Food web-assimilated resources and a century of environmental change in the NE Pacific

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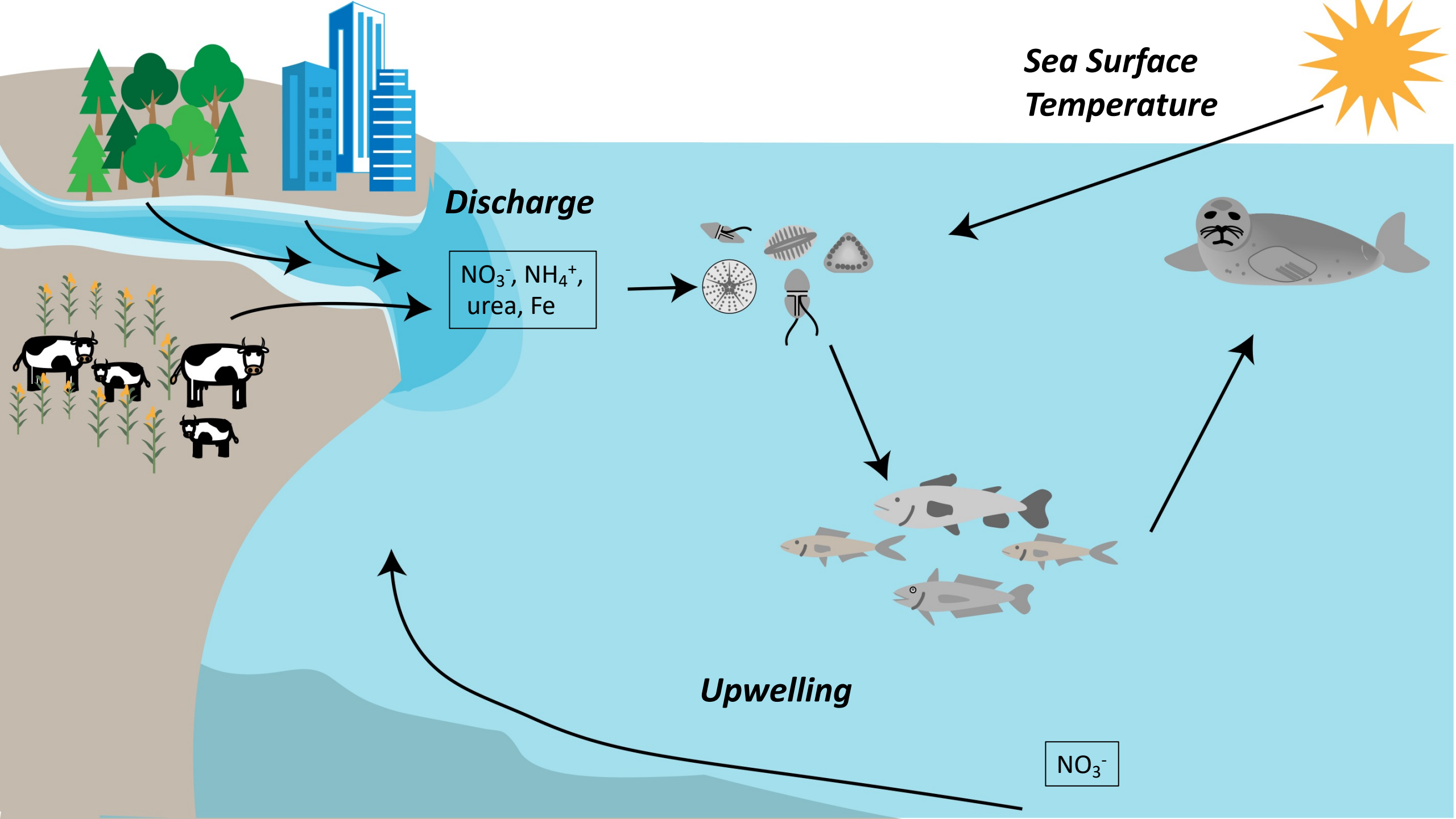
Graduate Student Symposium 2020

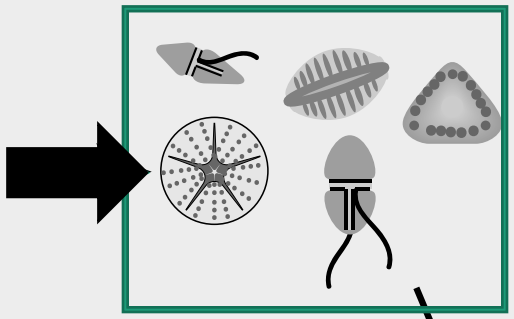

Sea Surface Temperature
Discharge
NO_3^-, NH_4^+, urea, Fe
Upwelling
NO_3^-

How does the environment impact ***resource utilization by coastal marine food webs?***

