DEFINING ISOSCAPES IN THE NORTHEAST PACIFIC AS AN INDEX OF OCEAN PRODUCTIVITY

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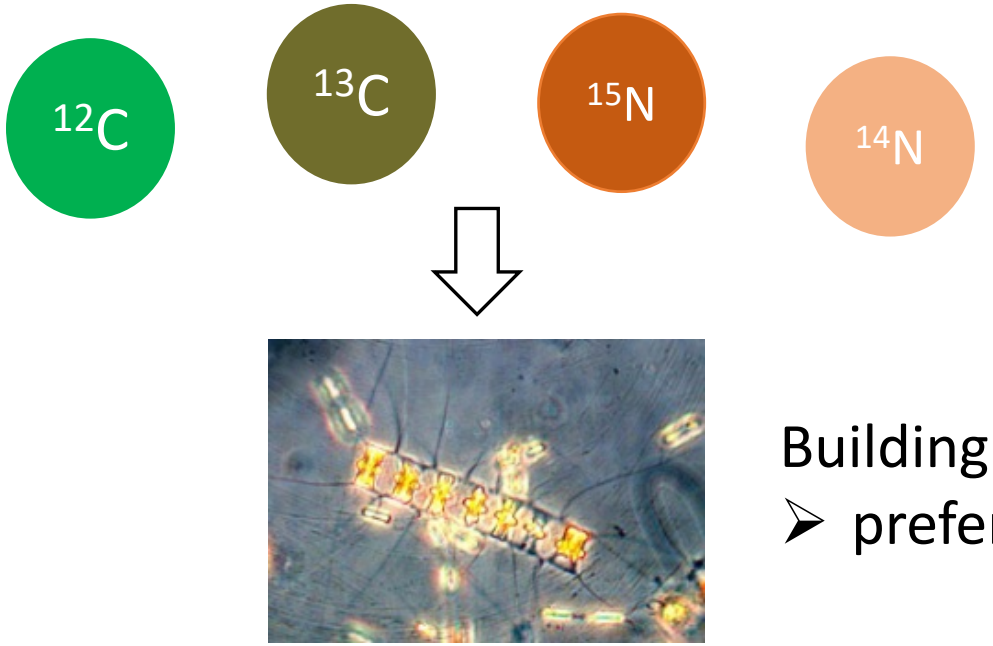
Hakai
Science on the Coastal Margin

INTRODUCTION

Stable isotopes of an element are naturally present in the environment.

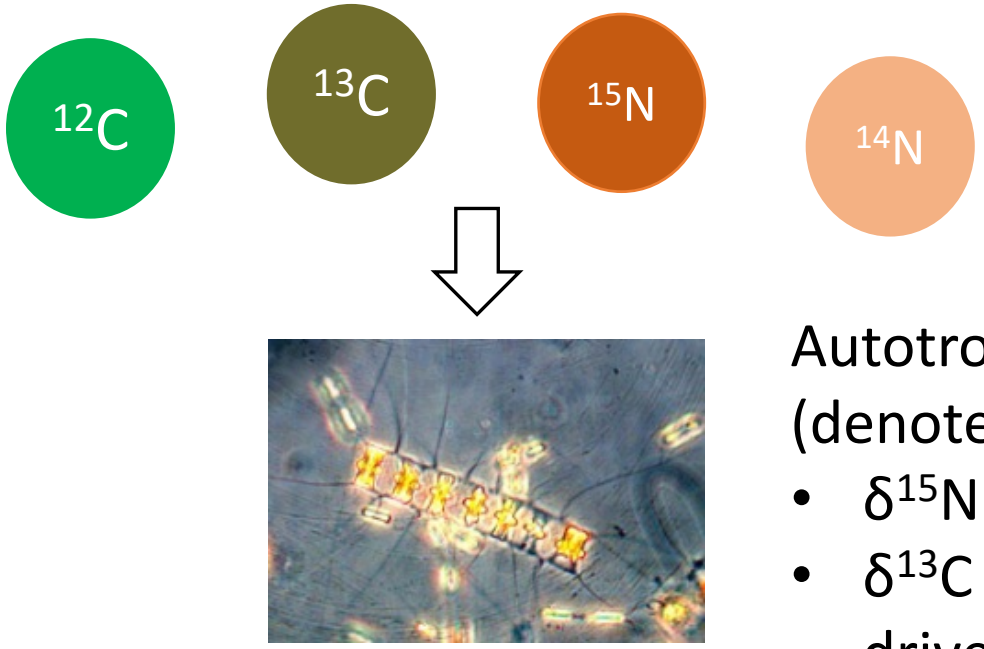


Building blocks for Autotrophs

- preferentially use lighter isotopes

INTRODUCTION

Stable isotopes of an element are naturally present in the environment.



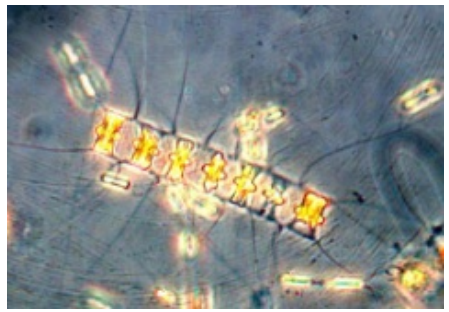
Autotrophs take up elements and their isotope ratio (denoted by δ) reflects the natural availability:

- $\delta^{15}N$ is inversely correlated with nitrate concentration.
- $\delta^{13}C$ is correlated to CO_2 concentration, which in turn is driven by water temperature.

INTRODUCTION

Stable isotope values are transferred conservatively though the food web with predictable enrichment of the heavy isotope at each trophic transfer due to metabolic processes.

