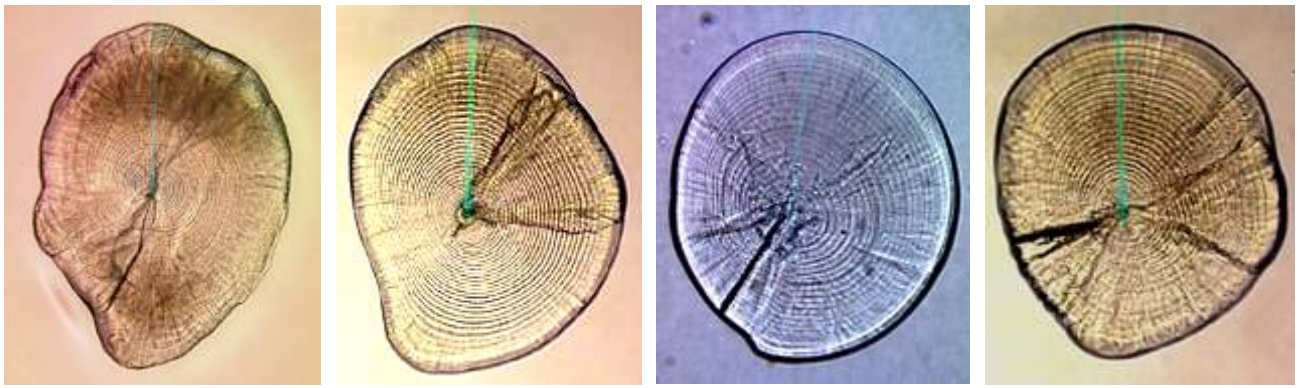
Growth of larval and early juvenile sardine (*Sardinops* spp.) and anchovy (*Engraulis* spp.) in the eastern and western North Pacific Ocean

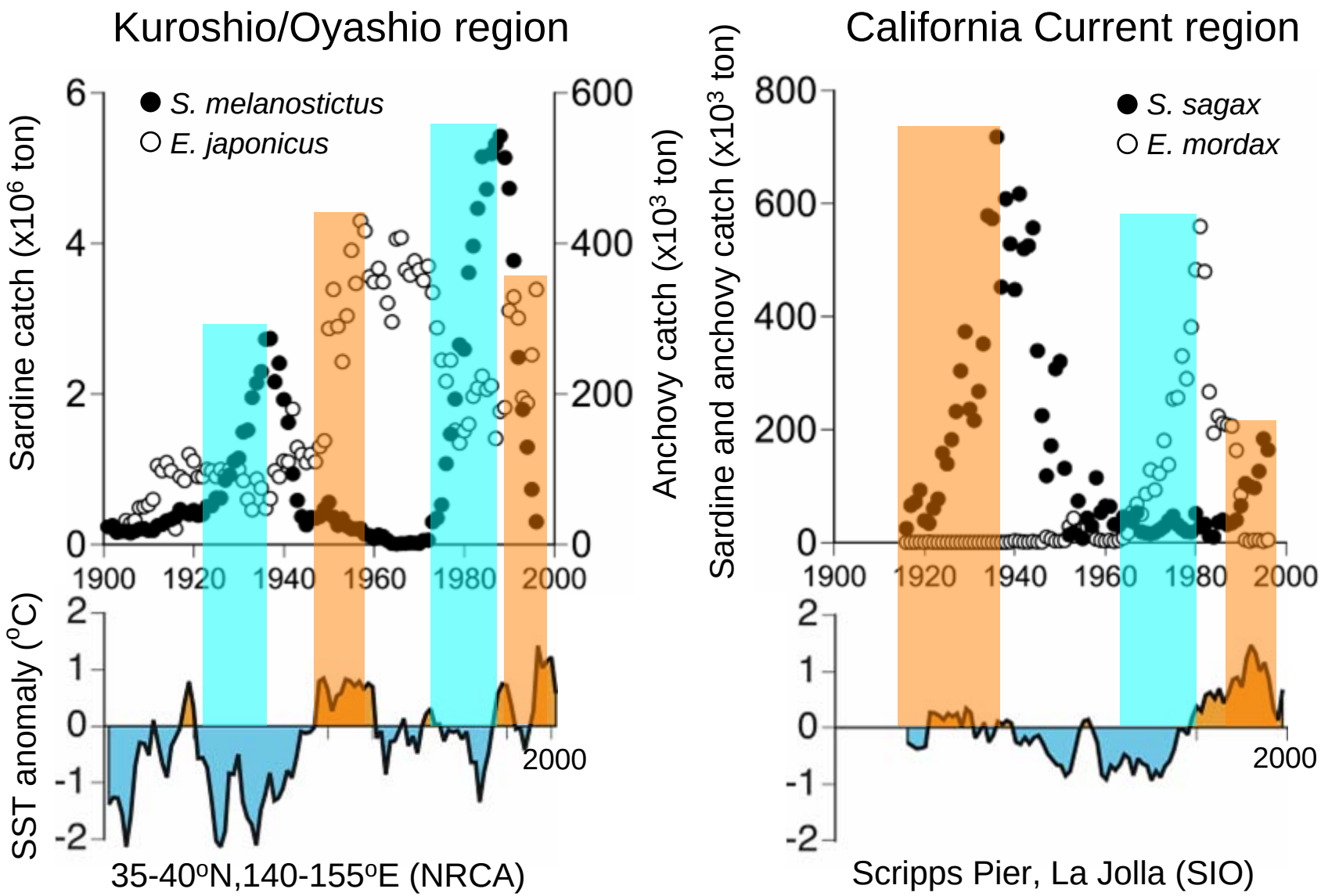


S. melanostictus *S. sagax* *E. japonicus* *E. mordax*

Motomitsu Takahashi, David M. Checkley Jr., Akihiko Yatsu and Yoshiro Watanabe

Scripps Institution of Oceanography, UCSD
(takahamt@coast.ucsd.edu)

Change in fishery catch for *Sardinops* and *Engraulis* and sea surface temperature in the 20th century



Studies on growth rate-dependent recruitment for *Sardinops* and *Engraulis*

Growth rates after metamorphosis were positive function of recruitment abundance in *S. melanostictus*.

(Takahashi et al. in preparation)

Late larvae with faster growth rates had greater probability of successful recruitment to the adult population than those with slower growth rates in *E. japonicus*.

(Takahashi and Watanabe 2004)

Growth rates during larval stage are critical determinant of population growth in *S. sagax* and *E. mordax*.

(Lo et al. 1995)

We hypothesize that differential growth due to different environmental conditions causes the out-of-phase population dynamics between the eastern and western N Pacific Ocean.

