This presentation contains preliminary results

From physics to fish and beyond: 70 years of subregional variability in the California Current

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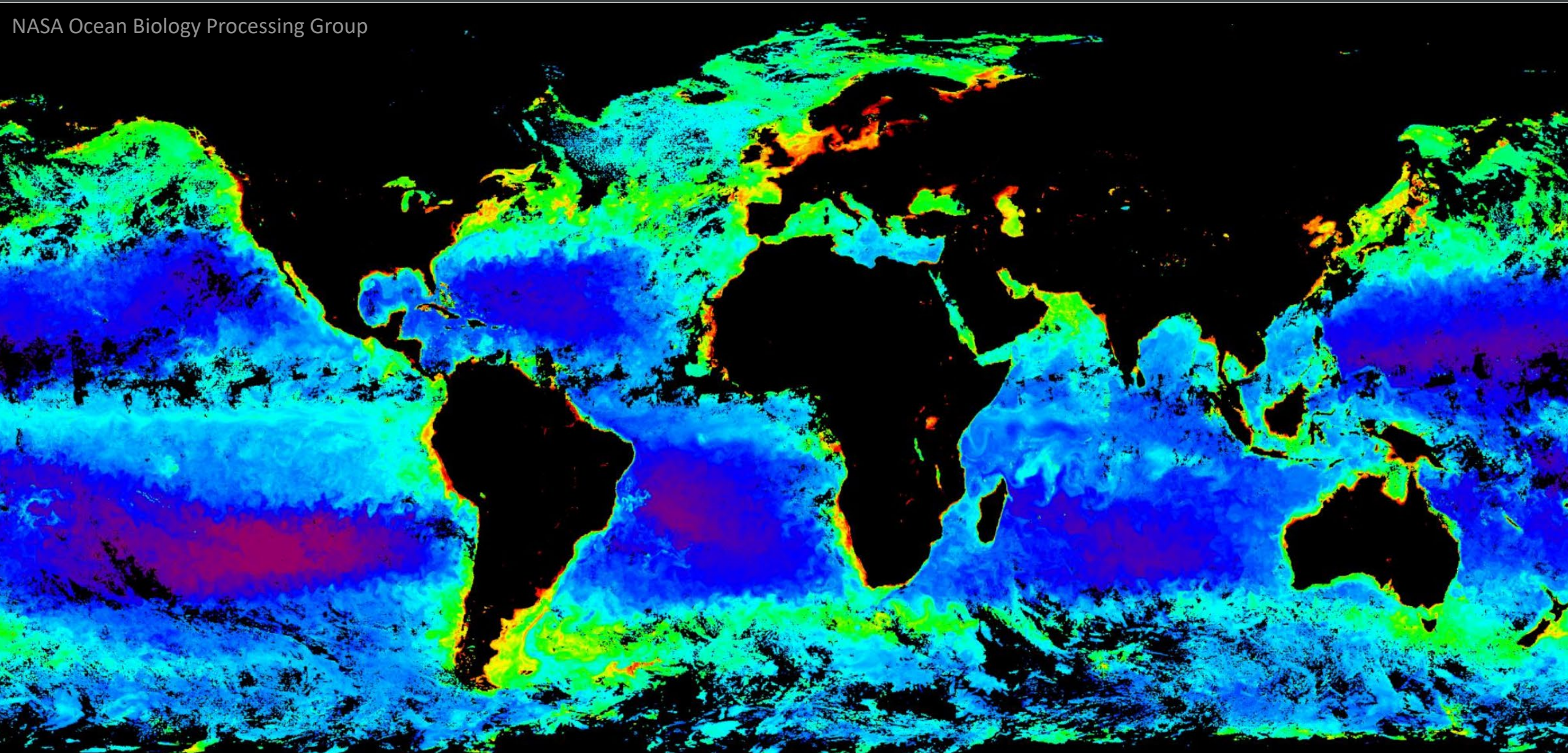
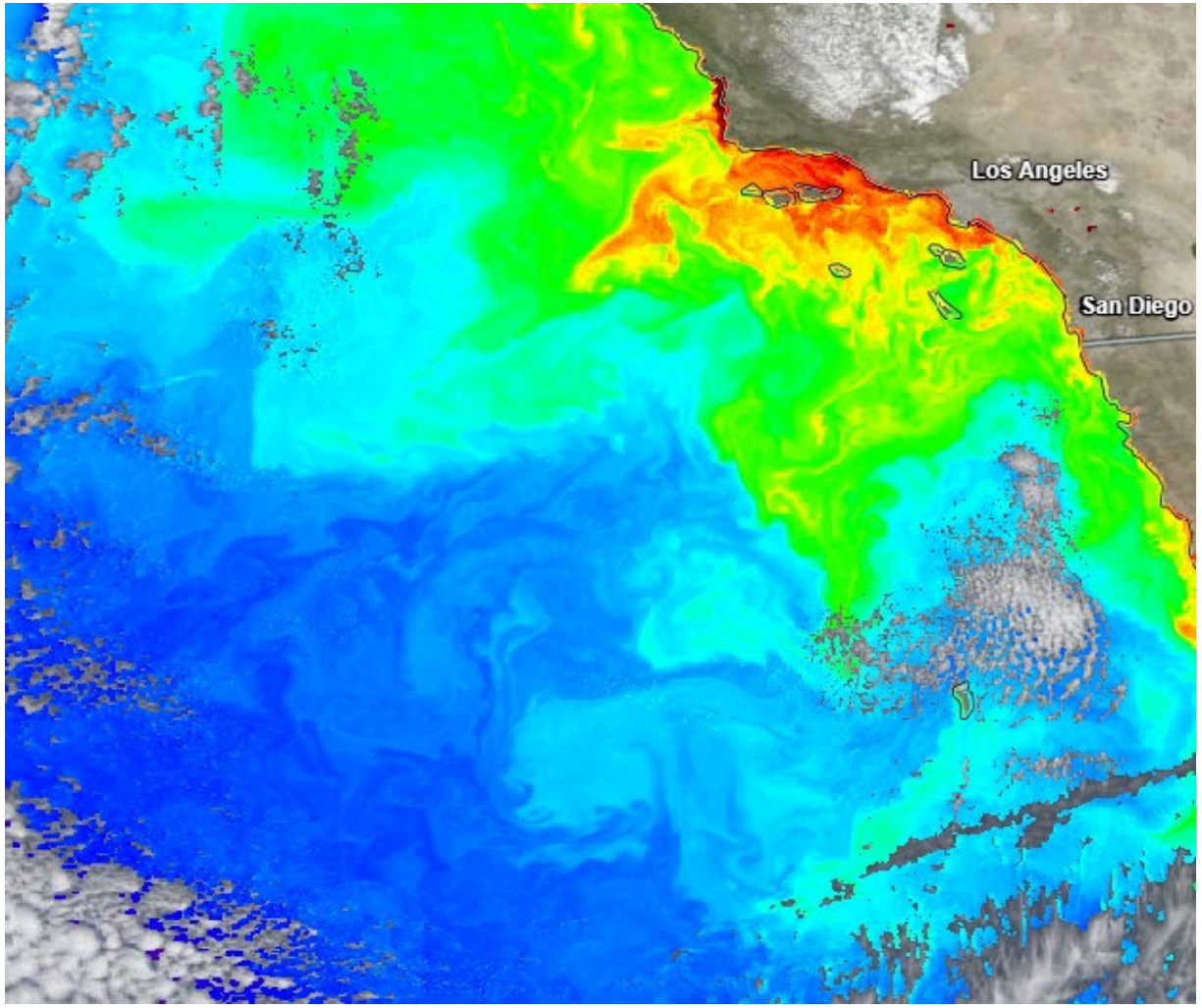
Marine Primary Production Greatly Varies Over Spatial Scales



The California Current Ecosystem Spans a Large Environmental Gradient

March 15, 2025 – Chlorophyll a concentration



NASA Worldview

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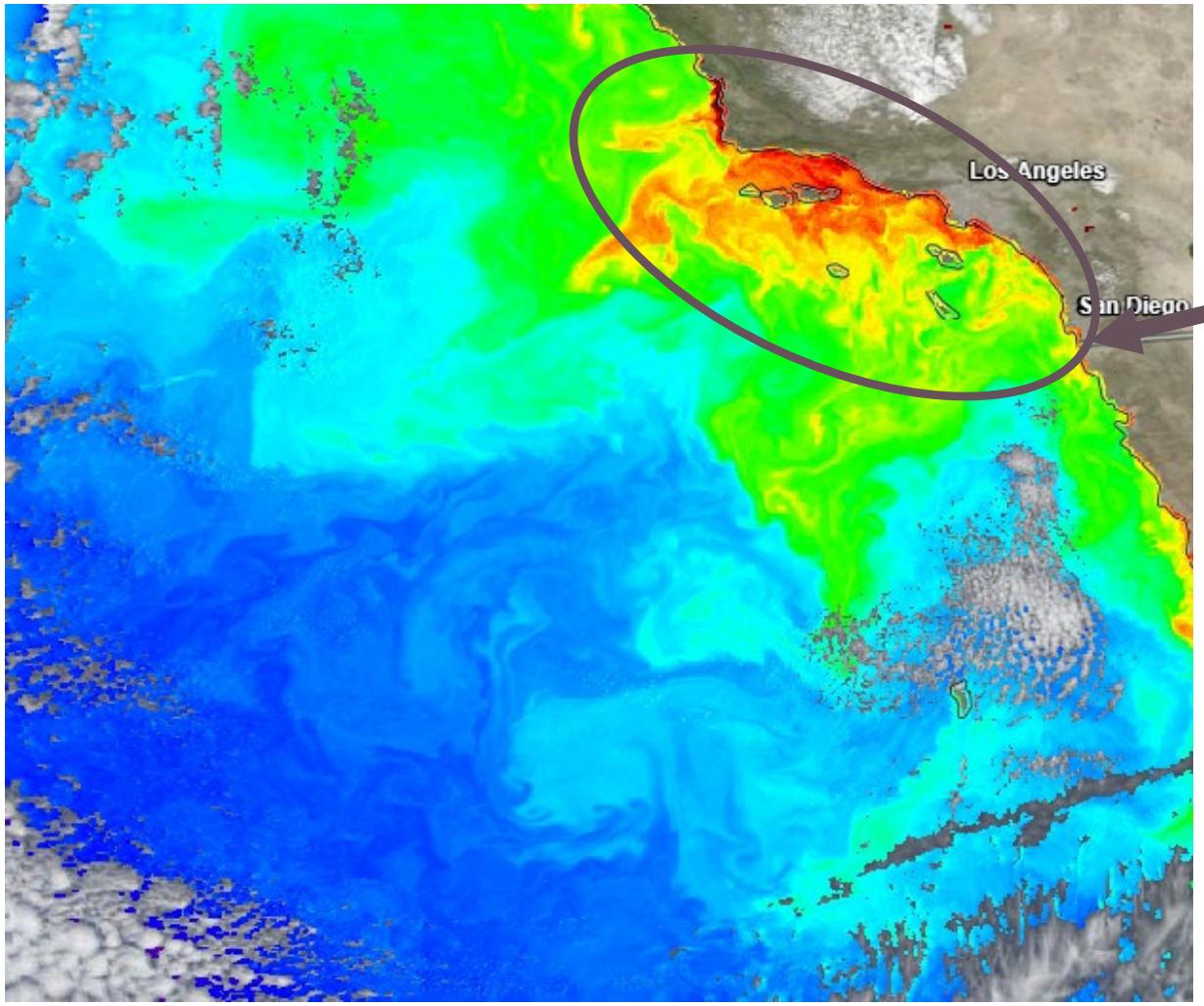

NASA Worldview

Onshore:

- Cool and nutrient rich
- High productivity

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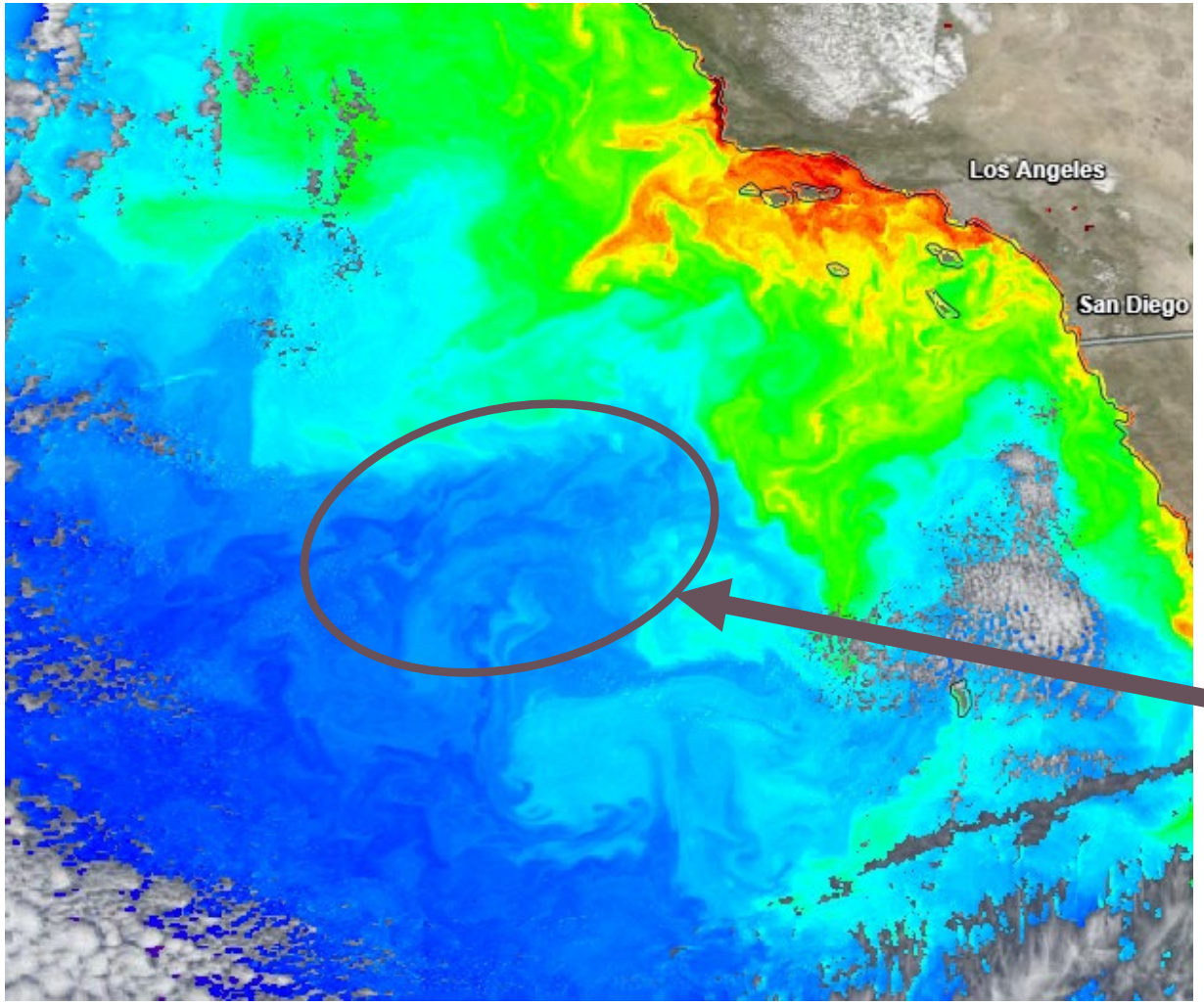

NASA Worldview

Offshore:

- Warm and nutrient poor
- Low productivity

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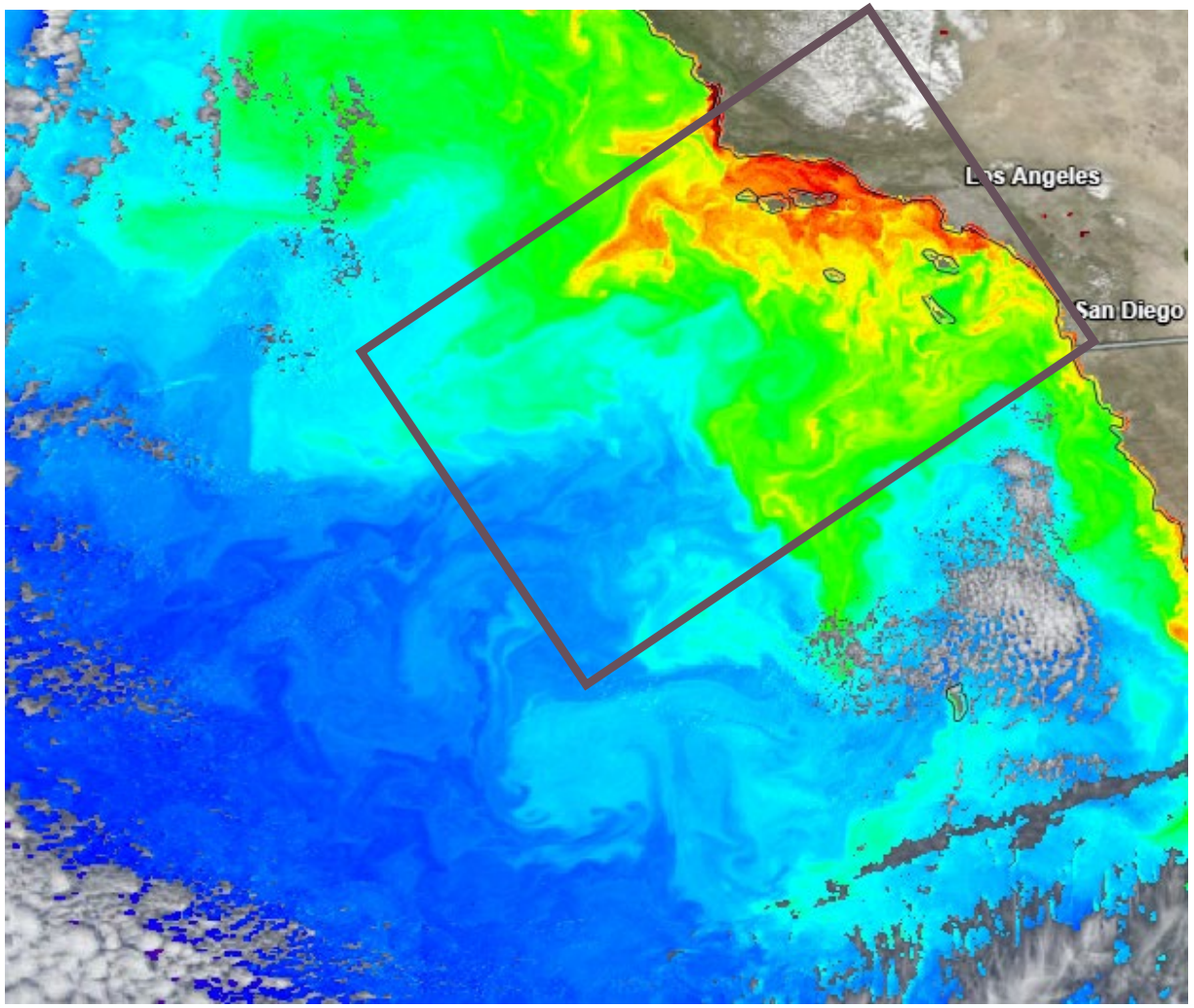

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Onshore:

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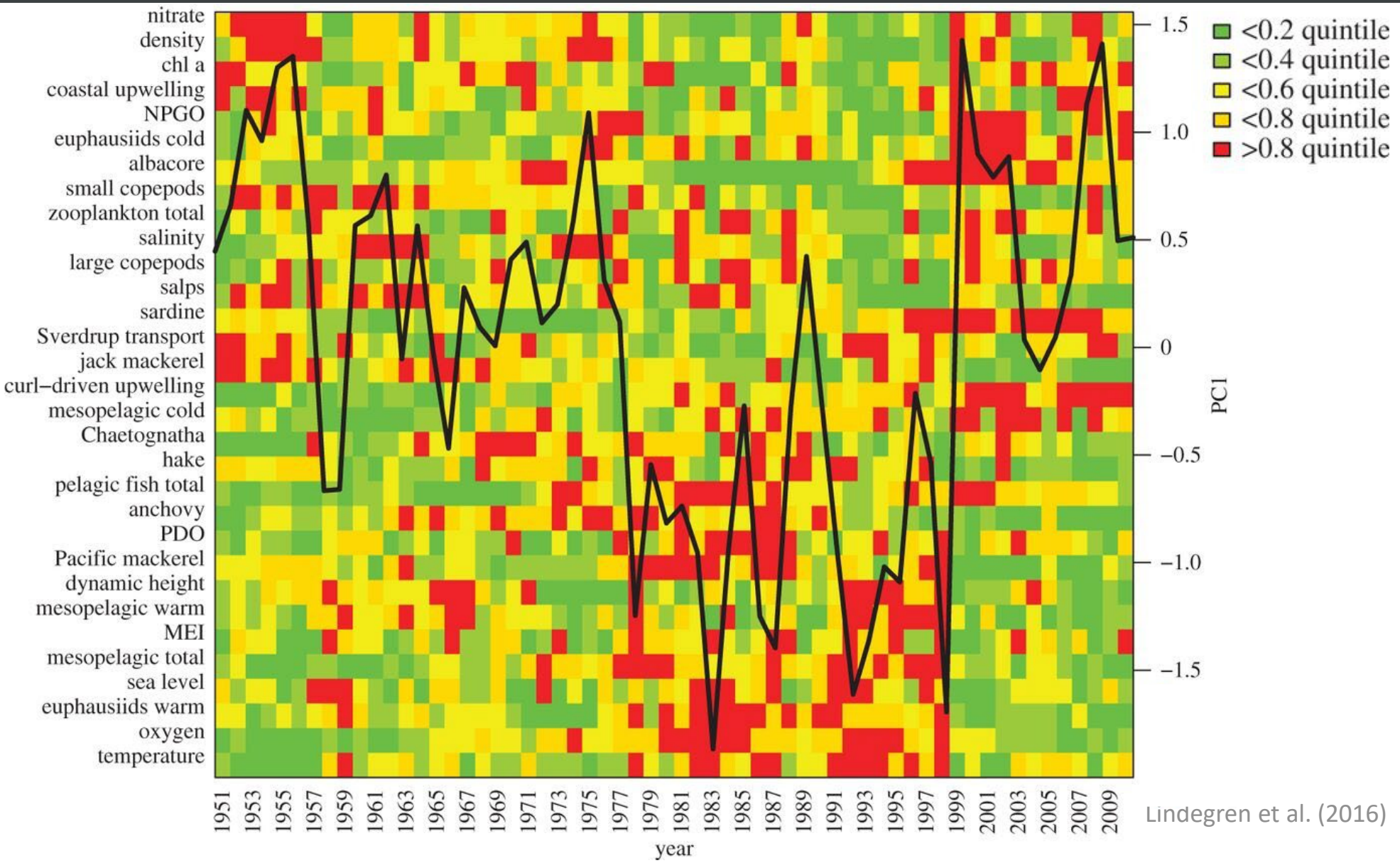
The California Current Ecosystem Oscillates Between Cool and Warm Phases



Lindegren et al. (2016)

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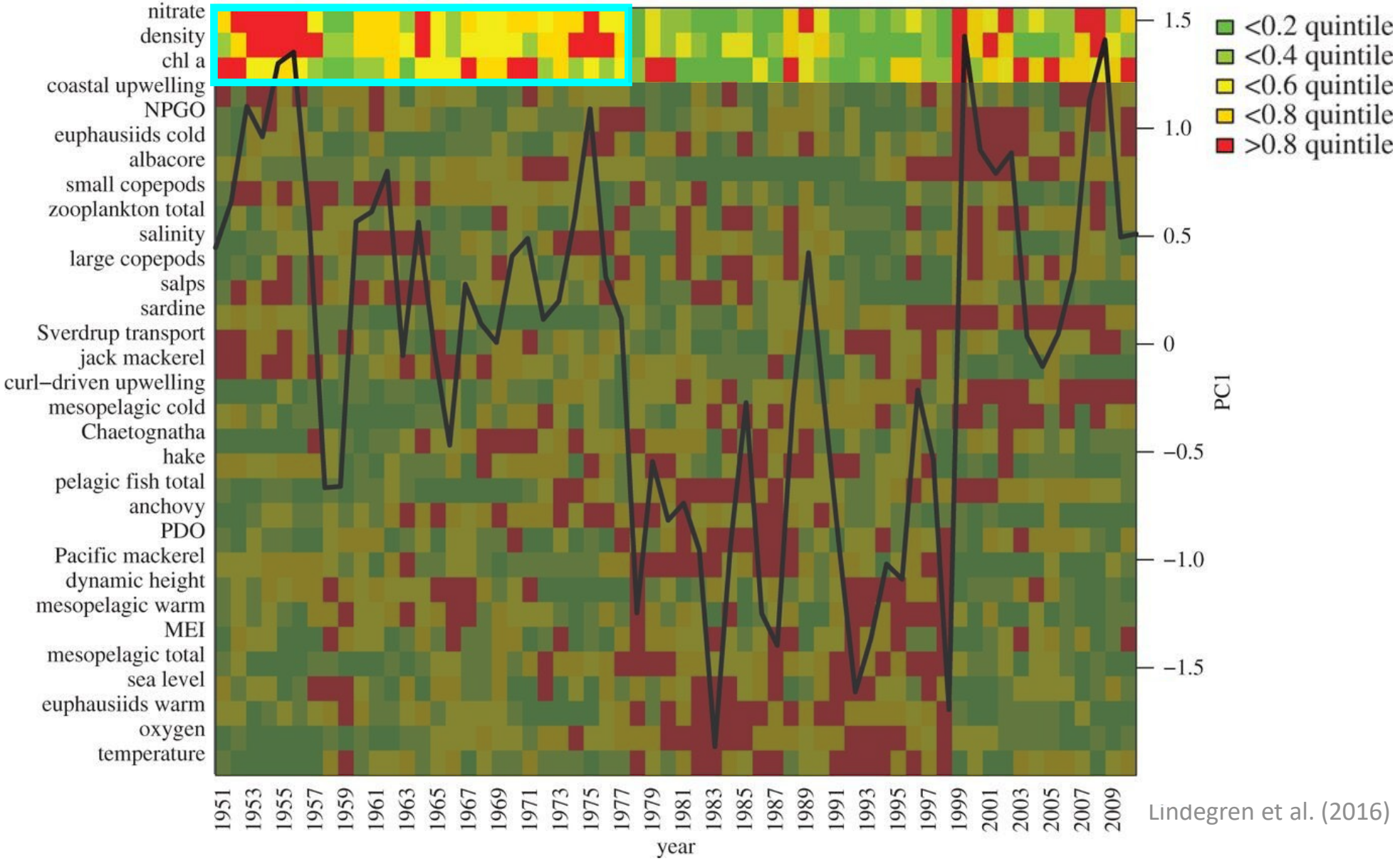

