Nitrogen baseline isoscape using amino acid nitrogen isotope of copepod *Calanus*

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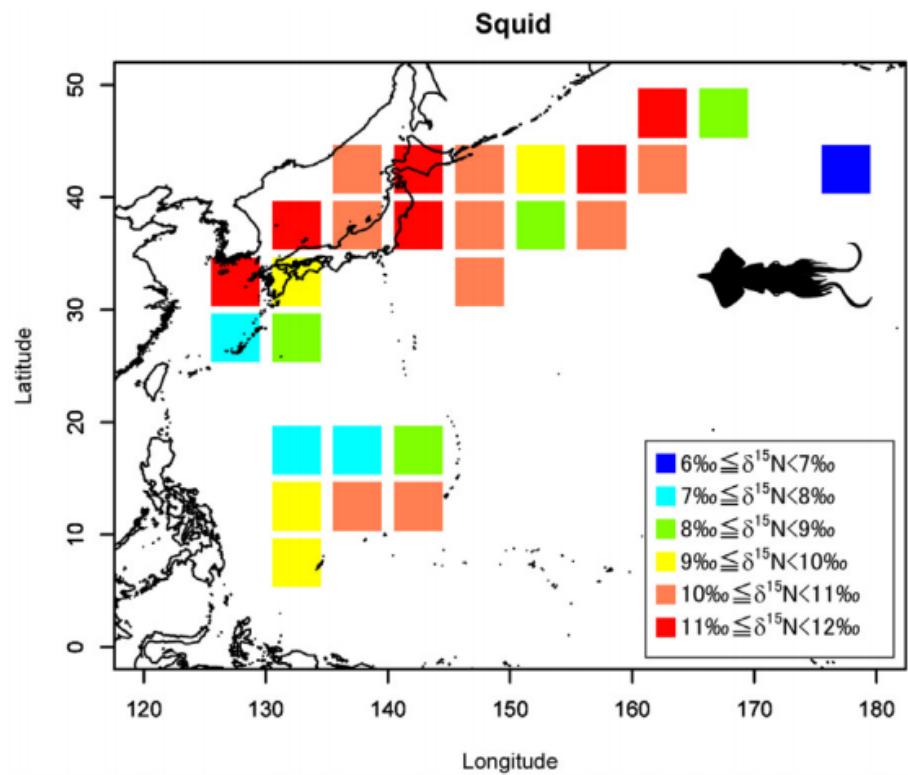