Geographical variations in carbon and nitrogen stable isotope ratios of Japanese anchovy, *Engraulis japonicus*

Hiroshige Tanaka[1], Akinori Takasuka[2],Ichiro Aoki[1],
Seiji Ohshimo[3] and Yozo Wada[4]

[1] Graduate School of Agricultural and Life Sciences, The University of Tokyo
[2] National Research Institute of Fisheries Science, Fisheries Research Agency
[3] Seikai National Research Institute of Fisheries Science, Fisheries Research Agency
[4] Kyoto Institute of Oceanic and Fishery Science

Introduction

Japanese anchovy *Engraulis japonicus*

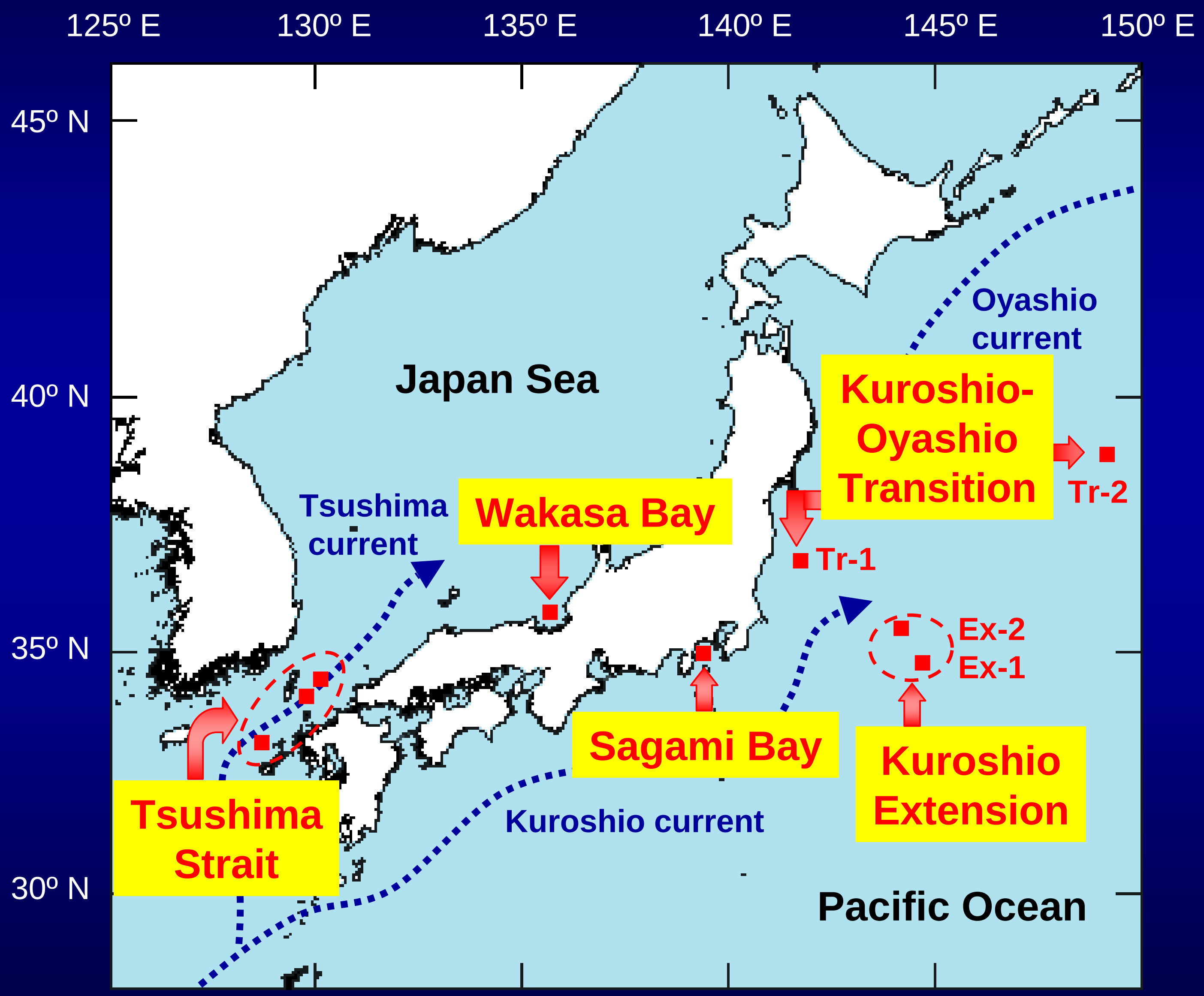
- Small pelagic fish which inhabit the waters of east Asia.
- Habitat varies depending on its stock size.
  (small: inshore water only; large: inshore and offshore water)
- Some characteristics of life history (e.g., spawning, growth) also vary between inshore and offshore waters.
- Feeding habit: zooplanktivorous (e.g., copepods)
- Structure of food web and ecosystem would vary among areas.

Objective

To compare the trophic ecology of Japanese anchovy among sea areas using the methods of $\delta^{13}C$ and $\delta^{15}N$.

