APPLICATION OF BULK AND COMPOUND SPECIFIC ISOTOPES TO RESOLVING REGIONAL PRODUCTIVITY REGIMES EXPERIENCED BY PACIFIC HERRING (*CLUPEA PALLASII*) ON THE COAST OF BRITISH COLUMBIA, CANADA

Brian P. V. Hunt, Evgeny A. Pakhomov, Wade Smith

University of British Columbia
Institute for the Oceans and Fisheries

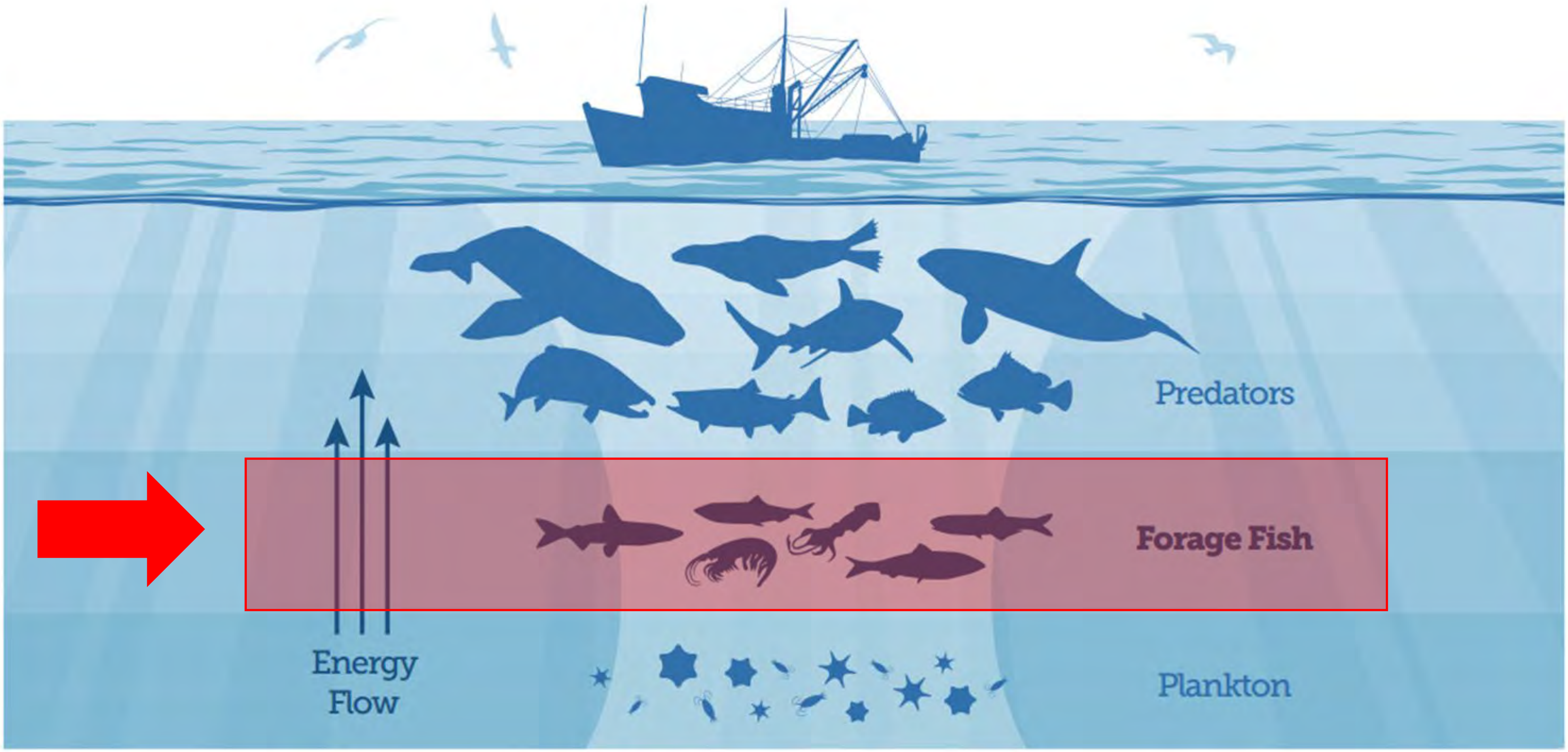
S11: Influence of climate and environmental variability on pelagic and forage species