^{12}C ^{13}C ^{15}N ^{14}N



Zooplankton

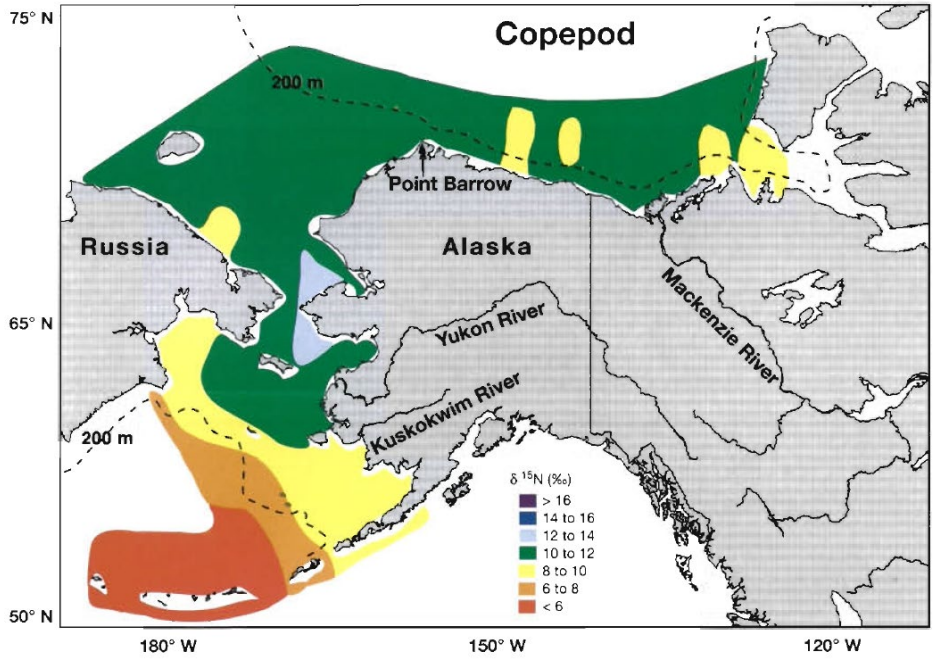
Salmon

Trophic enrichment factor:

- $\delta^{15}N$ = ~ 3.4‰
- $\delta^{13}C$ = ~ 1.1‰

INTRODUCTION: ISOSCAPES

The Isotopic “landscape” - Isoscapes are produced by mapping stable isotope distributions of organisms from a particular trophic level

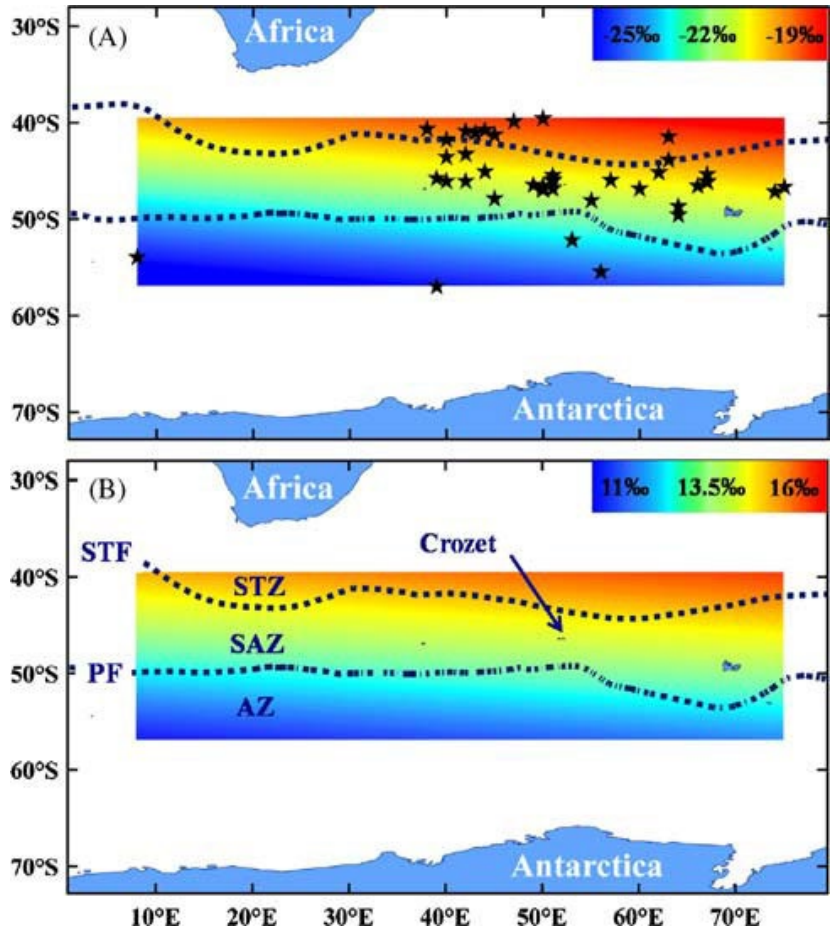


Potentially one of the first $\delta^{15}N$ isoscapes produced. *Schell et al., 1998*.

Depending on the generation time (autotrophs) or the turnover time of tissue collected (fish, birds), stable isotope values will be representative of different time scales.

INTRODUCTION: ISOSCAPE APPLICATIONS

- provide SI baseline for food web studies
- index of ocean productivity
- Identify predator foraging locations and movement in the ocean



Isoscapes produced in the Southern Ocean as a means to track albatross. *Jaeger et al., 2010*.