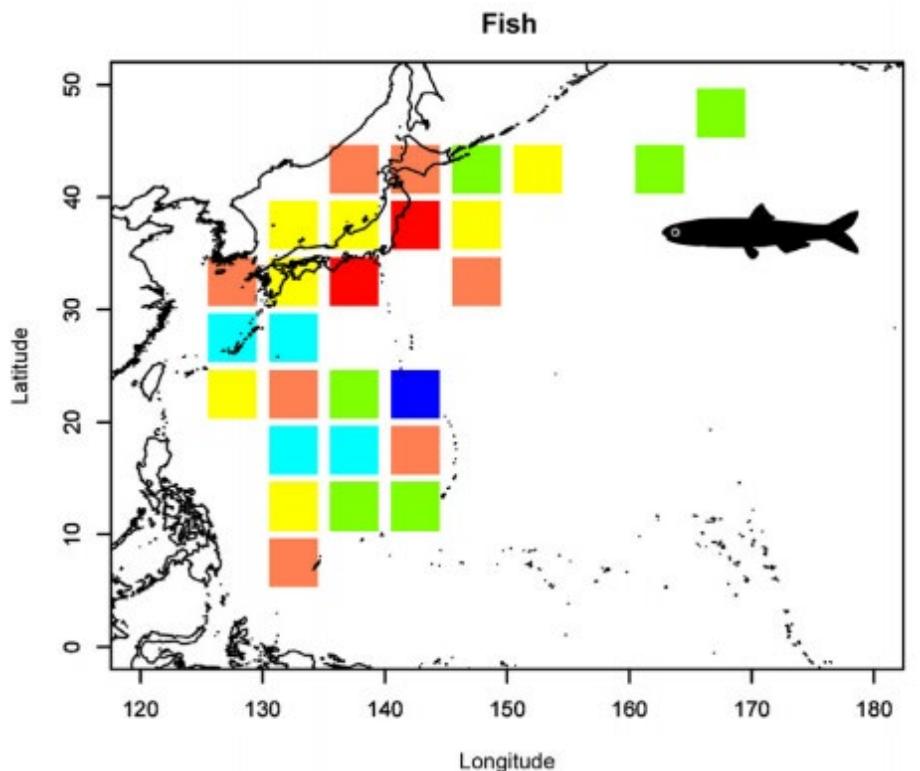
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Isotope + Landscape
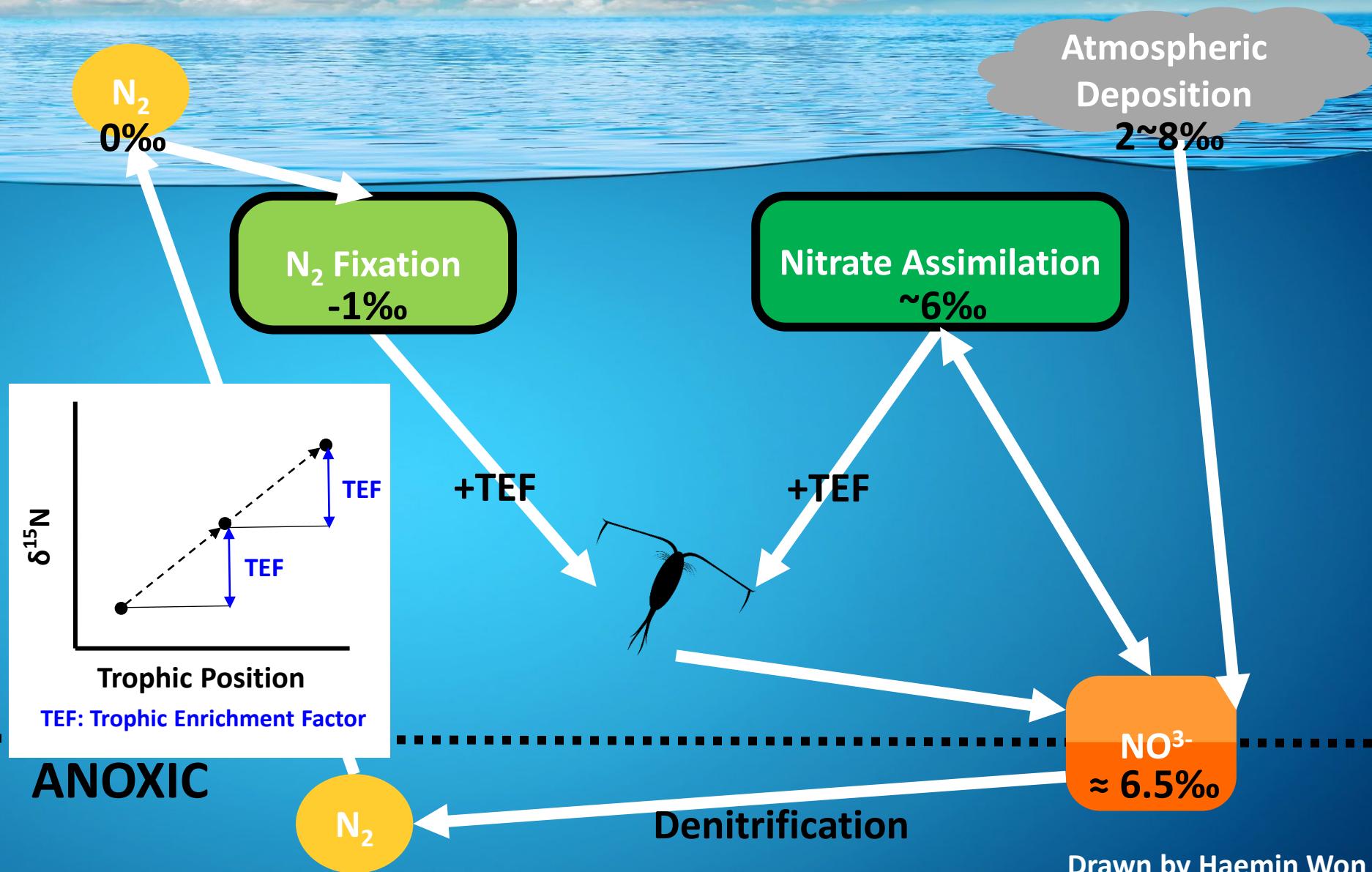
Establishing geochemical map of isotope for…

