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Session S2 14:40-15:00
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Comparative analysis of the early growth history of Pacific bluefin tuna *Thunnus orientalis* from different spawning grounds

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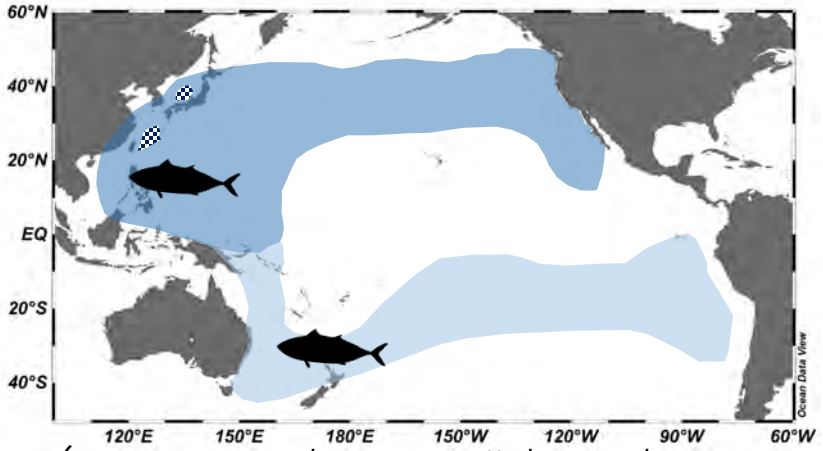
Introduction

Pacific bluefin tuna (PBT; *Thunnus orientalis*)

- **Geographical Distribution**



(Baustany *et al*.,2010; Fujioka *et al*.,2016; Reglero *et al*,2014)

- **Important fisheries target**

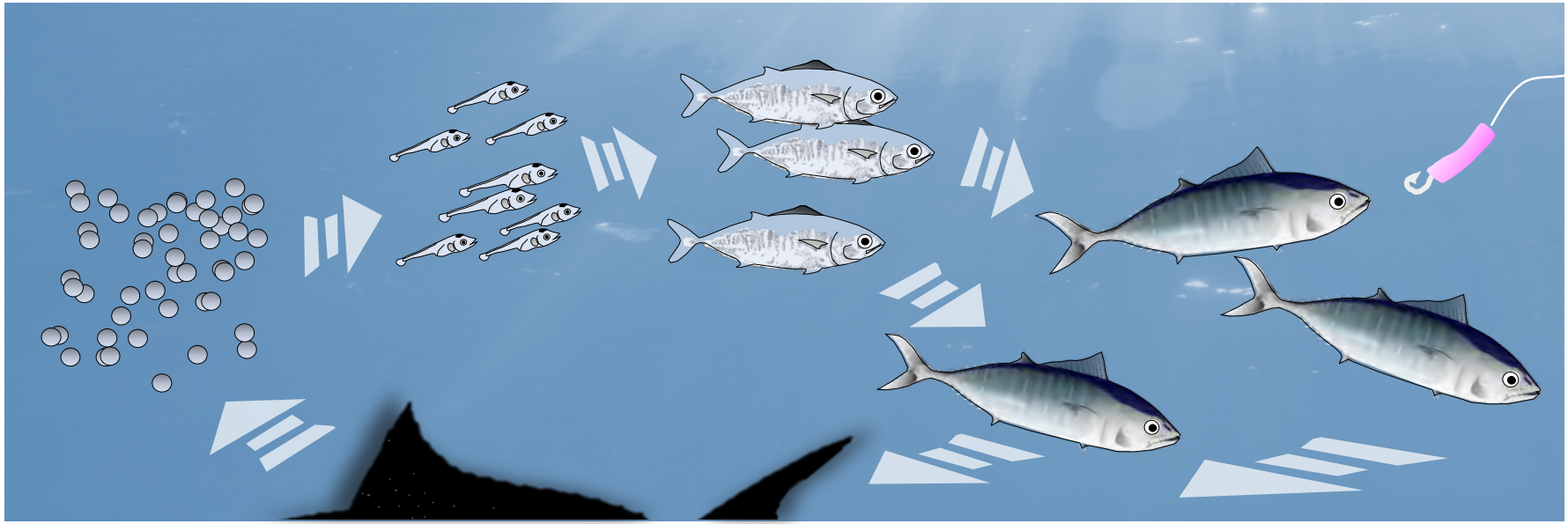
  purse seines, longlines, trolling lines, trap nets and others

- **Japan is the major consumer**

  27600 tons in 2015

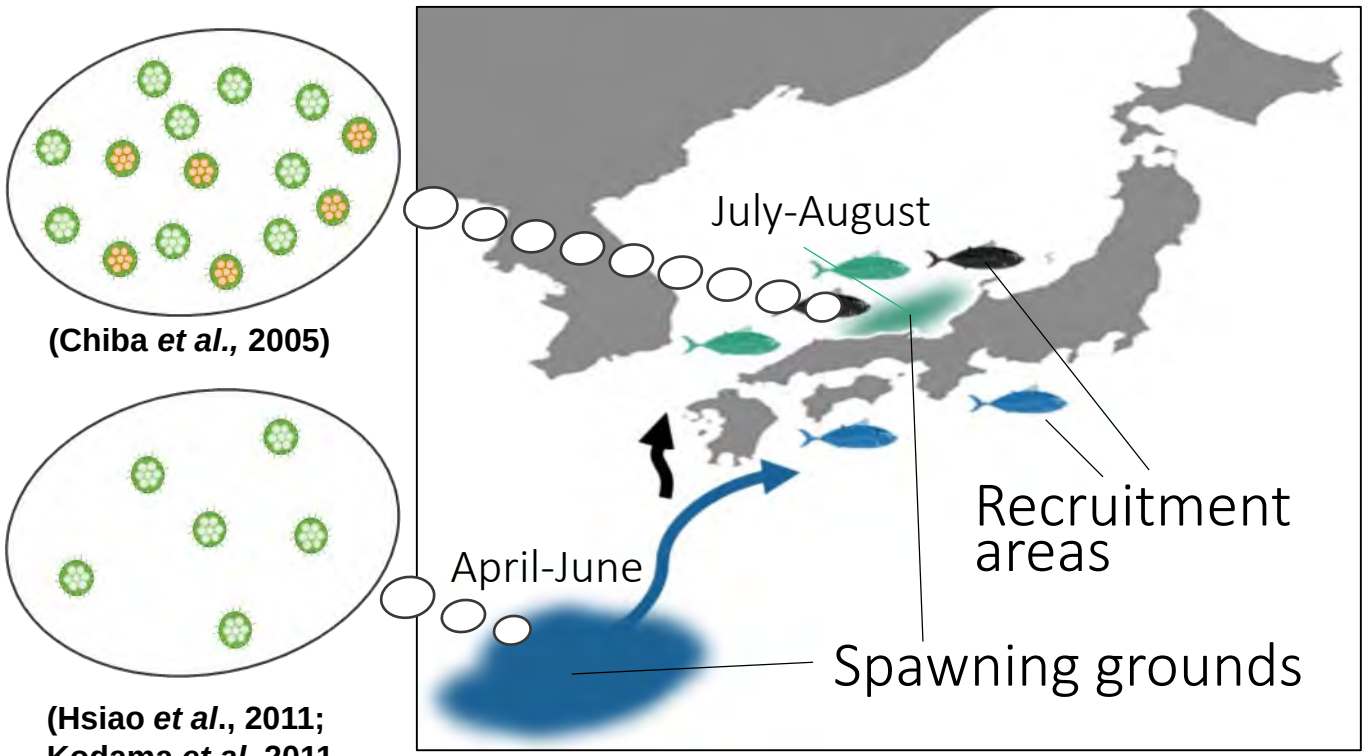
Knowledge on the life history and growth patterns are crucial for the management of fish resources