AIMS OF THIS STUDY

1. Define isoscapes for the Northeast Pacific using large calanoid copepods;

2. Determine if isoscapes can be used as an index for secondary productivity.

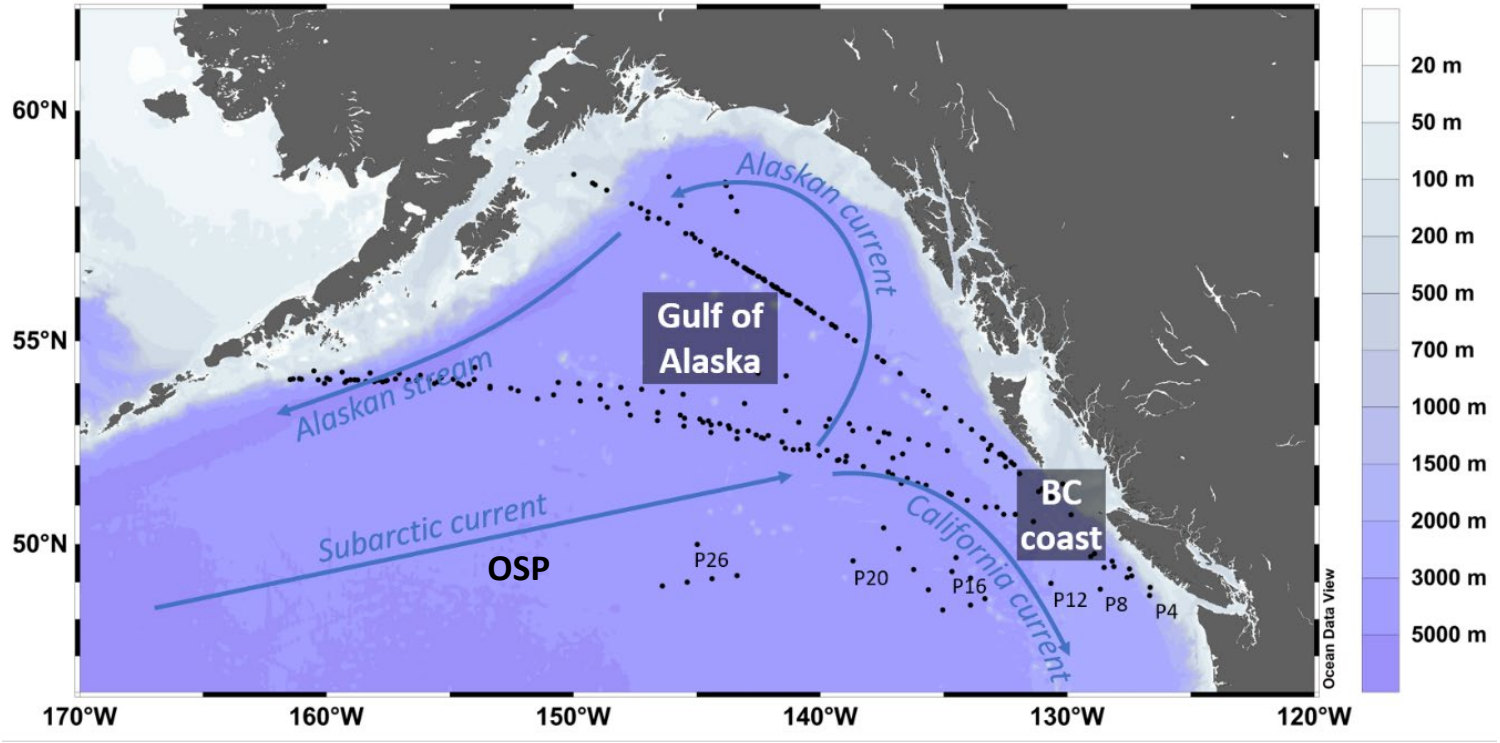
METHODS

Summer (June) zooplankton samples were collected from:

- Line P (Bongo) - 42 samples, 2009-2016, size class 2-4 mm;
- CPR - 240 samples, bulk (2010-2013), and large copepods only (2000-2007 and 2014-2017);

Stable isotopes analysis ($\delta^{15}N$ & $\delta^{13}C$);

- C Isotope values corrected for lipid and Suess effect.



Study area with location of zooplankton sampling

METHODS

A set of potential predictors was assembled using different sources:

Satellite data

- SST
- Chlorophyll *a* concentration
- Sea level anomaly (SLA)

