

# SALMON AS INTEGRATIVE SAMPLERS OF HIGH SEAS FOOD WEBS

*POSTER: INTEGRATING STABLE ISOTOPE ANALYSES OF ZOOPLANKTON  
& RETURNING ADULT SALMON TISSUES TO INFORM HIGH SEAS  
NORTH PACIFIC FOOD WEB DYNAMICS*

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Monell & Vetlesen  
Foundation

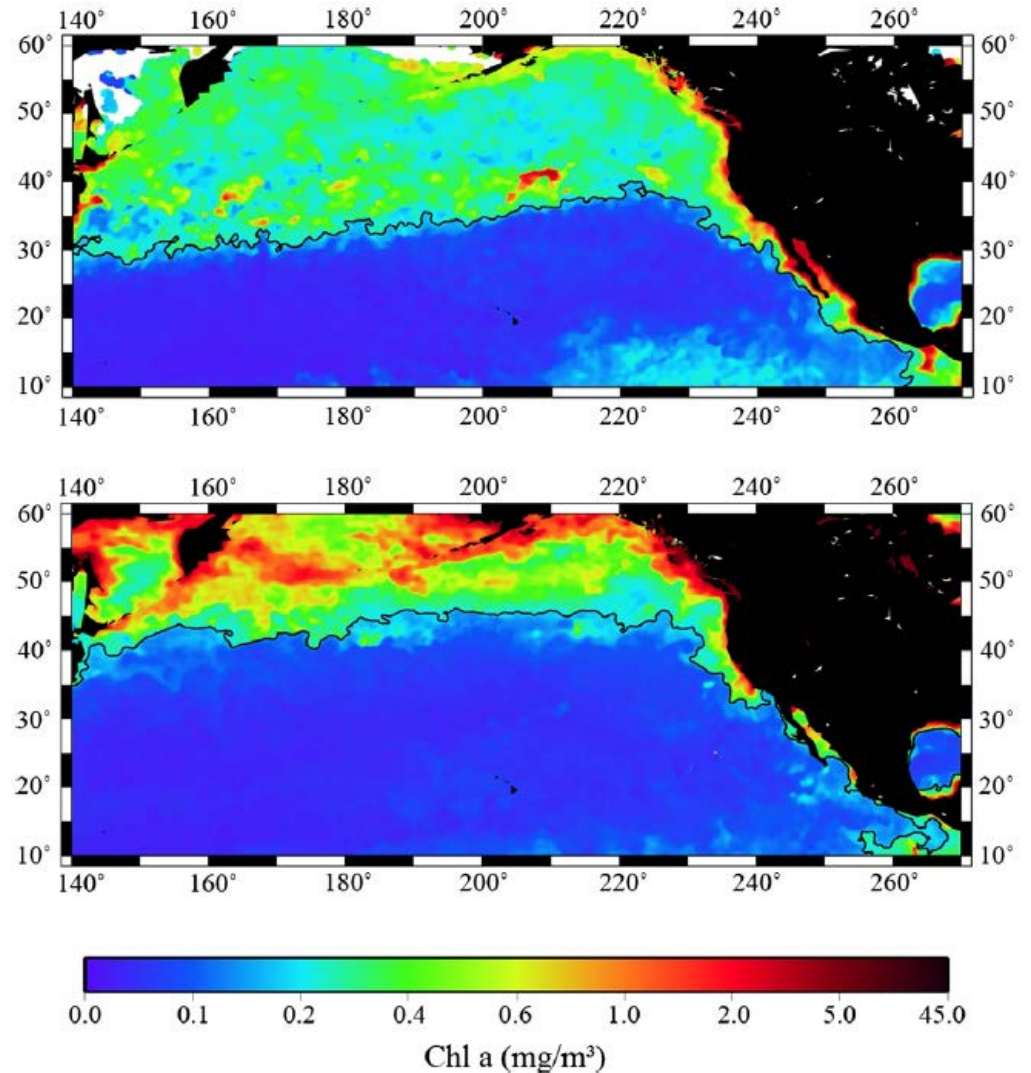


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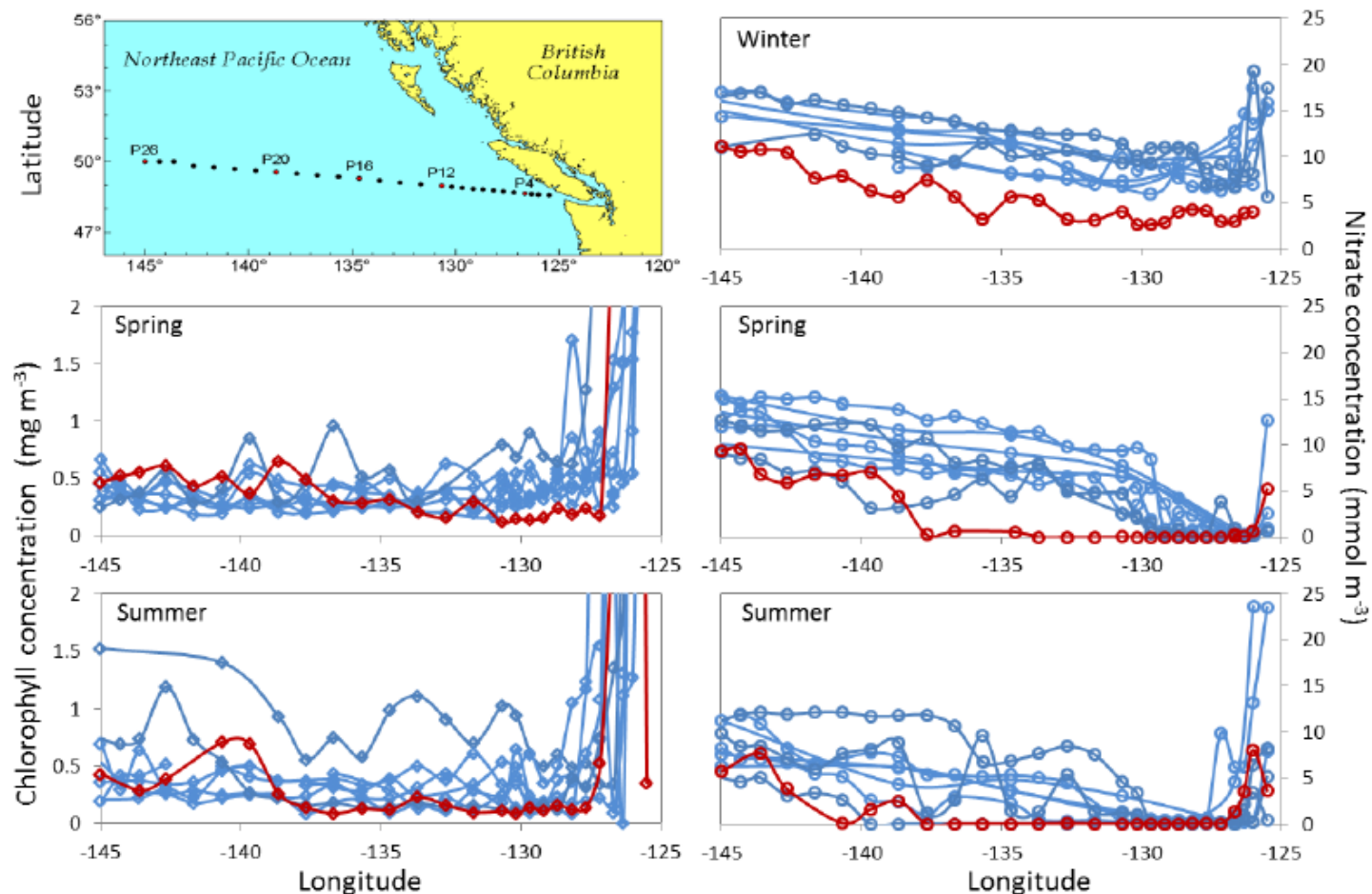


# THE HNLC HIGH SEAS NORTH EAST PACIFIC

Surface chlorophyll biomass  
March (top)  
September (below)



# PHYTOPLANKTON BIOMASS & NUTRIENTS



Chlorophyll-a & nitrate in surface waters along Line P in winter, spring and summer of 2015 (red symbols) and 2008-2014 (blue symbols).