- The fraction of the Pacific bluefin tuna fisheries catch represented by **immature fish** has become dominant (ISC, 2016).



Introduction

PBF spawning, nursery, and recruitment grounds



(Chiba *et al.*, 2005)

(Hsiao *et al.*, 2011; Kodama *et al.*,2011, 2015)

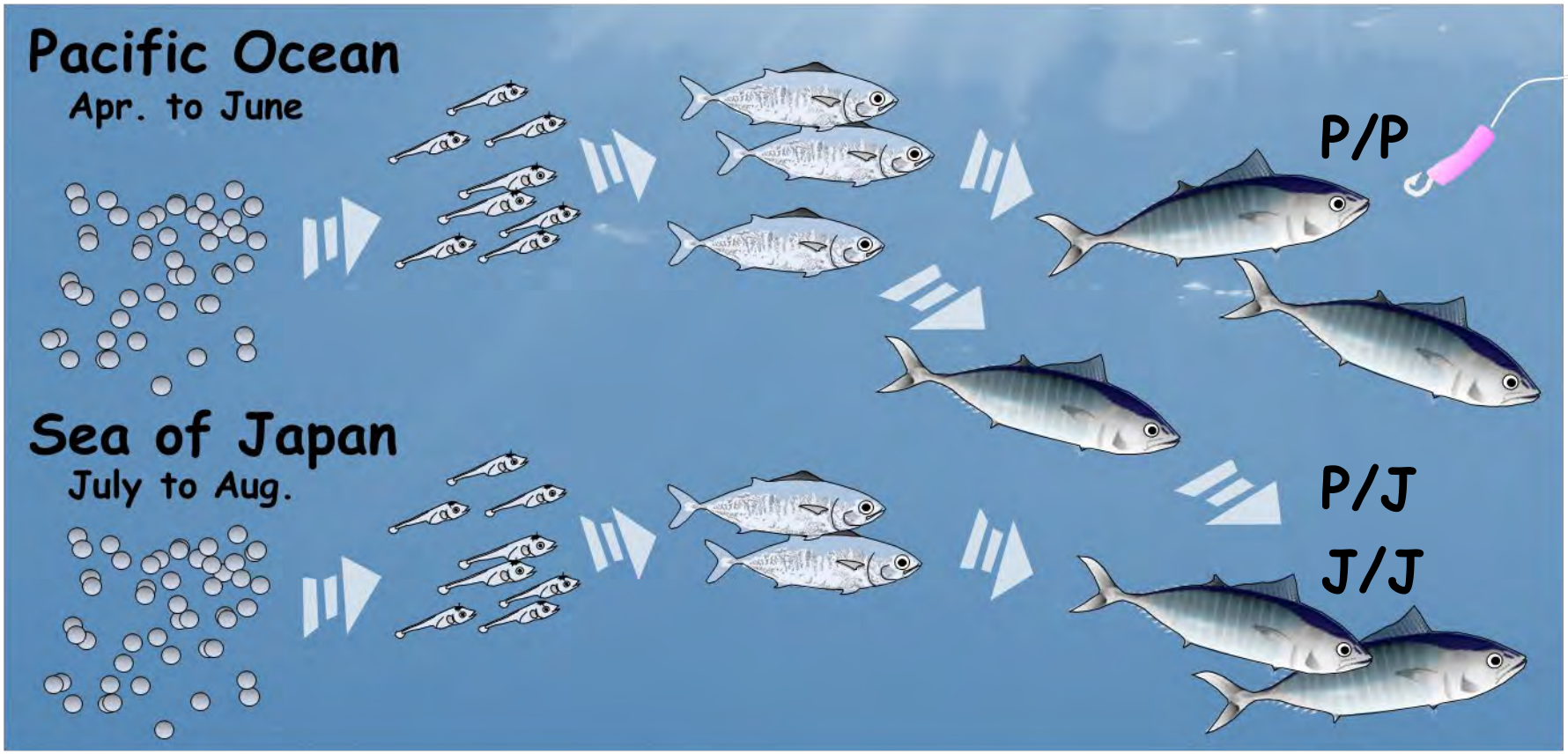
Kitagawa et al. (1995), Tanaka et al. (2007), Itoh (2009), Oshimo et al. (2017)

- Two main spawning areas have been identified: the Nansei Islands area and the Sea of Japan
- PBF born in the Sea of Japan grew up locally whereas those born in the Nansei Islands migrate to the recruitment areas

Objectives

Three possible cohorts of PBF

Birth	Juvenile/ YOY
Nansei Islands	Pacific coast = (P/P)
Nansei Islands	Sea of Japan = (P/J)
Sea of Japan	Sea of Japan = (J/J)