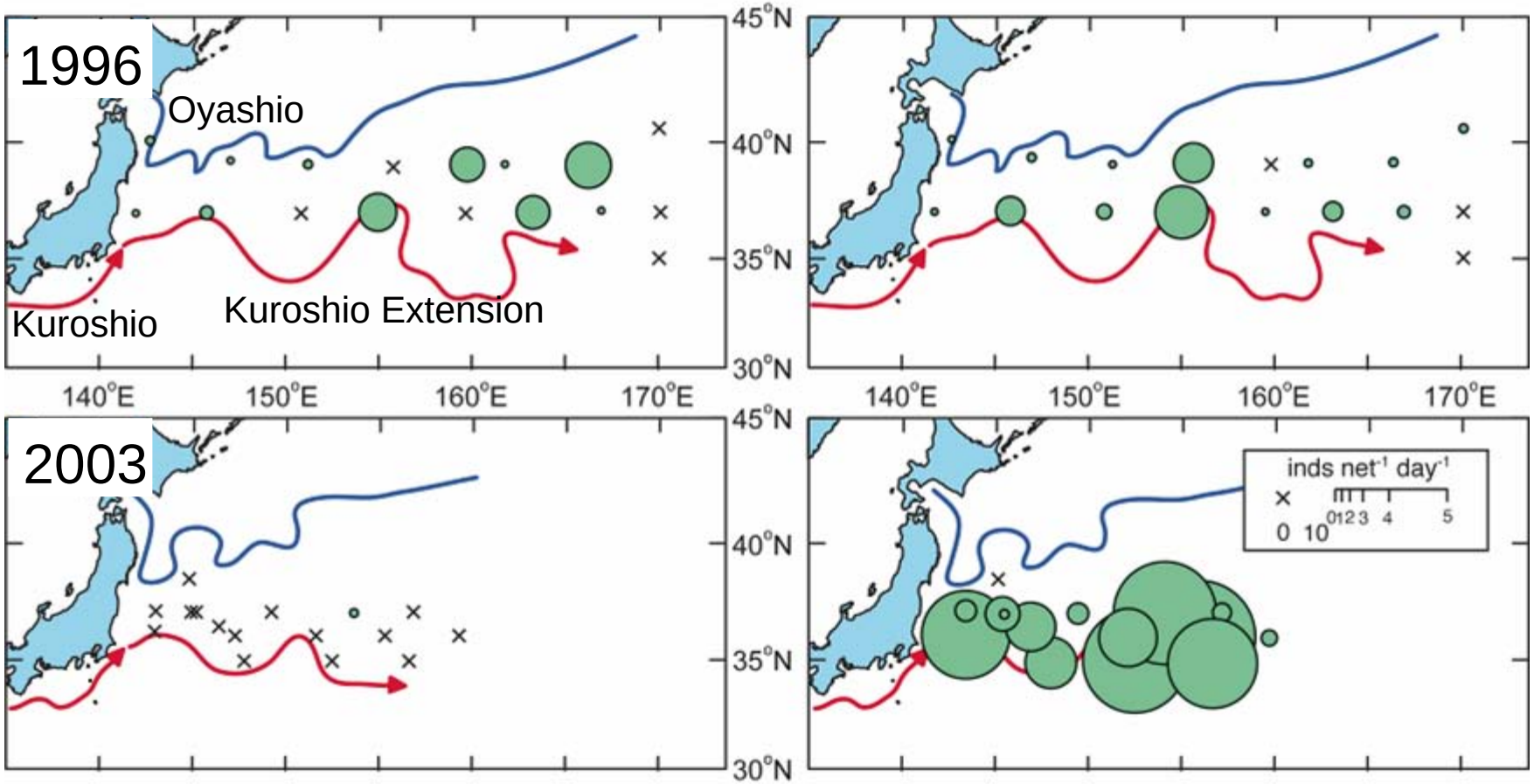
Objectives

Effects of temperature and food on growth rates during late larval and early juvenile stages of sardine (*Sardinops*) and anchovy (*Engraulis*) in the eastern and western North Pacific Ocean

- Somatic and otolith growth
- Growth standardization
- Growth variations in relation to SST and prey density
- Conclusions

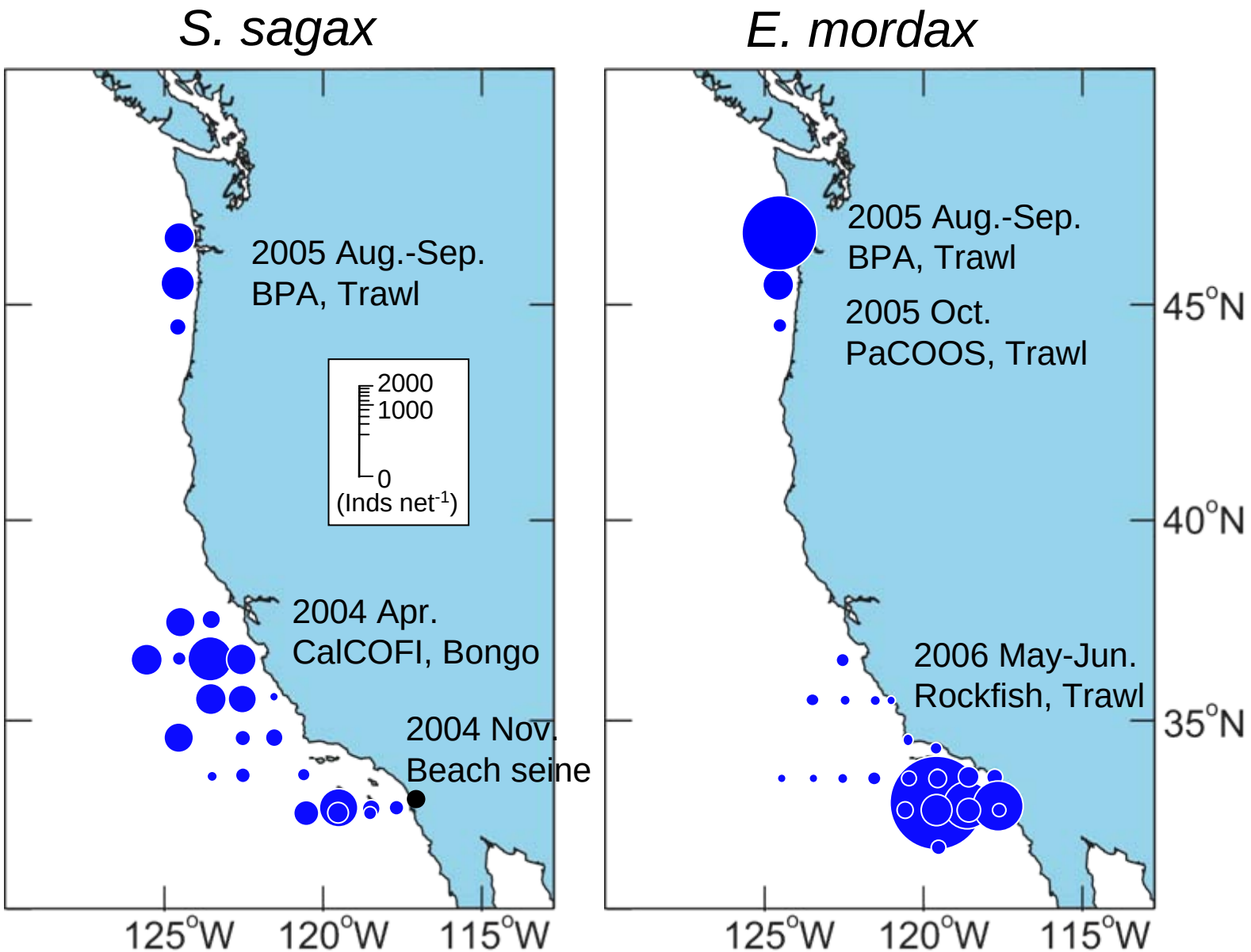
Occurrence of sardine and anchovy in Kuroshio-Oyashio transitional waters