Bathymetry

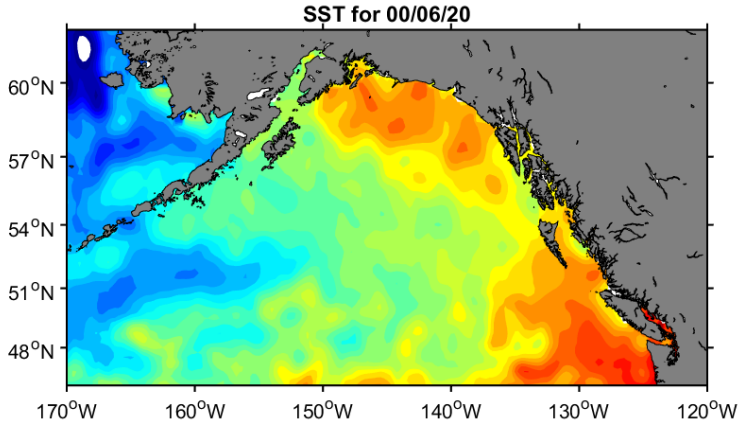
- Distance to 200 m isobath

Argo float

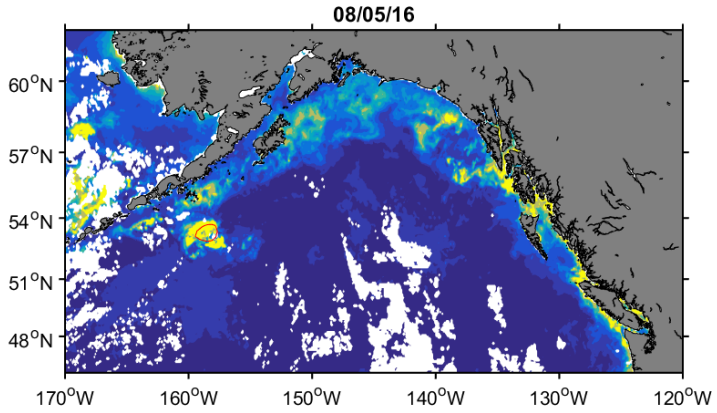
- Mixed layer depth

Atmospheric

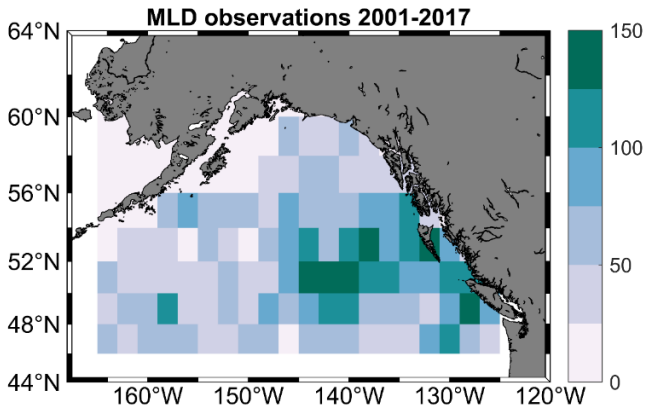
- Wind data

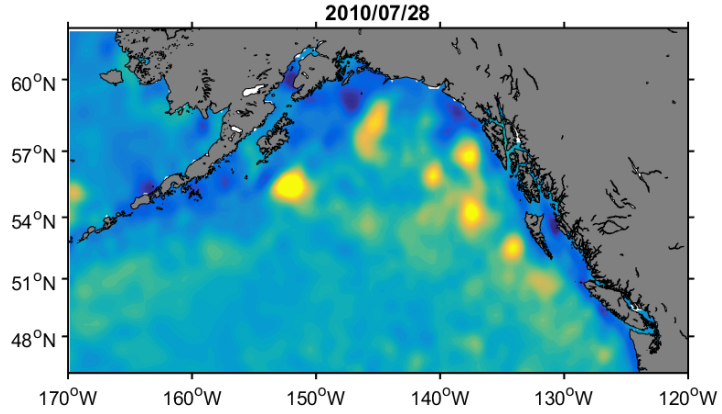


SST



chl-a





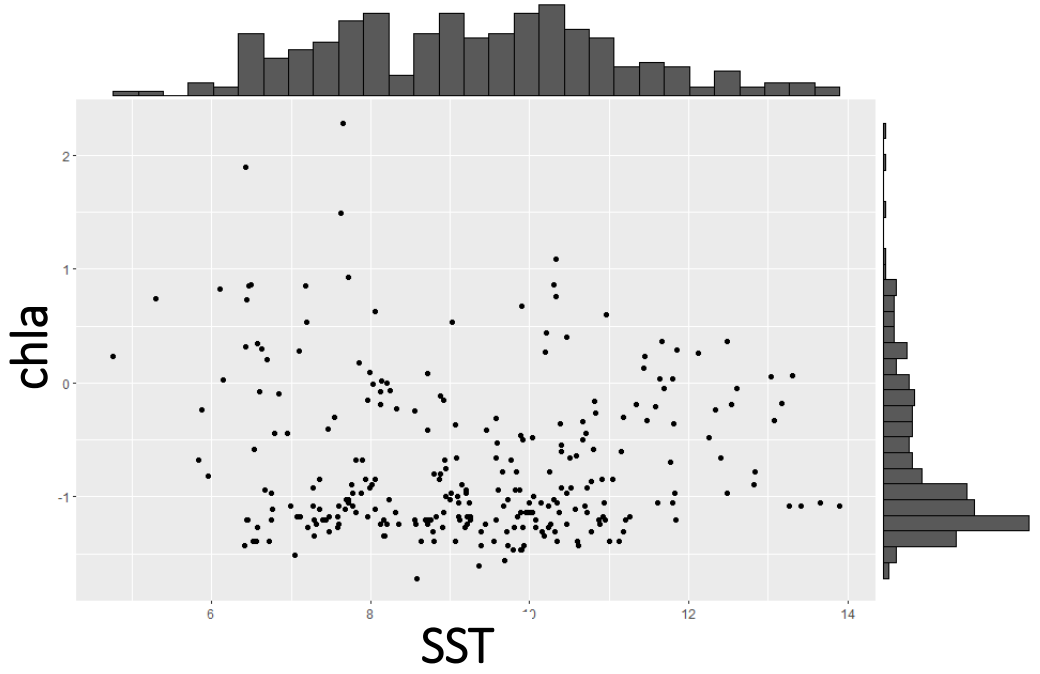
SLA

METHODS

Developing a Generalized Additive Model (GAM) :

Model parameters

- SST and sla averaged for 1-2 weeks before sampling date;
- Chl-a – different integration periods tested
- MLD - May 1 to July 31



Example of non-collinearity between two predictors

Checked for outliers, and collinearity between predictors.

Test relationship between the response variable and the predictors, keeping only significant ones.