- Understanding which element sources are used
- Tracking long-distance migration of marine animals

Ohshimo et al., 2019

The nitrogen cycle: which N source is used?

N_2
0‰

Atmospheric Deposition
2~8‰

N_2 Fixation
-1‰

Nitrate Assimilation
~6‰

$\delta^{15}N$

TEF

TEF

Trophic Position

TEF: Trophic Enrichment Factor

ANOXIC

+TEF

+TEF

NO^{3-}
≈ 6.5‰

N_2

Denitrification

Drawn by Haemin Won
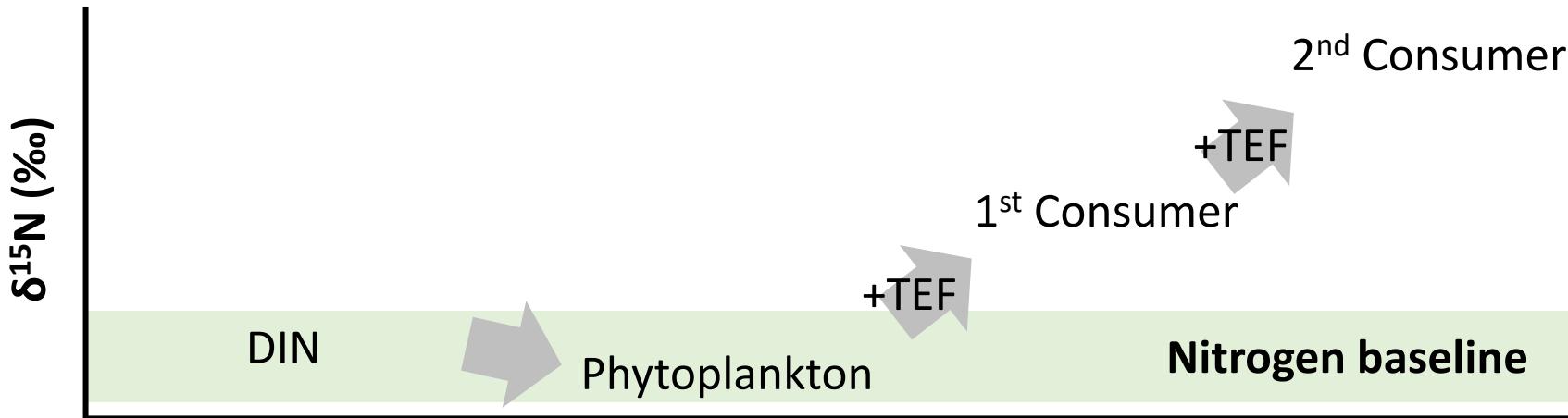
## Trophic structure based on nitrogen sources

Nitrogen isotope ratio can track the nitrogen sources (baseline)

TEF : Trophic enrichment factor
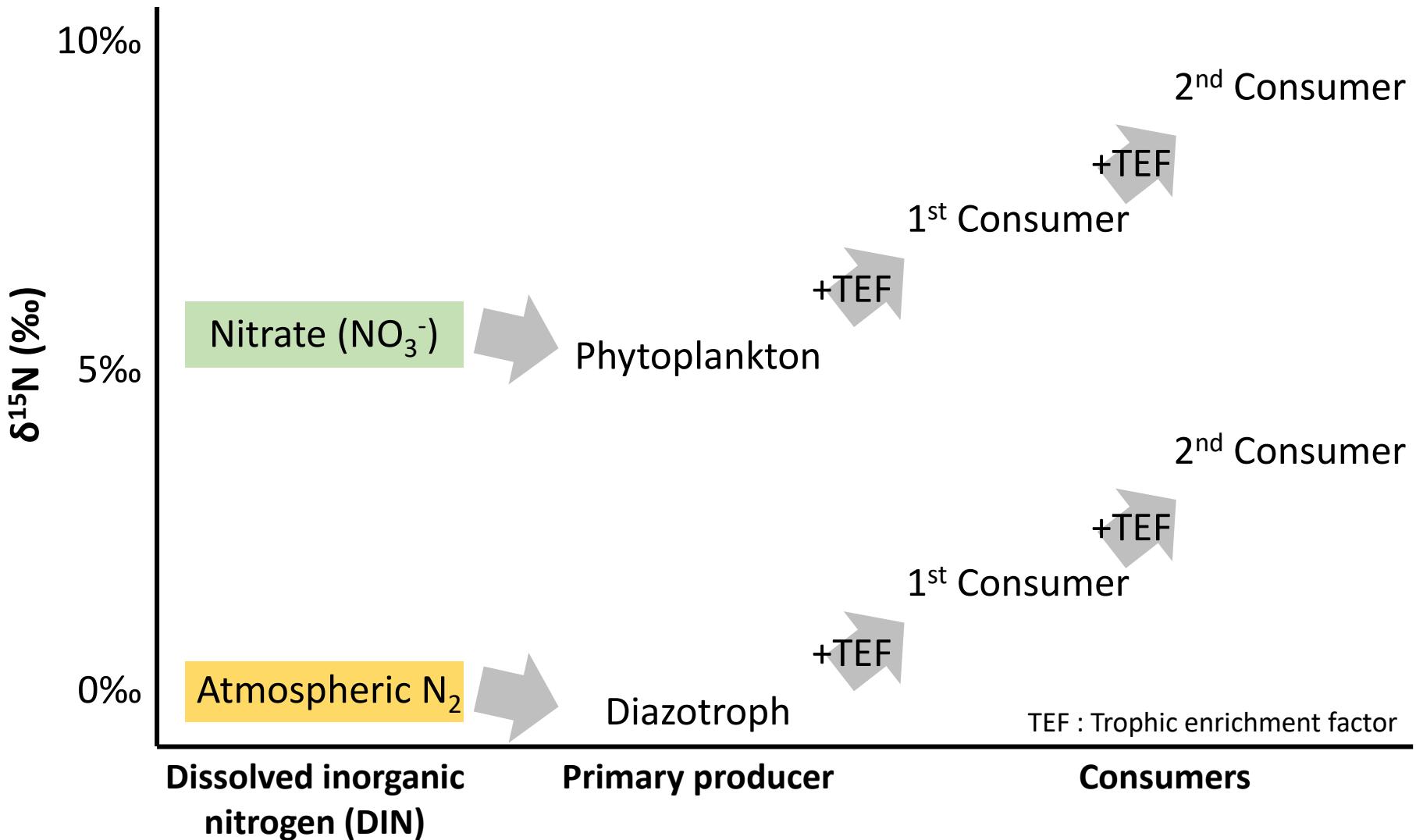
Understanding "real baseline" of $\delta^{15}N$ is difficult

| Sample type	Problem
Dissolved inorganic nitrogen (DIN)	Measurement isn't possible in oligotrophic condition
Particulate organic matter (POM)	Rapid $\delta^{15}N$ turnover (snapshot data)
Consumers (zooplankton, fish, and others…)	Mixed information on $\delta^{15}N$ Baseline + Trophic enrichment