Hakai
Science on the Coastal Margin

Contact: b.hunt@ocean.ubc.ca

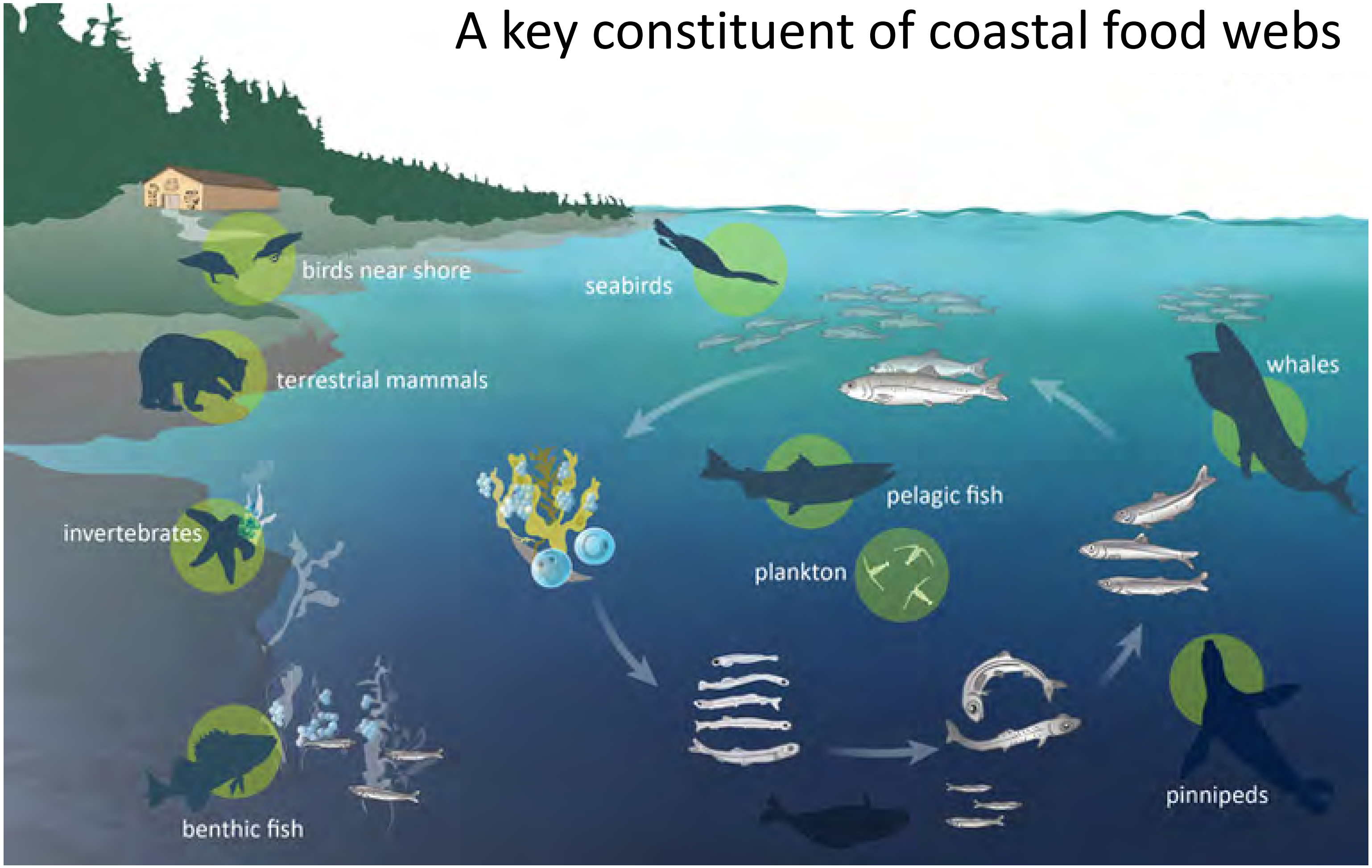
INTRODUCTION

Forage fish perform a pivotal role in marine food webs

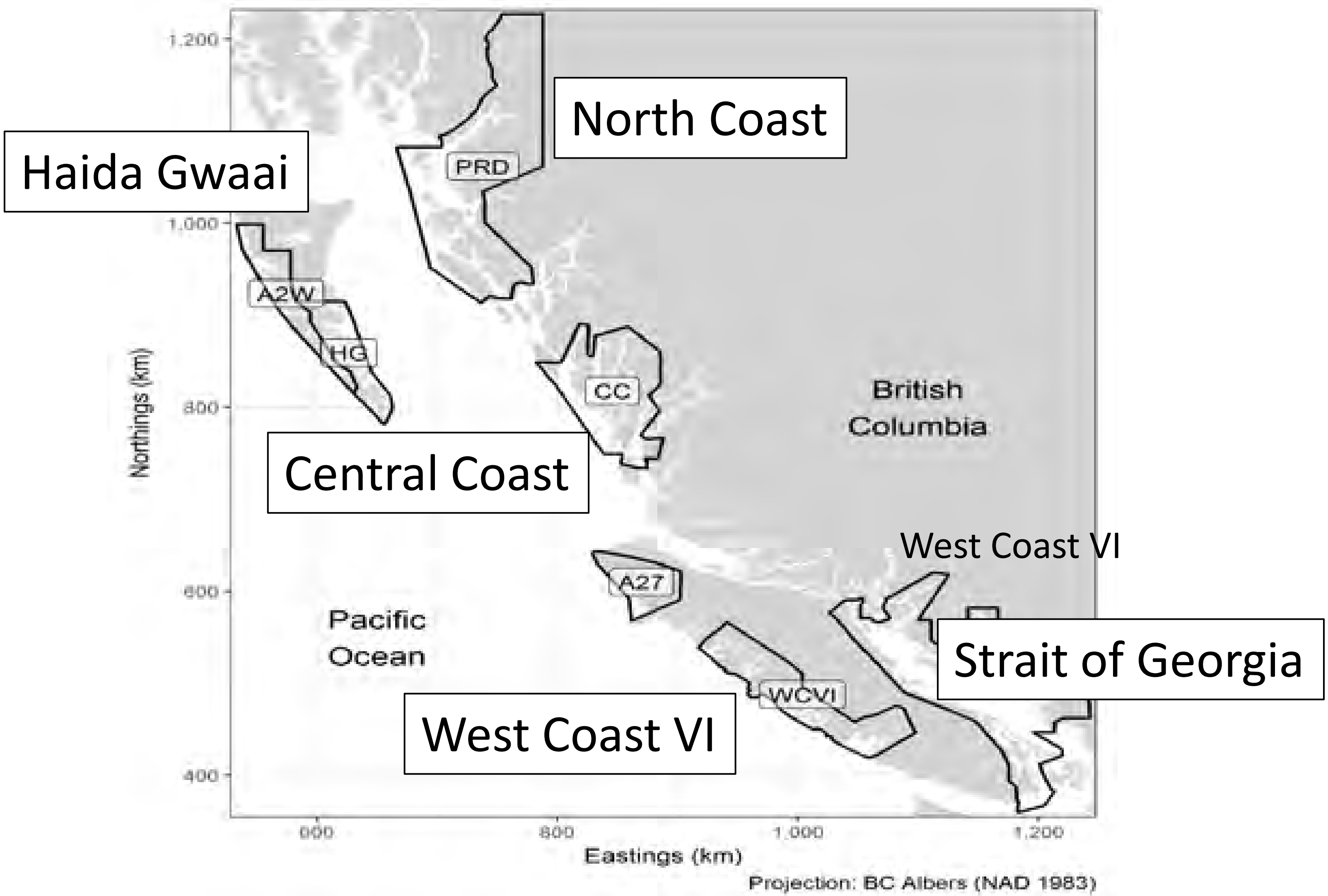


Herring in the NE Pacific

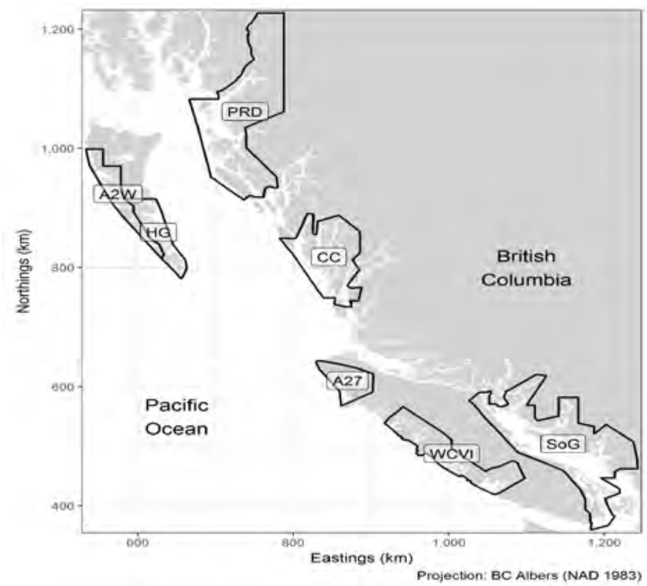
A key constituent of coastal food webs



BRITISH COLUMBIA HERRING STOCKS

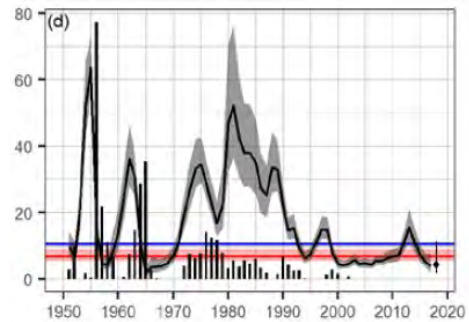


BRITISH COLUMBIA HERRING STOCKS

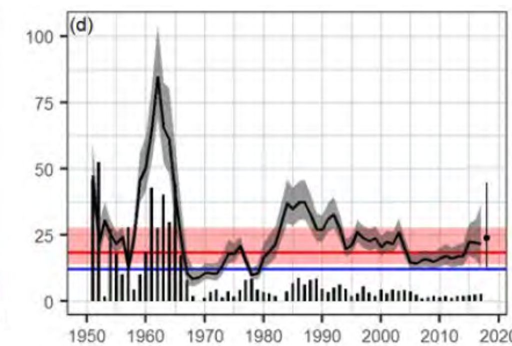


Spanning biomass

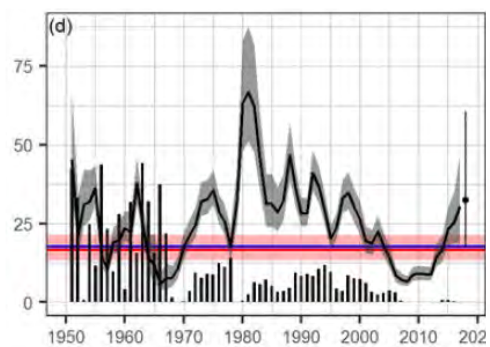
Haida Gwaai



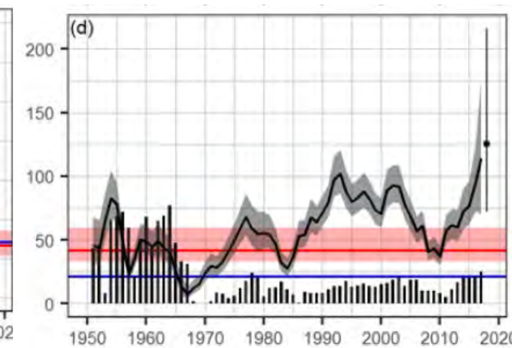
North Coast