# SAMPLING THE NORTH EAST PACIFIC

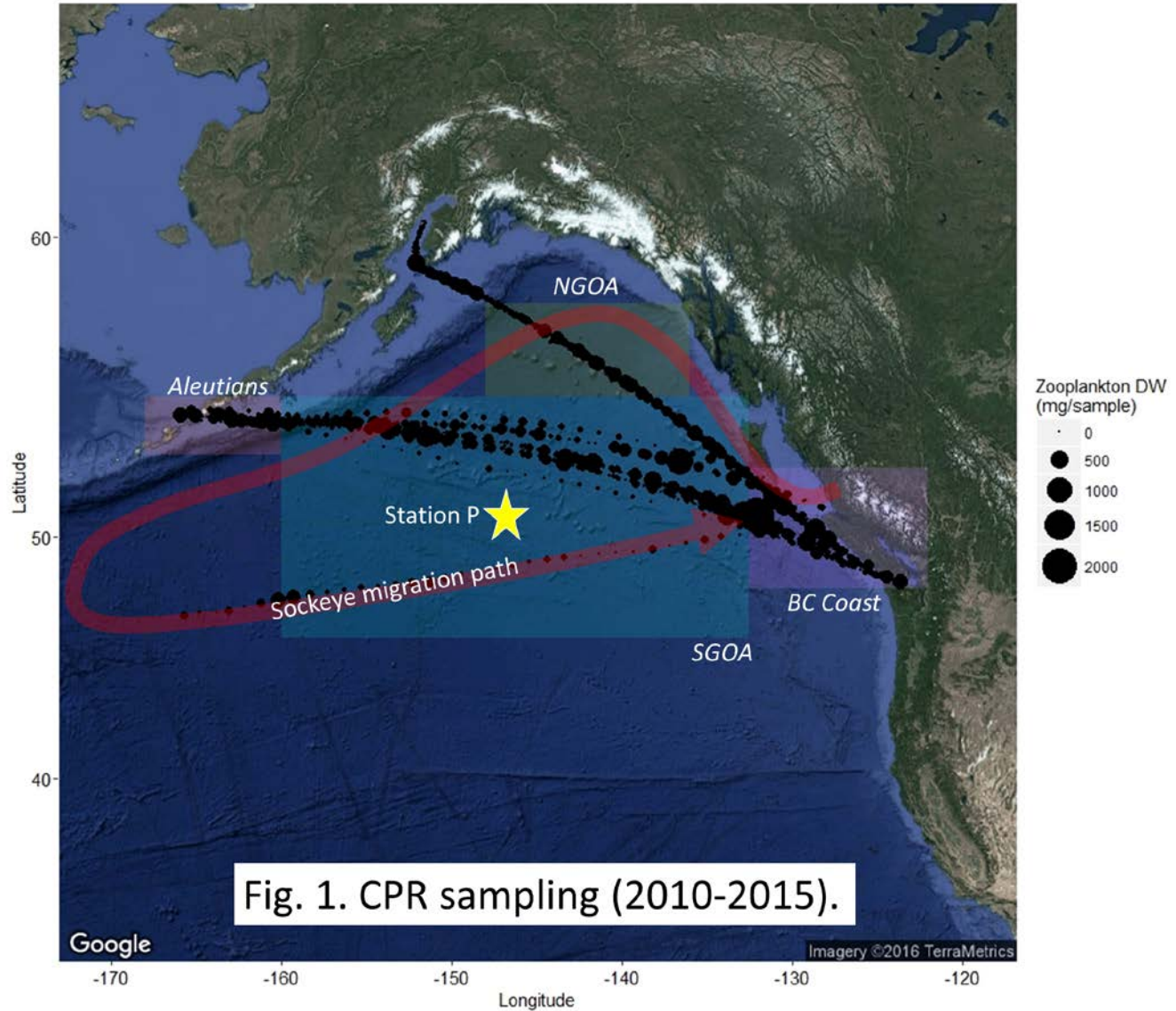


Fig. 1. CPR sampling (2010-2015).

# STUDY CONCEPT

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The body stable isotope ratios of returning salmon are expected to reflect the conditions that they experienced while on the high seas.

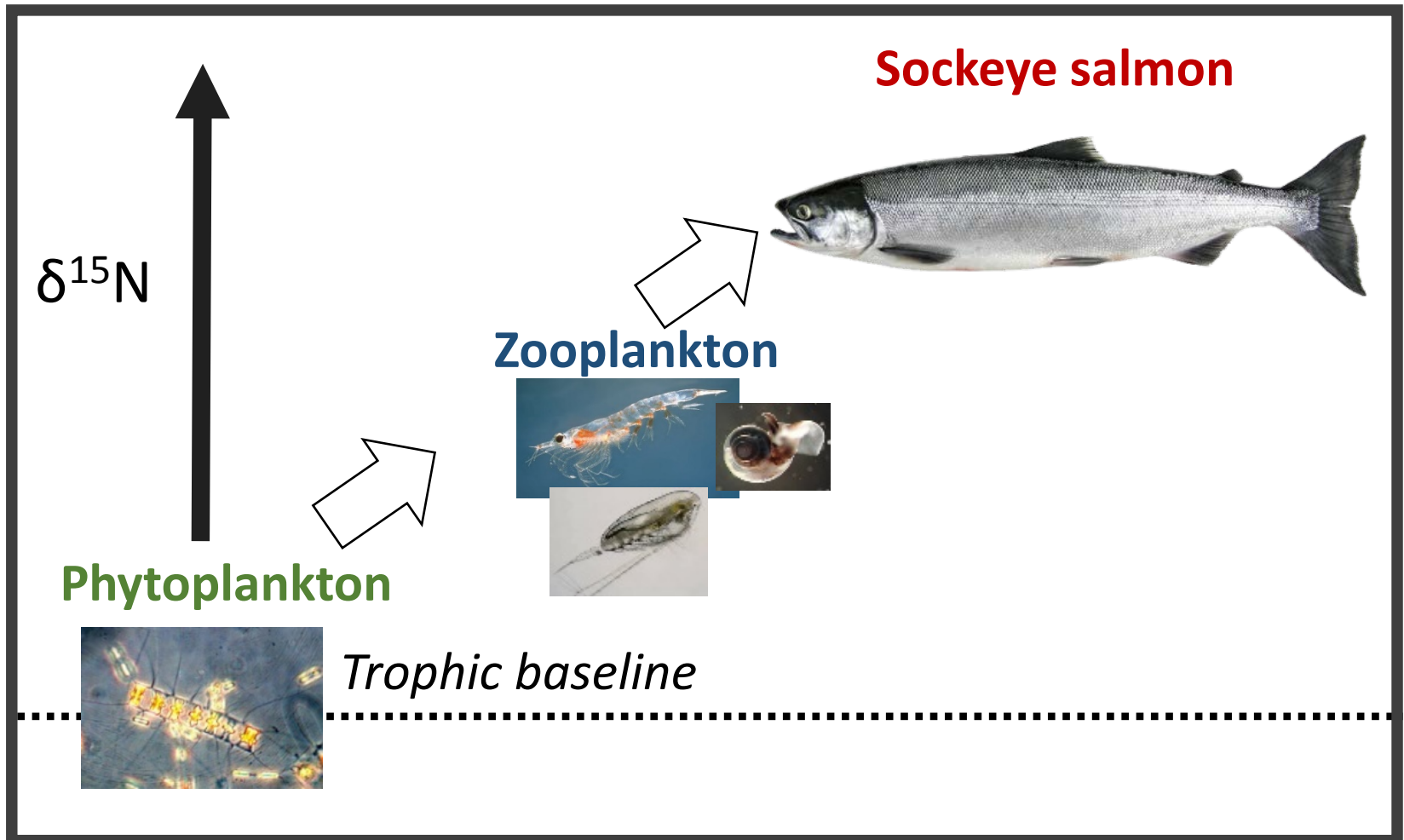
➤ Sockeye as integrative samplers of ocean conditions.

**Aim:** Long term measurement of Nitrogen ( $\delta^{15}\text{N}$ ) and Carbon ( $\delta^{13}\text{C}$ ) isotope ratios of salmon tissues to inform food-web dynamics, and fish life history experience.



