Recruitment processes of jack mackerel (*Trachurus japonicus*) in the East China Sea (ECS) in relation to environmental conditions

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Introduction (1)

- The shelf-break regions of the ECS have been considered to be an important spawning ground for various commercially valuable pelagic fishes.


jack mackerel


chub mackerel

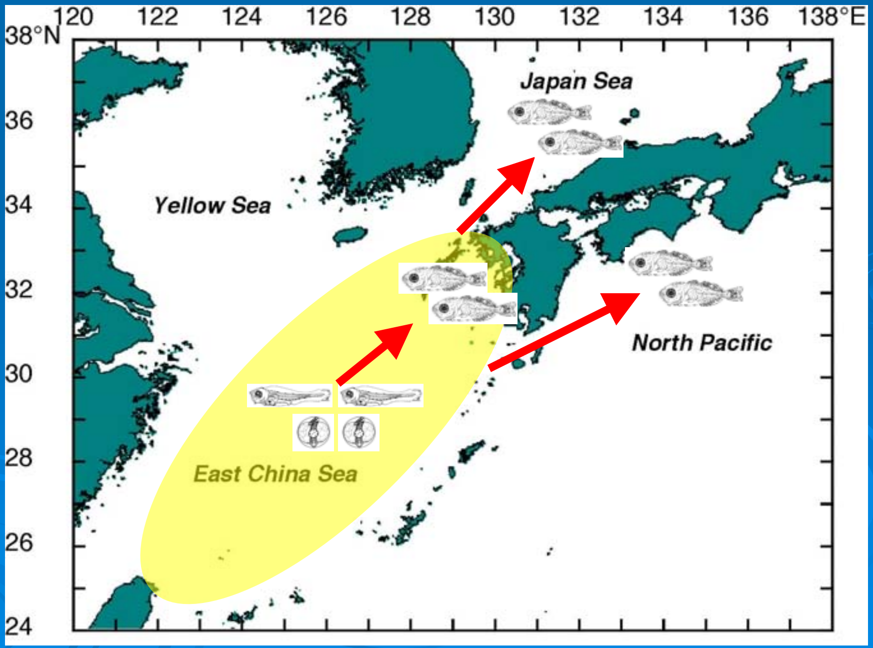

spotted chub mackerel


yellowtail

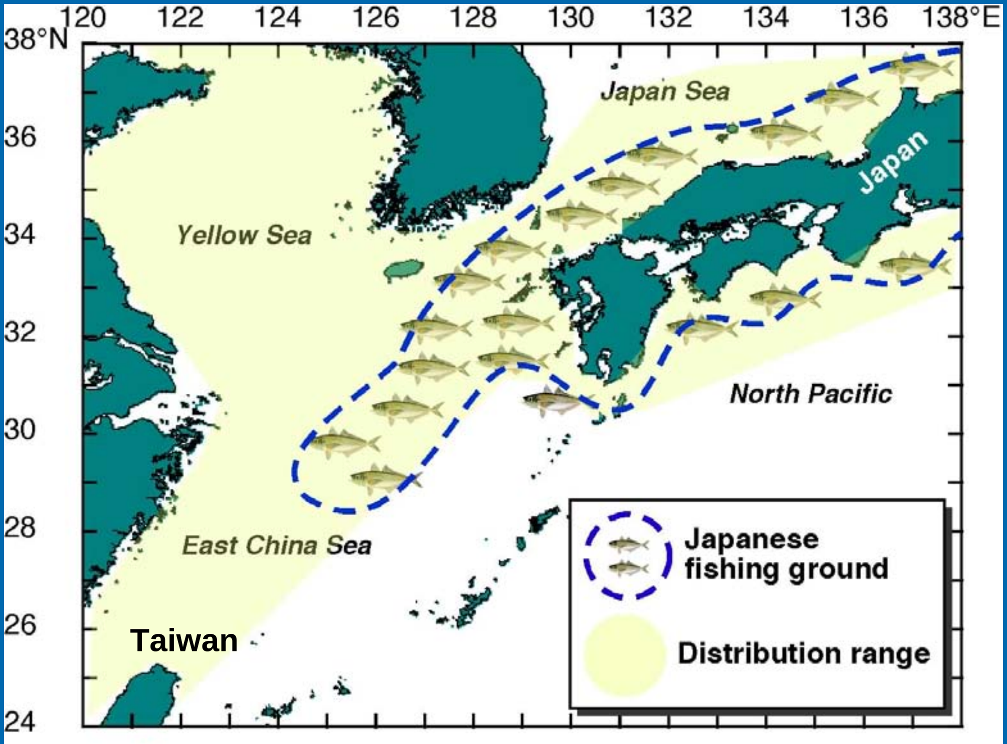

common squid

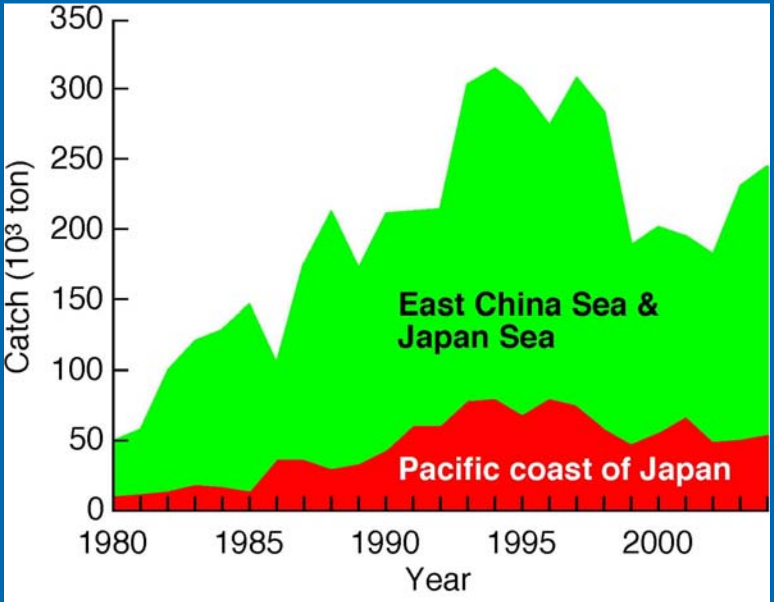
- A large proportion of their eggs, larvae and juveniles are transported to the northern ECS, Pacific and Japan Sea coasts by currents.

However, no comprehensive investigation has been made on their recruitment processes in the ECS.



Introduction (2)





The jack mackerel is one of the most exploited fishery resources in southern Japan

The annual catch during 1990–2004 ranged 180–310 thousand metric tons in Japanese waters

Annual catch in recent years

Korea = several ten thousand t

Taiwan = several thousand t

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2. **Key developmental stages and key area determining their year-class strength**

3. **The relationship between the yearly fluctuation of survival rate and environmental conditions**

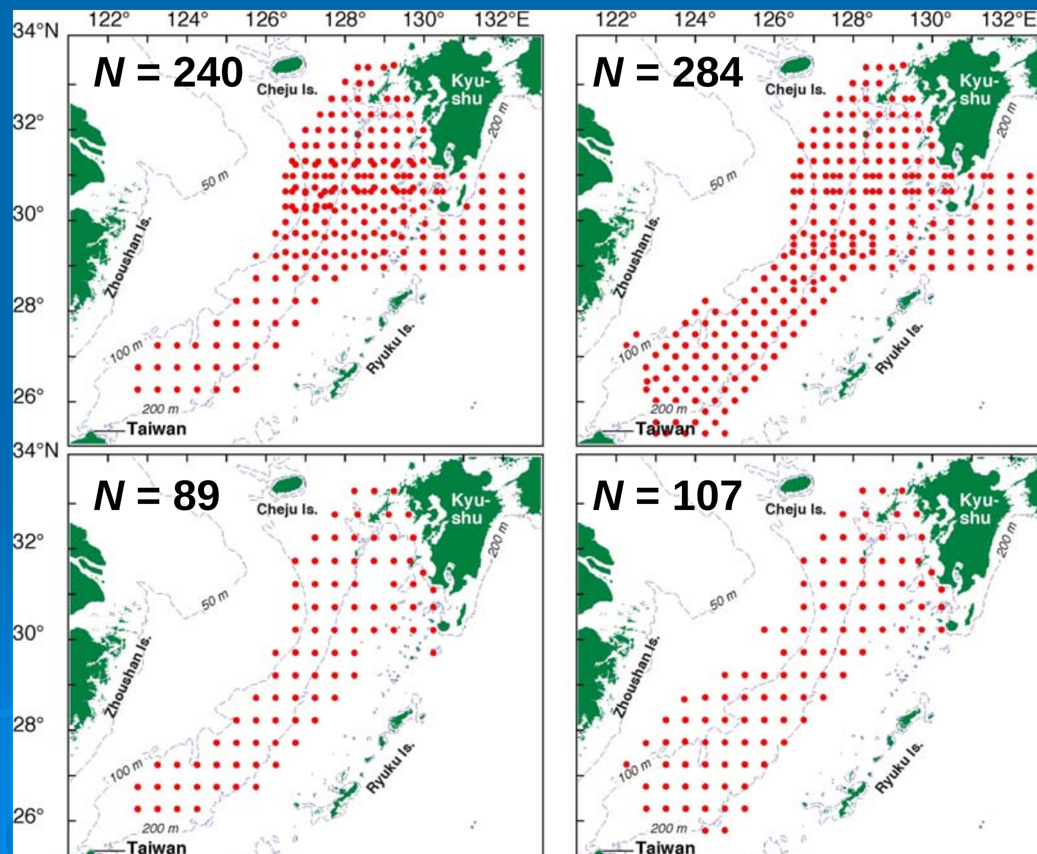
Sampling area

We conducted sampling in the shelf-break region of the East China Sea during February–March and April from 2001 to 2004. The total number of sampling stations during each month ranged from 89 to 284.

2001 **2002**

February –March

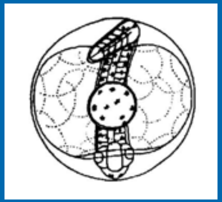
April



Yoko-Maru

How to estimate the location of the main spawning ground

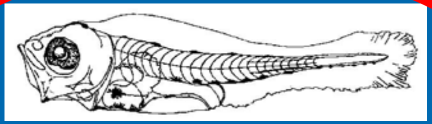
•At present, the identification of jack mackerel eggs by morphological characters is very difficult.



?

•Therefore, based on the catch of <u>the newly-hatched larvae < 3 mm notochord length</u>, we estimated their main spawning ground.

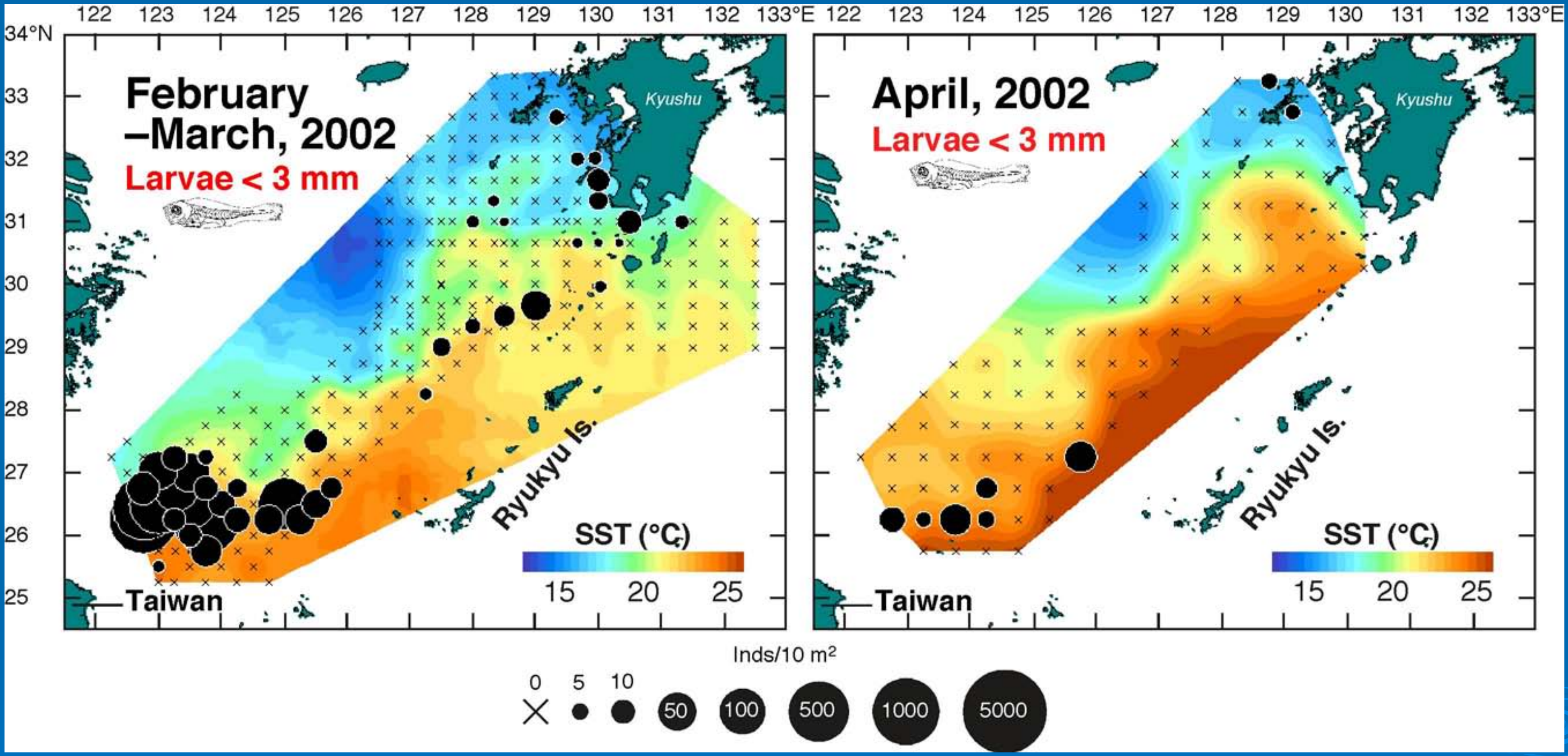
•This size of larvae is reported to be <u>less than 10 d old</u> after the fertilization.