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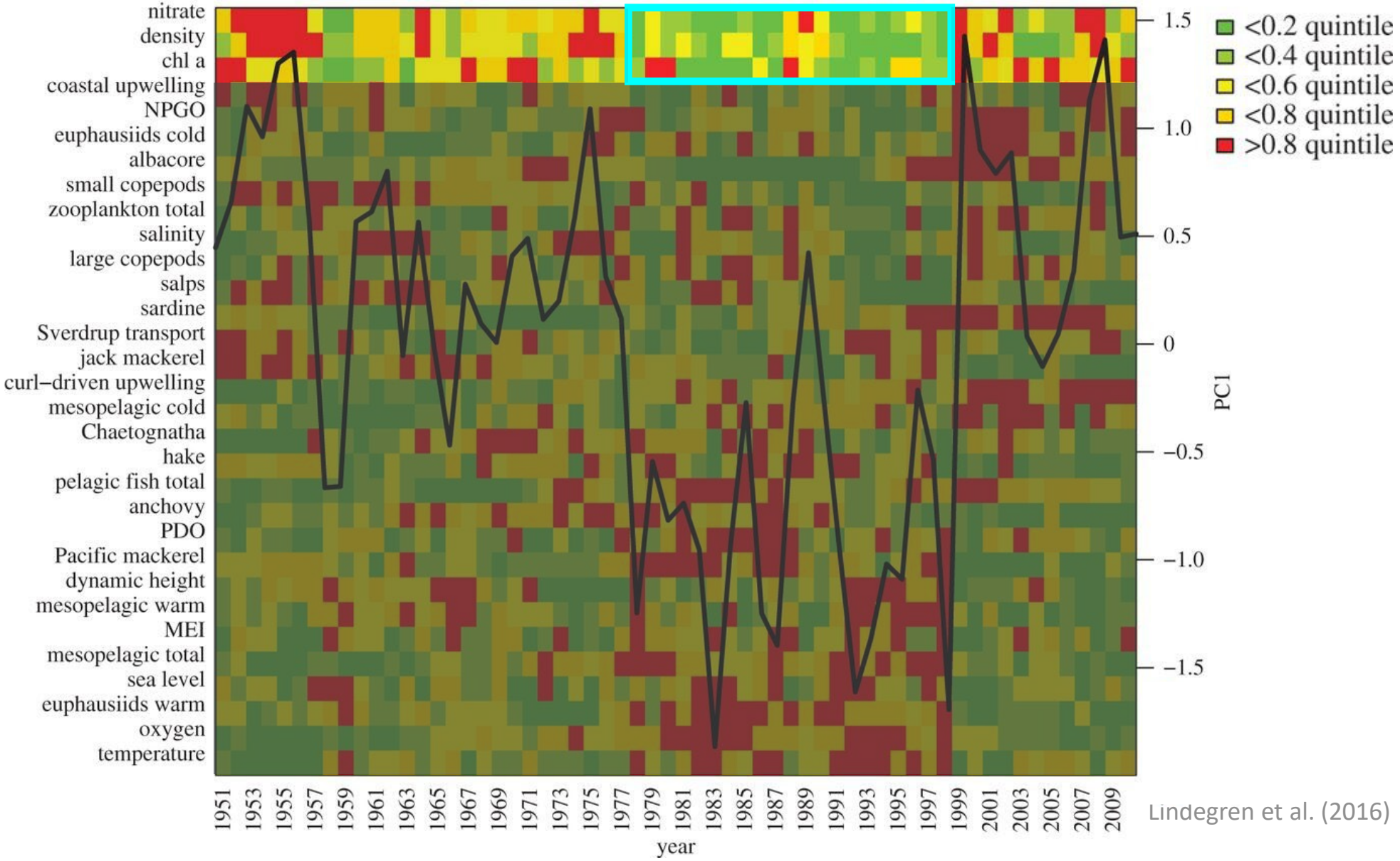

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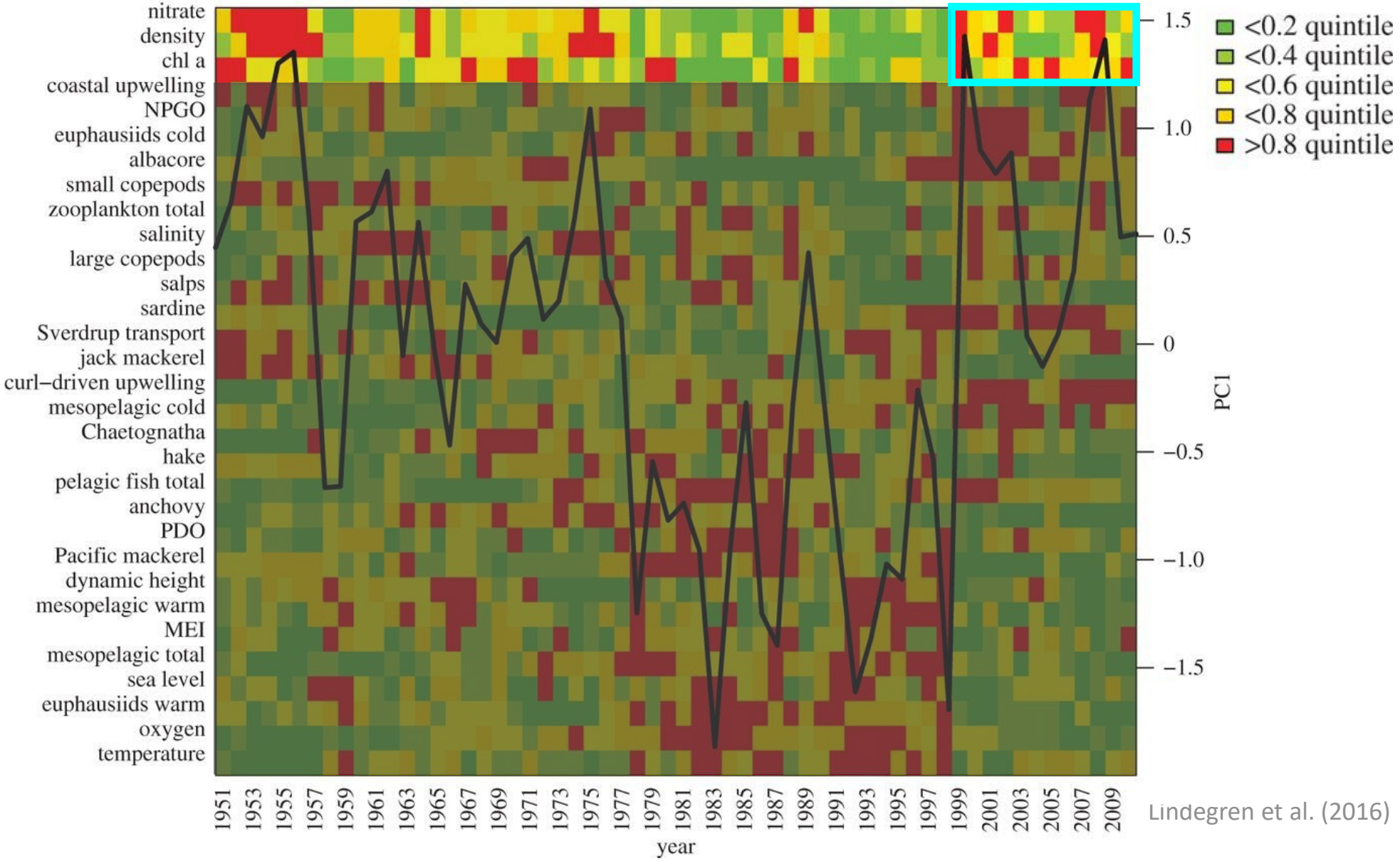

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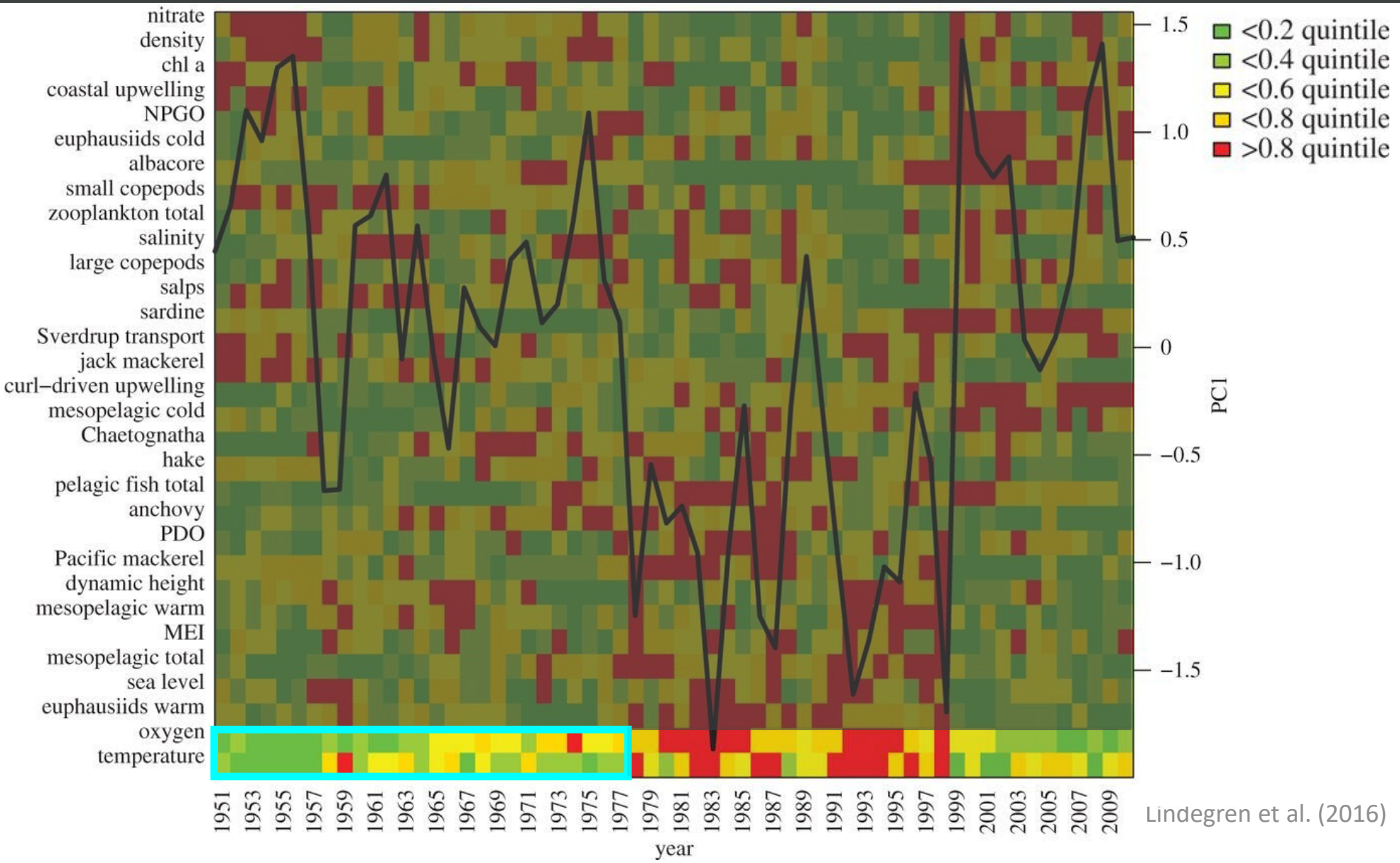

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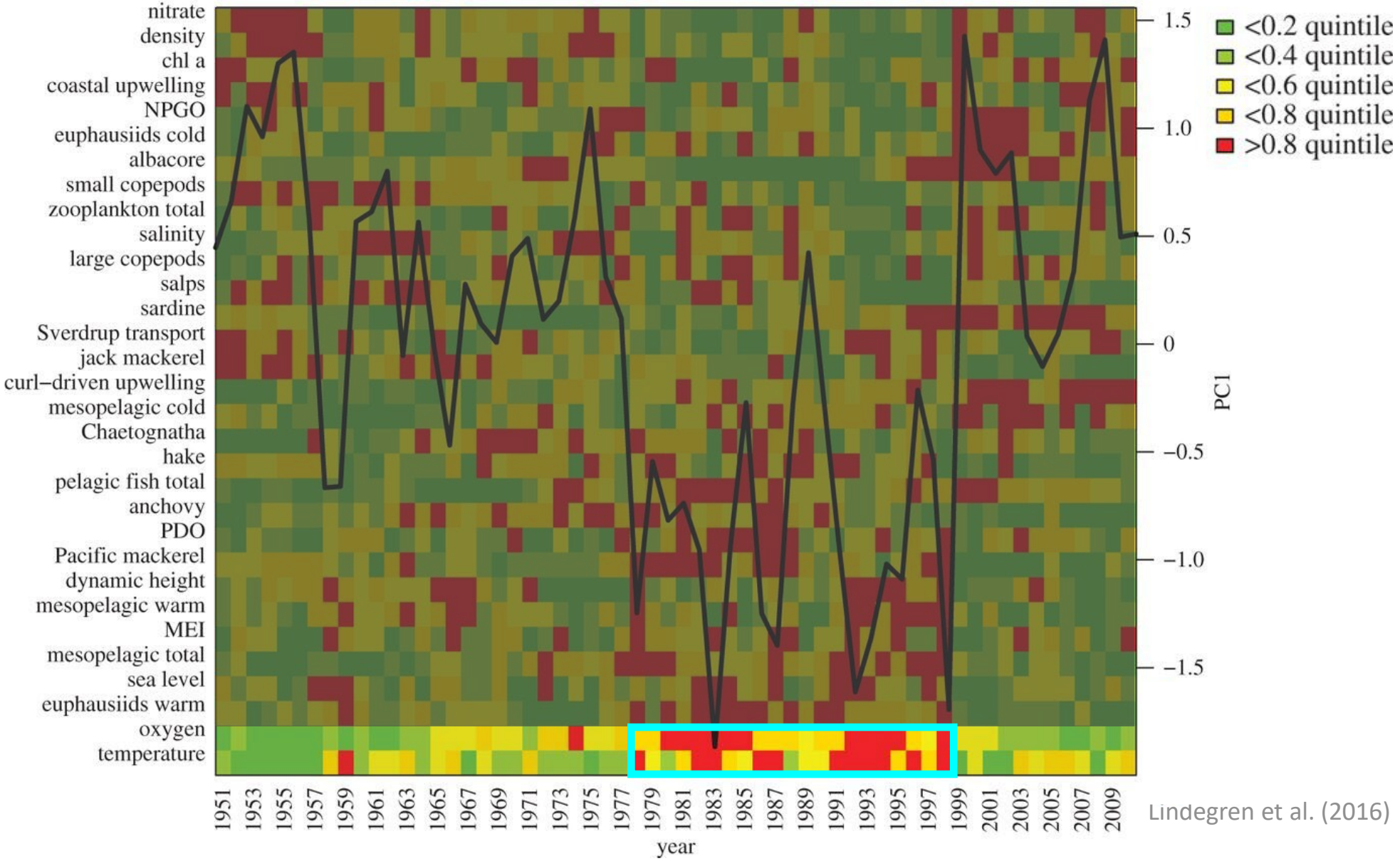

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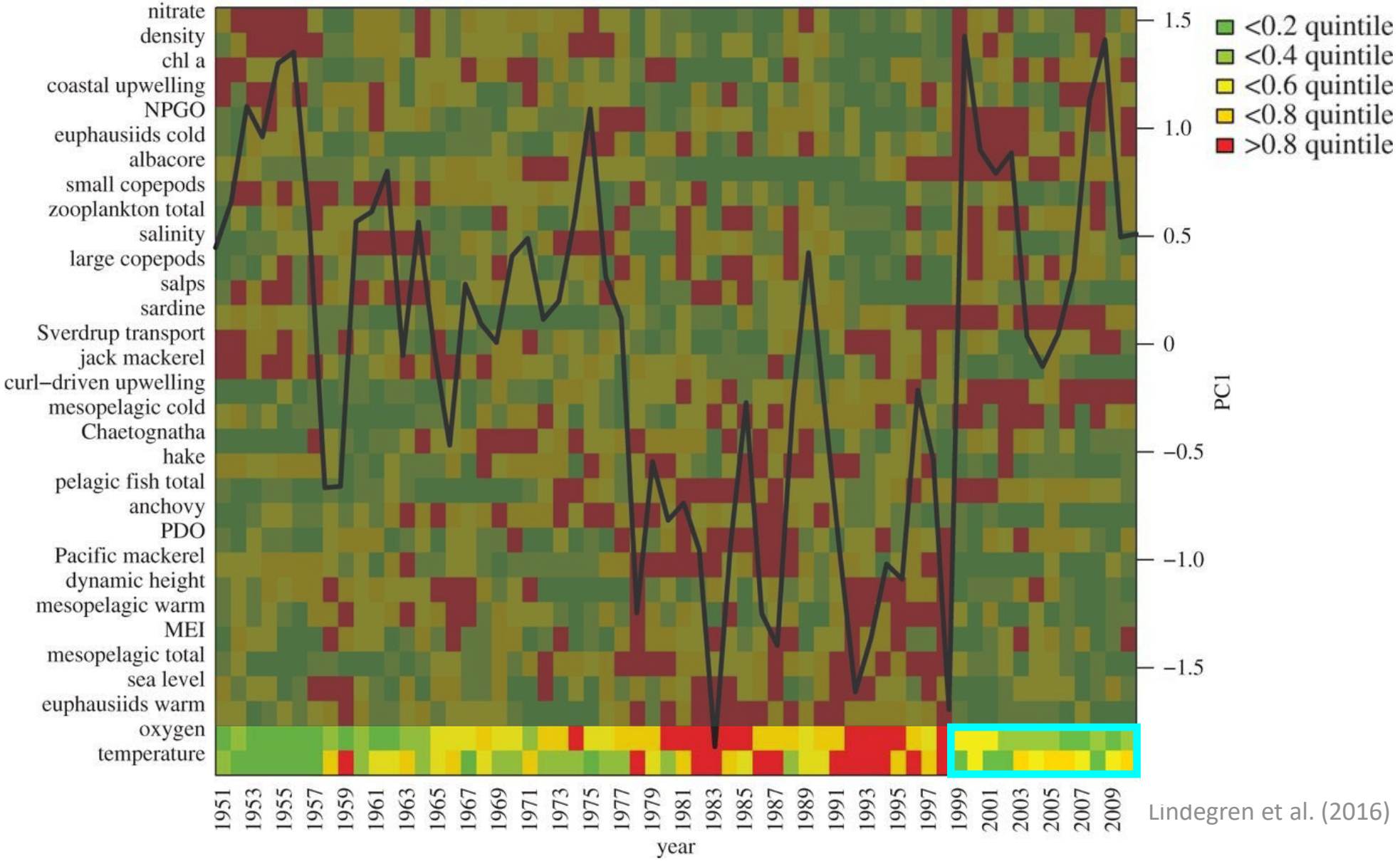

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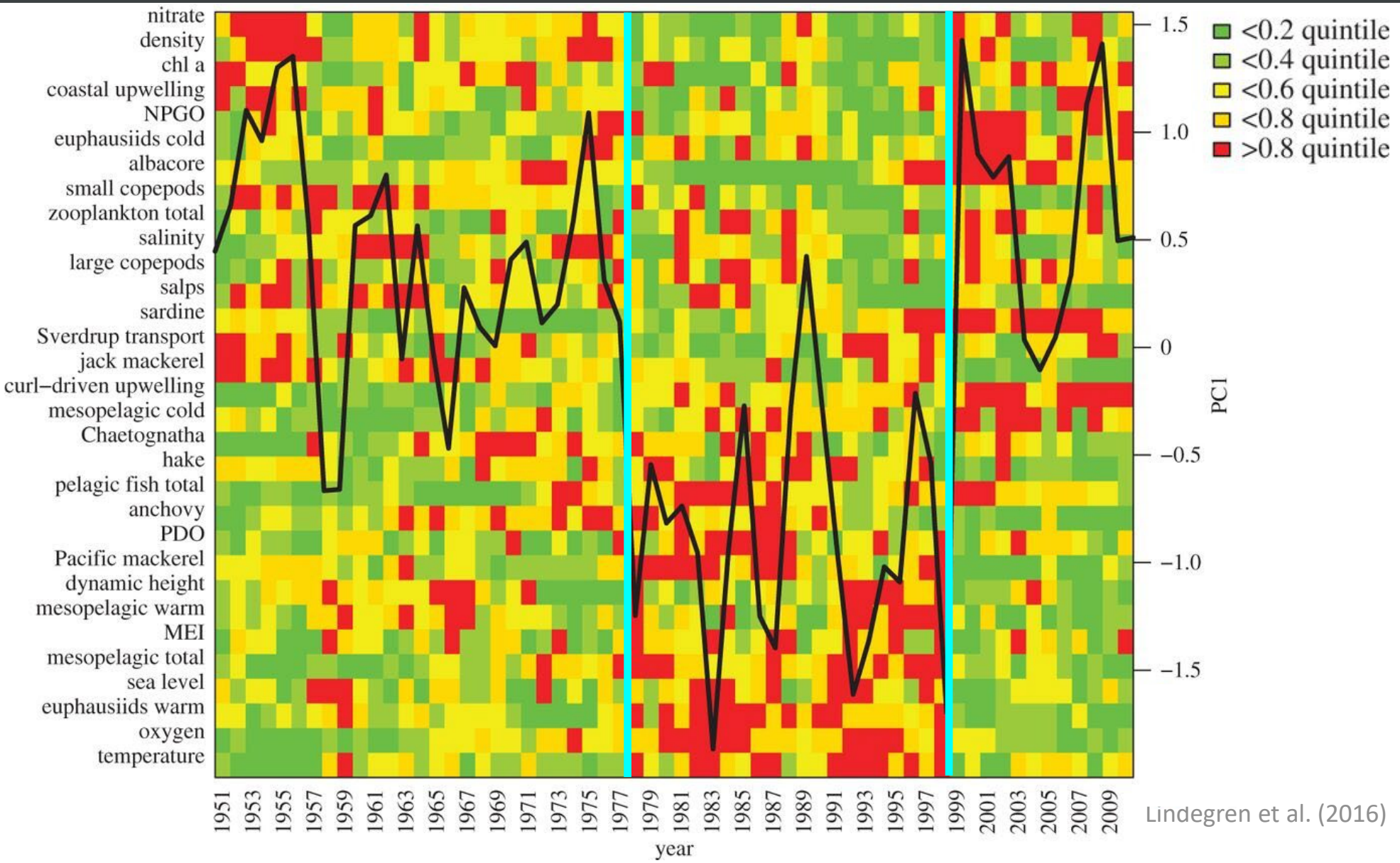
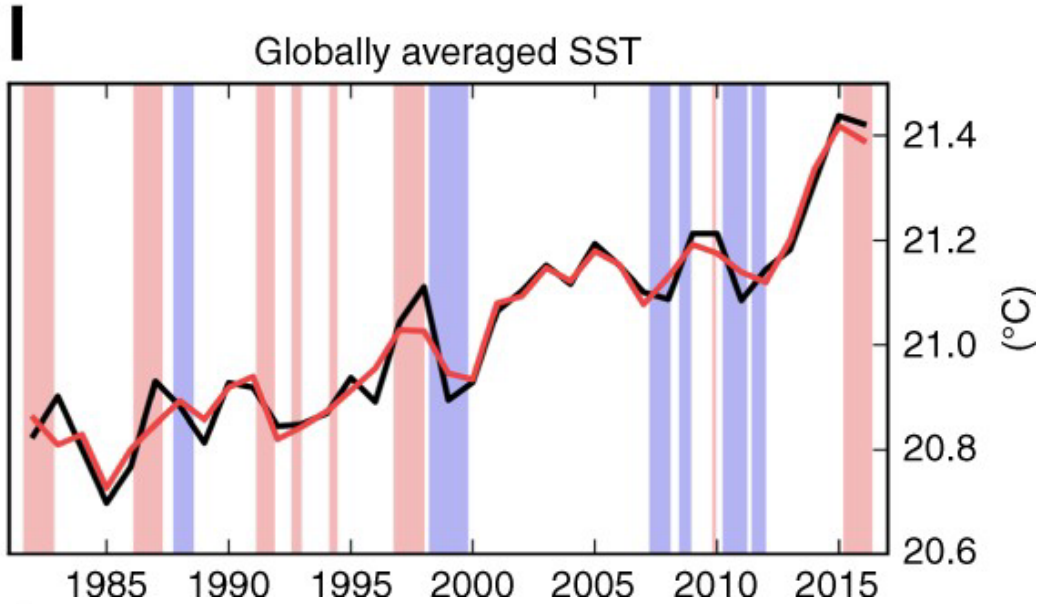
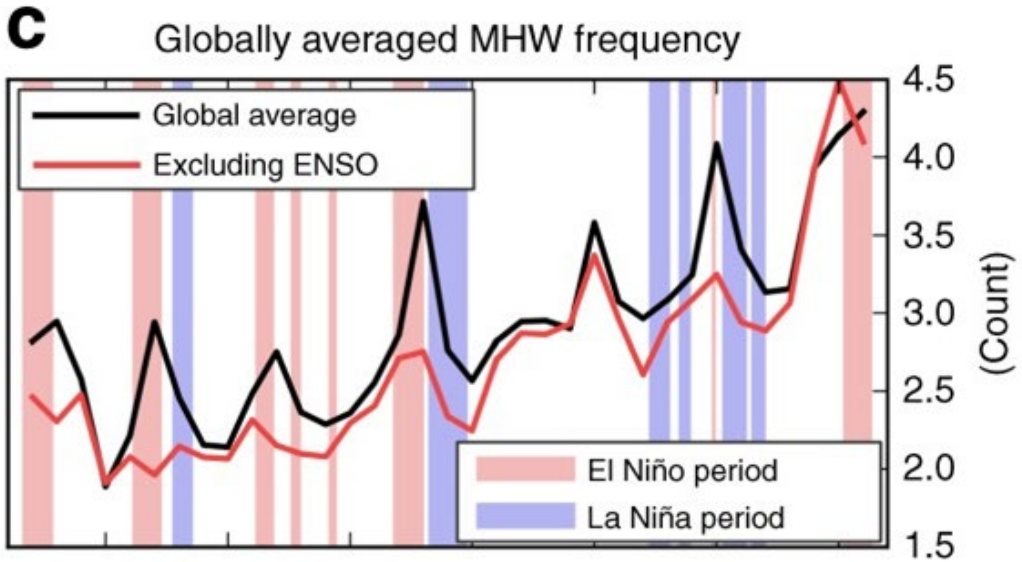


