Variation of commercial pelagic species under ENSO and Climate Change in the Northern South China Sea

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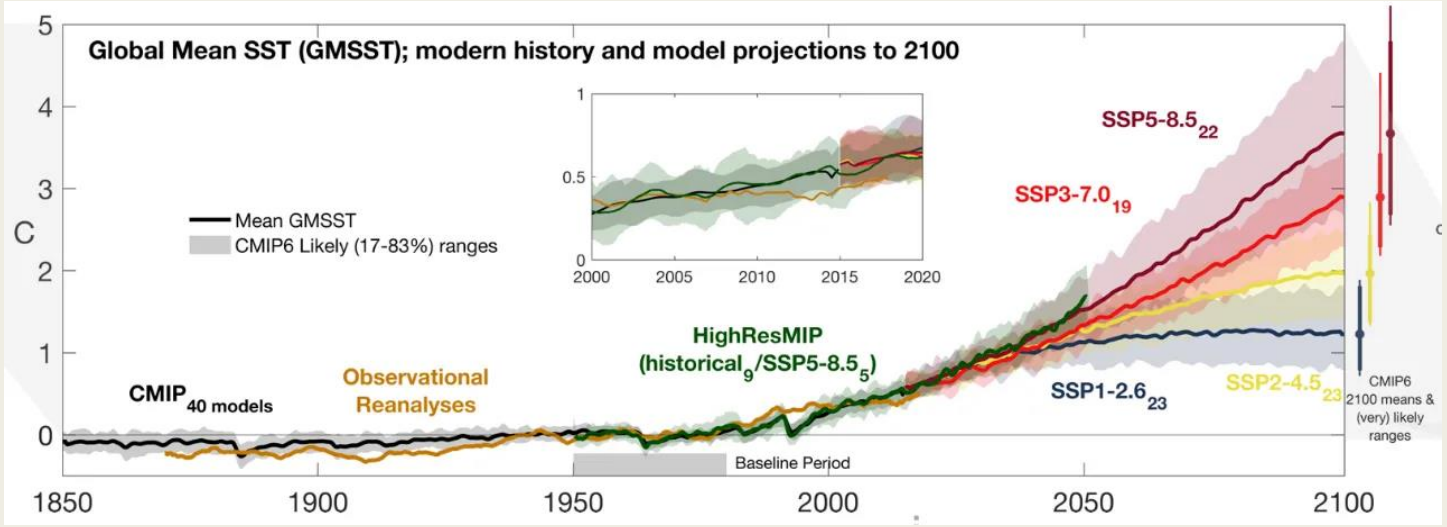
How climate change effect to you ?

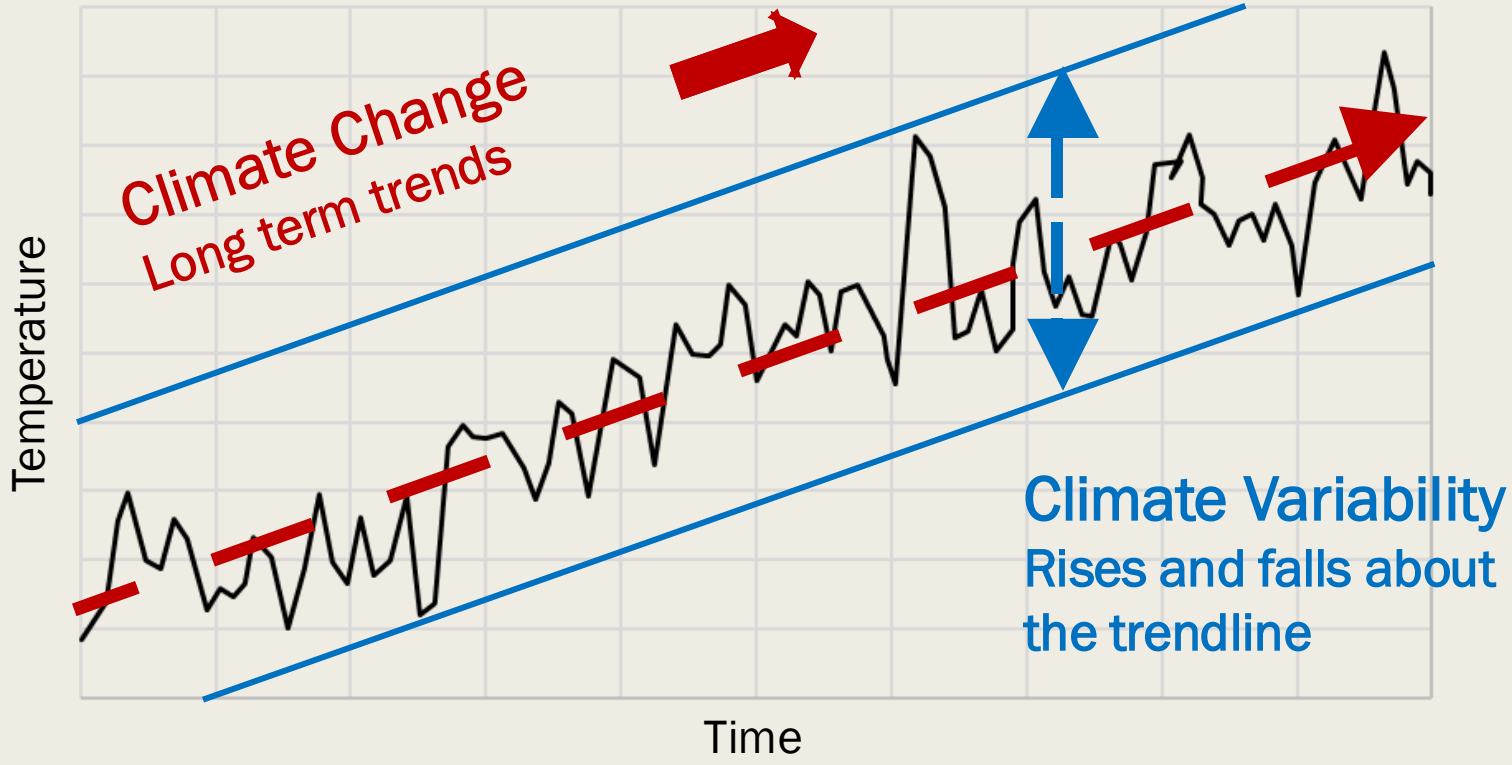
Climate change impact

Ocean and Water	Cryosphere	Atmospheric Composition	Temperature and Energy



(Cites : Carbonbrief. Source: IPCC (2021) Figure 9.3.)

Climate change



Climate Variability

El Niño-Southern Oscillation, ENSO

Pacific Decadal Oscillation, PDO

Western Pacific Oscillation, WPO

North Pacific Gyre Oscillation, NPGO

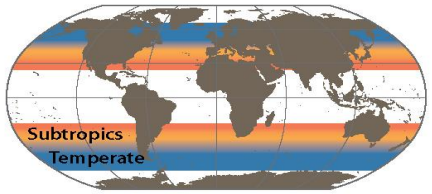
Pelagic species

Anchovy (Peruvian upwelling)

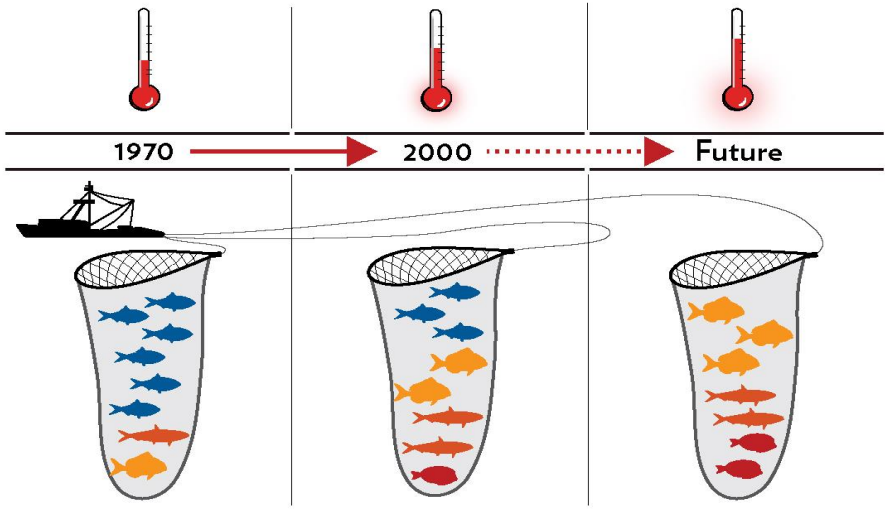
Warming Oceans Are Reshaping Fisheries

Marine species are gradually moving away from the equator into cooler waters, and, as a result, species from warmer waters are replacing those traditionally caught in many fisheries worldwide. Scientific studies show that this change is related to increasing ocean temperatures.

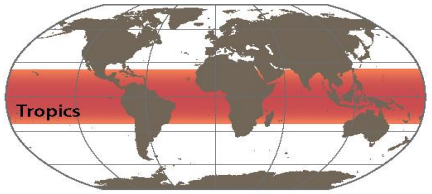
Subtropic and temperate ocean



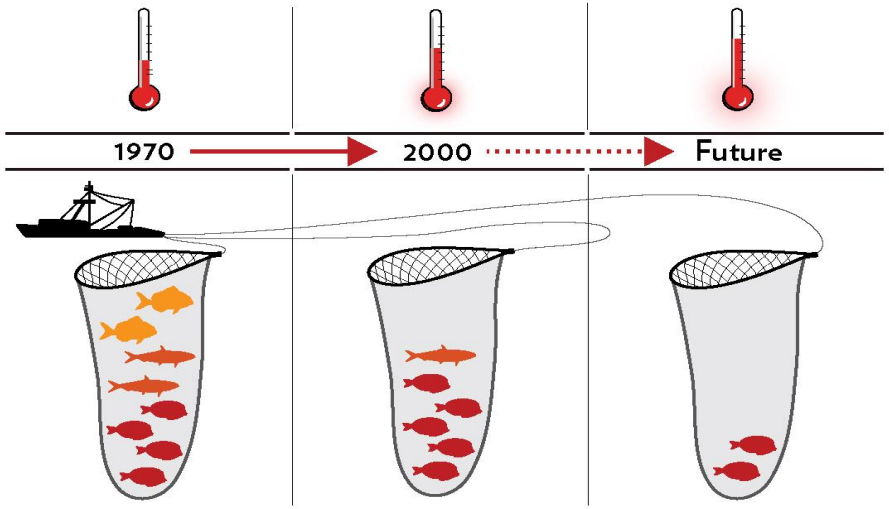
From 1970 to 2006, as open temperatures were rising, catch composition in the subtropic and temperate areas slowly changed to include more warm-water species and fewer cool-water species.



Tropics



In the tropics, the catch composition changed from 1970 to 1980 and then stabilized, likely because there are no species with high enough temperature preferences to replace those that declined.