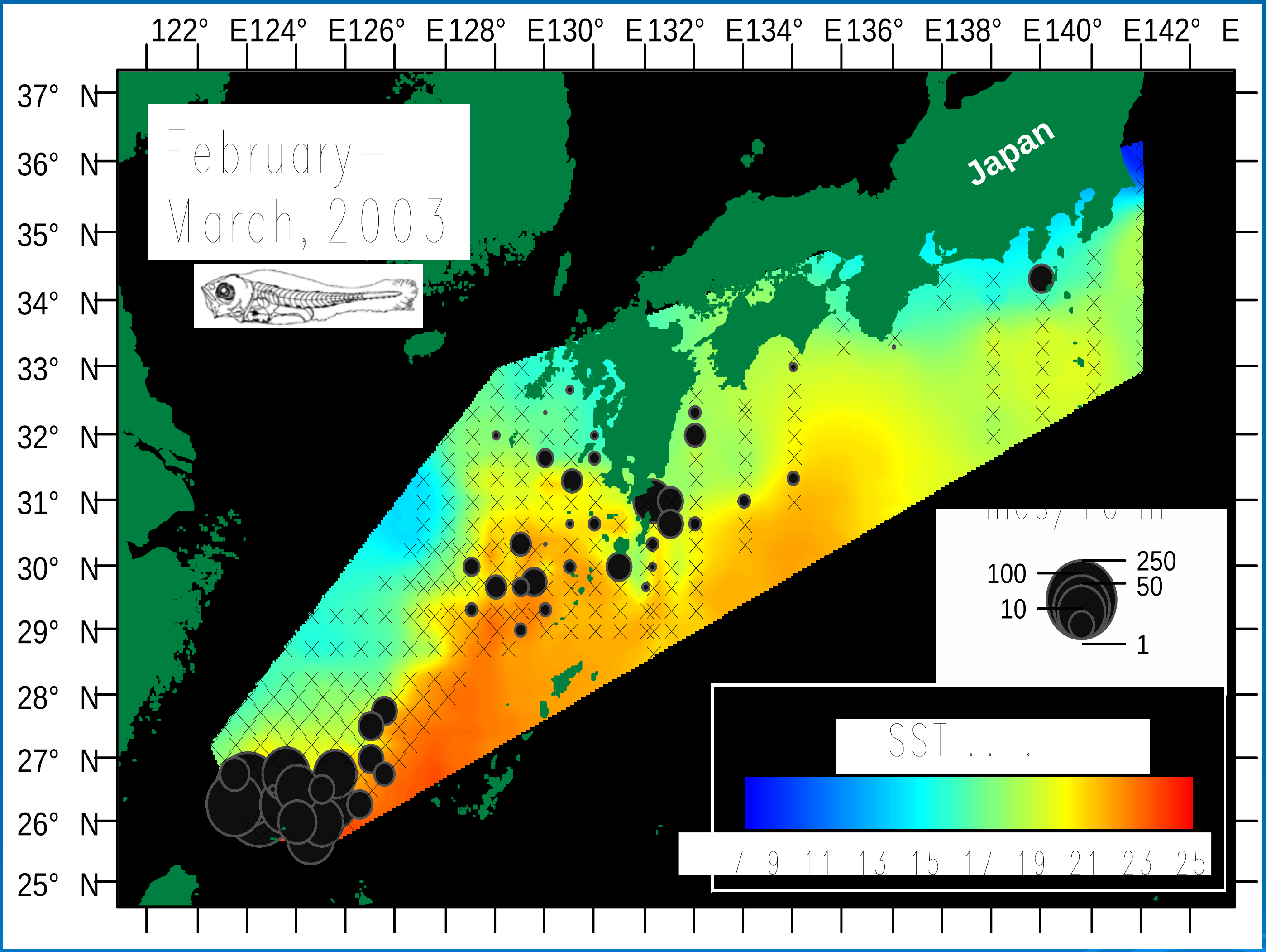
Larval sampling

Bongo net
mouth diameter, 60-cm; mesh size, 0.33-mm
Double-oblique tows (0–150 m layer)

The larvae < 3 mm were concentrated in the southern East China Sea south of 28°N during both periods.

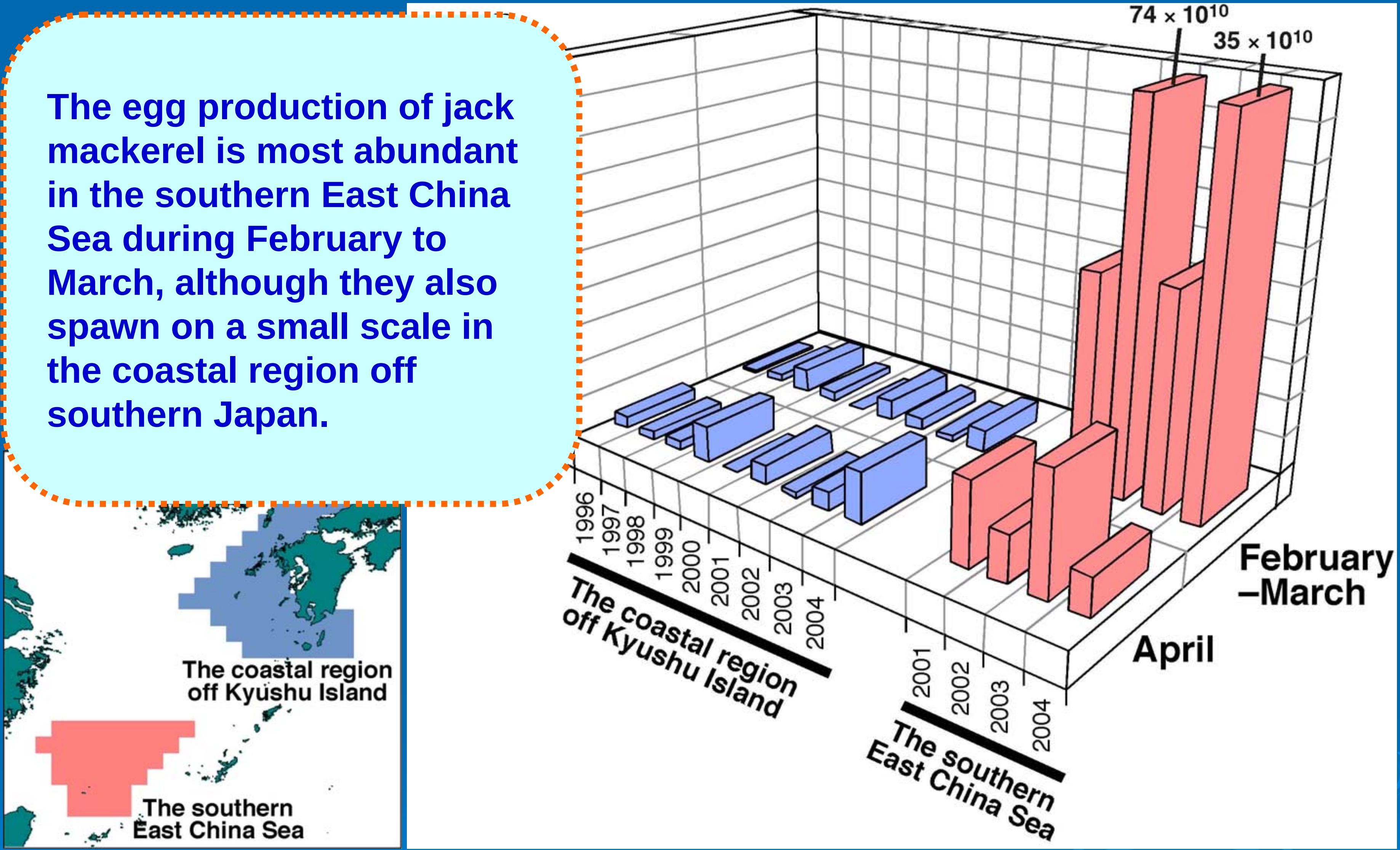


Horizontal distribution of the newly-hatched larvae < 3 mm during February–March and April, 2002.



Horizontal distribution of the jack mackerel larvae < 3 mm during February–March, 2003. **Data in the Pacific was after Uehara & Mori (2004).**

The egg production of jack mackerel is most abundant in the southern East China Sea during February to March, although they also spawn on a small scale in the coastal region off southern Japan.



Comparison of the larval abundance between the southern East China Sea and the coastal region off Kyushu Island.

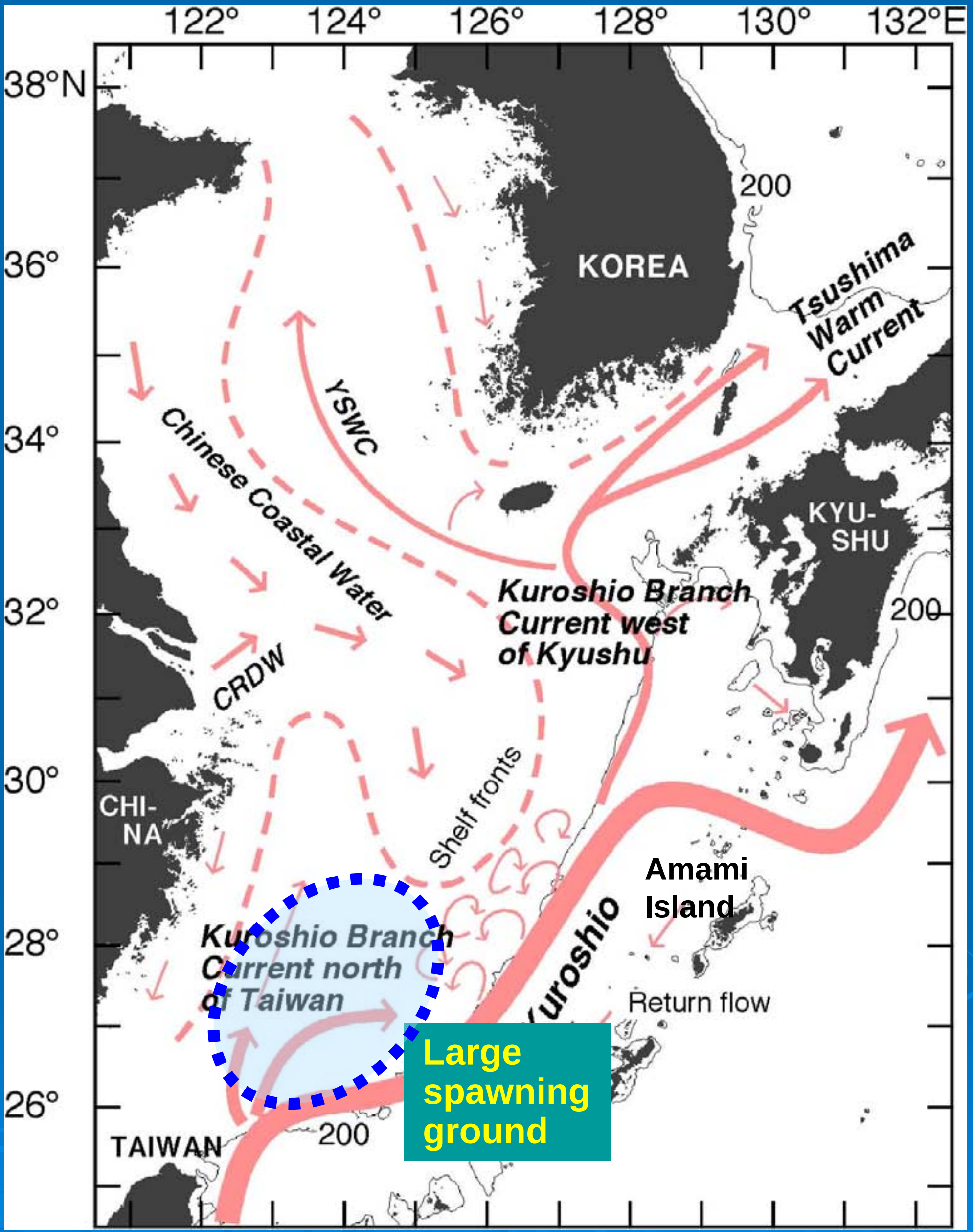
The following current systems in the East China Sea

(1) Kuroshio

(2) Kuroshio Branch Current north of Taiwan

(3) Kuroshio Branch Current west of Kyushu

are active in the continental shelf-break region.