δ¹⁵N of AAs for basal nitrogen indicator

Bulk δ¹⁵N analysis

Mixed information on N baseline and trophic level

→ Difficult baseline identification when N sources vary
→ Difficult estimation of trophic position

<Bulk δ¹⁵N enrichment pattern>
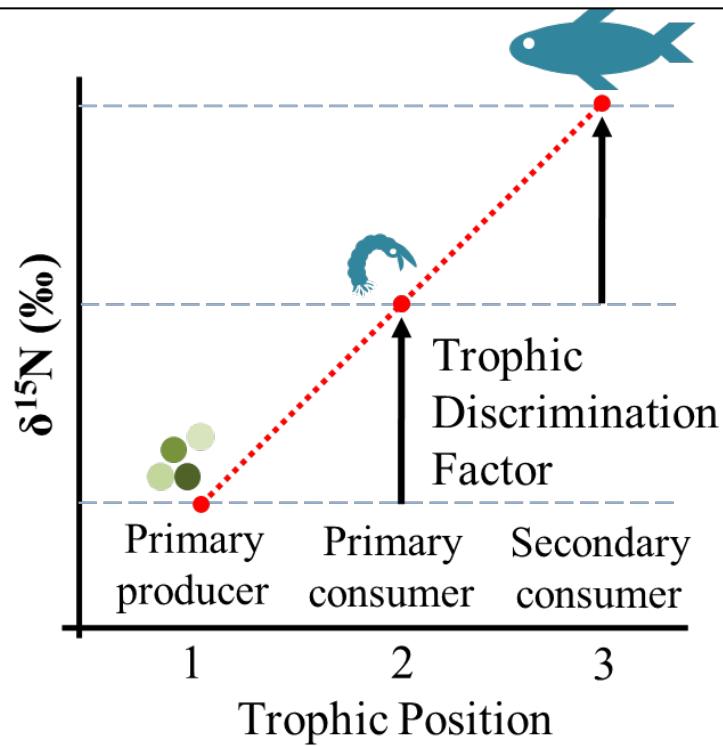
$$TP_{Bulk} = (\delta^{15}N_{Consumer} - \delta^{15}N_{Diet})/3.4 + 1$$

Post, 2002

Amino acid δ¹⁵N analysis

Separation of N baseline and trophic level

→ **N baseline** can be determined in consumer samples
→ **Trophic position** is more accurate

<AA δ¹⁵N enrichment pattern>
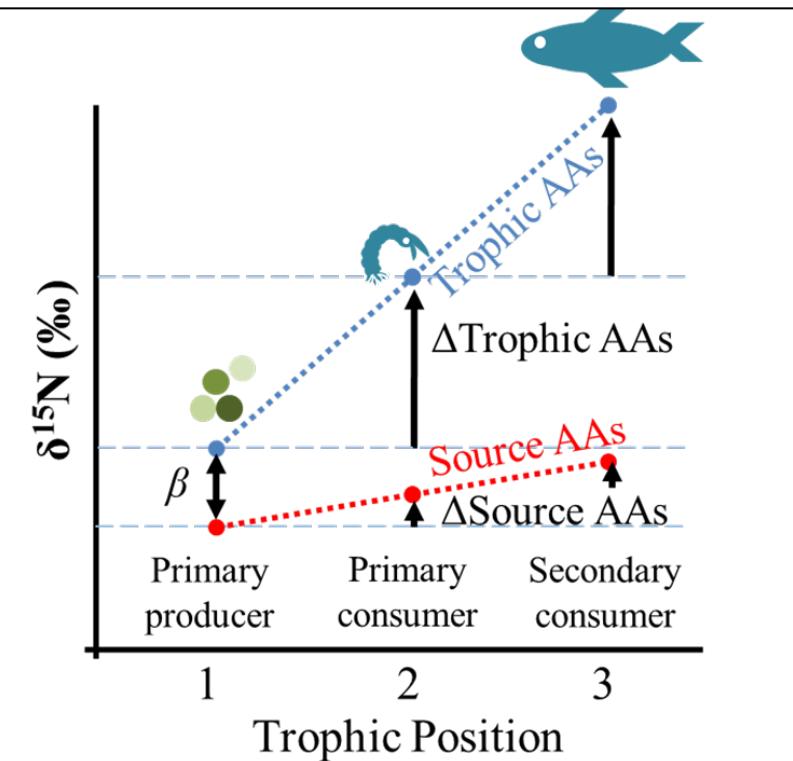
$$TP_{AAs} = (\delta^{15}N_{Glu} - \delta^{15}N_{Phe} - 3.4)/7.6 + 1$$