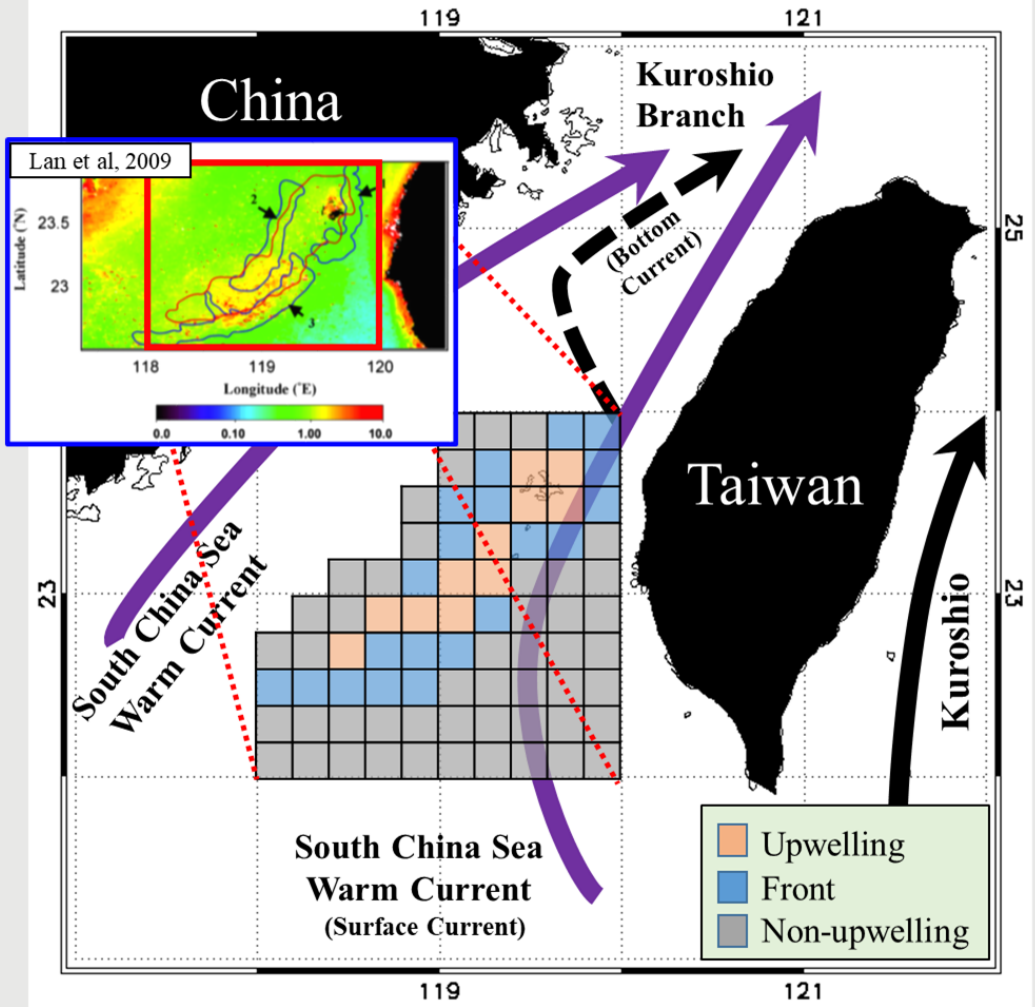


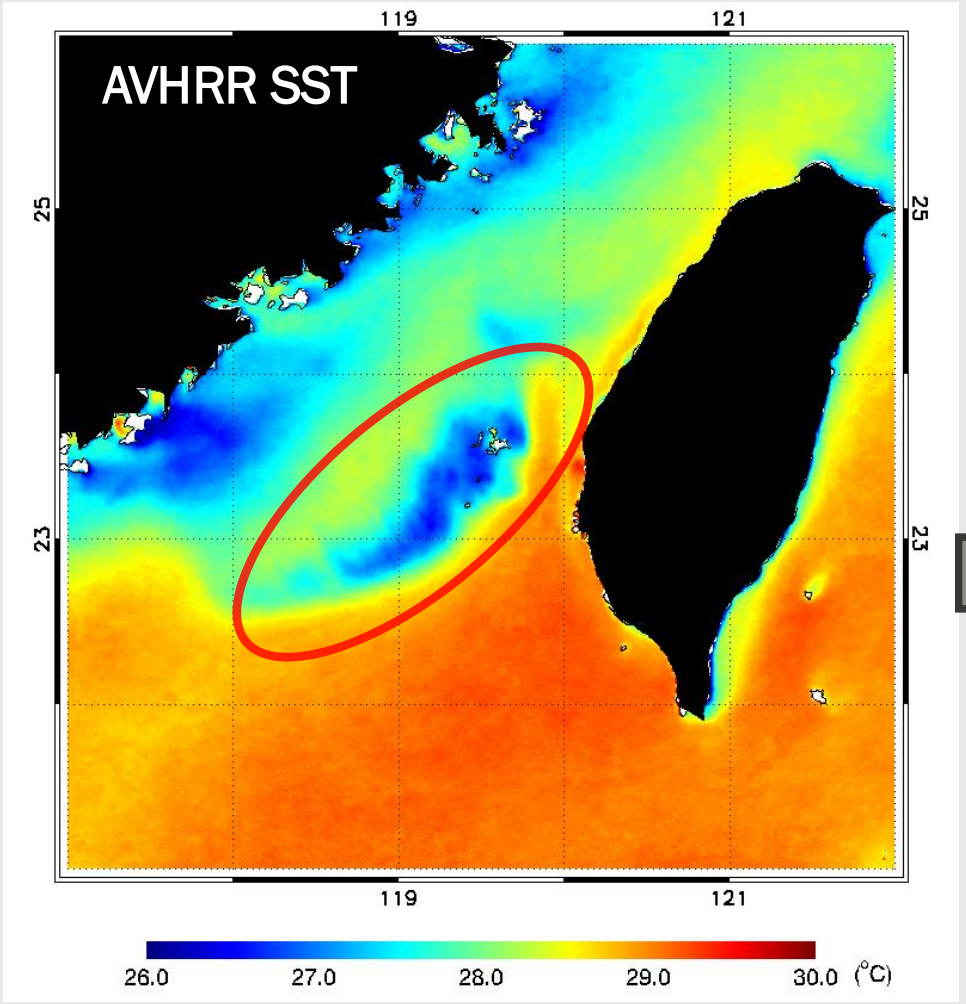
Temperate/cool-water fish Subtropical fish Tropical/warm-water fish

These shifts could have negative effects including loss of traditional fisheries, decreases in profits and jobs, conflicts over new fisheries that emerge because of distribution shifts, food security concerns, and a large decrease in catch in the tropics.

Graphic by The Pew Charitable Trusts' ocean science division, Concepts from: Cheung, W.W.L.. R. Watson and D. Pauly. 2013. Signature of ocean warming in global fisheries catch. Nature. DO!:10.1038/nature 12156.

Taiwan Bank upwelling area



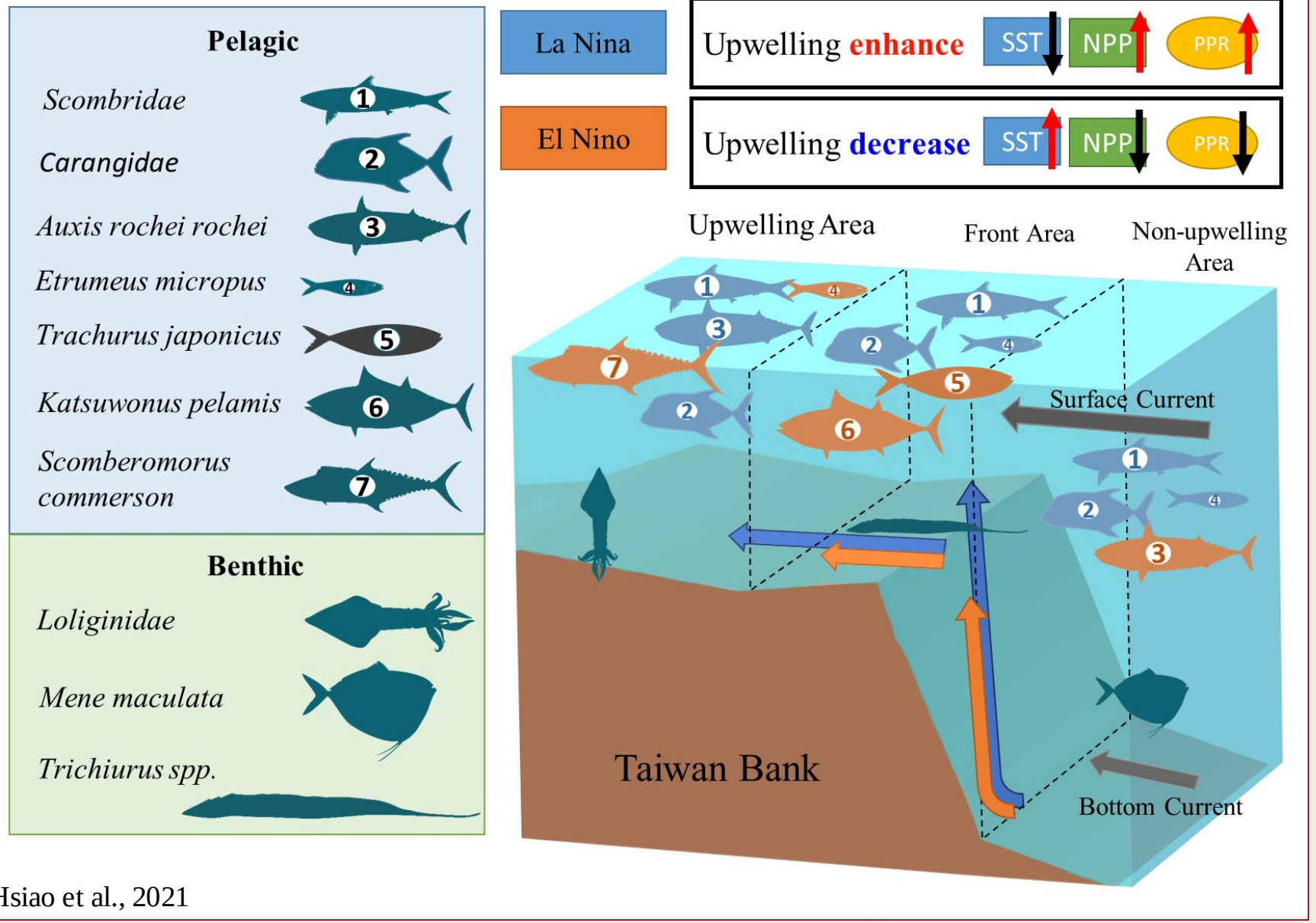


High Catch

Hsiao et al., 2021

Taiwan Bank (TB)