S. melanostictus *E. japonicus*

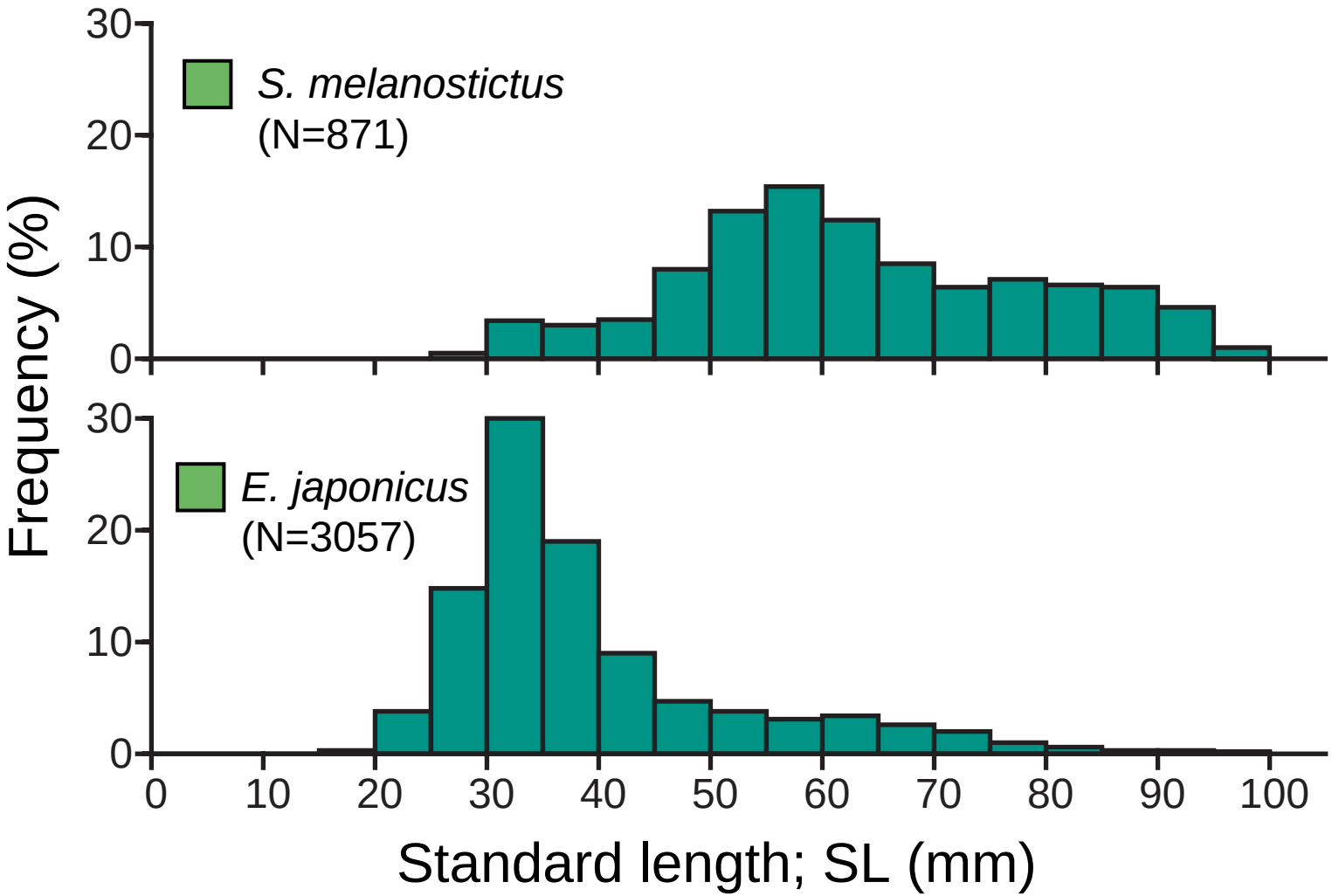


1996-2003, May-Jun., FRA cruise, Trawl

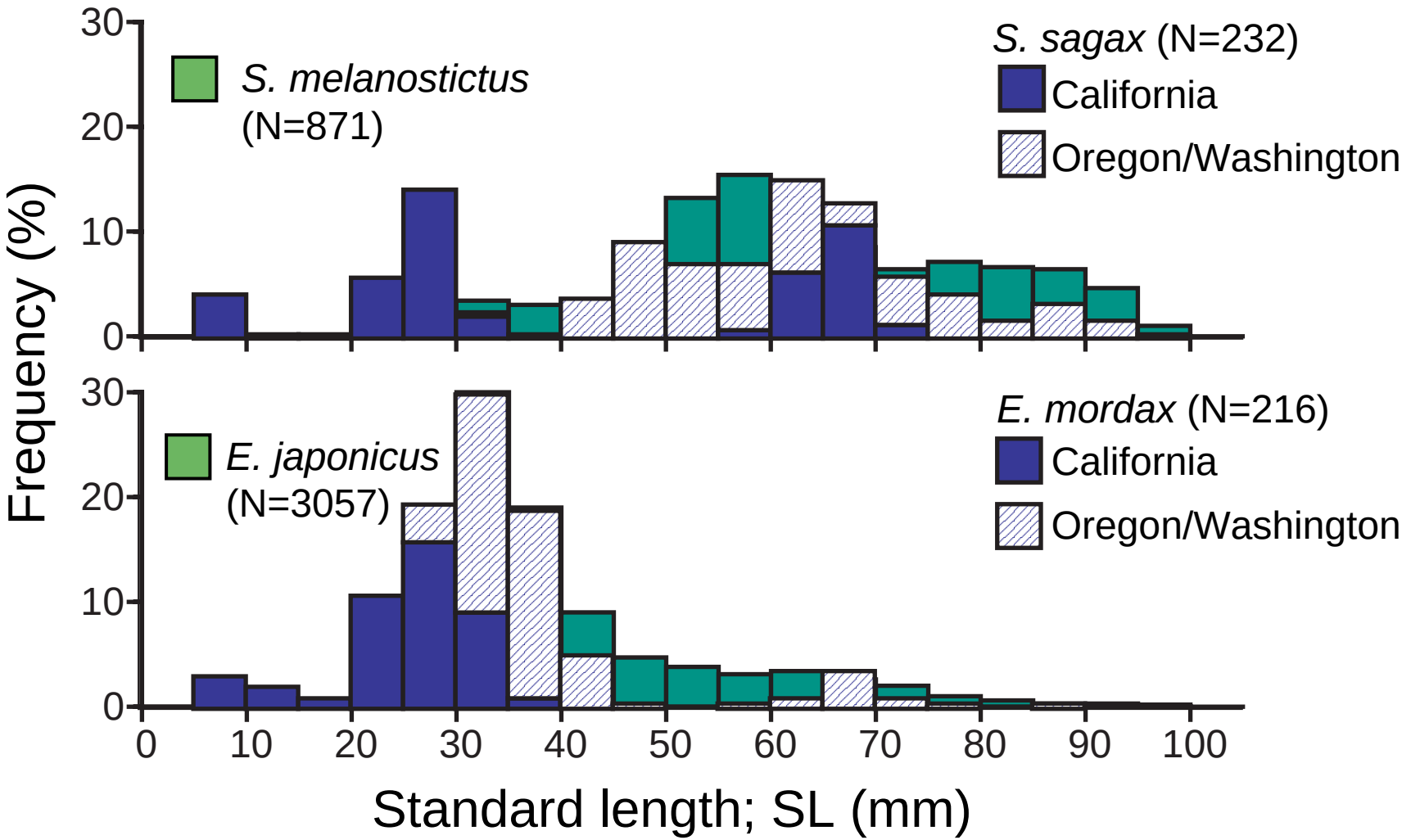
Occurrence of sardine and anchovy in California Current region