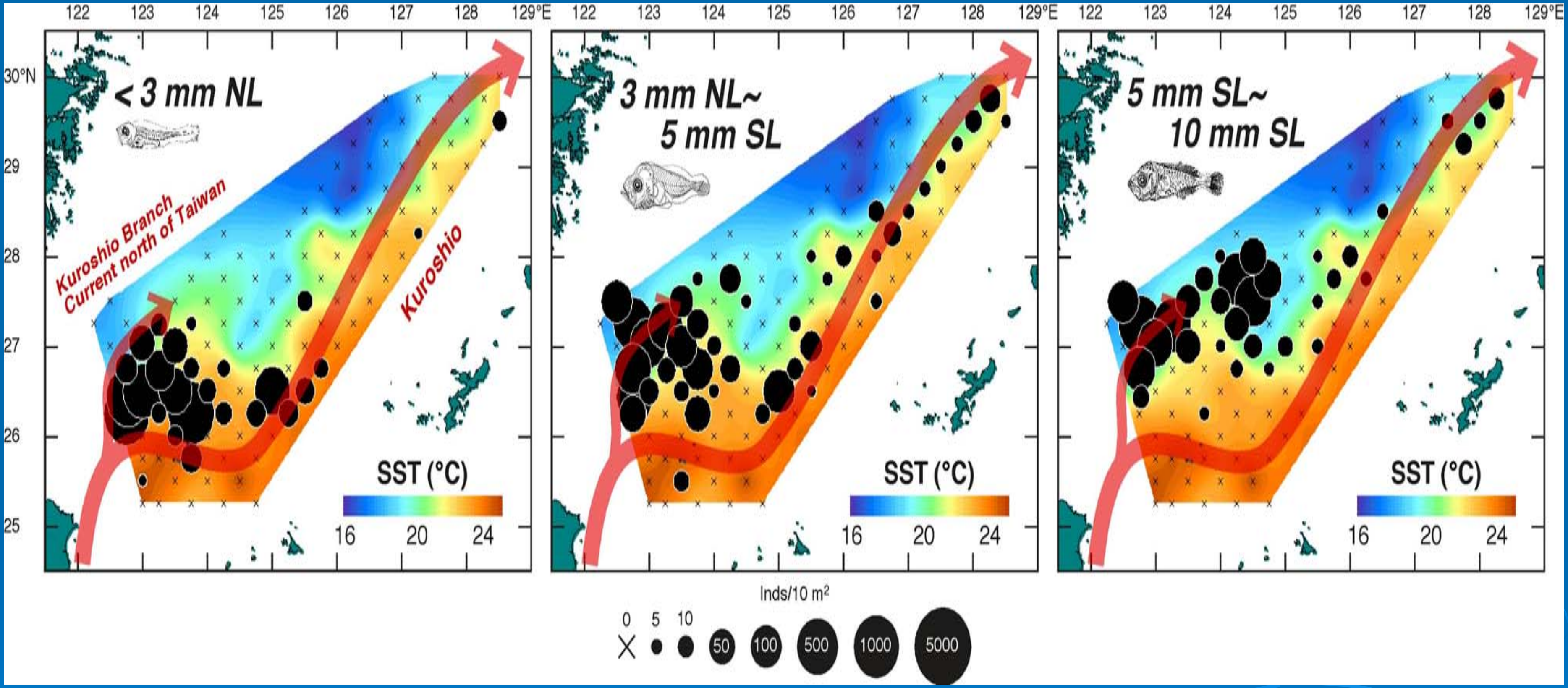


Northeastward larval transport from the main spawning ground (February–March, 2002)

< 11 d ol

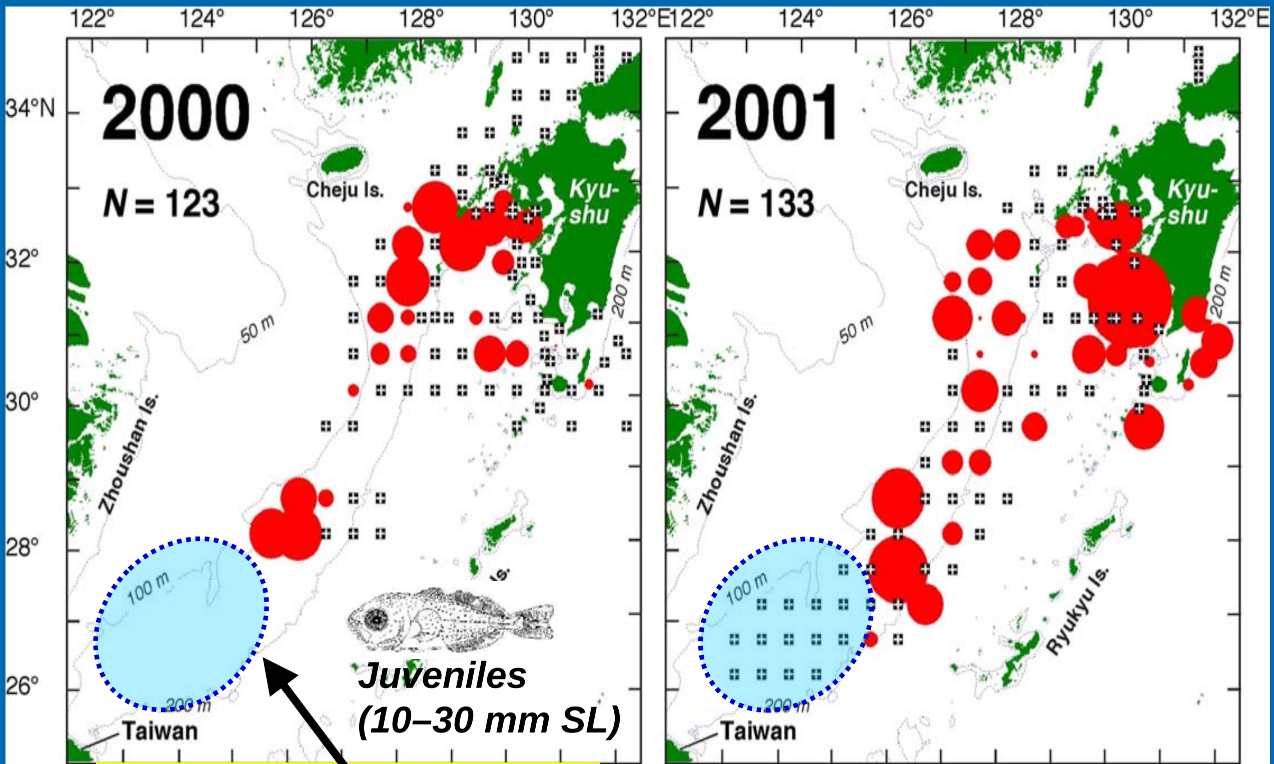
11-16 d ol

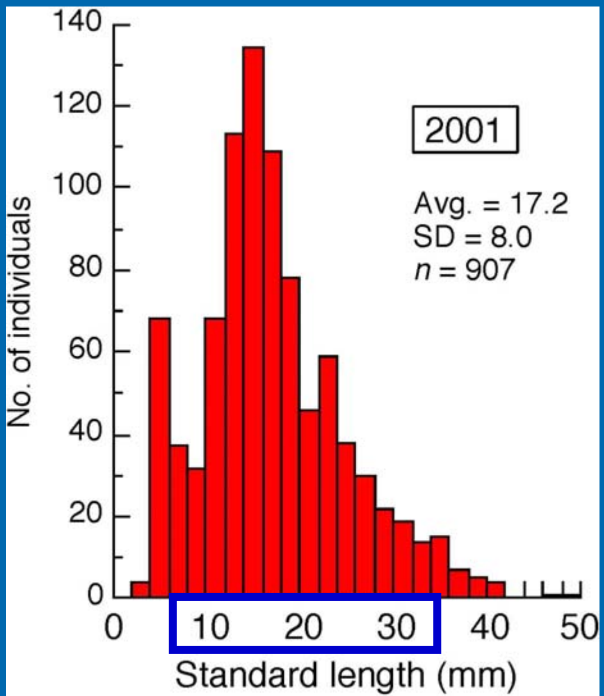
17-22 d ol

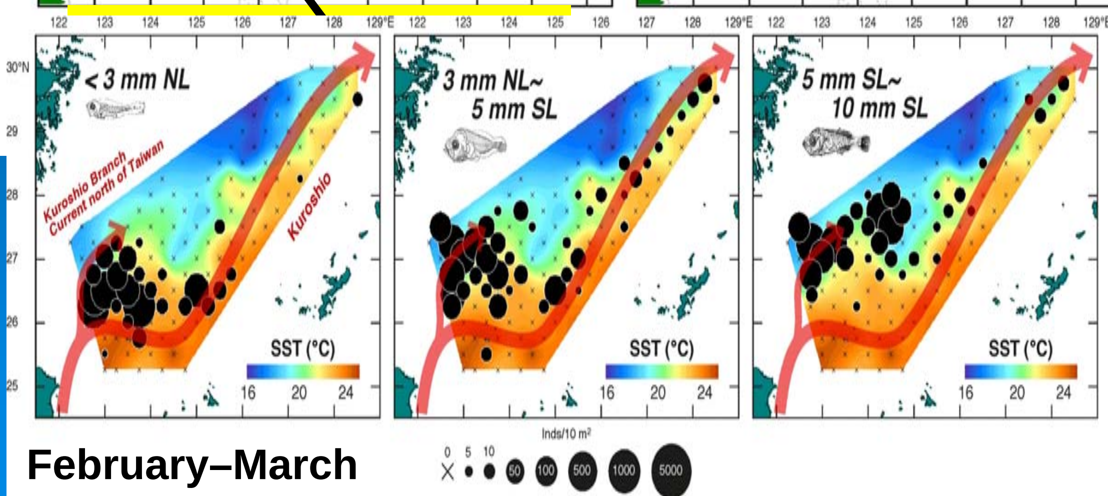


Horizontal distribution of larvae are shown for three body length categories, < 3 mm, 3–5 mm, and 5–10 mm, in relation to the current features.

Juveniles occurred in the downstream area of the main currents of the southern ECS where a large spawning ground was not observed.





