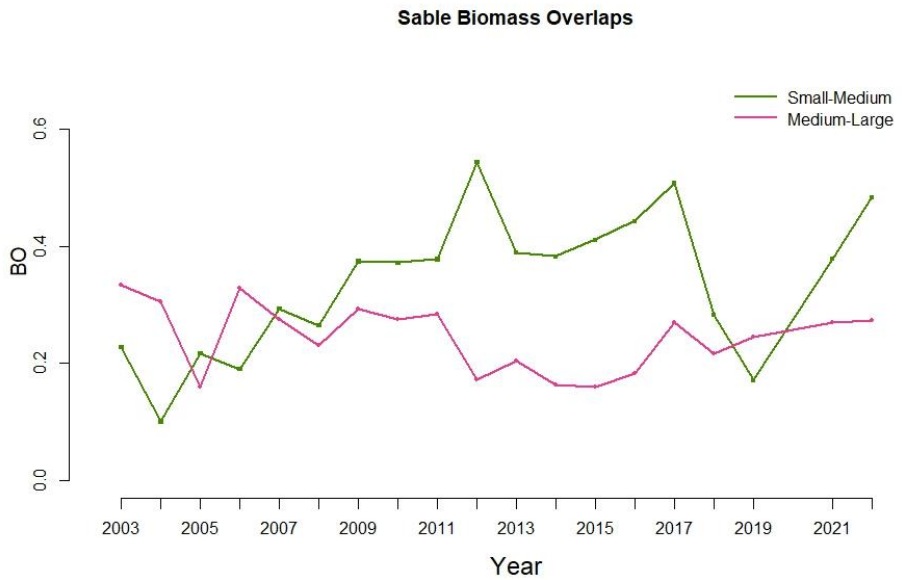
Metric	Description	Equation
Area overlap (AO) Saraux et al. (2014)	Estimates area of co-occurrence across a predefined region	Area (small, medium)/Area total
Biomass-weighted overlap (BO) Hurlbert (1978)	Useful where relative biomass of two length classes is of interest	$\frac{\sum_i^n [\text{smalli/max(small)} * \text{mediumi/max}(medium)]}{\sum_i^n \text{mediumi/max}(medium)}$

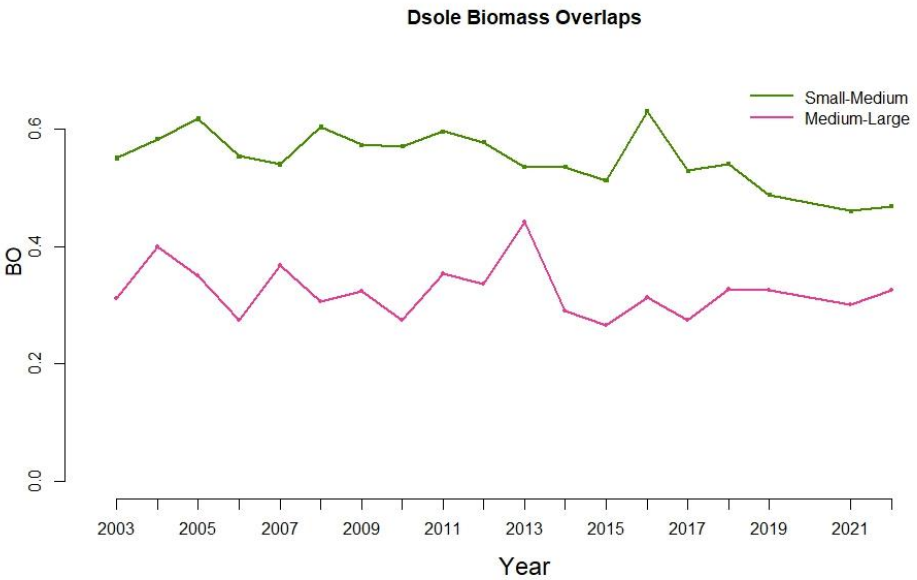
- Small-Medium (SM) and Medium-Large (ML) Area and Biomass overlaps were calculated.