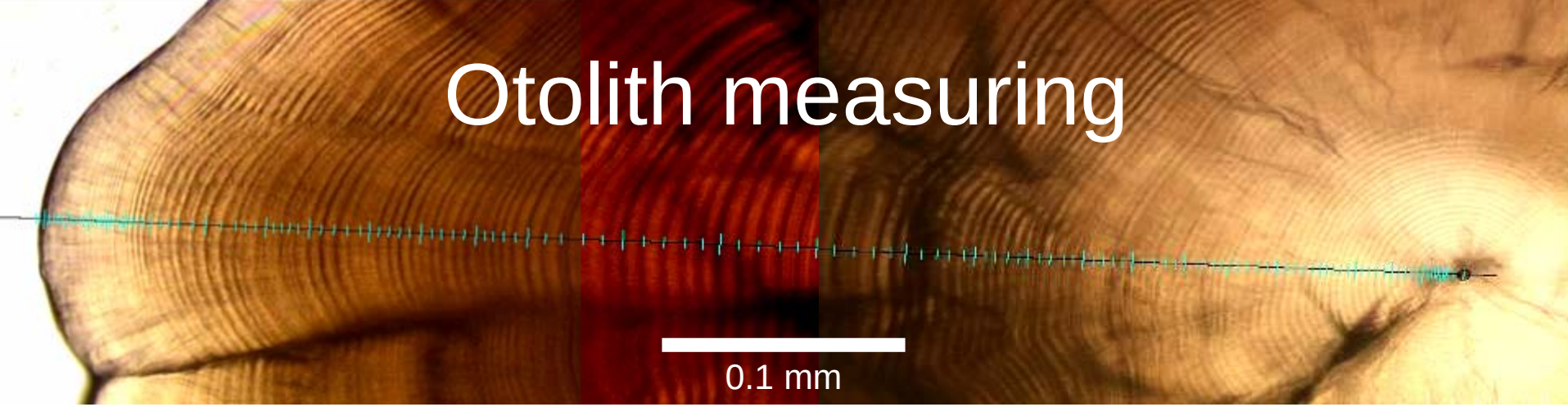
Frequency distribution of SL



Frequency distribution of SL



Otolith measuring



Otolith of juvenile *S. sagax* (65.8 mm SL, 150 days after hatching)

Measuring

- Number of increments (N)
- Width of increments (IW)
- Otolith radius (OR)

Age in days

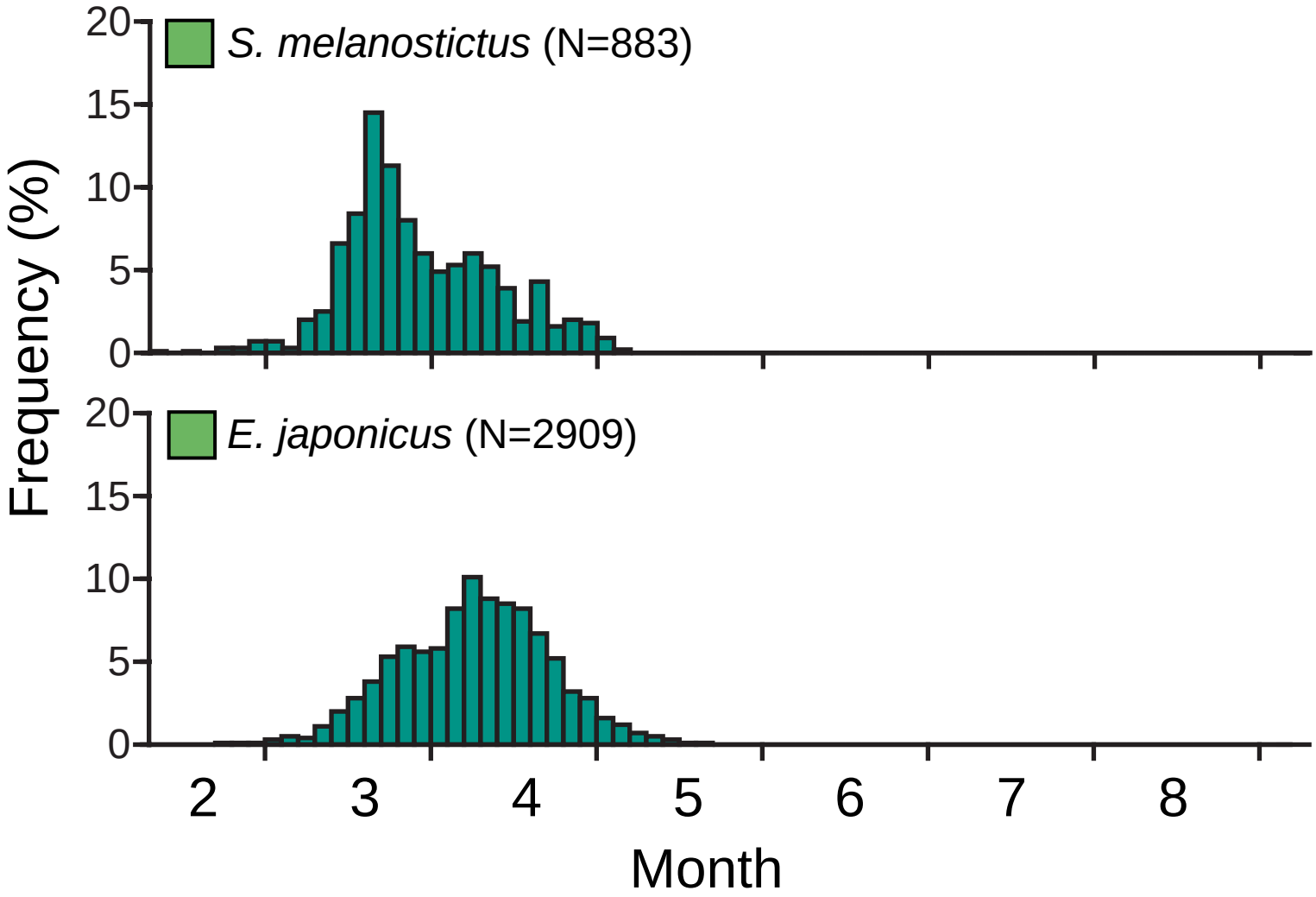
- N + 2 (*S. melanostictus*)
- N + 3 (*E. japonicus*)
- N + 3 (*S. sagax*)
- N + 4 (*E. mordax*)

Otolith measurement system
(Ratoc System Engineering Co., Ltd.)