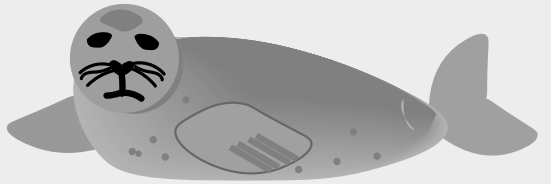
Challenges of Scale

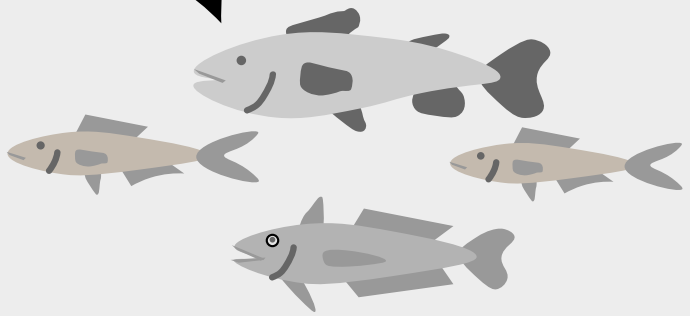
NO_3^-, NH_4^+, urea

1. We can measure resources directly

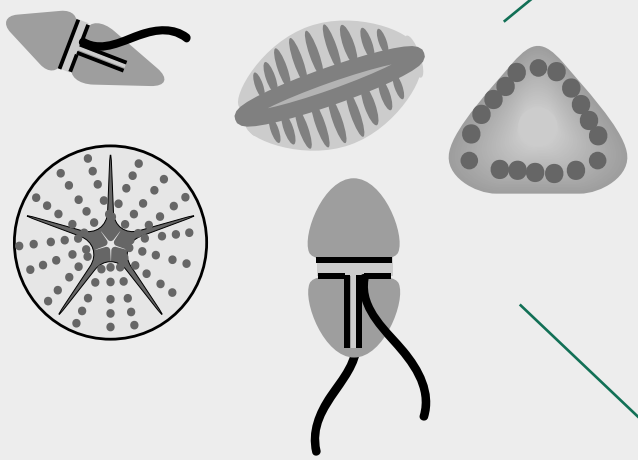


2. We can measure primary producers directly





Utilizing Chemical Tracers



$\delta^{13}C$

- Community Composition
- Cellular Growth
- $[CO_2]$

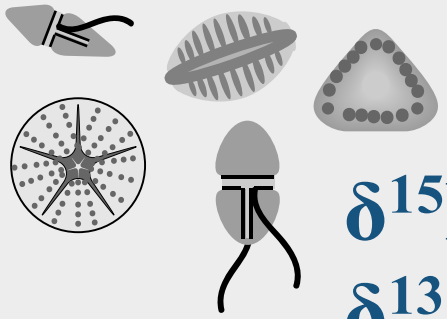
Additive & Subtractive

$\delta^{15}N$

- Nitrogen Sources
- Isotope composition of N

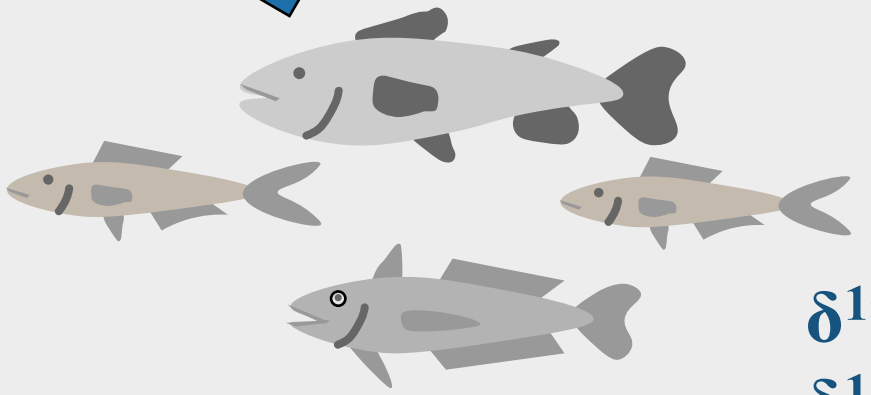
Large scale indicators

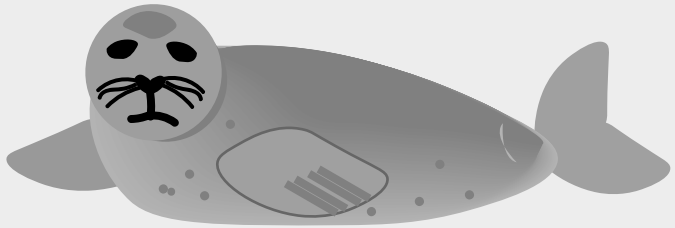
Scaling to food webs



$\delta^{15}N$
$\delta^{13}C$

Transferred



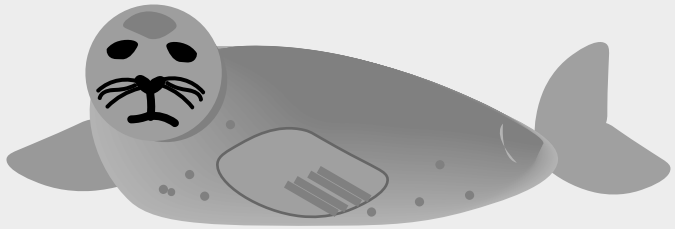


Conserved