Chikaraishi et al., 2009

Photo from WoRMS

Hopcroft/NOAA
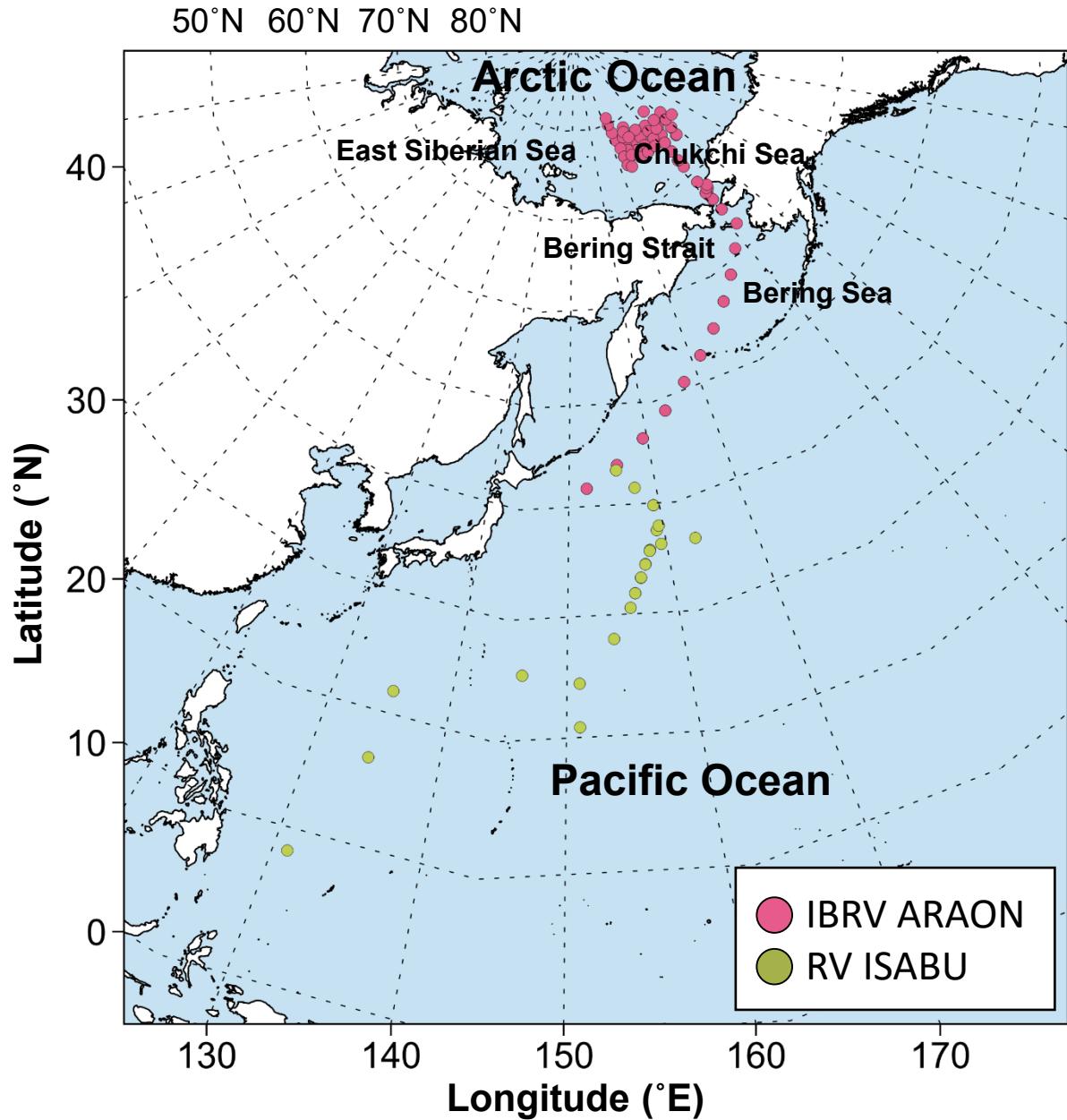
Target Sample

Calanus spp. (adult)

- Calanoid copepod
- Filter feeder (non-selective)

Understanding geographical distribution of $\delta^{15}N$ baseline using copepod sample

Question 1. Are copepod samples suitable for isoscape?

Question 2. Which factors lead geographical distribution of $\delta^{15}N$ baseline?