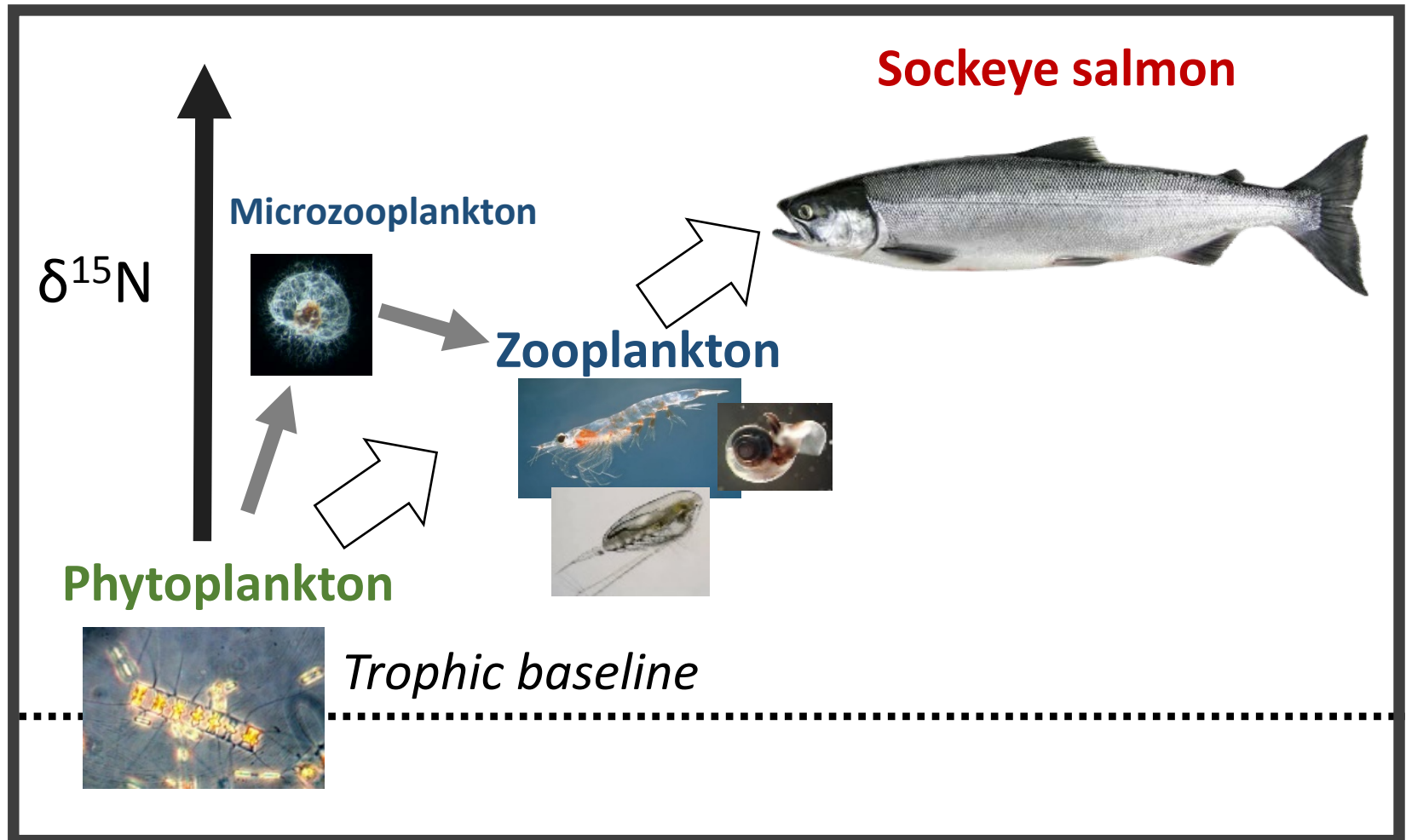
# ISOTOPE BASED TROPHIC LEVEL ESTIMATES

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



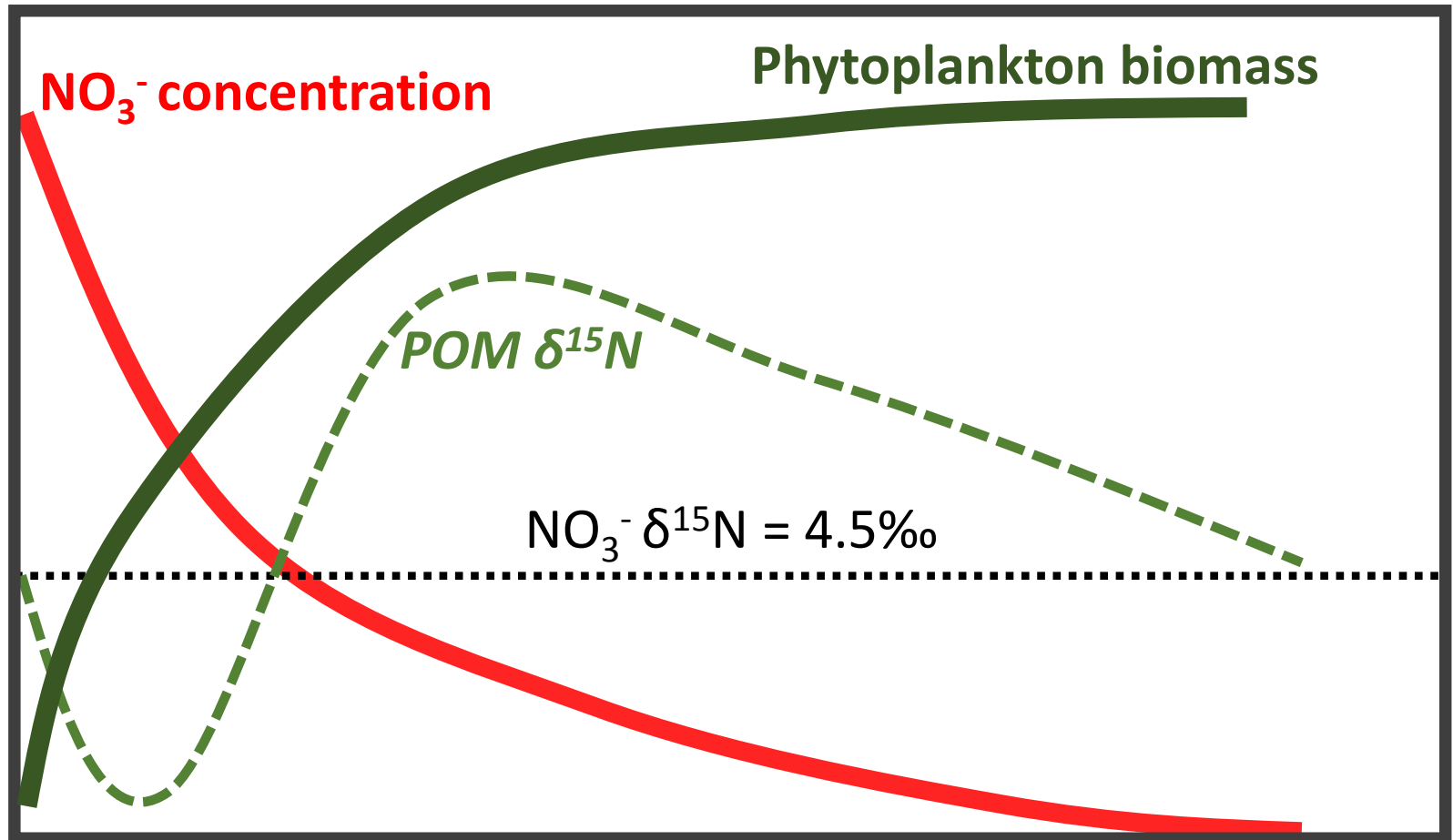
# ISOTOPE BASED TROPHIC LEVEL ESTIMATES

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



# THE TROPHIC BASELINE & NUTRIENT DYNAMICS

Nutrient concentrations & primary productivity set phytoplankton  $\delta^{15}\text{N}$ .





# METHODS

Adult **sockeye muscle** tissue collected from Rivers Inlet, British Columbia (2011-2016):