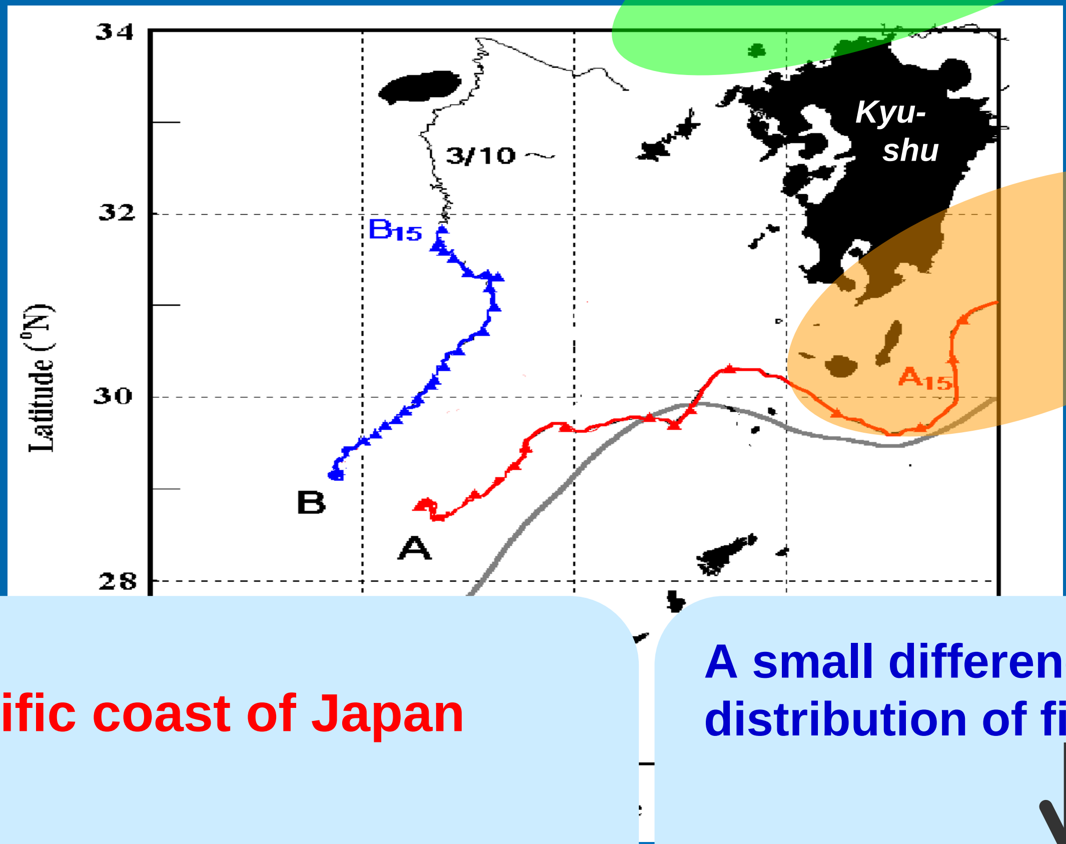


February–March

old

Neuston net
mouth size, 1.3×0.75-m
mesh size, 1.0-mm

The drifter with drogue at 15 m depth



Juveniles (30–90 mm NL) In May–June

Juveniles (20–50 mm SL) In April

Drifter A
→ **Pacific coast of Japan**

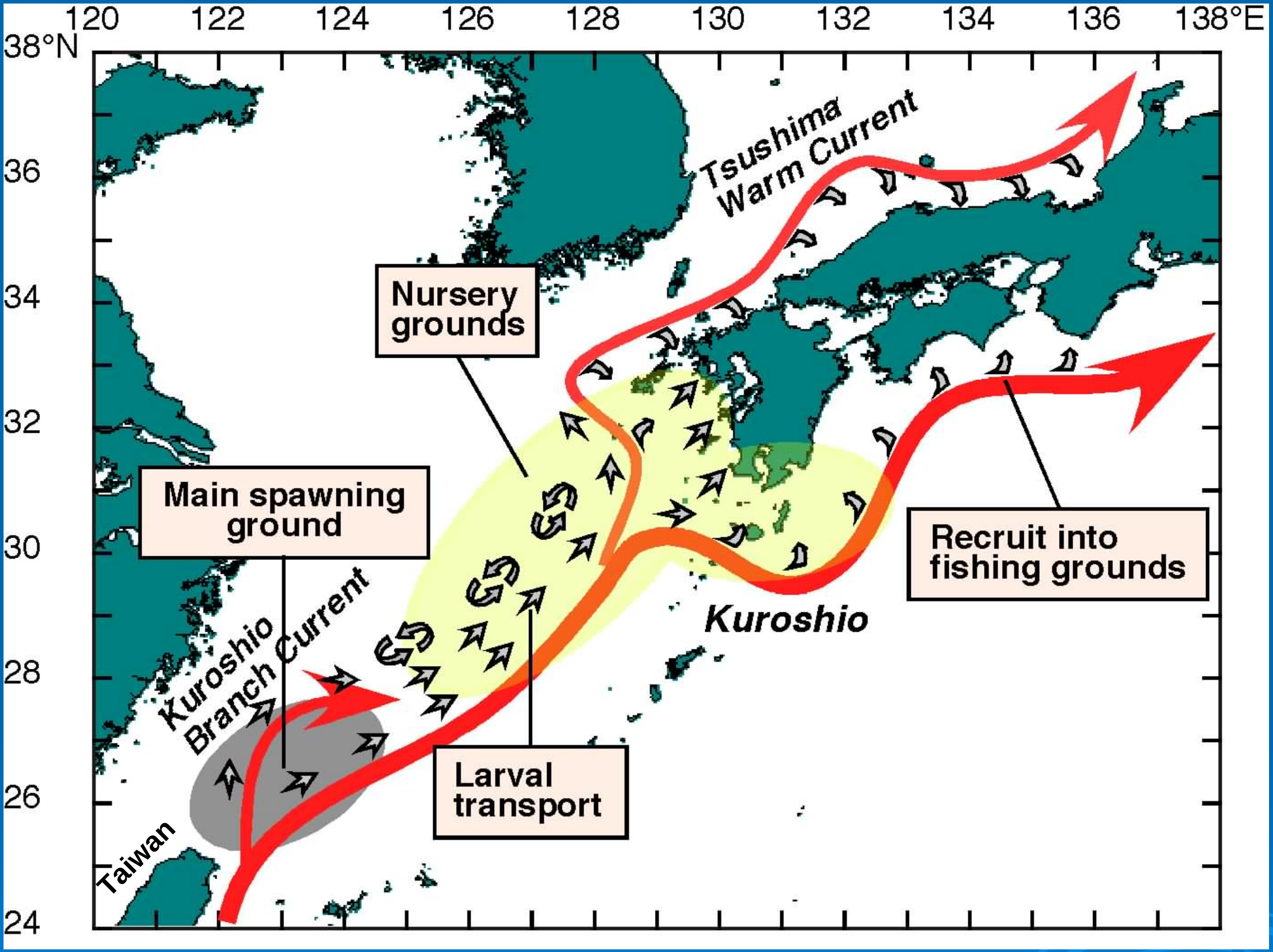
Drifter B
→ **coastal region off Kyushu Japan Sea**

A small difference in the distribution of fish larvae

↓

A remarkable difference in the transport route in the ECS

Conclusion (1)



Schema showing the main spawning ground, larval transport, and recruitment into the fishing grounds, in relation to the current features.

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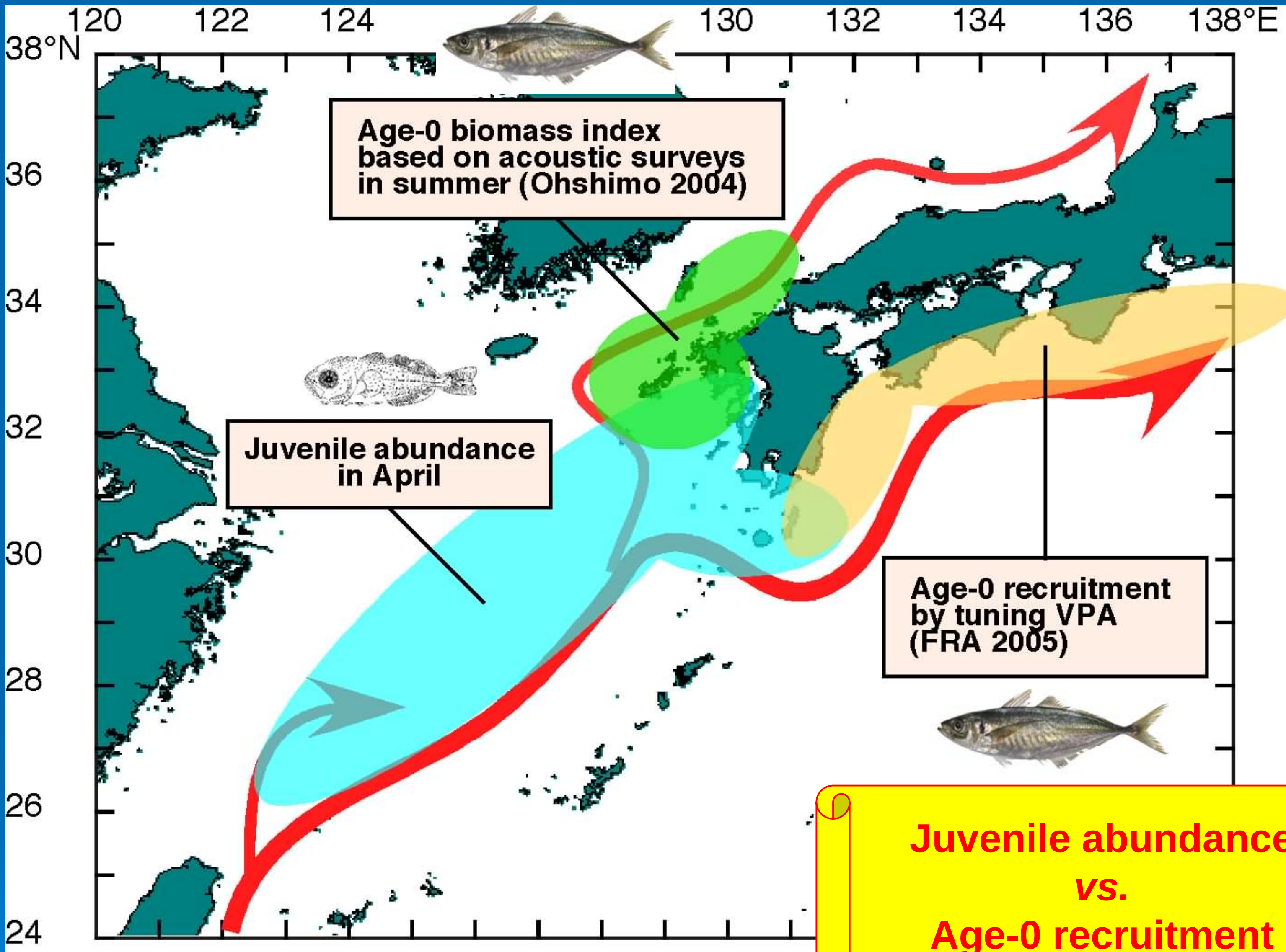
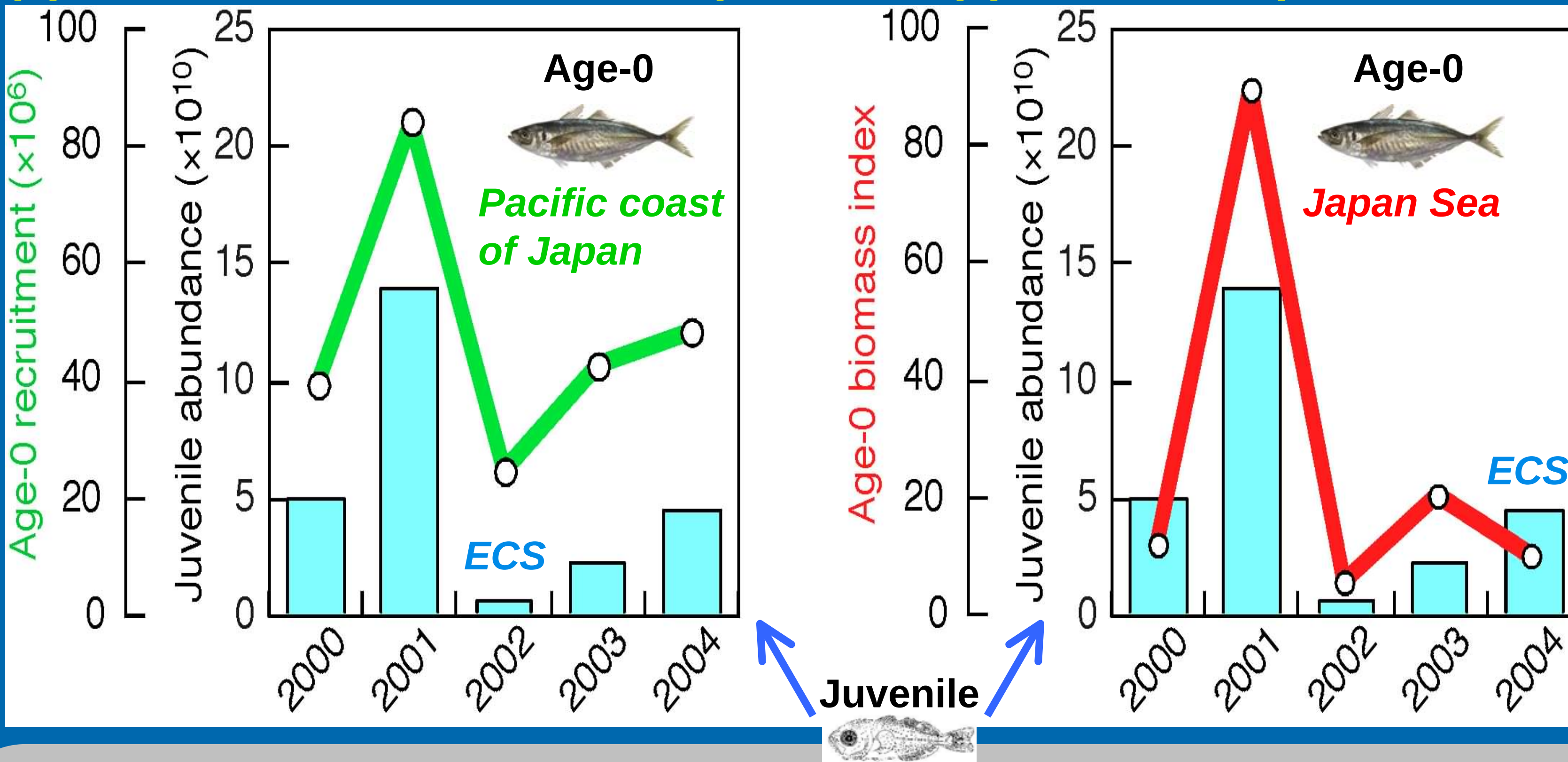