Nitrate concentration in sampling stations

Nitrate concentrations (depth-integrated) were spatially different

Data: World Ocean Atlas 2018 (monthly data)
KOPRI open data (ARA06B, ARA07B, ARA08B, ARA09B)
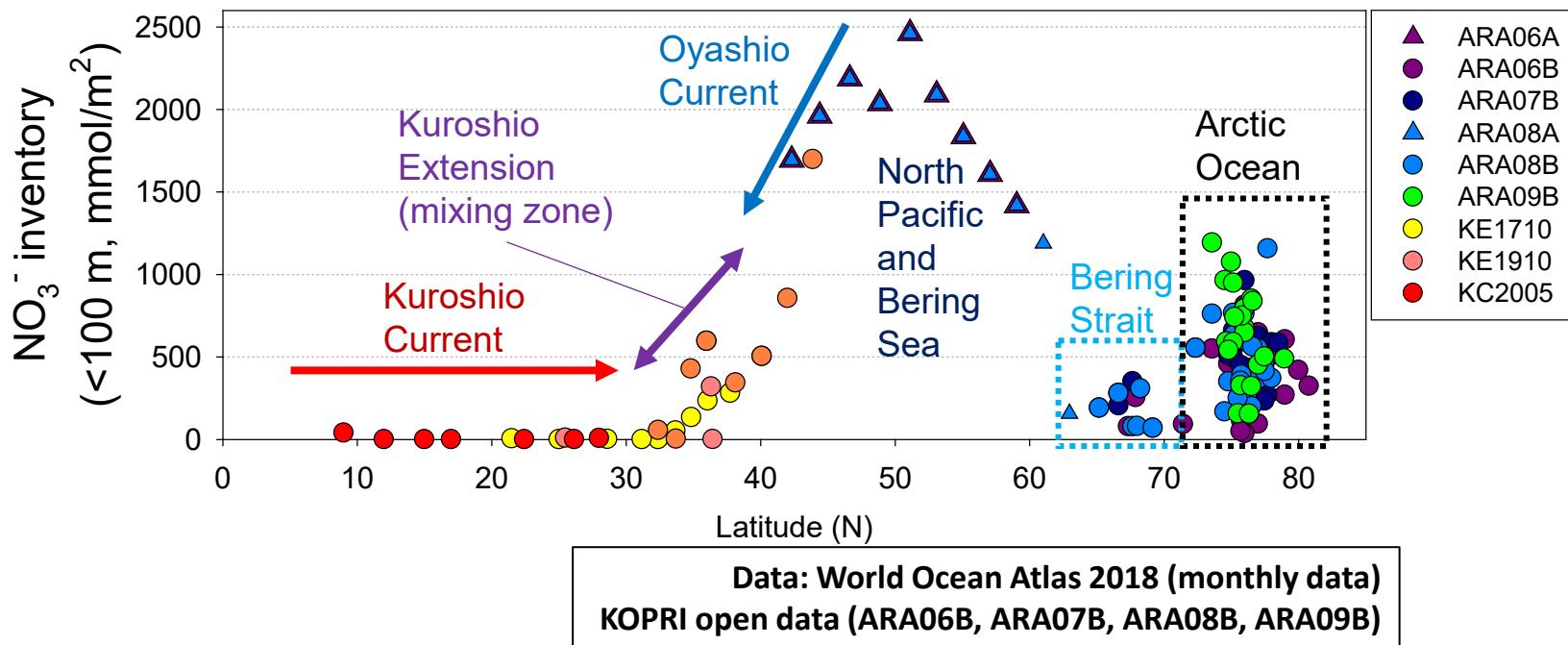
Variation in nitrate concentration → Different nitrate availability for primary producer → Variation in nitrogen isotope ratio (baseline) → Transferred to consumer

δ¹⁵N isoscape using *Calanus* spp.

Nitrogen baseline ($\delta^{15}N_{Baseline}$) = $\delta^{15}N_{Bulk\_consumer}$ − (TP − 1) * TEF_{Bulk}

Choi et al., 2021

TP = (($\delta^{15}N_{Glutamic\ acid}$ − $\delta^{15}N_{Phenylalanine}$ − 3.4) / 7.6) + 1