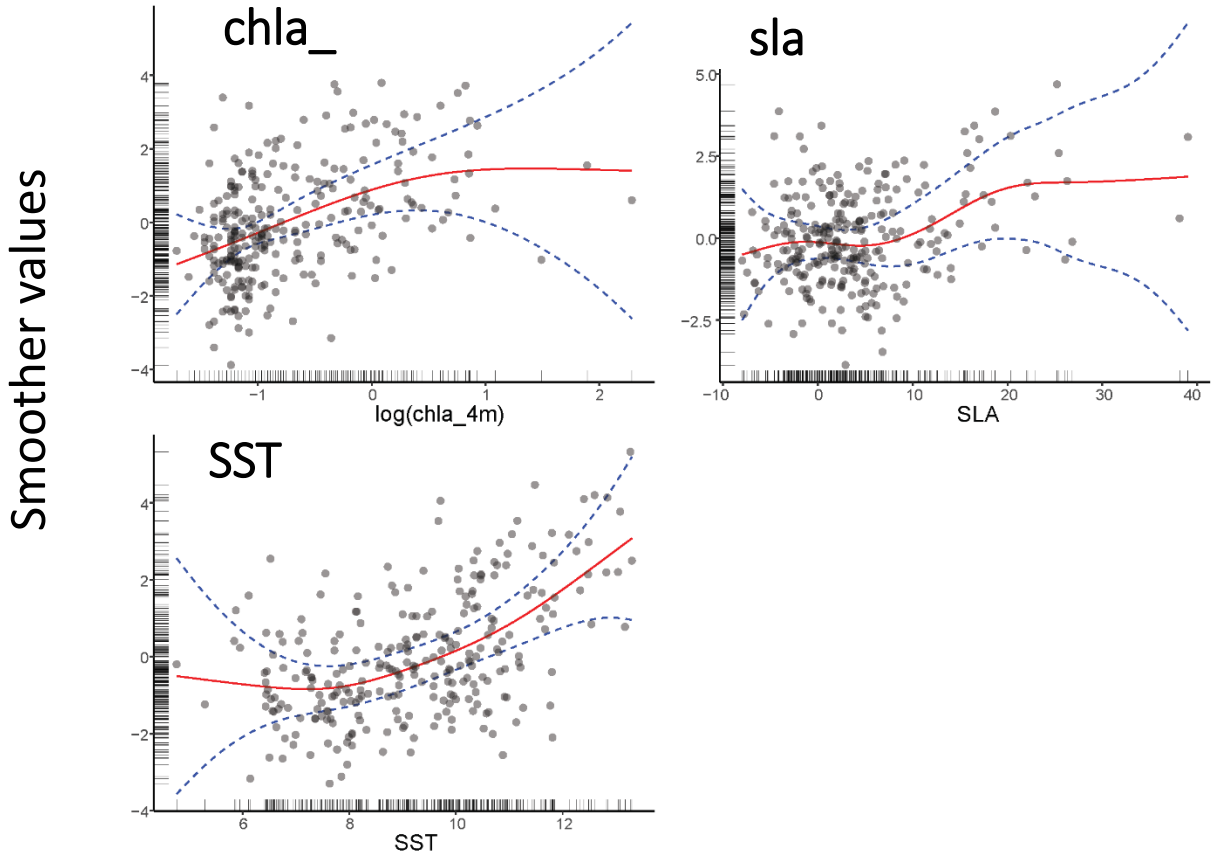
METHODS

Best model results: $\delta^{15}N \sim s(chla\_4m) + s(sla) + s(SST) + s(MLD)$

- 50.3% of variance explained
- up to 59.4% if MLD included

** Limited spatial coverage for MLD estimates therefore excluded.*

$\delta^{15}N$ *Smoothers values associated with predictors*

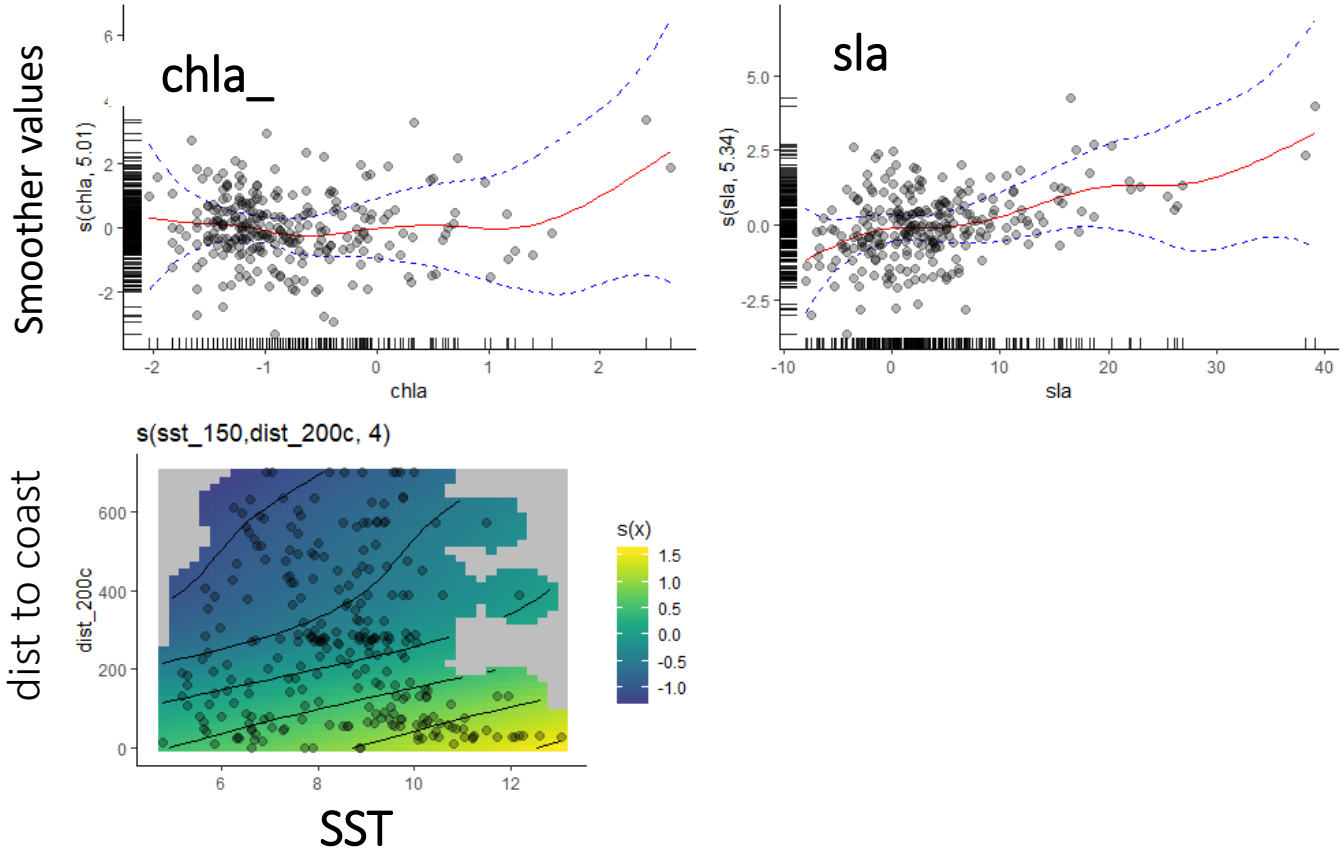


METHODS

Best model results: $\delta^{13}C \sim s(chla\_4m) + s(sla) + s(SST\_June, dist2coast)$

- $\delta^{13}C$: 43% of variance explained

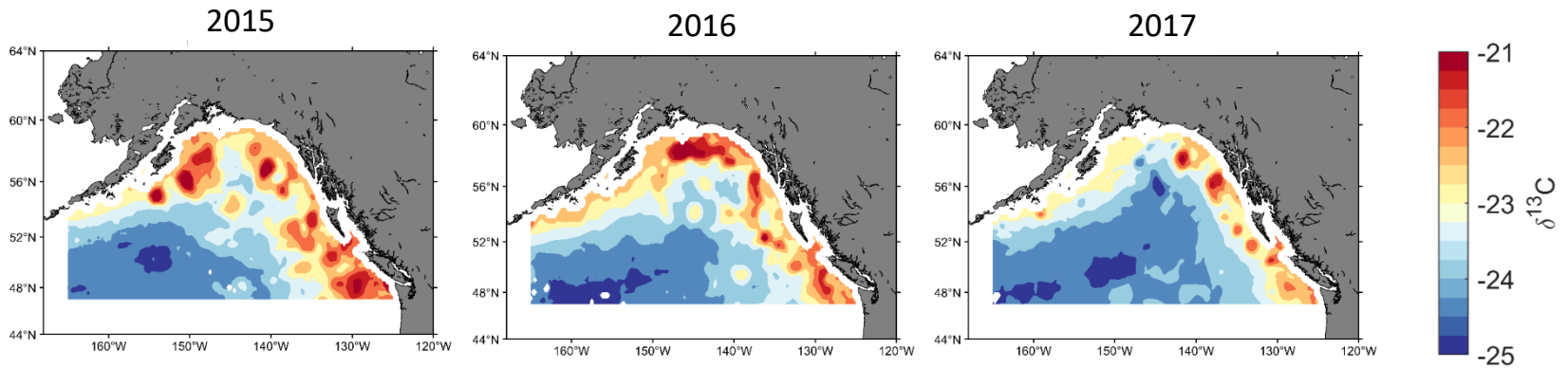
$\delta^{13}C$ *Smoothers values associated with predictors*