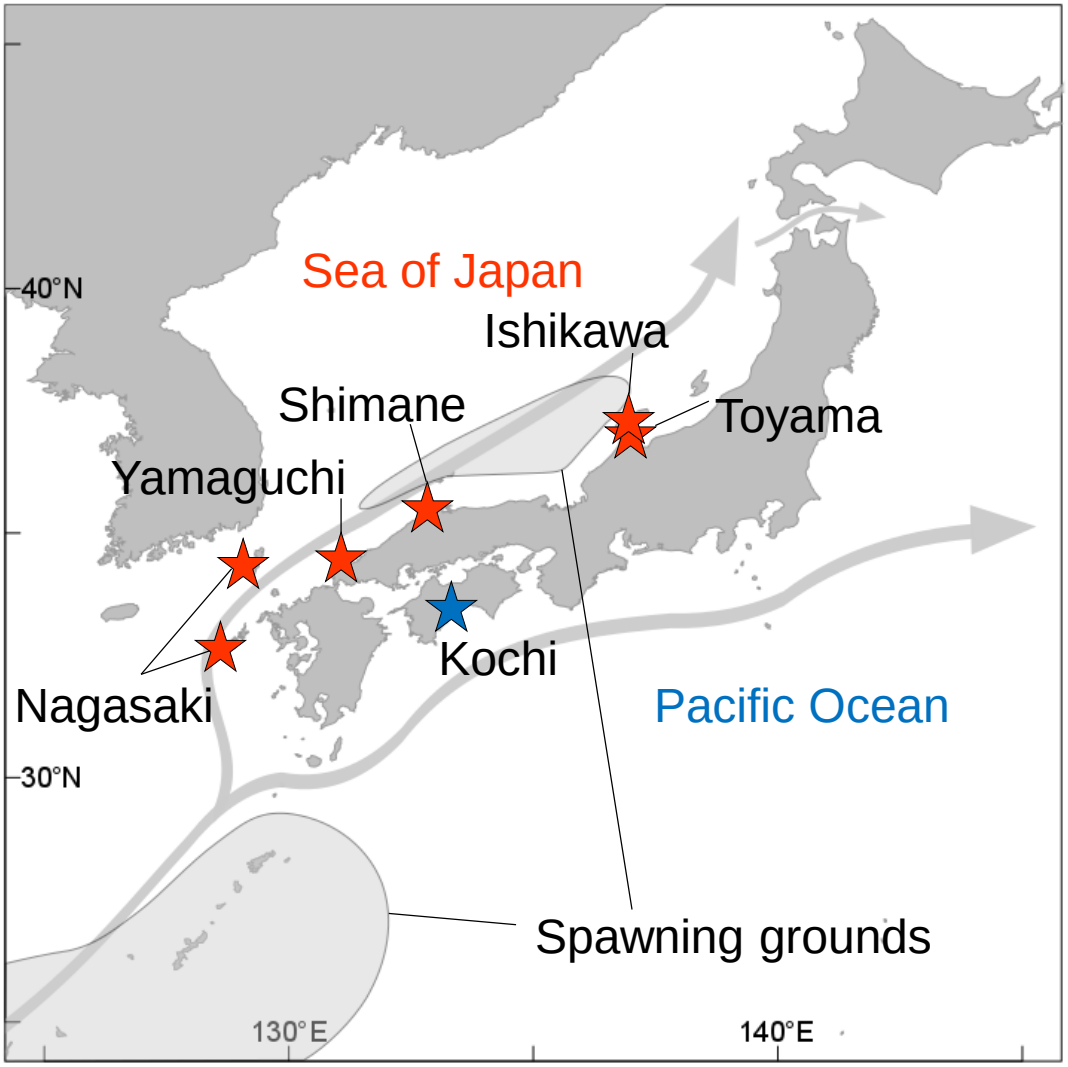


- This study was designed to compare **the growth patterns of the three cohorts** from their birth until the young-of-the-year stage during a 5 year period

Materials and Methods

Sampling and measurements

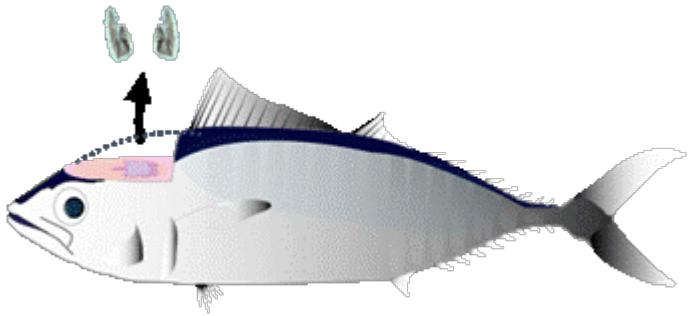
- Young-of-the-year (17-68 cm FL, n=429)
- trolling lines, purse seines, or set nets
- 2011～2015 year



Materials and Methods

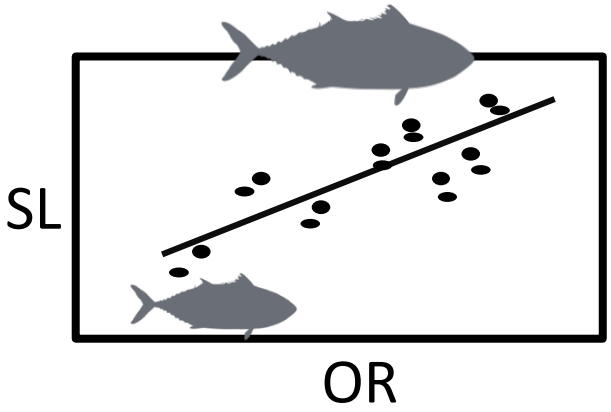
Otolith analysis

- Measurement of increment widths
- Estimation of the hatch date



Otolith-based growth back-calculation

- Based on the relationship between otolith radius (OR) and SL
- Akaike information criterion (**AIC**) to **select the best model for the OR–SL relationship**