Chikaraishi et al., 2009

TEF_{Bulk} = 3.4‰

Post, 2002
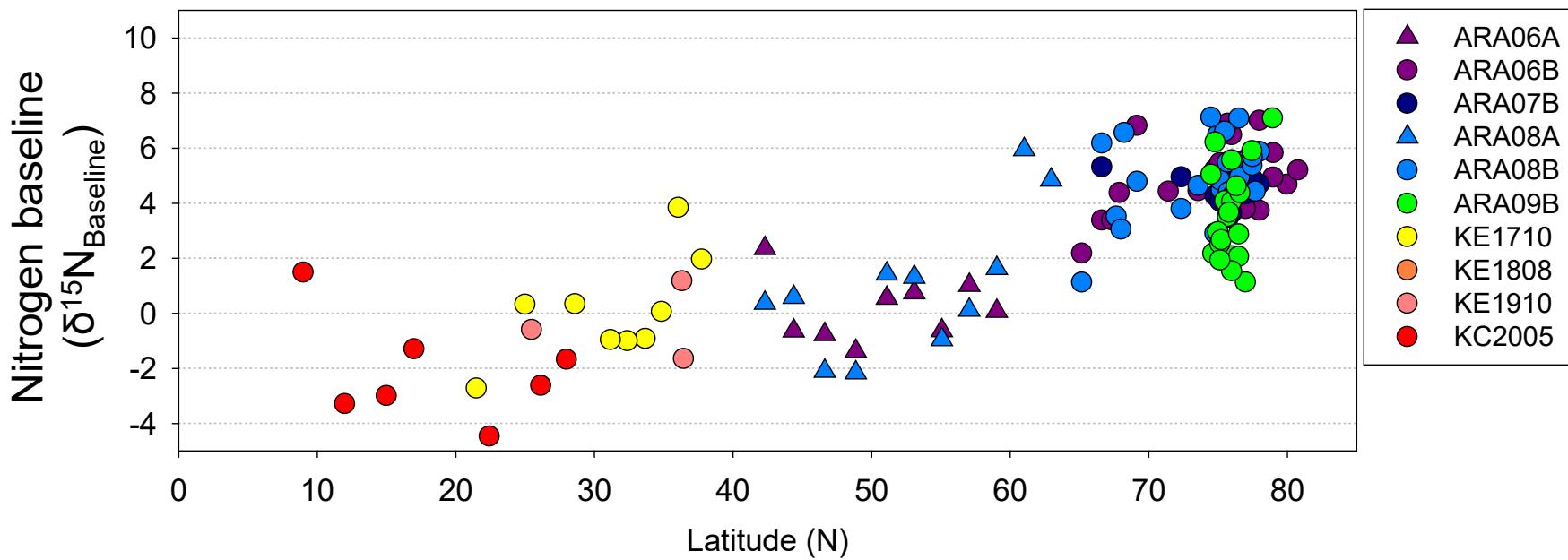
δ¹⁵N isoscape using *Calanus* spp.
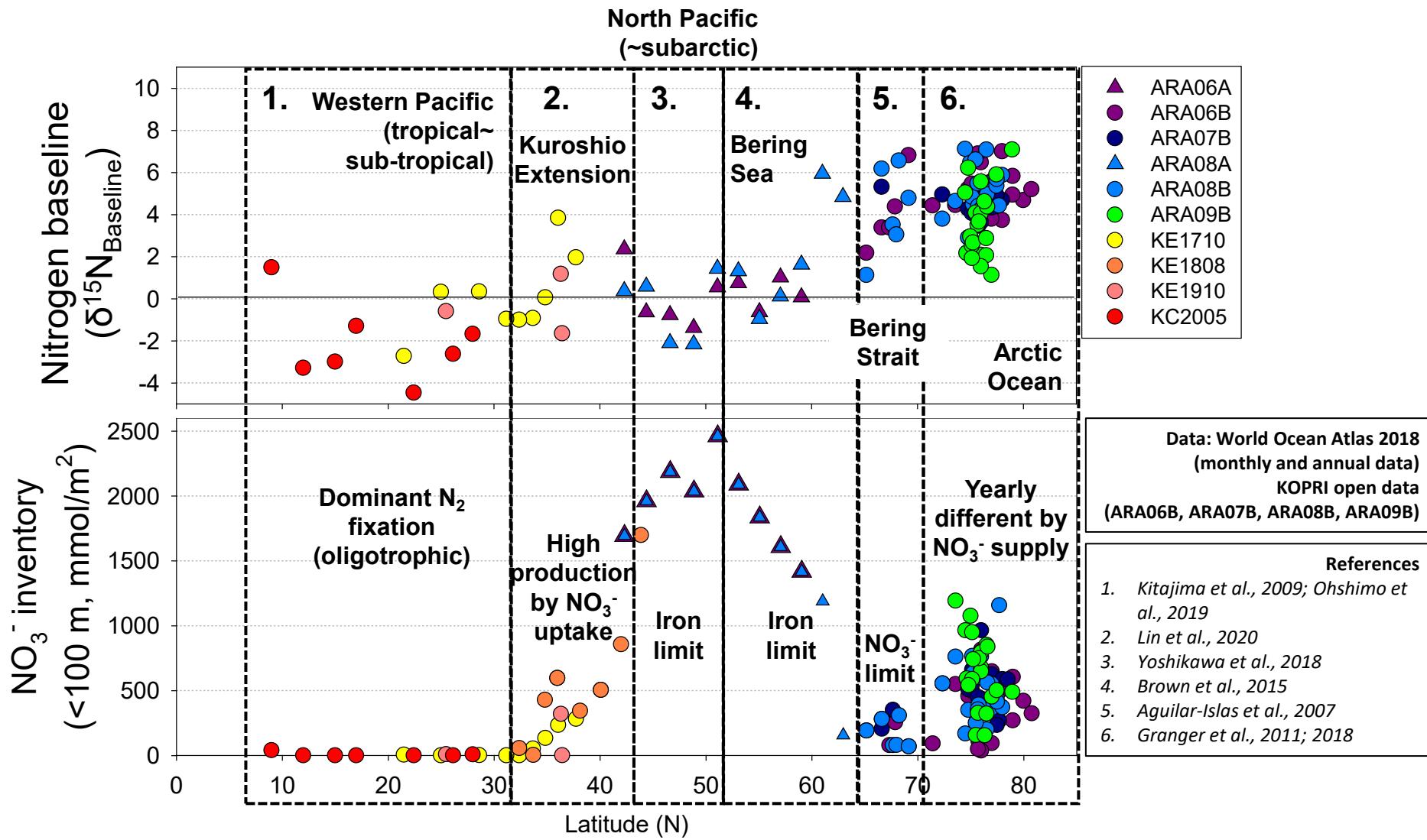
Nitrate concentration and/or availability for primary producers led to variations in δ¹⁵N baseline

δ¹⁵N isoscape using *Calanus* spp.