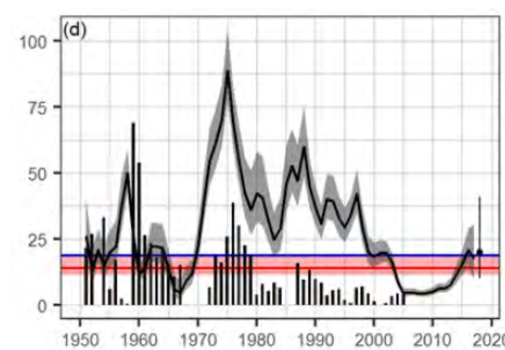
Central Coast



Strait of Georgia

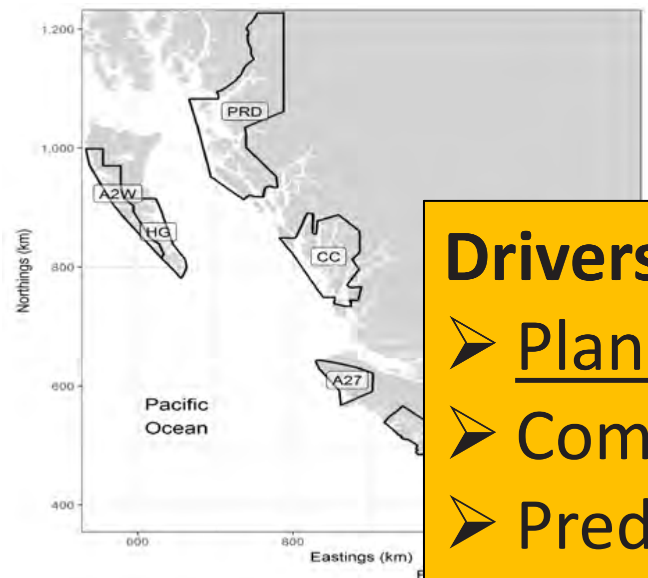


West Coast VI

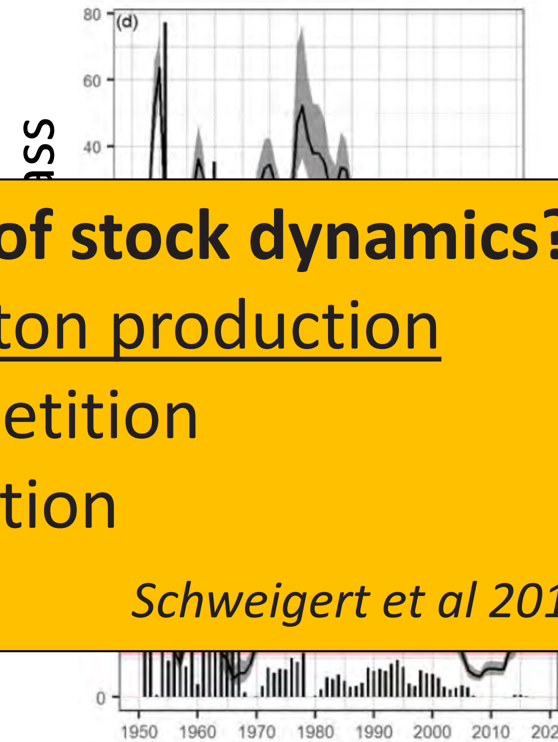


DFO. 2018. Stock assessment for Pacific Herring (Clupea pallasii) in British Columbia in 2017 and forecast for 2018. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/002.

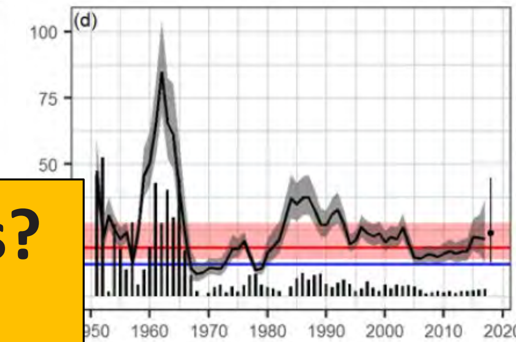
British Columbia Herring Stocks



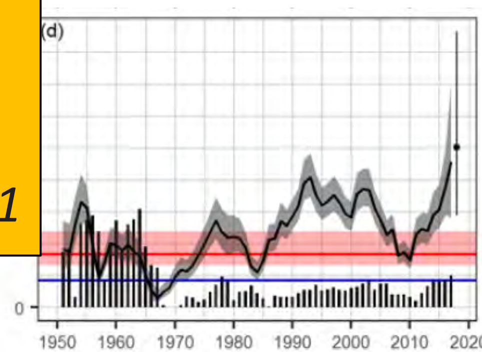
Haida Gwaai



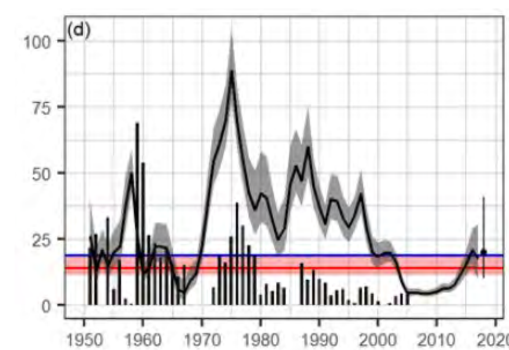
North Coast



Strait of Georgia



West Coast VI

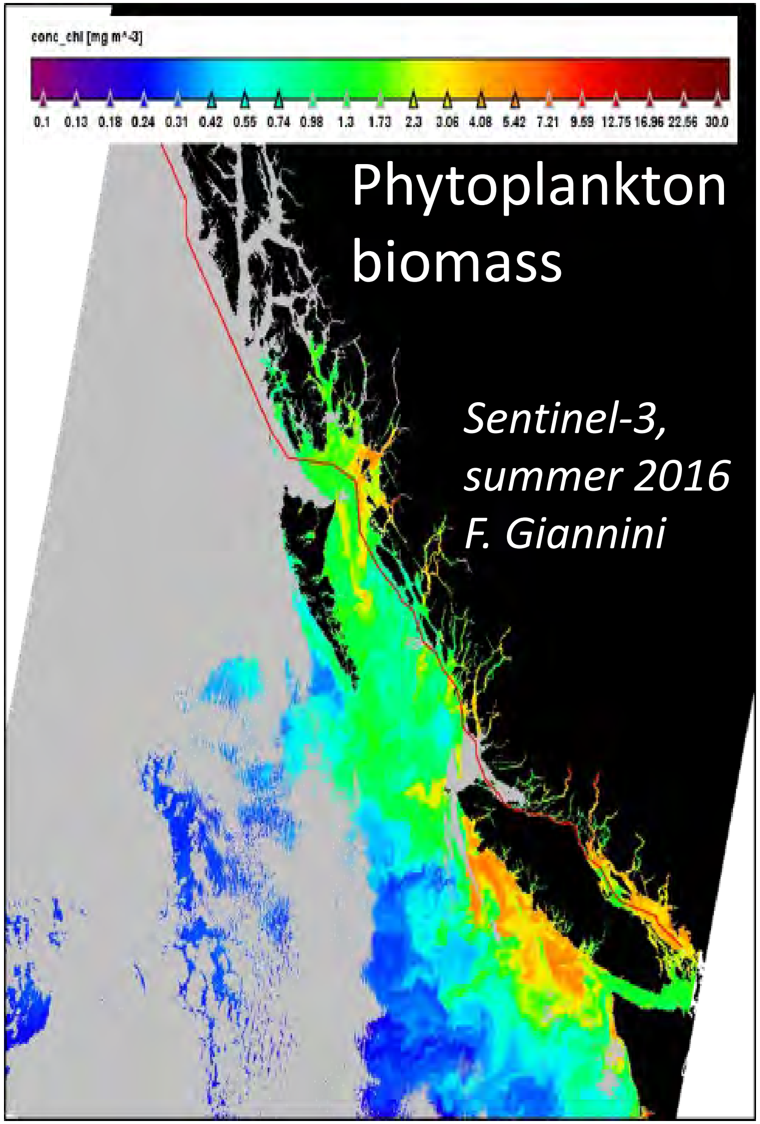


Drivers of stock dynamics?