$\delta^{15}N$ of phenylalanine
$\delta^{13}C$

Indices spatially and temporally integrated on food web relevant scales

Consumer tissues



$\delta^{13}C$ *Phytoplankton dynamics*

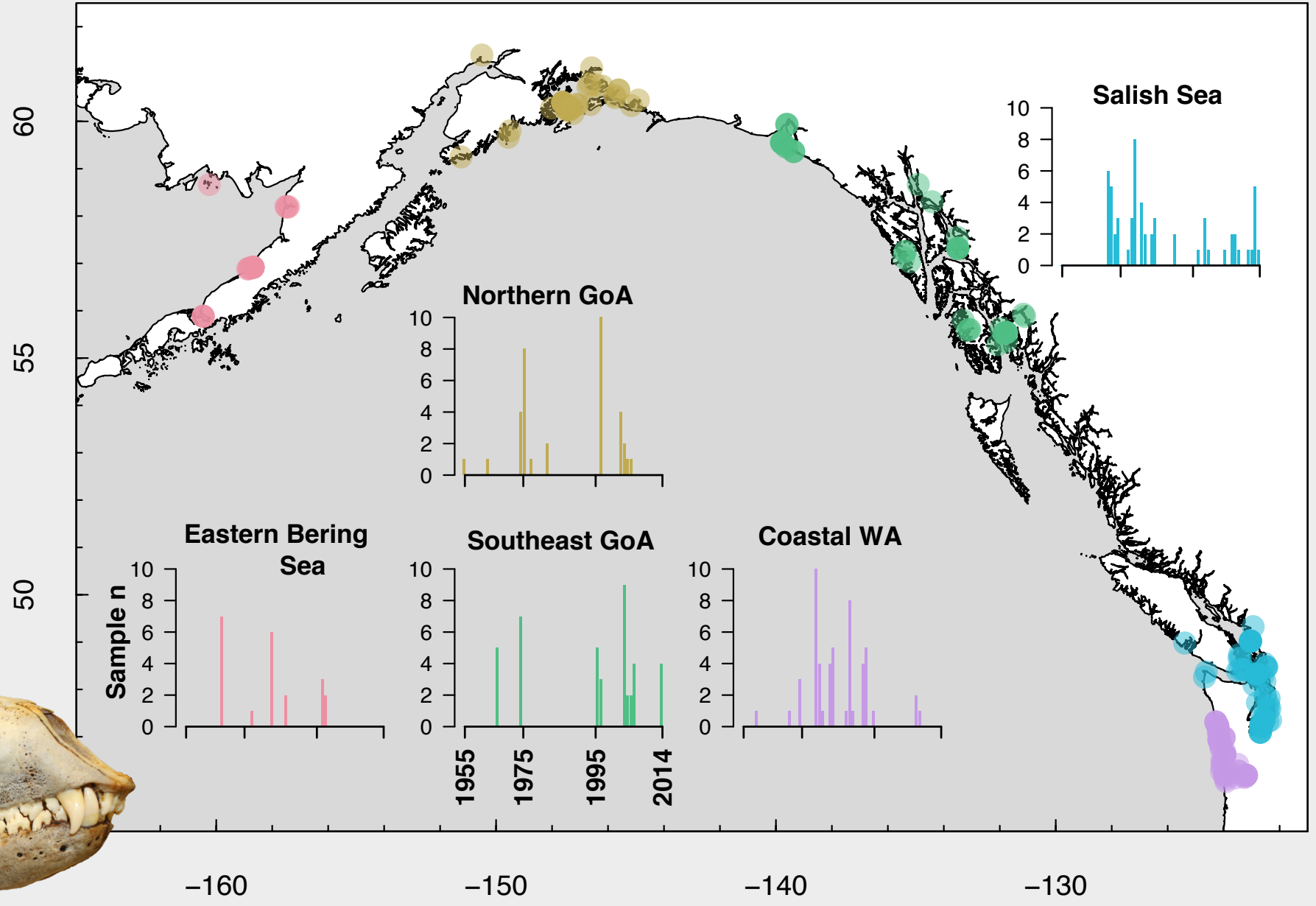
Food web assimilated primary production

$\delta^{15}N_{Phe}$ *Nitrogen resource*

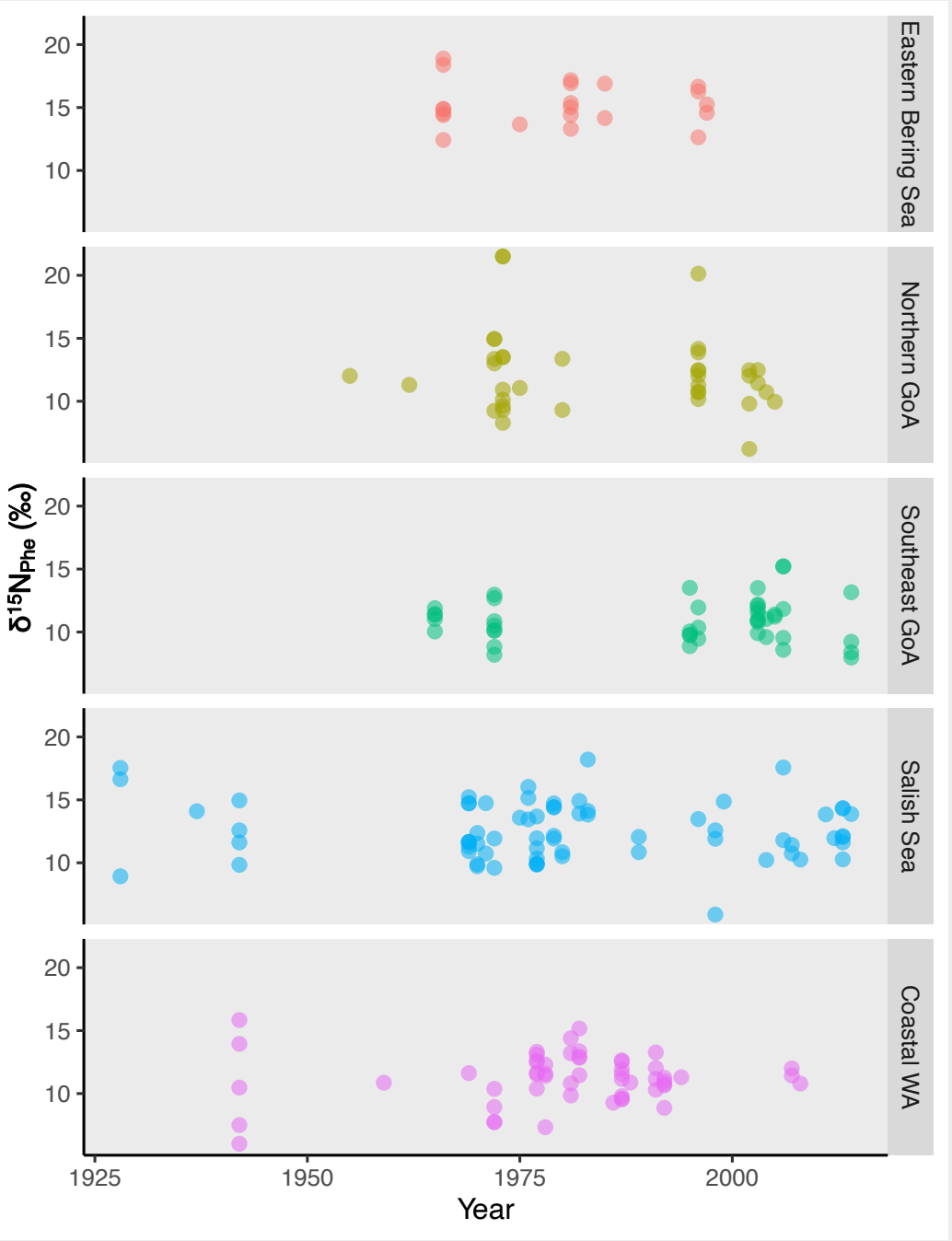
Food web assimilated nitrogen resources

$\delta^{15}N_{Phe}$

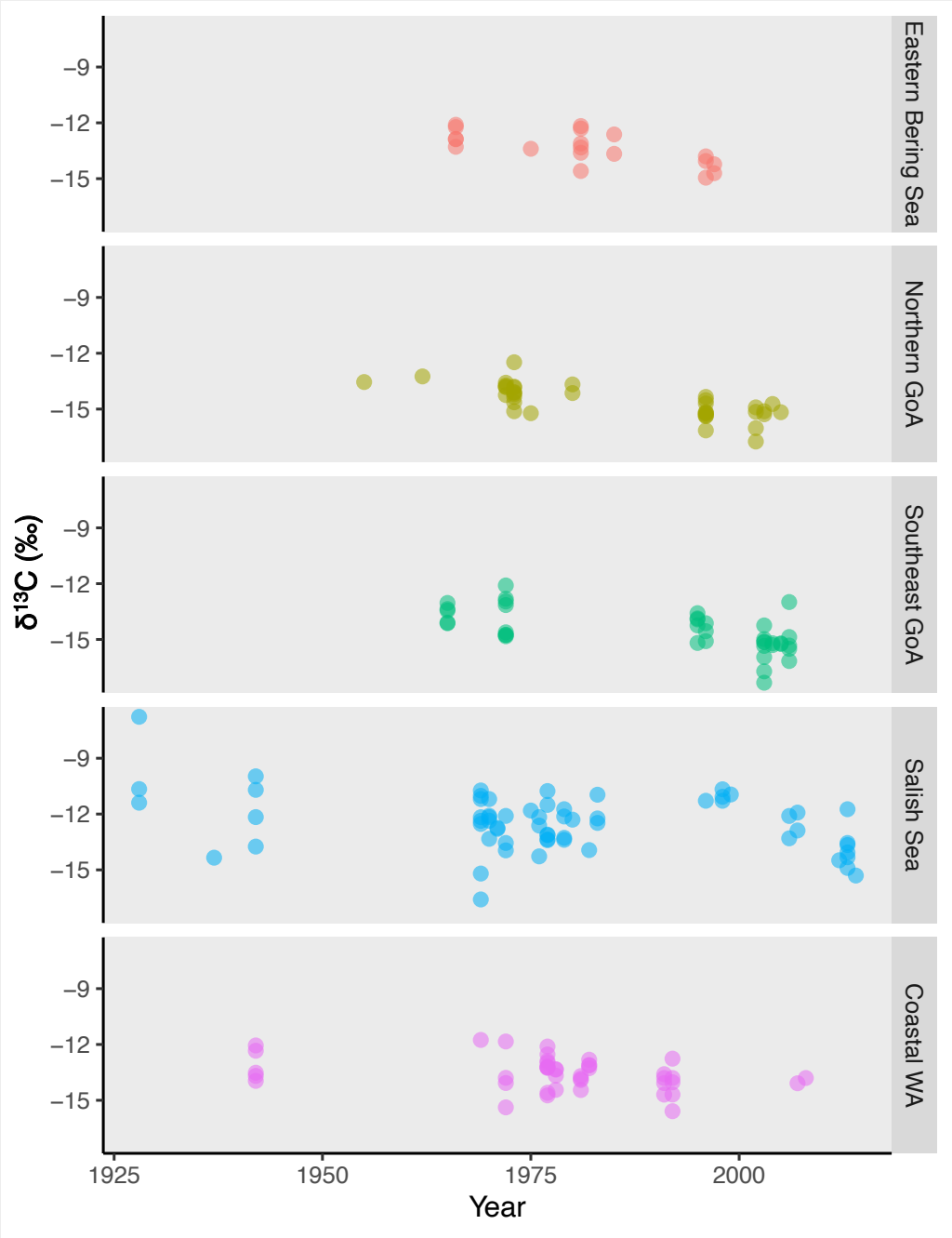
$\delta^{13}C$



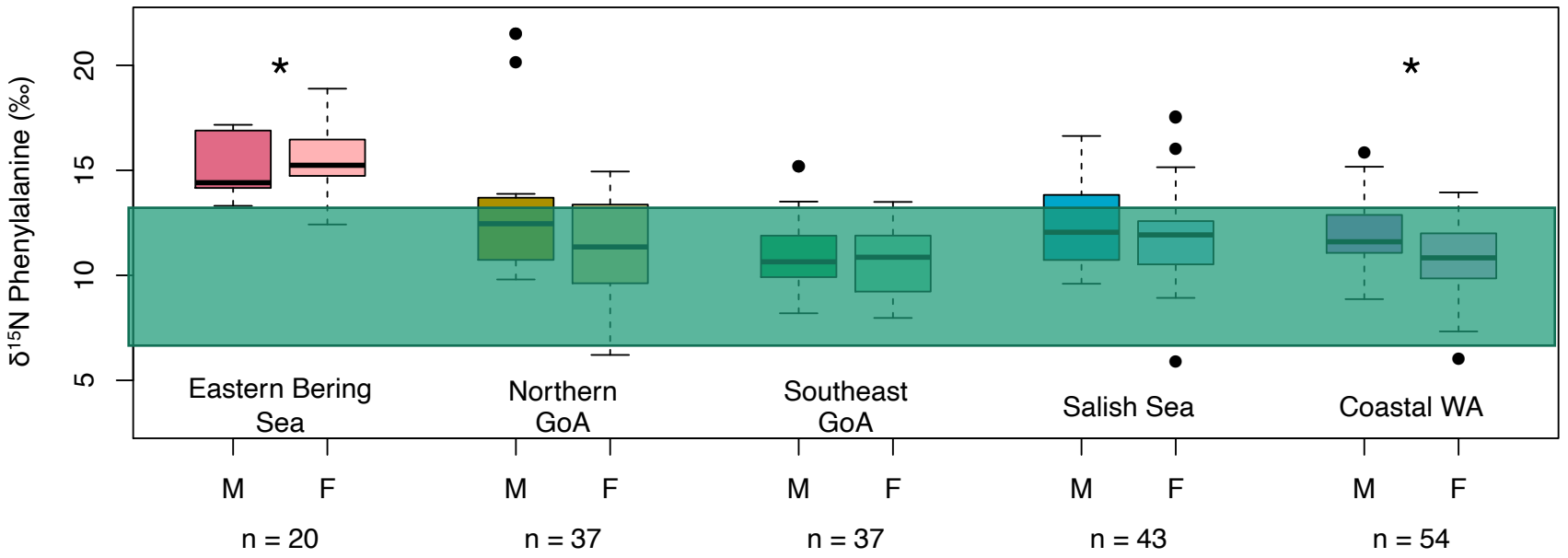
$\delta^{15}N_{Phe}$ is variable but relatively stable through time across regions



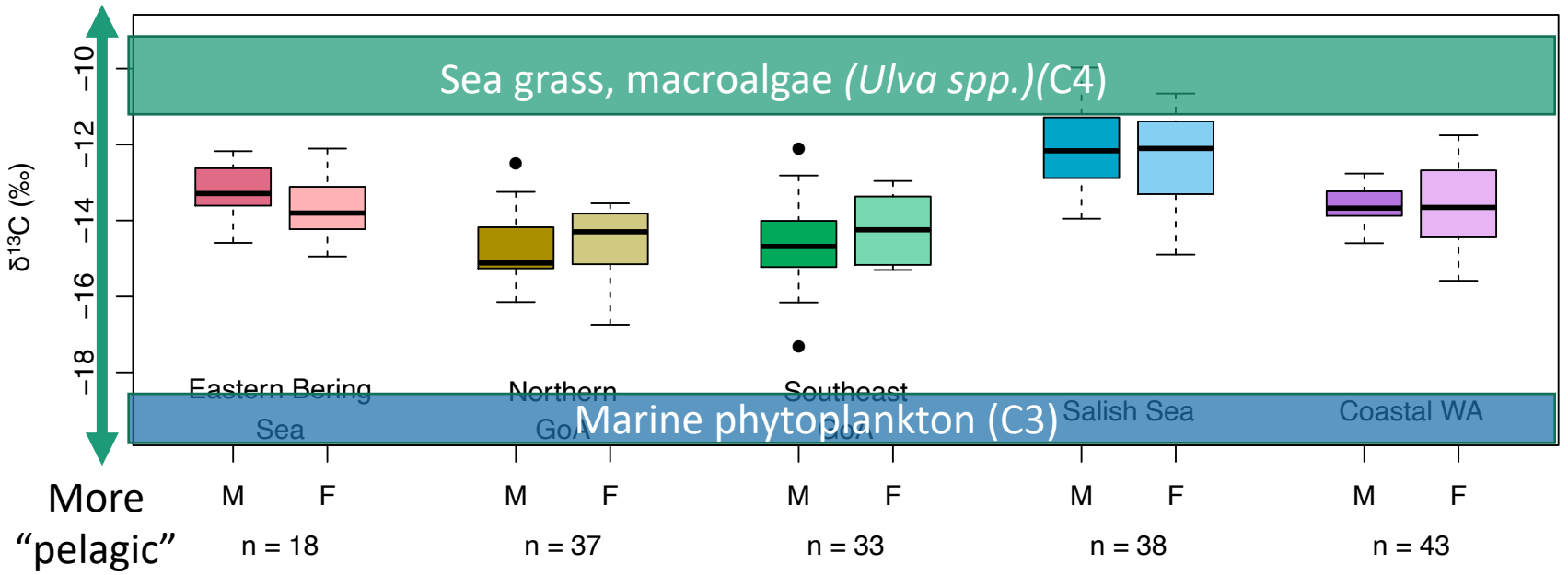
$\delta^{13}C$ appears to decrease during recent decades in most regions