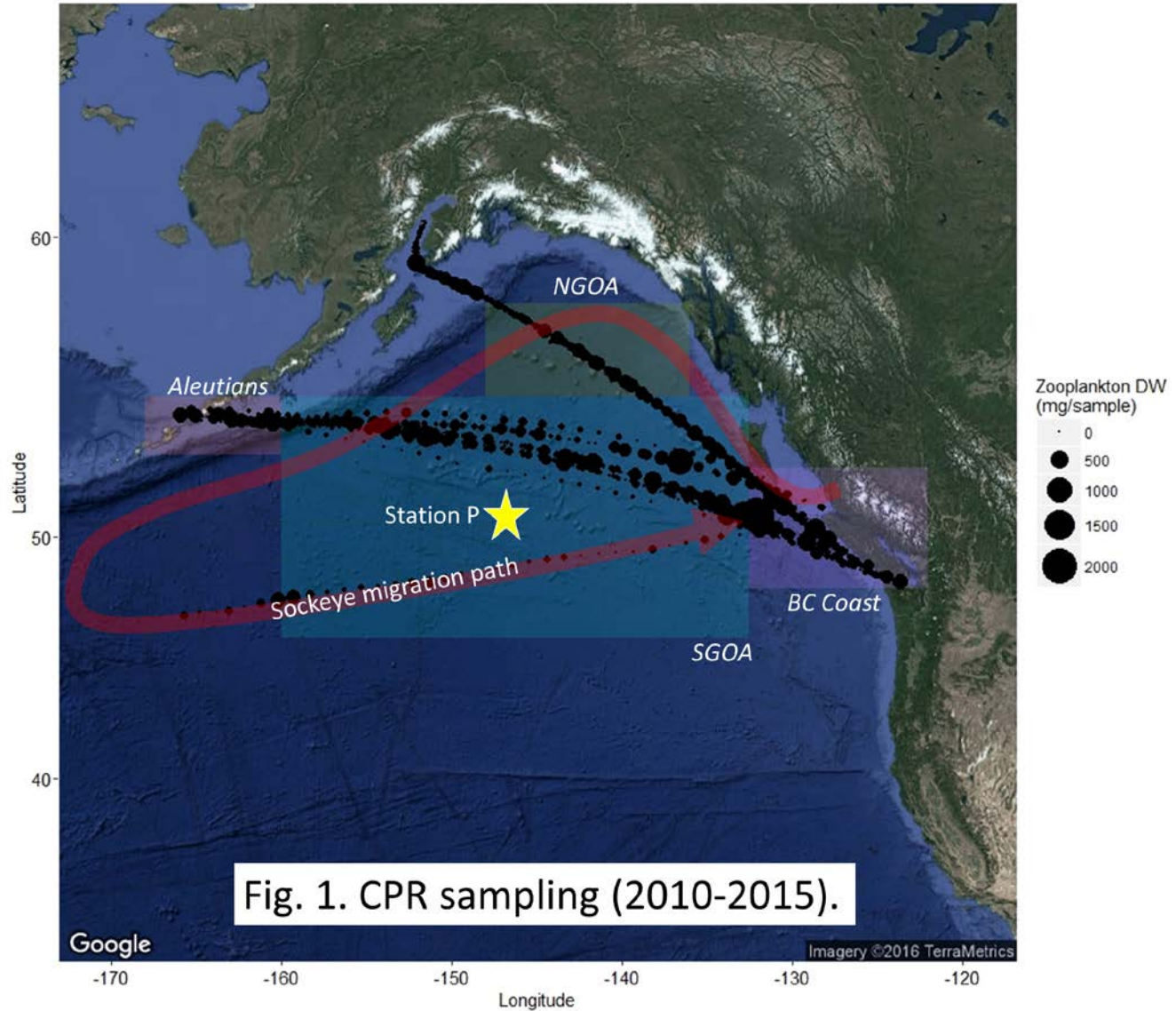
- **Bulk C & N** isotopes ( $n > 100/\text{yr}$ ).
- **Amino Acid Specific N** isotopes ( $n = 1/\text{yr}$ ).

**Continuous Plankton Recorder (CPR)** zooplankton samples:

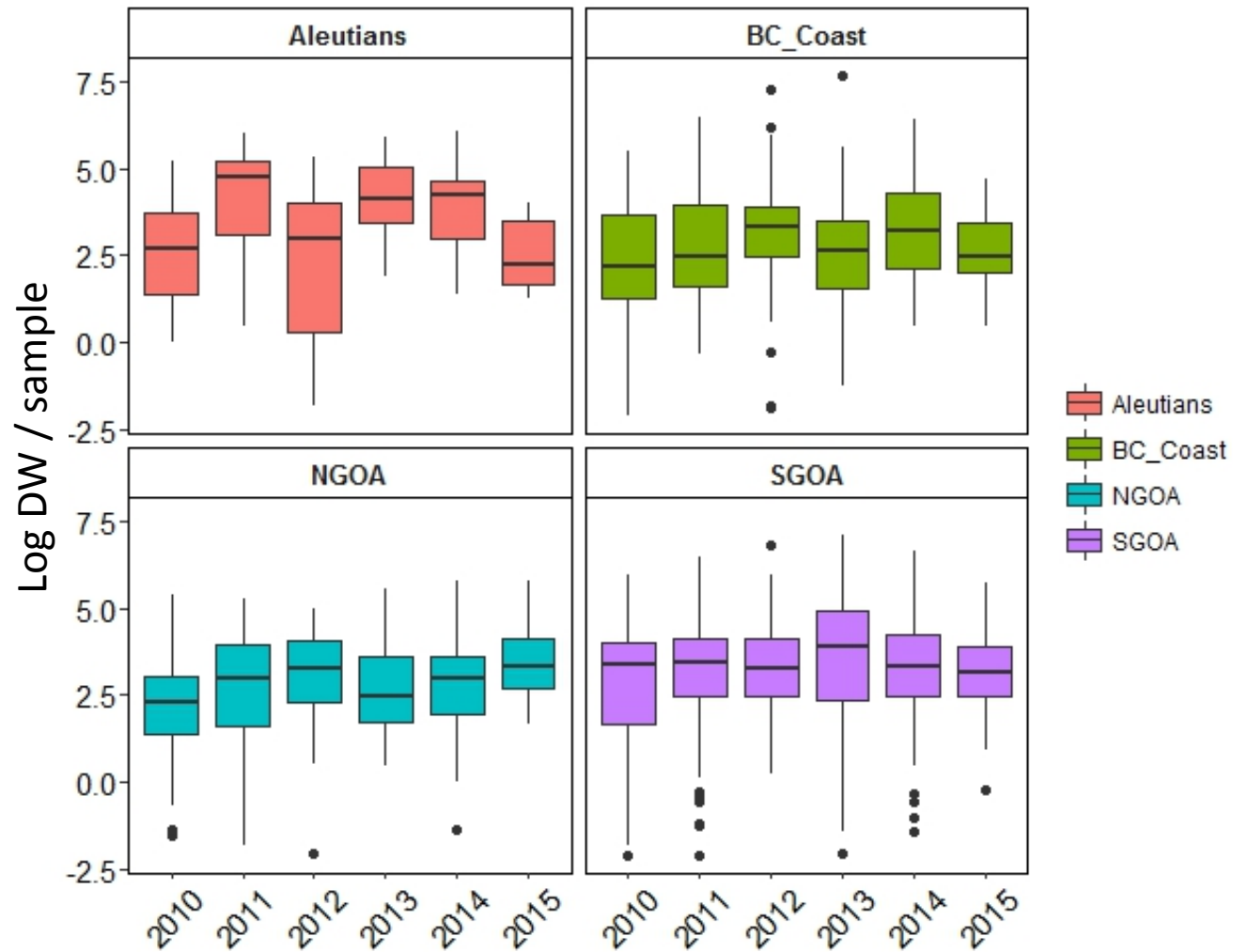
- **Bulk N** isotopes (2010-2013)
- **Biomass** (2010-2015)