- Plankton production
- Competition
- Predation

Schweigert et al 2011

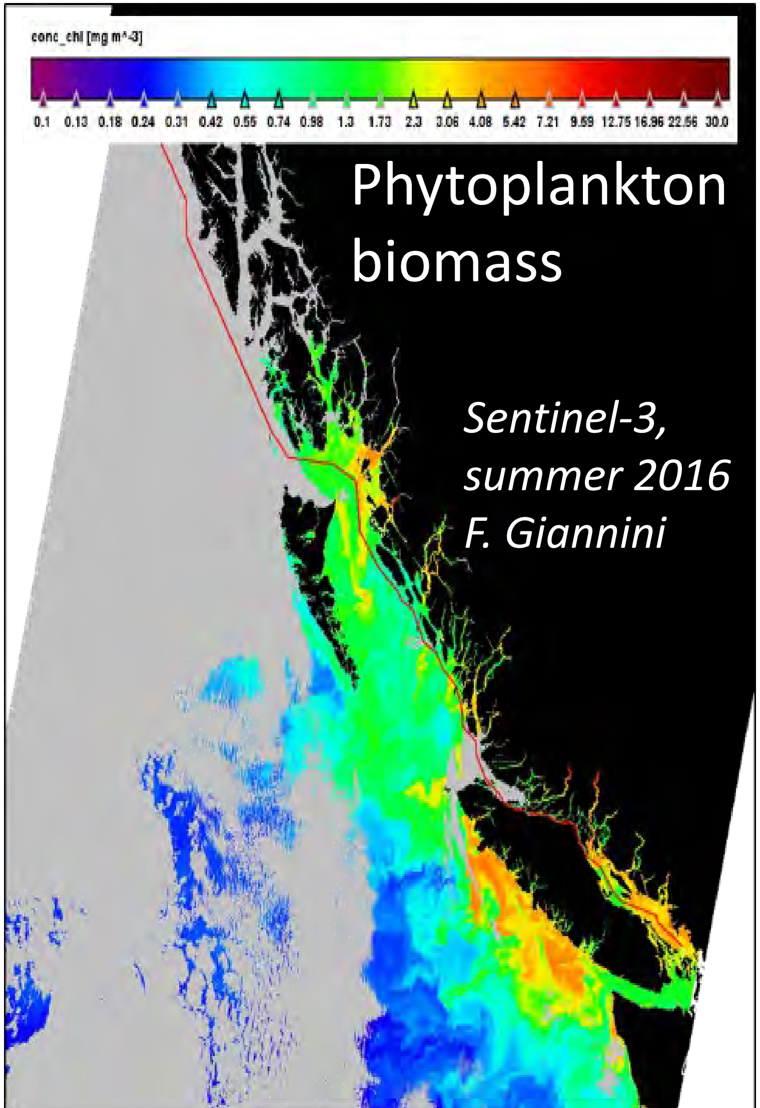
PHYTOPLANKTON PRODUCTION ON THE BC COAST



Substantial regional variability in plankton productivity;

May be accompanied by differences in food web size structure and hence food chain length.

PHYTOPLANKTON PRODUCTION ON THE BC COAST

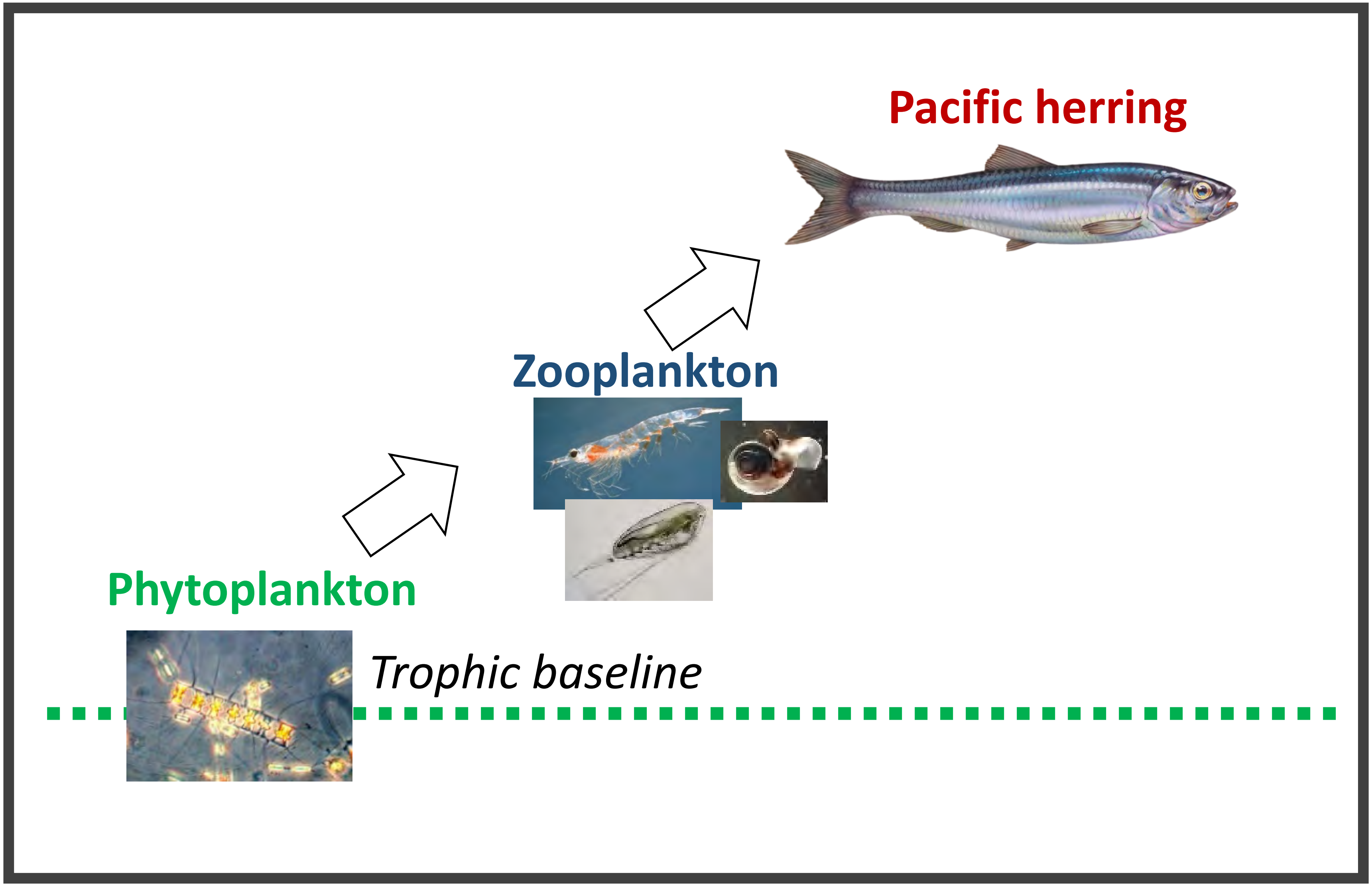


Hypotheses explaining regional stock fluctuations:

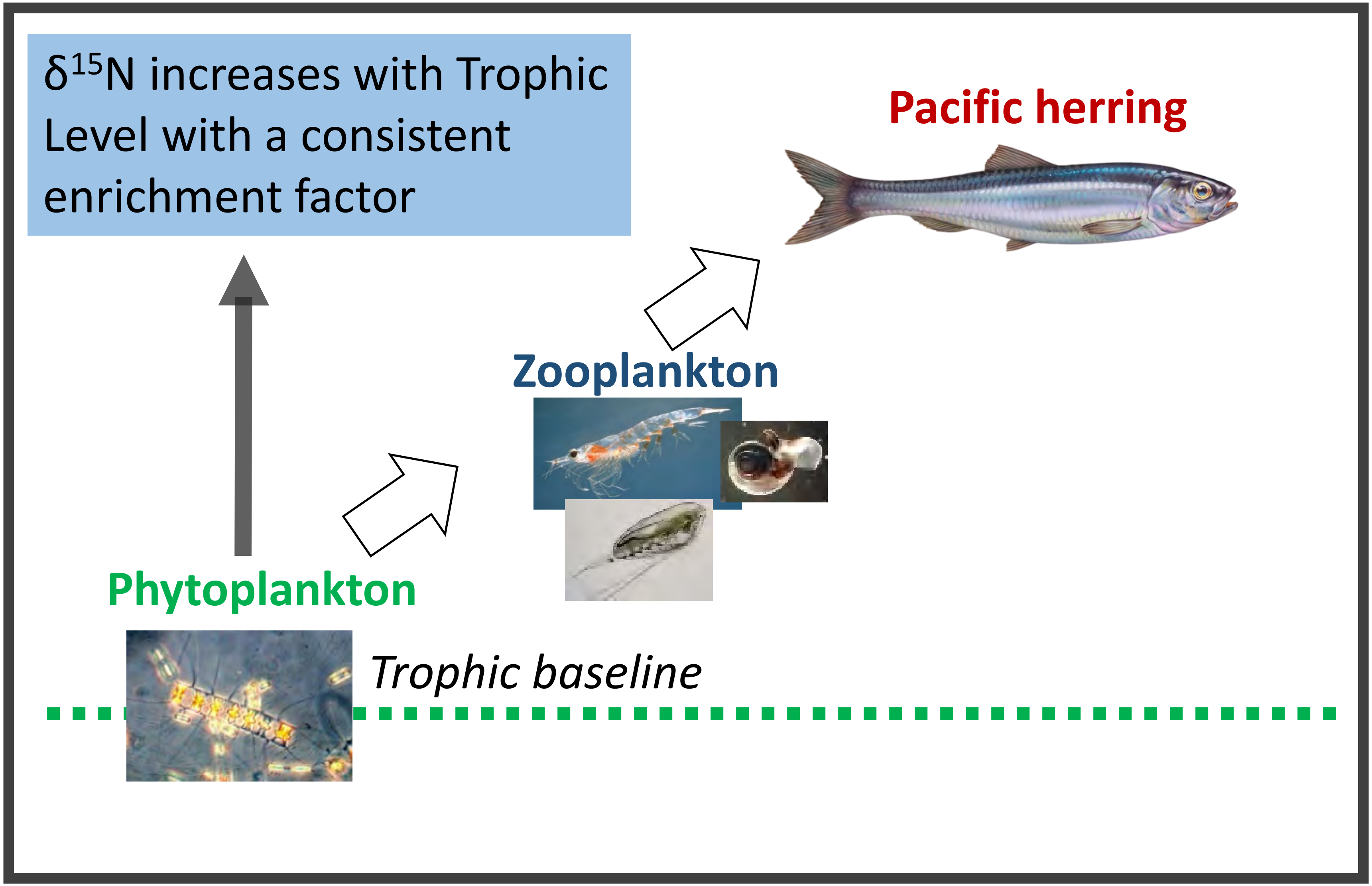
1) Herring stocks experience different productivity regimes;

2) Herring stocks experience different regional food chain length which will be reflected by their trophic level (TL).

Using isotopes to resolve relative TL & Production



Using isotopes to resolve relative TL & Production



USING ISOTOPES TO RESOLVE RELATIVE TL & PRODUCTION

$\delta^{15}N$ increases with Trophic Level with a consistent enrichment factor

Pacific herring

Zooplankton

Phytoplankton

Trophic baseline

- $\delta^{15}N$ increases with system productivity
- $\delta^{13}C$ increases with T°C

Using isotopes to resolve herring life history

Stable isotopes of herring

δ^{13}C informs **thermal history**

δ^{15}N reflects one or a combination of:

- Shifts in the phytoplankton baseline due to changes in **productivity**;
- Shifts in the **trophic level** of the fish due to changing trophic structure

AIMS OF THIS STUDY

Use stable isotopes to resolve regional trophic ecology of adult Pacific herring in BC. Specifically answering the questions:

1) Are there **regional differences** in herring **trophic level** that reflect differences in food web structure?

2) Are their **regional differences** in **productivity** experienced by BC herring stocks?

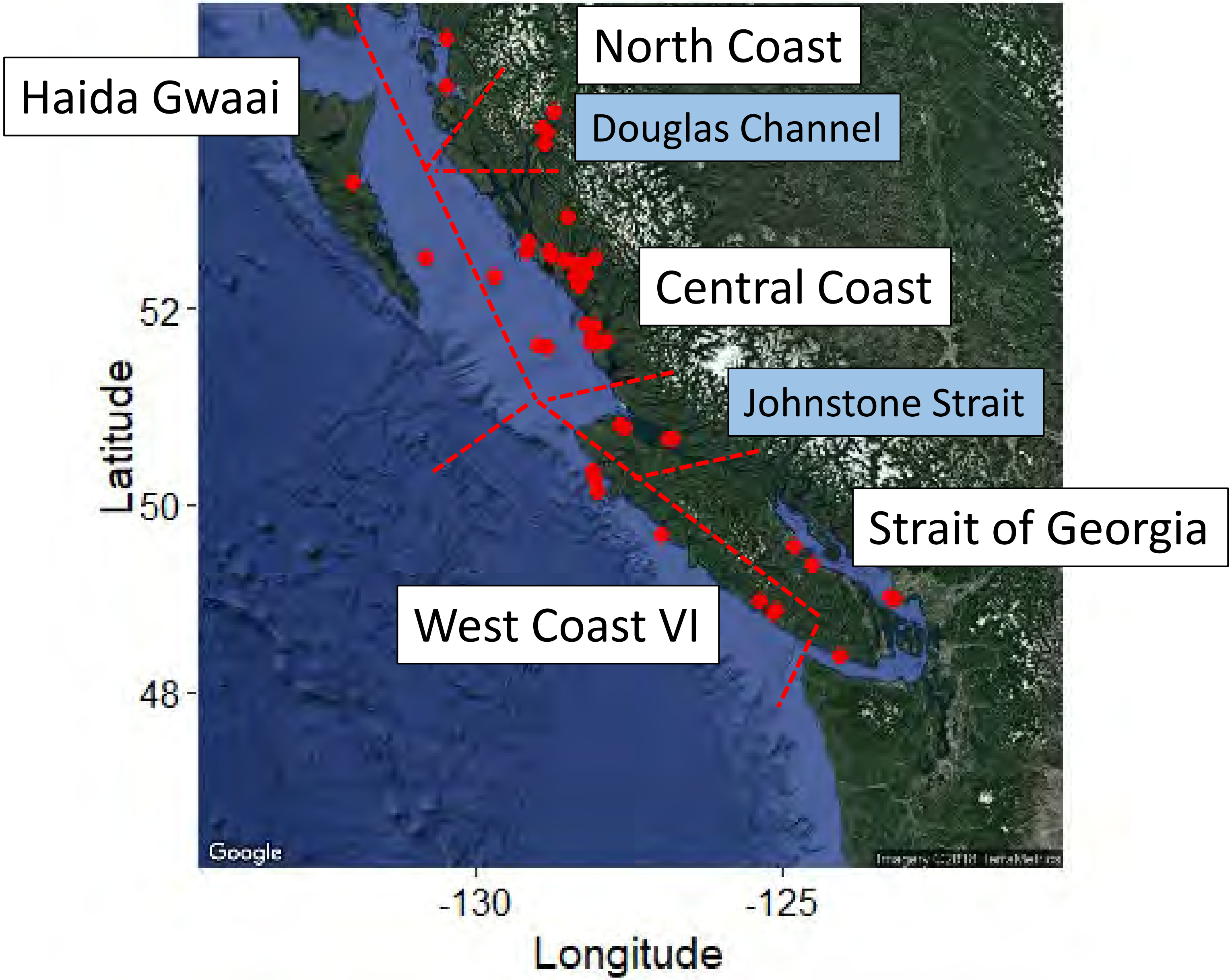
3) Are there **interannual differences** in TL & productivity experienced by Central Coast herring?