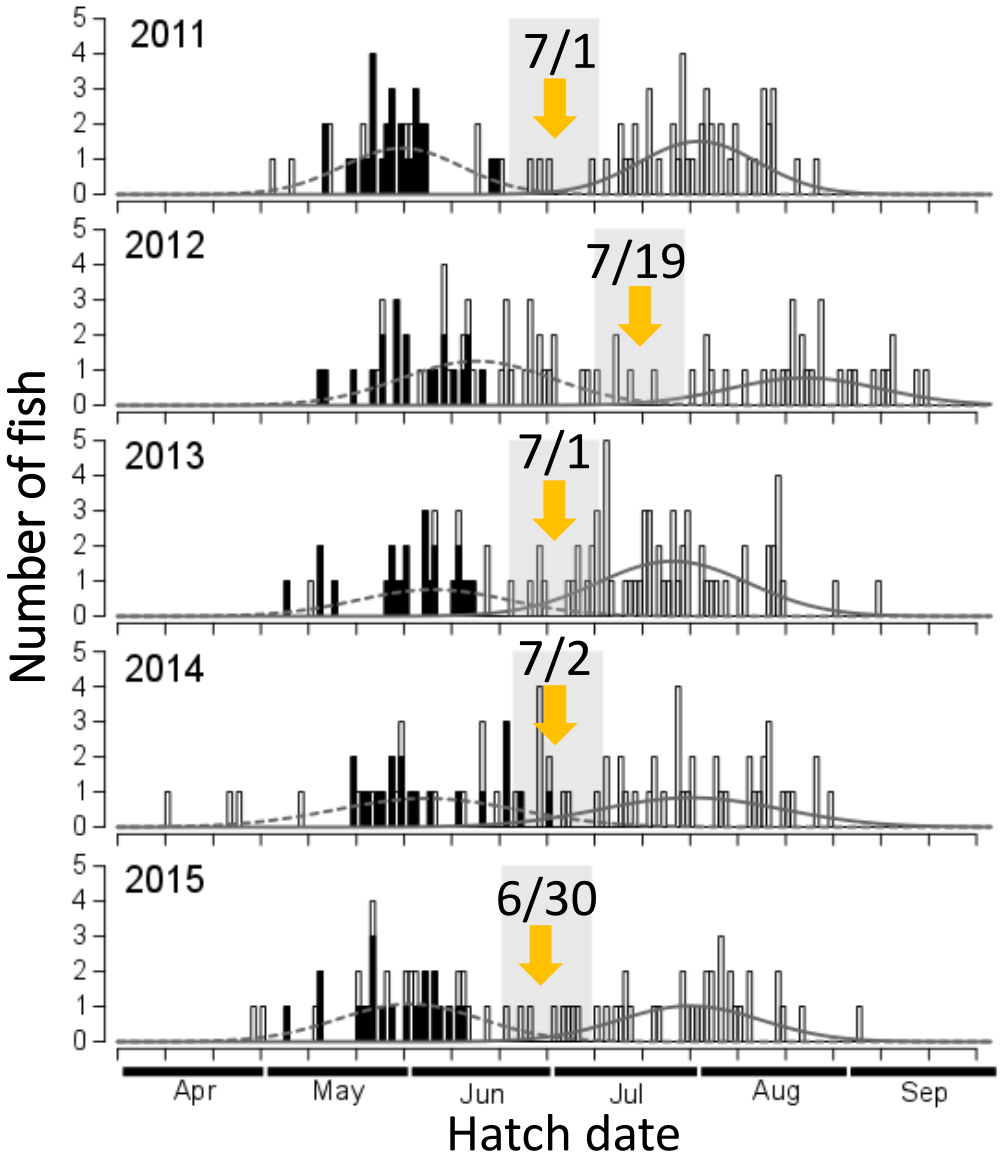
Statistical analysis

- Analysis of variance (**ANOVA**) followed by Tukey's multiple comparison test to evaluate the significance of the **difference between means**

- a Gaussian mixture model (**GMM**) was first fit to the hatch date frequency distributions to discriminate cohorts of "early-" and "late-born" individuals

Results

Distribution of hatch dates



Capture site

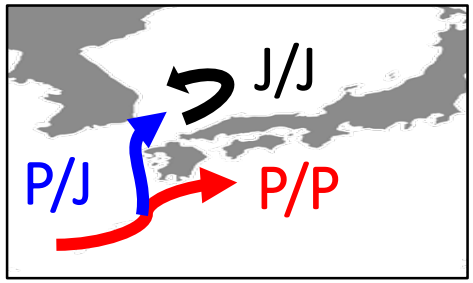
- ■ Pacific coast of Japan
- □ Sea of Japan

- Early- and late-born groups of specimens separated by the GMM model.
- Birth Juvenile/ YOY

Sea of Japan ↦ Sea of Japan (**J/J**)
Nansei Islands ↦ Sea of Japan (**P/J**)
Nansei Islands ↦ Pacific coast (**P/P**)

*: P<0.05 (ANOVA followed by the Tukey's Multiple Comparison Test or T test)

Growth back-calculation (0~50DAH)

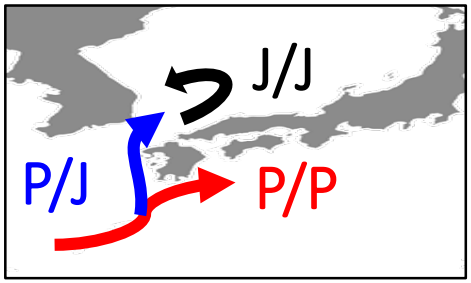


Comparison of the mean SL in the larval stage :
P/P・P/J < J/J in **2012** , J/J < P/P・P/J in **2014・2015**

Results

Mean growth rates (5~19DAH)

a, b, c: P<0.05 (ANOVA followed by the Tukey's Multiple Comparison Test or T test)



Comparison of the mean growth rates in the larval stage:

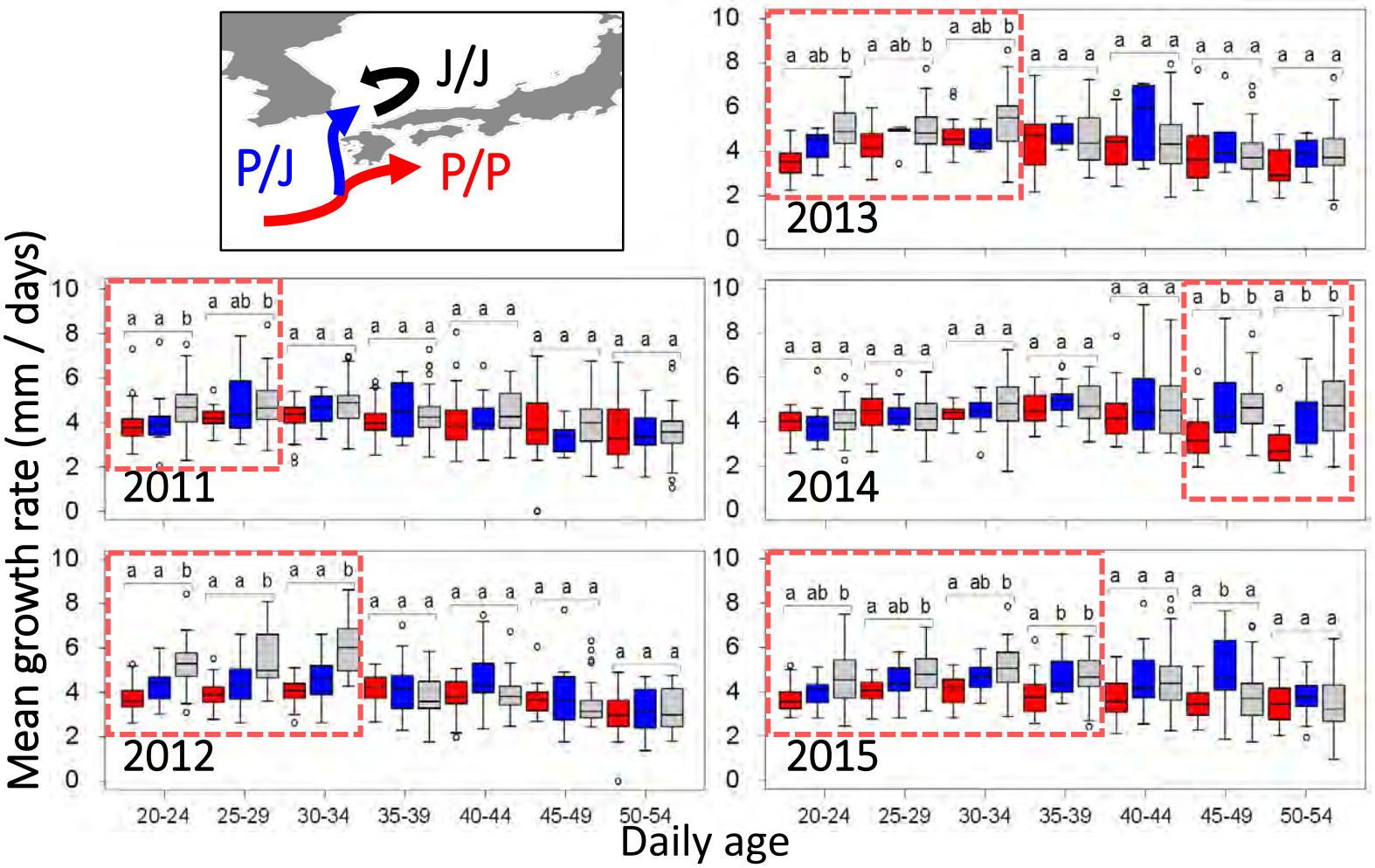
2012: J/J > P/J

2014・2015: P/J > J/J

Results

Mean growth rates (20~54DAH)

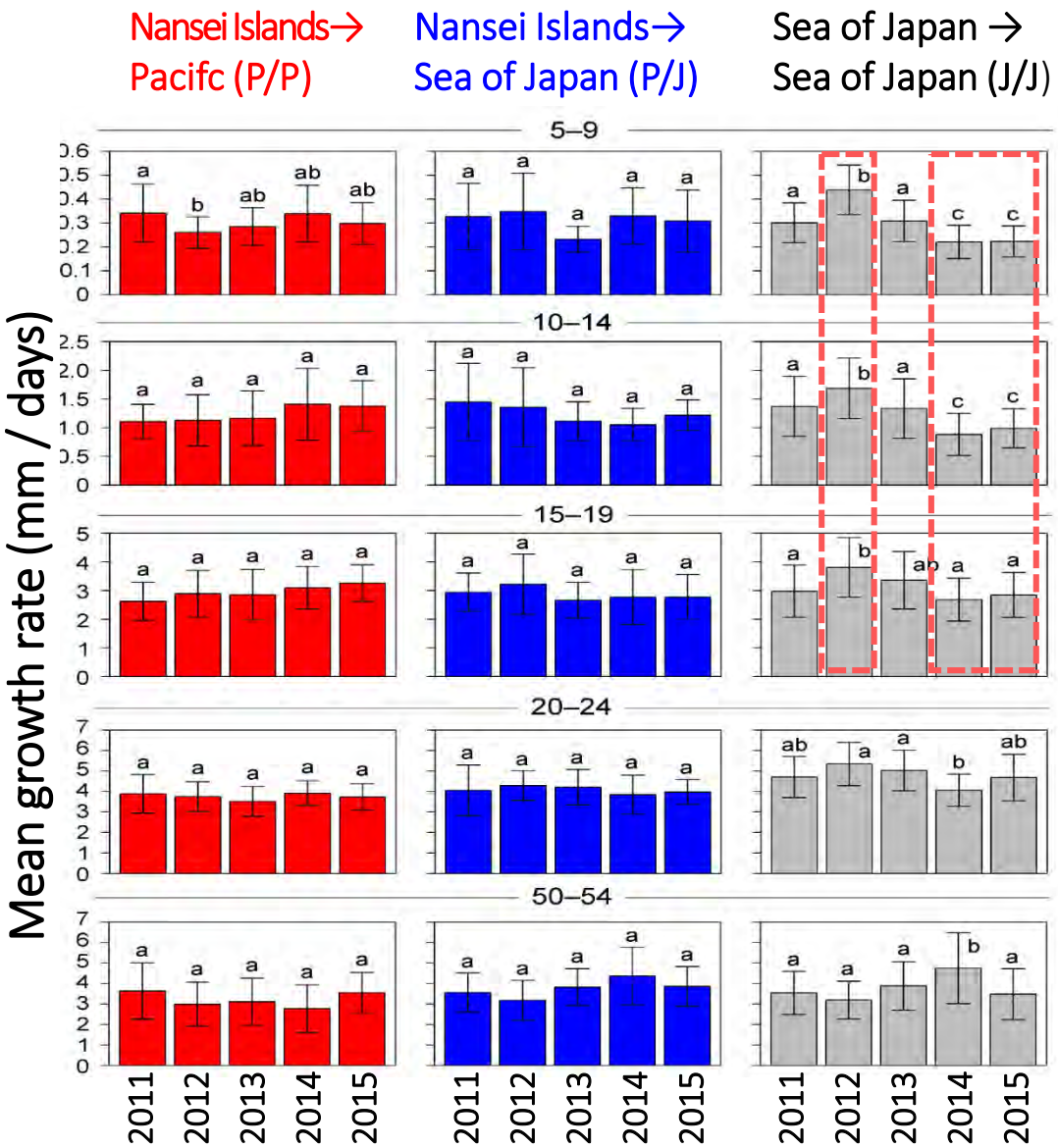
a, b, c: P<0.05 (ANOVA followed by the Tukey's Multiple Comparison Test or T test)

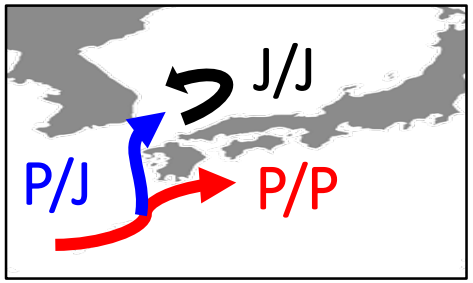


Comparison of the mean growth rates in the juvenile stage: J/J > P/P; occasionally P/J > P/P