# SAMPLING THE NORTH EAST PACIFIC

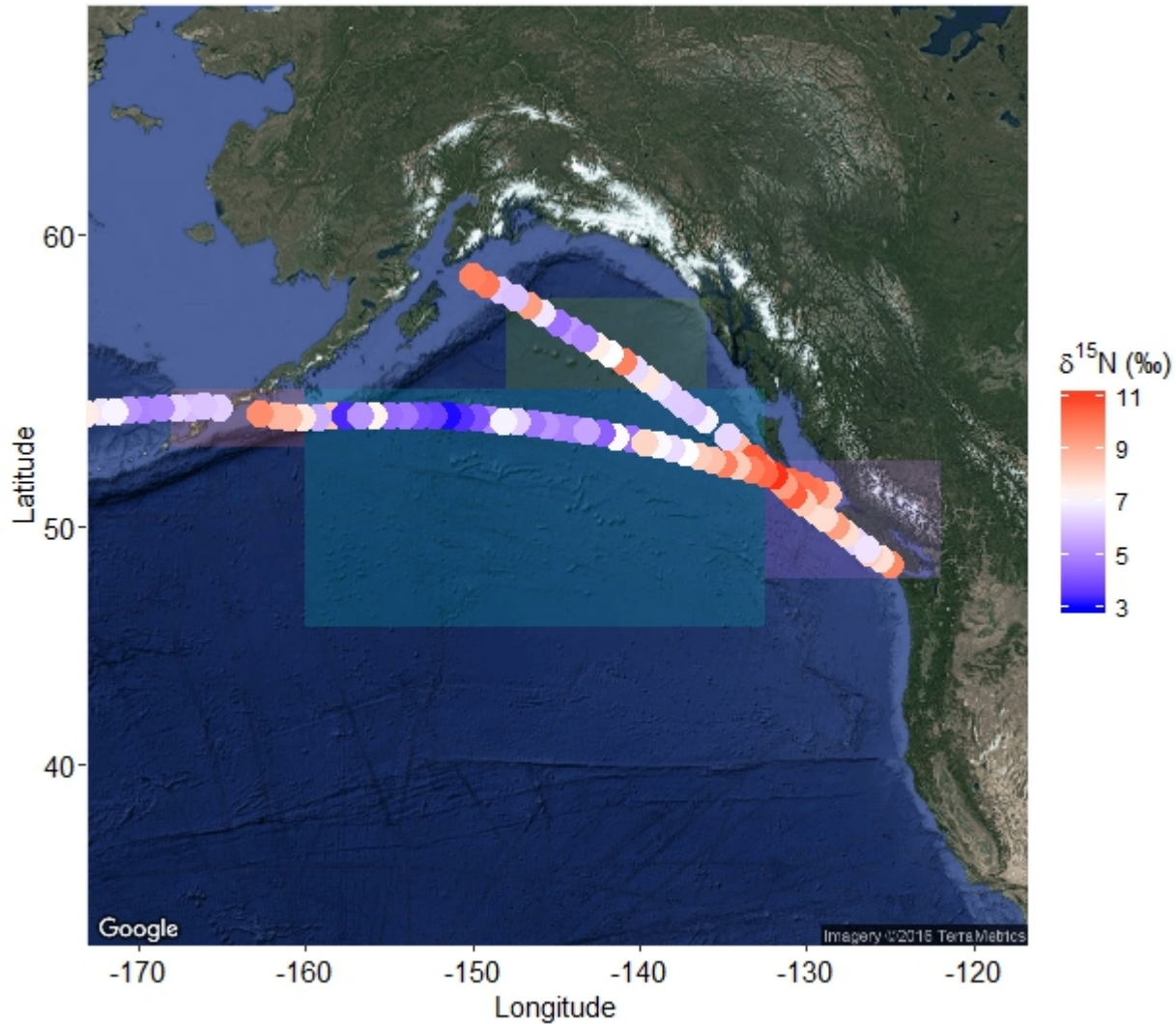


# CPR ZOOPLANKTON BIOMASS TIME SERIES

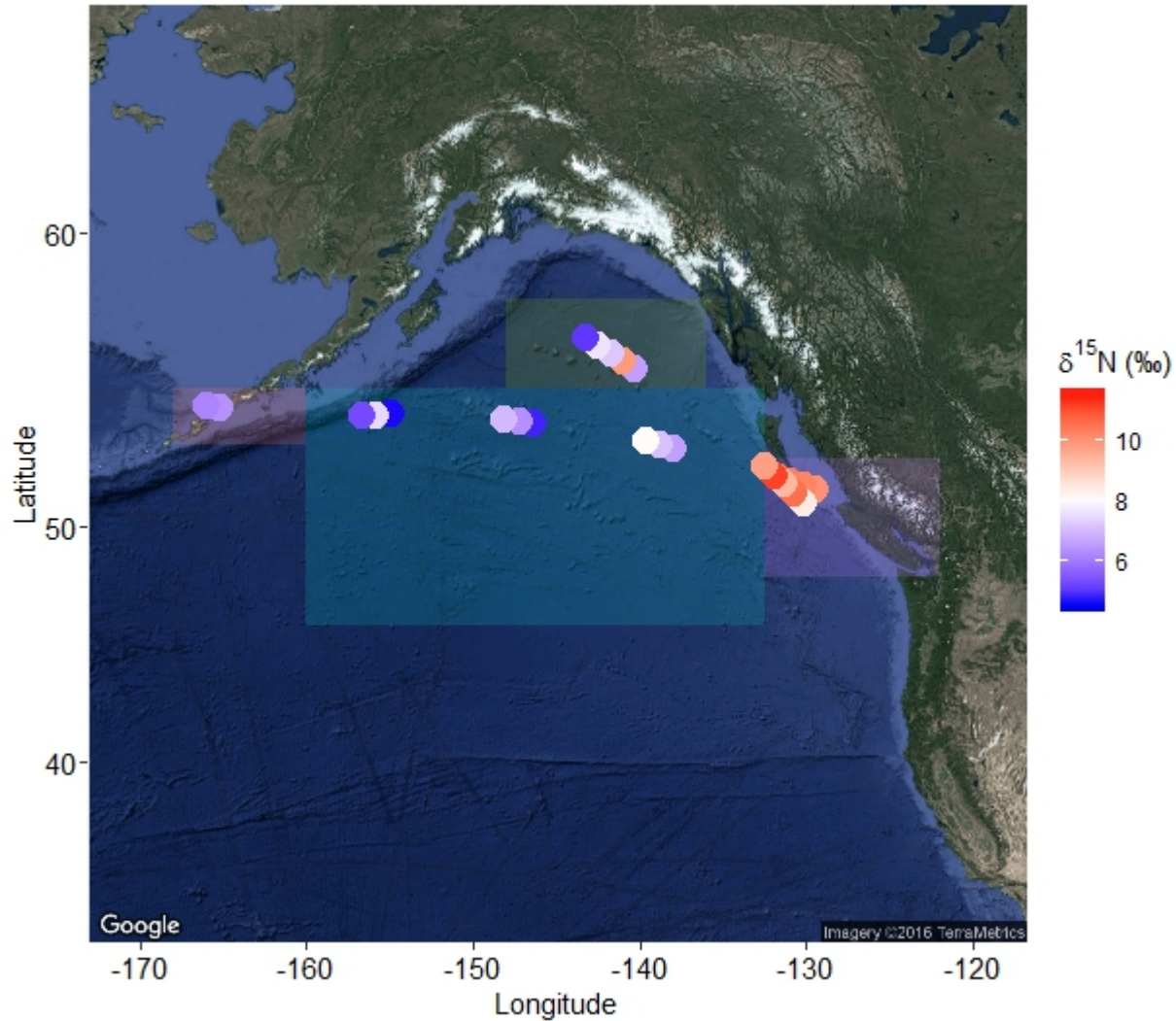




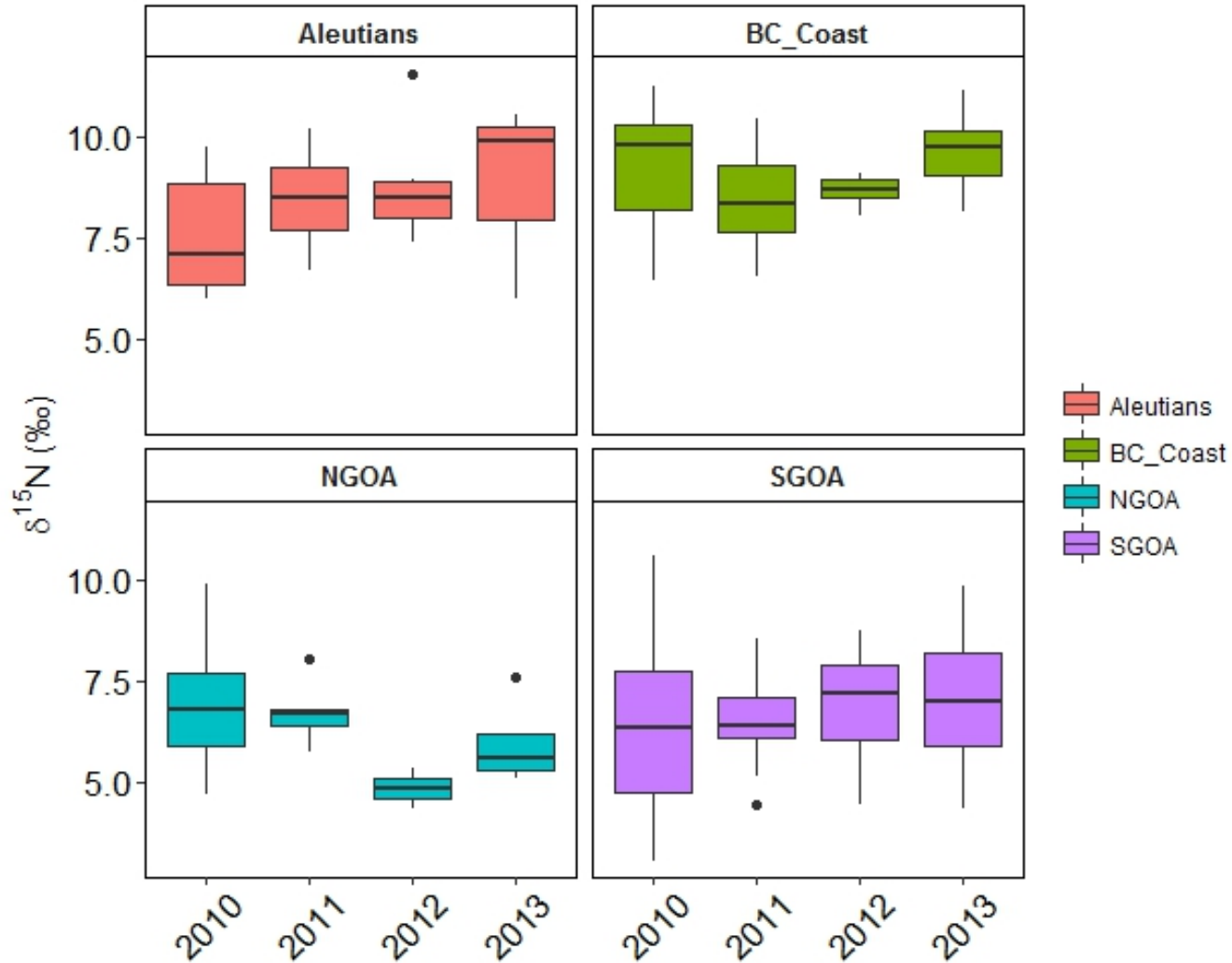
# CPR ISOTOPES AND $\delta^{15}\text{N}$ - 2010