METHODS

Herring sampling

- Collection during spring spawning events (W. Smith)
- Opportunistically on DFO trawl surveys

Methods: Location of samples



METHODS: SAMPLE NUMBERS

	2007	2010	2011	2014	2015	2016
Prince Rupert						8 (3)
Haida Gwaai				16		
Douglas Channel				21		
Central Coast	6	8	4	97	28	16 (3)
Johnstone Strait				13		
Strait of Georgia				14	5	10 (3)
West Coast of VI				20	5	8 (3)

- A total of 279 fish analyzed
- Bulk isotopes measured from all fish
- Amino Acid $\delta^{15}N$ measured from a subset of 2016 fish

METHODS: ISOTOPE DATA TREATMENT

Bulk isotopes

- Standardized $\delta^{15}N$ for size by using residuals of the length vs $\delta^{15}N$ relationship [$\delta^{15}N = 11 + 0.01x$; $r2 = 0.33$]
- Standardized $\delta^{13}C$ values for lipid content using the C:N ratio

(Hoffmann & Sutton 2010)

Methods: Trophic level (TL) estimation

Compound specific isotopes

TL can be derived from Amino Acid $\delta^{15}N$

- "Source" AA's, e.g., Phenylalanine
- "Consumer" AA's, e.g., Glutamic acid

$$(TL_{Glu/Phe}) = (\delta^{15}N_{Glu} - \delta^{15}N_{Phe} - 3.4) / 7.6 + 1$$

Methods: Testing assumptions

δ^{15}N and productivity

Tested the relationship between surface particulate organic matter (POM) δ^{15}N and Nitrate concentration *[Hakai Institute database];*

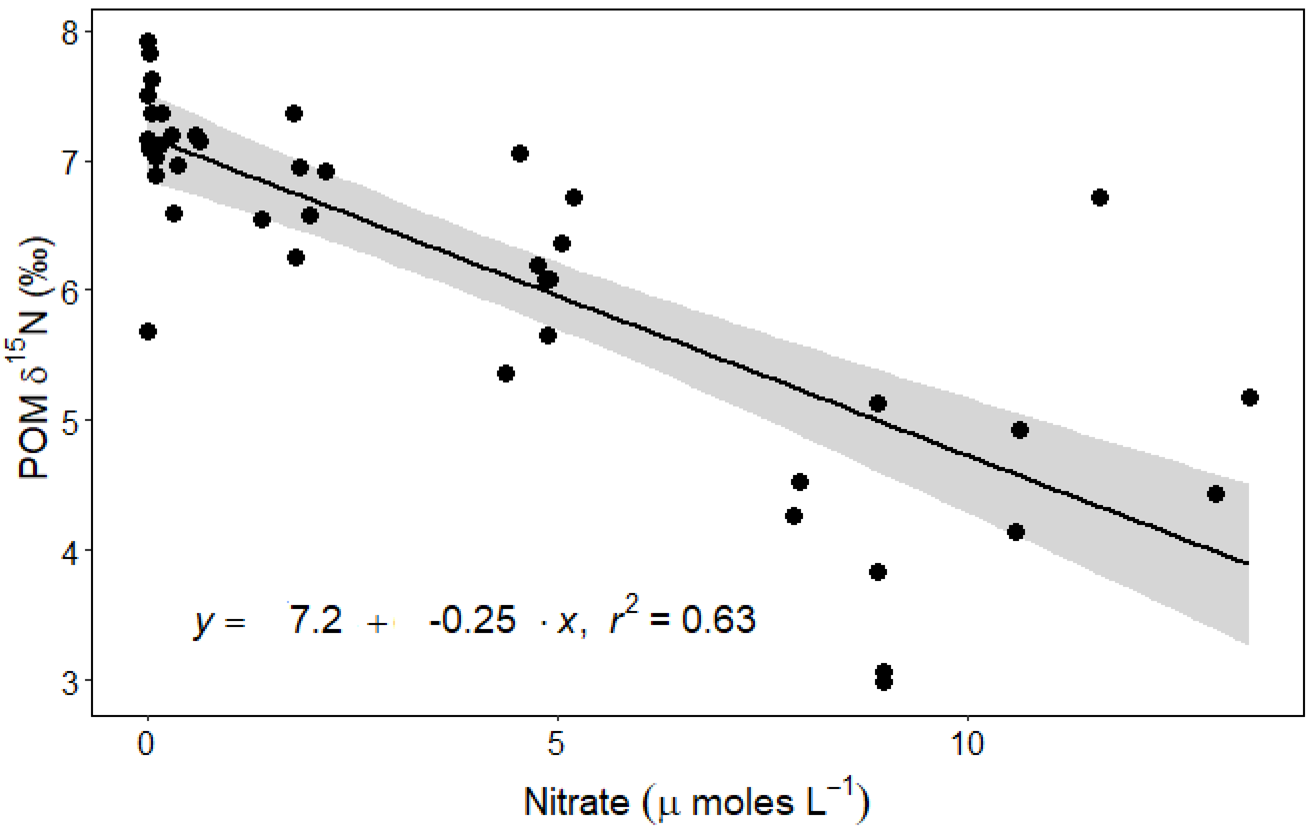
δ^{13}C and Temperature

Tested the relationship between mean herring lipid corrected δ^{13}C and sea surface temperature from the BC lighthouse database *[DFO Canada]*.

RESULTS: $\delta^{15}N$ AND PRODUCTIVITY

Does the trophic baseline reflect productivity?

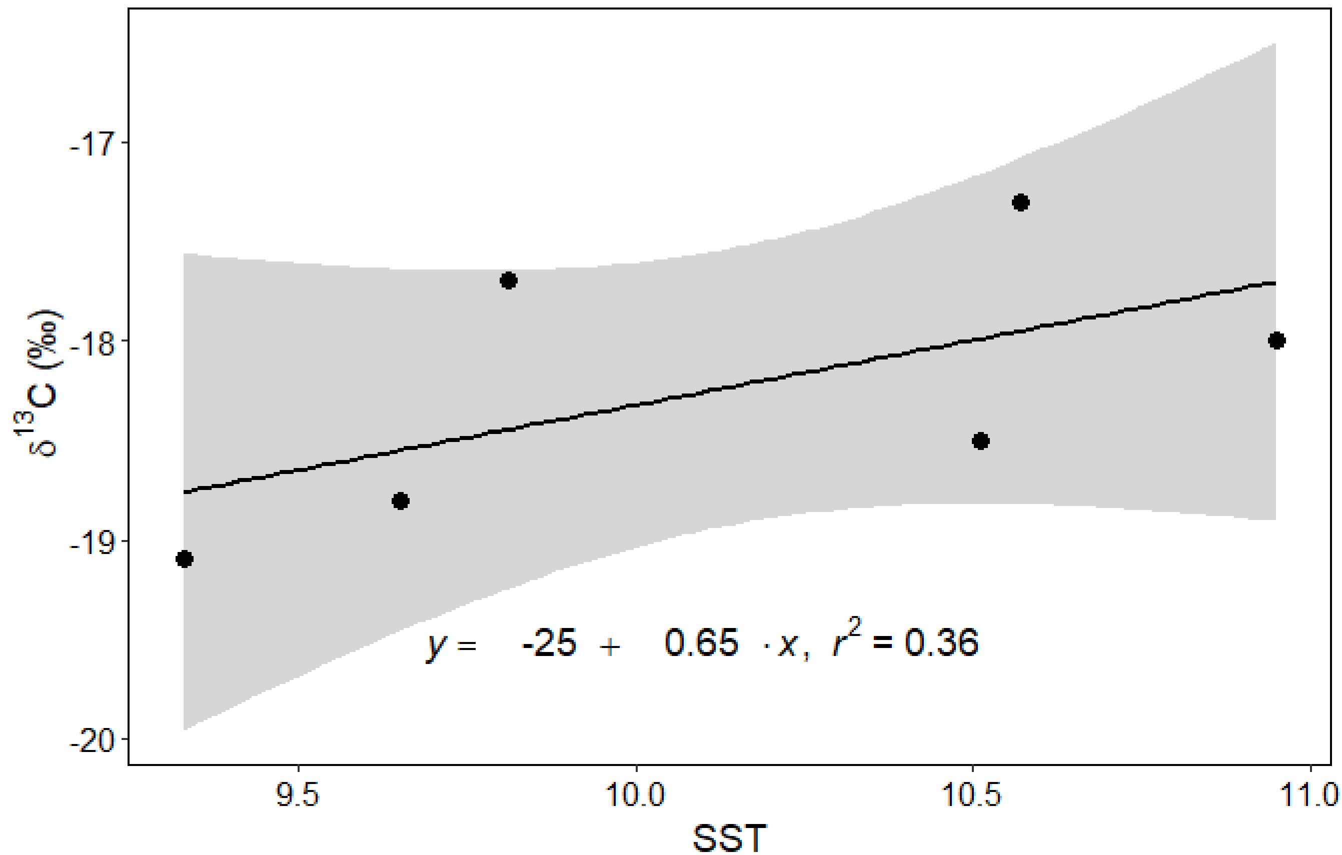
- Yes - Particulate organic matter $\delta^{15}N$ increases with nitrate drawdown