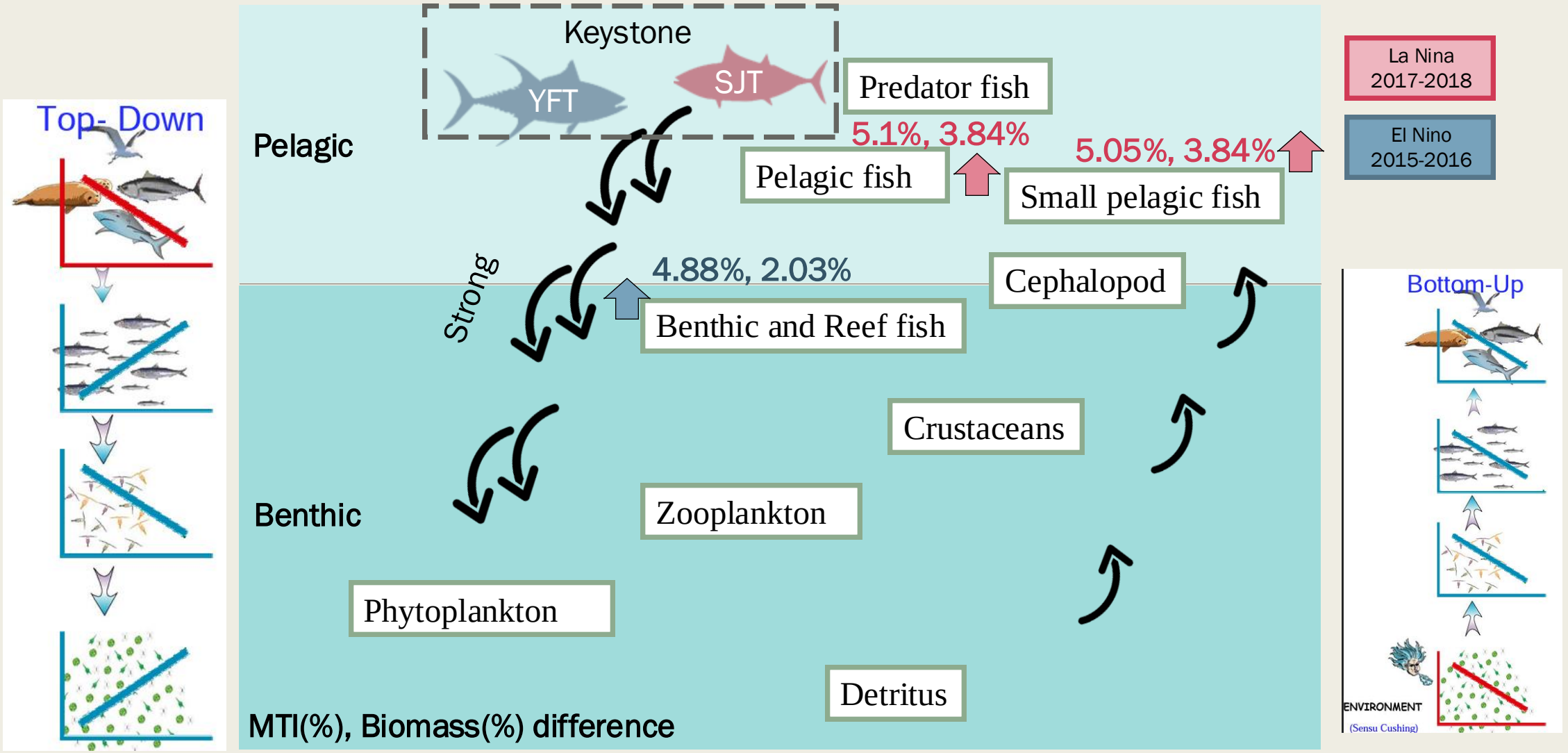
ENSO effect on the TB ecosystem



Hsiao et al., 2021

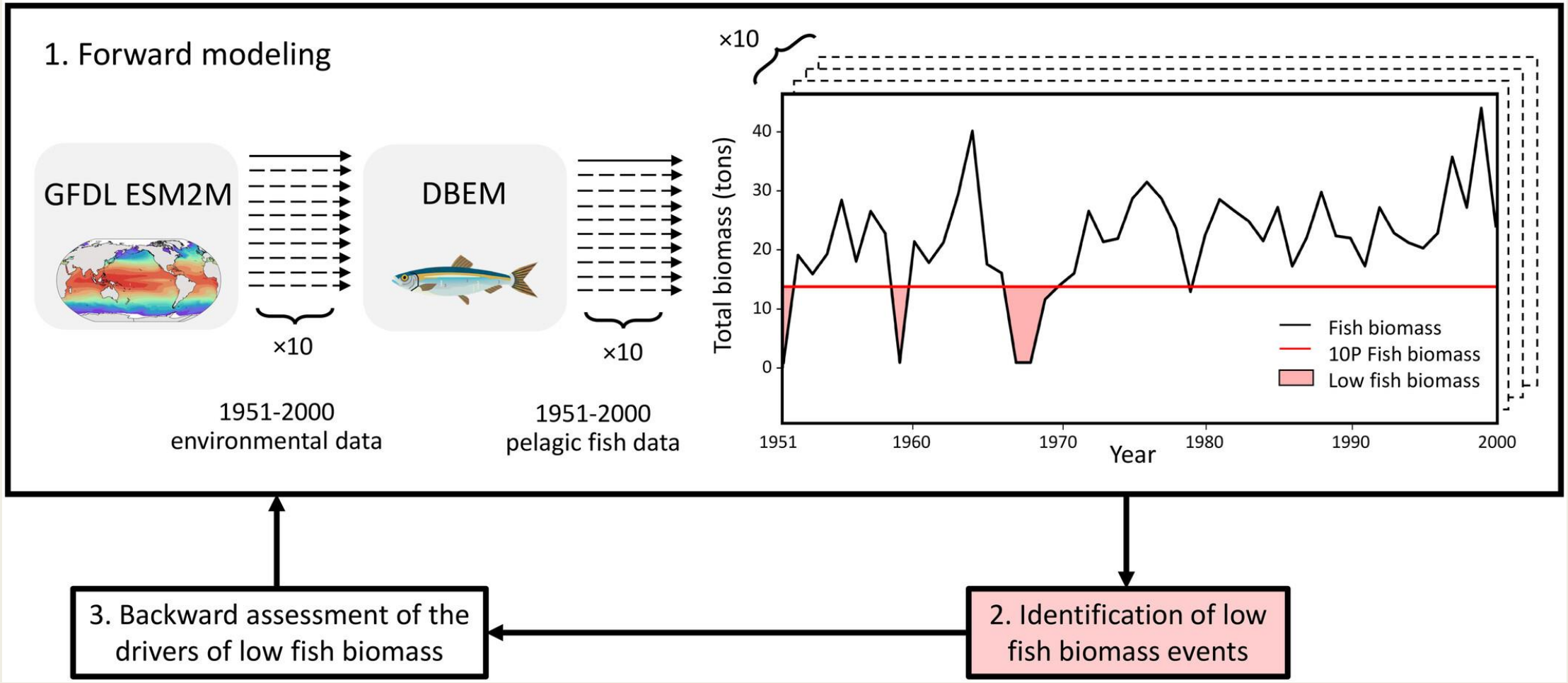
- In La Nina events, the upwelling enhance leading the Pelagic species abundance increased (through the environments factors).
- In the other hand, El Nino periods upwelling getting weaker, the pelagic species composition also shifting.

ENSO effect on the TB ecosystem

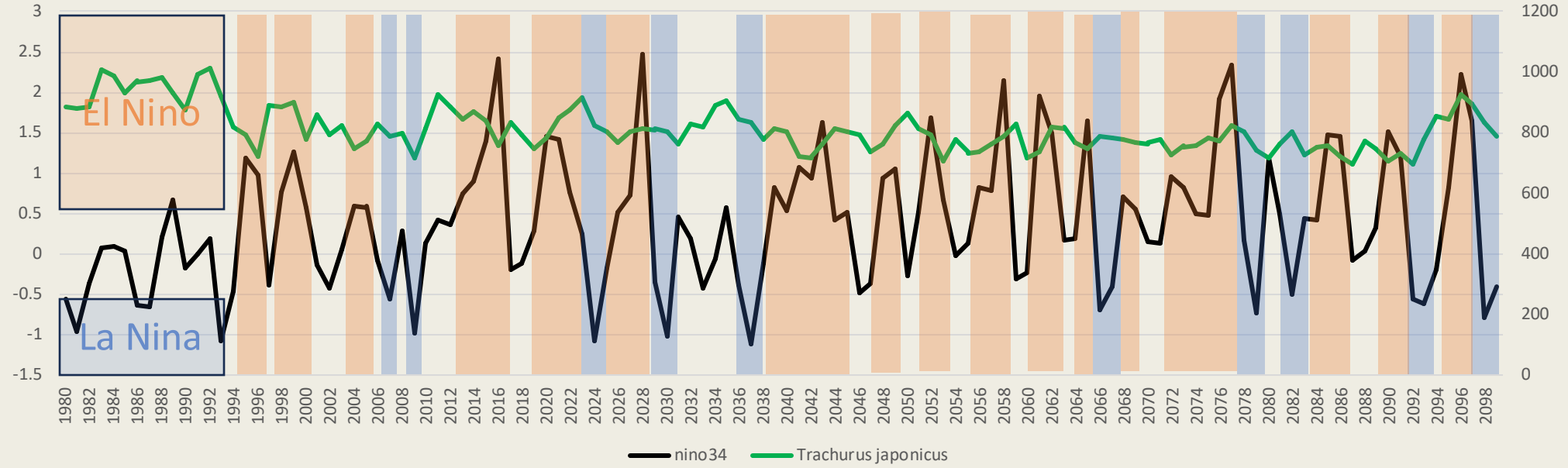


- In La Nina event, upwelling enhance, SST decreased, NPP increased PPR increased, and vice versa.
- The variation of species composition is caused by the portion changing in pelagic species and Benthic species.
- The keystone species also shifted to the predator fish *Thunnus albacares* and *Katsuwonus pelamis* during El Niño and La Niña events, respectively.