# CPR ISOTOPES AND $\delta^{15}\text{N}$ – 2010 NIGHT

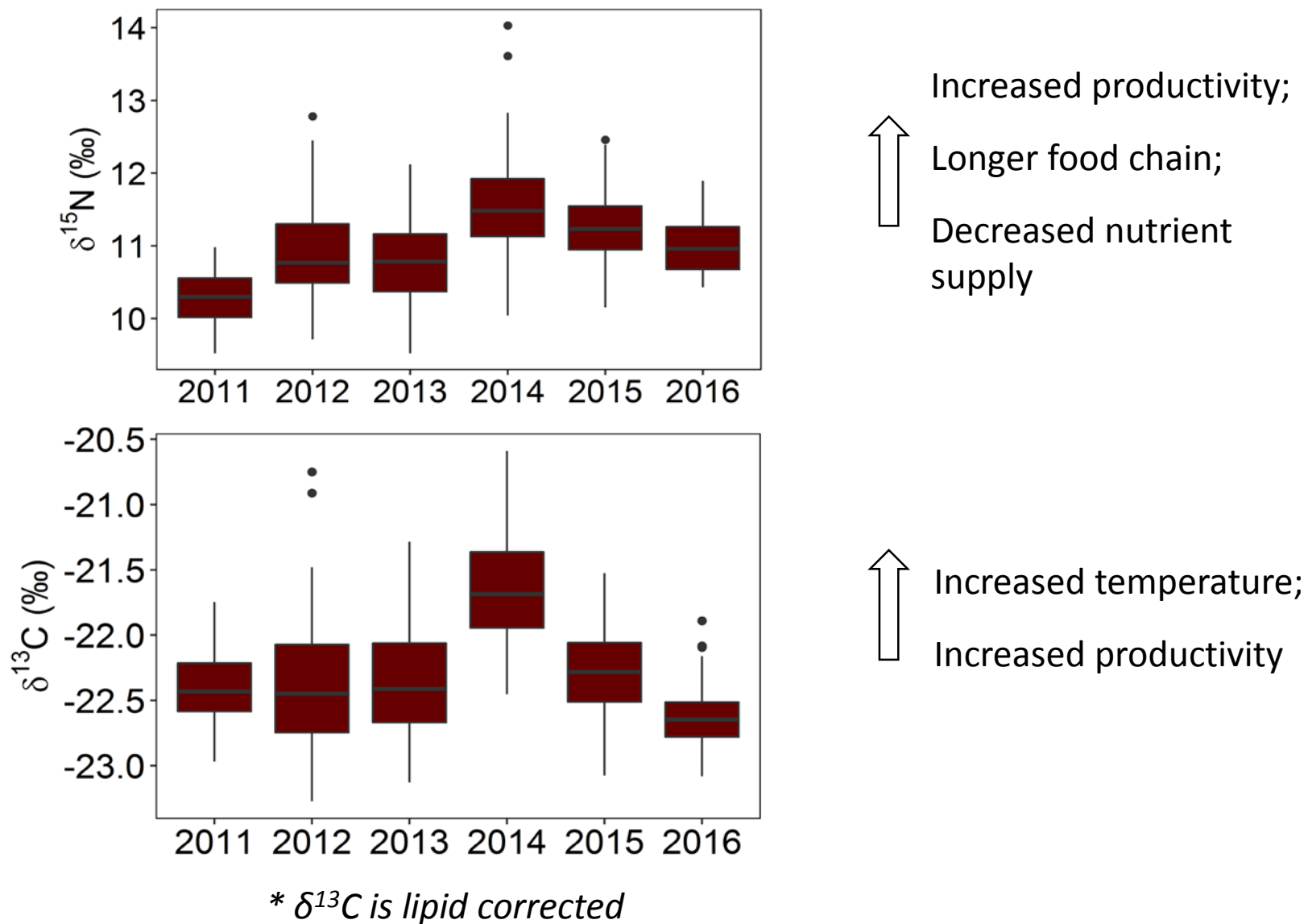


# ZOOPLANKTON N ISOTOPES – REGION X YEAR

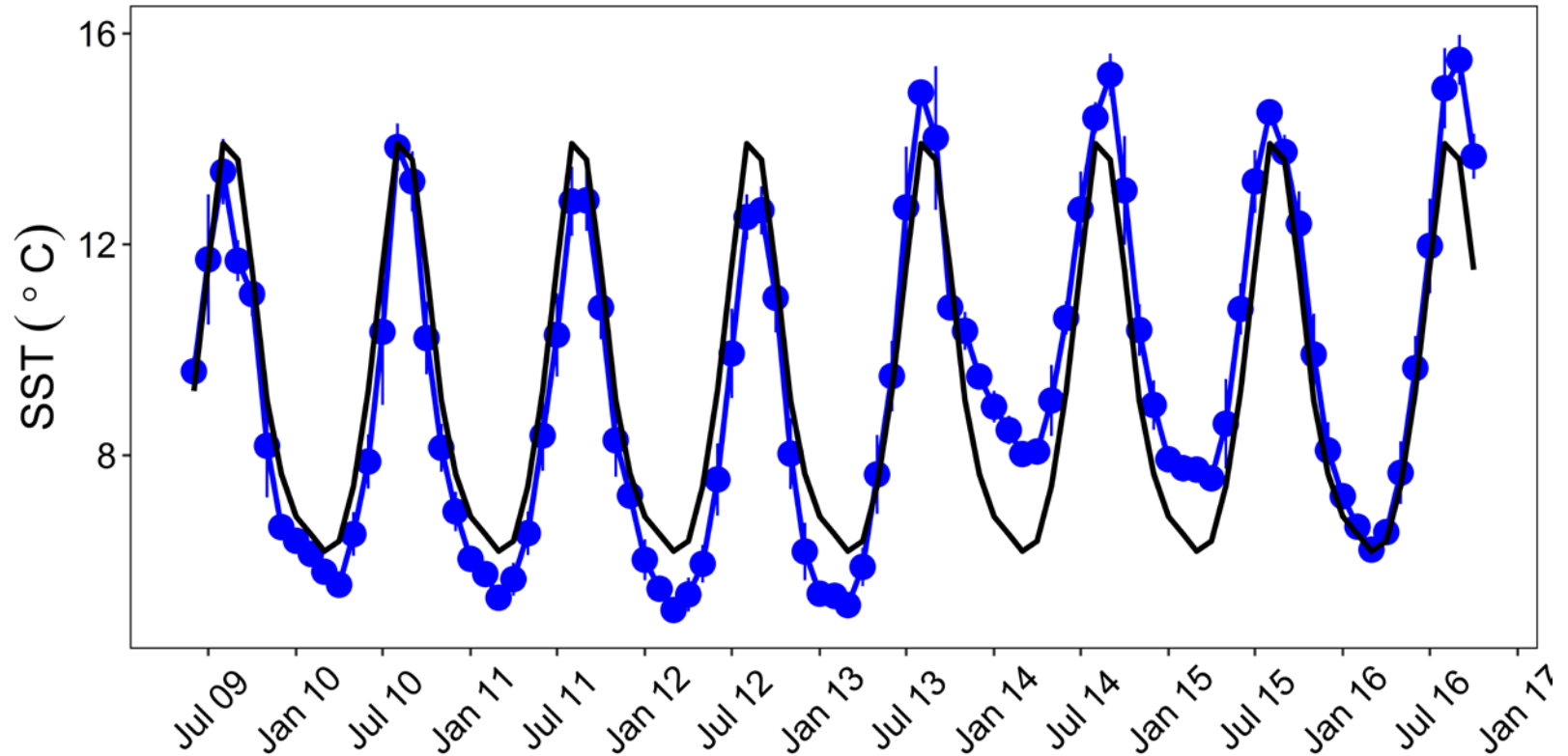




# SOCKEYE ISOTOPES – 2011 TO 2016



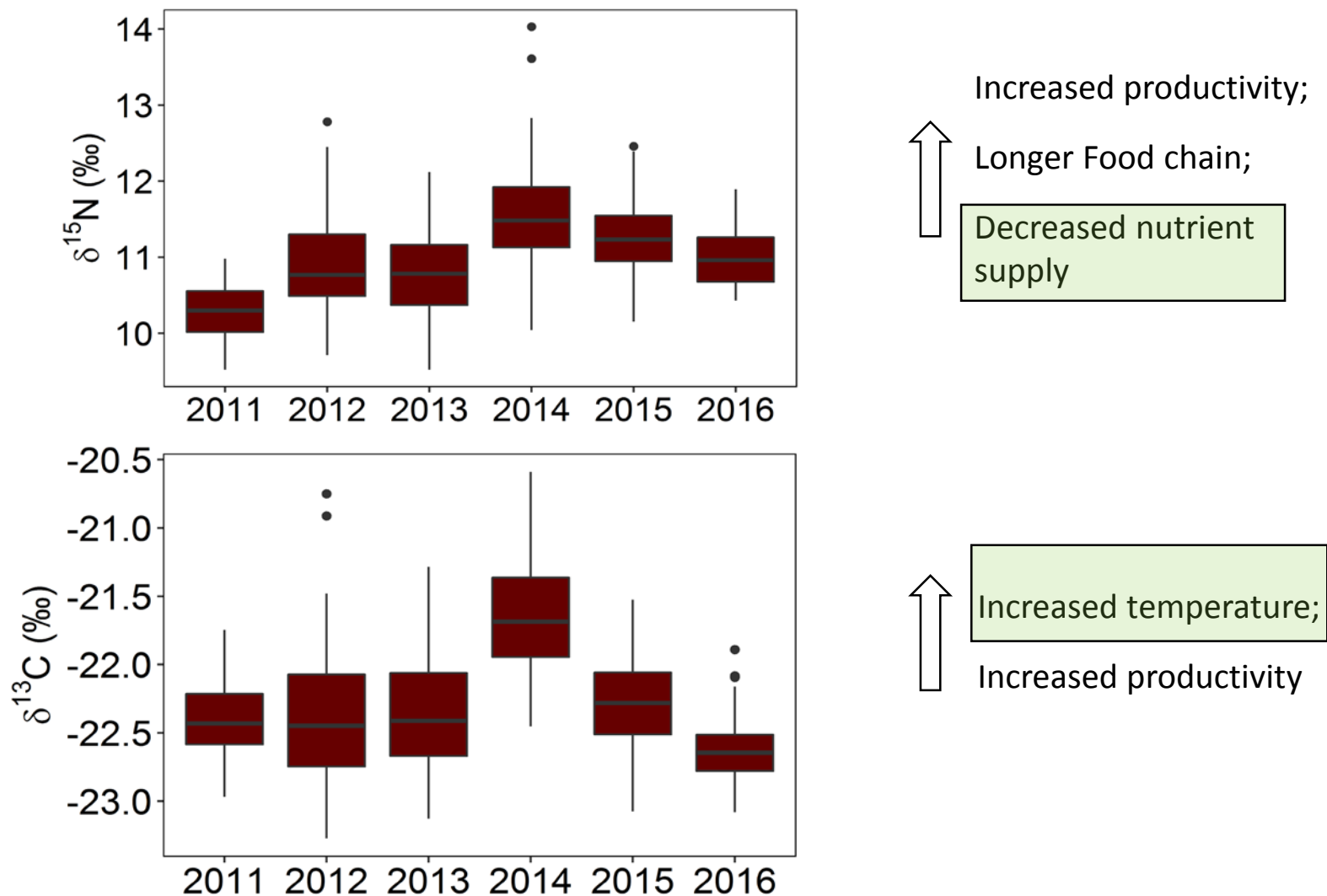
# SST AT STATION P (2009-2016)



Monthly average across all years (black); Monthly average (blue).