Sex specific foraging patterns are not a long-term phenomenon



More "coastal"



More "pelagic"

How does the environment impact ***resource utilization by coastal marine food webs?***

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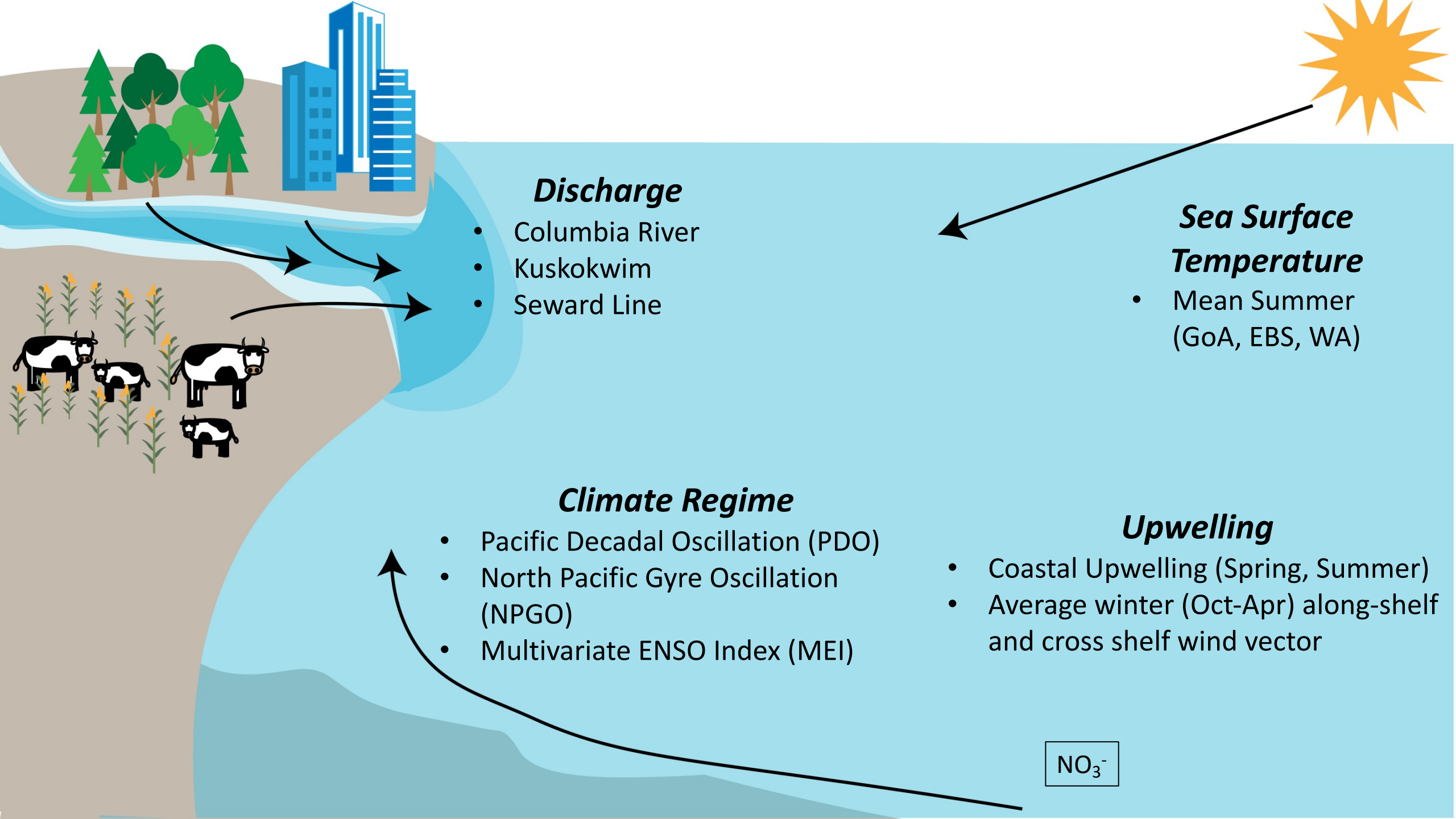
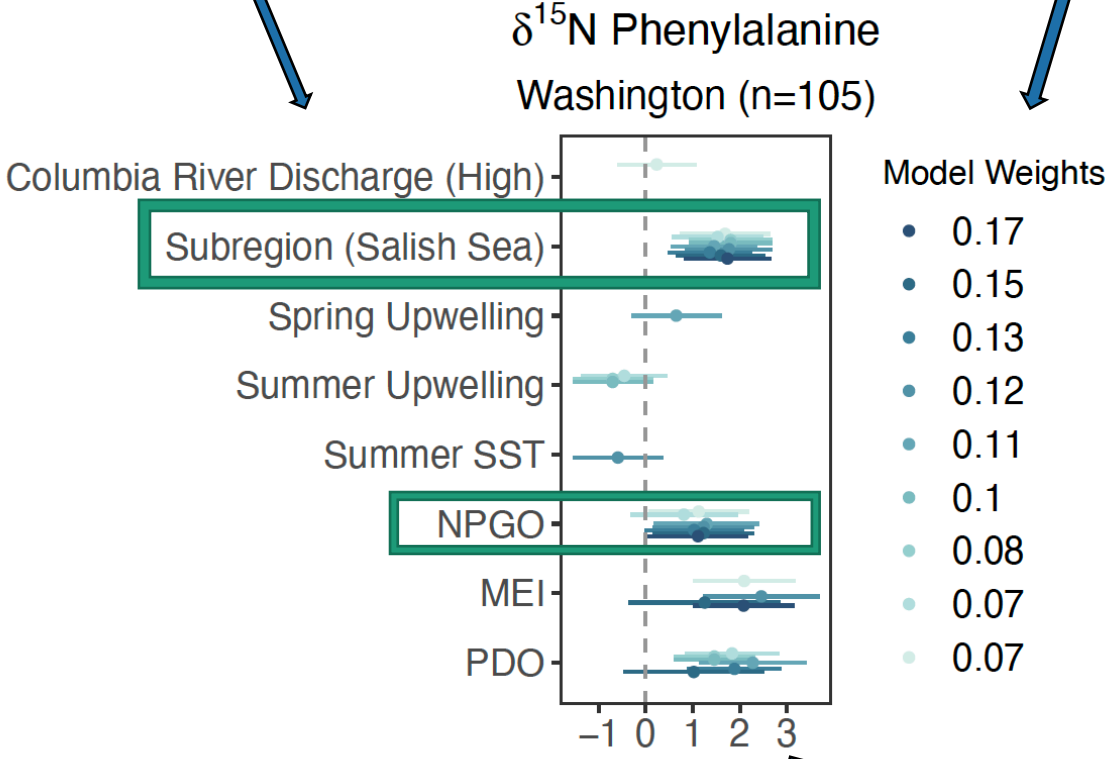

Discharge
Columbia River
Kuskokwim
Seward Line
Sea Surface Temperature
Mean Summer (GoA, EBS, WA)
Climate Regime
Pacific Decadal Oscillation (PDO)
North Pacific Gyre Oscillation (NPGO)
Multivariate ENSO Index (MEI)
Upwelling
Coastal Upwelling (Spring, Summer)
Average winter (Oct-Apr) along-shelf and cross shelf wind vector
NO_3^-