Trend of Area and Biomass overlaps over years and length classes

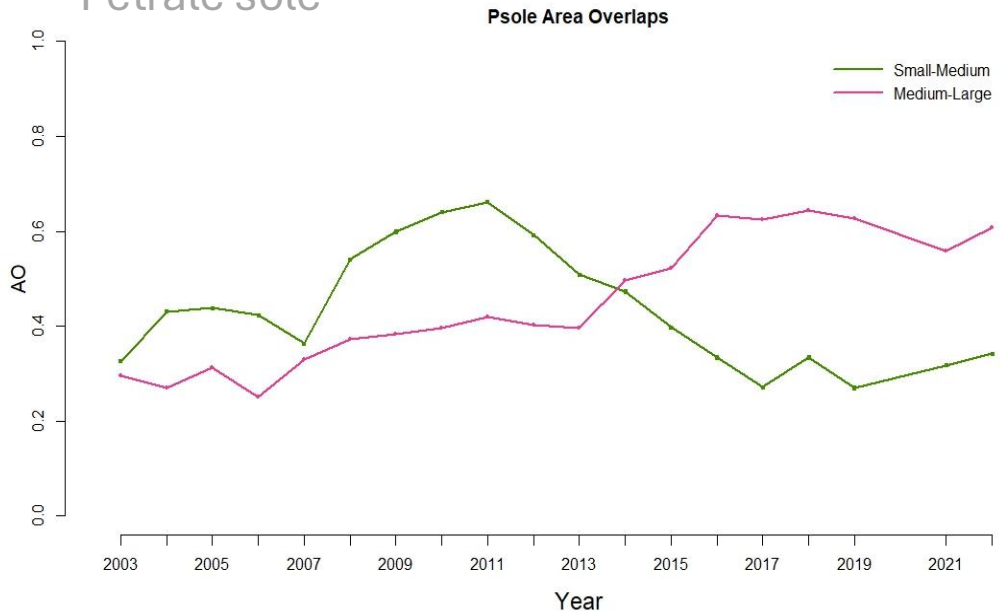


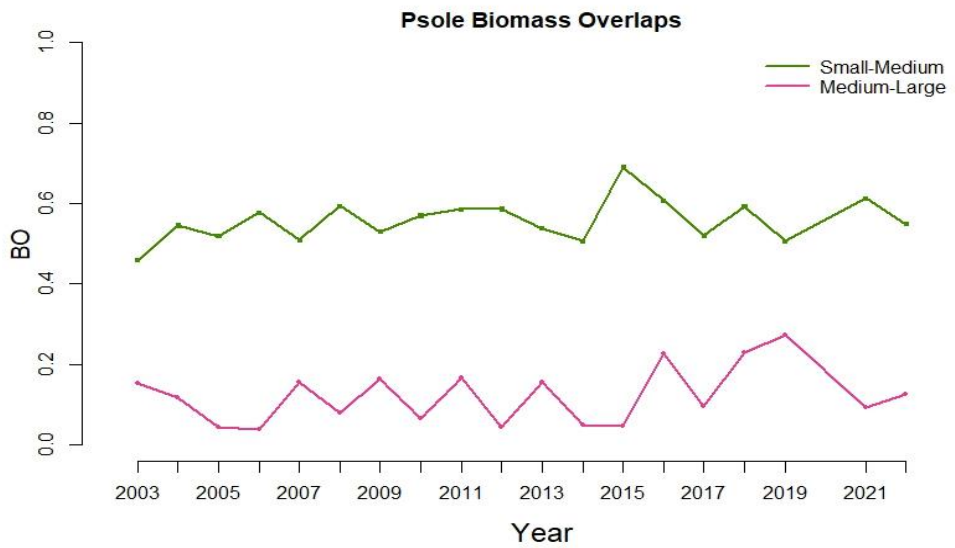






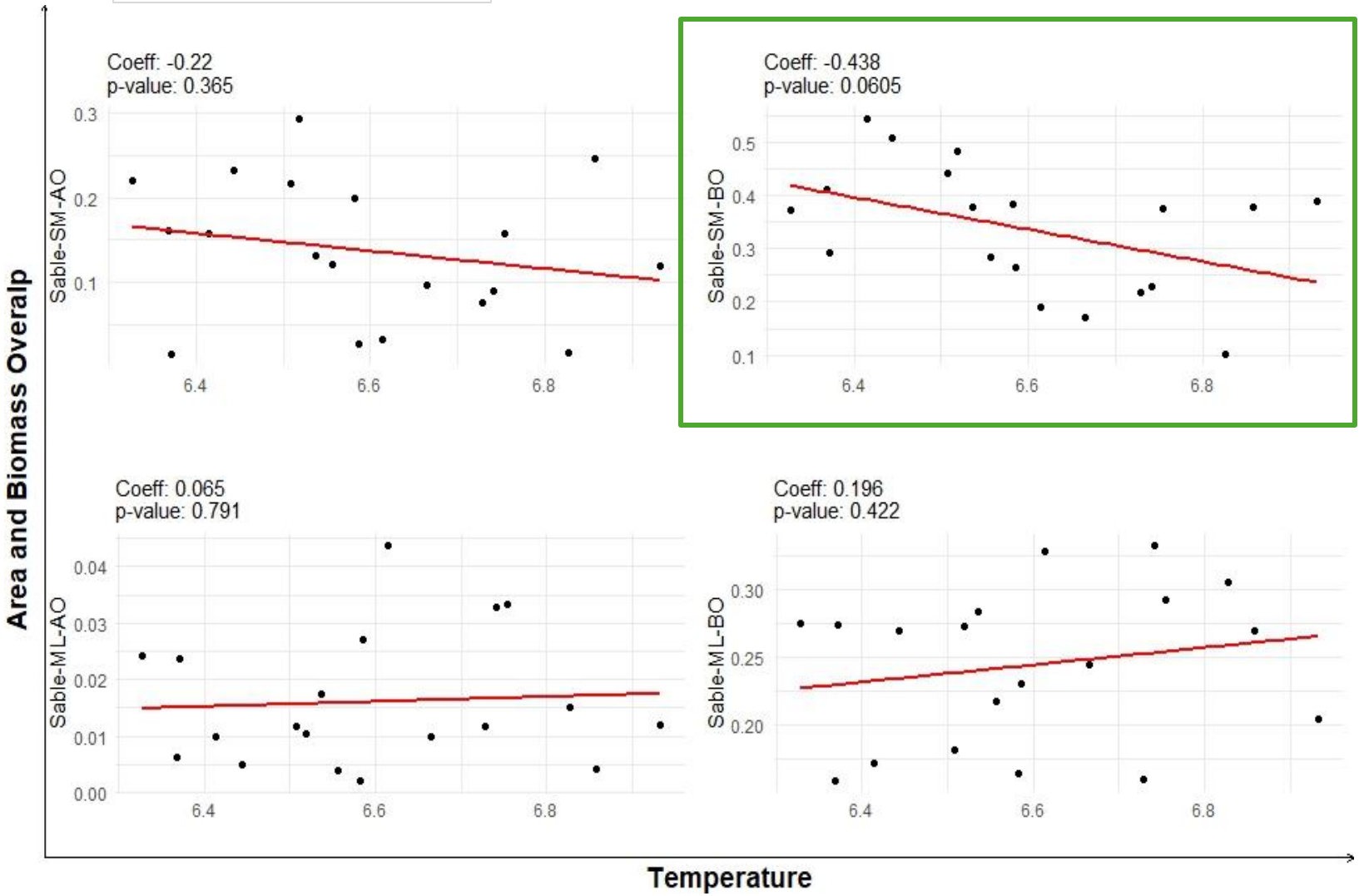
Petrale sole





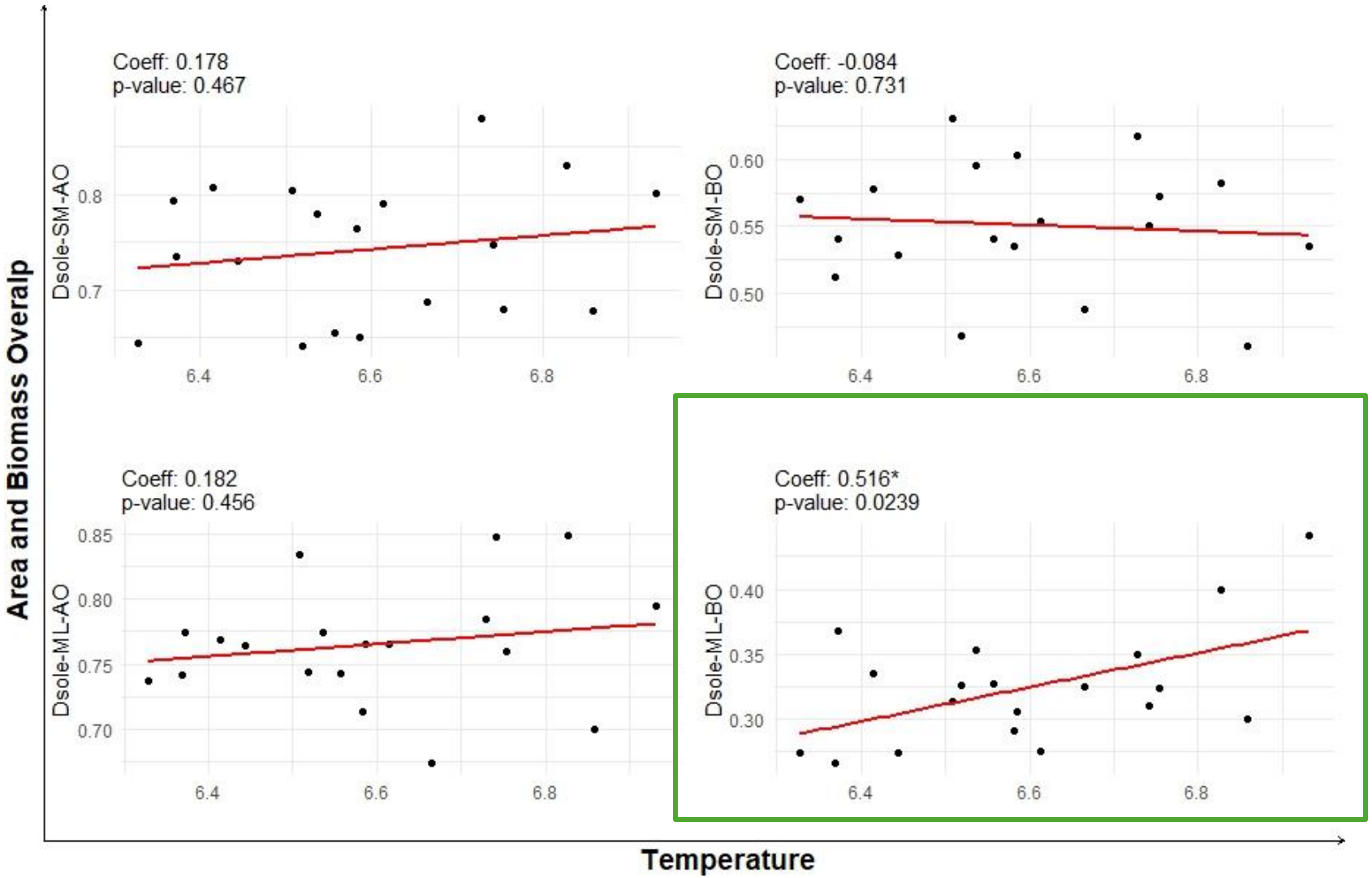
Area and Biomass Overlaps – Correlation

Sablefish

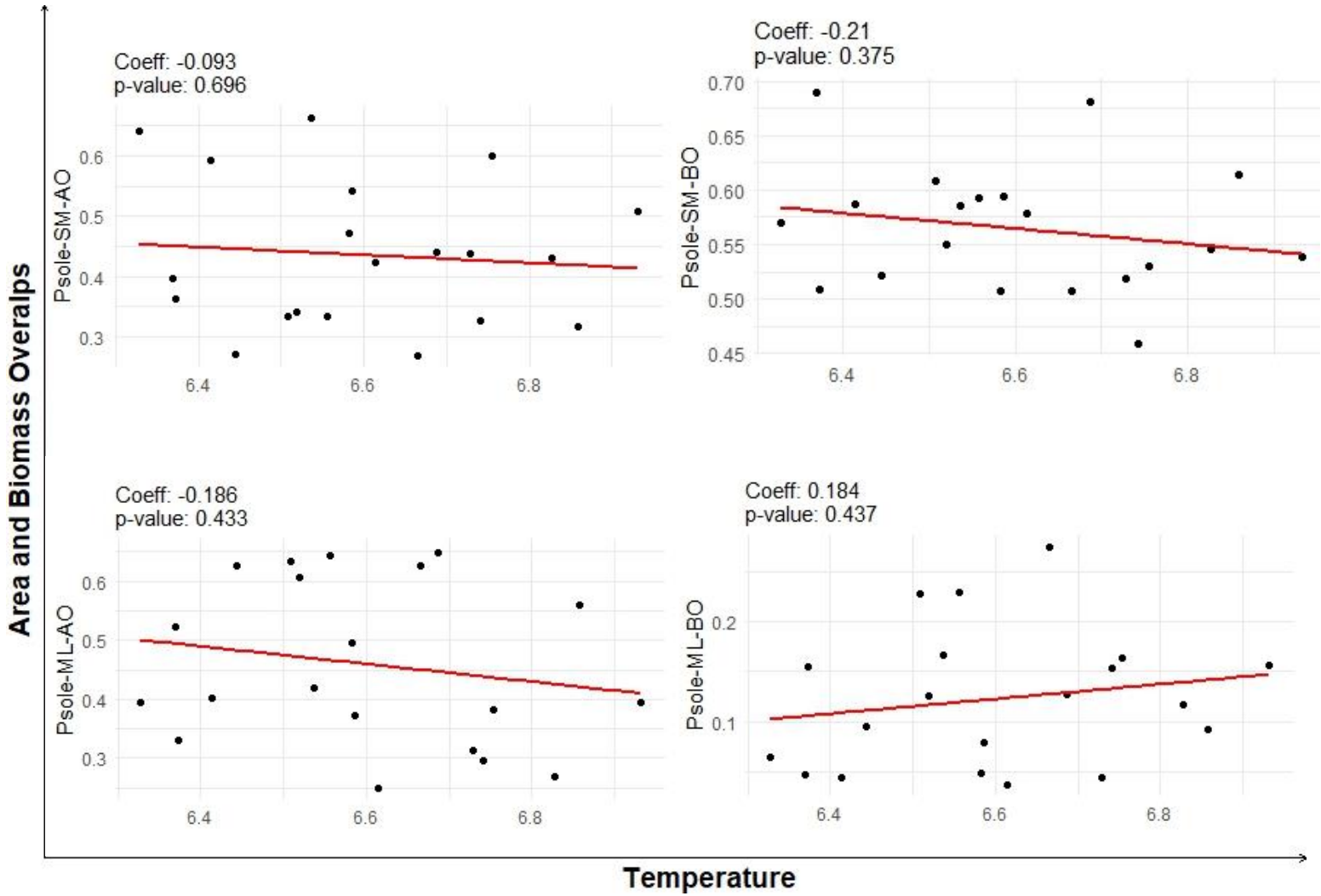


Temperature – Mean temperature

Dover sole


Area and Biomass Overalp
Temperature
Coeff: 0.178
p-value: 0.467
Dsole-SM-AO
0.8
0.7