Tools for the trophic study

Study areas



Sagami Bay
(July and Nov. 2001)
larvae and adults

Wakasa Bay
(Nov. 1999, Feb, Mar, April and June 2000)
adults

Tsushima Strait
(Aug. 2001) adults

Kuroshio Extension
Ex-1 (June 1997)
larvae and juvenile
Ex-2 (May 1999)
larvae and adults

Kuroshio-Oyashio Transition
Tr-1 (June 1997)
larvae
Tr-2 (June 1999)
larvae and adults

Methods

Stable isotope analysis

- Adults: White dorsal muscle was used for analysis.
- Larvae: Whole body was used for analysis.
- Lipid fraction was removed from all samples.
- $^{13}C/^{12}C$ and $^{15}N/^{14}N$ were analyzed by FINNIGAN MAT isotope ratio mass spectrometer.

$$\delta^{13}C \text{ or } \delta^{15}N = (R_{sample} / R_{standard} - 1) * 1000 \text{ (‰)}$$

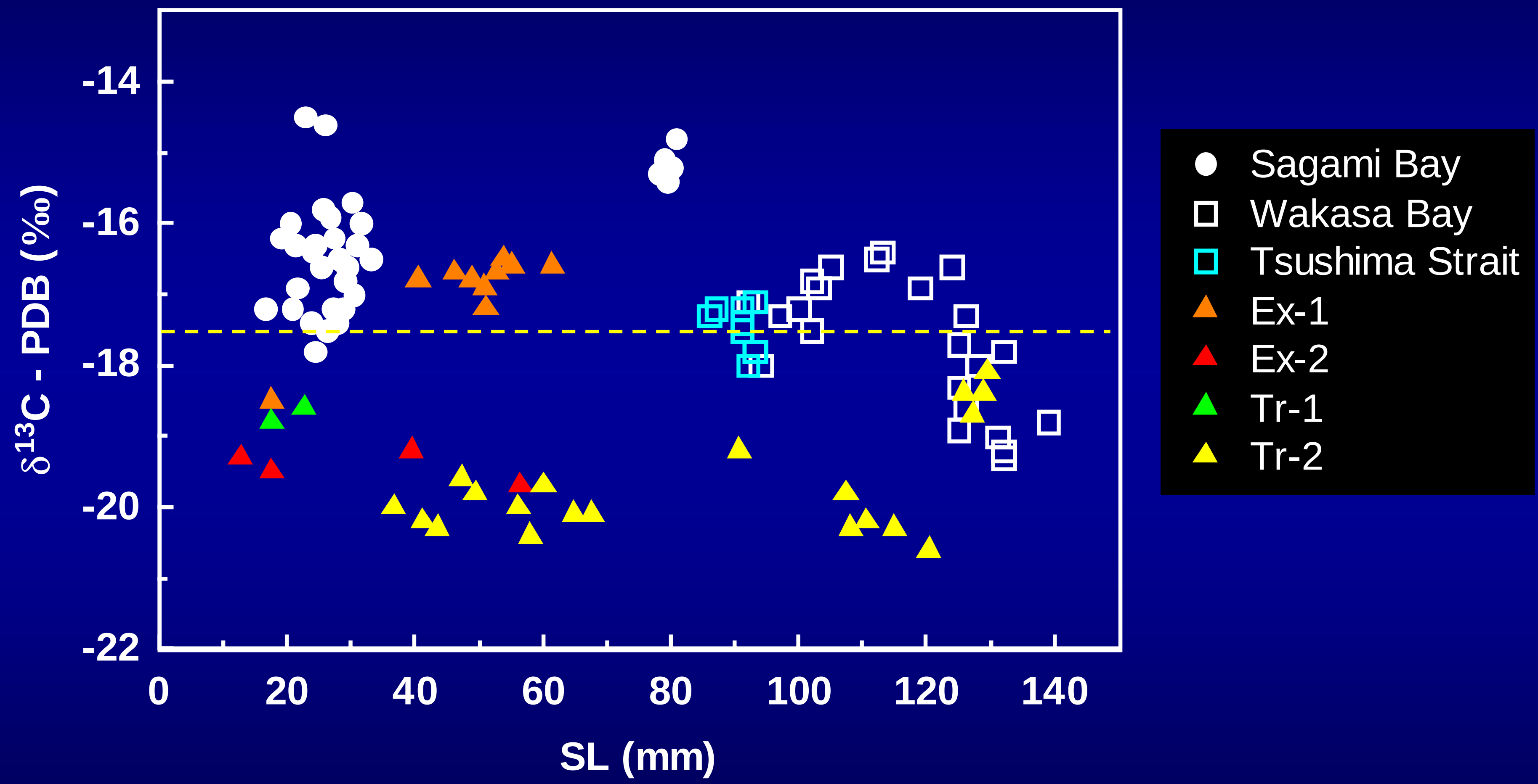
$$(R = {}^{13}C/{}^{12}C \text{ or } {}^{15}N/{}^{14}N)$$

$R_{standard}$:

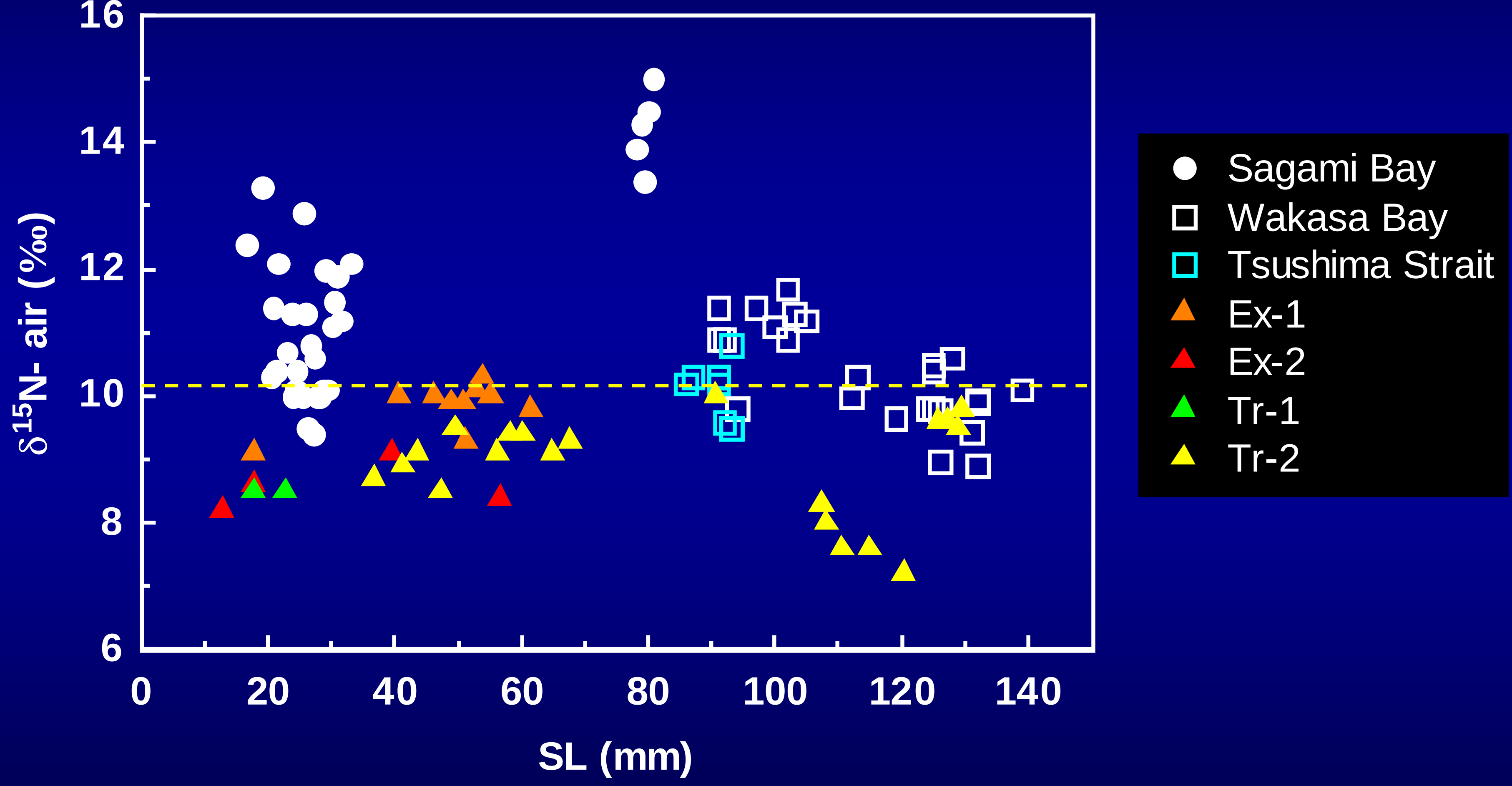
Carbon: PDB (Peedee Belemnite)