Lindegren et al. (2016)

Since 2010, We Have Seen Major Changes in The System



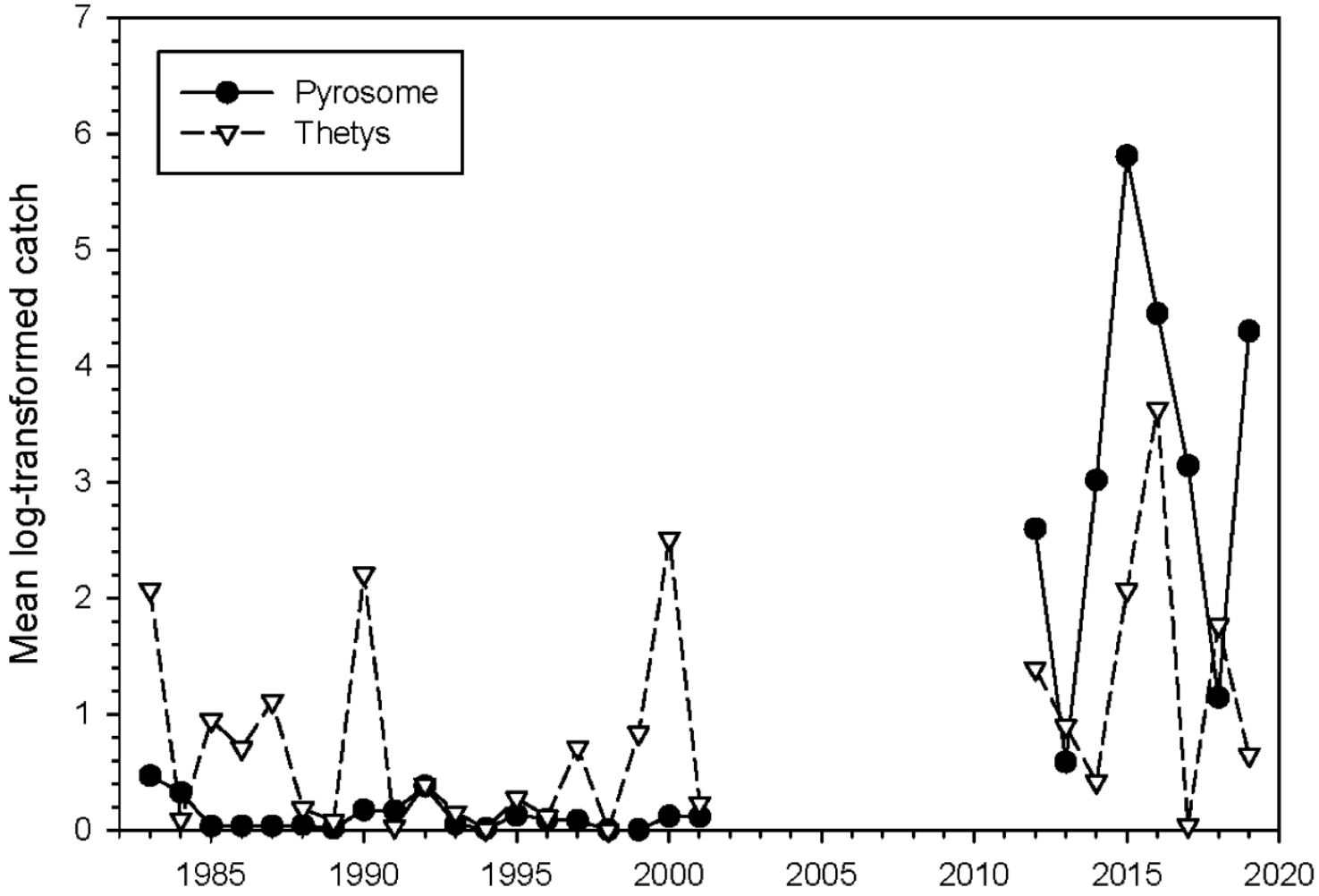


Oliver et al. (2018)

Sea surface temperatures are increasing

Marine heat waves (MHWs) are increasing in frequency, duration, and intensity

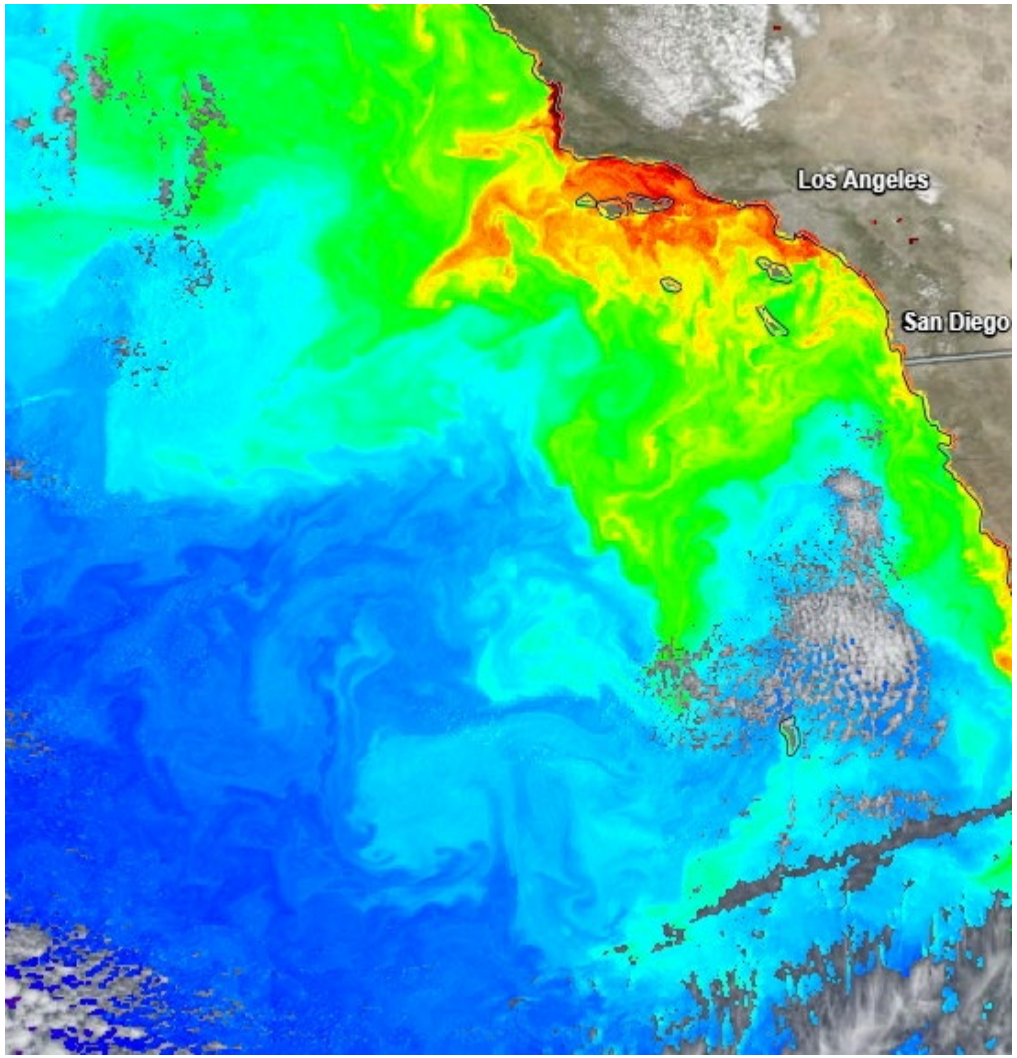
Since 2010, We Have Seen Major Changes in The System



Miller et al. (2019)

Zooplankton community composition is changing

Motivating Questions



1. With the recent El Niño events, increasing SST and MHWs, is the CCE still driven by the same physical processes? And can ecosystem variability still be described by interdecadal fluctuations between warm and cool phases?

2. Do the subregions of the California Current Ecosystem (CCE) respond similarly to physical forcing over time?

3. Do the subregions equally influence ecosystem variability?

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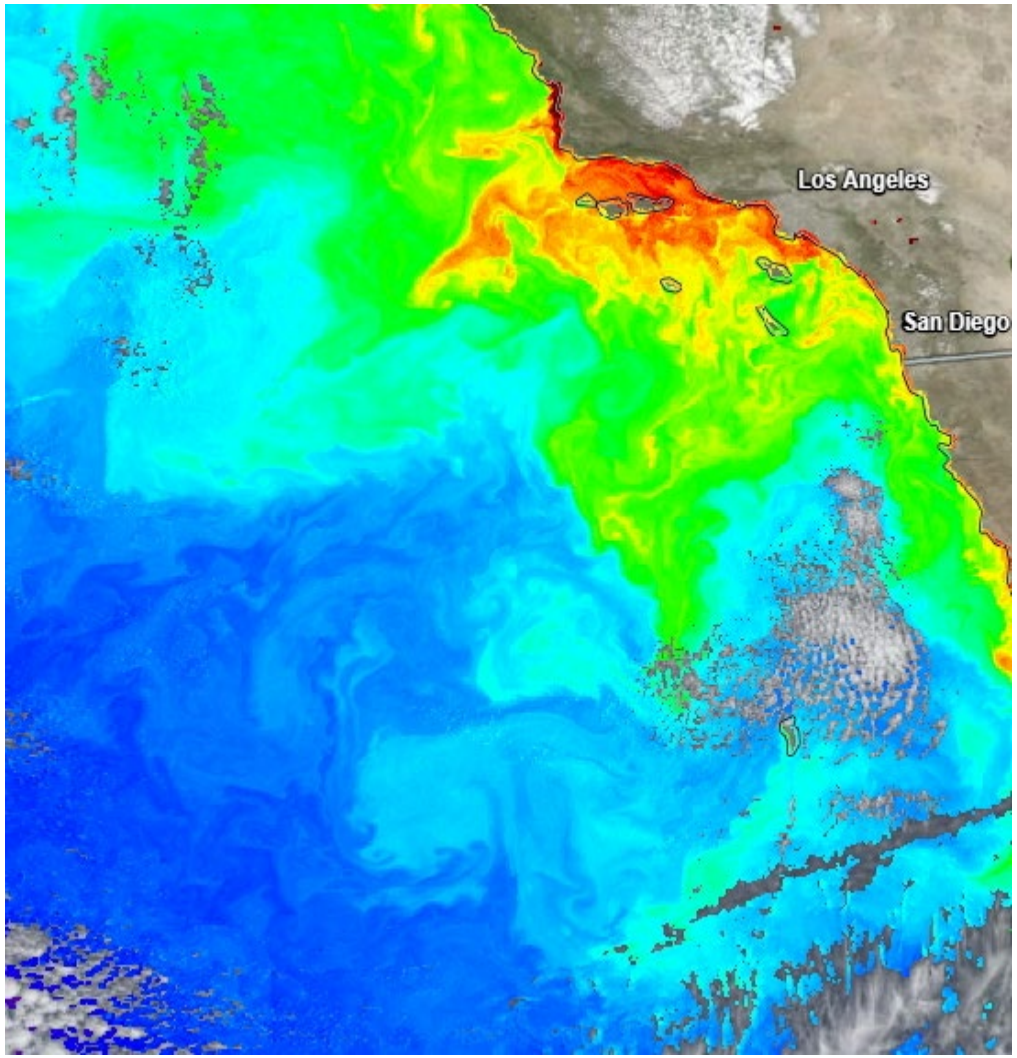

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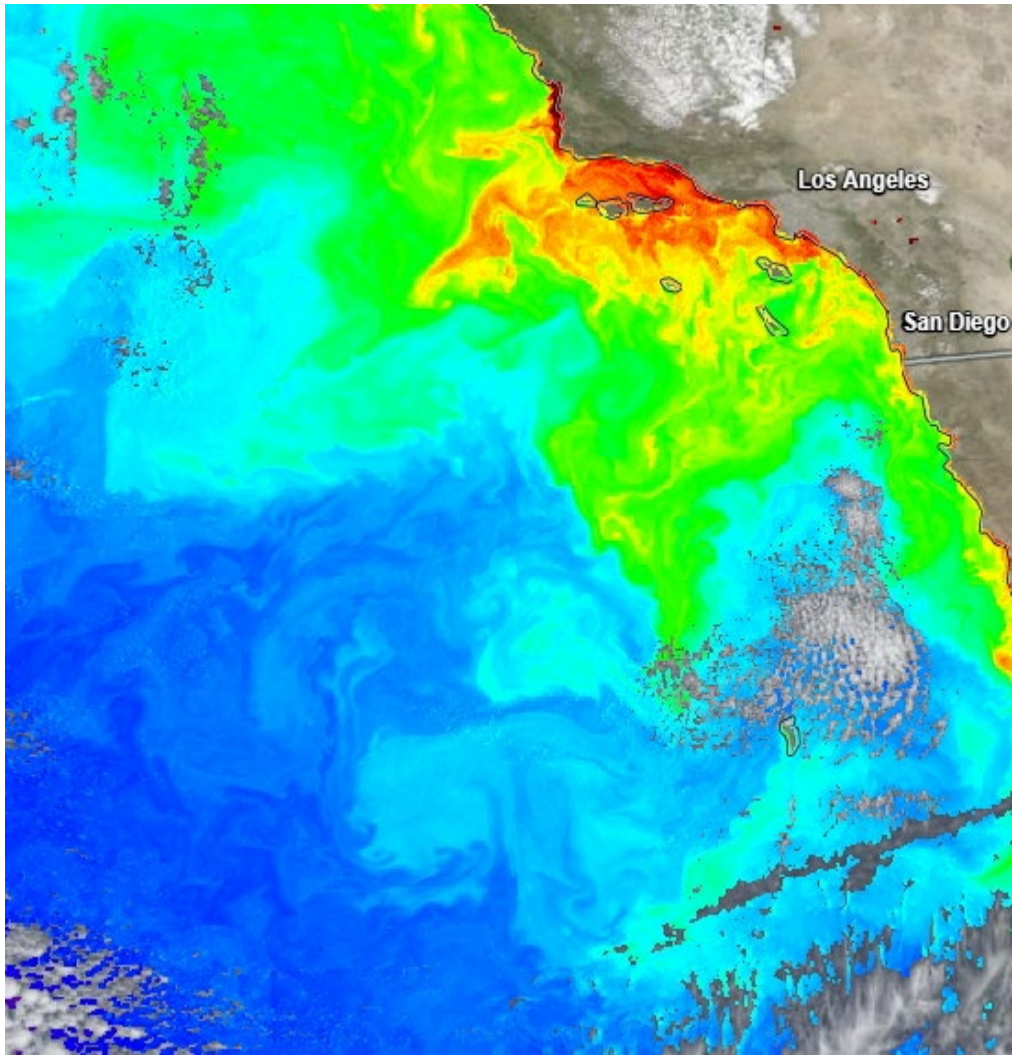

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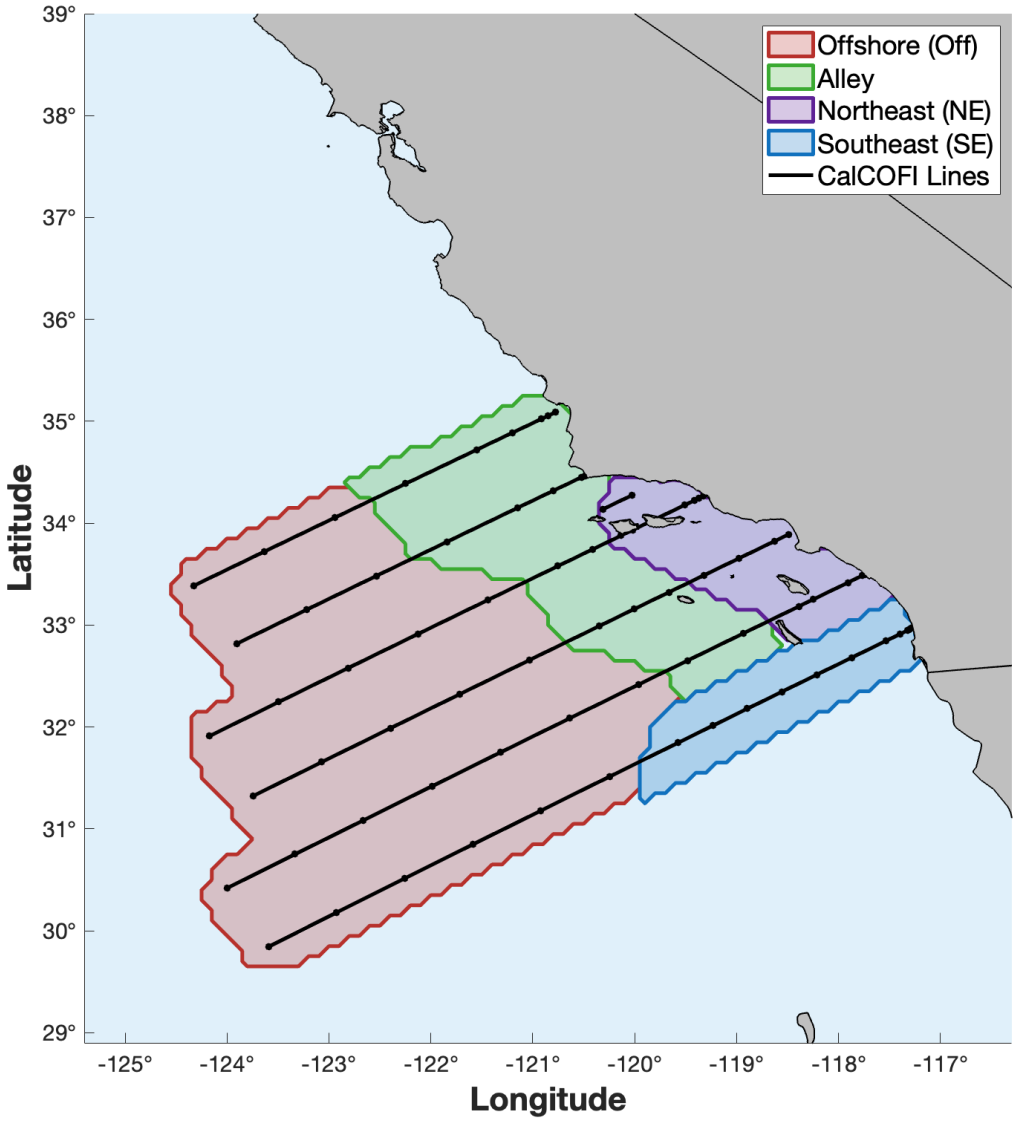
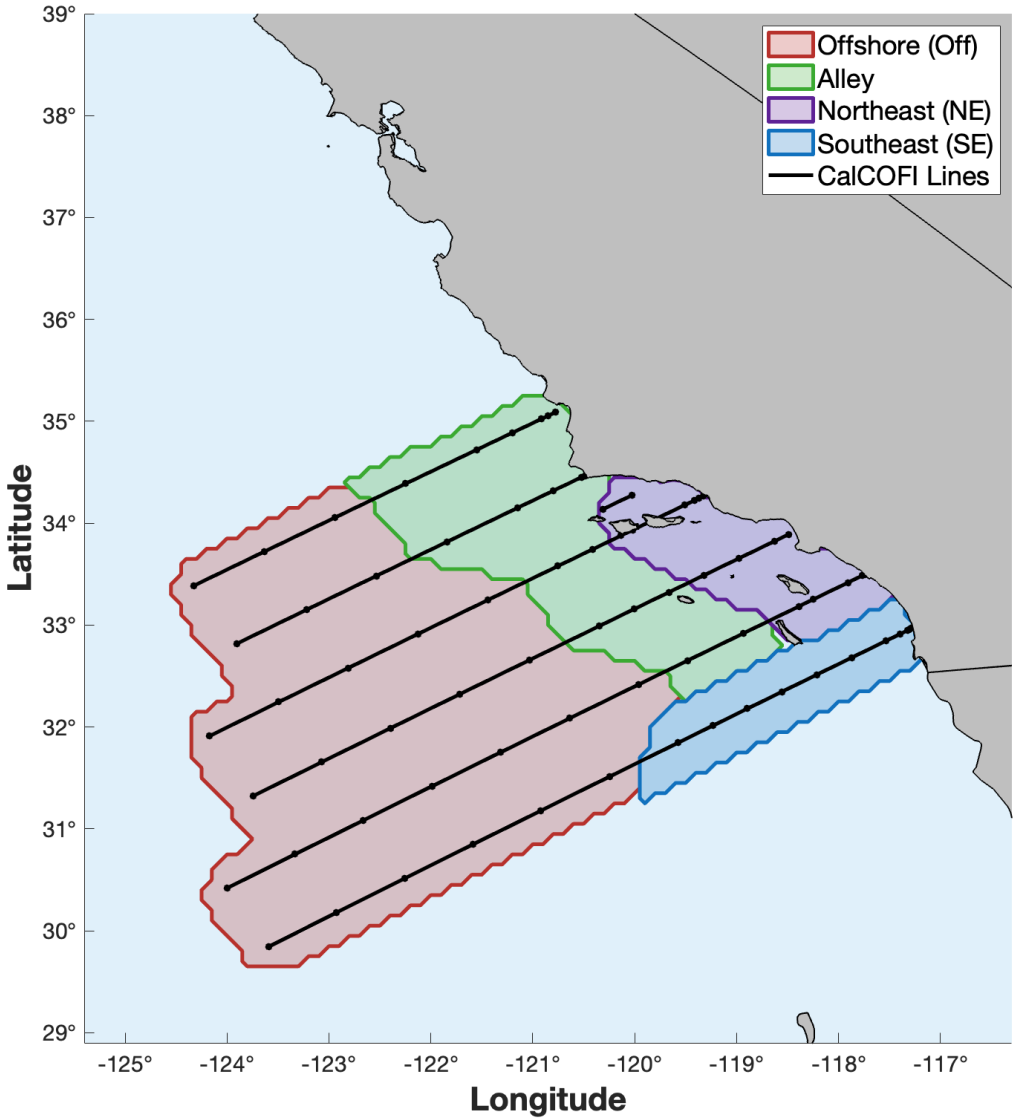
California Current Ecosystem Subregions



Southern CalCOFI “Core” Stations

Subregions based on phytoplankton community compositions and defined by Hayward and Venrick, 1998

Spring Variables Included in PCA



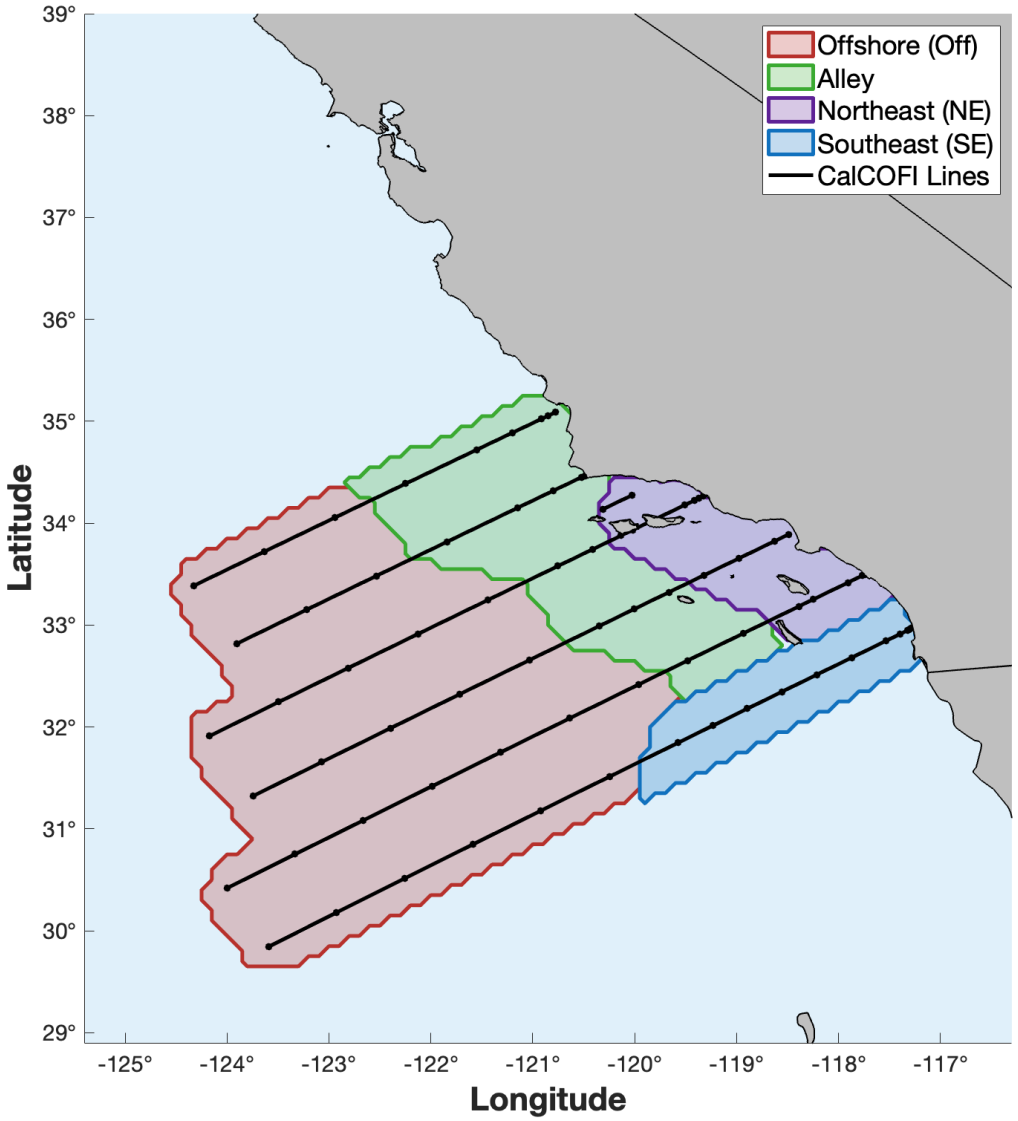
Abiotic Variables

Phytoplankton

Zooplankton

Higher Trophic Levels

Spring Variables Included in PCA



Abiotic Variables

North Pacific Gyre Oscillation (NPGO)