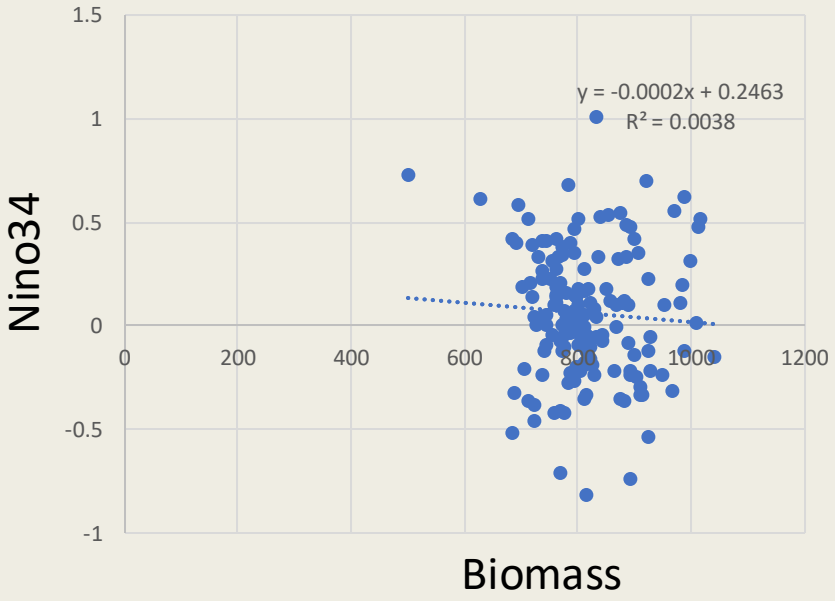
Extreme and compound ocean events are key drivers of projected low pelagic fish biomass



Le Grix, N., Cheung, W. L., Reygondeau, G., Zscheischler, J., & Frölicher, T. L. (2023). Extreme and compound ocean events are key drivers of projected low pelagic fish biomass. Global Change Biology, 29, 6478–6492. https://doi.org/10.1111/gcb.16968



Trachurus japonicus



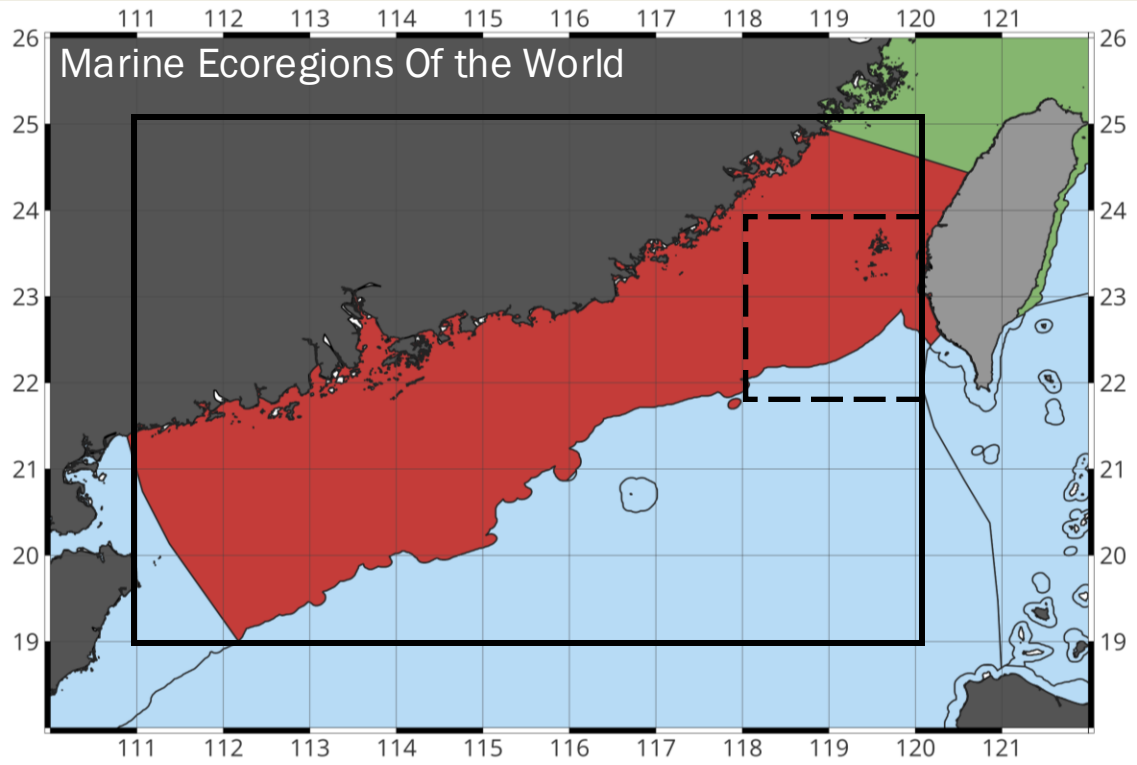
Literature Review

- In Northern South China Sea, after La Nina event, Japanese jack mackerel (*Trachurus japonicus*) and Japanese scad (*Decapterus maruadsi*) biomass increasing. (Li et al., 2023; Zhang et al., 2022)
- Different fish species respond differently to ENSO, non-surface species like silver pomfret (*Pampus argenteus*) and *Branchiostegus argentatus* show a brief biomass increase after El Niño events. (Hong et al., 2023)

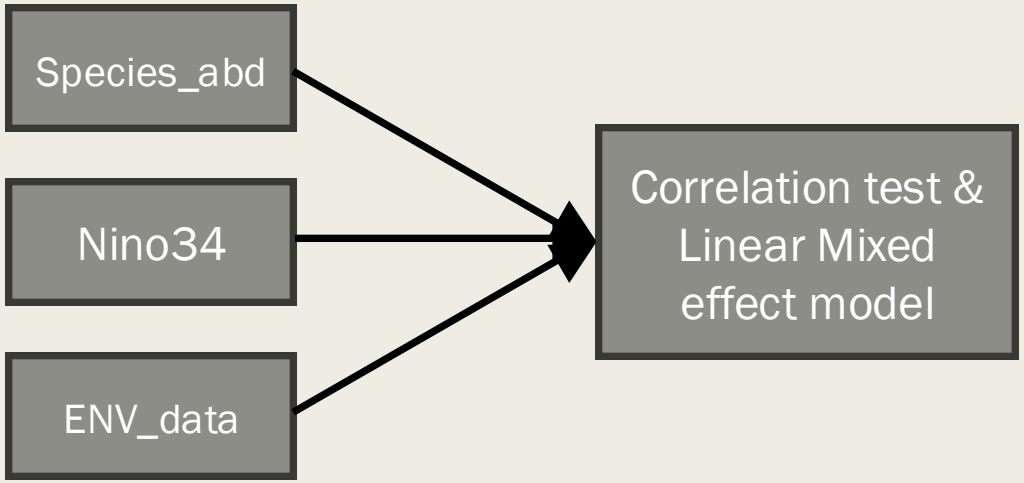
Research Purpose

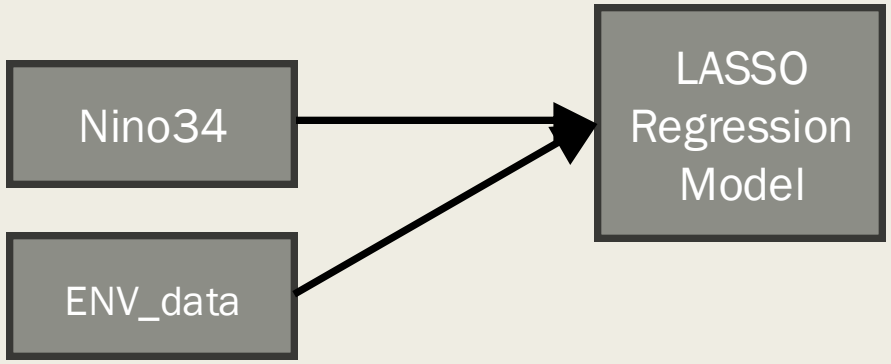
Analysis the relationship between ENSO and species abundance changes under future climate conditions, focusing on biomass shifts.

Northern South China Sea



- 1950-2100, resolution 0.5*0.5
- Environment data from Earth System Model GFDL ESM2M
- Biomass data were simulated using a species-based Dynamic Bioclimate Envelope Model (DBEM)
- 10 Ensemble members
- Log transform and z-score normalization