Juvenile abundance
vs.
Age-0 recruitment

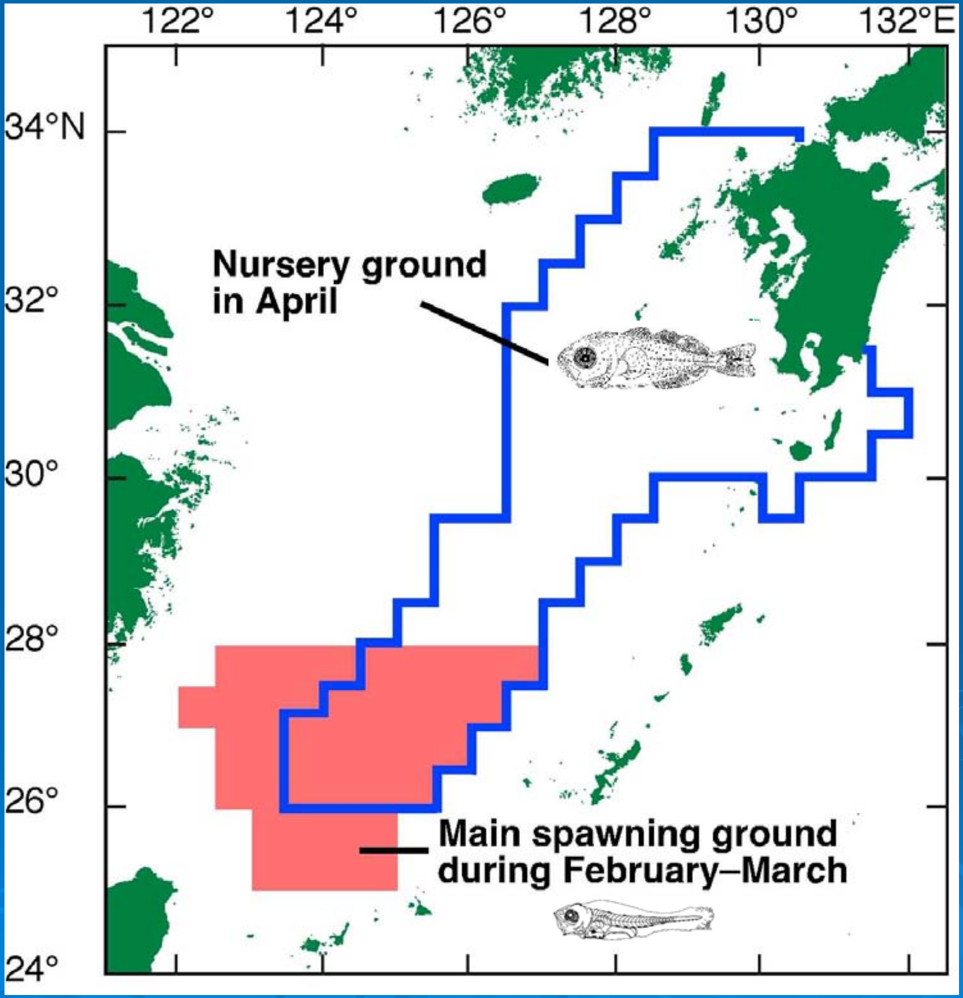
(a) ECS vs. Pacific coast of Japan **(b) ECS vs. Japan Sea**



Springtime juvenile abundance in the ECS is important for age-0 recruitment into the southern Japan.

Survival processes in the ECS are key to understanding the fluctuations in their recruitment.

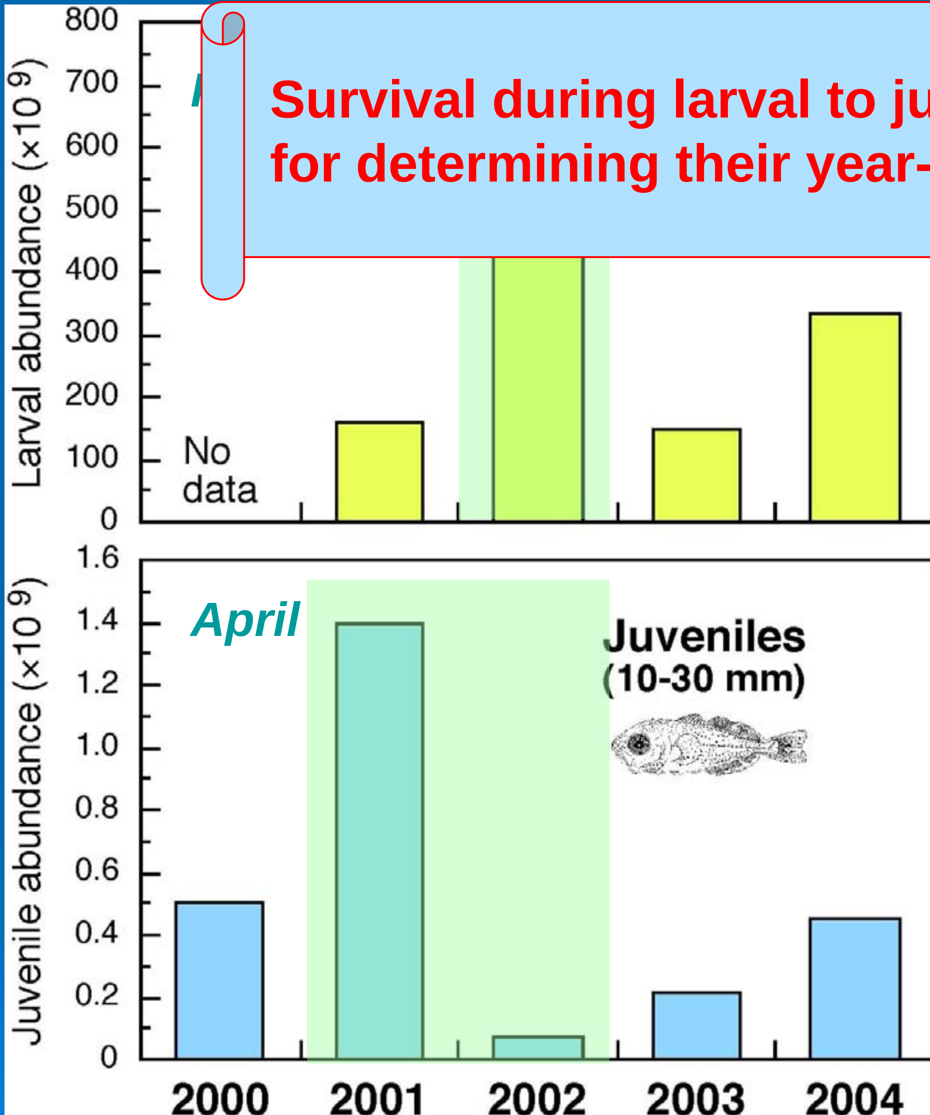
Jack mackerel's survival during the early life stages in the ECS



We compared the abundance of newly-hatched larvae (< 3 mm) in the main spawning ground and juveniles (10–30 mm) in the nursery grounds.

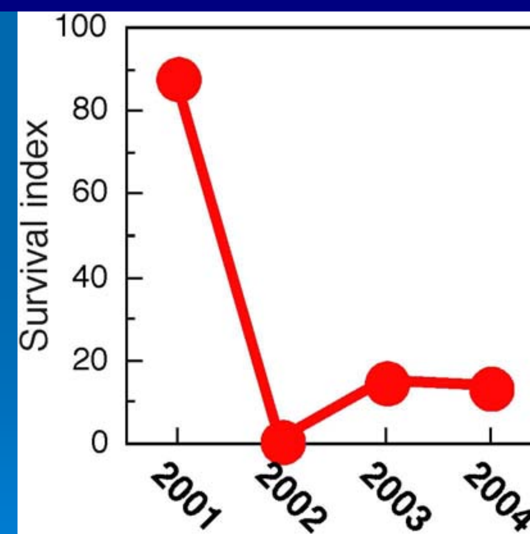
Larval abundance (< 3 mm) *vs.* juvenile abundance

Survival during larval to juvenile stages is important for determining their year-class strength.



Survival index =

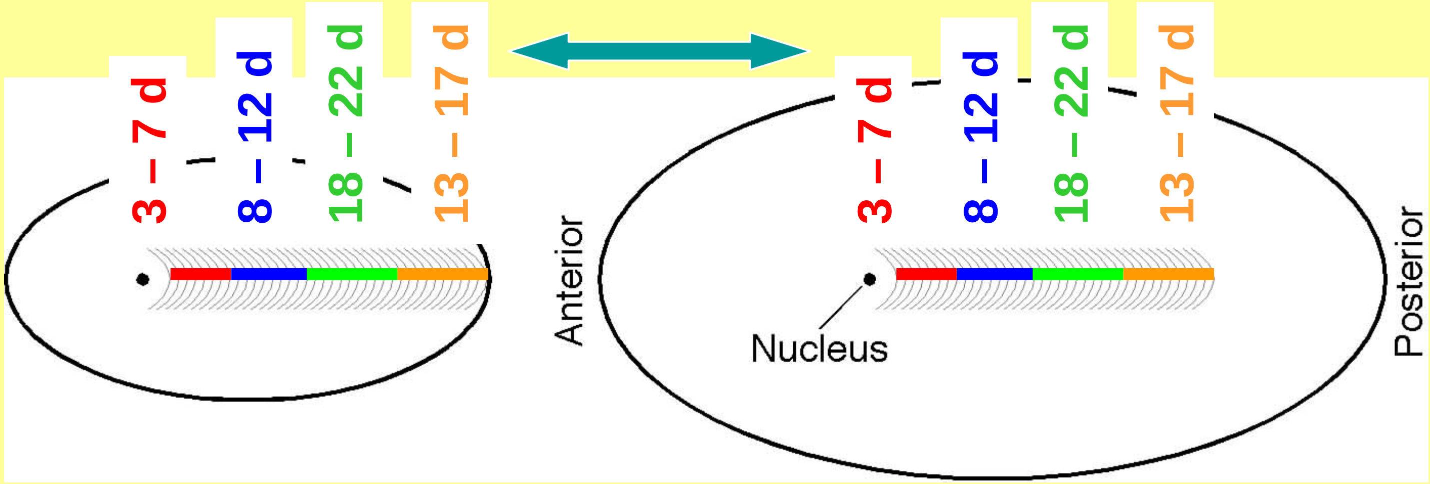
$$\frac{\text{Juvenile abundance}}{\text{Larval abundance}} \times 10000$$



Year-to-year fluctuation of survival during postlarval and juvenile stages

Relationship between the larval growth rate and survival in the ECS using otolith analysis

Comparison of the growth trajectory based on the otolith increment widths between larvae and juveniles



Larvae
(as Original population)