Pacific Decadal Oscillation (PDO)

Multivariate ENSO Index (MEI)

Wind stress curl upwelling

Coastal Upwelling (BEUTI, CUTI, Bakun)

Nitracline depth

Nutrients

Oxygen

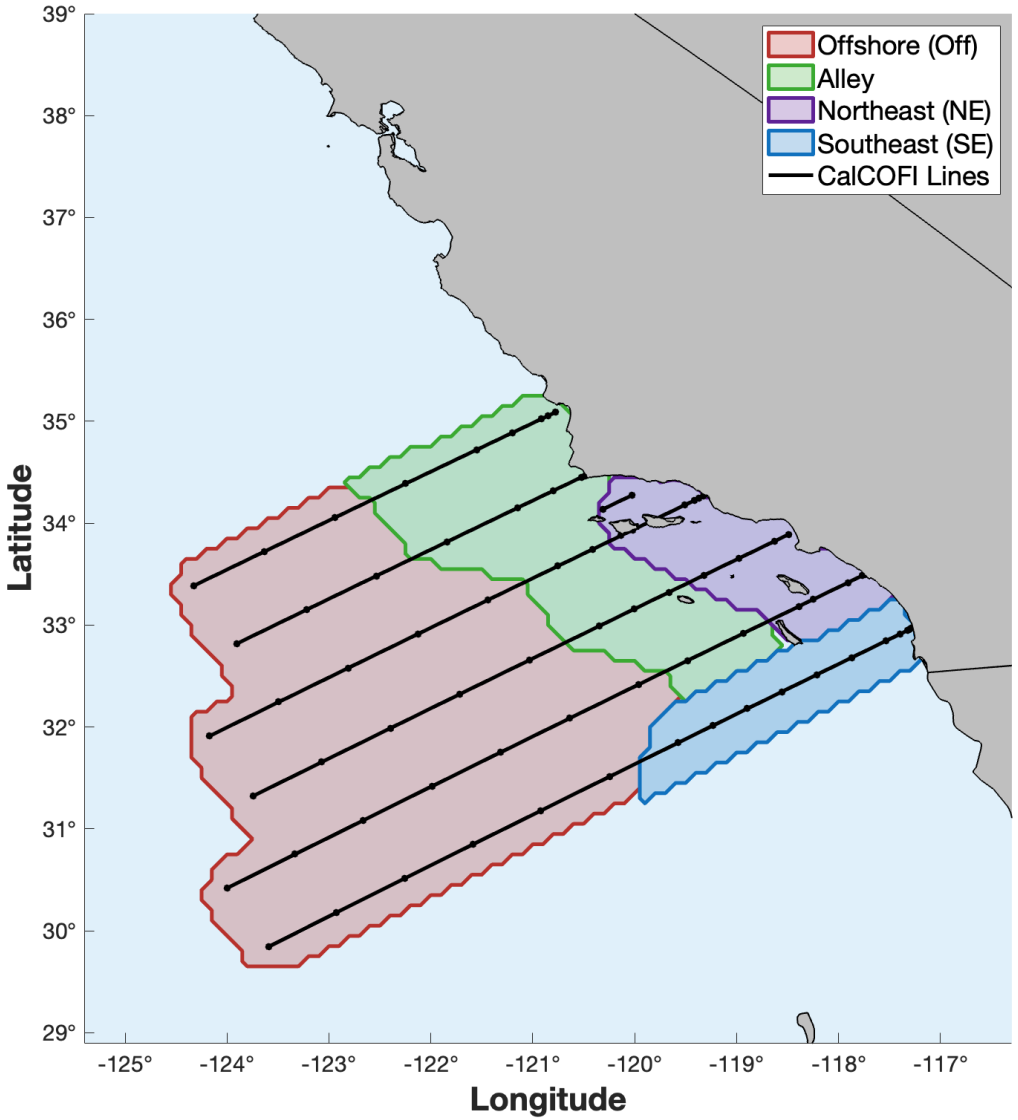
Sea Level Height

Phytoplankton

Zooplankton

Higher Trophic Levels

Spring Variables Included in PCA



Abiotic Variables

Phytoplankton

Chlorophyll a

Zooplankton

Higher Trophic Levels

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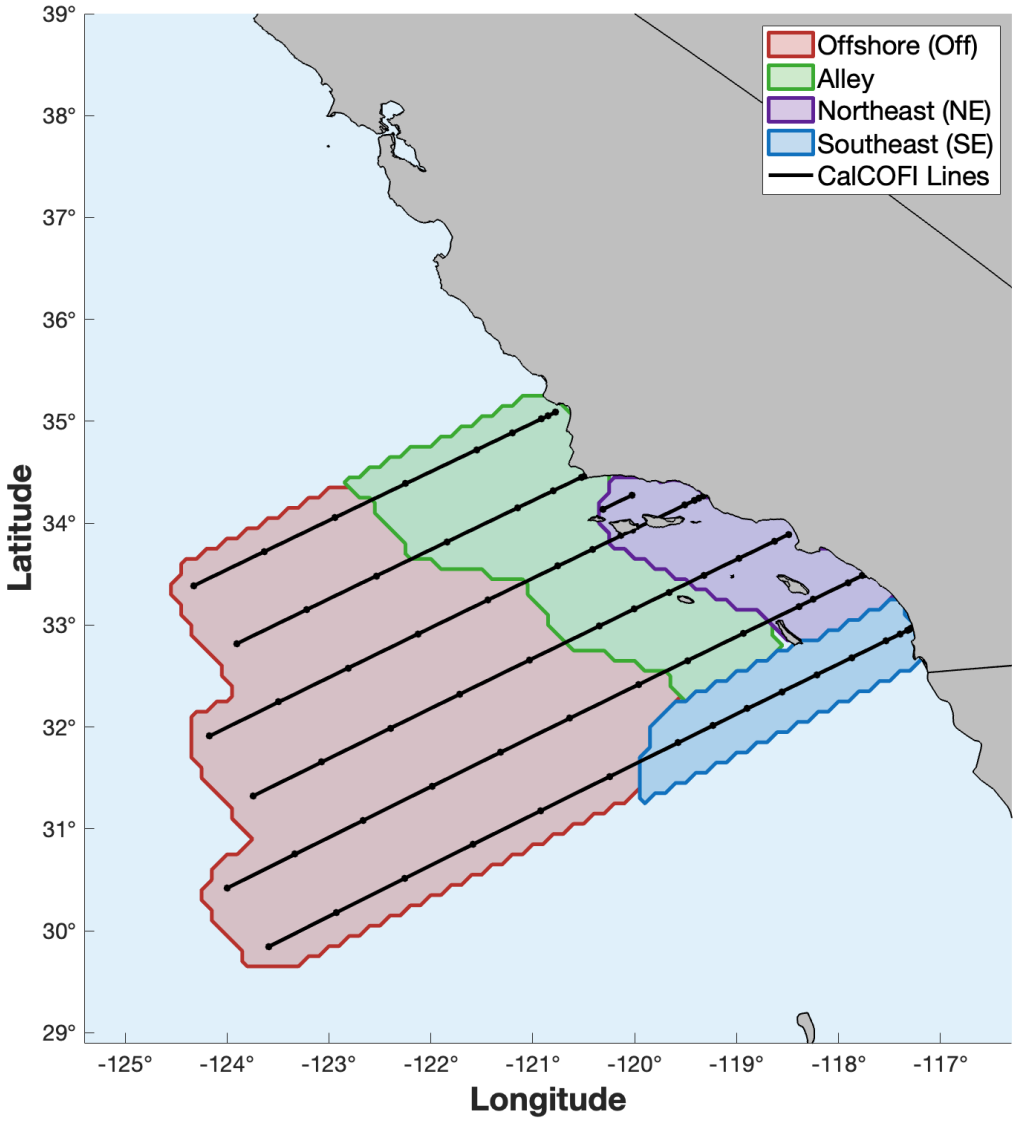


Abiotic Variables

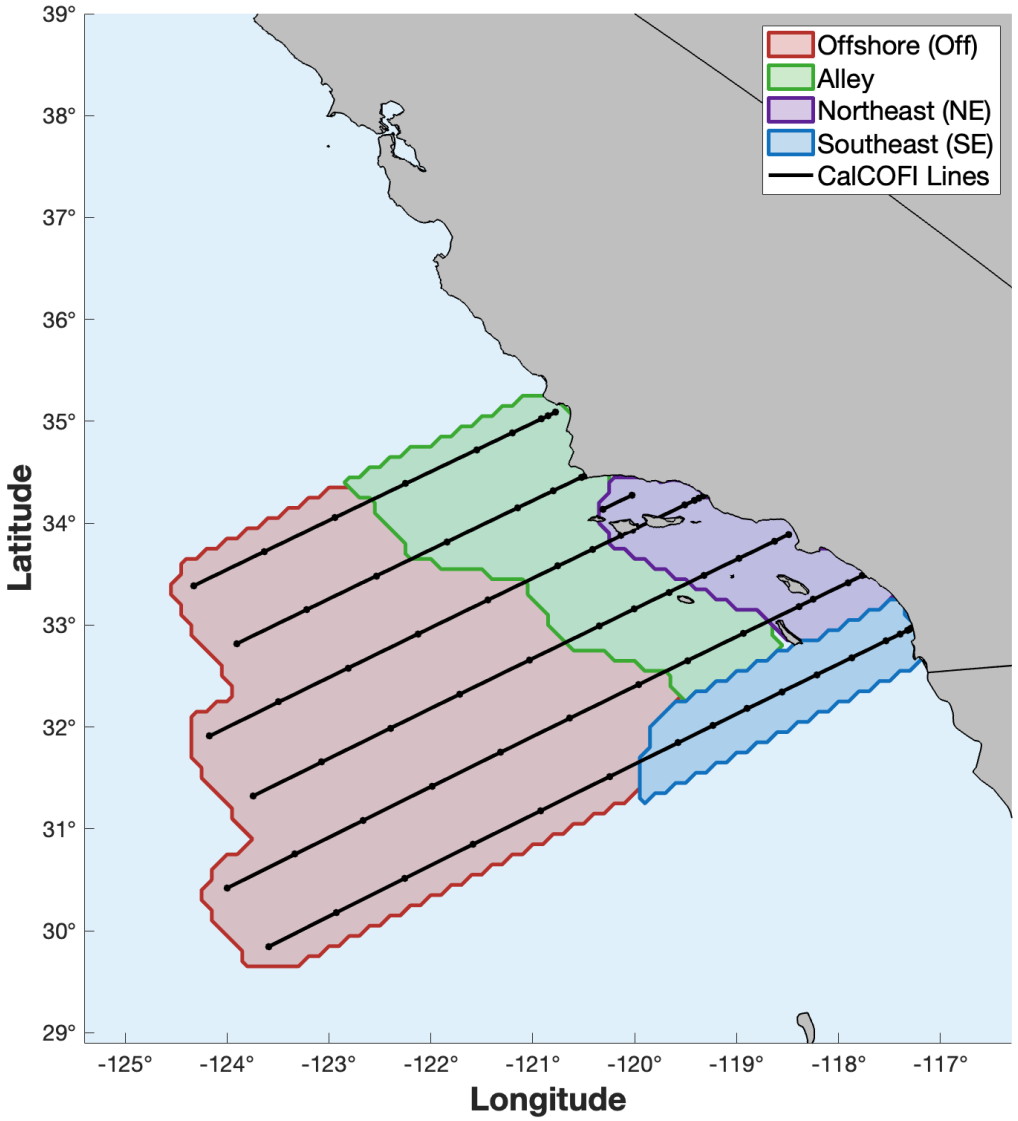
Phytoplankton

Zooplankton

Zooplankton Biovolume
Euphausiids (warm and cool)
Appendicularians
Amphipods
Copepopds (large and small)
Chaetognaths
Ctenophores
Decapoda
Hydromedusa
Mollusca
Ostracoda
Polychaetes
Pyrosoma
Siphonophora
Salpida

Higher Trophic Levels

Spring Variables Included in PCA



Abiotic Variables

Phytoplankton

Zooplankton

Higher Trophic Levels

Sardines

Anchovies

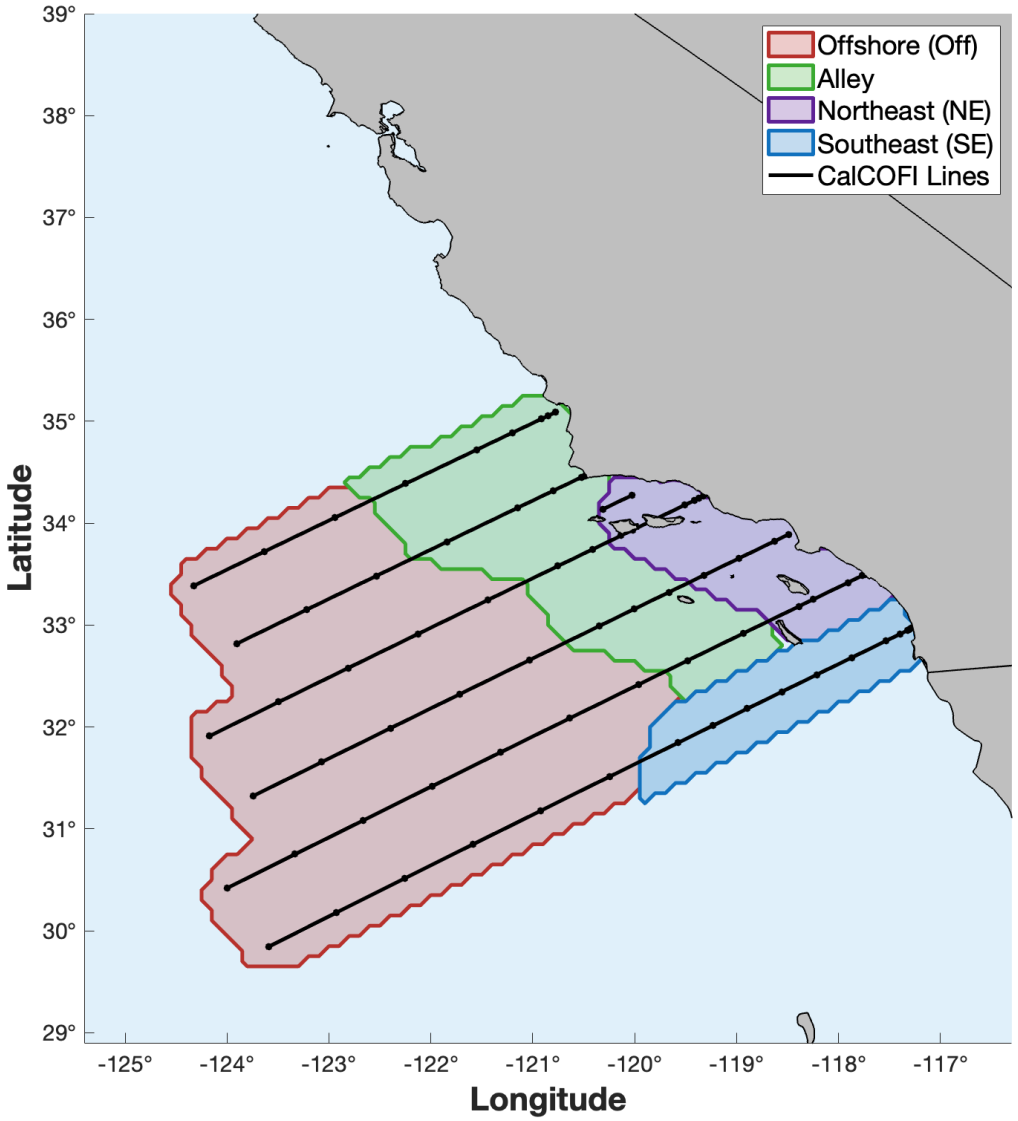
Jack Mackerel

Pacific Mackerel

Albacore

Hake

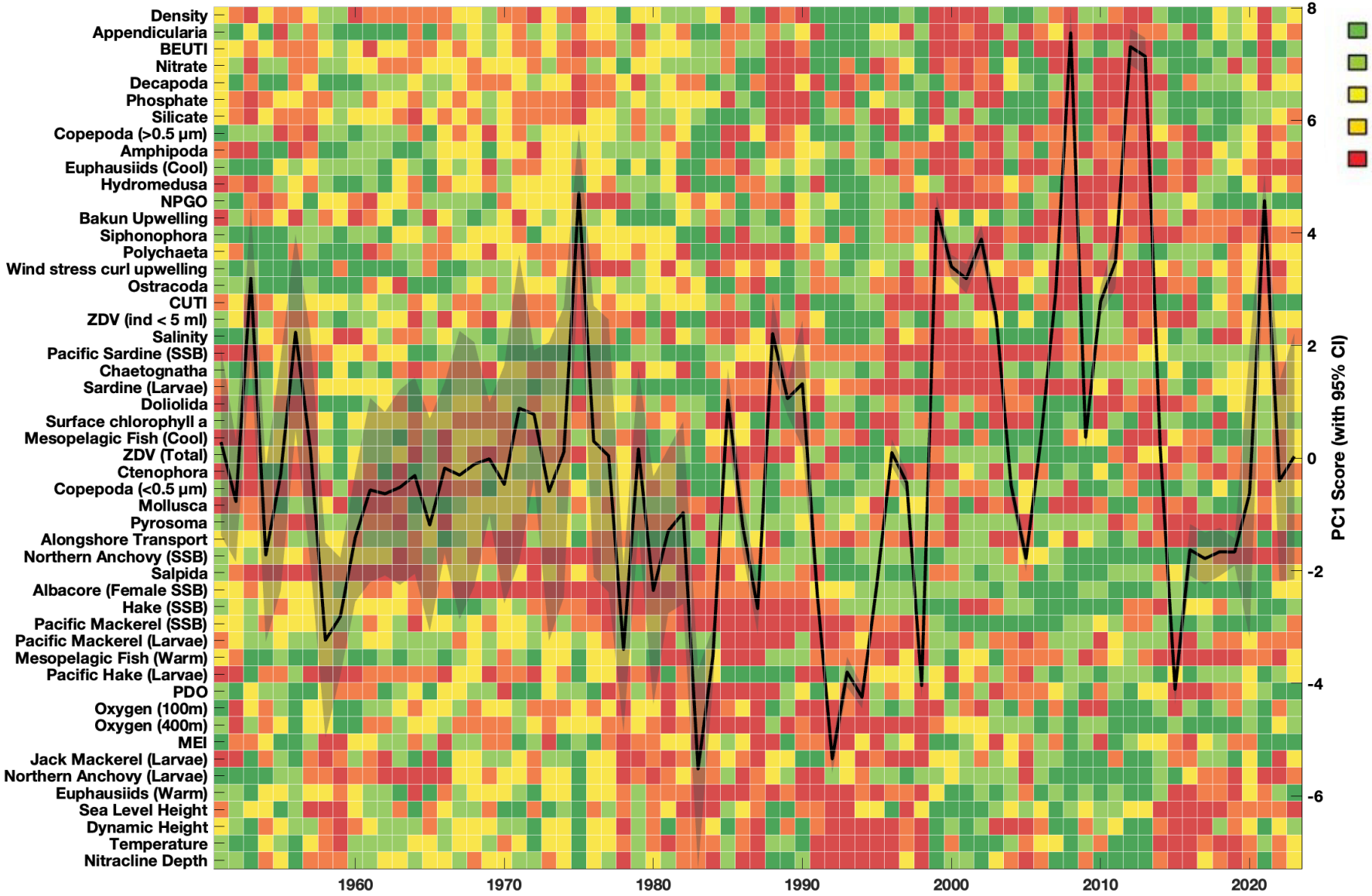
Statistical Analyses



Filled in missing data with multiple imputation

Conducted several Principal Component Analyses (PCAs)

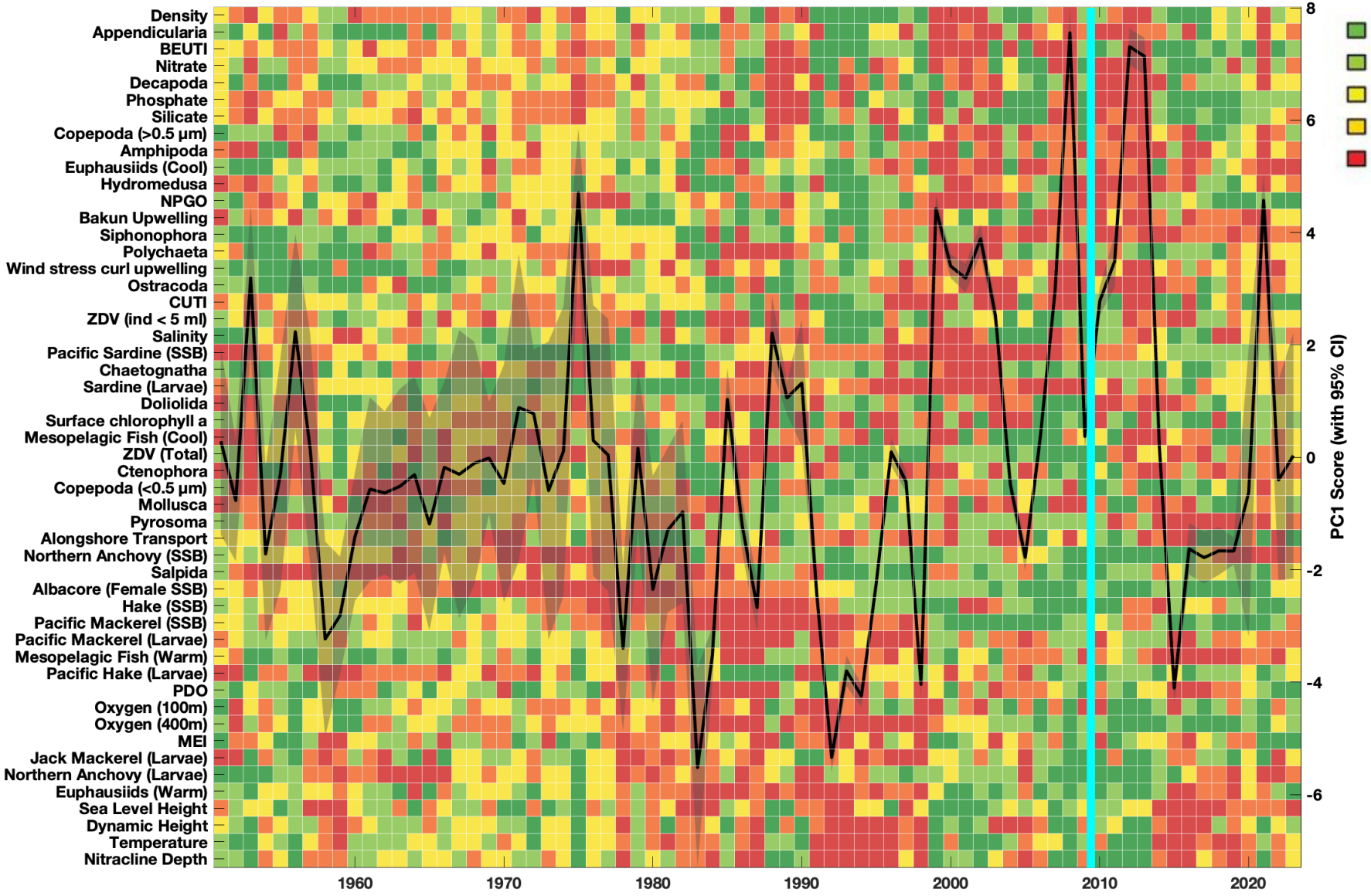
Drivers of Regional Change



PC1 remains the same after updating time series and explains 15.69% of total variance