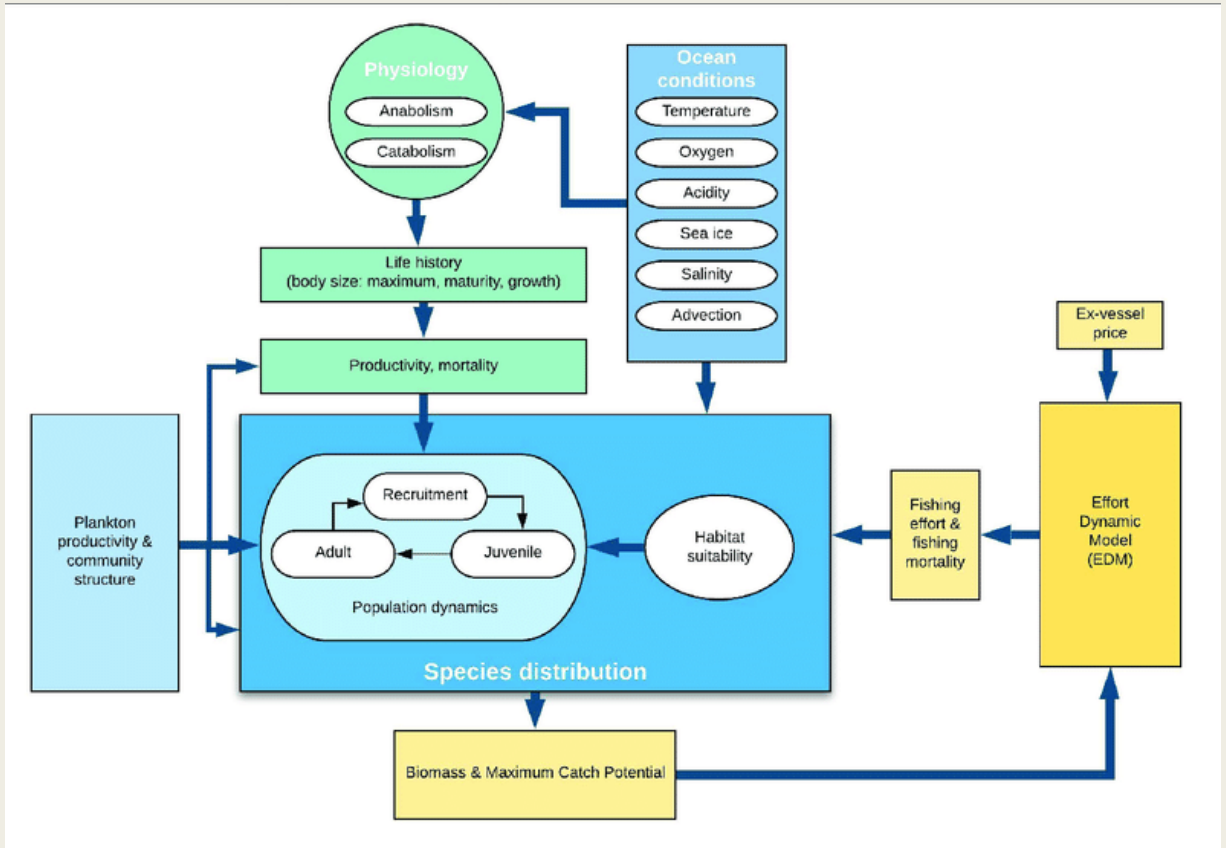


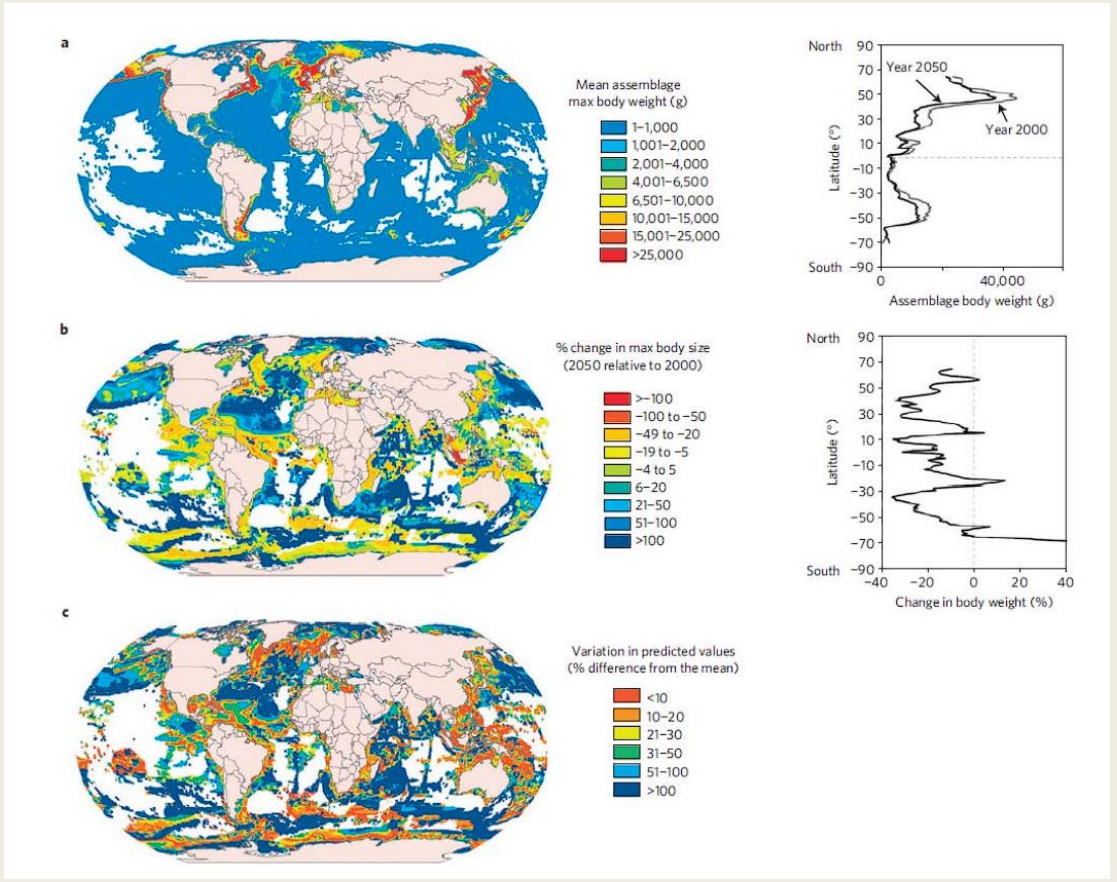


Dynamic Bioclimate Envelope Model (DBEM)

The DBEM predicts marine species distribution and biomass changes under climate change scenarios. It integrates bioclimate envelopes, dynamic migration, and growth modeling with IPCC climate projections. This tool supports fisheries management, ecosystem assessment, and biodiversity conservation efforts.

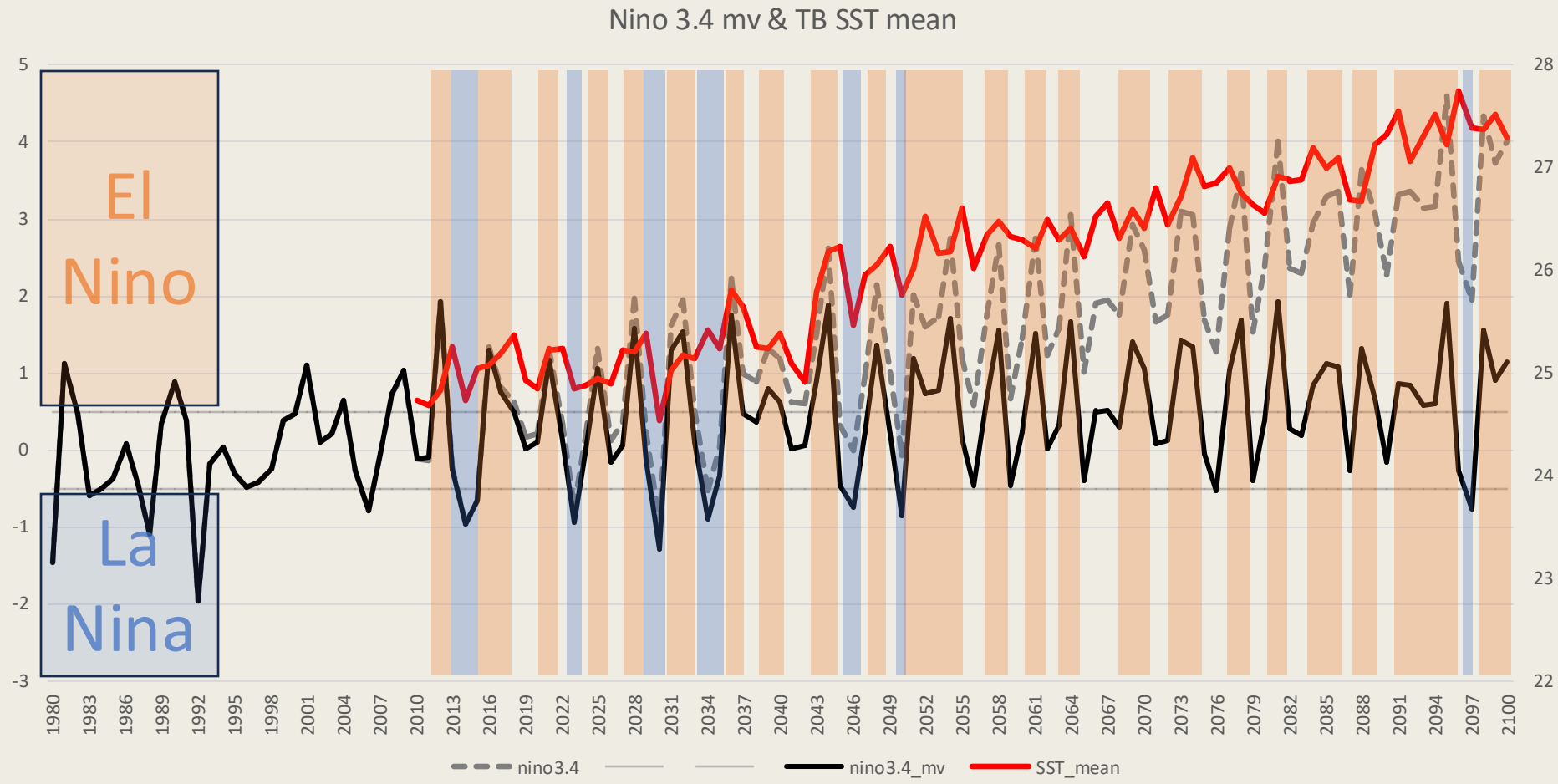
Dynamic bioclimate envelope model, DBEM





Cheung et al., 2013

Define ENSO like events



- Annual SST anomalies in the Niño3.4 area over the past 30 years
- Shift the baseline every 5 years

moving average	Check other papers
Detrending	Ensemble models

ENSO under climate scenario

2.2. *Methods*

In this study, El Niño and La Niña events were selected by using the SST anomaly averaged over the Niño3 region (5°S-5°N, 150°W-90°W, Niño3 index). In each observation and model, the El Niño and La Niña events were selected as periods when the Niño3 index exceeded half of its standard deviation (SD) for over six months (Levine et al., 2016). For

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ENSO phase-locking biases from the CMIP5 to CMIP6 models and a possible explanation

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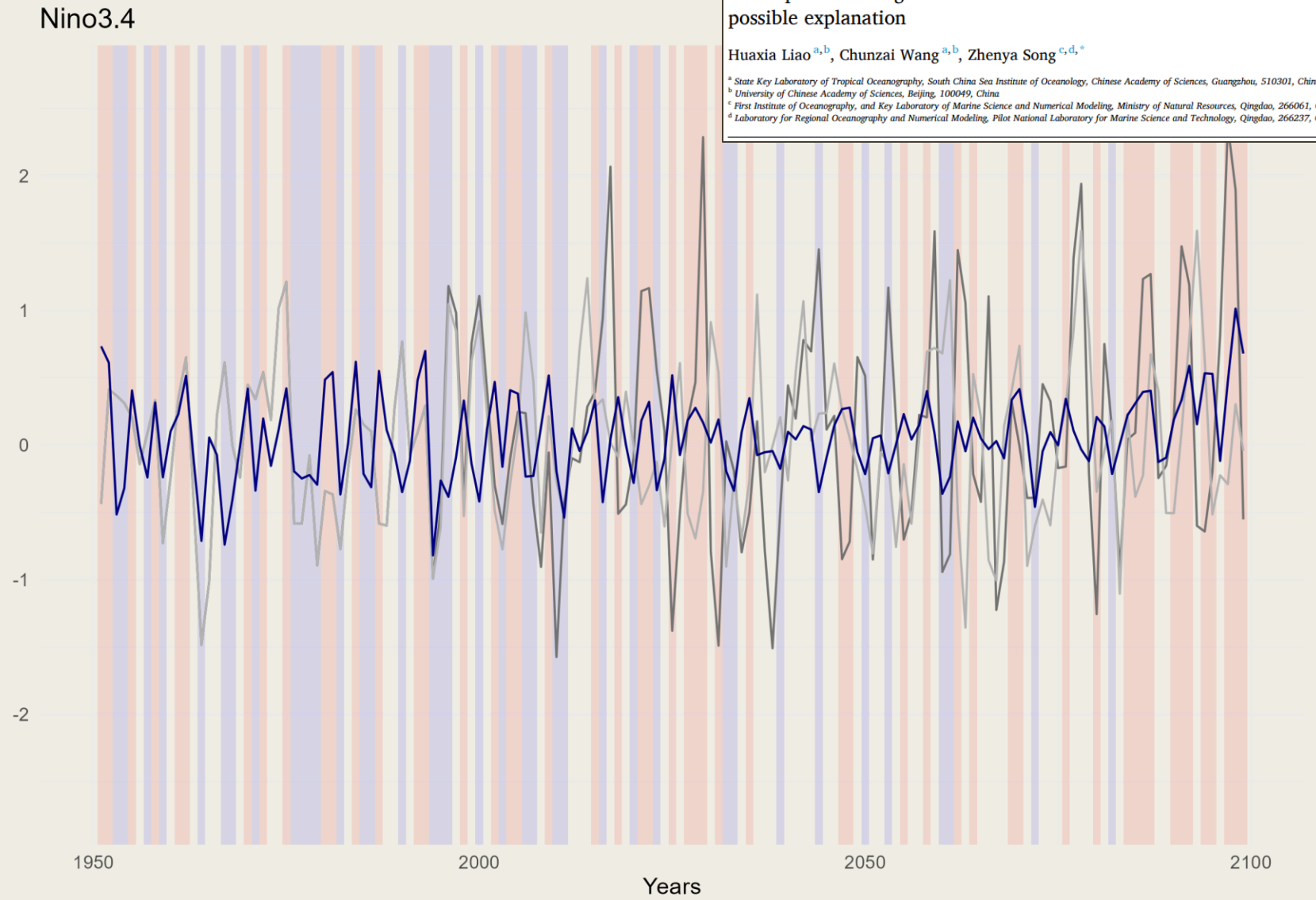
ENSO like events

Thresholds, +- 0.5 Standard Deviation (Liao et al., 2021) (SD, 0.3053365)