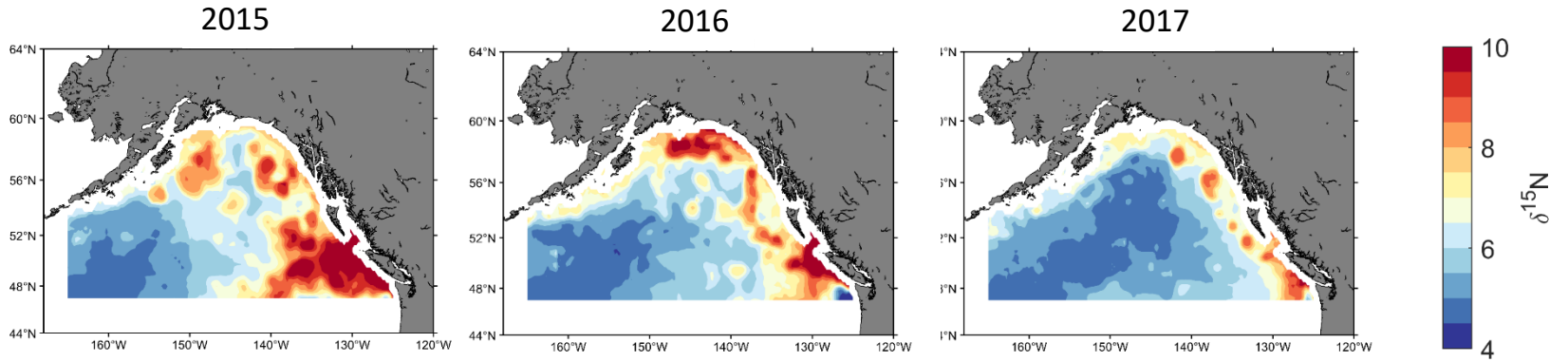
RESULTS

Model based Isoscapes were produced for 1998-2017.

$\delta^{13}C$



$\delta^{15}N$



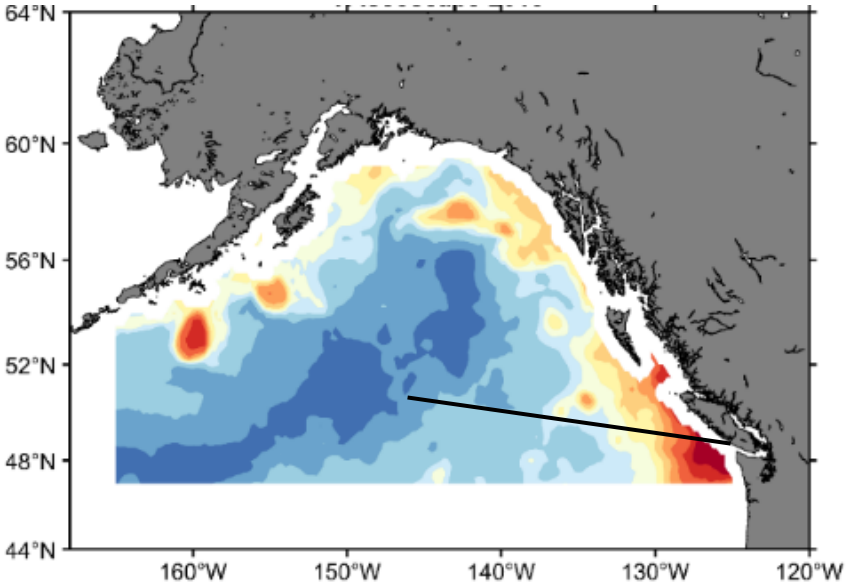
Similarities between C and N stable isotope distributions, but also differences.

- Values higher on shelf
- Elevated in eddies (particularly $\delta^{15}N$)

Results: Model validation

Compared observed and predicted $\delta^{15}N$ & $\delta^{13}C$ values along Line P.

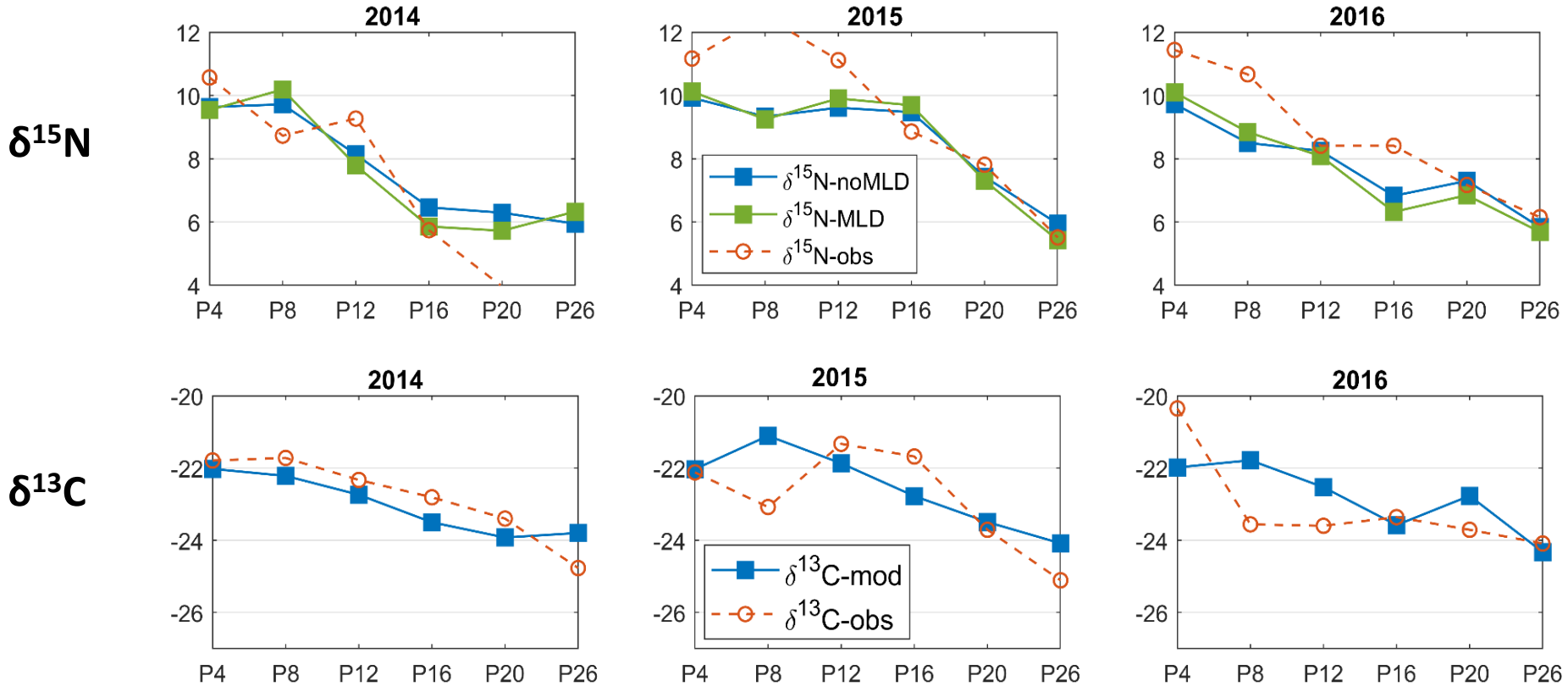
- The modelled $\delta^{15}N$ & $\delta^{13}C$ values used came from a submodel that did not include the Line P data.