Return to a warm phase that is characteristic of the 1980's and 90's

Drivers of Regional Change



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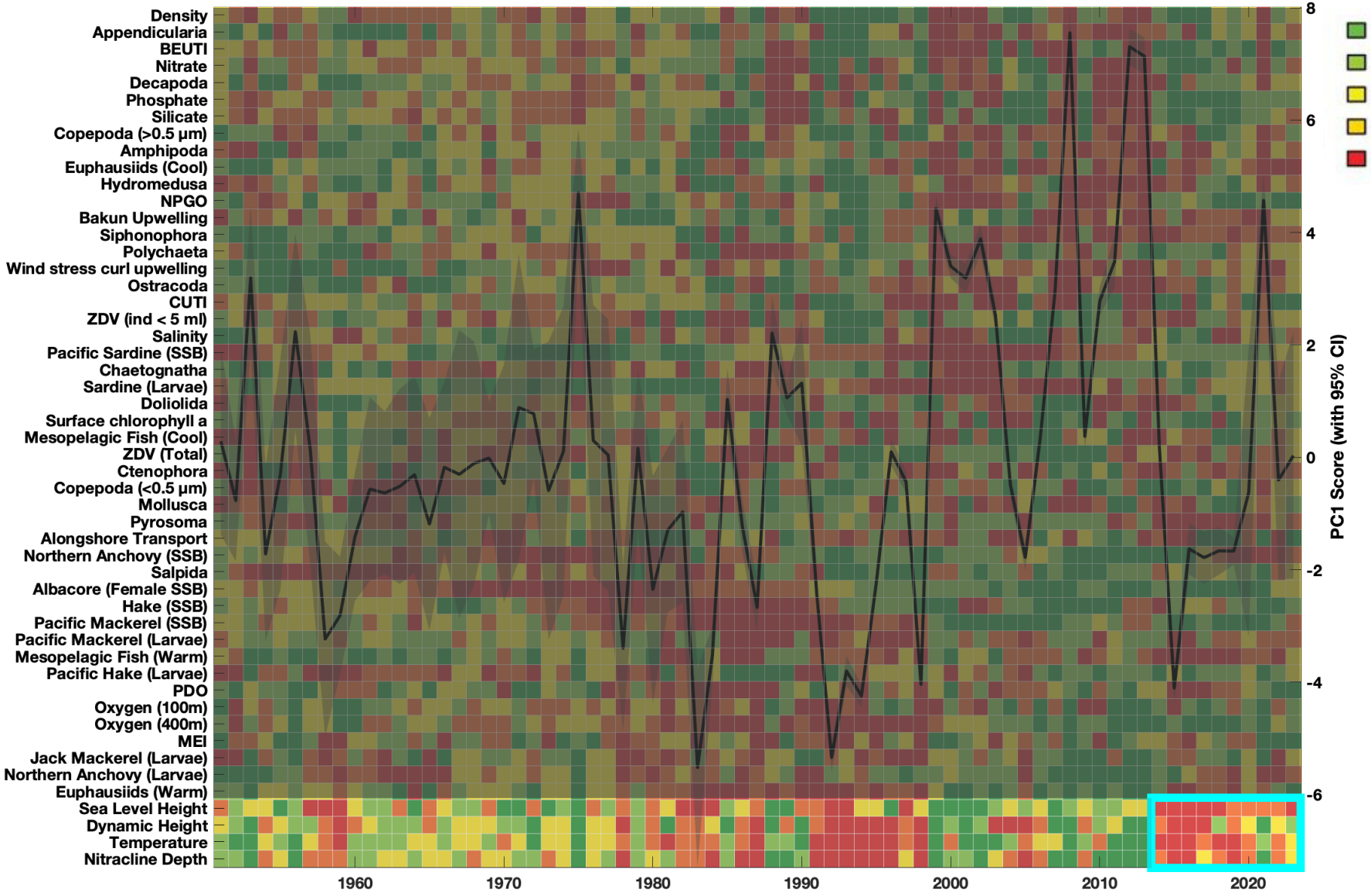

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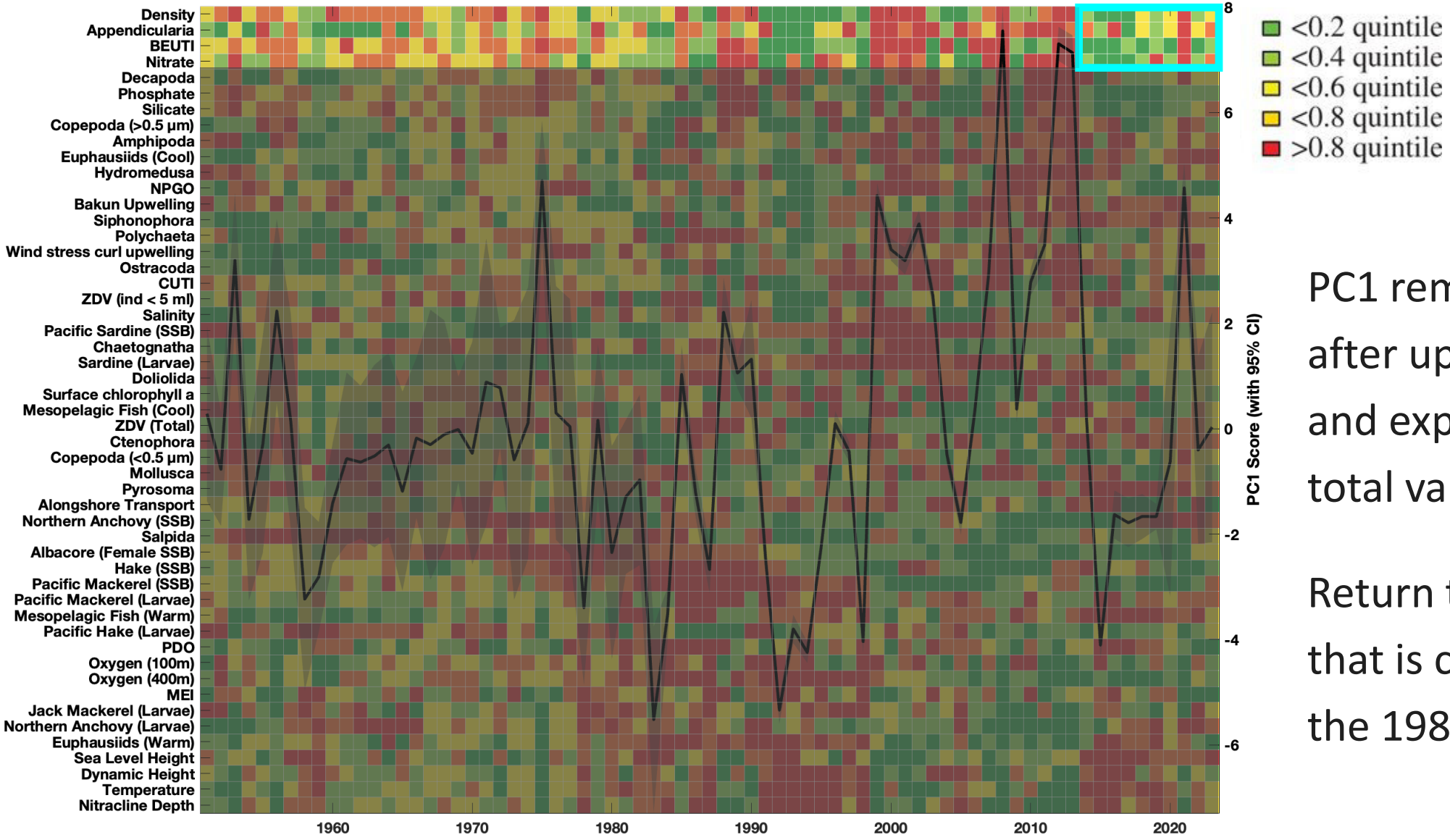

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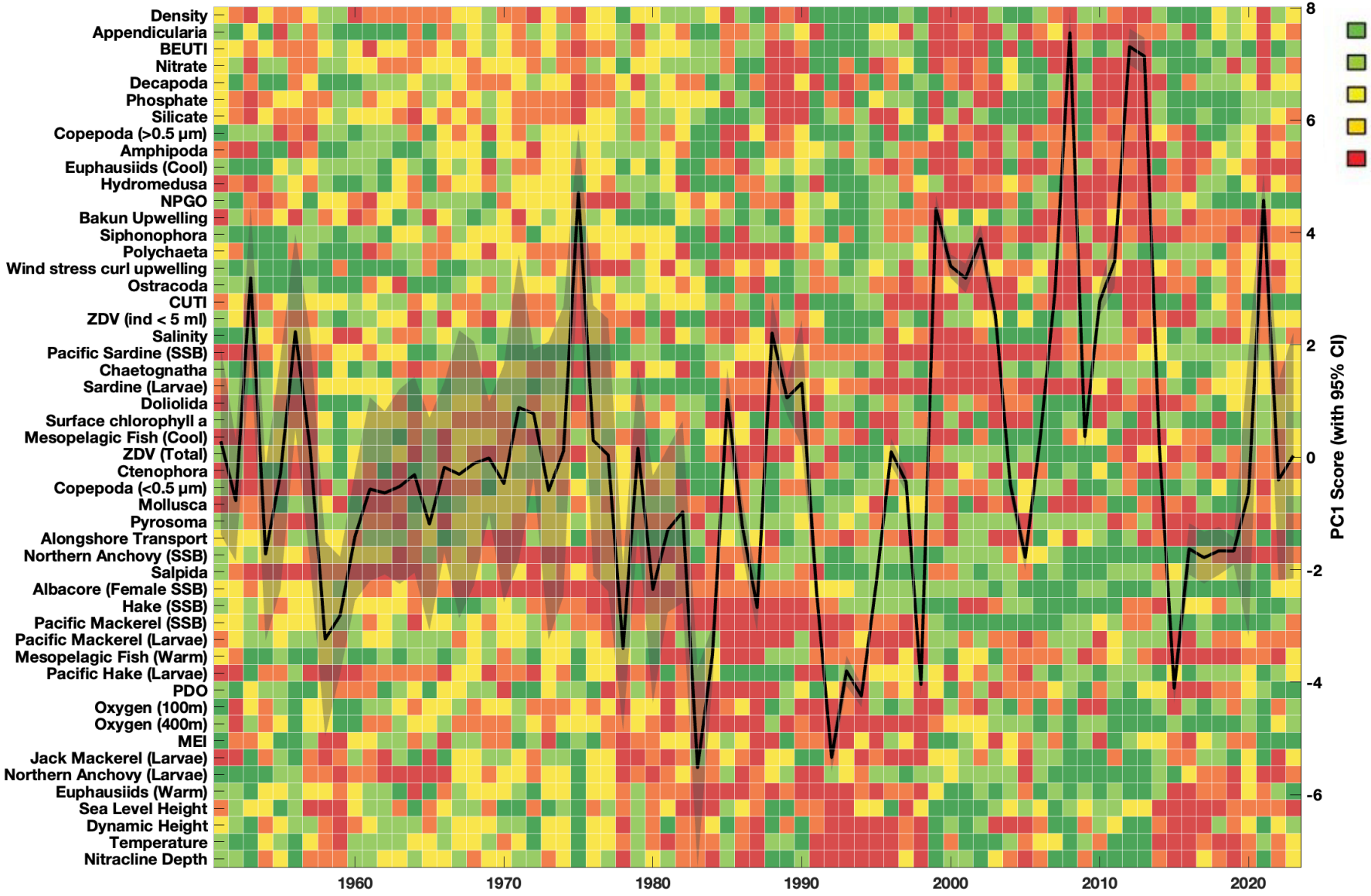

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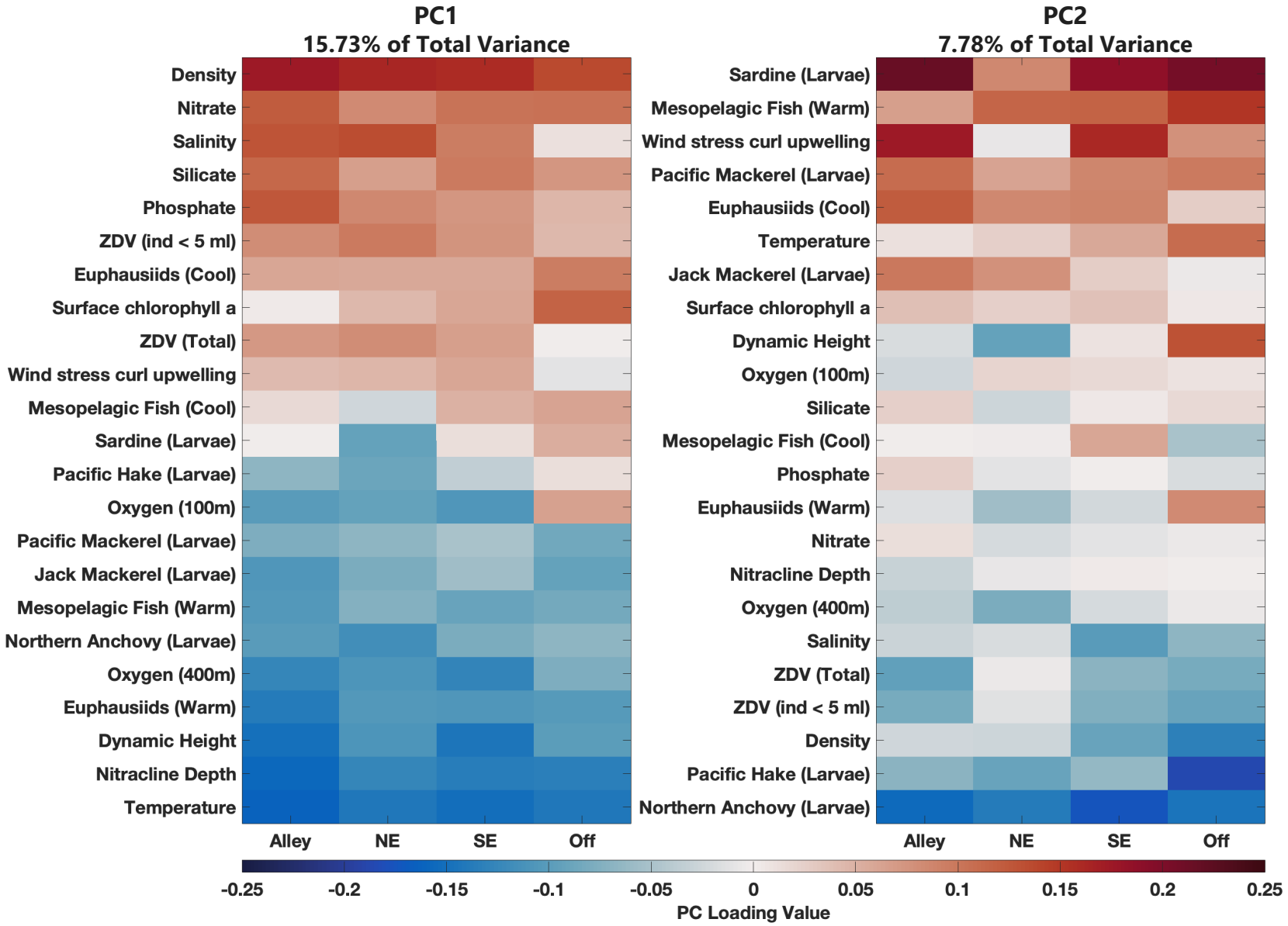
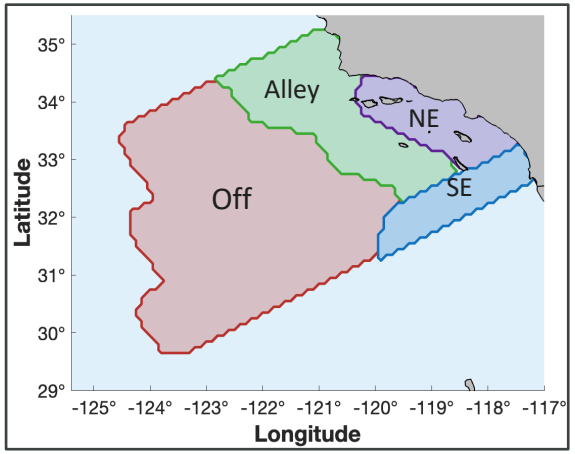
Subregional Variability Across the CCE



PCA on abiotic and biotic subregional averages



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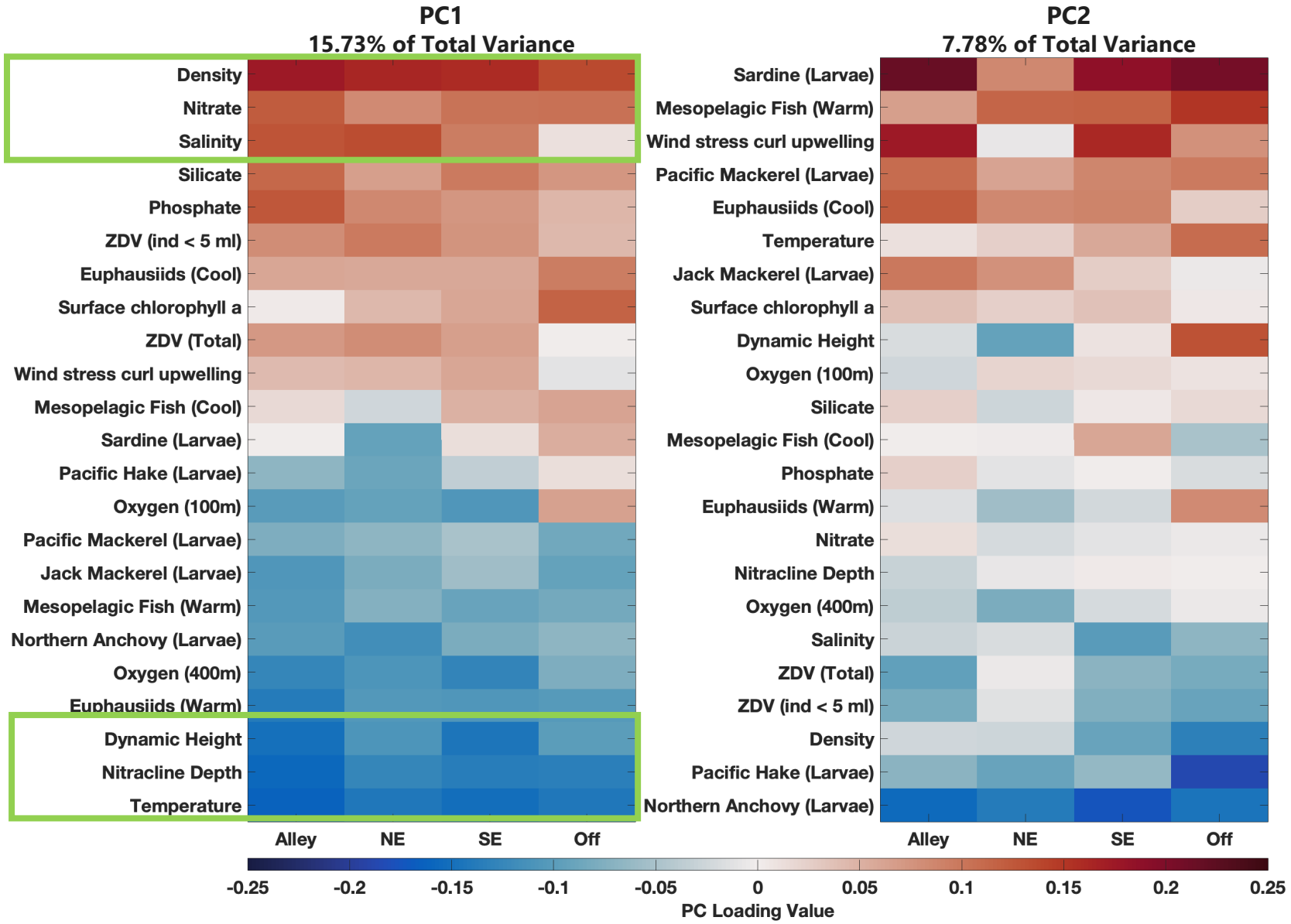
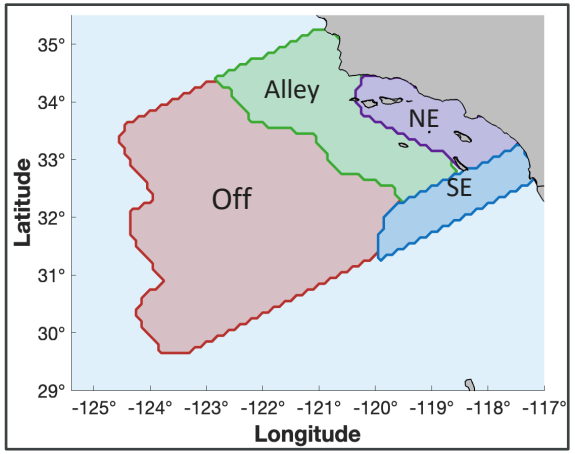


PC1 highlights basin-scale forcing and strong synchrony across subregions



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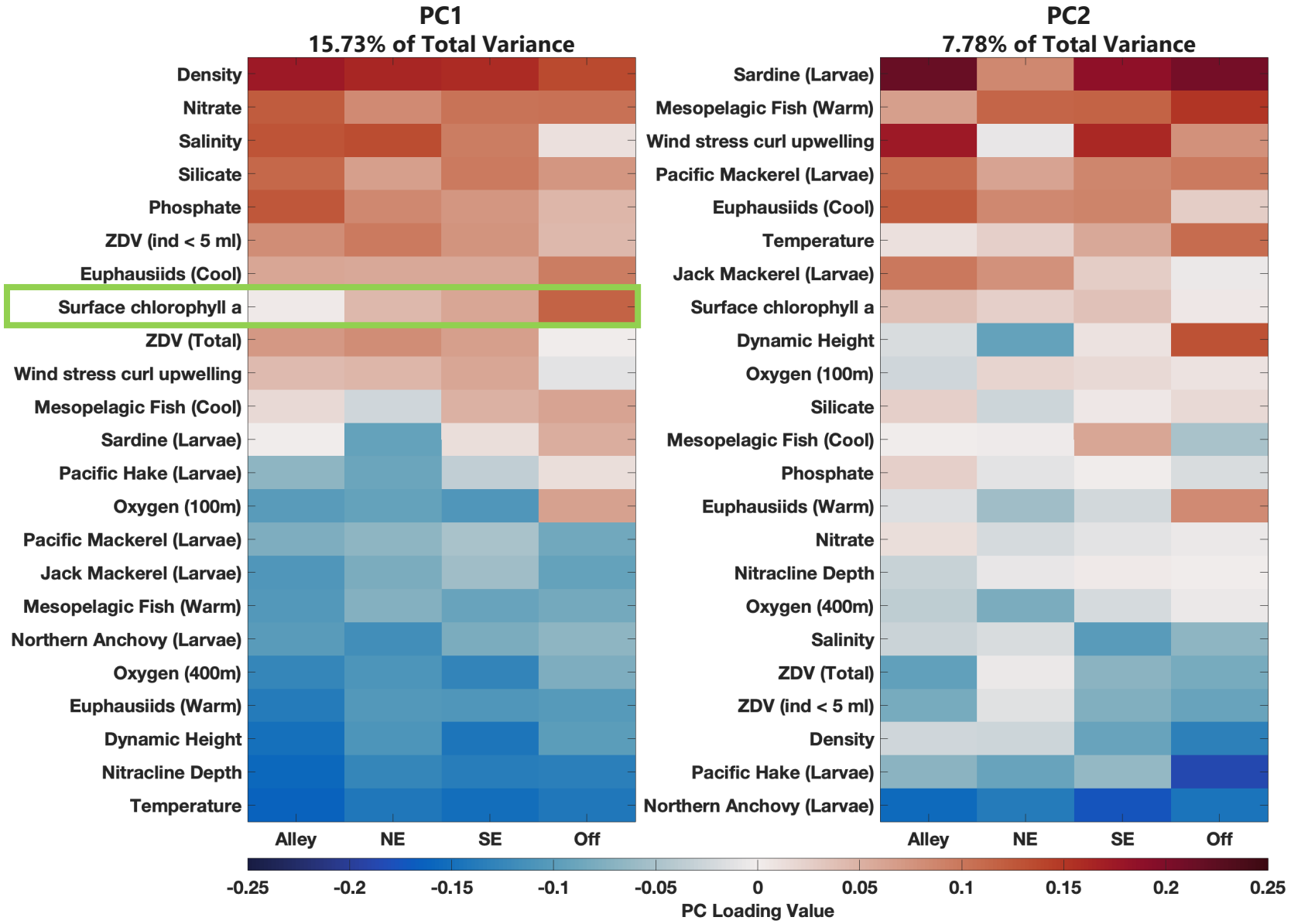

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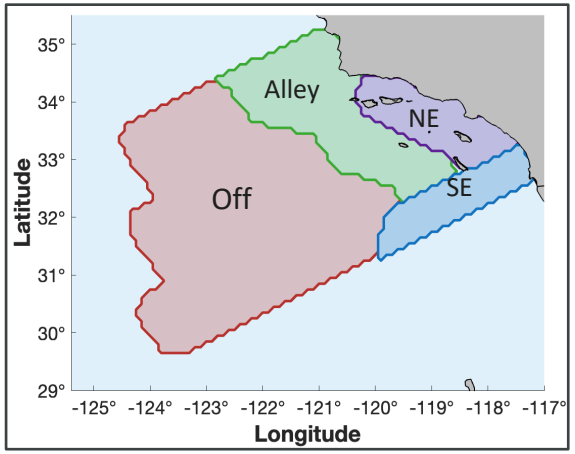