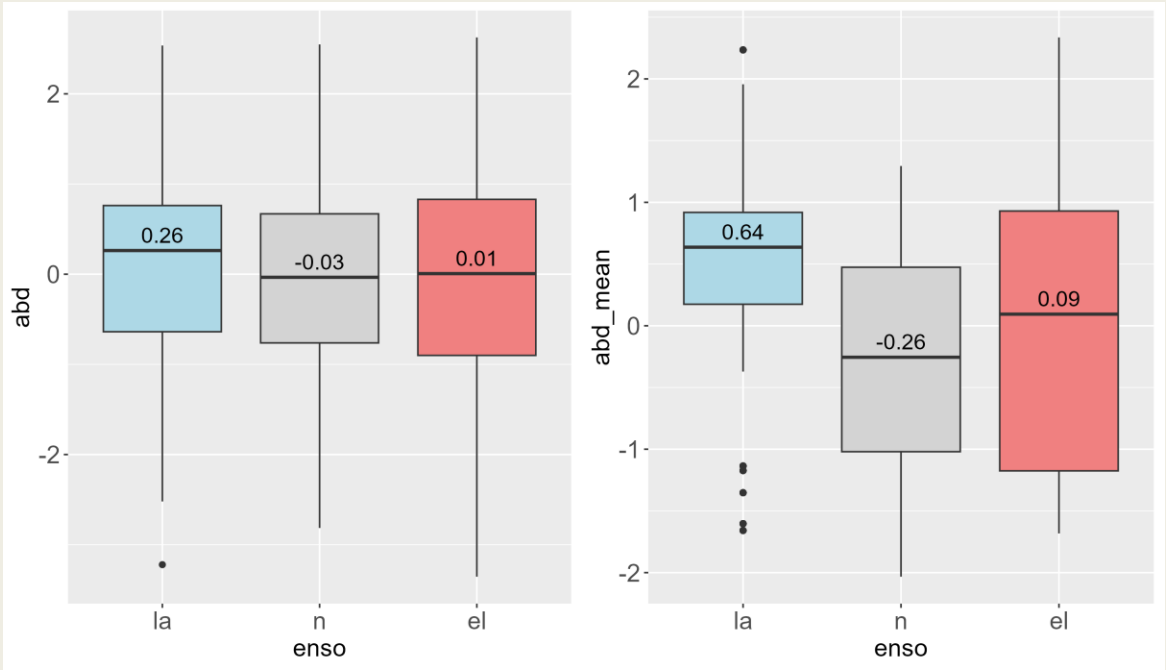
1950-2100 (150)
ENSO 90
La Nina 38
El Nino 52

	p1	p2	p3
LA	20	13	5
N	14	21	24
EL	16	16	20

Ensemble models
(10 Ensemble members)

Species

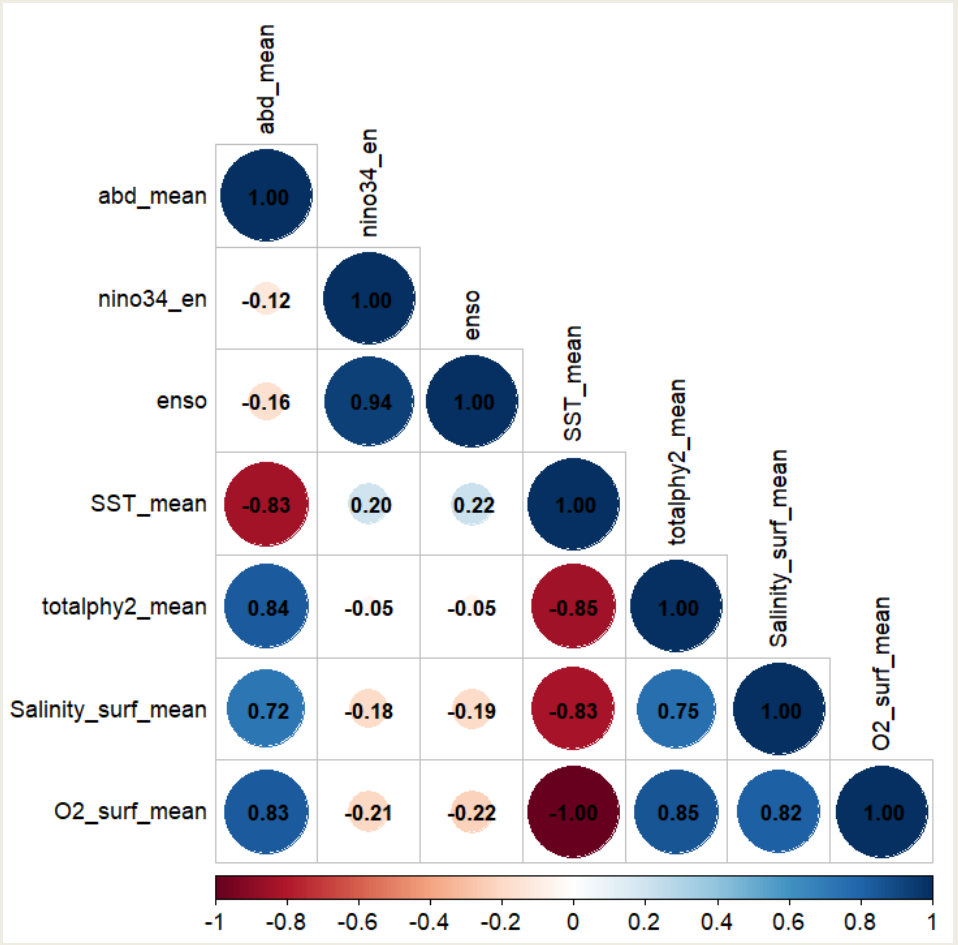
		Scientific_Name	common_name	taxa_code
1	Predator	Thunnus albacares	Yellowfin Tuna	600143
2	fish	Coryphaena hippurus	Dolphinfish	600006
3		Scomberomorus commerson	Spanish mackerel	600121
4	Pelagic	Scomber australasicus	Blue mackerel	600116
5	fish	Scomber japonicus	Chub mackerel	600117
6		Auxis rochei	Bullet tuna	600093
7		Decapterus maruadsi	Japanese scad	601939
8		Trachurus japonicus	Japanese jack mackerel	600366
9		Rastrelliger kanagurta	Indian mackerel	600111
10	Small pelagic fish	Sardinella lemuru	Bali sardinella	601510
11	Benthic	Seriola dumerili	Amberjack	601005
12	and Reef	Mene maculata	Moonfish	600390
13	fish	Psenopsis anomala	Pacific rudderfish	600497
14		Pennahia argentata	Silver croaker	600434
15		Pennahia anea	Donkey croaker	613664
16		Trichiurus lepturus	Hairtail	601288
17		Priacanthus macracanthus	Red bigeye	600356
18		Saurida tumbil	Lizardfish	606479
19		Saurida undosquamis	Brushtooth lizardfish	601055
20		Nemipterus virgatus	Golden threadfin bream	600396
21		Nemipterus japonicus	Japanese threadfin bream	604559

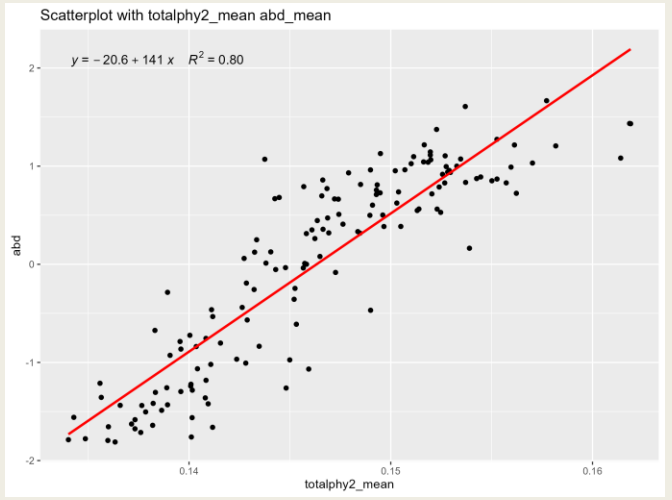


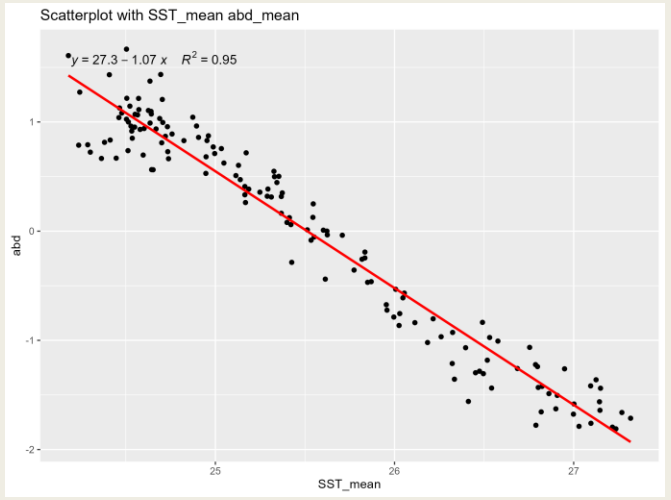
anova

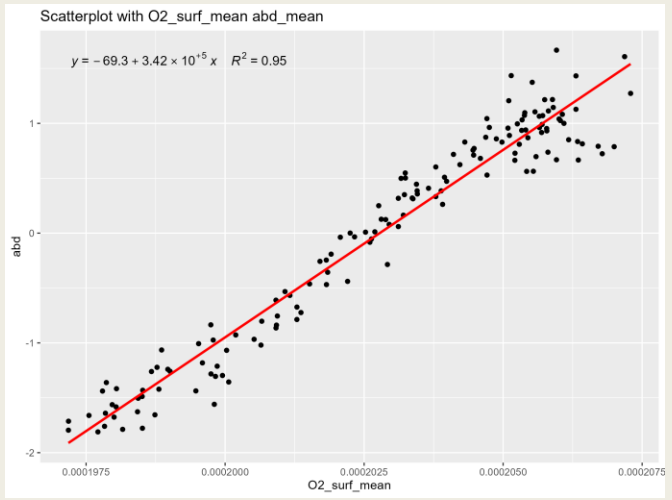
	Df	Sum Sq	Mean Sq	F value	Pr(>F)
enso_group	2	204.8	102.39	5.283	0.0062**
Residuals	132	2558.1	19.38		