Comparison with δ¹⁵N of nitrate

- $\delta^{15}N_{Baseline}$ was lower than $\delta^{15}N_{Nitrate}$ → N fractionation through assimilation ?
- More supporting information is required (e.g., N_2 fixer contribution in total primary production)

1.
Western Pacific
(tropical~sub-tropical)

2.
Kuroshio Extension

3.
North Pacific (~subarctic)

4~5.
Bering Sea and Strait

6.
Arctic Ocean

$\delta^{15}N_{Nitrate}$=8.0‰
Beaufort Sea
Granger et al., 2018

$\delta^{15}N_{Nitrate}$=7.0‰
Yoshikawa et al., 2018

$\delta^{15}N_{Nitrate}$=6.5‰
Granger et al., 2011

$\delta^{15}N_{Nitrate}$= 3.5~4.0‰
This study

Atmospheric N_2 =0‰

Nitrogen baseline $(\delta^{15}N_{Baseline})$

Latitude (N)
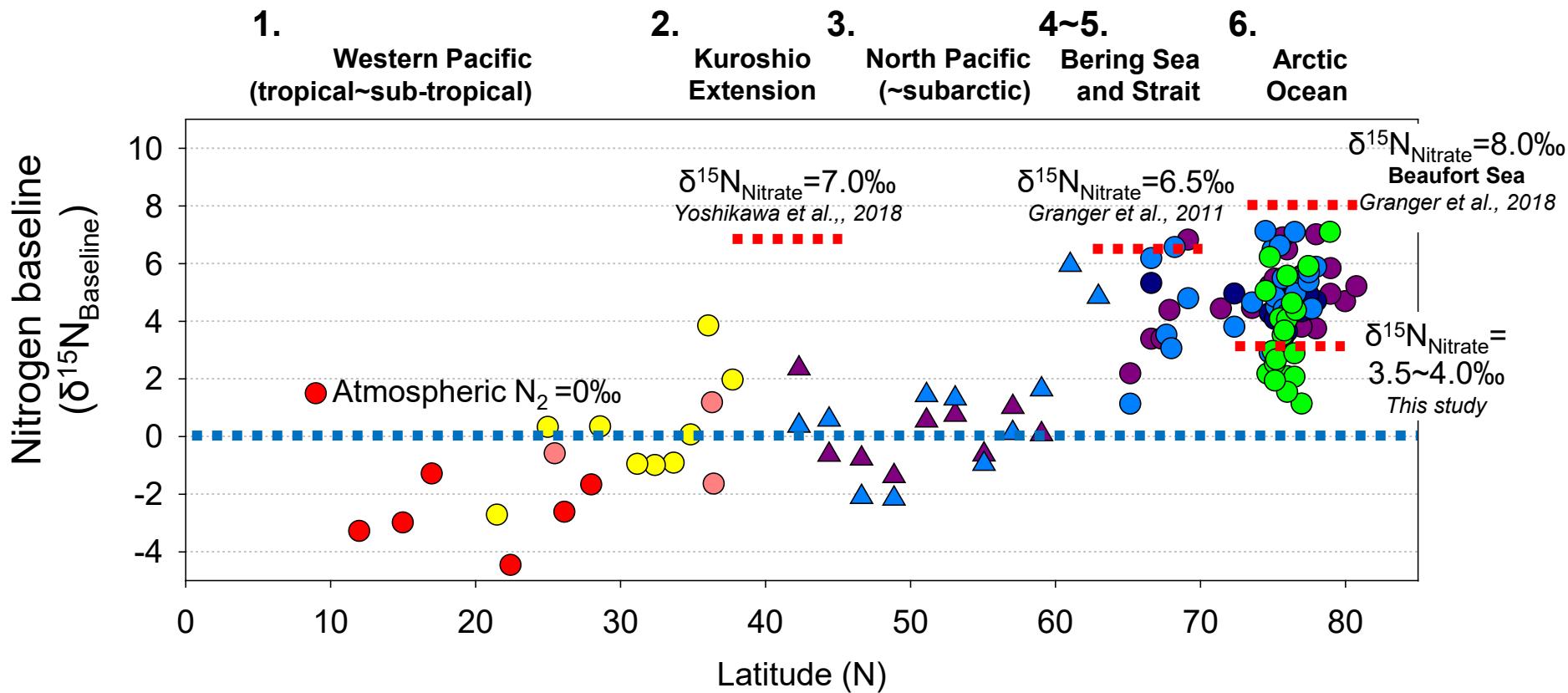
Research objective: Understanding geographical distribution of $\delta^{15}N$ baseline using copepod sample

Question 1. Are copepod samples suitable for isoscape?
→ Yes. It also can be applied in nutrient-depleted environment (oligotrophic)

Question 2. Which factors lead geographical distribution of $\delta^{15}N$ baseline?
→ Concentration of NO_3^- and its availability for primary producers
→ $\delta^{15}N$ of nitrate would be also important for data validation