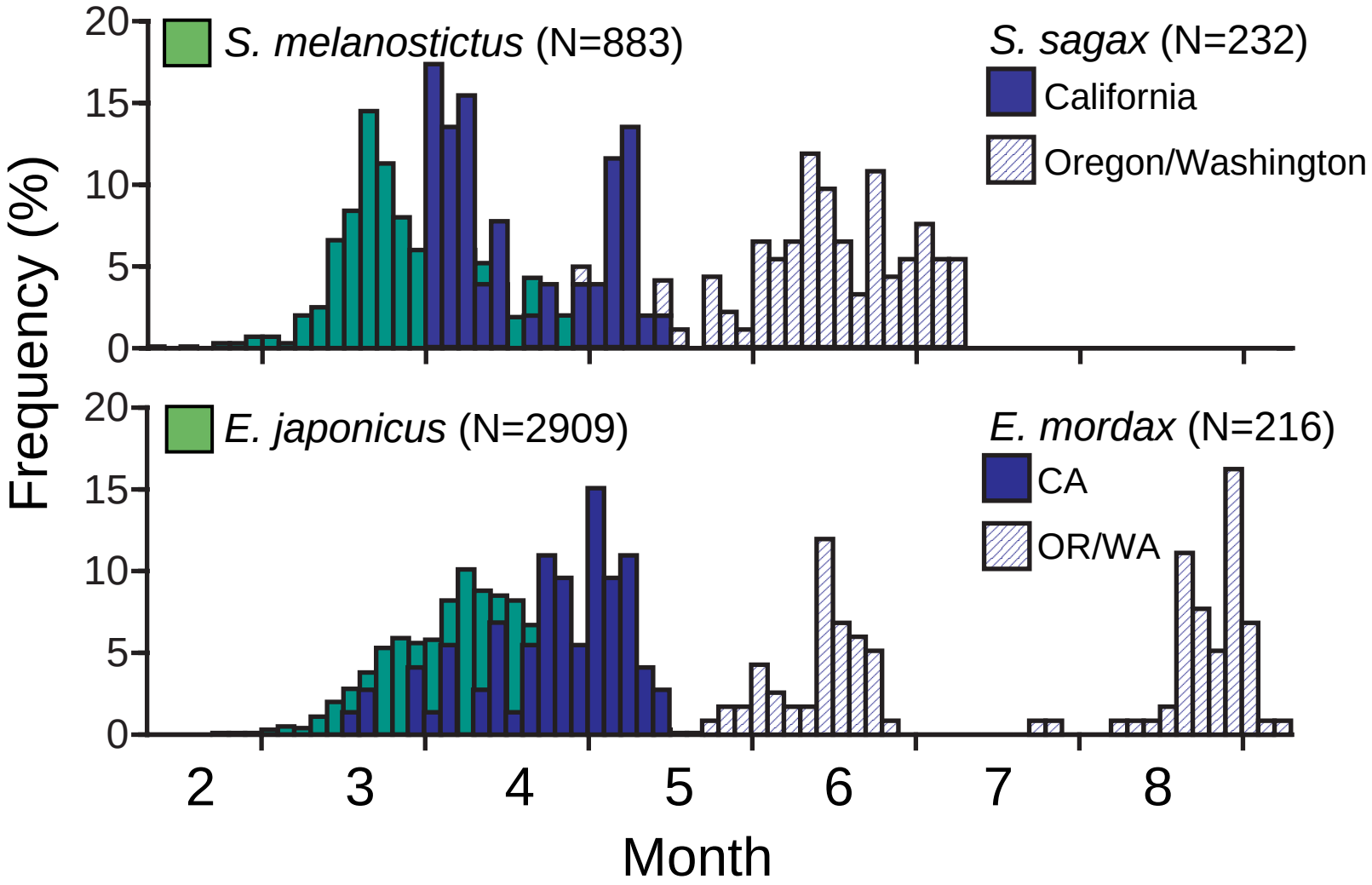
Yokohama

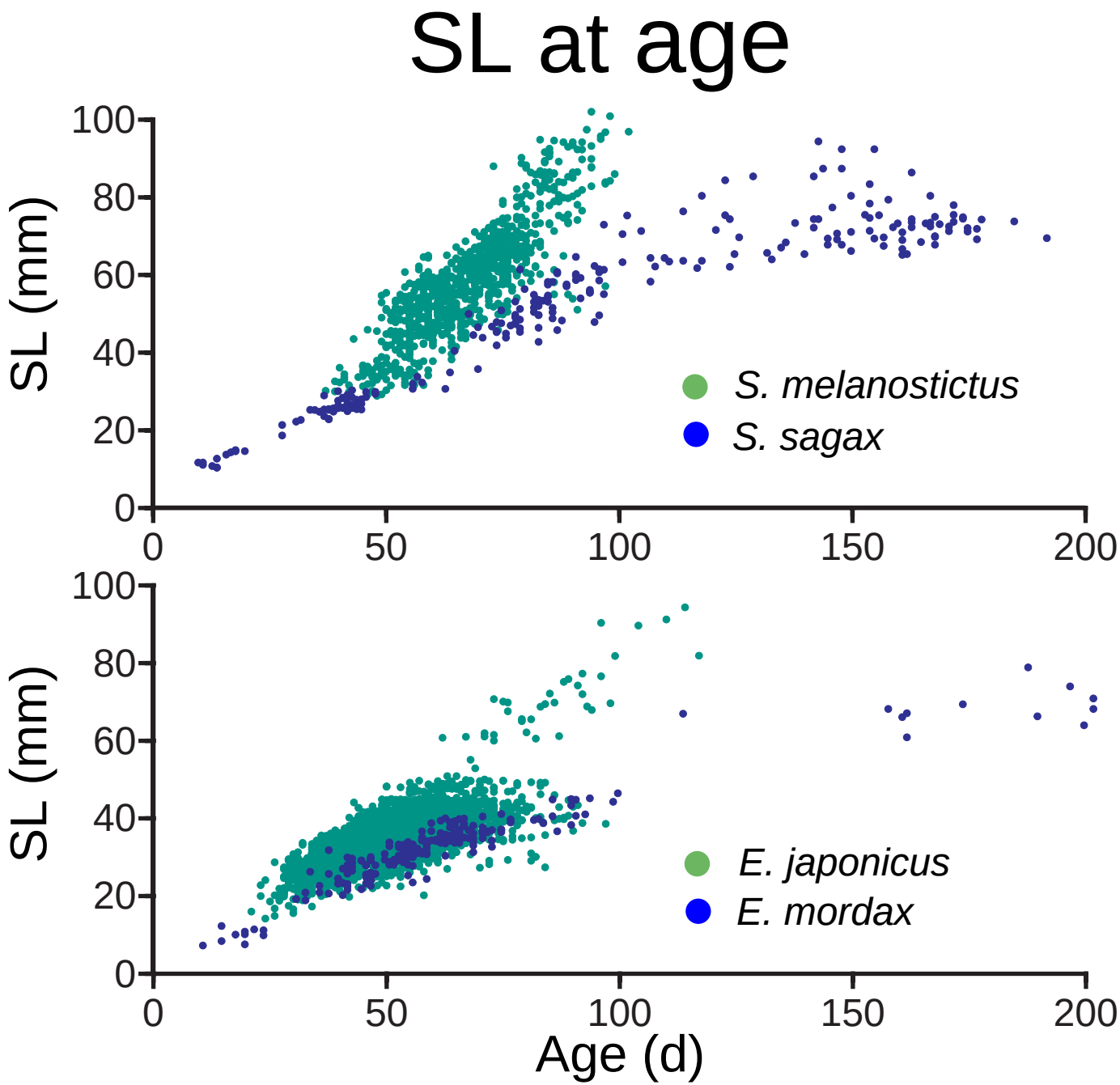
La Jolla

Frequency distribution of hatch dates

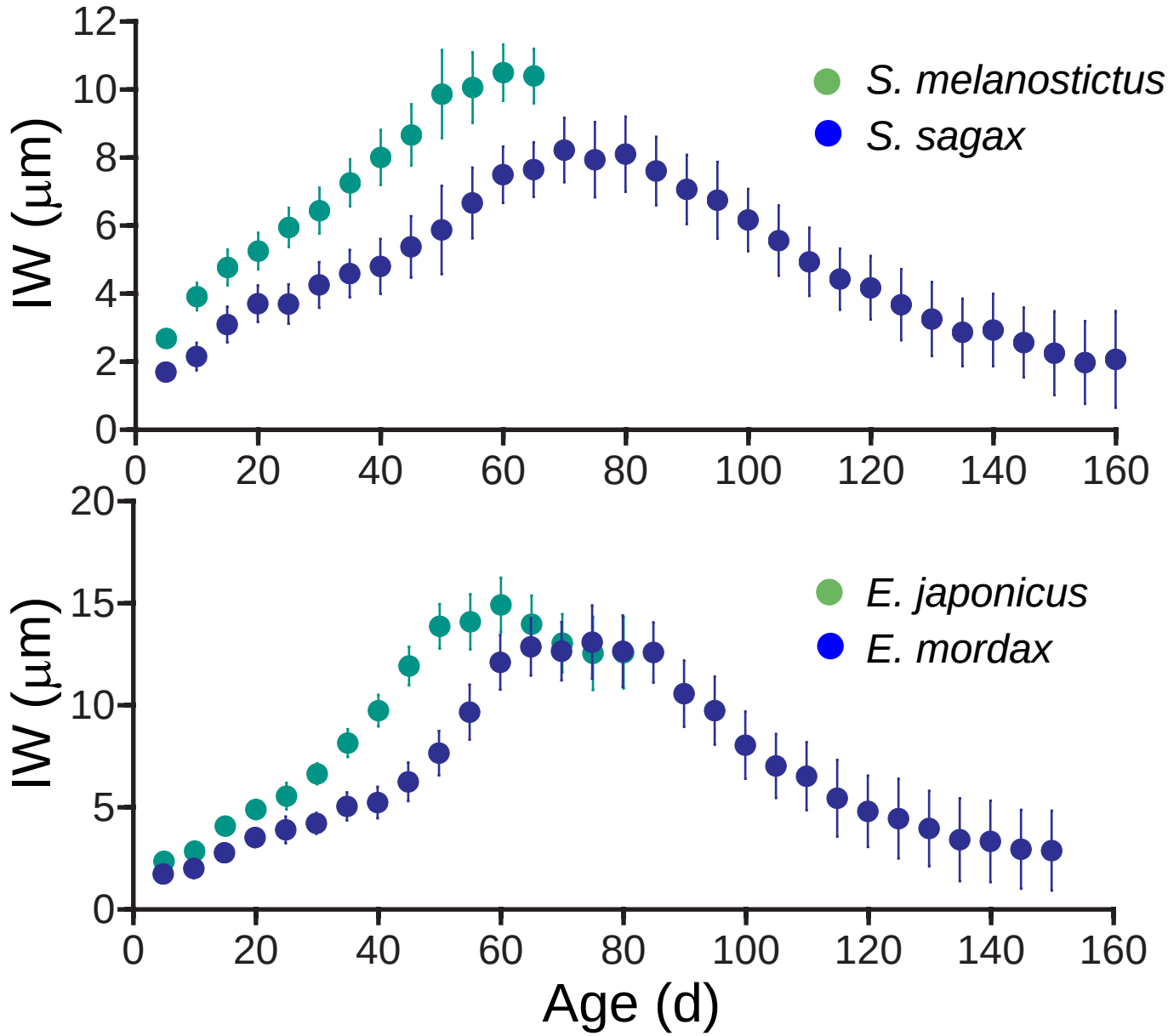


Frequency distribution of hatch dates

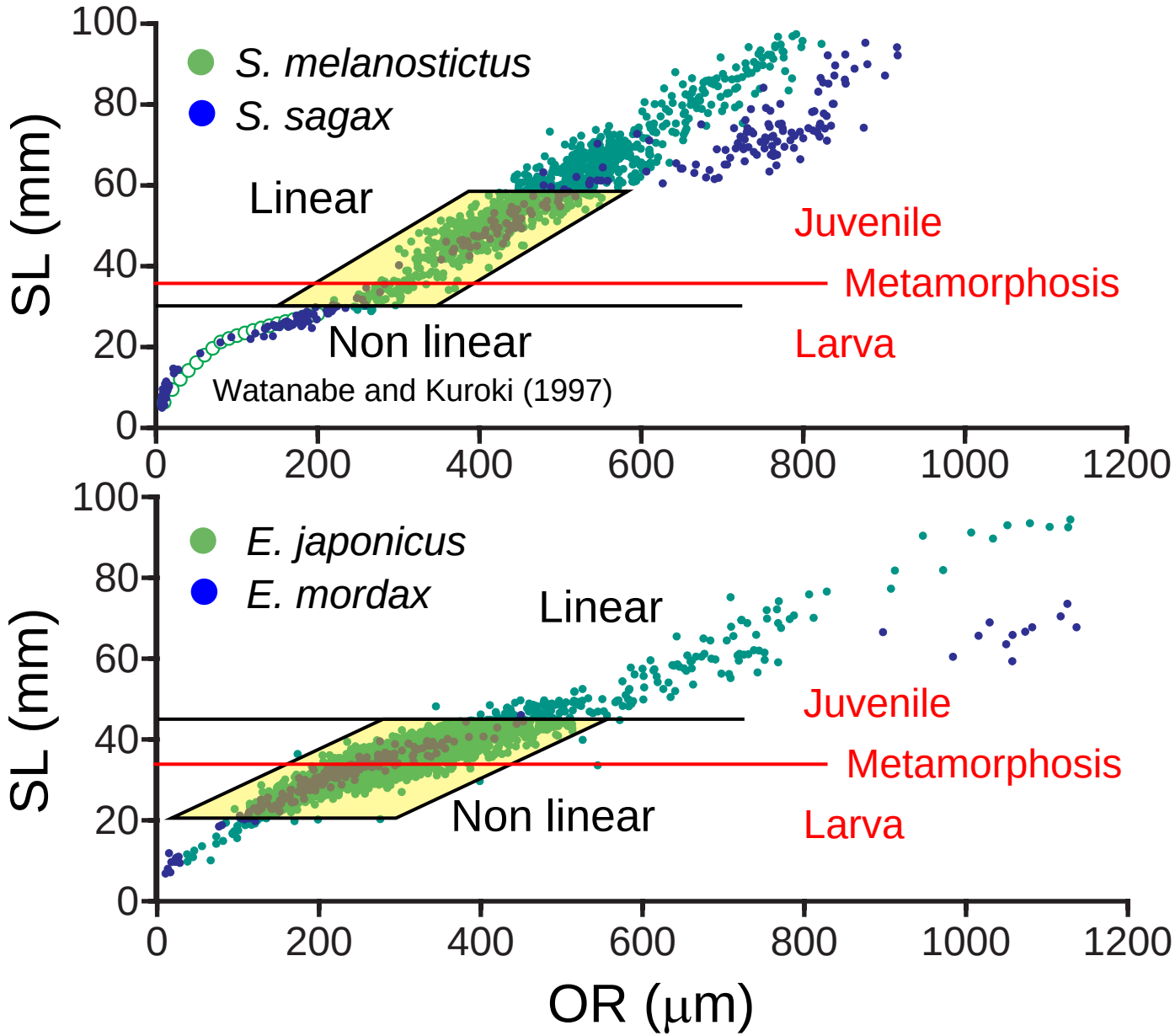