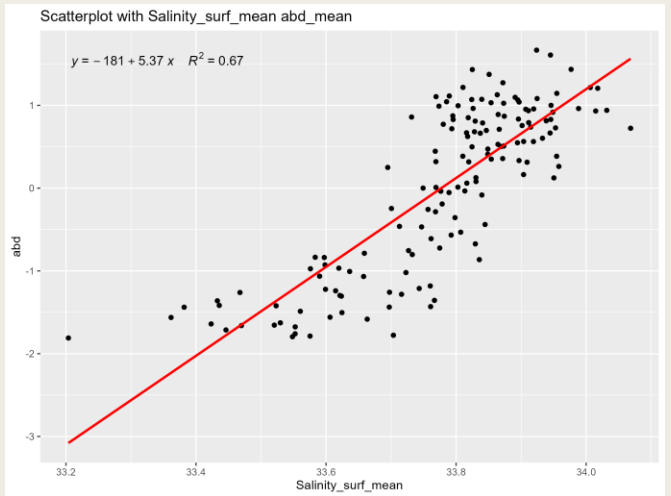
Correlation





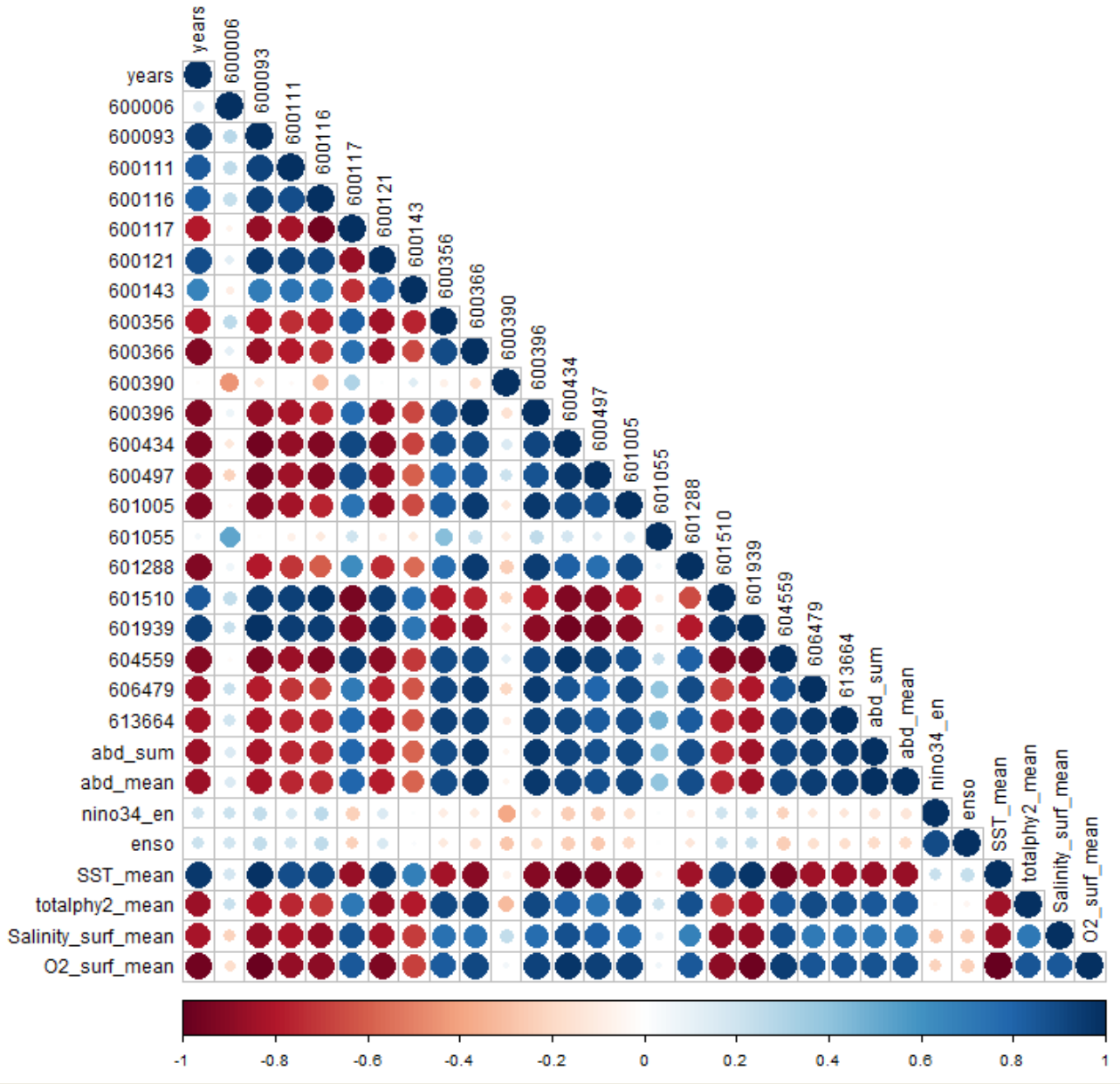






- ENSO and the Nino3.4 index exhibit low correlations with yearly mean species abundance and the environmental factors, with correlation coefficients (r) mostly ranging between 0.2 and 0.3.
- The environmental factors themselves show high correlations with each other.
- Strong negative correlation with SST, and positive correlations with NPP, O2, and salinity.
- Linear relationship between yearly mean species abundance and the four environmental factors.

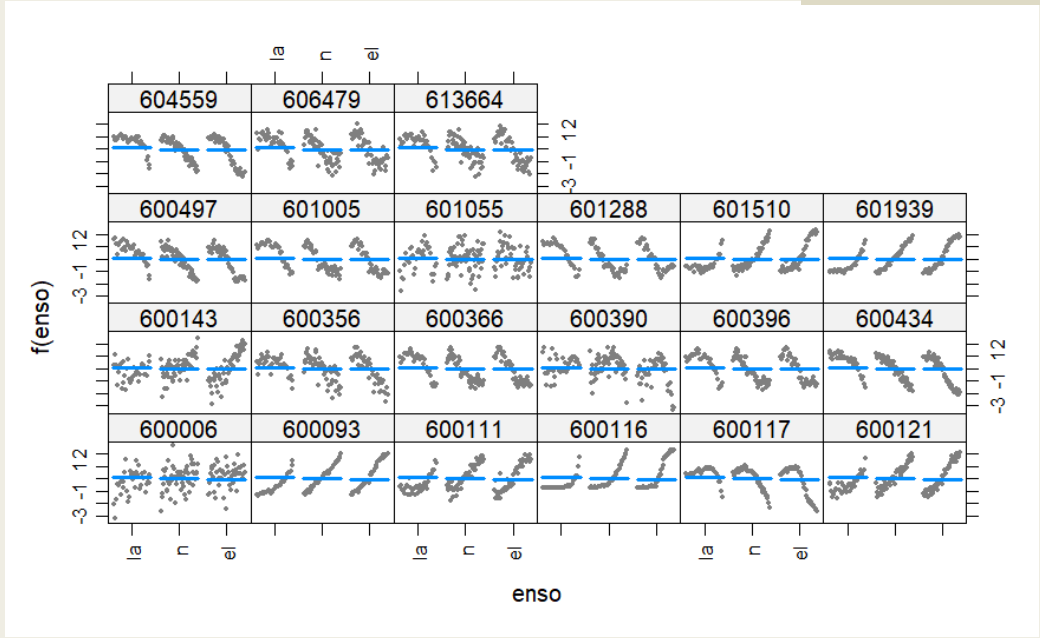
Correlation



- The correlations between species abundance and both ENSO and the Nino3.4 index also fall between 0.2 and 0.3. Different species show opposite responses to El Niño and La Niña events, indicating interspecies variability
- Different species also show varying preferences for environmental factors.
- However, the results consistently show that SST has an opposite effect compared to the other three environmental factors.
- The correlation between species abundance and SST is generally consistent with that of the Niño index and ENSO; species that show a positive correlation with SST also tend to be positively correlated with the Niño index and ENSO, and vice versa.

Abd ~ ENSO + (1|species)

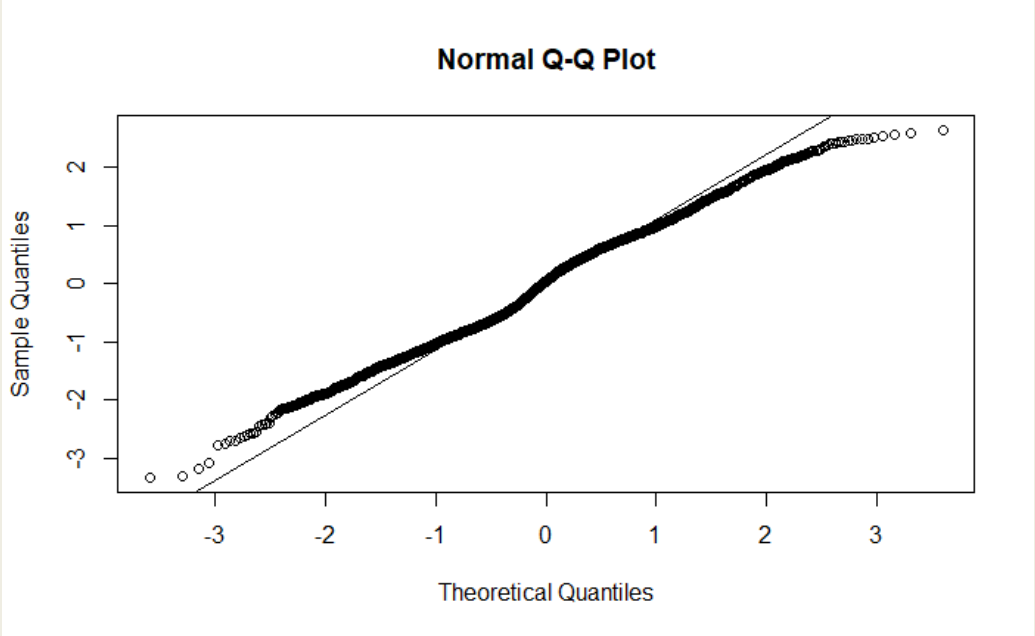
- Random intercept variance for species nearly 0, which means random effect is negligible.
- ENSO variable has a statistically significant impact on abundance, with an R^2 value of 0.003262. Notably, both Neutral and El Nino have a significant negative influence compared to the La Nina category.
- Although ENSO shows significant but still explain almost nothing.

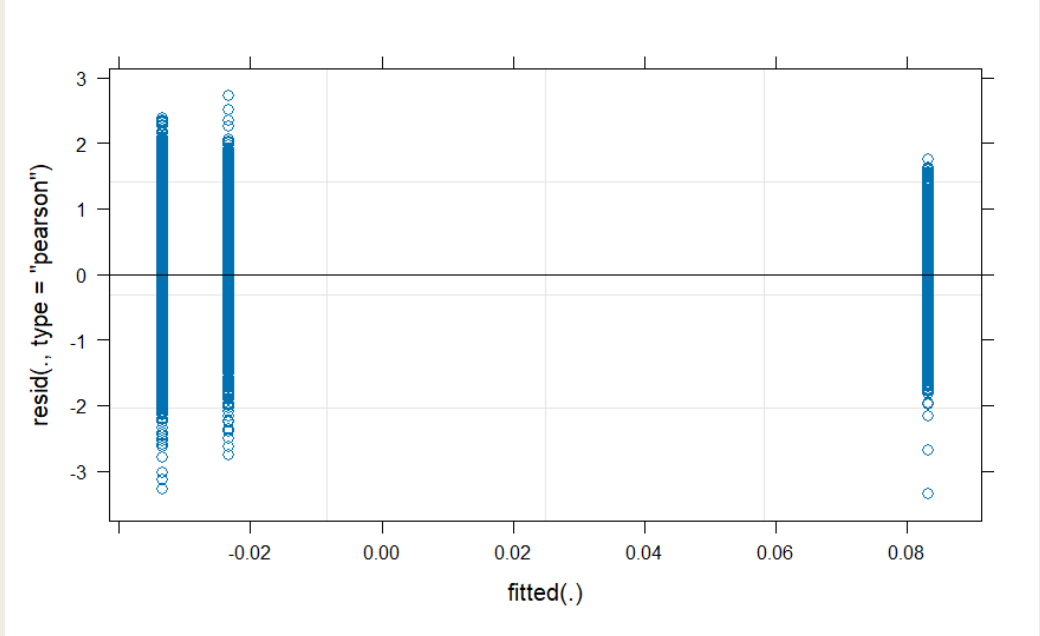


ENSO

Log trans

Z-score





LMM

Marginal R^2 Conditional R^2

	Estimate	Std. Error	df	t value	Pr(>|t|)		AIC	R2m	R2c
(Intercept)	0.09544	0.03524	3126	2.708	0.0068	**	8873.732	0.003262	0.003262
enson	-0.1402	0.04519	3126	-3.103	0.00193	**	8873.732	0.003262	0.003262
ensoel	-0.11439	0.04636	3126	-2.467	0.01366	*	8873.732	0.003262	0.003262
SST_mean	-0.18488	0.01938	3127	-9.538	<2e-16	***	8789.213	0.02826	0.02826
totalphy2_mean	29.9727	2.7649	3127	10.84	<2e-16	***	8753.594	0.036209	0.036209
Salinity_surf_mean	0.8823	0.1159	3127	7.612	3.54E-14	***	8817.901	0.018188	0.018188
O2_surf_mean	59674.23	6184.349	3127	9.649	<2e-16	***	8761.789	0.028905	0.028905