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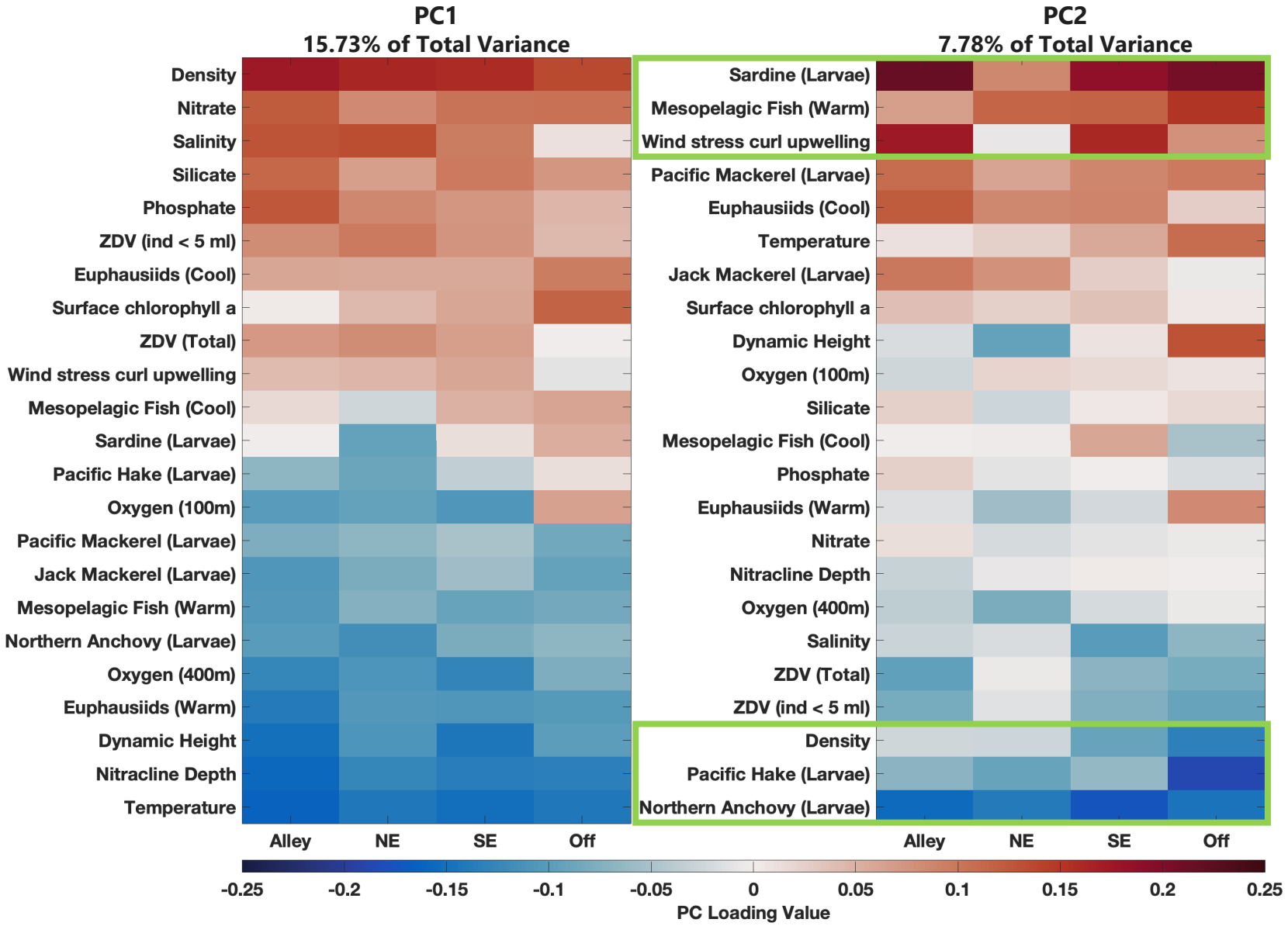
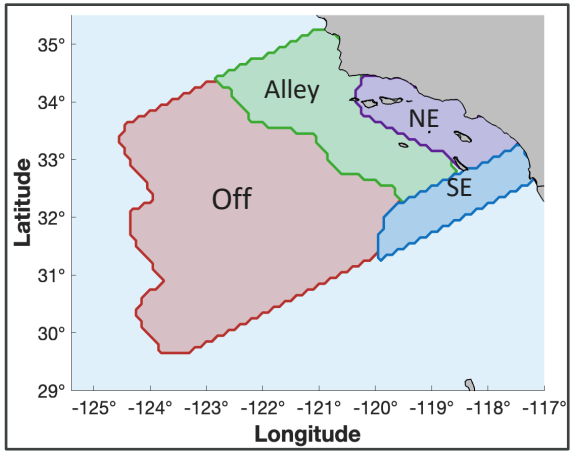


PC2 shows regional heterogeneity

PC2 shows the impacts of wind stress curl and coastal upwelling on the system



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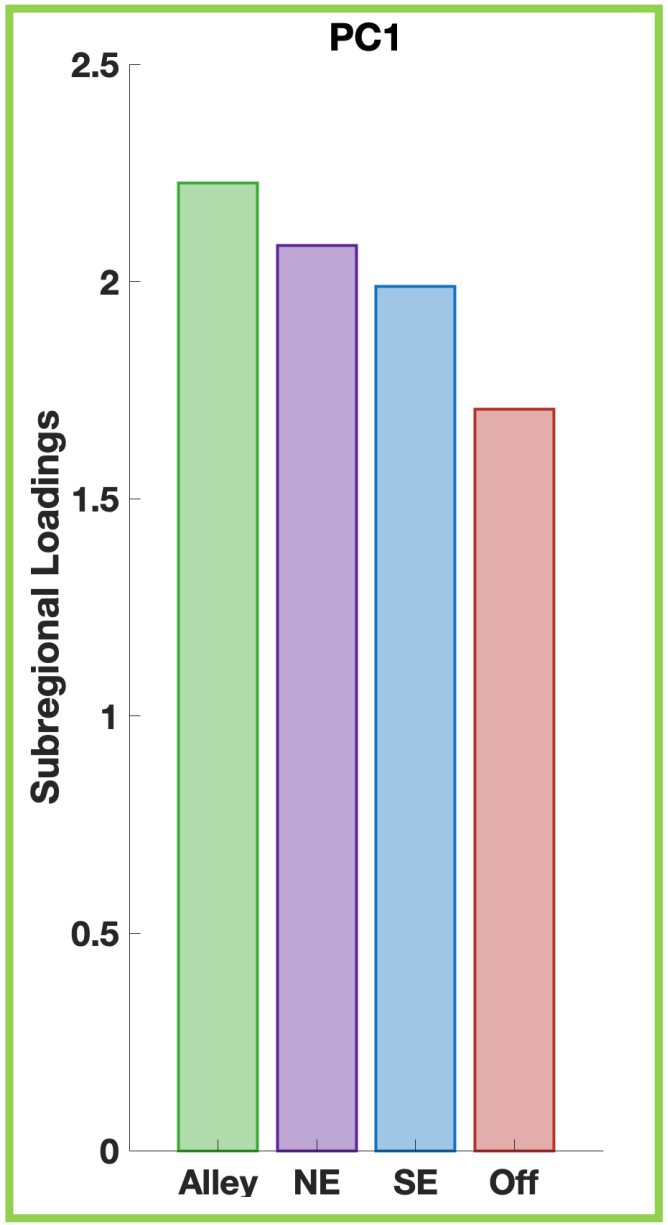
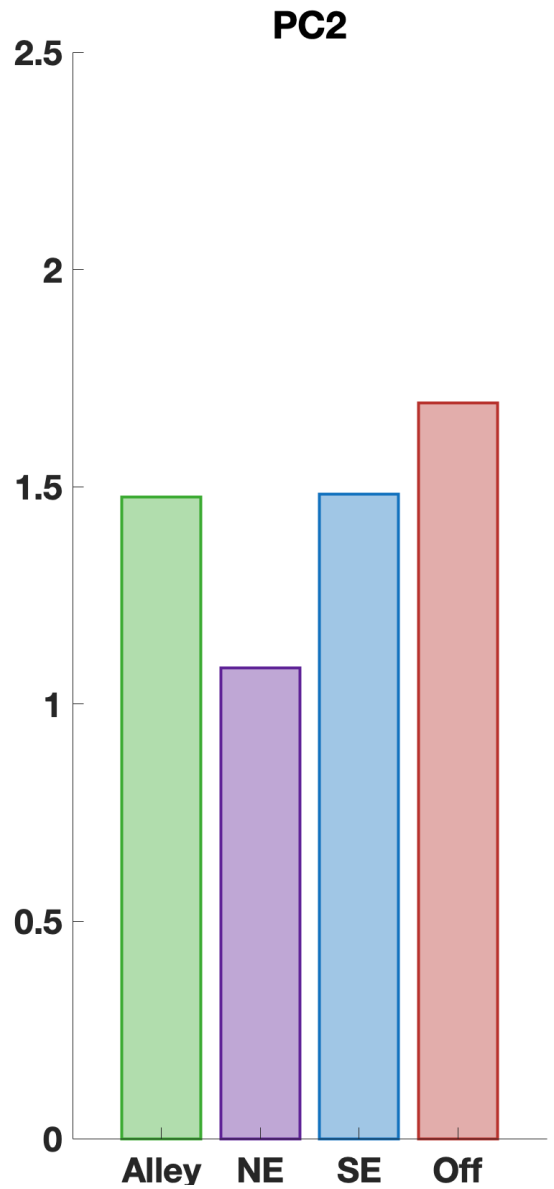
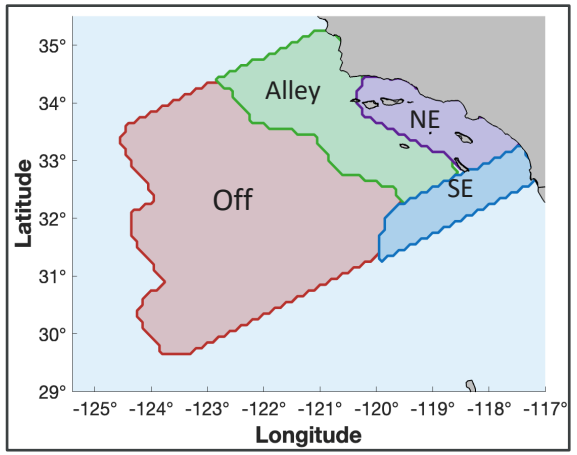




The alley has the highest influence on PC1

The offshore region contributes most to PC2



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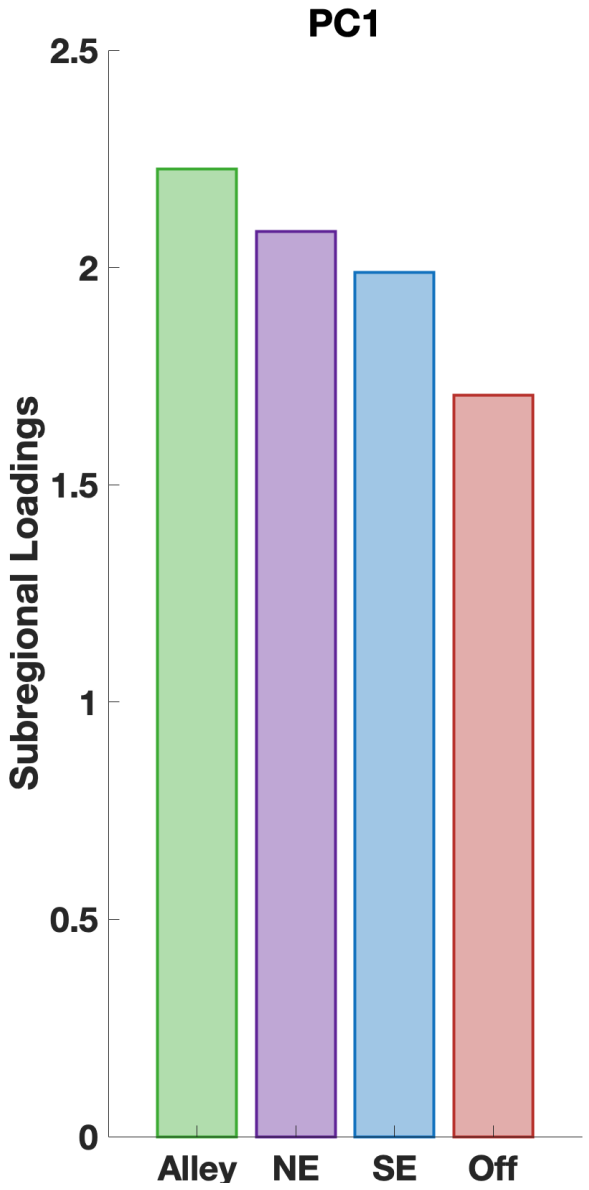

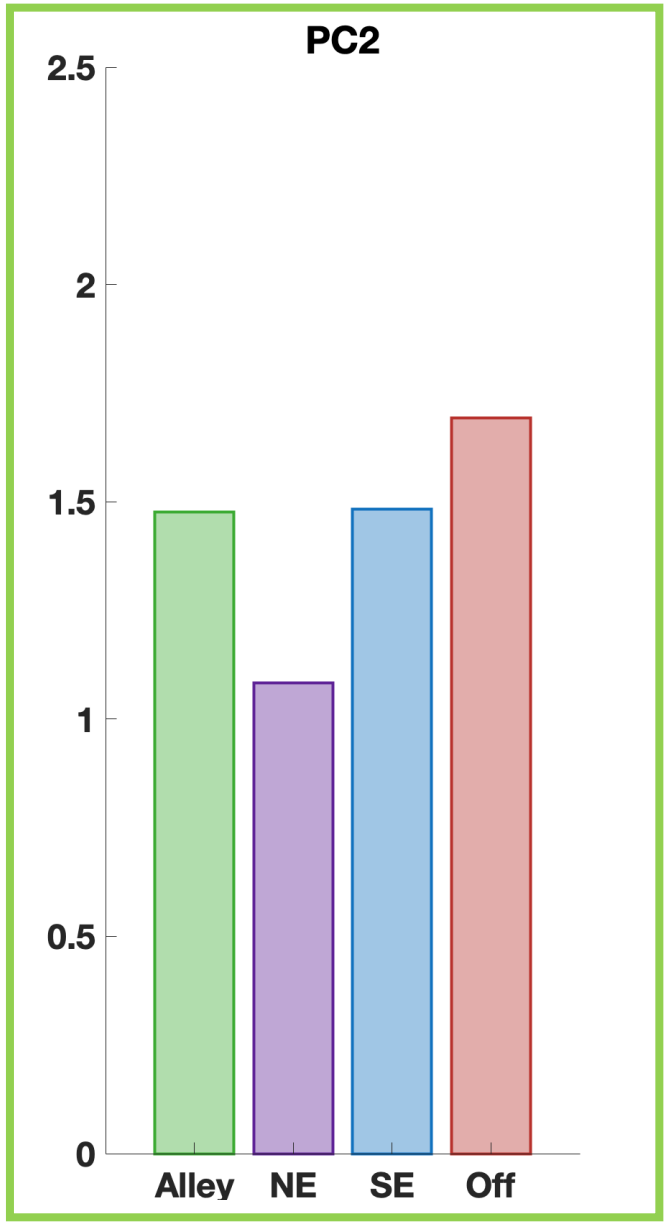

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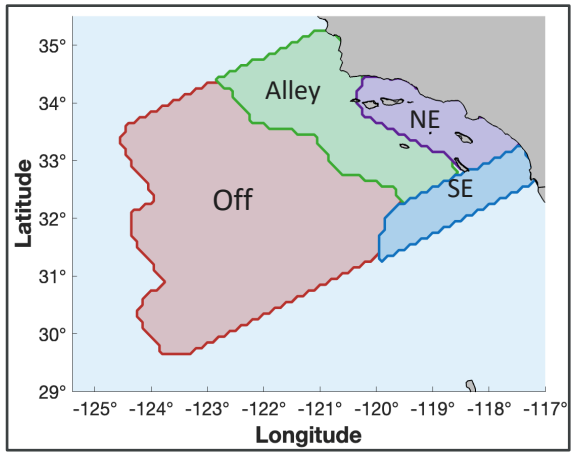
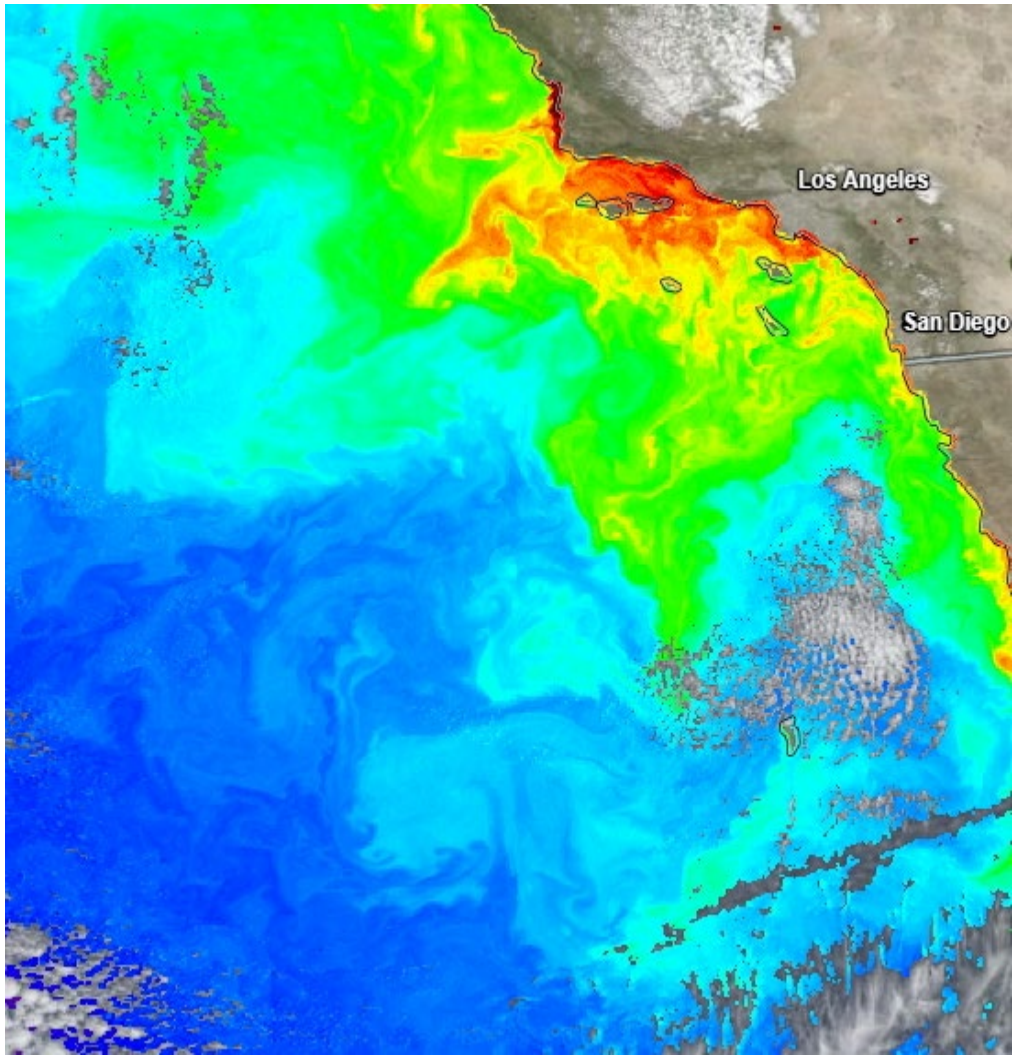


Take Home Points

NASA Worldview



1. When averaging across the whole region, the ecosystem fluctuates between warm and cool phases

2. Long term change is mainly synchronous across subregions; however, cross regional synchrony begins to break down when looking at the effects of upwelling on the system

3. Changes in temperatures have the highest impact on the alley, while changes in nutrient input from upwelling affect the offshore region

Alison Appelgate

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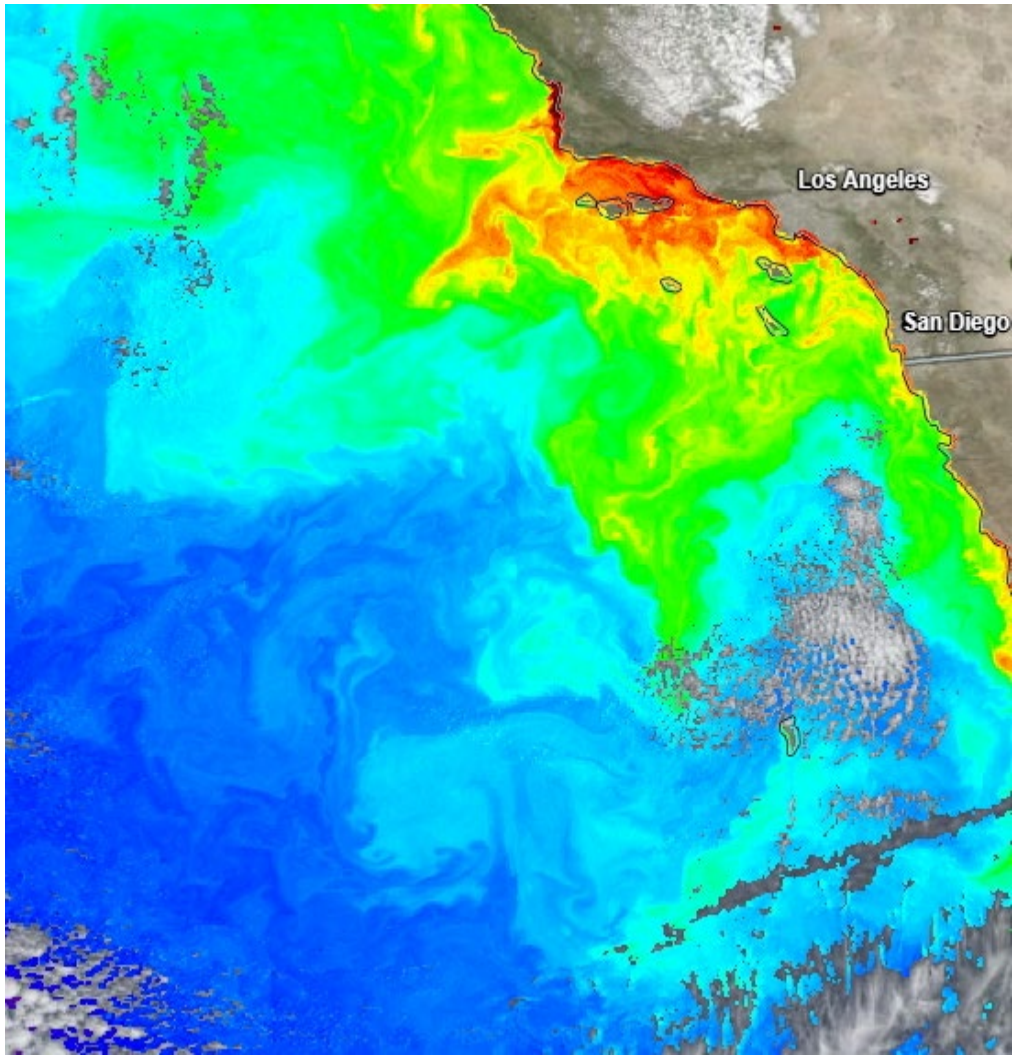
Take Home Points

NASA Worldview



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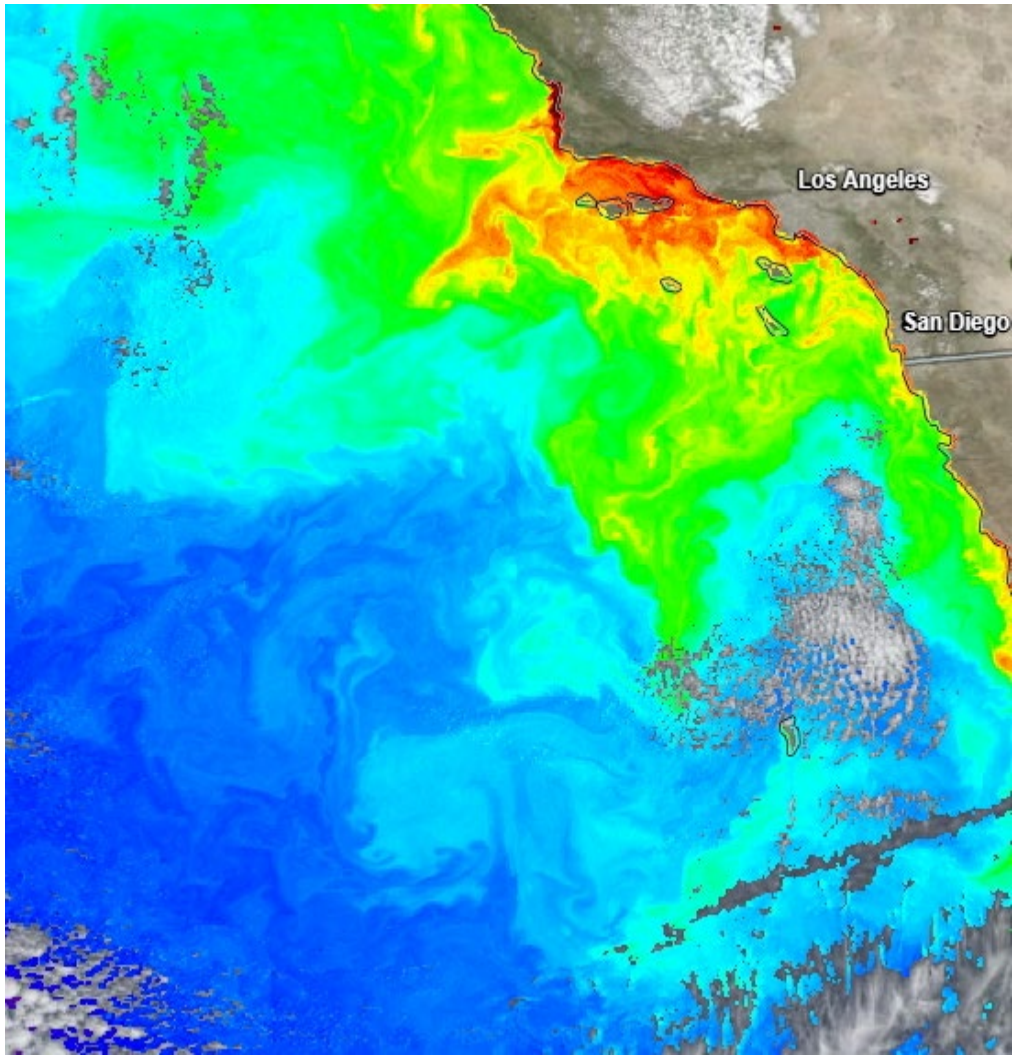
Take Home Points

NASA Worldview



1. When averaging across the whole region, the ecosystem fluctuates between warm and cool phases

2. Long term change is mainly synchronous across subregions; however, cross regional synchrony begins to break down when looking at the effects of upwelling on the system

3. Changes in temperatures have the highest impact on the alley, while changes in nutrient input from upwelling affect the offshore region

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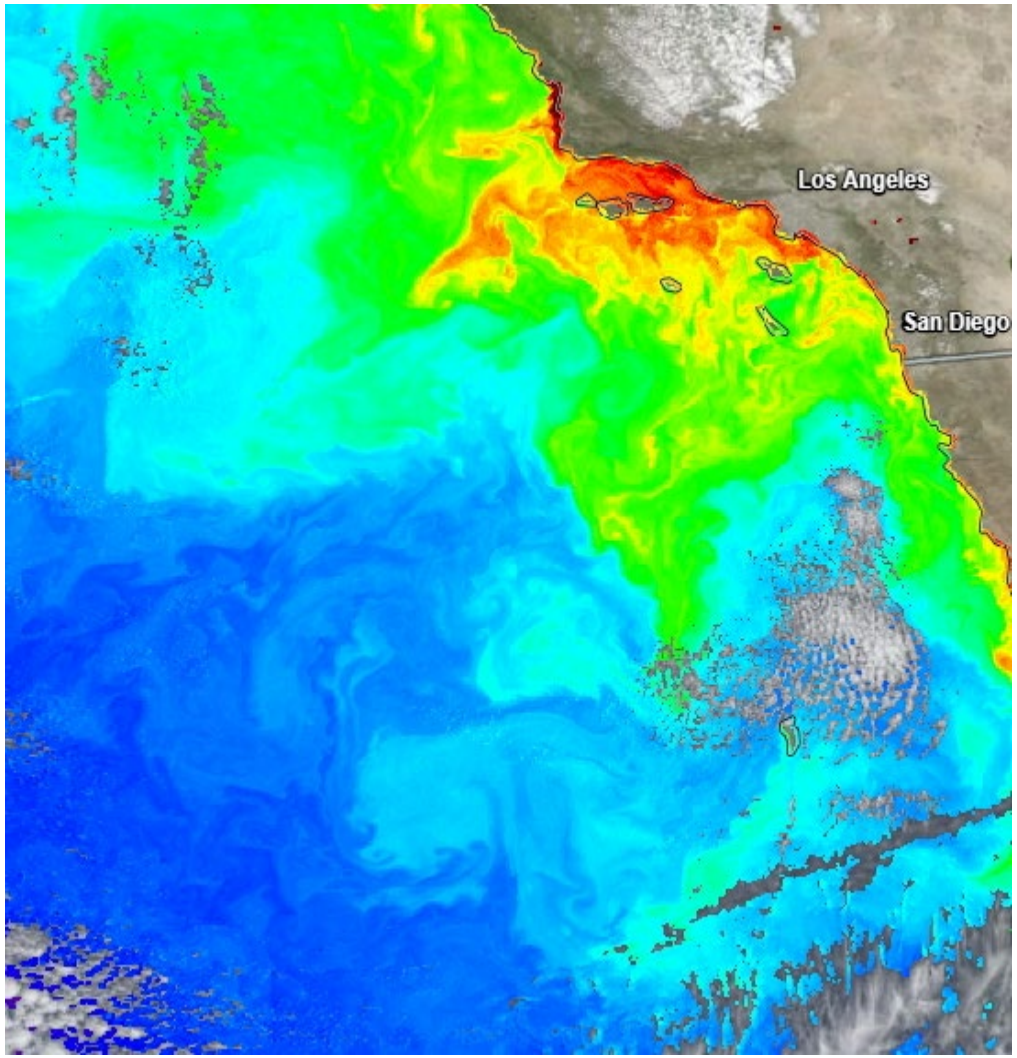

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Literature Cited

Lindegren, Martin, David M. Checkley, Mark D. Ohman, J. Anthony Koslow, and Ralf Goericke. “Resilience and Stability of a Pelagic Marine Ecosystem.” *Proceedings of the Royal Society B: Biological Sciences* 283, no. 1822 (2016): 20151931. https://doi.org/10.1098/rspb.2015.1931.