SL at age
SL (mm)
100
80
60
40
20
0
0
50
100
150
200
S. melanostictus
S. sagax
SL (mm)
100
80
60
40
20
0
0
50
100
150
200
E. japonicus
E. mordax
Age (d)

Increment width (IW) at age of 60-80 mm SL fish

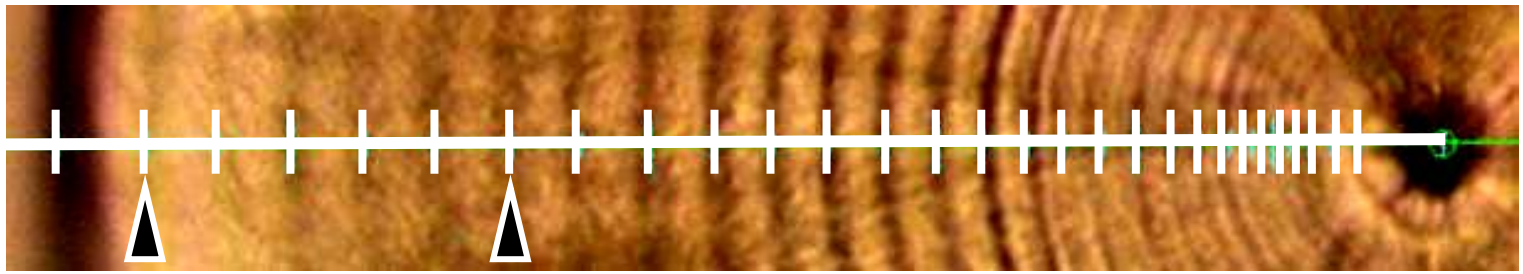