RESULTS: $\delta^{13}C$ AND TEMPERATURE

Does the $\delta^{15}C$ of herring reflect temperature?

- Yes - Central Coast herring $\delta^{15}C$ is positively correlated with local SST data.



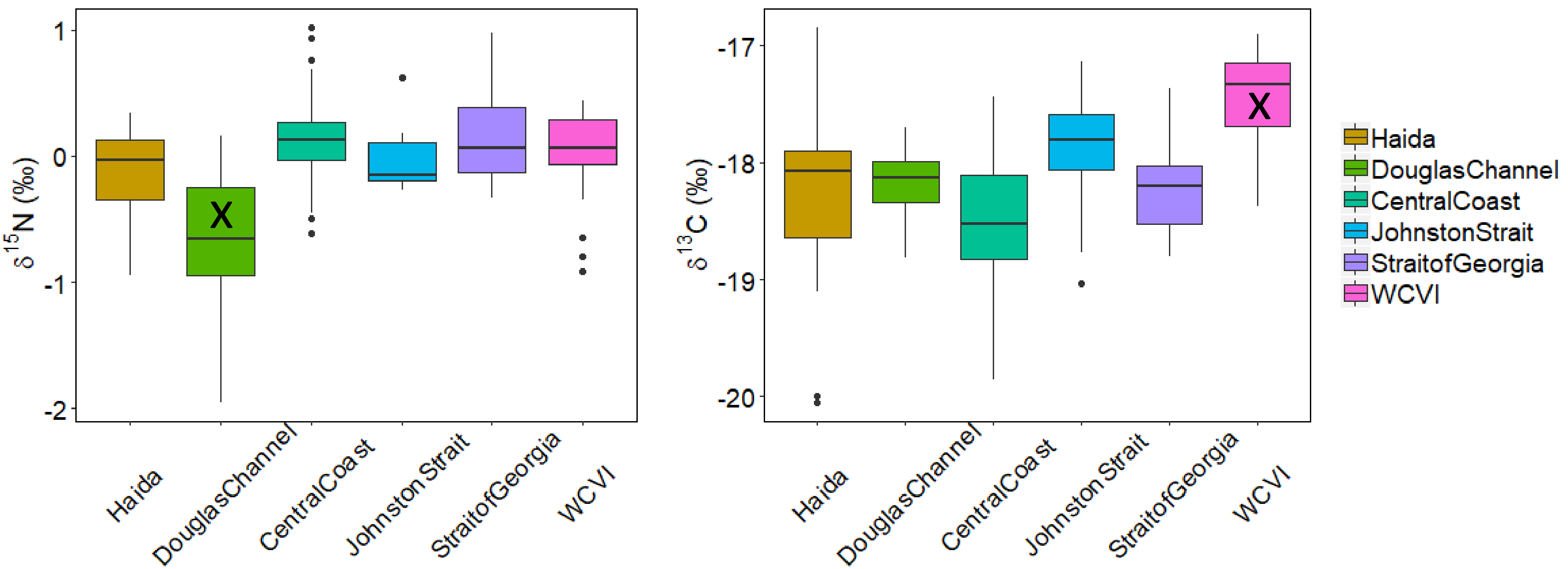
Results: Trophic level from CSIA

Region	**Ave. TL**	**SD**
Strait of Georgia	2.94	0.08
West Coast of VI	2.89	0.06
Prince Rupert	3.00	0.08
Central Coast	3.03	0.12
All regions	**2.96**	**0.08**

Highly consistent TL in 2016

- Herring bulk $\delta^{15}N$ is indicative of changes in productivity not changes in food chain length.