Time series covariates

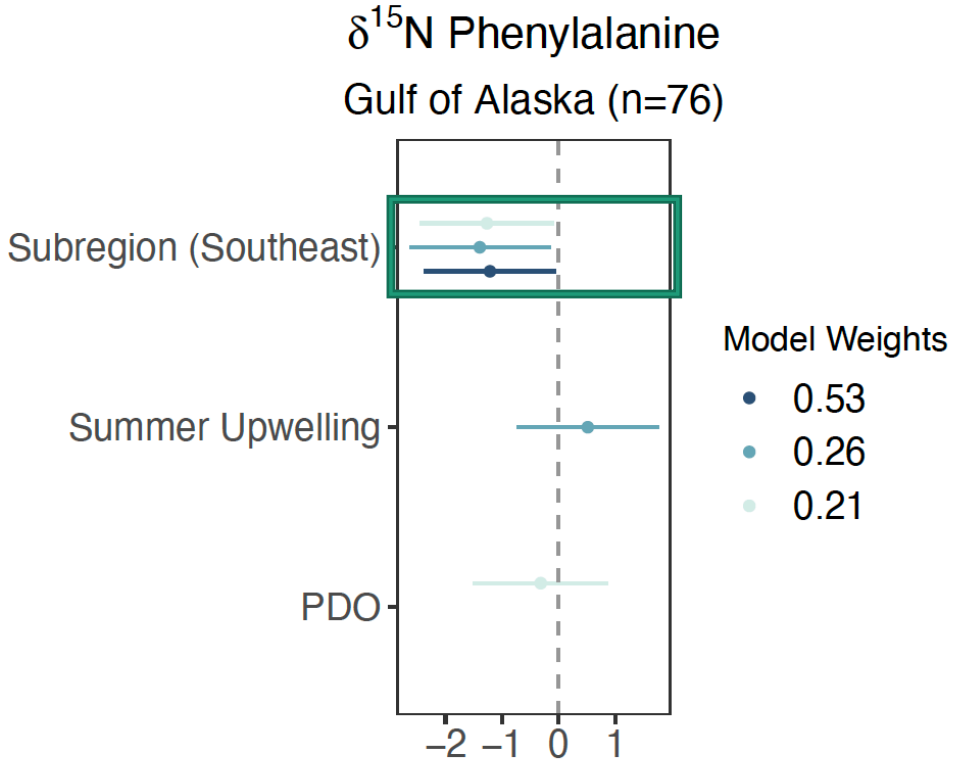
delAIC < 2



Covariate Values

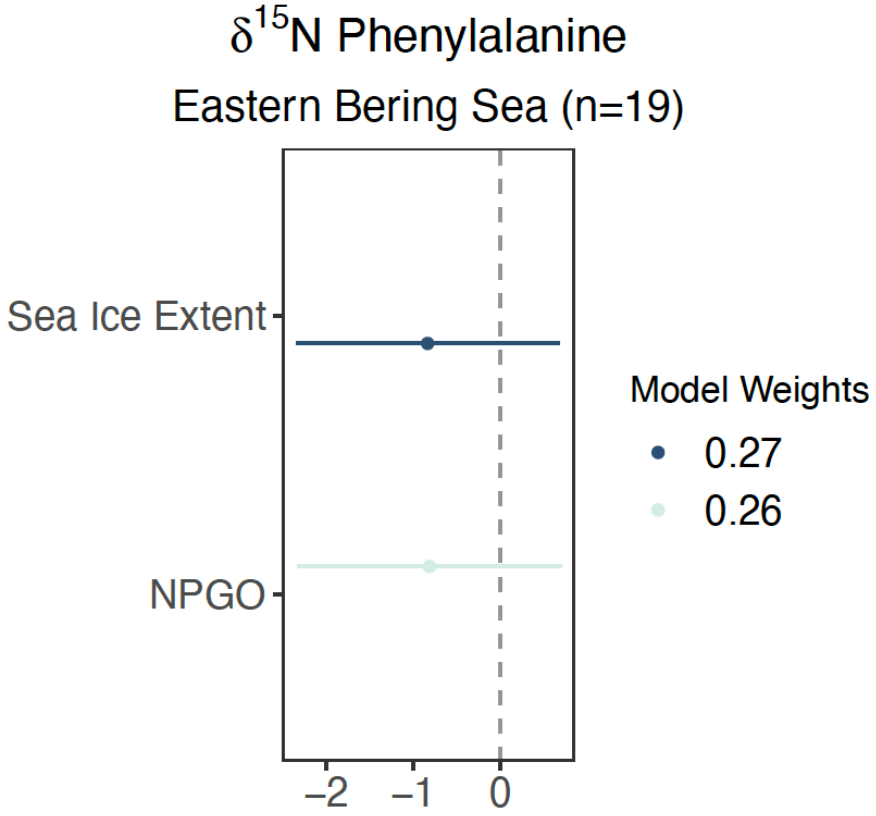
WASHINGTON

- Climate regime is an important indicator of food web assimilated nitrogen
- Salish Sea food webs incorporate significantly higher $\delta^{15}N_{Phe}$ and $\delta^{13}C$ compared to coastal WA
  - $\delta^{13}C$ combined difference in taxa (Seagrass or macroalgae)
  - $\delta^{15}N$ legacy of anthropogenic influence