RESULTS: VALIDATING MODELS

More variability in observational data but general patterns are reproduced.

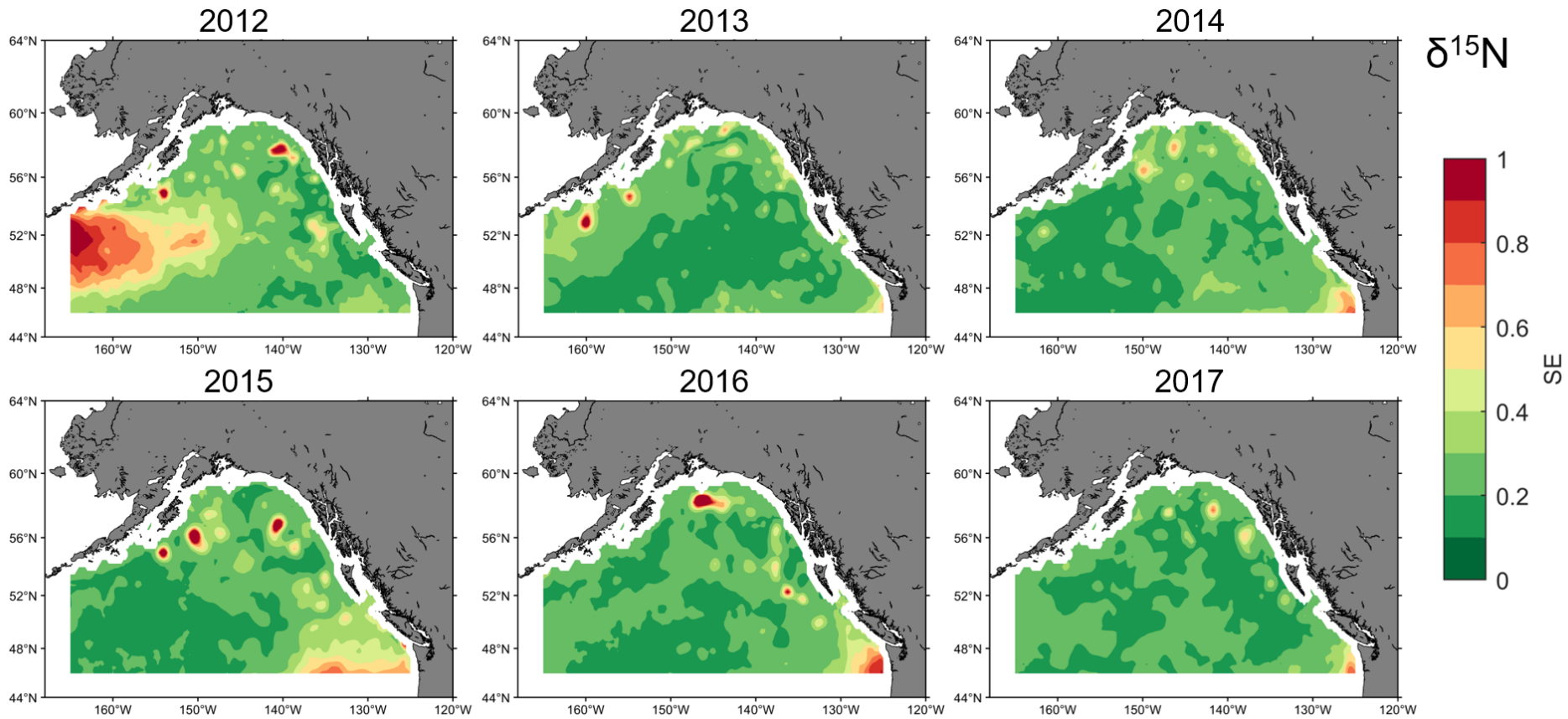
coast ⇨ offshore



Modelled C and N values compared to observation data along Line P

RESULTS: VALIDATING MODELS

Standard error associated with predicted value



Usually low, except when predictors values were out of the range define by the sampled values (for example SST < 4°C in the eastern part of the domain in 2012); and eddies.

APPLICATIONS

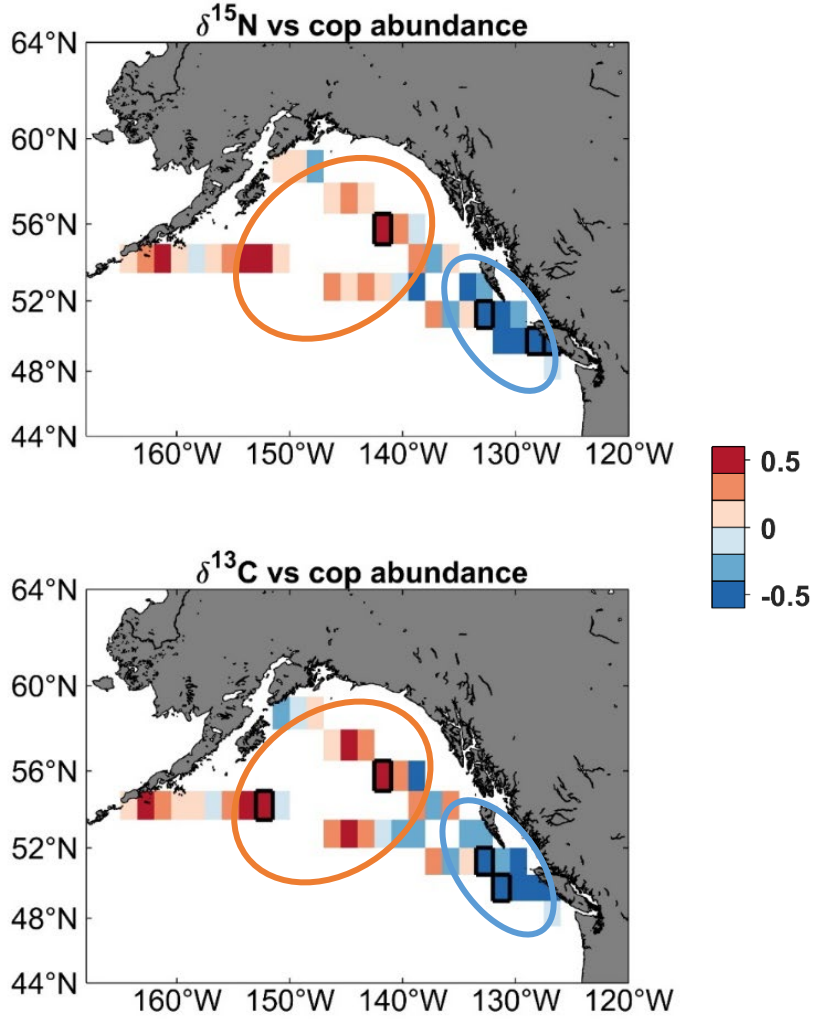
Index of ocean productivity requires defining relationship between SI values and zooplankton abundance/biomass.