6.4
6.6
6.8
Coeff: -0.084
p-value: 0.731
Dsole-SM-BO
0.60
0.55
0.50
6.4
6.6
6.8
Coeff: 0.182
p-value: 0.456
Dsole-ML-AO
0.85
0.80
0.75
0.70
6.4
6.6
6.8
Coeff: 0.516*
p-value: 0.0239
Dsole-ML-BO
0.40
0.35
0.30
6.4
6.6
6.8

Petrale sole



- Biomass overlaps of Sablefish Small-Medium (negative correlation) and Dover sole Medium-Large (positive correlation) are statistically significant. Whereas Petrale sole Area and Biomass overlaps do show correlations, but they are not statistically significant.

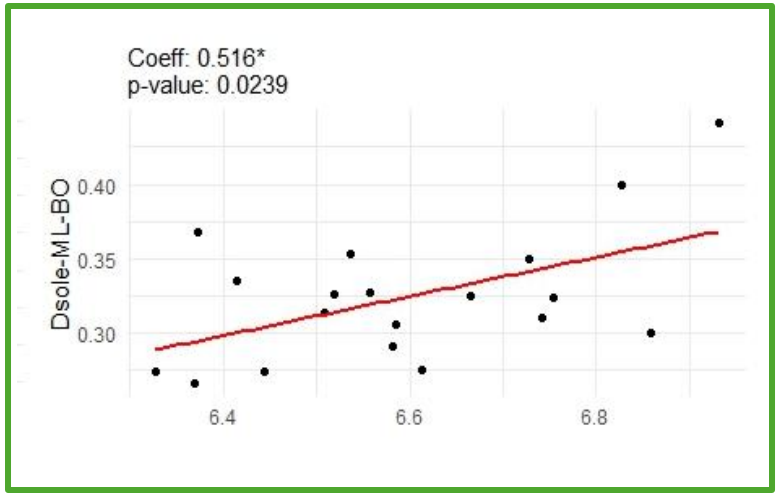
SUMMARY

Work in progress !

- Each species and length class exhibits an optimal window of temperature and depth for distribution.
- Fish species show changes in overlap indices with temperature over years but the significance depends on response each species and length class
- Preliminary results support that there likely exists changes in ontogenetic distributional changes of fishes in response to the changing oceanographic conditions and the response is species and stage specific.
- To conclude the results further analysis is in progress.

Table summarizing the model results:

	Sable Fish	Dover sole	Petrale sole
Small	6-12 degrees < 200 m	6-10 degrees < 200 m	< 200 m.
Medium	4-10 degrees 200 –1200 m	4-10degrees 200 m - 1000 m	6-12 degrees - <300 m.
Large	<8 degrees 200m - 500 m	< 8 degrees 200 m – 1000 m	6-10 degrees <400 m.



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