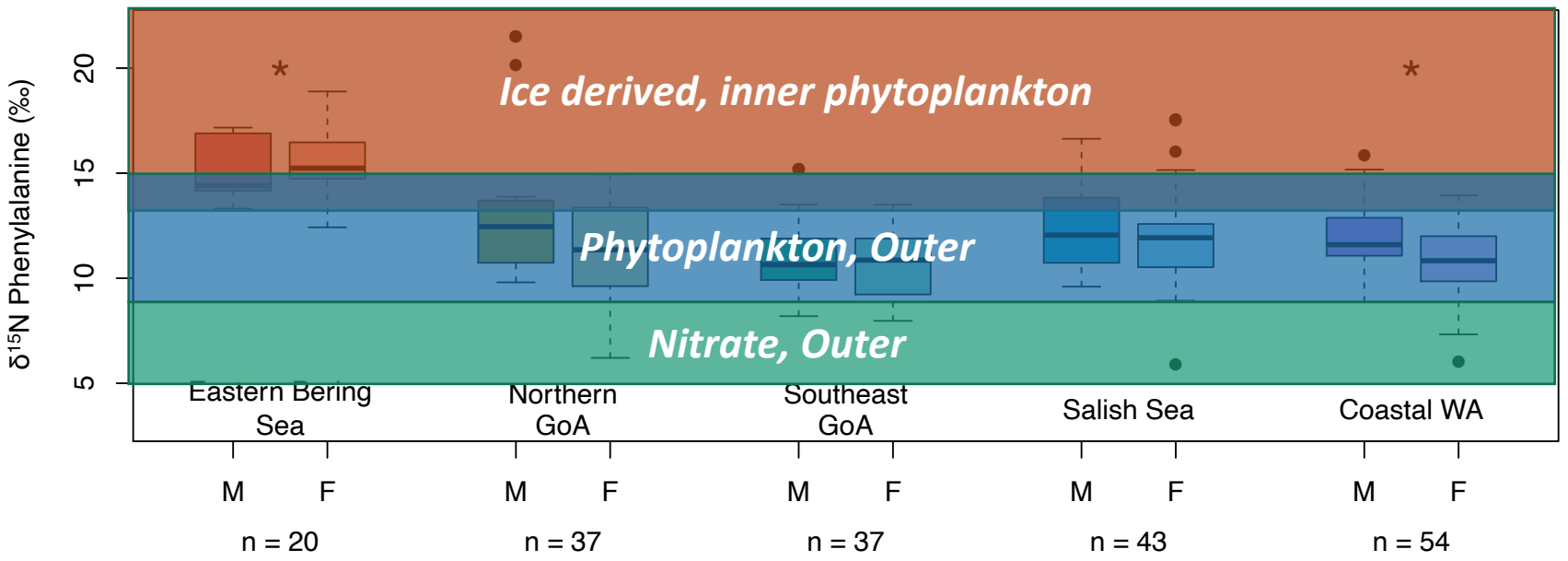
GULF OF ALASKA

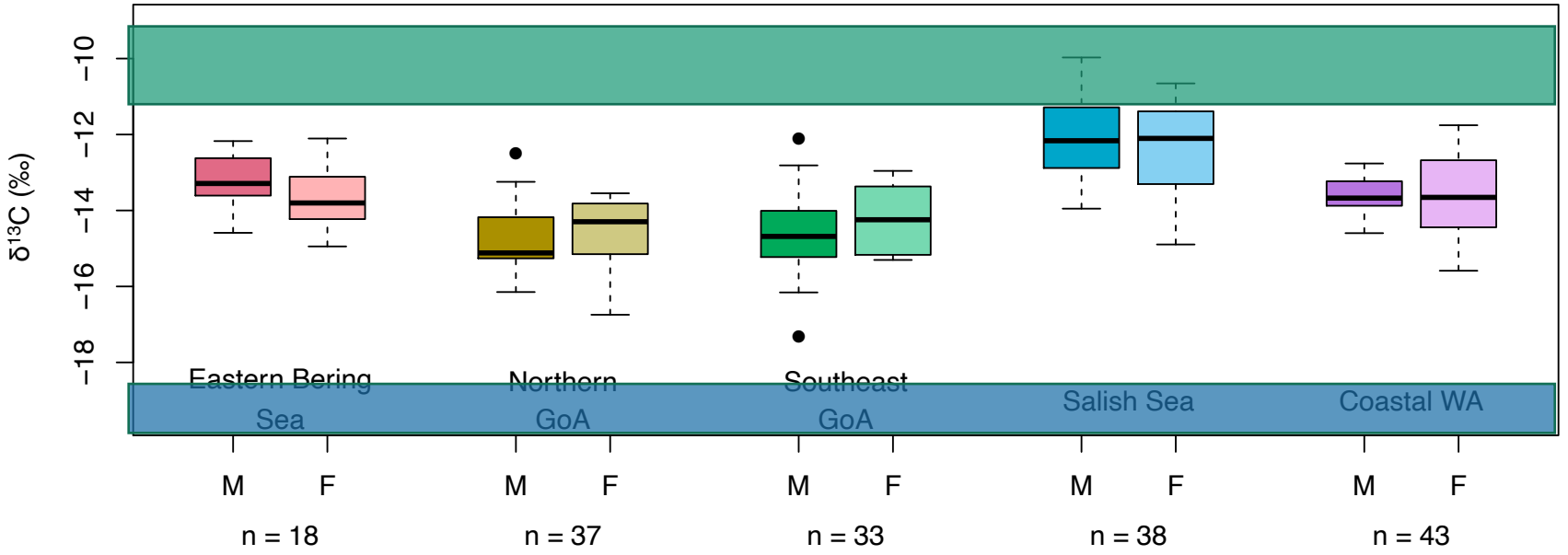
- Regionally distinct food web assimilated nitrogen
- Negative correlation with SST
  - CO_2 concentration
  - Community composition
- Opposite effect of NPGO on food web assimilated production compared to WA



EASTERN BERING SEA

- A lot of model uncertainty for **$\delta^{13}C$ (likely due to low sample size)**
- **$\delta^{15}N_{Phe}$ sea ice** derived resources appear important


δ15N Phenylalanine (‰)
5
10
15
20
Ice derived, inner phytoplankton
Phytoplankton, Outer
Nitrate, Outer
Eastern Bering Sea
Northern GoA
Southeast GoA
Salish Sea
Coastal WA
M
F
n = 20
n = 37
n = 37
n = 43
n = 54


δ13C (‰)
−10
−12
−14
−16
−18
Eastern Bering Sea
Northern GoA
Southeast GoA
Salish Sea
Coastal WA
M
F
n = 18
n = 37
n = 33
n = 38
n = 43

- Chemical tracers of consumer tissues provide food web-specific information
  - Sea ice, anthropogenically derived nitrogen
- Oceanic conditions are the primary drivers of temporal changes in food web assimilated primary production and nitrogen resources

Acknowledgments

Burke Museum

University of Alaska Museum of the North

Royal BC Museum

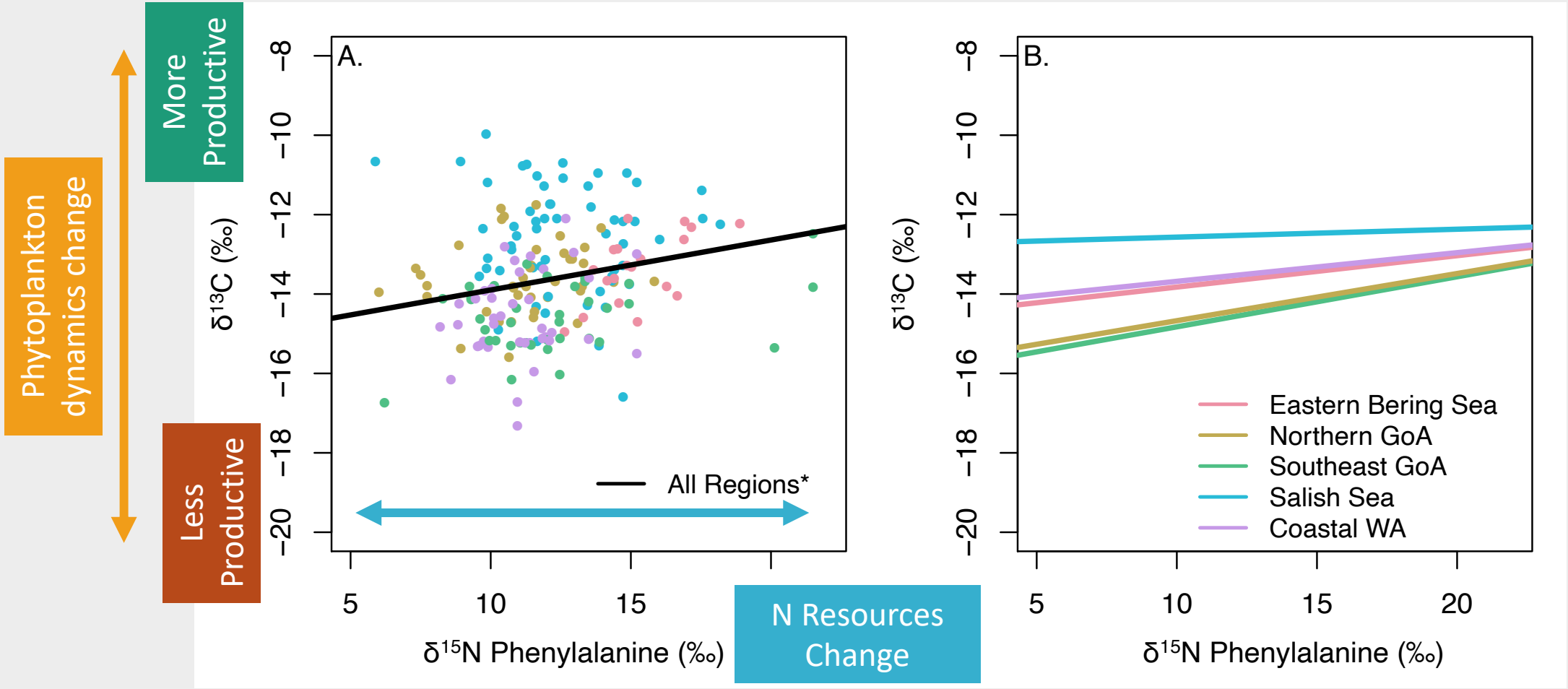
NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

Sea Grant Washington

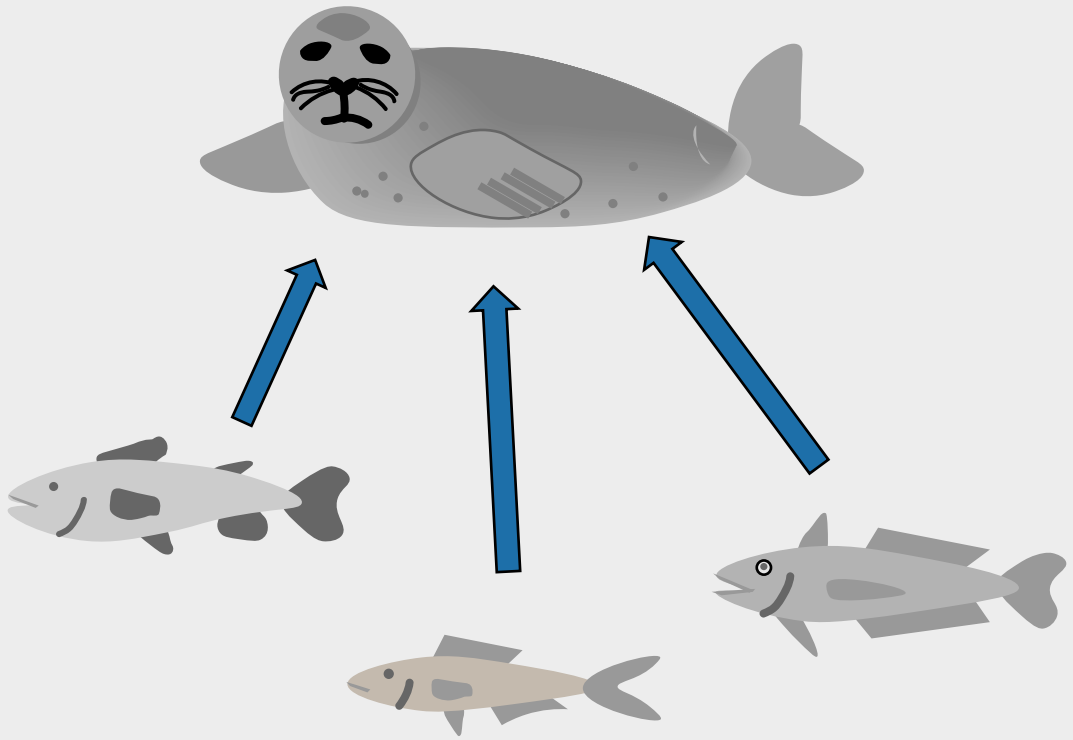
Smithsonian Institution

Slater Museum of Natural History University of Puget Sound

Variation in bottom up control of food web assimilated productivity by nitrogen resources