Otolith radius (OR) and SL



How to backcalculate growth

Biological Intercept Method (Campana 1990)



BL_{last} BL_{last-5}

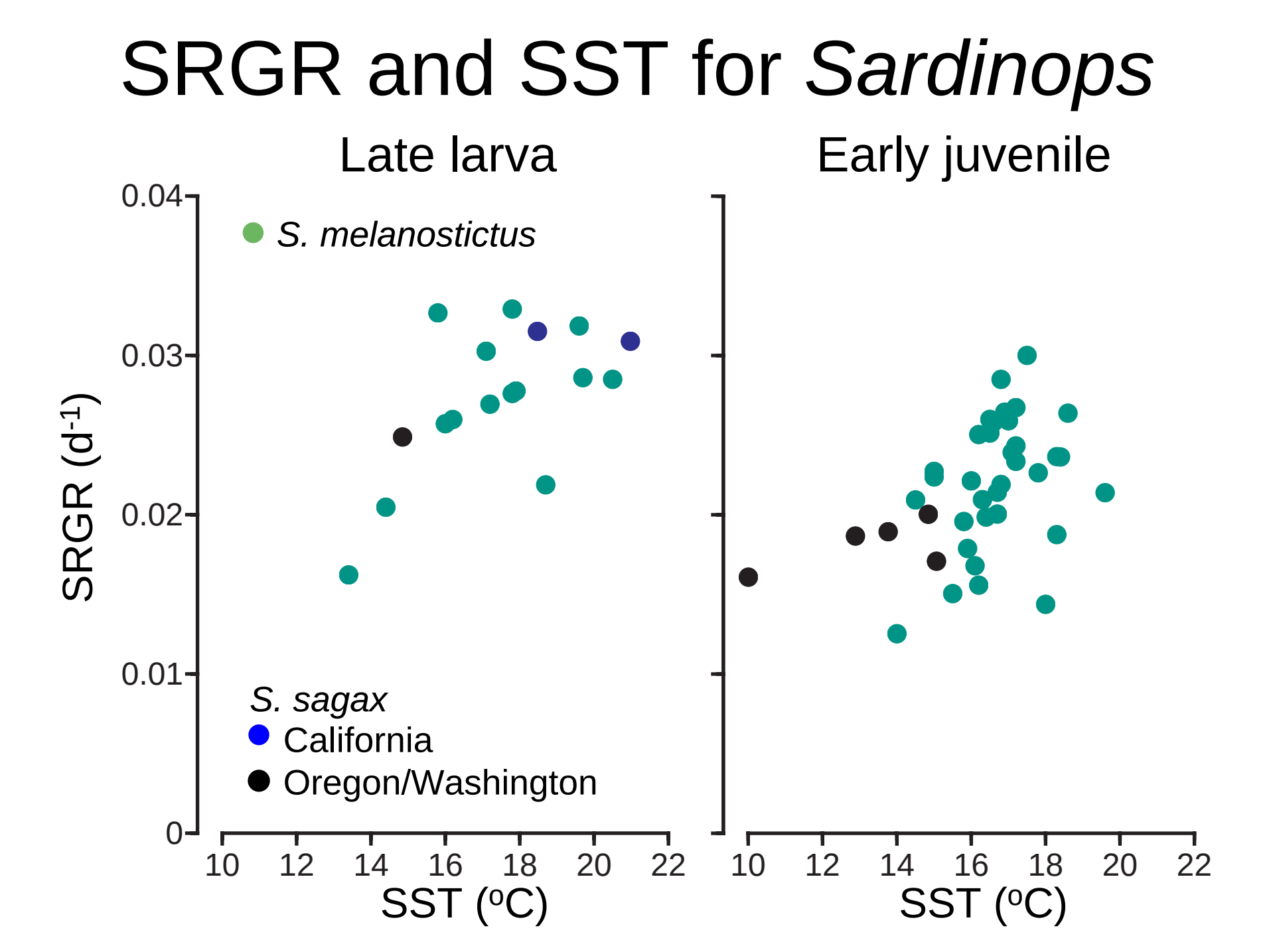
BL_{last} : Backcaluculated SL at deposition of the last increment