Nitrogen: N_2 in the atmosphere

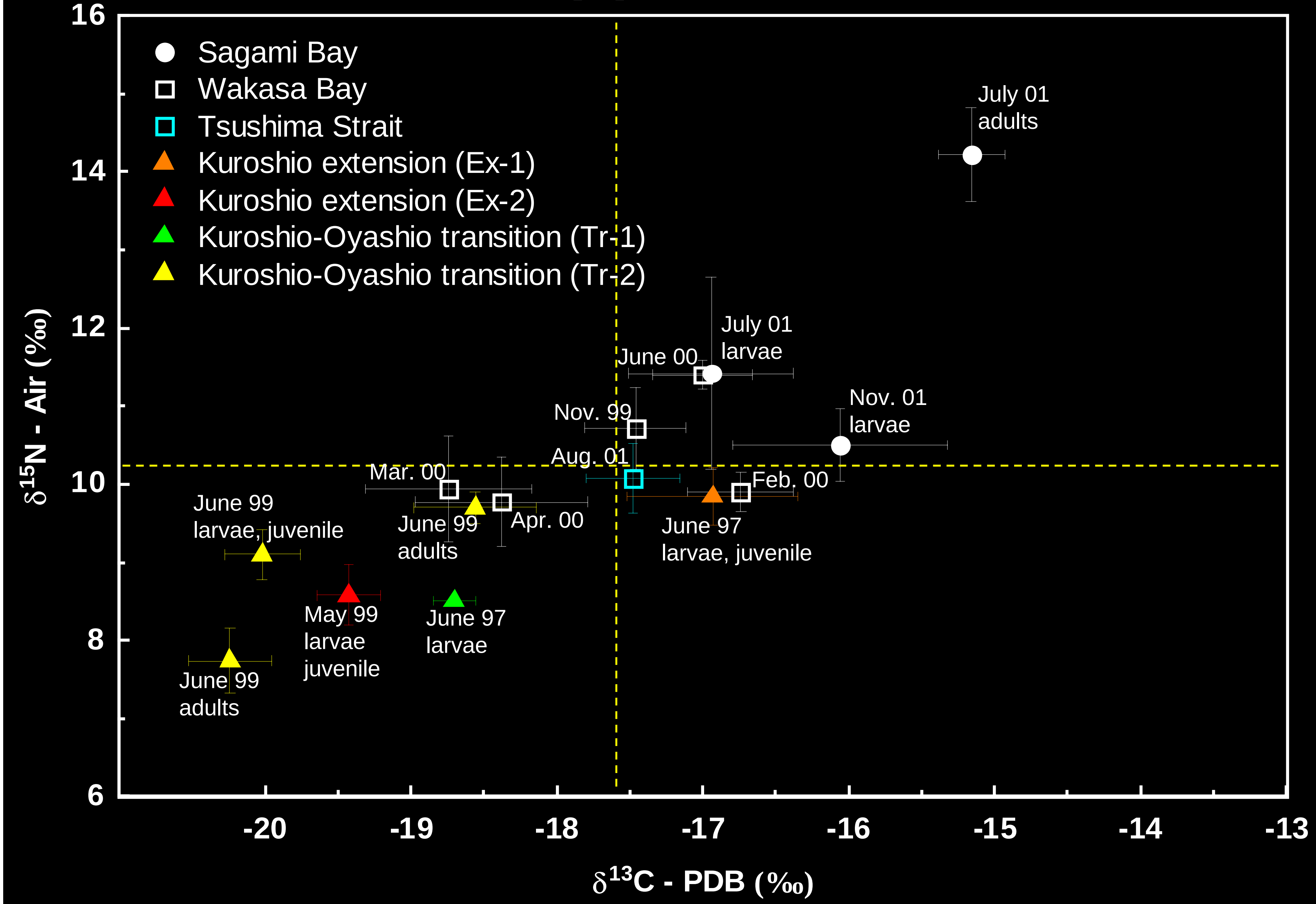
Results (1) $\delta^{13}C$



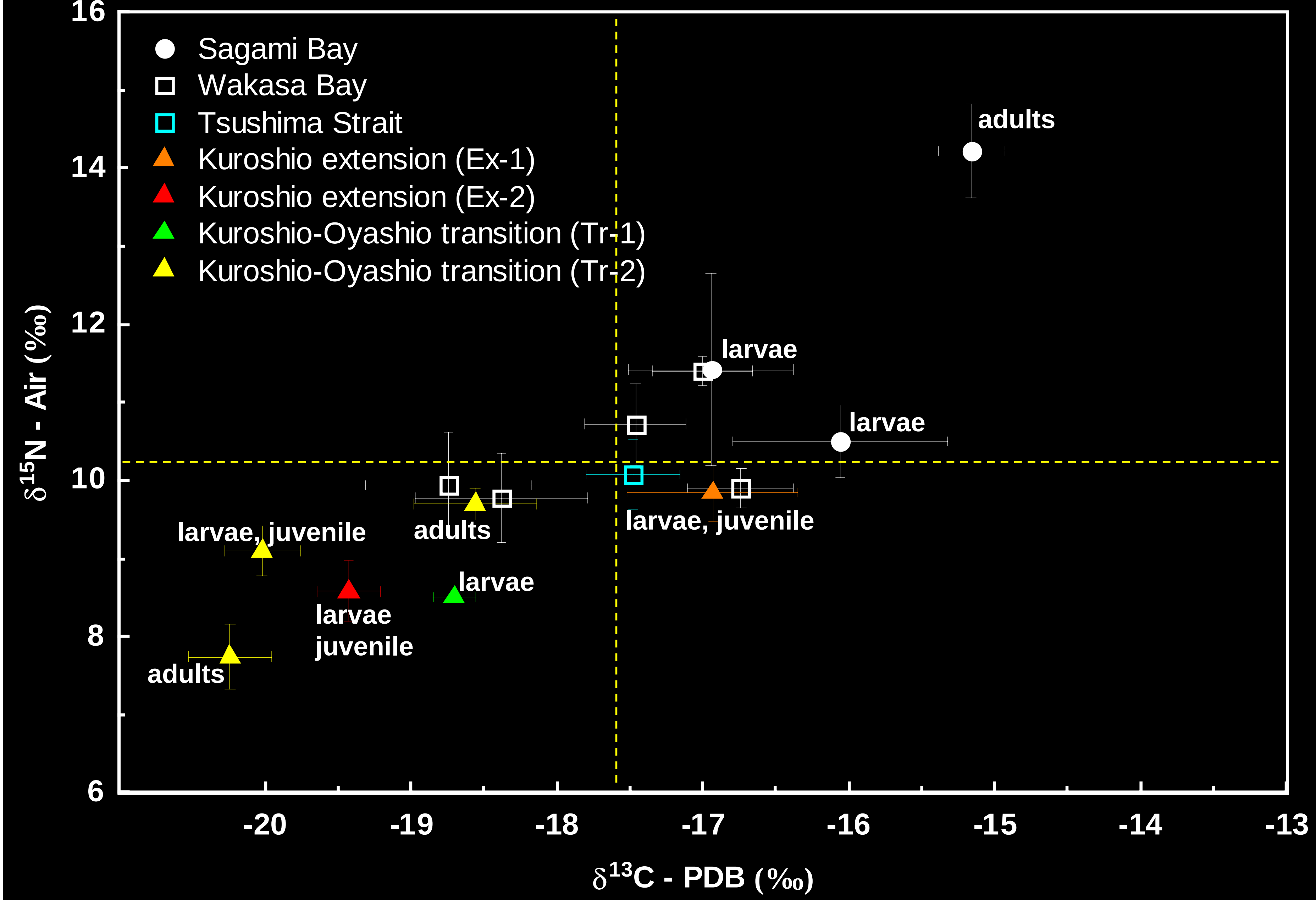