Generalists integrate over multiple resource pathways



Limited migration, high site fidelity

Are not utilizing resources in different locations

5 - 10 km from haul out sites and at depths < 200 m

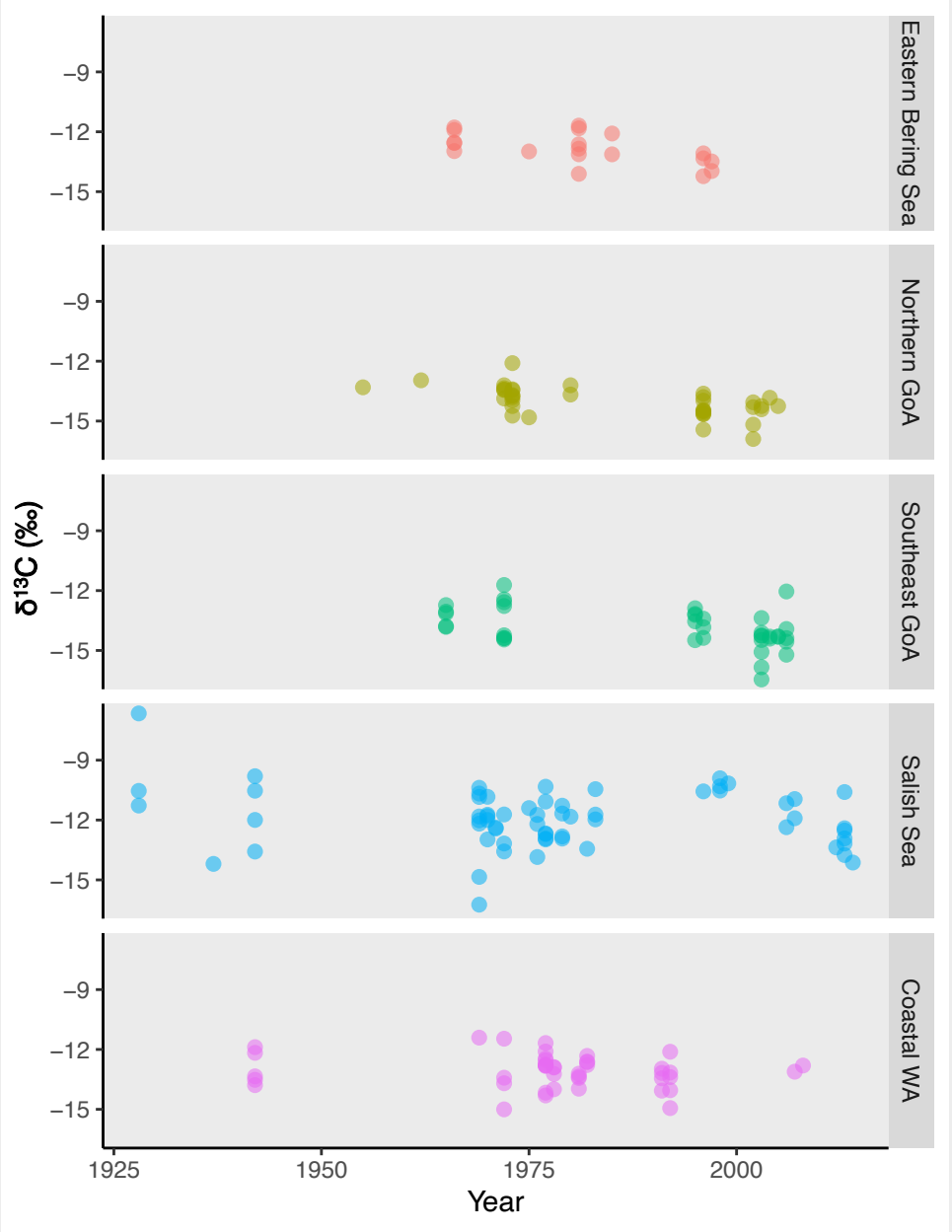
Are not susceptible to integrating nearshore vs. offshore $\delta^{13}C$ gradients