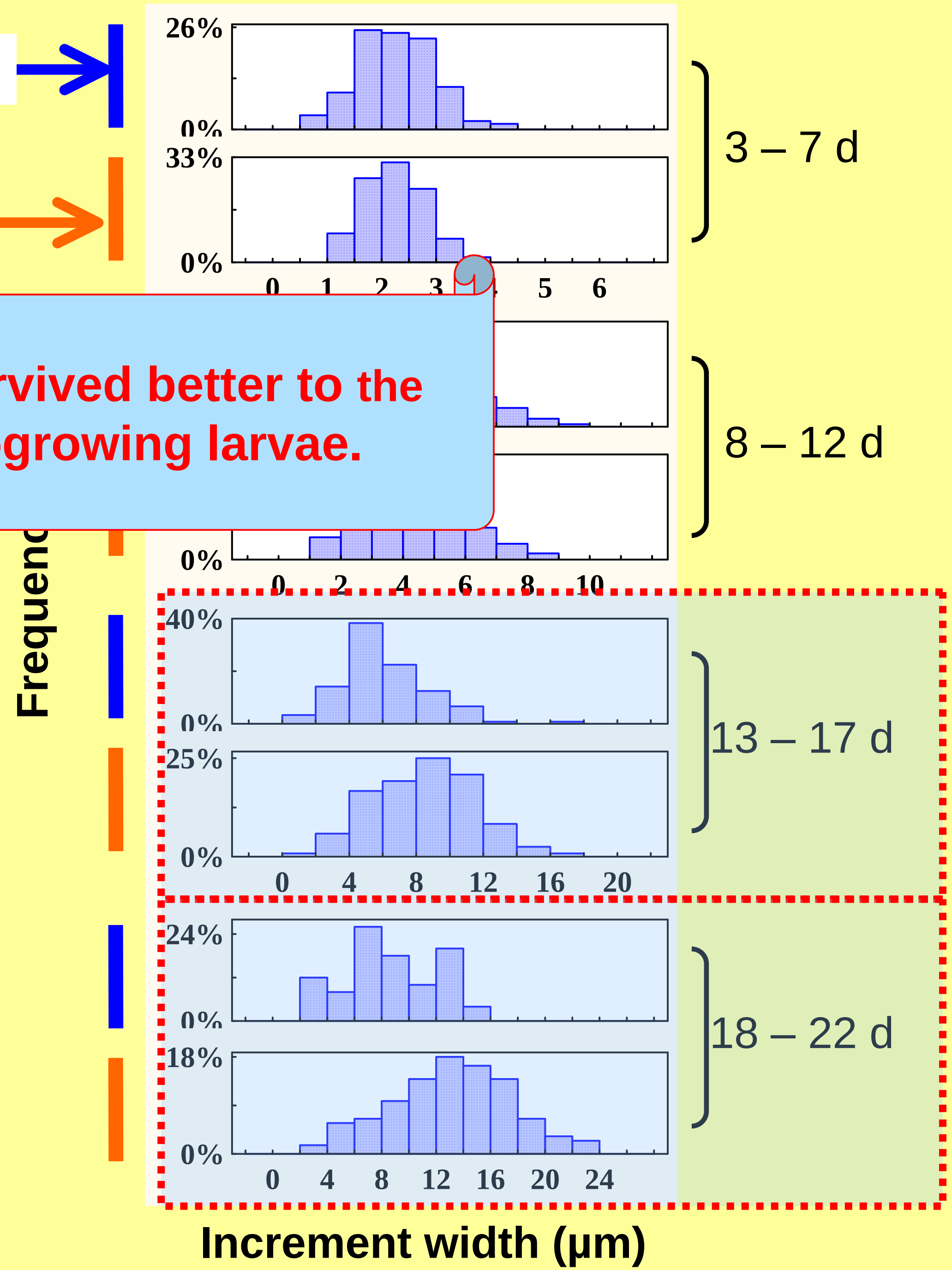
(Sagittal otolith)

Juvenile
(as Survivors)

Larvae (as Original population)

Juvenile (as Survivors)

The faster-growing larvae survived better to the juvenile stage than the slower-growing larvae.



Frequency distributions of increment width were compared between larvae and juveniles.

Conclusion (2)

1. Survival during postlarval and juvenile stages in the ECS was important for determining their year-class strength.

2. Survival rate was very high in 2001 during our study period.

3. The early growth is one of the important factors determining recruitment success of jack mackerel.

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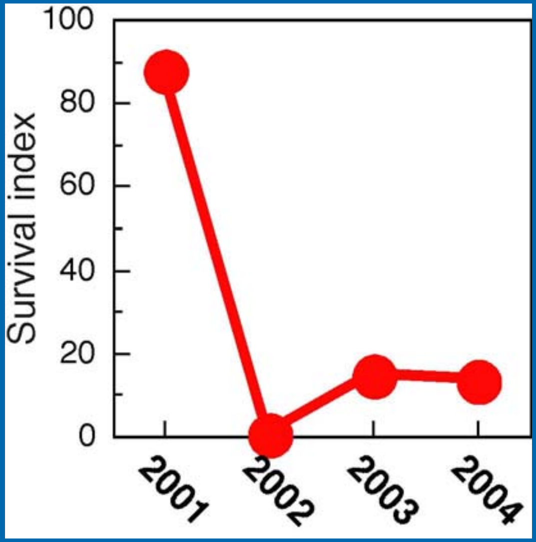
Why was the survival of jack mackerel so different between 2001 and the other three years

Possibilities

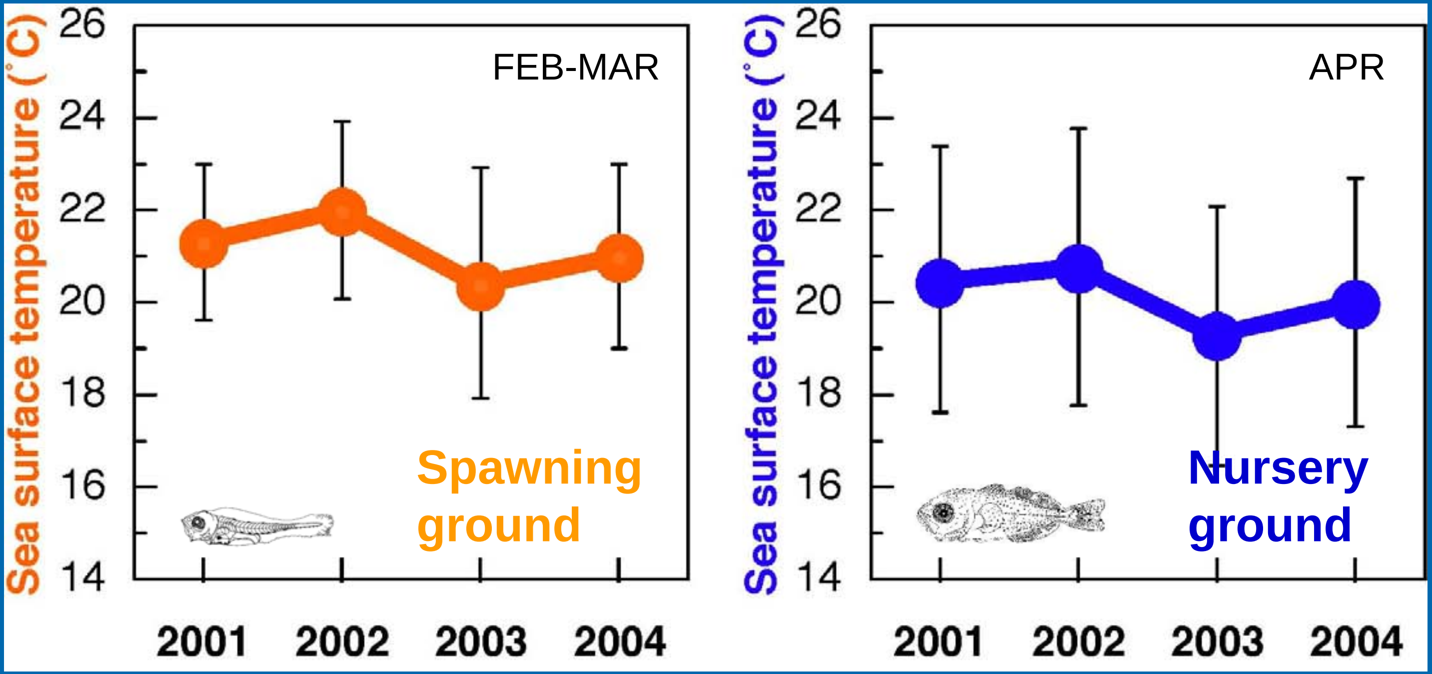
Year-to-year variation of

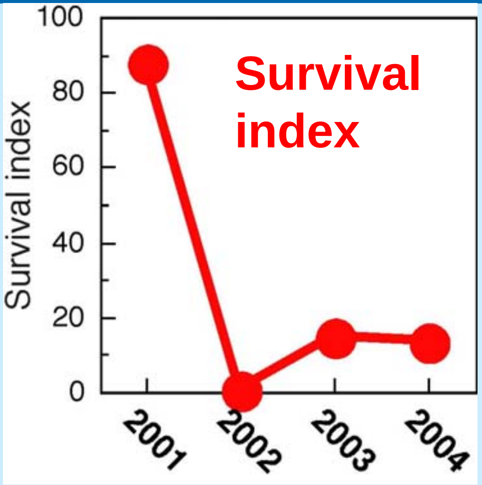
(1) Habitat temperature
(2) Food availability
(3) Larval transport condition
(4) Medusa abundance



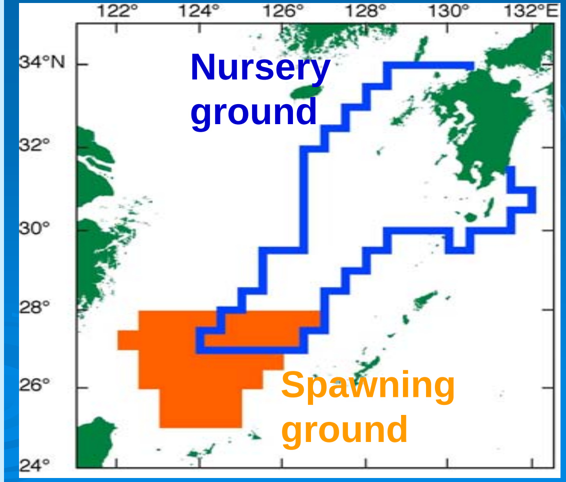
Year-to-year fluctuation of survival during postlarval and juvenile stages

Possibilities (1)
Year-to-year variation of habitat temperature



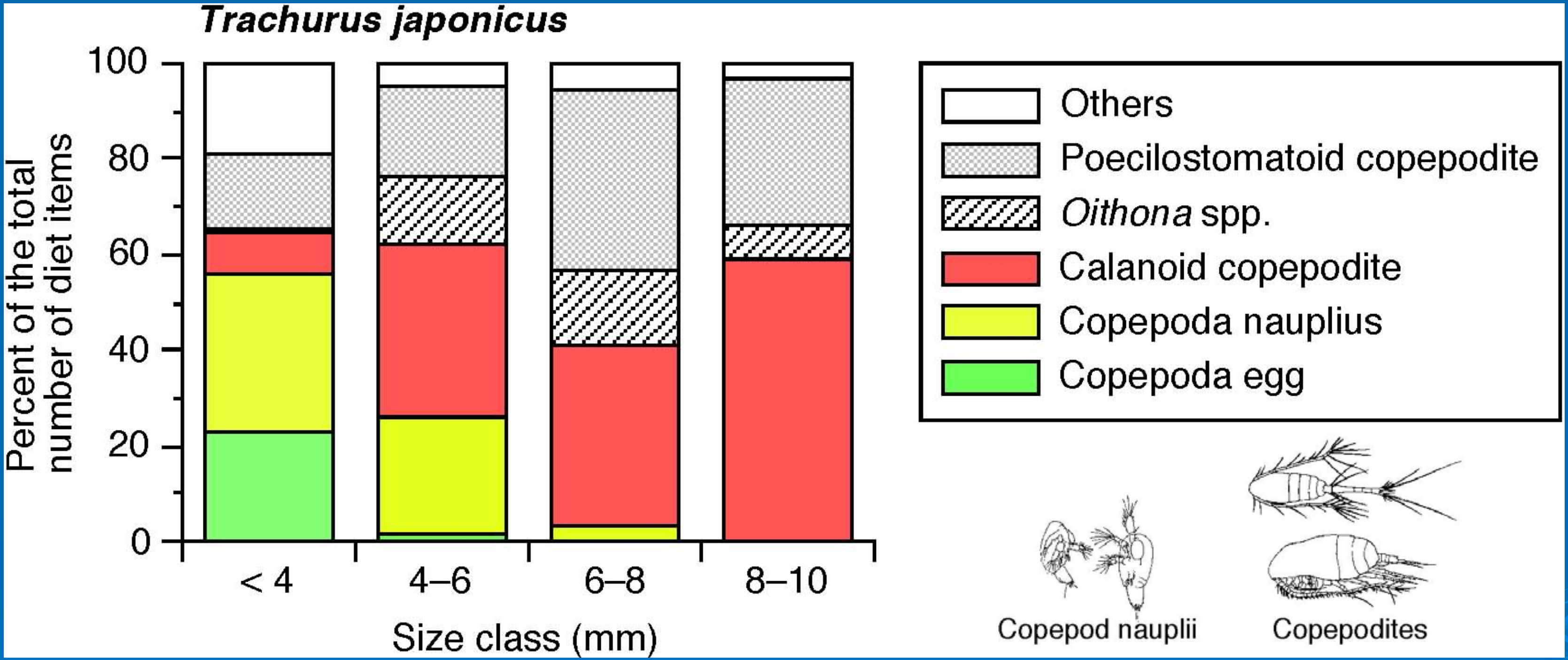


No clear relationship was recognized between survival index and habitat temperature in this study.