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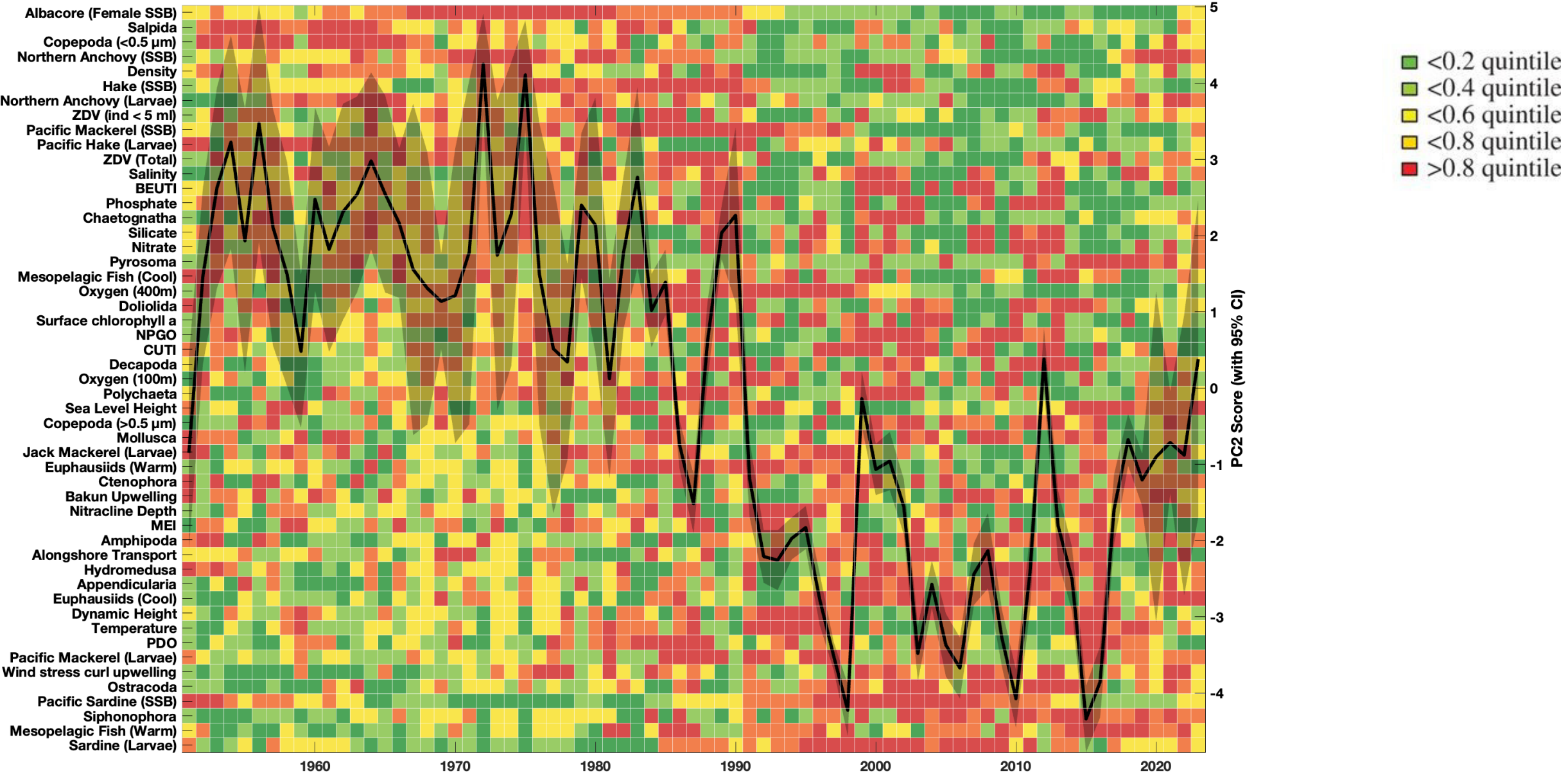
Oliver, Eric C. J., Markus G. Donat, Michael T. Burrows, et al. “Longer and More Frequent Marine Heatwaves over the Past Century.” *Nature Communications* 9, no. 1 (2018): 1324. https://doi.org/10.1038/s41467-018-03732-9.

Subregional PC1 Stoplight – Matches Whole Region PC1



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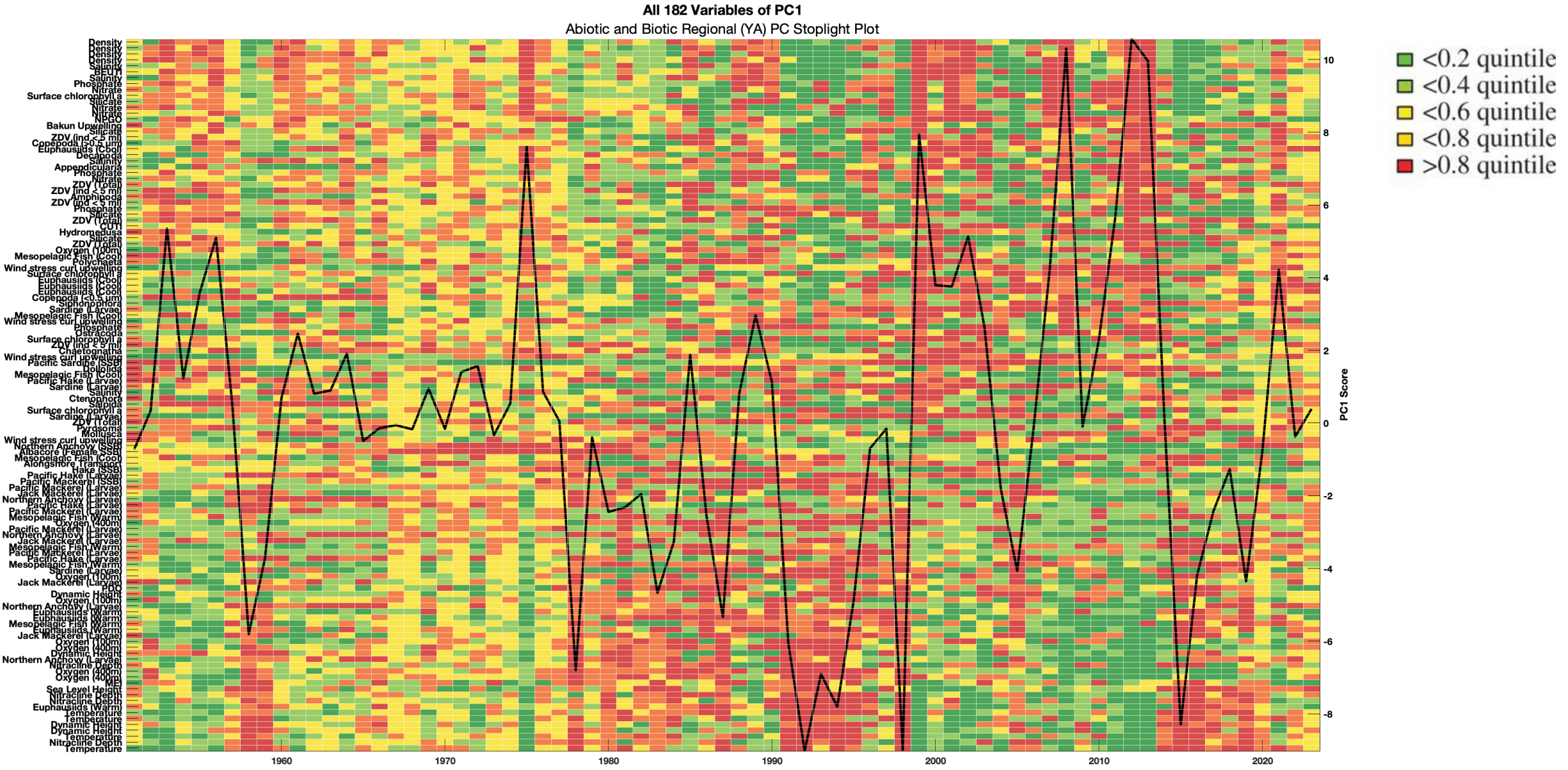
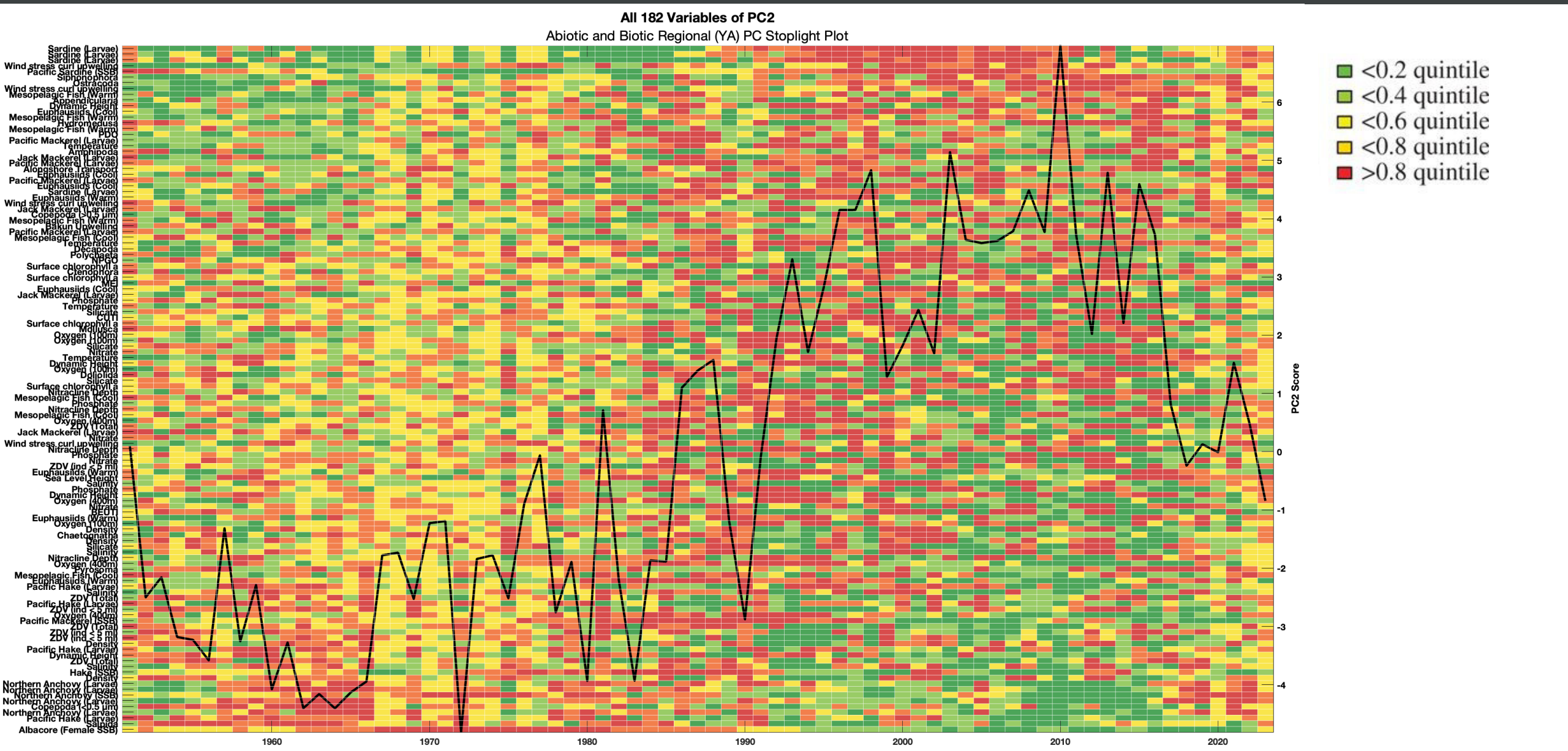
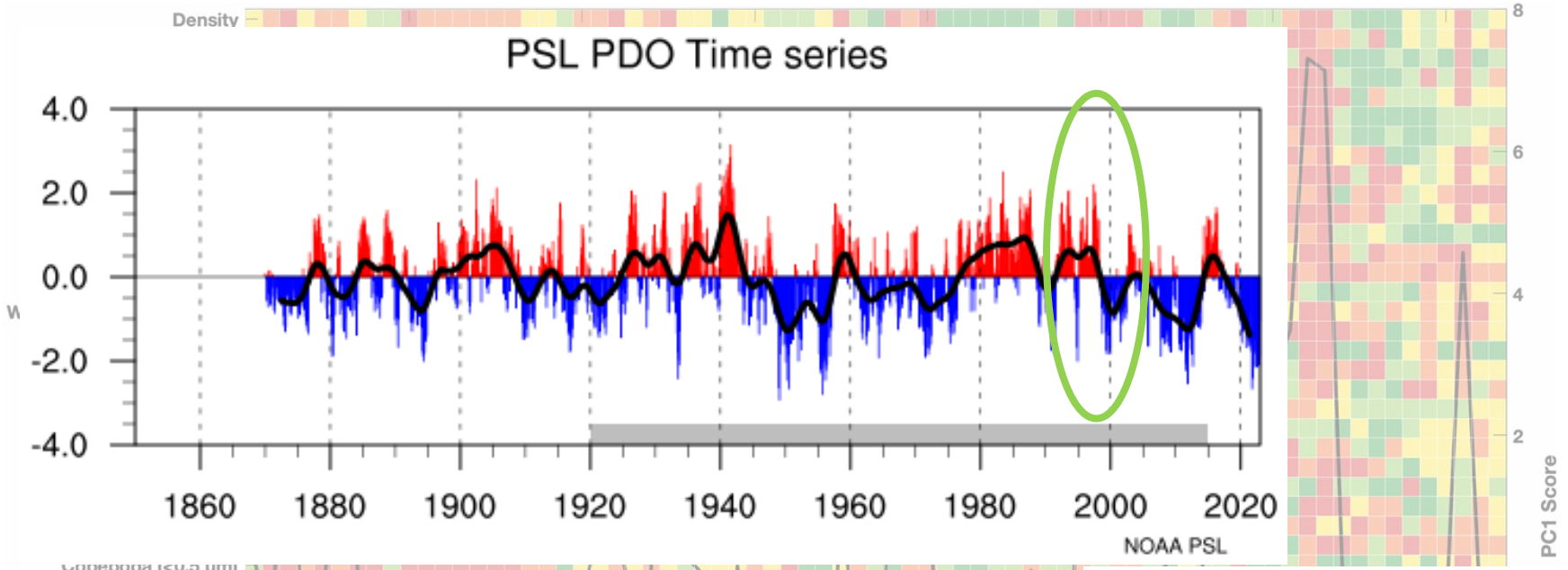
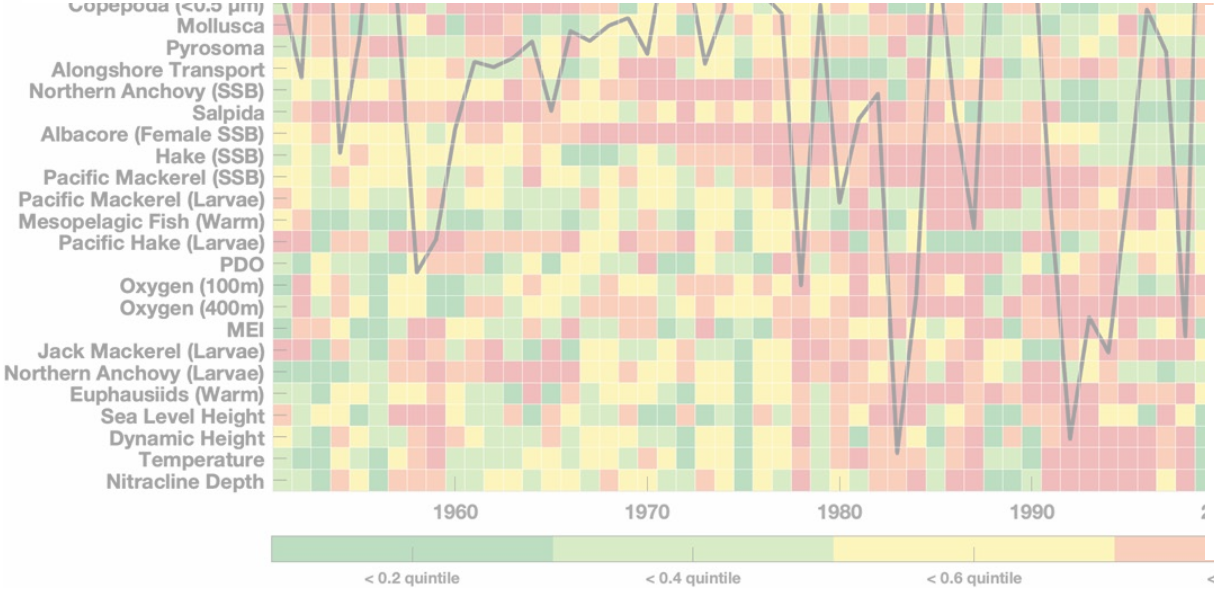