Results

Annual differences of growth rates (5~24DAH)



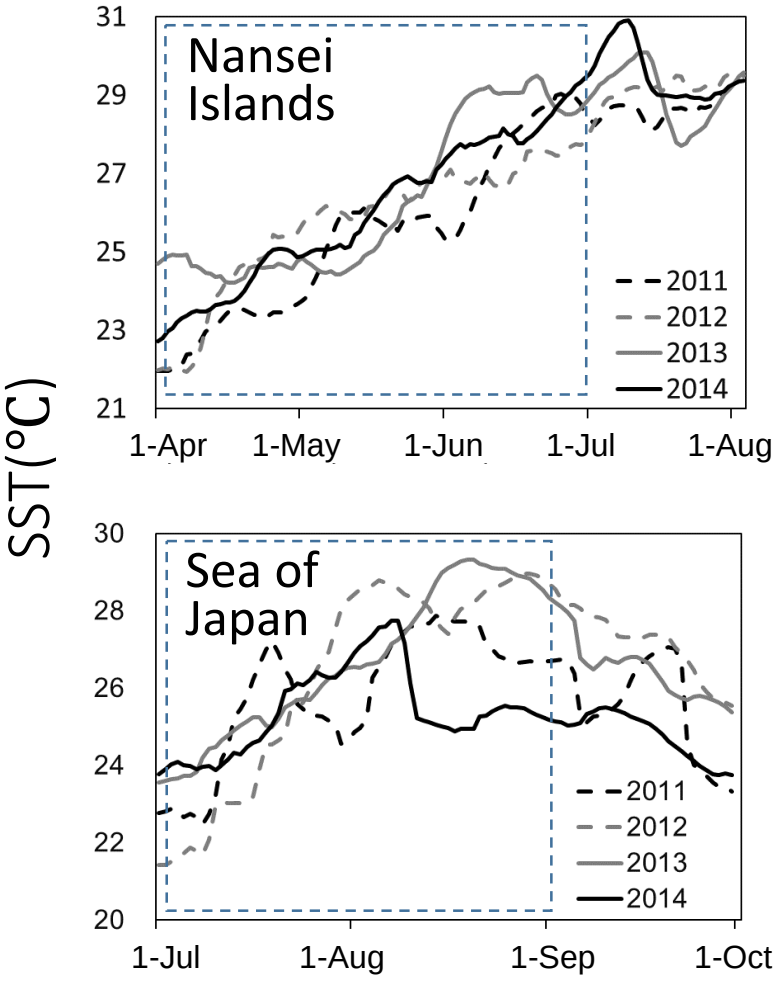


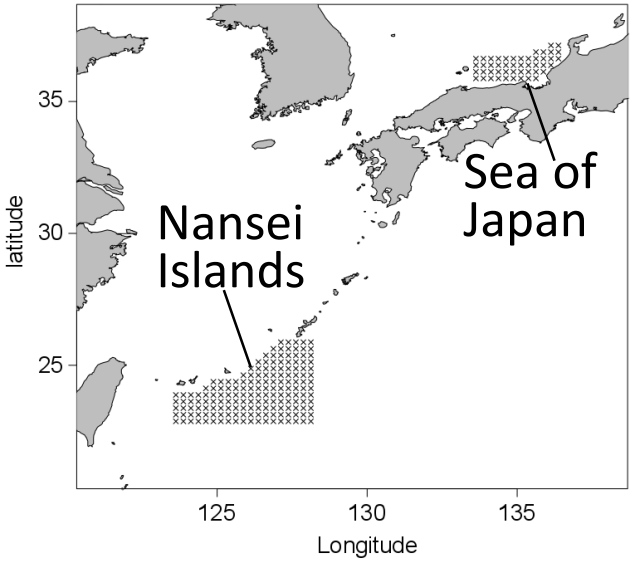
- Growth of P/P and P/J: **No clear annual differences**
- Growth of J/J: **2012 > 2011▪2013 > 2014▪2015**

a, b, c: P<0.05 (ANOVA followed by the Tukey's Multiple Comparison Test or T test)

Results

Sea surface temperatures (SSTs) profiles during the spawning season in the Nansei Islands and Sea of Japan