Results (2) $\delta^{15}N$



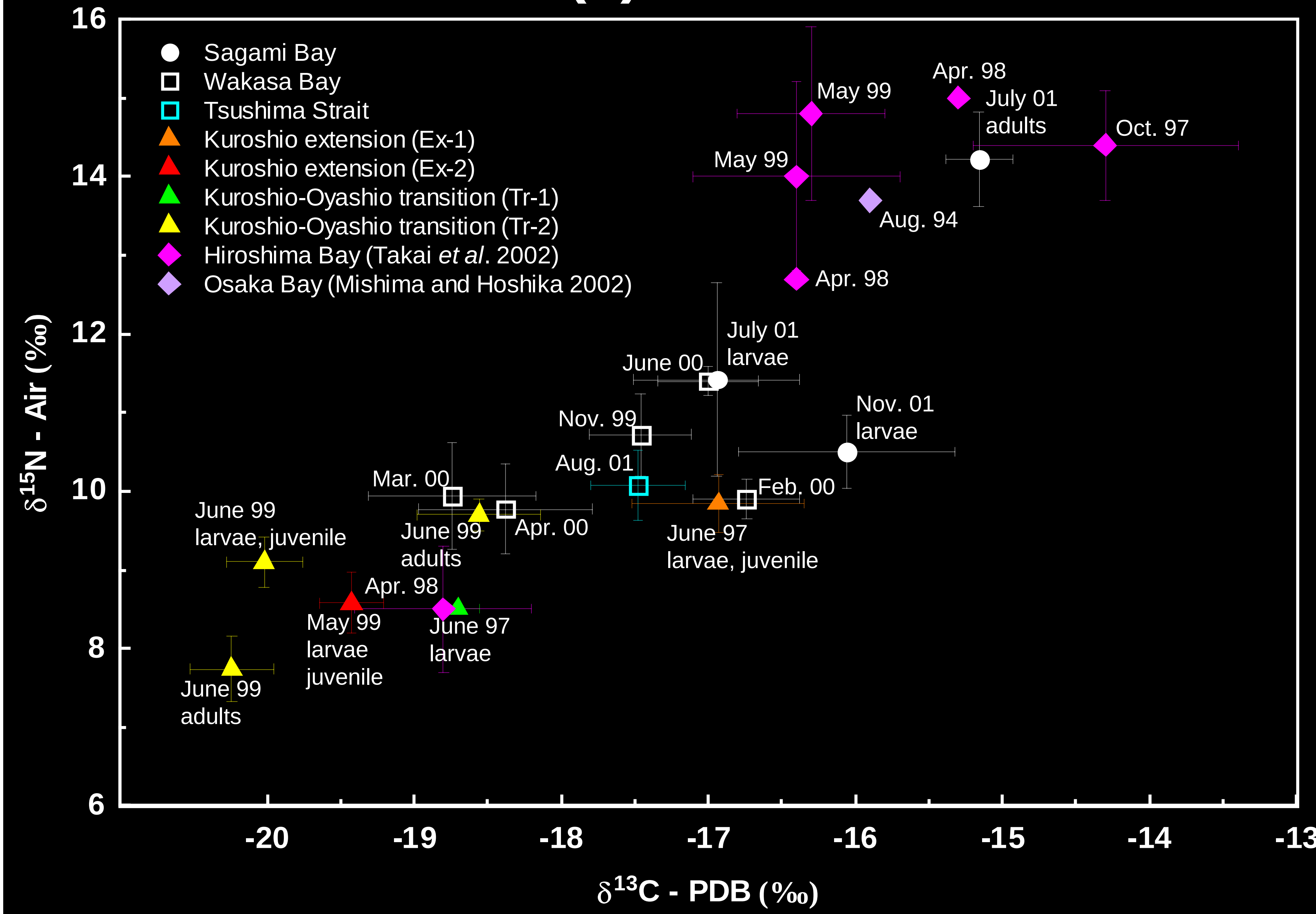
Results (3) $\delta^{13}C$-$\delta^{15}N$