Possibilities (2)
Year-to-year variation of food availability

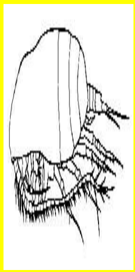
What do the jack mackerel larvae eat?



Percent of the total number of major prey taxa in relation to size of jack mackerel larvae.

Summary of prey items in *Trachurus japonicus* larvae from the East China Sea. The product (% N % F) of frequency of occurrence (% F) and percentage number (% N) of each prey type is a measure of the importance of each prey type.

Prey taxon	% N	% F	IRI
…l copepodite			
…calanus spp.	0.64	2.13	1.35
…acilis	0.51	2.13	1.08
…nus spp.	0.13	0.71	0.09
…calanus pavo	0.00	0.00	0.00
…lacia sp.	0.76	2.84	2.17
…socalanus spp.	0.64	2.13	1.35
…arcuicornis	0.13	0.71	0.09
Paracalanus spp.	1.27	3.55	4.51
P. parvus	16.41	20.57	337.56
P. aculeatus	0.25	1.42	0.36
Temora turbinata	1.15	4.96	5.68
T. discaudata	0.13	0.71	0.09



***Paracalanus* spp.**

We estimated the egg production rate of *Paracalanus* spp. which are dominant copepods in the southern ECS (Hsieh & Chiu 2002)

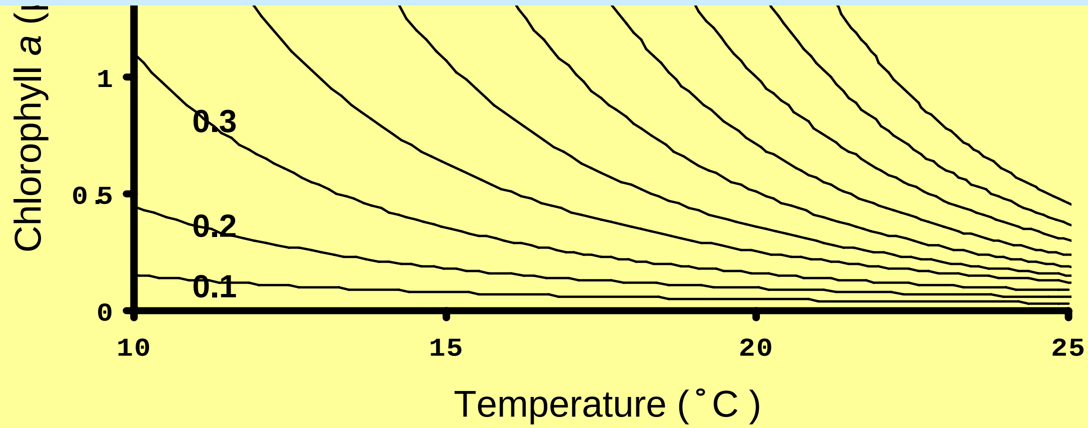
Model of the copepod egg production (Prestidge et al. 1995)

$$\text{Egg Production Rate (EP)} = \text{MaxEP}\, e^{(T-24)/\theta} \times \frac{\text{Chl. } a}{\text{Chl. } a + \text{Chl. } a_h}$$

(eggs/female/day)

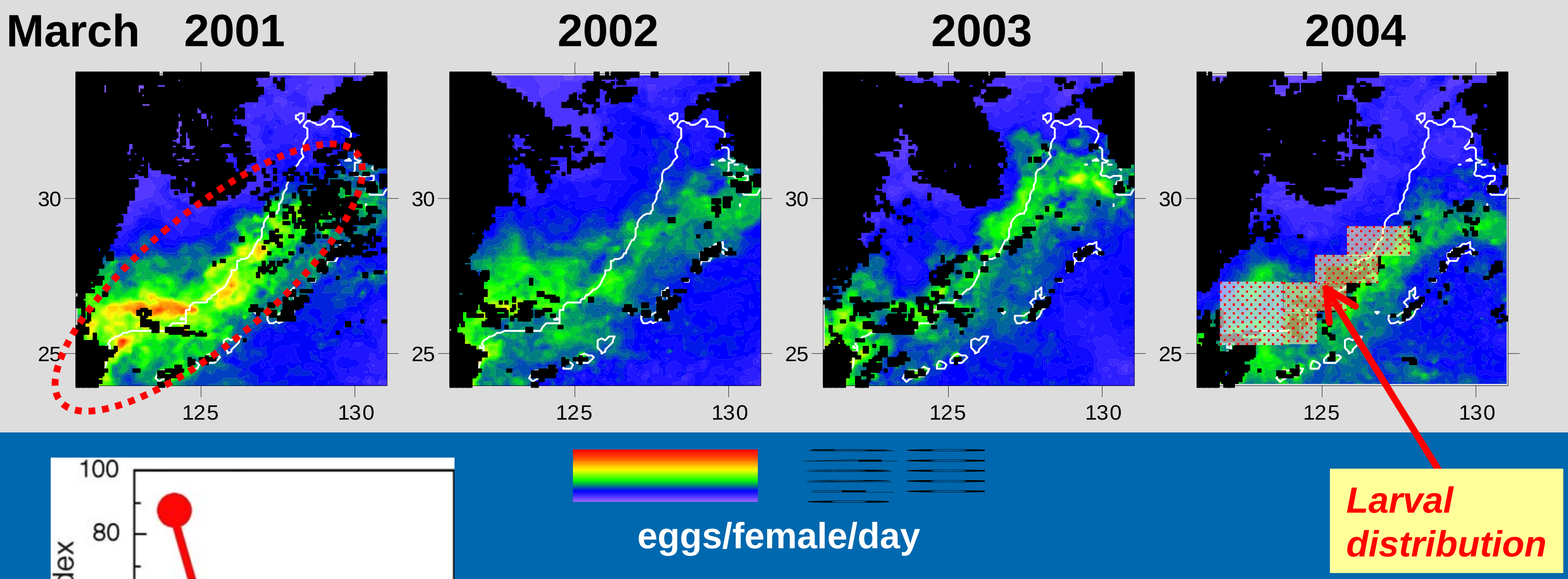
Parameter values for *Paracalanus*

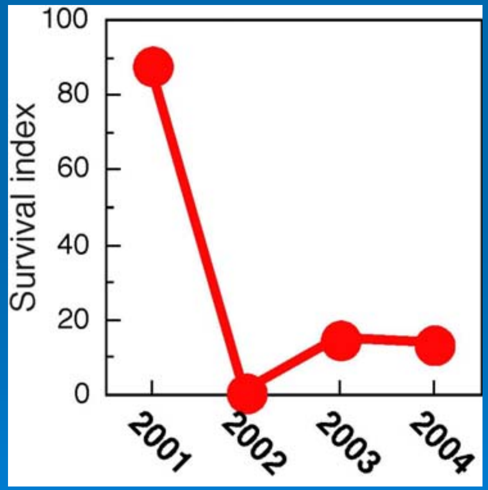
1. MaxEP: 60 d^{-1} at 24˚C (Uye & Shibuno 1992)
2. θ : temperature coefficient 6˚C (Prestidge et al. 1995)
3. T: Monthly average sea surface temperature (after AVHRR [NOAA])
4. Chl. *a*: Monthly average chlorophyll *a* concentration (after SeaWiFS [NASA])



Characteristics of this model

Year-to-year variation of the copepod egg production rate





Year-to-year fluctuation of survival during postlarval and juvenile stages

The copepod egg production rate in 2001 was much higher than the rates in 2002–2004.

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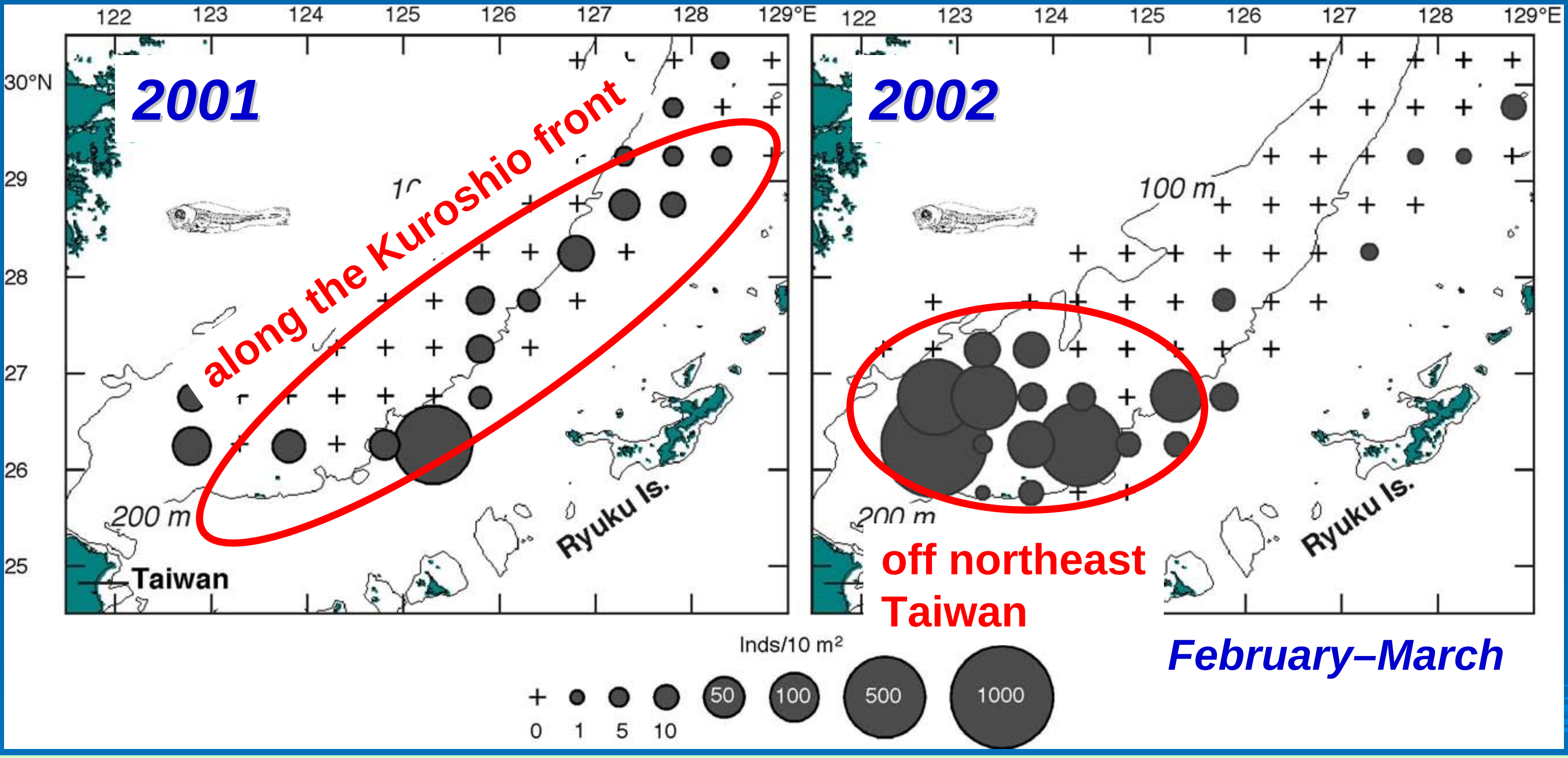
The higher survival in 2001 might be related to the high food availability.