Data source: <http://www.pmel.noaa.gov/ocs/data/disdel>

# SOCKEYE ISOTOPES – 2011 TO 2016

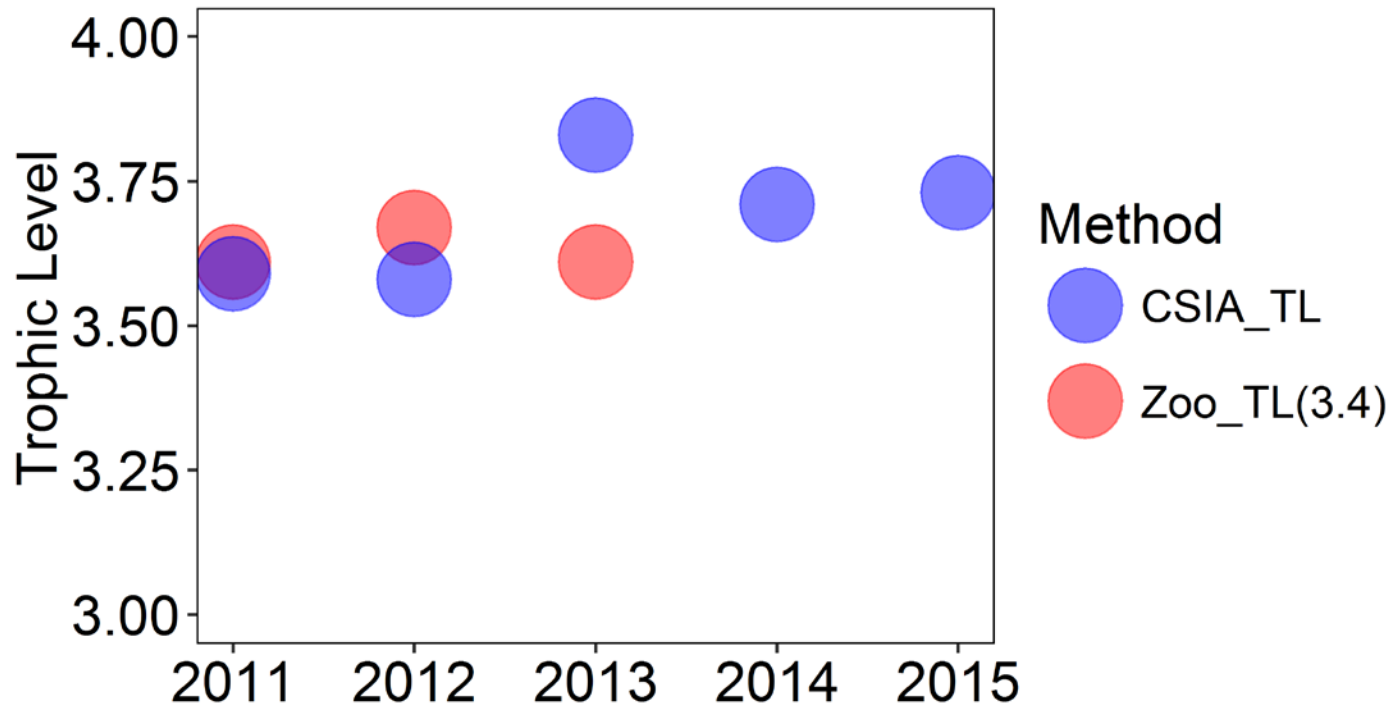


\*  $\delta^{13}\text{C}$  is lipid corrected

# SOCKEYE TROPHIC LEVEL

## Trophic Level calculation

1. Bulk:  $TL = (\text{Sockeye } \delta^{15}\text{N} - \text{zoo } \delta^{15}\text{N} / 3.4) + 2.5$  [used SGOA]
2. CSIA:  $TL = (\text{Glu-Phe} - 2.4) / 7.6 + 1$