Two sub-regions appear:

1. the Gulf of Alaska
2. off BC coast

with opposite correlation signs.

Correlation between $\delta^{15}N$ / $\delta^{13}C$ and large copepod abundance from CPR



APPLICATIONS

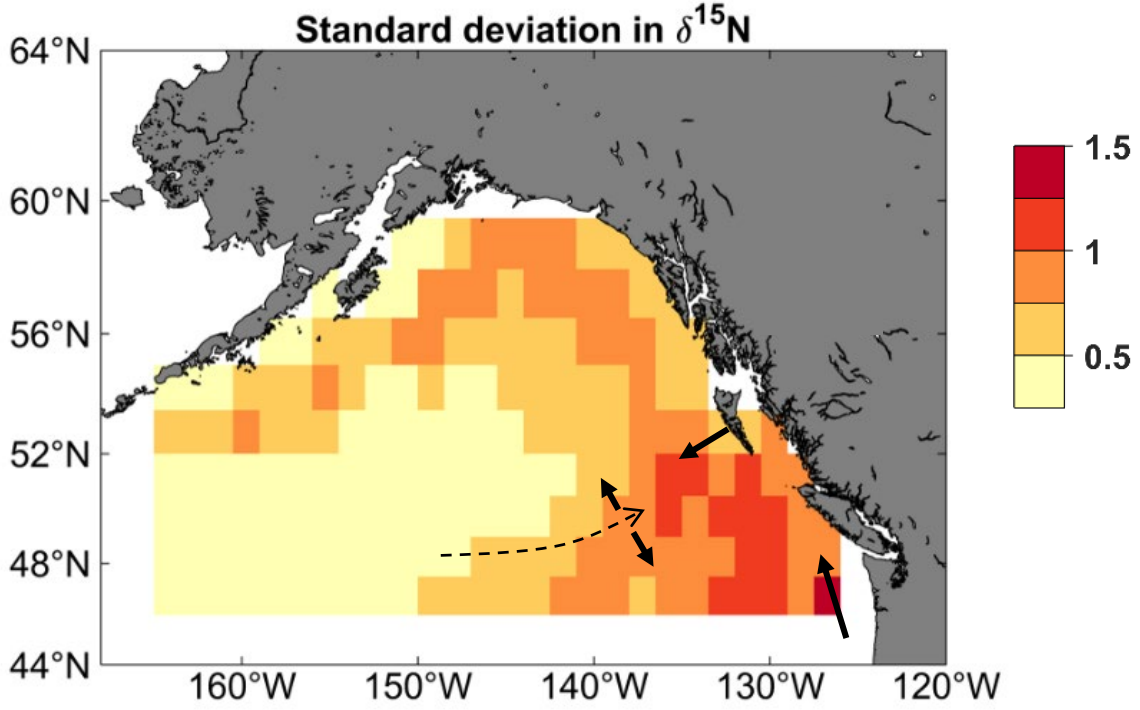
Why different sign in the sub-regions?

Positive correlation in Gulf of Alaska

- High $\delta^{15}N$ is usually associated with higher productivity, therefore higher $\delta^{15}N$ = more large copepods.

Negative correlation along BC coast

- Propose that this reflects off-shelf transport of copepods from high productivity coastal regions (and circulation dynamics)



Interannual variability in modelled $\delta^{15}N$

SUMMARY

- $\delta^{15}N$ and $\delta^{13}C$ isoscapes at for the primary consumer level (calanoid copepods) were generated for 1998-2017.

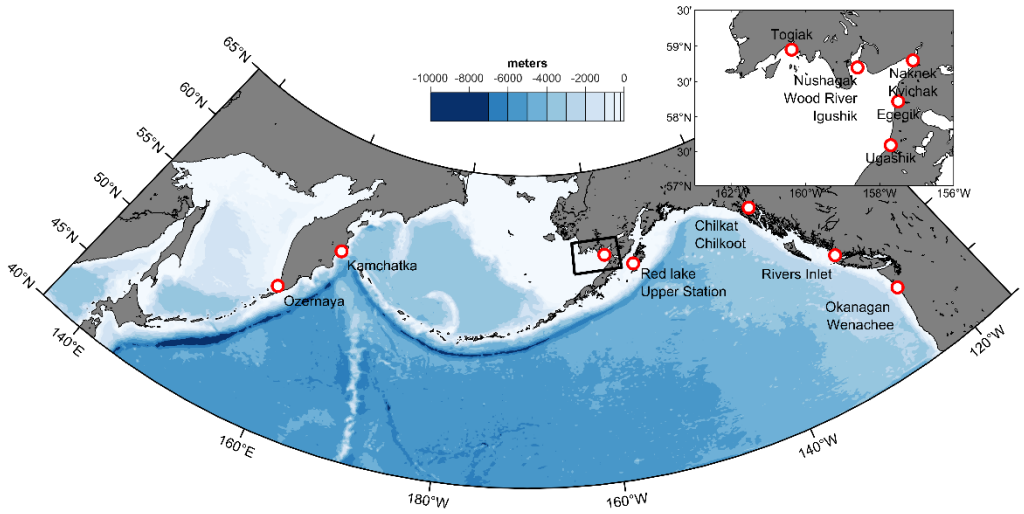
- We identified two different regimes in the Northeast Pacific based on the relationship between $\delta^{15}N$ and $\delta^{13}C$ and copepod abundance:
  - GoA characterized by subarctic species
  - Off BC coast characterized by frequent intrusion of Boreal shelf and southern copepods

- Data can be used for different purposes (ocean productivity, fish tracking, SI baseline) and are freely available (doi:10.5061/dryad.d2547d7z6).

**Paper in press in Global Ecology and Biogeography*

Next steps – Couple isoscapes with predicted salmon distributions

Salmon stocks



In review

Predicted distributions
(estimated using salmon isotopes time series)