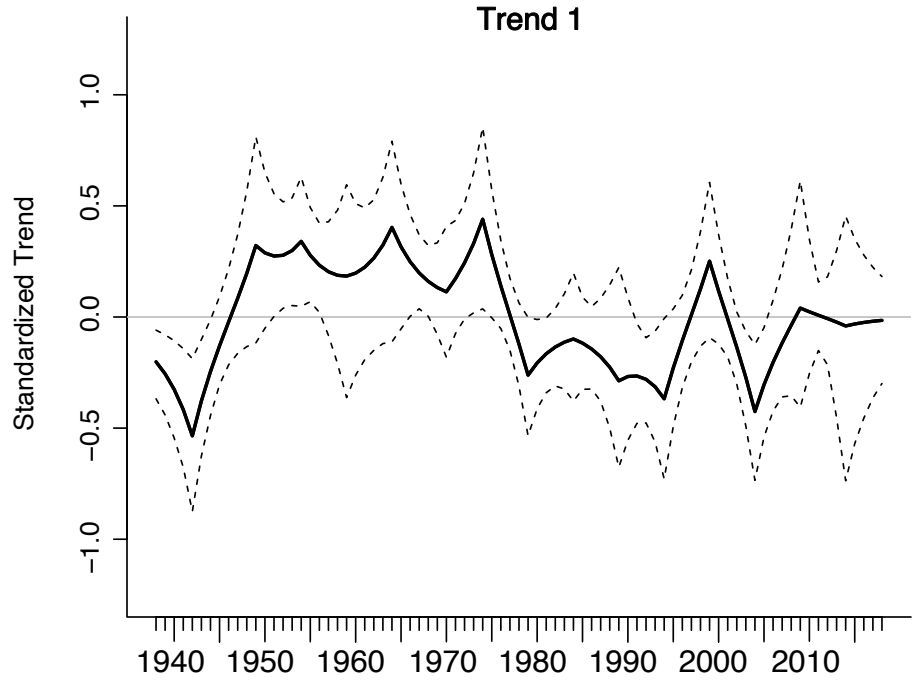
Controlled feeding studies

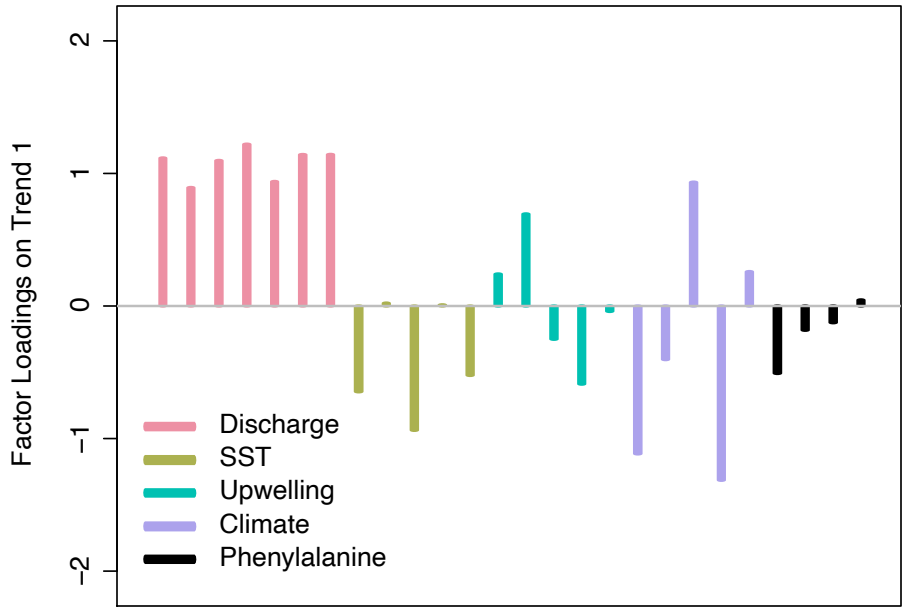
Minimal trophic enrichment

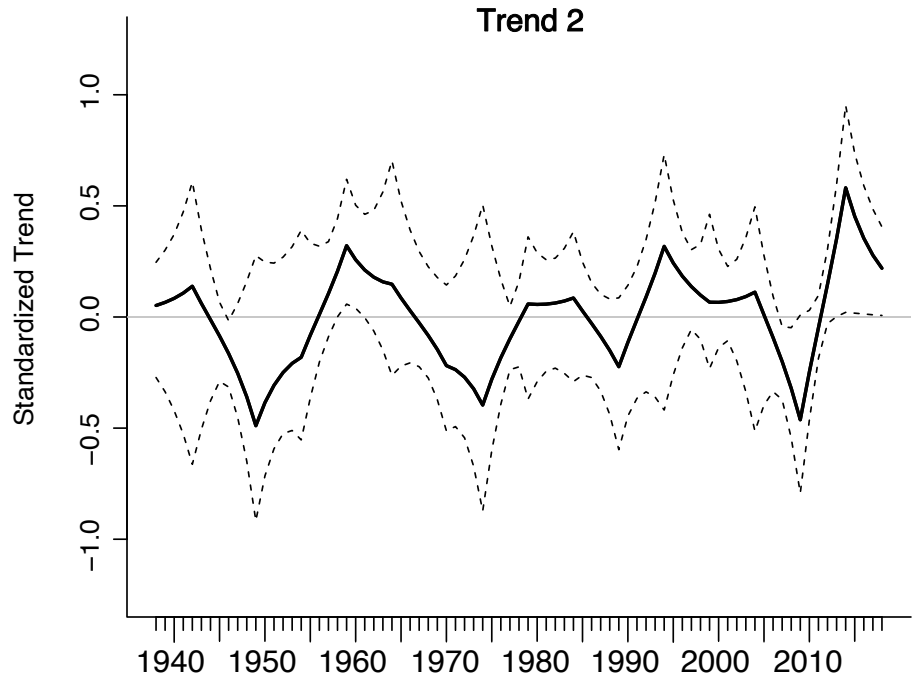
Optimal consumer for stable isotope interpretation

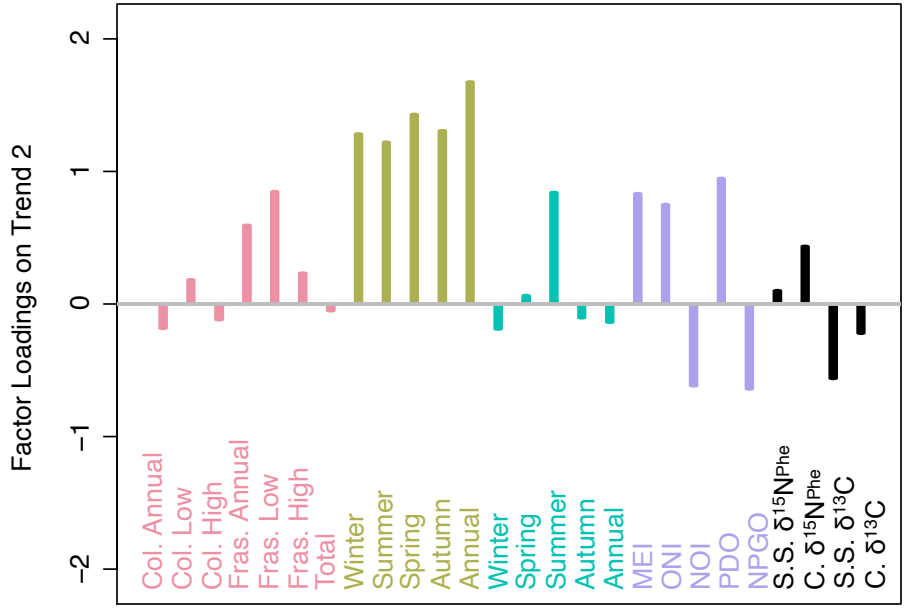
$\delta^{13}C$ declining trend remains after Suess effect correction

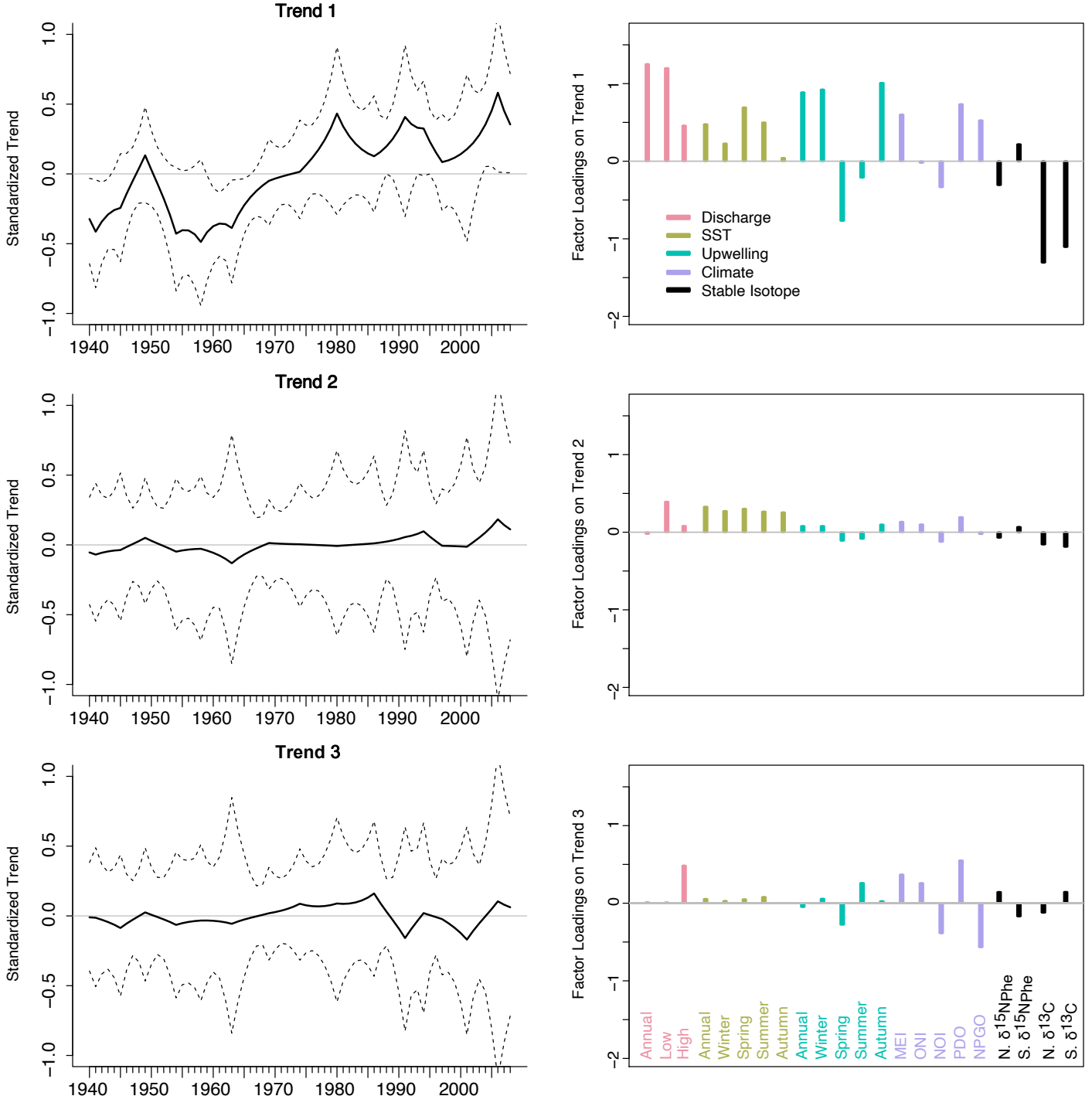



Trend 1
Standardized Trend
1.0
0.5
0.0
−0.5
−1.0
1940
1950
1960
1970
1980
1990
2000
2010


Factor Loadings on Trend 1
2
1
0
−1
−2
Discharge
SST
Upwelling
Climate
Phenylalanine


Trend 2
Standardized Trend
1.0
0.5
0.0
−0.5
−1.0
1940
1950
1960
1970
1980
1990
2000
2010


Factor Loadings on Trend 2
2
1
0
−1
−2
Col. Annual
Col. Low
Col. High
Fras. Annual
Fras. Low
Fras. High
Total
Winter
Summer
Spring
Autumn
Annual
Winter
Spring
Summer
Autumn
Annual
MEI
ONI
NOI
PDO
NPGO
S.S. δ15NPhe
C. δ15NPhe
S.S. δ13C
C. δ13C


Trend 1
Standardized Trend
1.0
0.5
0.0
−0.5
−1.0
1940
1950
1960
1970
1980
1990
2000
Factor Loadings on Trend 1
1
0
−1
−2
Discharge
SST
Upwelling
Climate
Stable Isotope
Trend 2
Standardized Trend
Factor Loadings on Trend 2
Trend 3
Standardized Trend
Factor Loadings on Trend 3
Annual
Low
High
Annual
Winter
Spring
Summer
Autumn
Annual
Winter
Spring
Summer
Autumn
MEI
ONI
NOI
PDO
NPGO
N. δ15NPhe
S. δ15NPhe
N. δ13C
S. δ13C