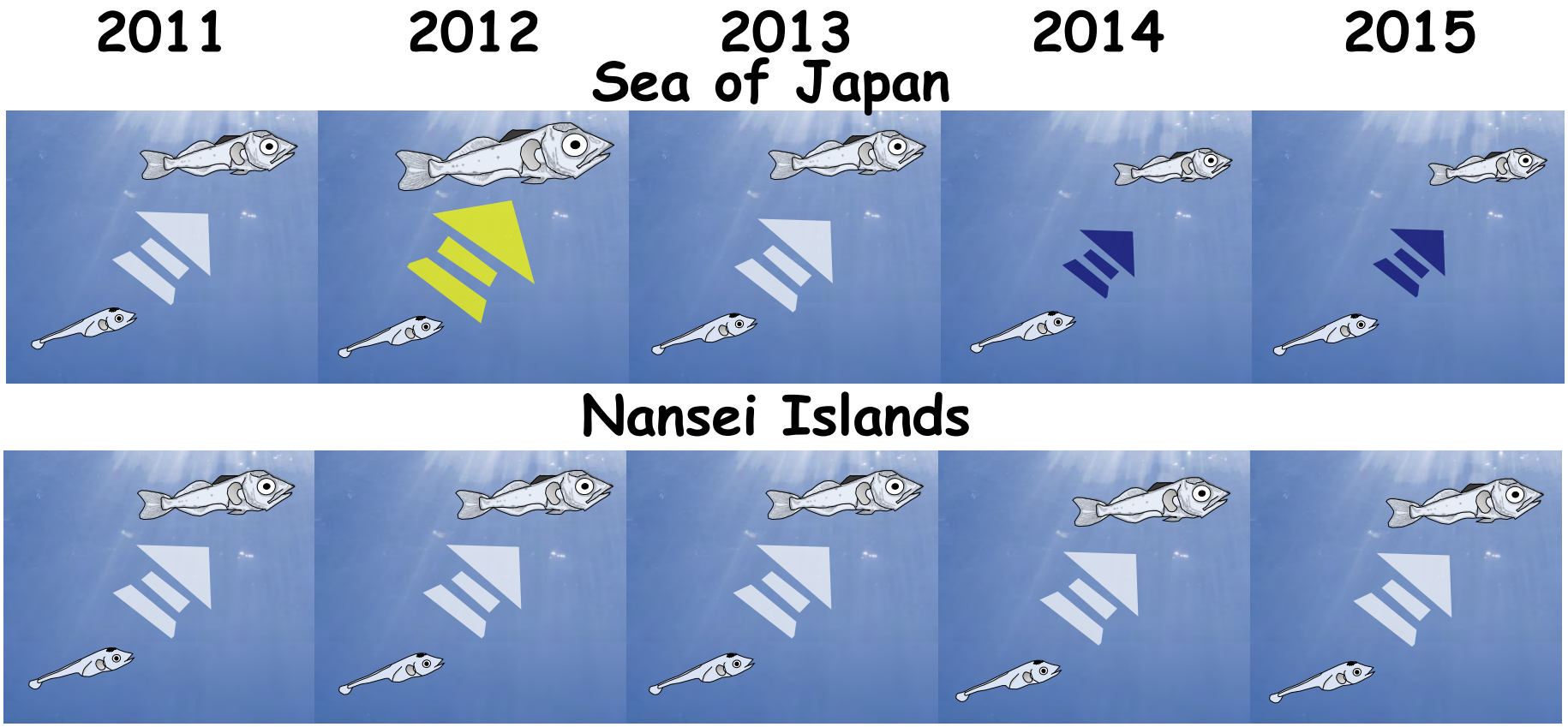


- Similar range of SSTs (22-29°C)
- Nansei Islands: increase steadily during the period; relatively stable
- Sea of Japan: decrease at the end of the period; high intra- and inter-annual variation

Discussion

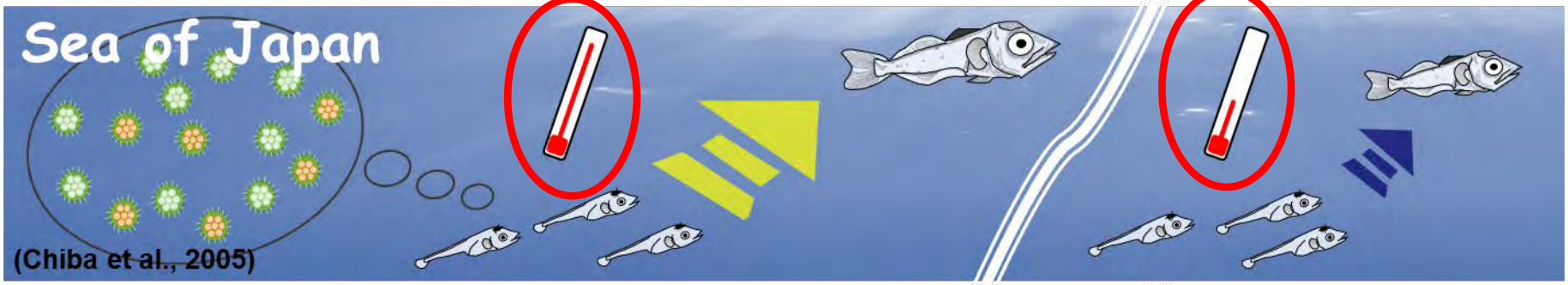
Growth rate differences in the larval stage

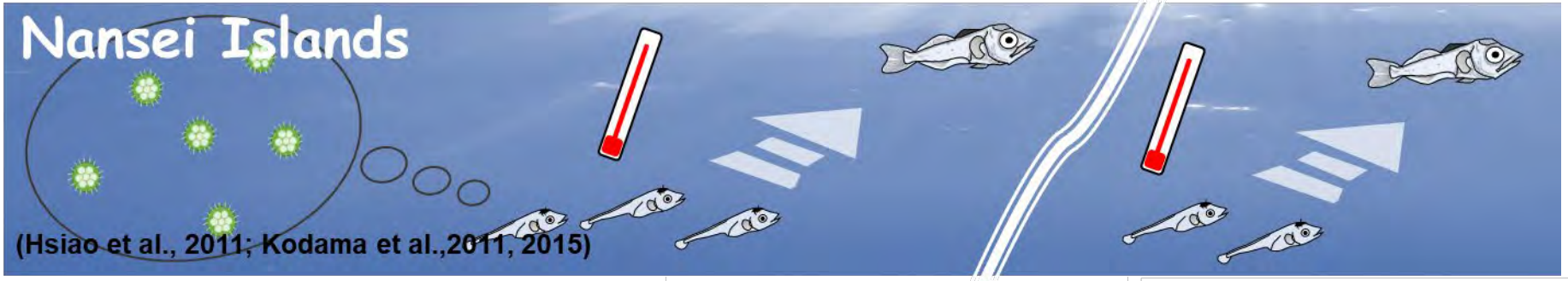
- PBF larvae (5-20 DAH) in the Sea of Japan showed marked inter-annual variation in growth rates during 2011-2015
- Larvae in the Nansei Islands area showed relatively stable growth rates in the same period

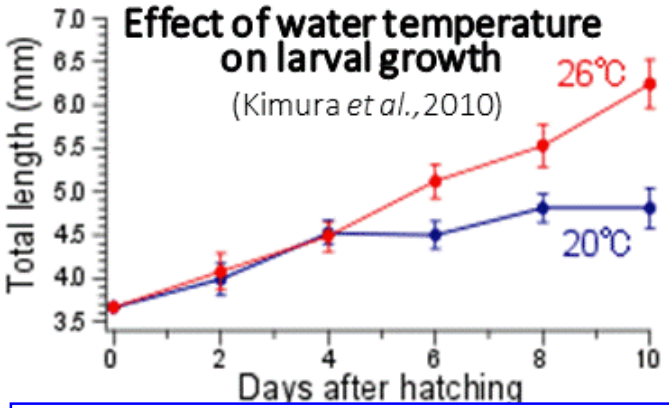


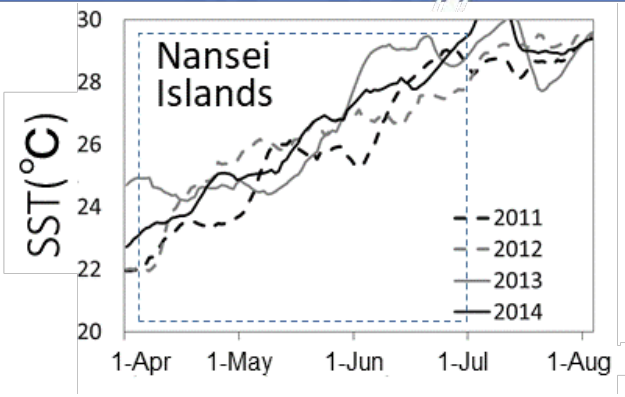
Discussion

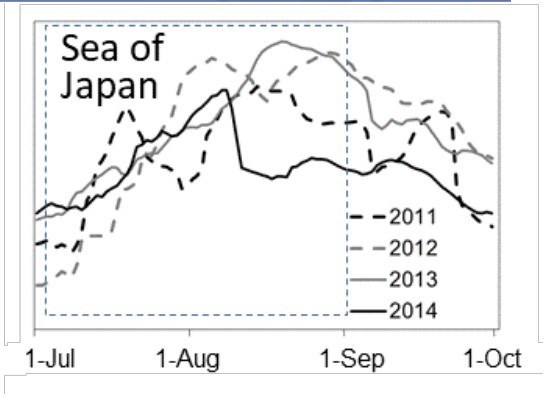
Temperature effects on growth rates of larvae