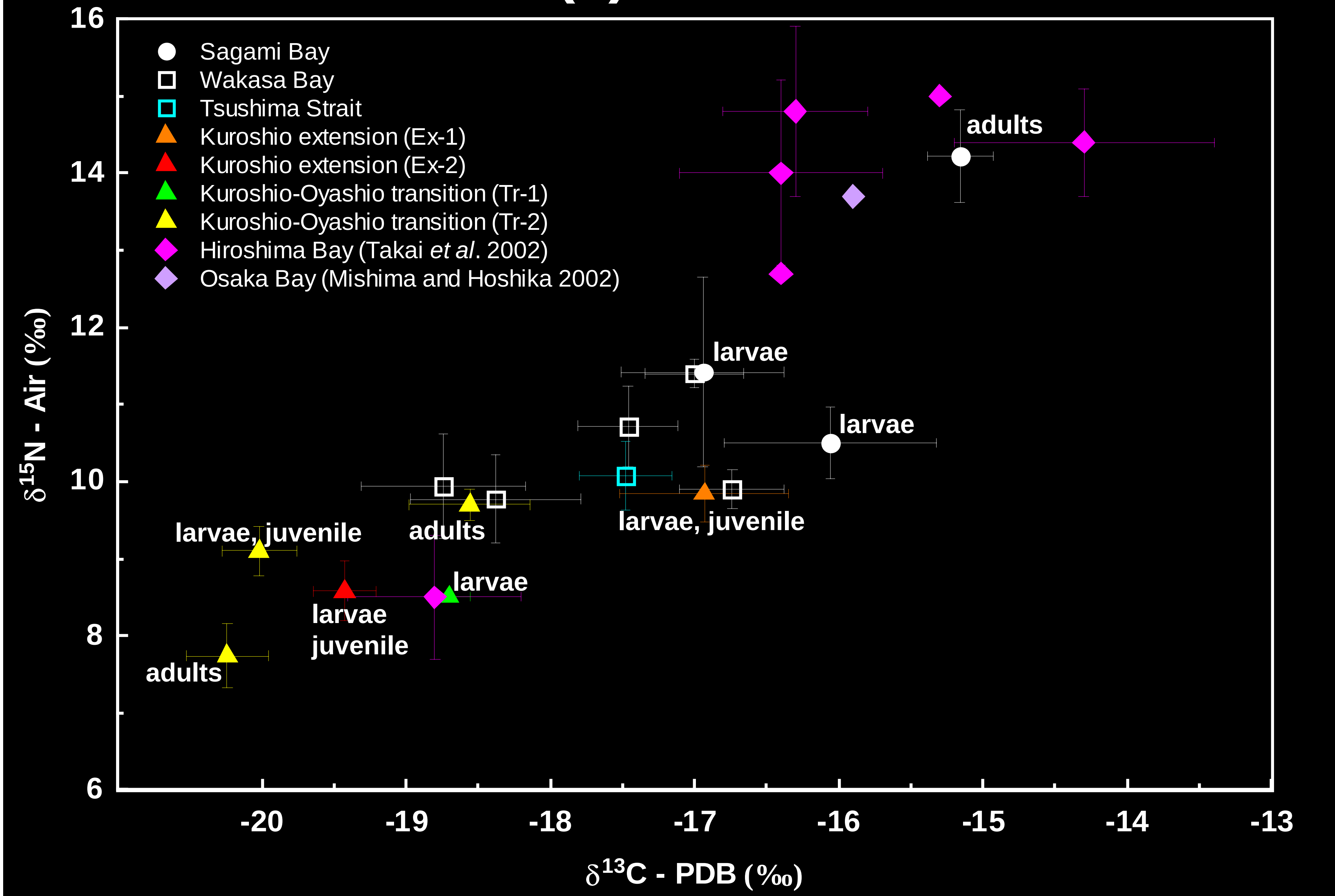
Results (3) $\delta^{13}C$-$\delta^{15}N$



Results (3) $\delta^{13}C$-$\delta^{15}N$



Results (3) $\delta^{13}C$-$\delta^{15}N$



Discussion

What caused the variation in δ^{13}C ?

- Stepwise enrichment: 0~1.5 ‰ per one trophic level
- δ^{13}C is used to detect the carbon source of primary production.

Low	Kuroshio-Oyashio transition and Kuroshio extension →	offshore
High	Sagami bay and other inland sea →	inshore

- δ^{13}C of phytoplankton: ca. –22 ‰ (France 1995) → offshore
- δ^{13}C of benthic algae: ca. –17 ‰ (France 1995) → inshore

carbon source (possibility)	**offshore**	**phytoplankton**
	inshore	**phytoplankton + benthic algae**

↓

Benthic carbon may affect the pelagic food web because of the shallow depth.

Discussion

What caused the variation in δ^{15}N ?

- Stepwise enrichment: 3~4 ‰ per one trophic level
- δ^{15}N is often used as an index of trophic level.

Low Kuroshio-Oyashio transition and Kuroshio extension → offshore

High Sagami bay (adults >> larvae) and other inland sea → inshore

Larvae Prey size may not drastically differ.

Oceanographic conditions for primary producers such as nitrogen source (nitrate, ammonia) may differ.

Adults Size range of available prey is broader.

Ontogenetic shift of feeding habit may occur more clearly in Sagami bay (inshore water) than in Tr-2. (offshore water). (Availability of the prey at high trophic levels may differ.)

Summary

Large geographical variations in $\delta^{13}C$ and $\delta^{15}N$ were found in Japanese anchovy, especially between inshore and offshore waters.