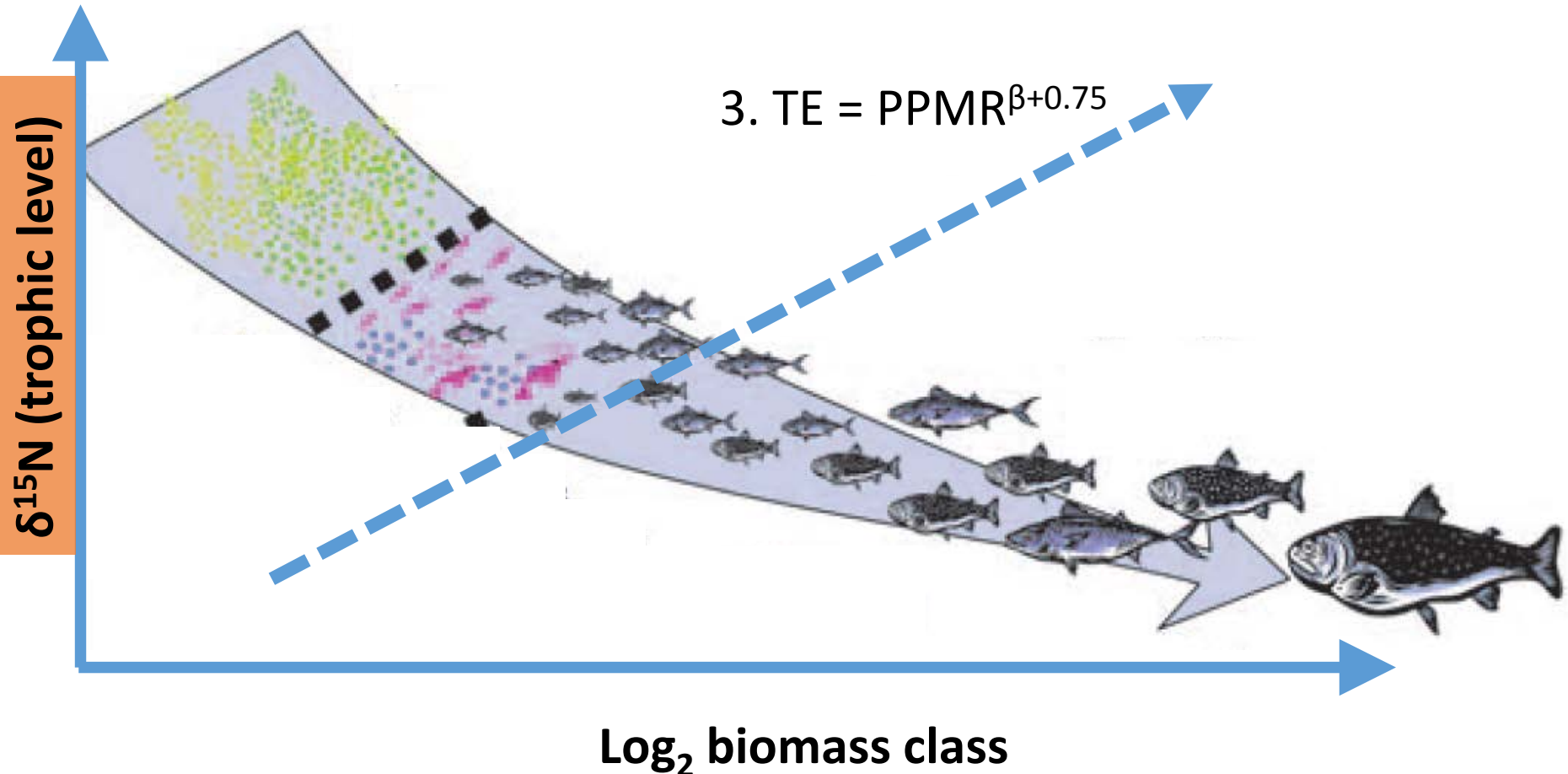


# APPLYING BIOMASS SPECTRUM THEORY

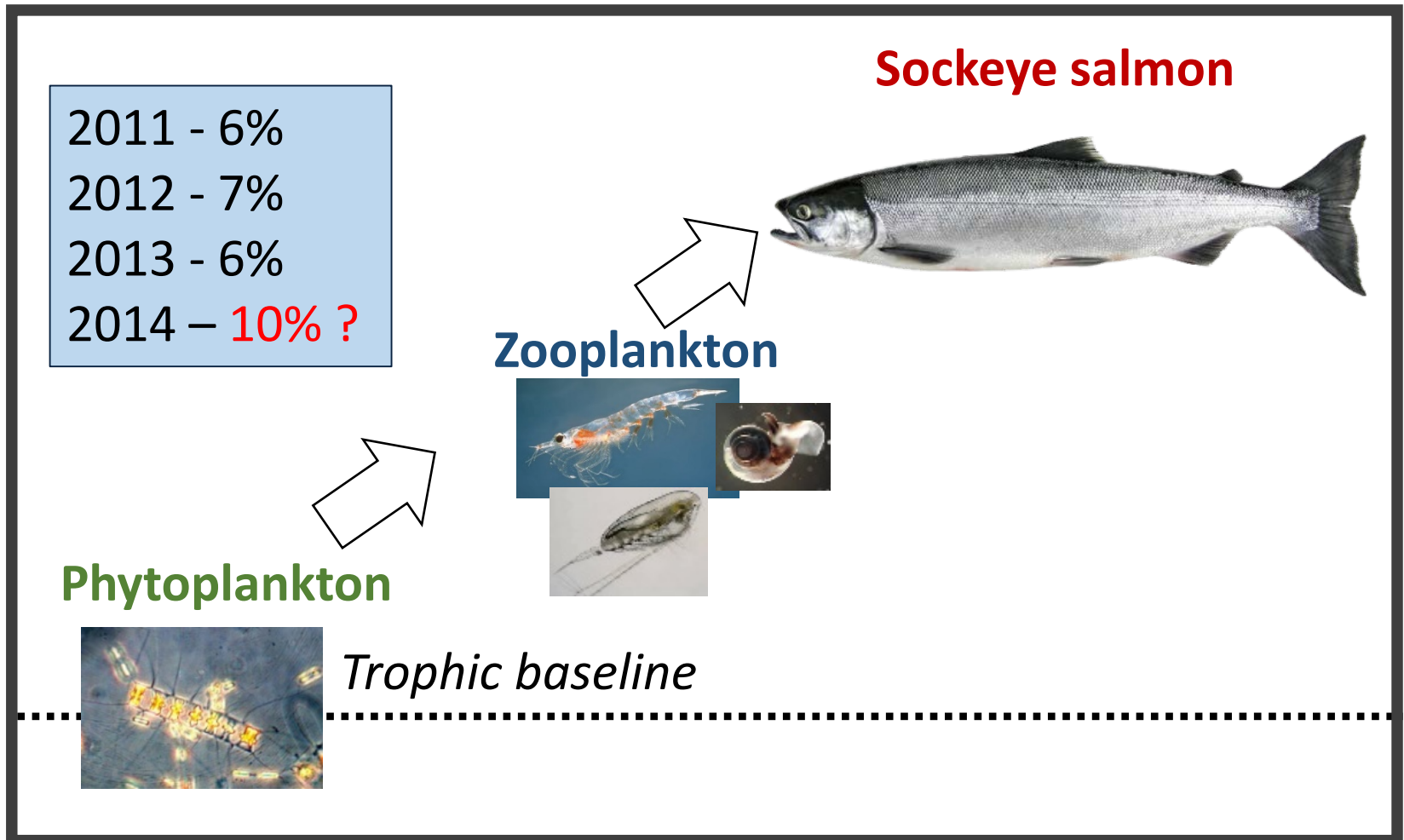
1.  $\delta^{15}\text{N} = m \cdot (\log_2 \text{wet weight}) + c$

2.  $\text{PPMR} = 2^{\text{TEF}/m}$  (e.g.  $\text{TEF} = 3.4$ )

3.  $\text{TE} = \text{PPMR}^{\beta+0.75}$



# TRANSFER EFFICIENCY IN THE SALMON FOOD WEB





# SUMMARY

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## Zooplankton $\delta^{15}\text{N}$

- 7.5-10 ‰ in shelf regions = high productivity
- 5-7.5 ‰ in off-shelf regions = low productivity

## Sockeye salmon isotope signatures

- $\delta^{15}\text{N}$  &  $\delta^{13}\text{C}$  elevated after warm “Blob” conditions (2014), indicating stratification induced nutrient limitation.
- Productivity appeared unaffected  
*BUT cellular stoichiometry and food quality?*

## Sockeye Salmon Trophic dynamics

- Bulk & CSIA yielded similar TL estimates of  $\sim 3.7$
- Energy transfer efficiency in this system is low & potentially variable.

# SUMMARY

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## Next steps:

- Resolve the relationship between zooplankton  $\delta^{15}\text{N}$  and Nutrient-Phytoplankton part of the food web.
- Fill in the CPR  $\delta^{15}\text{N}$  time series
- Further Amino Acid specific  $\delta^{15}\text{N}$  measurements.