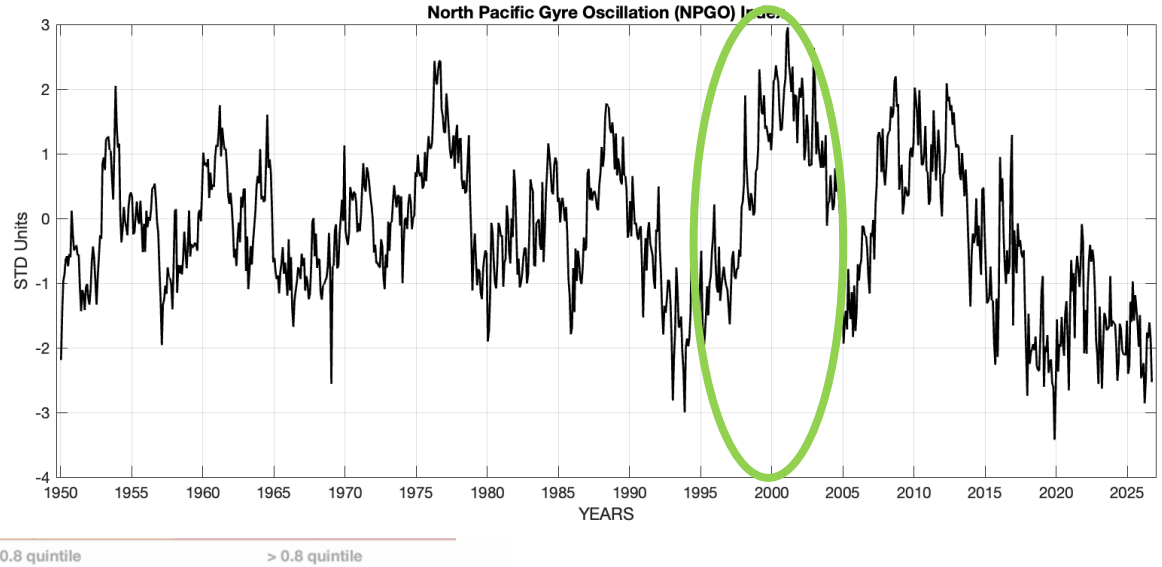
Subregional PC2 Stoplight



Drivers of Regional Change







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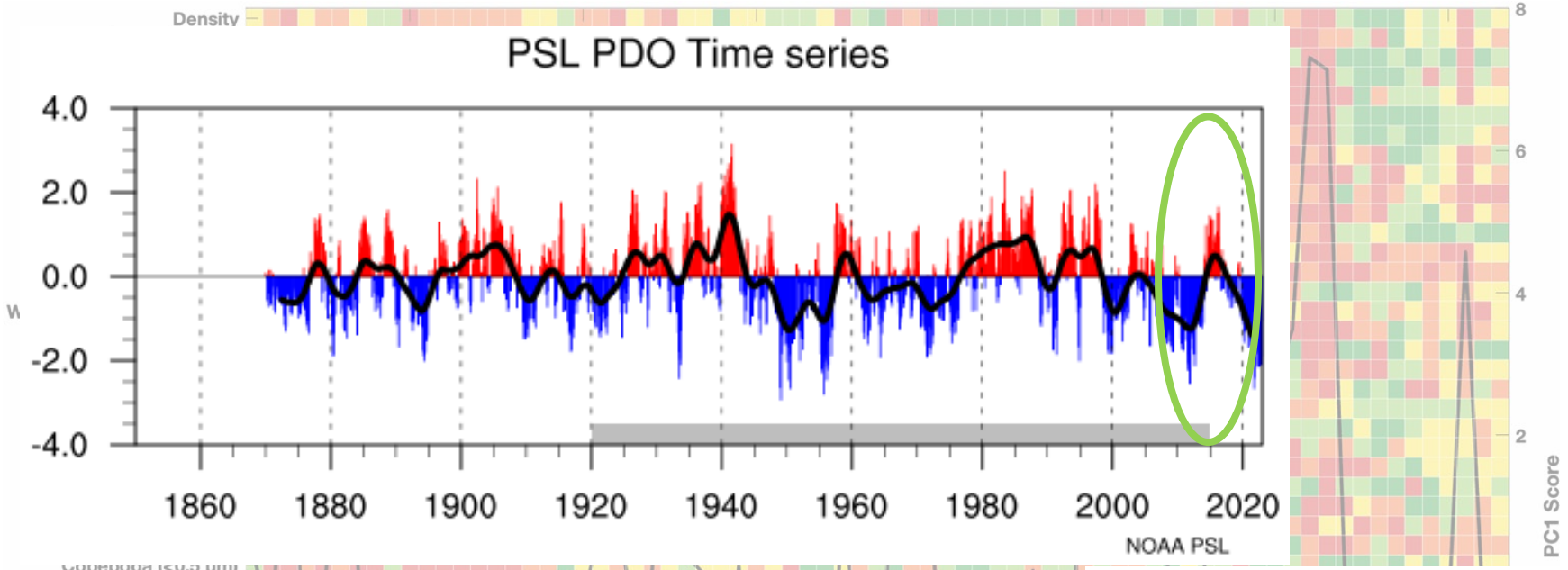
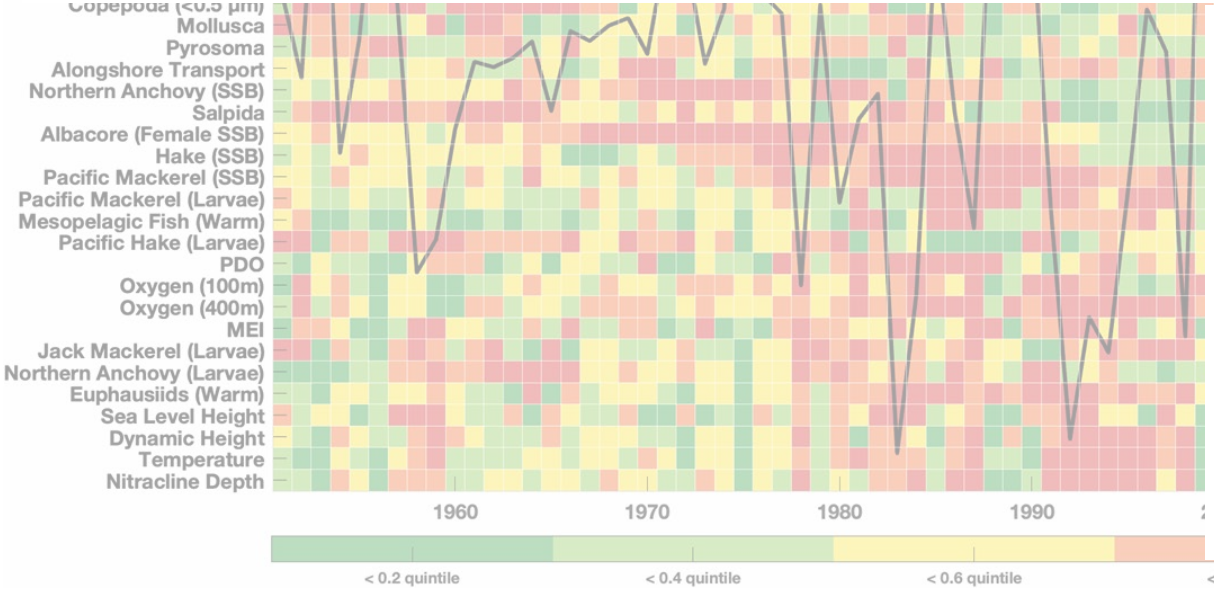
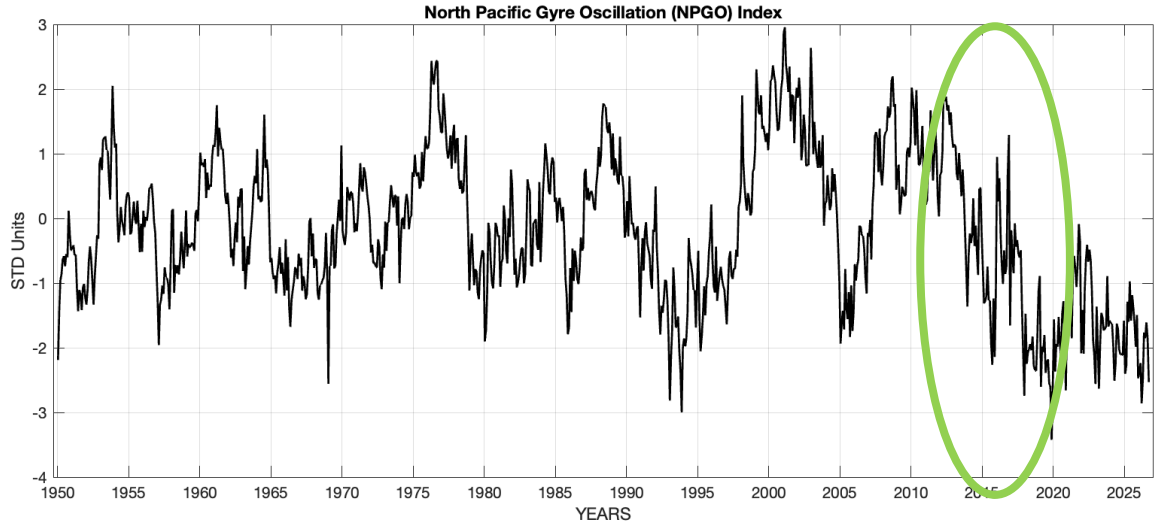
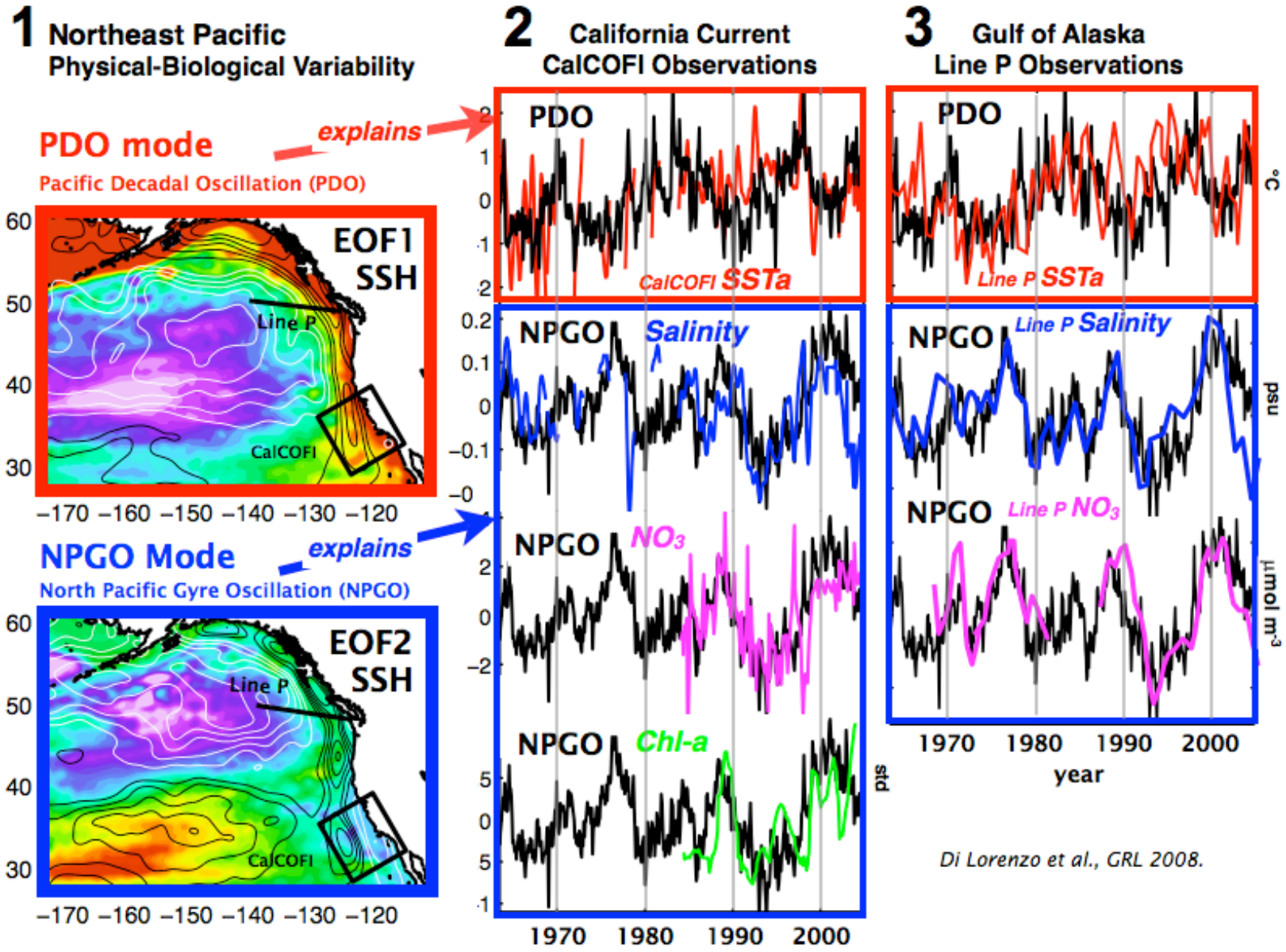
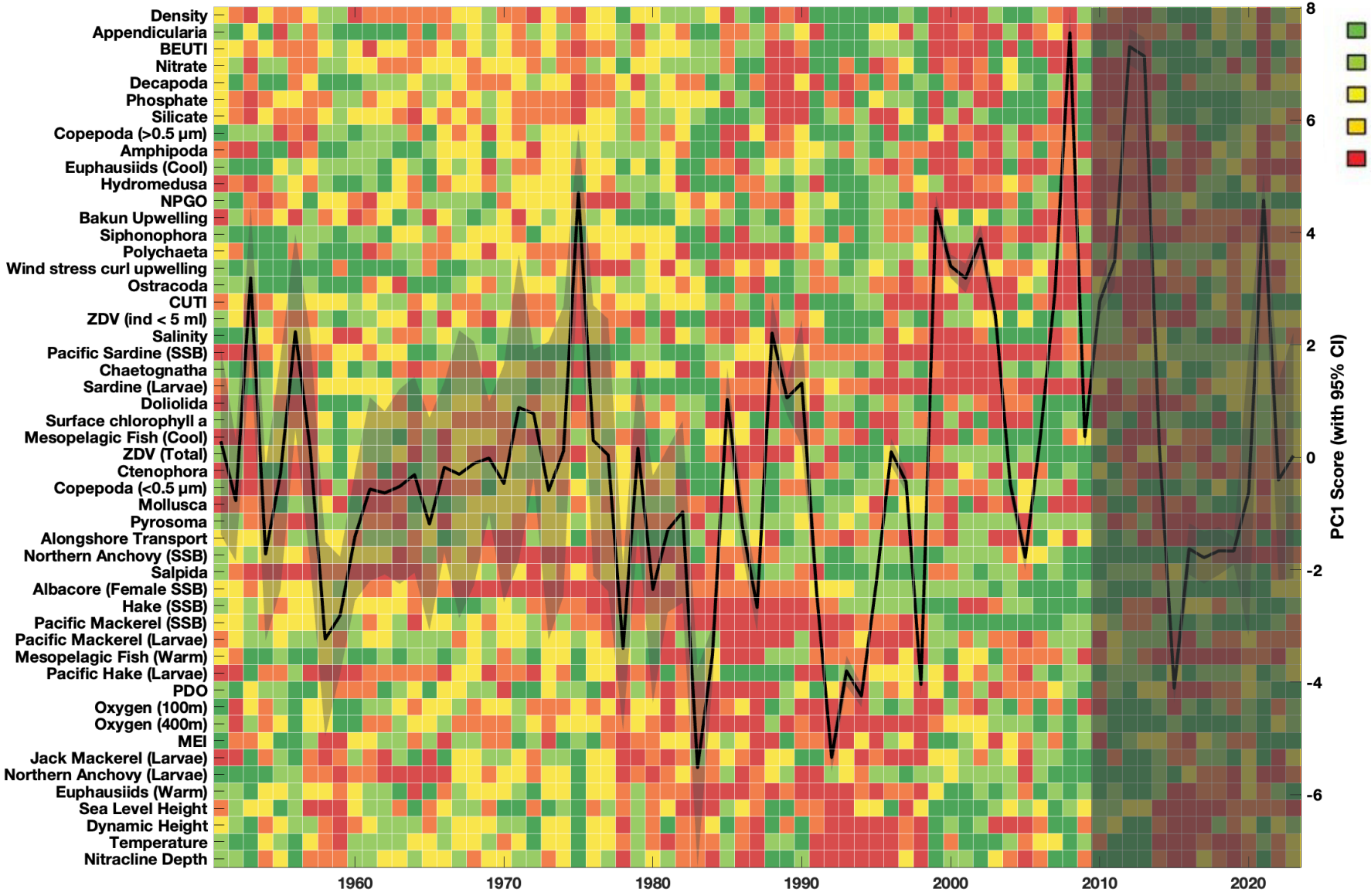







1 Northeast Pacific
Physical-Biological Variability
PDO mode
explains
Pacific Decadal Oscillation (PDO)
EOF1
SSH
Line P
CalCOFI
NPGO Mode
explains
North Pacific Gyre Oscillation (NPGO)
EOF2
SSH
Line P
CalCOFI
60
50
40
30
−170 −160 −150 −140 −130 −120
2 California Current
CalCOFI Observations
3 Gulf of Alaska
Line P Observations
PDO
CalCOFI SSTa
PDO
Line P SSTa
°C
NPGO
Salinity
NPGO
Line P Salinity
psu
NPGO
NO3
NPGO
Line P NO3
μmol m-3
NPGO
Chl-a
std
1970 1980 1990 2000
year
Di Lorenzo et al., GRL 2008.

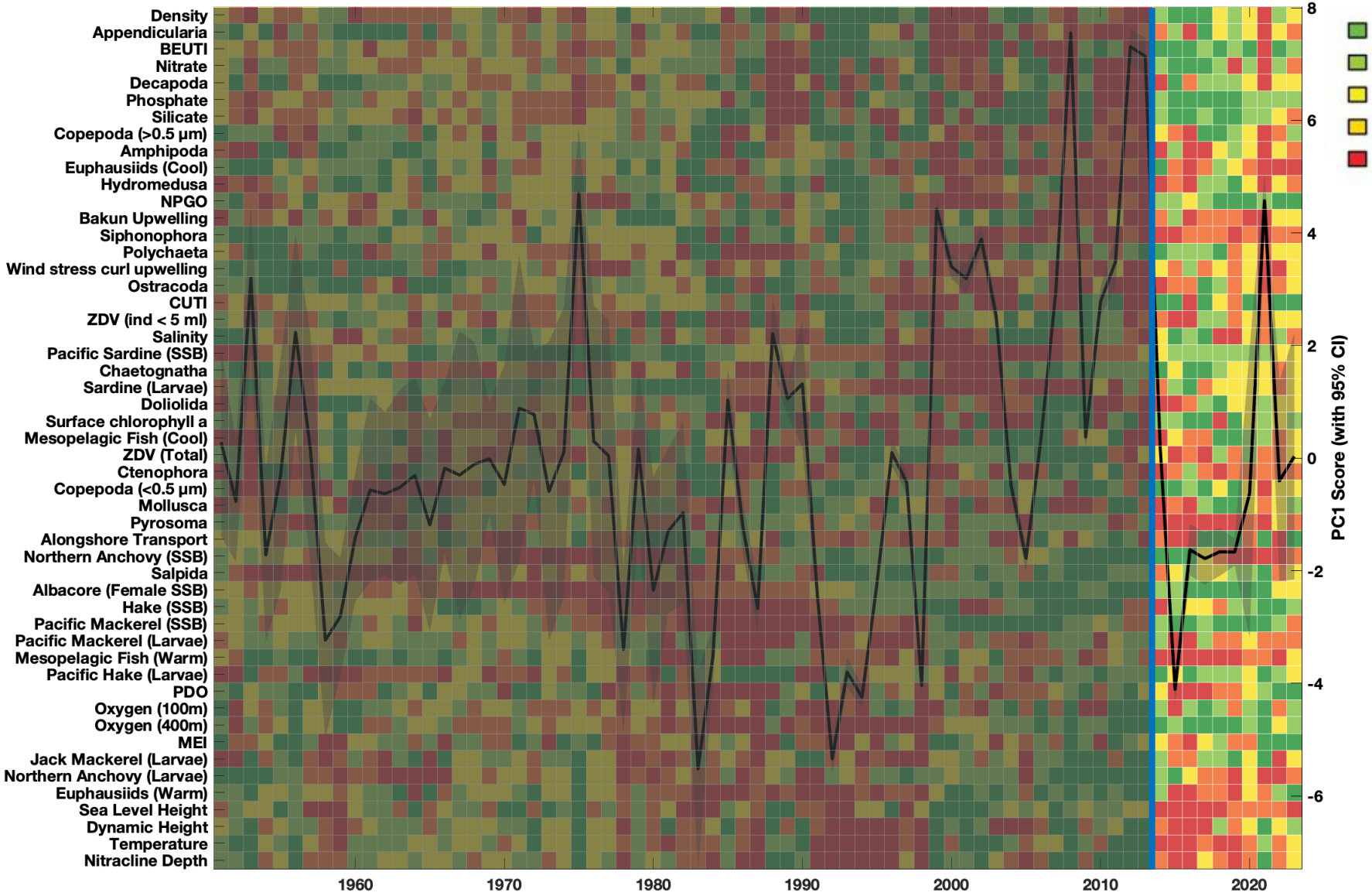
Drivers of Regional Change



PC1 remains the same after updating time series

Return to a warm phase that is characteristic of the 1980's and 90's

Drivers of Regional Change



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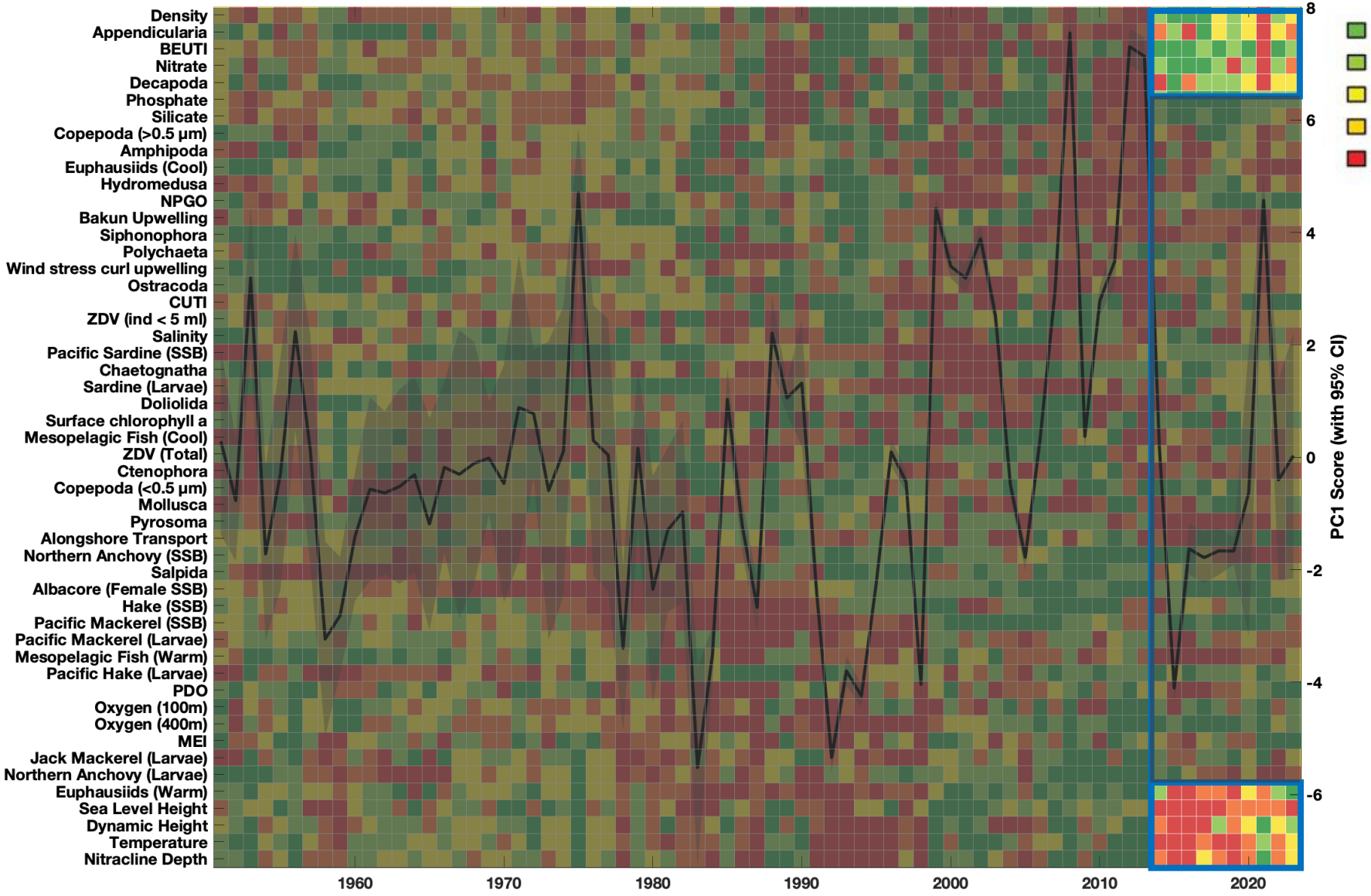

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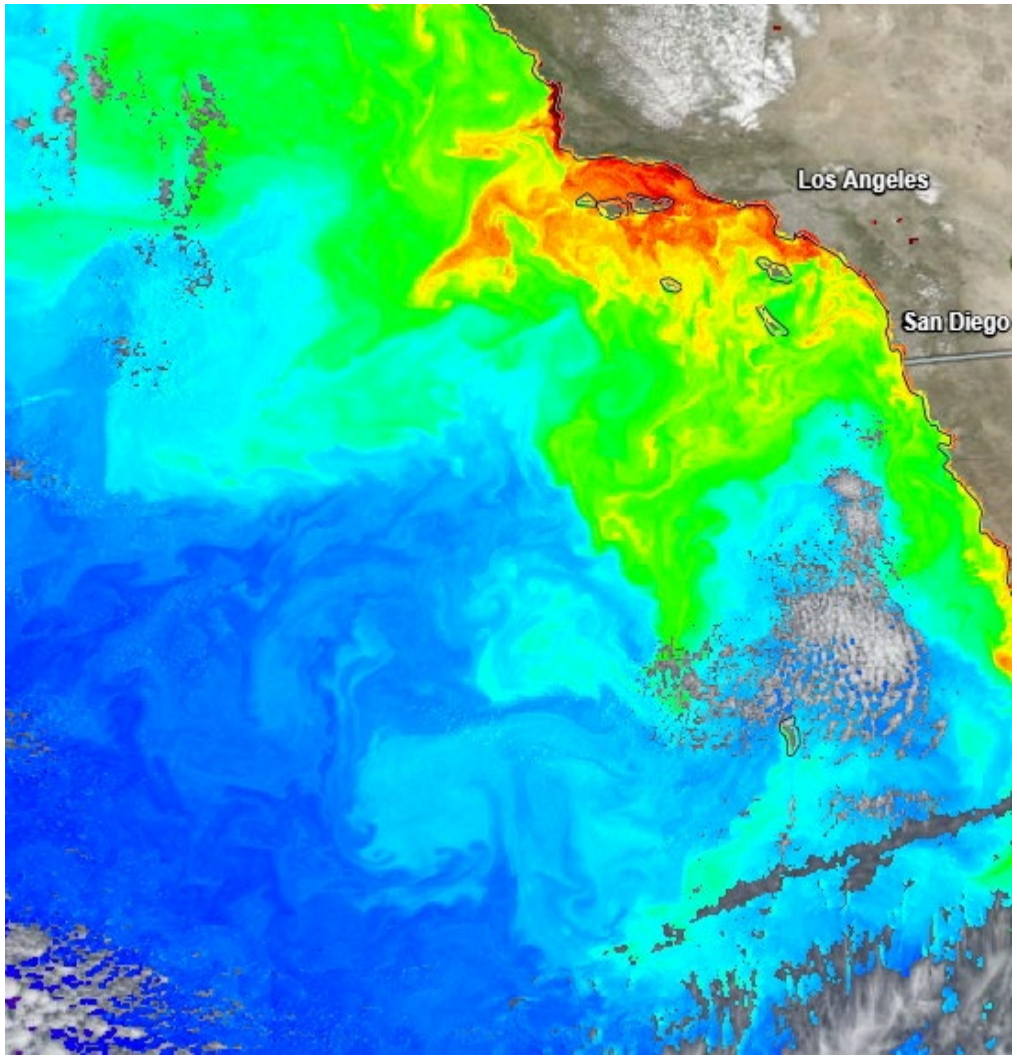

1. When looking at the whole region, you see the ecosystem respond to the PDO and NPGO by fluctuating between warm and cool phases

2. Long term change is mainly synchronous across subregions; however, cross regional synchrony begins to break down when looking at the effects of upwelling on the system

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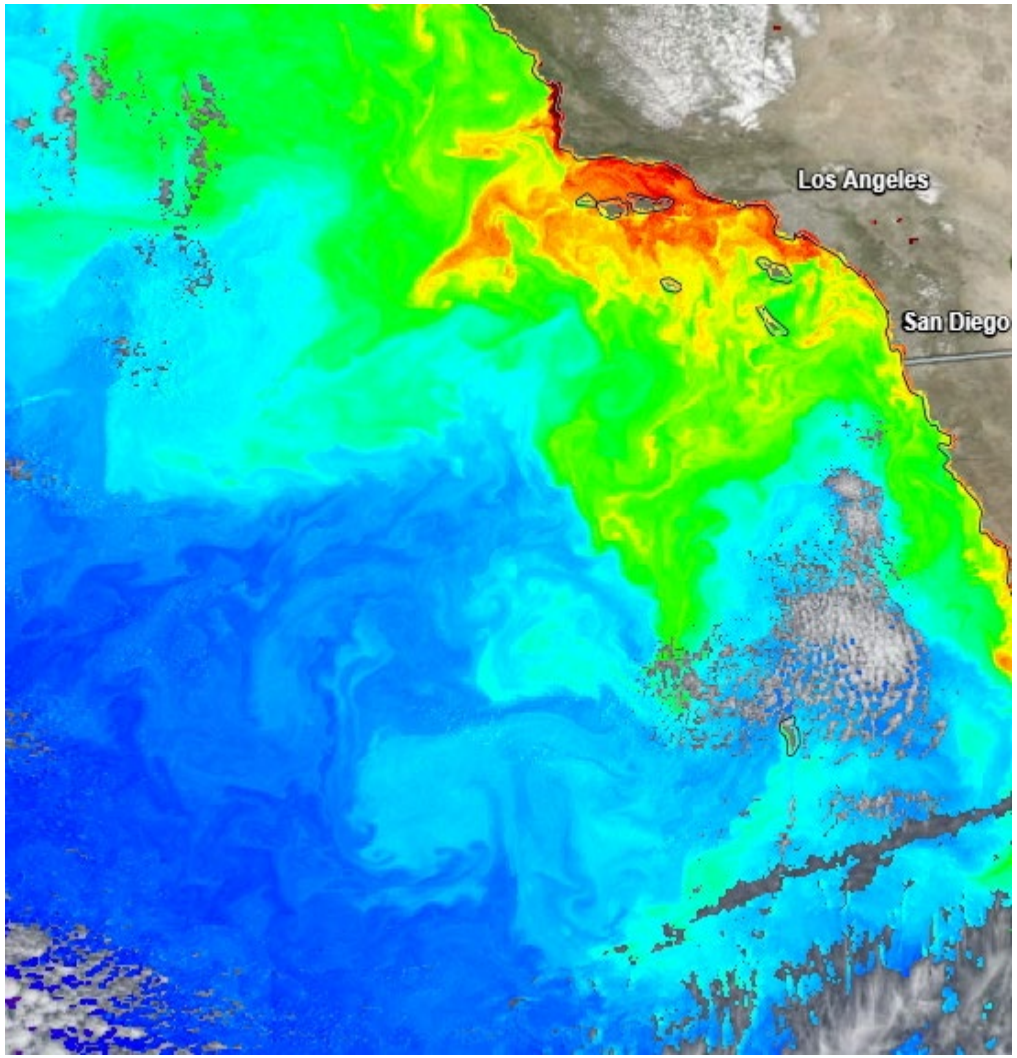

1. PCAs of annual averages of the region show interdecadal fluctuations between warm and cool phases, linked with the PDO and NPGO

2. Long term change is mainly synchronous across subregions; however, variables that are influenced by physical mechanisms respond differently across the southern California Current Ecosystem due to its large environmental gradient

3. The cold, nutrient rich Alley and Northeast regions may have a stronger influence over southern CCE ecosystem dynamics

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