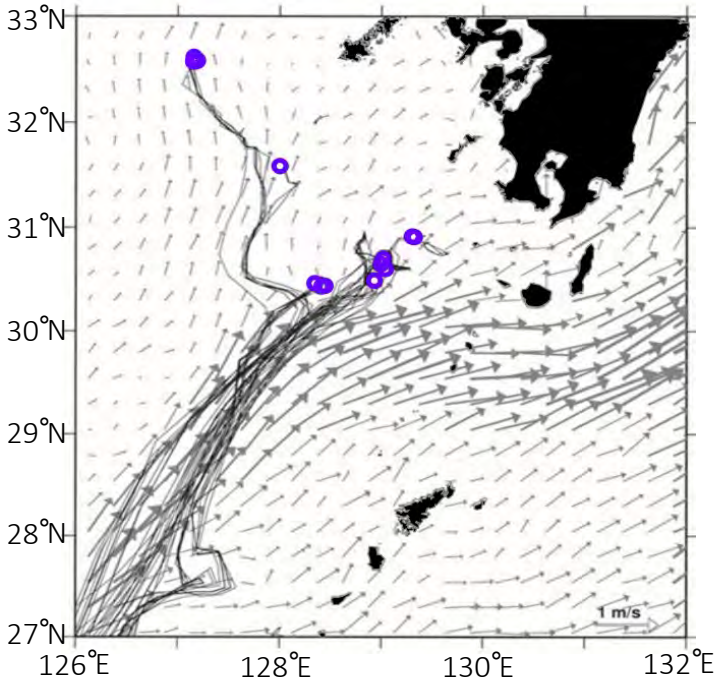


Growth of larval PBF is positively affected by temperature

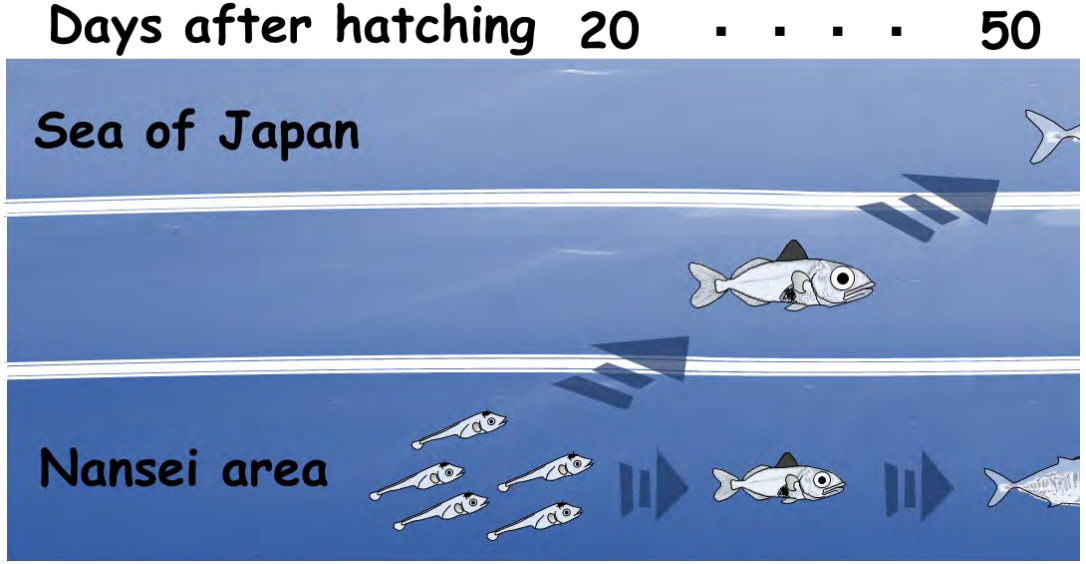
Thermal variations (or lack of) determine growth rates?

Discussion

Growth rate variation between P/P and P/J juveniles: possible implication of northward transport timing

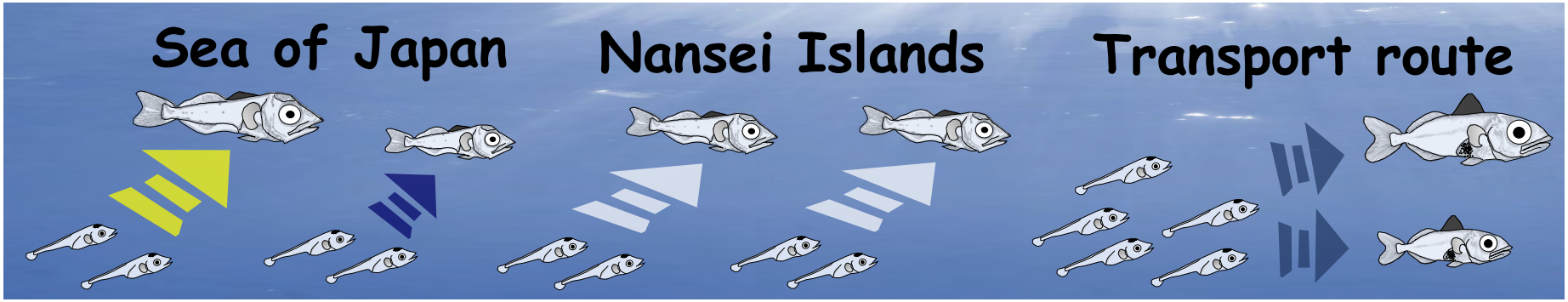


(Masujima *et al*.2014)



- **Differences between P/J and P/P fish became evident already from about 20 DAH:**
  - **Northward migration starts earlier (20 DAH) than assumed?**

Conclusion



- Larvae showed marked inter-annual variation, likely-temperature dependent, in growth rates in the Sea of Japan but not in the Nansei Islands area
- The Sea of Japan supports better juvenile growth than the Pacific coast of Japan

Thank you for your attention