Inshore water

Carbon source: phytoplankton + benthic algae

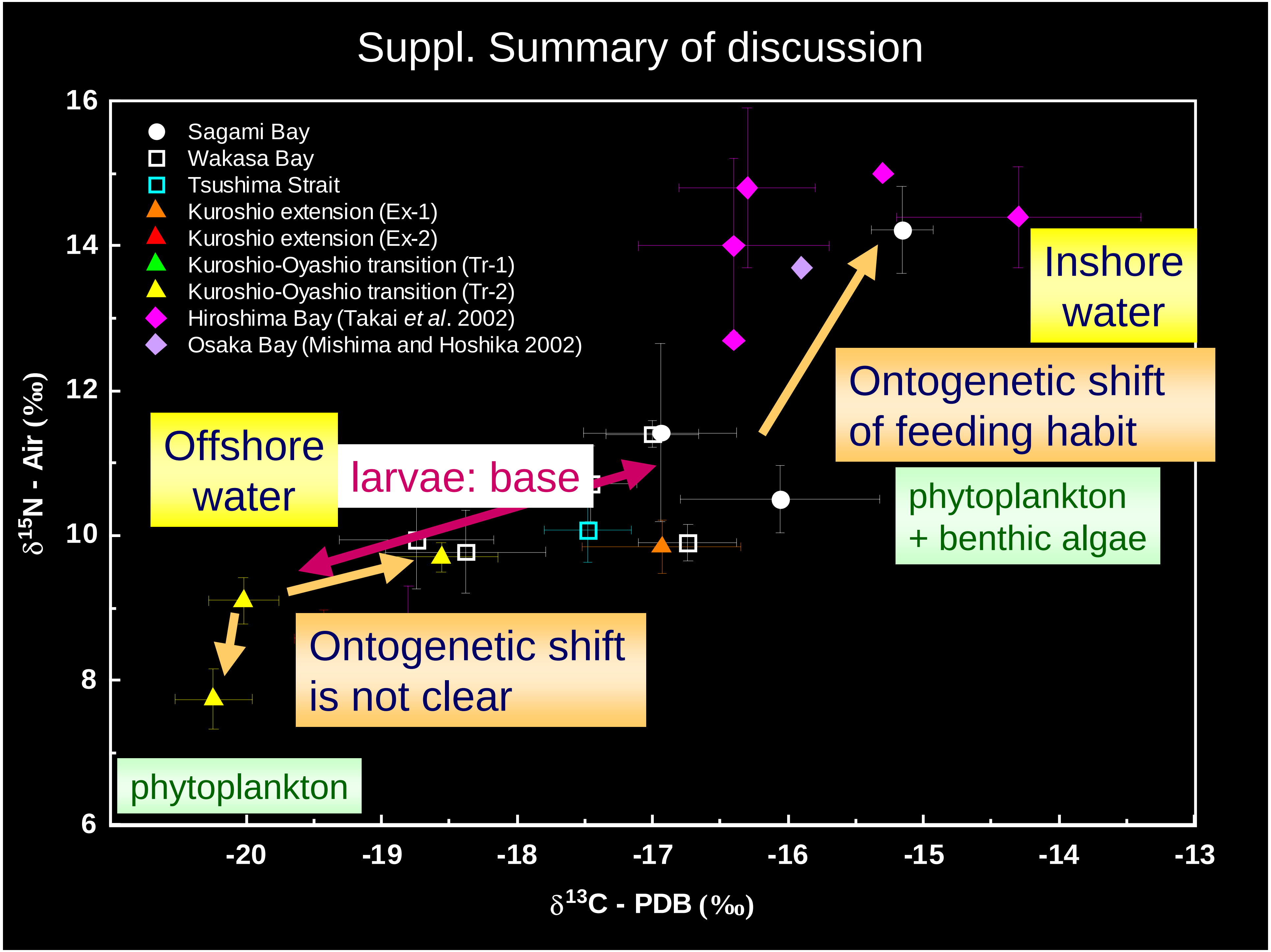
Ontogenetic shift of feeding habits may occur more clearly.