*nino34 has no significant, p-value 0.0756

- Regarding the fixed effects, in all combinations, only single parameter results showed significance, while models with two or more parameters were not significant.
- Among environmental factors, the model with the lowest AIC was for NPP, at 8753.594, and it also had the highest R^2 value of 0.036209.
- Overall, the results indicate that the LMM model has a low explanatory and is unable to account for changes in species abundance, with species as a random effect being nearly zero.

Random effect

boundary (singular) fit

Variance very small

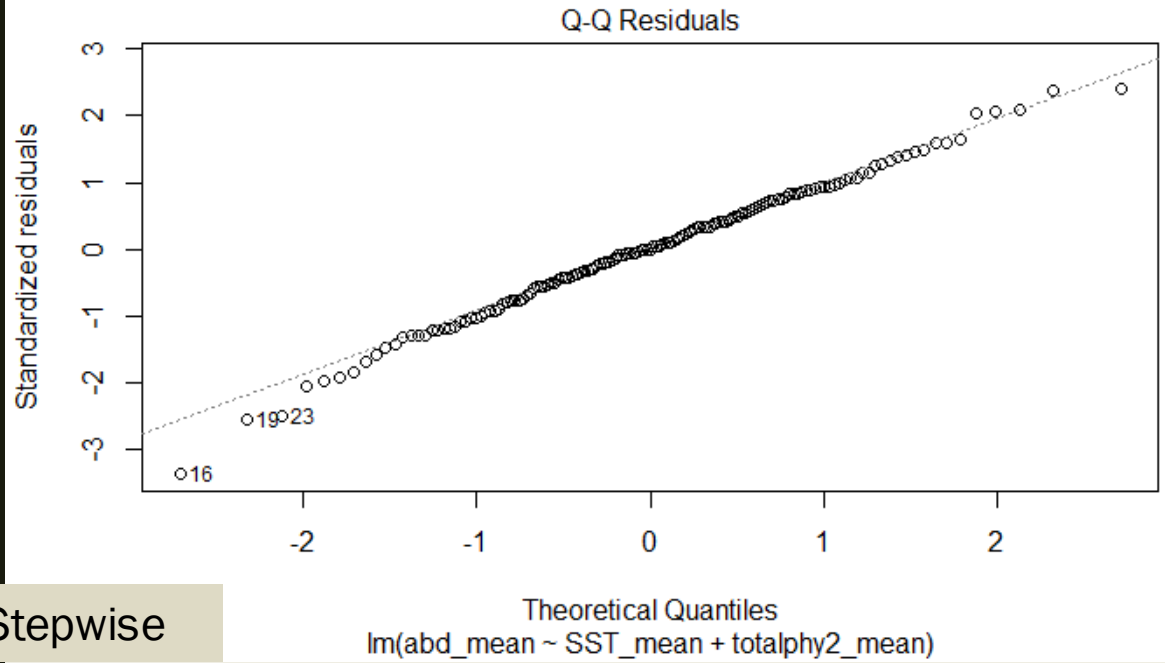
(1|Species) cannot explain the variance, less/no effect

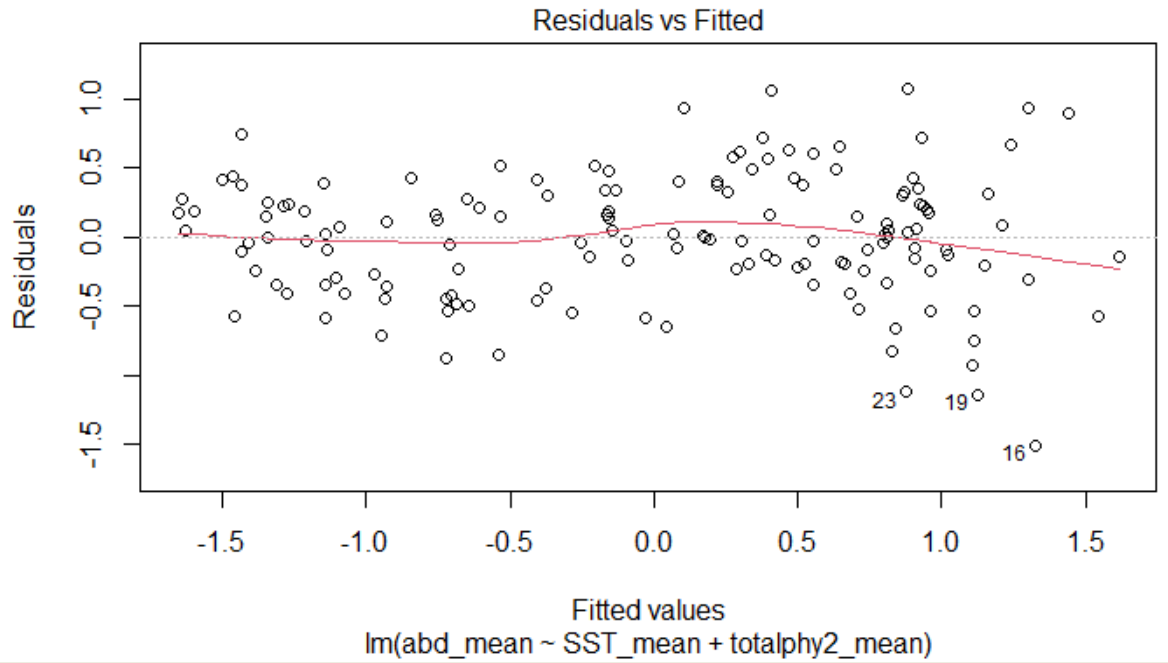
Interaction ?

Multicollinearity?

Fixed effect

Only single NPP has lowest AIC, but explanatory still low





Stepwise

lm(abd_mean ~ SST_mean + totalphy2_mean)

	Estimate	Std. Error	t value	Pr(>|t|)		Partial R^2	Multiple R-squared:	Adjusted R-squared:	AIC
(Intercept)	-1.14E-14	3.72E-02	0	1					
SST_mean	-5.34E-01	6.98E-02	-7.65	2.49E-12	***	0.286			-184.37
totalphy2_mean	3.95E-01	6.98E-02	5.65	8.12E-08	***	0.179			-205.13
total							0.797	0.7942	-232.59

Coefficient for SST of -0.5341 and for NPP of 0.3945.
The overall R^2 was 0.79, with Partial R^2 values of 0.286 for SST and 0.179 for NPP

N=149

Model performance

Shapiro-Wilk	Residual normality	W = 0.99244 · p-value = 0.6193
Durbin-Watson	Residual autocorrelation?	D-W = 1.058929 · p-value = 0
VIF	Multicollinearity?	

VIF

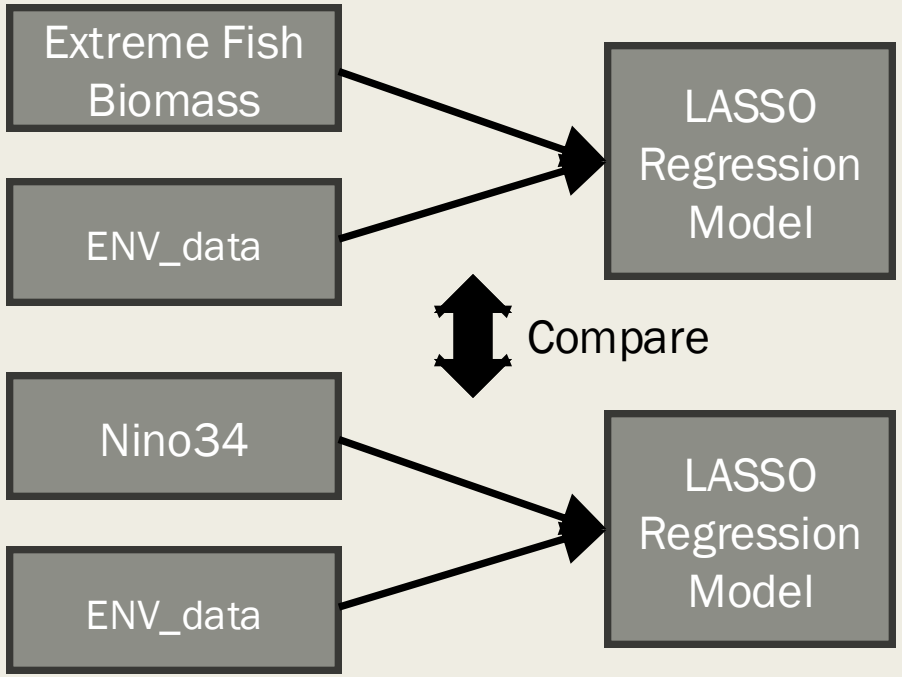
nino34_en	SST_mean	totalphy2_mean	Salinity_surf _mean	O2_surf _mean
1.238329	580.936482	4.339453	5.495035	548.713333

- NPP may be influenced by SST or O2, causing it to capture part of their effects in the model and appear more significant.
- The absence of significant results for species as a random effect may stem from interactions and collinearity among variables.
- While ENSO, SST, O2, and salinity do affect species abundance, their influence is less pronounced than that of NPP.

Preliminary Summary

- **ENSO and Abundance Changes**: El Niño events increase, with higher species abundance during La Niña; ENSO's impact is overshadowed by environmental factors, making it non-significant.
- **Environmental Factors**: Species abundance is negatively correlated with SST and positively correlated with NPP, O_2, and salinity.
- **Model Performance**: Species as a random effect has little influence; R^2 of the model without random effects is 0.79, but autocorrelation and multicollinearity affect explanatory power.
- **Future Direction**: ENSO effects may be nonlinear; using a GAM is recommended for further analysis.

Working on……



Improve currents LM,LMM:

Stepwise Comparison		LM
↓	Or	↓
Multimodel Comparison		GAM

THANKS FOR LISTENING