Possibilities (3)

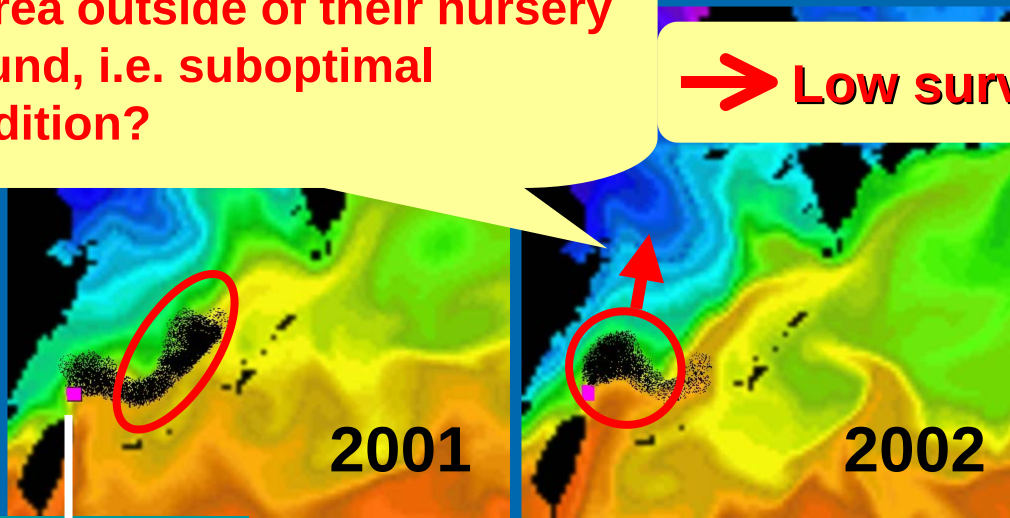
Year-to-year variation of larval transport condition



Transport condition	Good	Poor

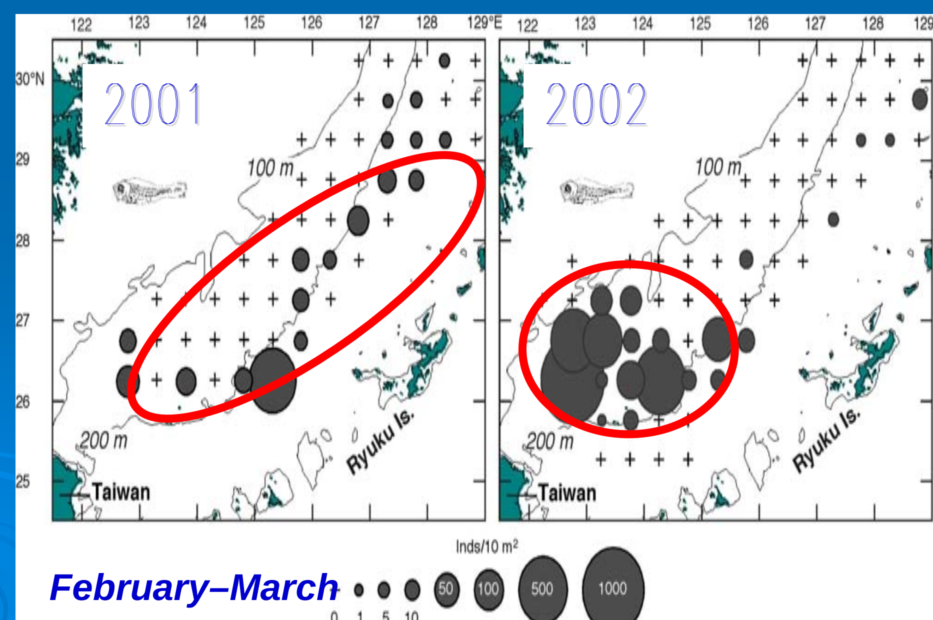
In 2002 larvae were transported to area outside of their nursery ground, i.e. suboptimal condition?

→ Low survival?



Release point

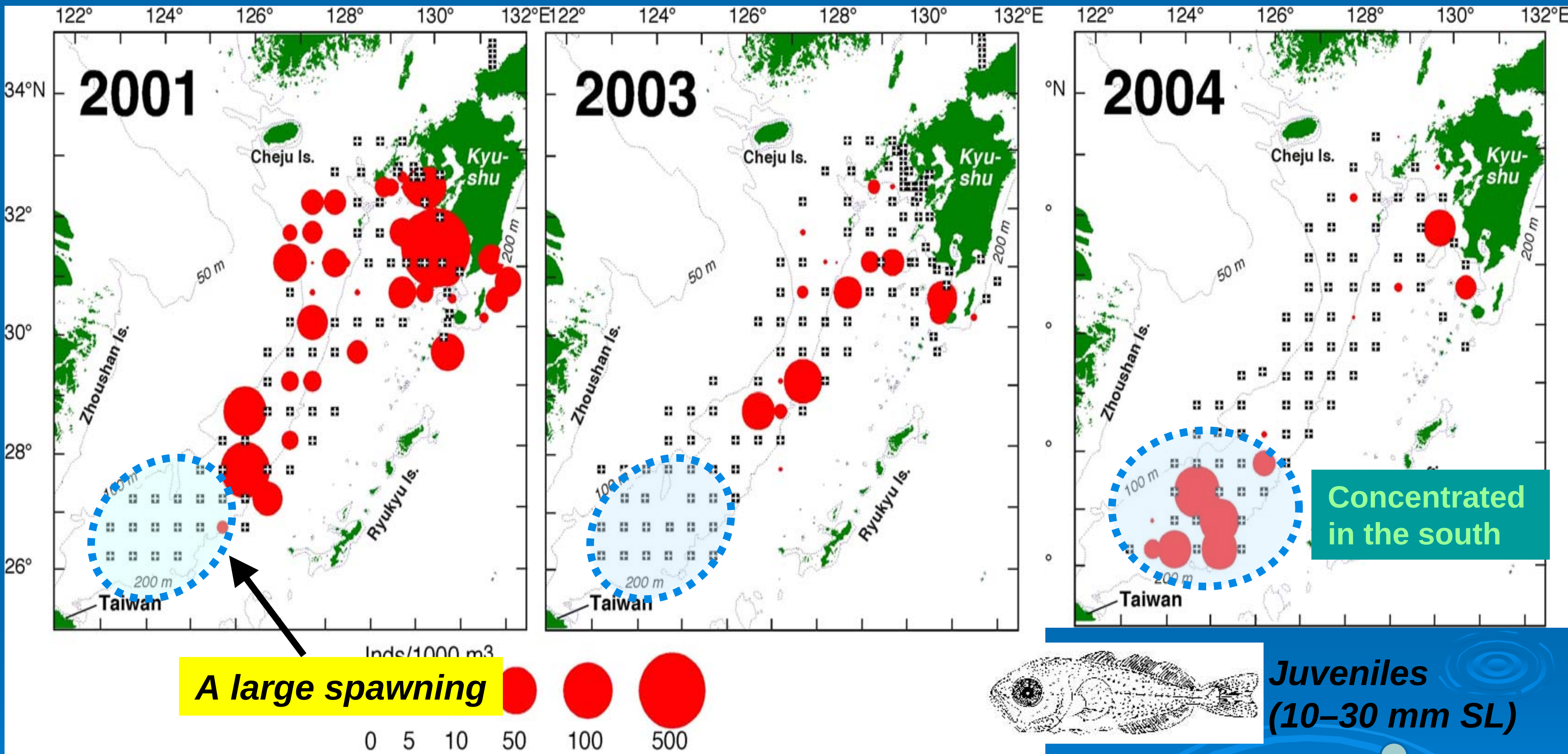
The particle-tracking model by Komatsu



Larval transport conditions in the southern ECS

Horizontal distribution of the juveniles in April 2001 & 2003 *vs.* 2004

Different pattern



Concentrated in the south

A large spawning

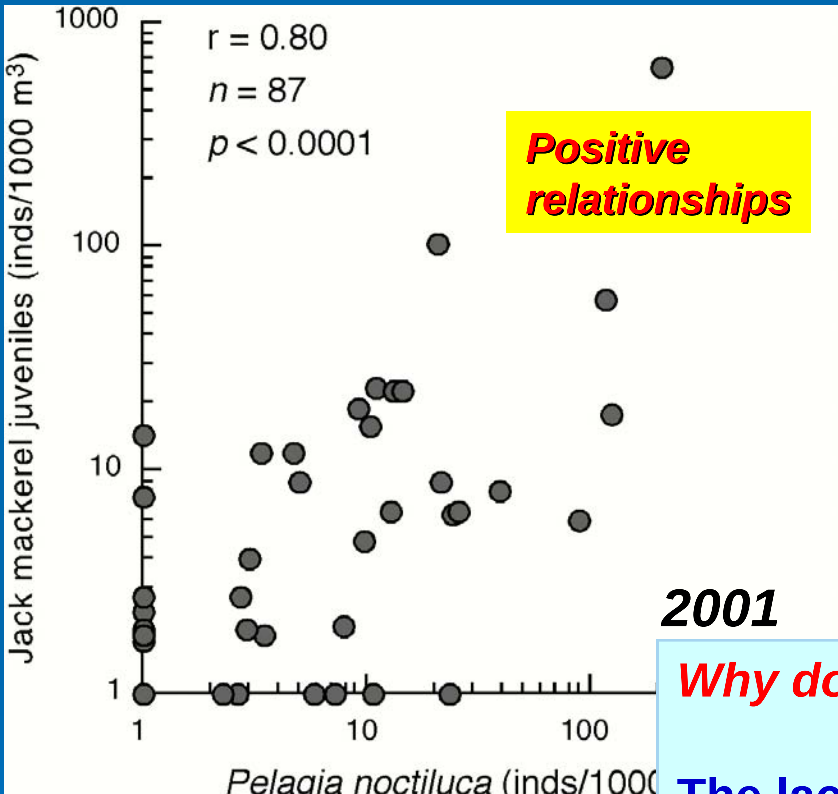
Juveniles (10–30 mm SL)

Larval transport condition from the spawning ground to nursery ground varied largely year-to-year.

Possibilities (4)

Year-to-year variation of medusa (*Pelagia noctiluca*) abundance

Late stage larvae and juveniles of jack mackerel associate with medusa.



Relationship between densities of mackerel juveniles and the medus ECS collected by the Neuston net.

Why do jack mackerel associate with medusae?

The lack of gelatinous material in the stomachs of jack mackerel

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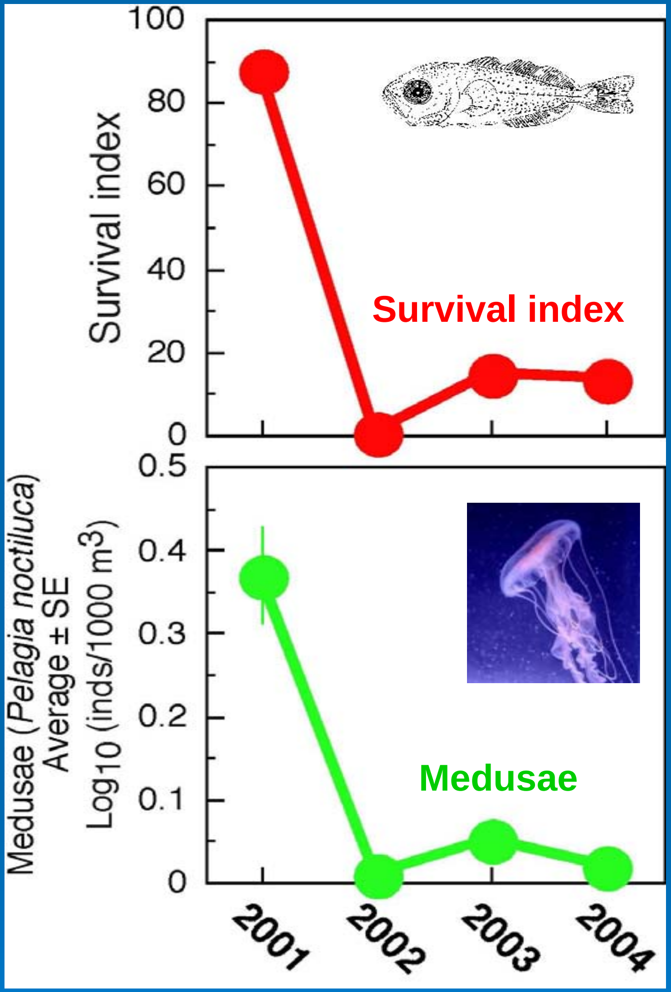
Jack mackerel juvenile associate to gain shelter from predation?

Year-to-year variation of the survival index *vs.* medusae abundance



In 2001 the medusae abundance in the neuston net samples was very high compared to 2002–2004. This might be related to the higher survival in 2001.

If these jack mackerel juveniles substantially decrease their vulnerability to predation by seeking shelter within medusae tentacles,

↓

this commensal behavior with medusae may have important implications relevant to jack mackerel recruitment dynamics in the East China Sea.

Conclusion (3)

1. The copepod egg production rate in 2001 was higher than in 2002–2004, corresponding well with the jack mackerel survival.

2. Yearly fluctuations of larval transport condition were observed, which would affect the survival and recruitment processes.

3. Yearly fluctuations of medusae abundance and jack mackerel survival rate corresponded well in the ECS.

Summary

1. We have found the location of the jack mackerel's main spawning ground and described the larval transport processes.

2. Survival during postlarval to juvenile stages in the ECS was important for determining their year-class strength.

3. We discussed the relationship between the yearly fluctuation of survival during early life stages and the environmental conditions.

Thank you very much

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