RESULTS: REGIONAL DIFFERENCES IN 2014



$\delta^{15}N$

Douglas Channel << all other regions

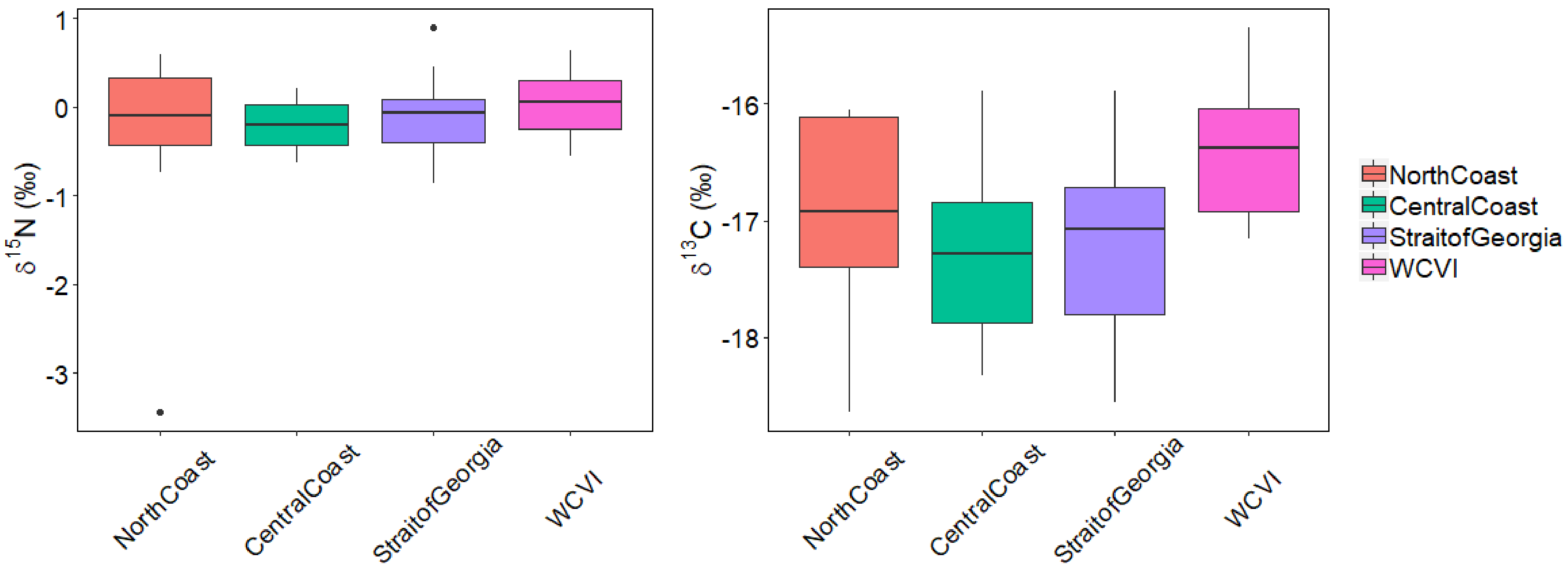
$\delta^{13}C$ I

WCVI >> all regions except JS

$\delta^{15}N$ *Kruskall-Wallis: $p < 0.001$

$\delta^{13}C$ *Kruskall-Wallis: $p < 0.001$

RESULTS: REGIONAL DIFFERENCES IN 2016

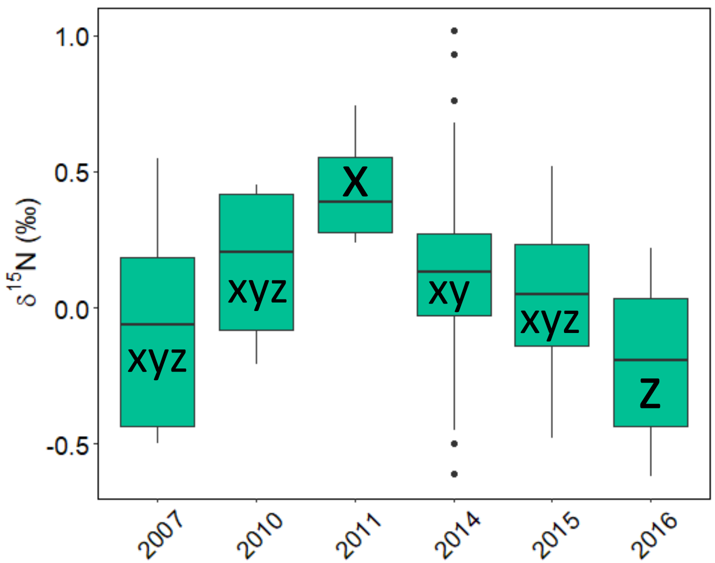


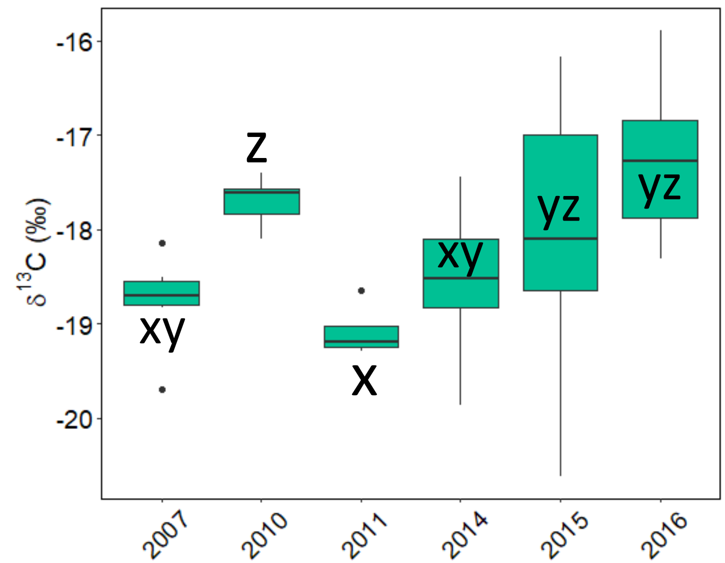
- No significant regional difference in $\delta^{15}N$ or $\delta^{13}C$;
- $\delta^{13}C$ was 1.2‰ higher in 2016 than 2014 *(equivalent to ~ 1.8^{o}C)*

$\delta^{15}N$ *Kruskall-Wallis: $p = 0.6$

$\delta^{13}C$ *Kruskall-Wallis: $p = 0.07$

RESULTS: INTERANNUAL DIFFERENCES – CENTRAL COAST





Significant interannual differences in δ^{15}N or δ^{13}C

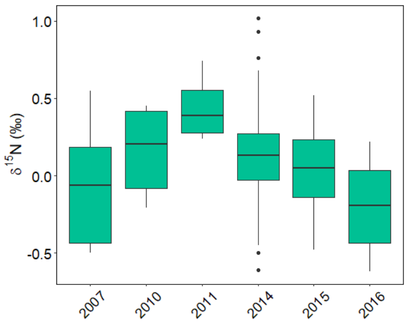
- **δ^{15}N** highest in 2011, lowest in 2016 (Δ 3.5 µM L^{-1} Nitrate)
- **δ^{13}C** lowest in 2011, highest in 2016 (Δ 2.7°C)

δ^{15}N *Kruskall-Wallis: $p < 0.001$

δ^{13}C *Kruskall-Wallis: $p < 0.001$

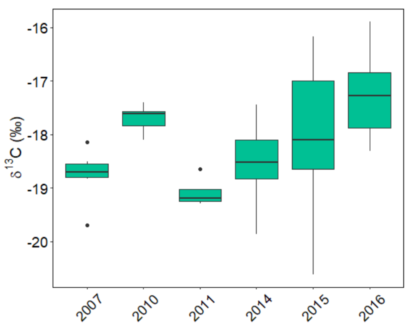
RESULTS: INTERANNUAL DIFFERENCES – CENTRAL COAST

$\delta^{15}N$



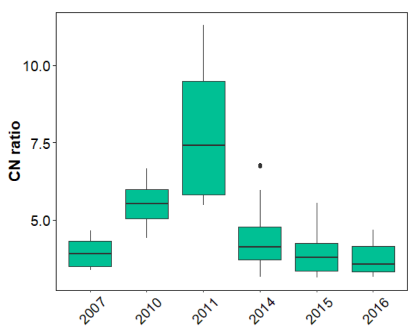
Productivity

$\delta^{13}C$



Productivity

CN



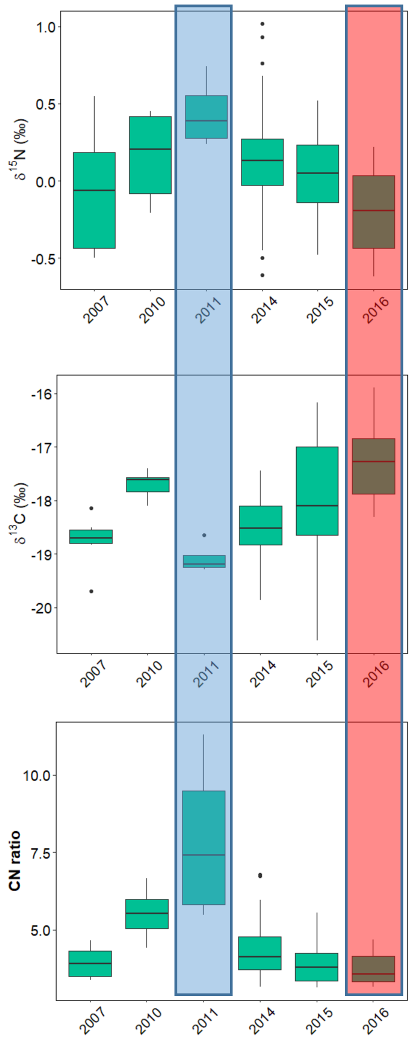
Condition

RESULTS: INTERANNUAL DIFFERENCES – CENTRAL COAST

$\delta^{15}N$

$\delta^{13}C$

CN



Productivity

Productivity

Condition

Productivity & lipid content:

- **Highest during cold year (2011)**
- **Lowest during warm year (2016)**

Aims of this study

1) Are there regional differences in herring trophic level that reflect differences in food web structure?

TL estimates indicated consistent food chain length

2) Are their regional differences in productivity experienced by BC herring stocks?

Yes, but overall high consistency in 2014 and 2016.

3) Are there interannual differences in trophic conditions experienced by Central Coast herring?

Yes, substantial interannual differences that impacted lipid content.

CONCLUSIONS

Herring stable isotopes integrate environmental conditions and inform both life history experience and ocean conditions.

Next steps:

1. Time series development;
2. Juvenile life history phase

Contact: b.hunt@ocean.ubc.ca