Offshore water

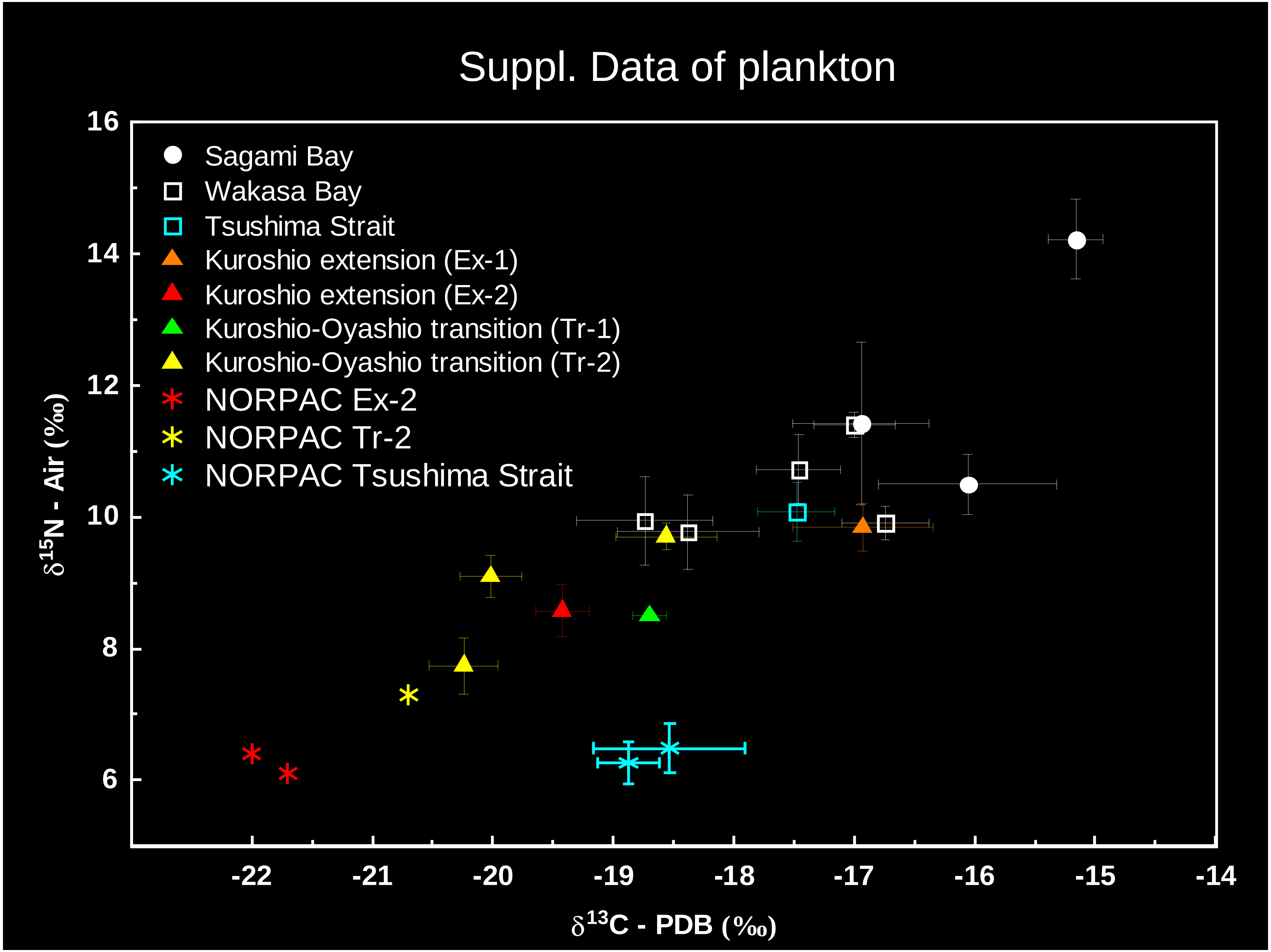
Carbon source: mainly phytoplankton

Ontogenetic shift of feeding habits may not occur drastically.

Differences in food web structure may be reflected in the trophic ecology of Japanese anchovy.



Suppl. Summary of discussion
Sagami Bay
Wakasa Bay
Tsushima Strait
Kuroshio extension (Ex-1)
Kuroshio extension (Ex-2)
Kuroshio-Oyashio transition (Tr-1)
Kuroshio-Oyashio transition (Tr-2)
Hiroshima Bay (Takai et al. 2002)
Osaka Bay (Mishima and Hoshika 2002)
Inshore water
Ontogenetic shift of feeding habit
phytoplankton + benthic algae
Offshore water
larvae: base
Ontogenetic shift is not clear
phytoplankton
δ15N - Air (‰)
δ13C - PDB (‰)
16
14
12
10
8
6
-20
-19
-18
-17
-16
-15
-14
-13



Suppl. Data of plankton
Sagami Bay
Wakasa Bay
Tsushima Strait
Kuroshio extension (Ex-1)
Kuroshio extension (Ex-2)
Kuroshio-Oyashio transition (Tr-1)
Kuroshio-Oyashio transition (Tr-2)
NORPAC Ex-2
NORPAC Tr-2
NORPAC Tsushima Strait
δ15N - Air (‰)
δ13C - PDB (‰)
16
14
12
10
8
6
-22
-21
-20
-19
-18
-17
-16
-15
-14

suppl. Samples

Area	Length (mm)	N	Date	Sampling gear
Sagami bay	16.5-29.0	7	July 1, 2001	Shirasu trawl
	19.0-33.0	7	July 5, 2001	Shirasu trawl
	20.4-31.4	14	Nov. 8, 2001	Shirasu trawl
	78.2-80.8	5	July 2, 2001	Set net
Wakasa bay	91-102	5	Nov. 29, 1999	Set net
	112-126	5	Feb. 24, 2000	Set net
	125-132	5	Mar. 14, 2000	Set net
	125-139	5	April 6, 2000	Set net
	91-105	5	June 15, 2000	Set net
Tsushima strait	91-93	3	Aug. 26, 2001	Midwater trawl
	91-93	3	Aug. 27, 2001	Midwater trawl
	86-91	3	Aug. 29, 2001	Midwater trawl
Kuroshio-extention	14.7-61.4	10 (54)	June 11, 1997 (ex-1)	FMT, ORI
	10.3-56.5	4 (19)	May 22, 1999 (ex-2)	FMT, ORI
Kuroshio-Oyshio transition	15.2-26.4	2 (29)	June 13, 1997 (tr-1)	FMT, ORI
	35.8-129.5	20 (27)	June 1, 1999 (tr-2)	FMT, ORI