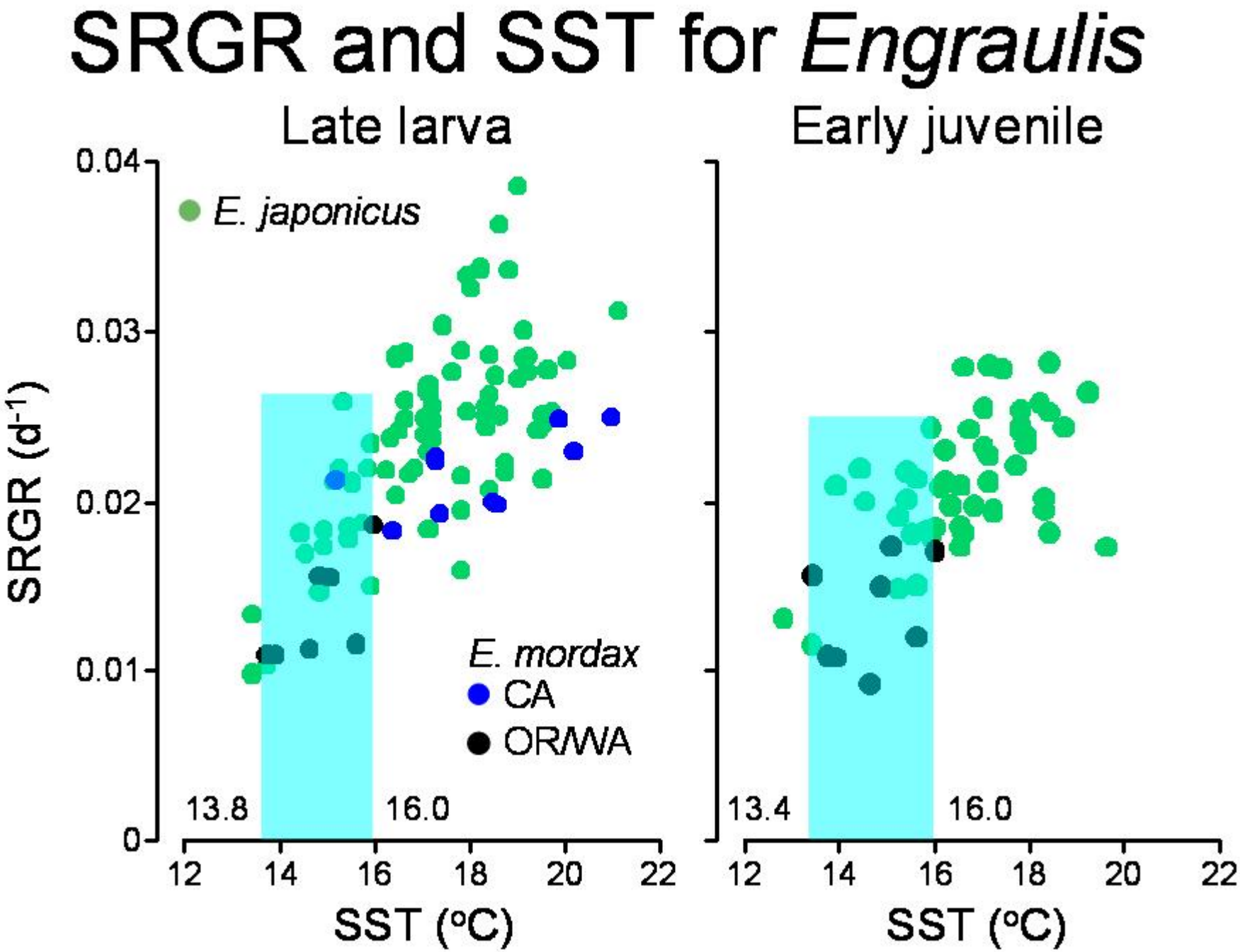
BL_{last-5} : Backcaluculated SL at 5 days before the last deposition

Standardized recent growth rate (SRGR, d^{-1})

$$SRGR = (\ln BL_{last} - \ln BL_{last-5}) / 5$$

(Jones 2002)

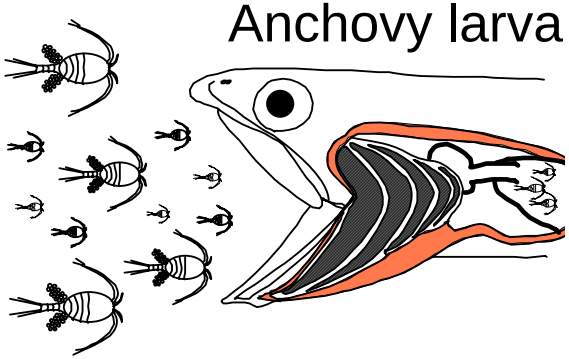

SRGR and SST for Sardinops
Late larva
Early juvenile
0.04
0.03
0.02
0.01
0
SRGR (d-1)
S. melanostictus
S. sagax
California
Oregon/Washington
10
12
14
16
18
20
22
SST (ºC)
SST (ºC)

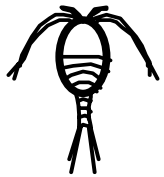

SRGR and SST for *Engraulis*
Late larva
Early juvenile
SRGR (d-1)
0.04
0.03
0.02
0.01
0
E. japonicus
E. mordax
CA
OR/WA
13.8
16.0
13.4
16.0
12
14
16
18
20
22
SST (°C)
SST (°C)

SRGR and available prey density for *Engraulis*

Available copepod size

Anchovy larva





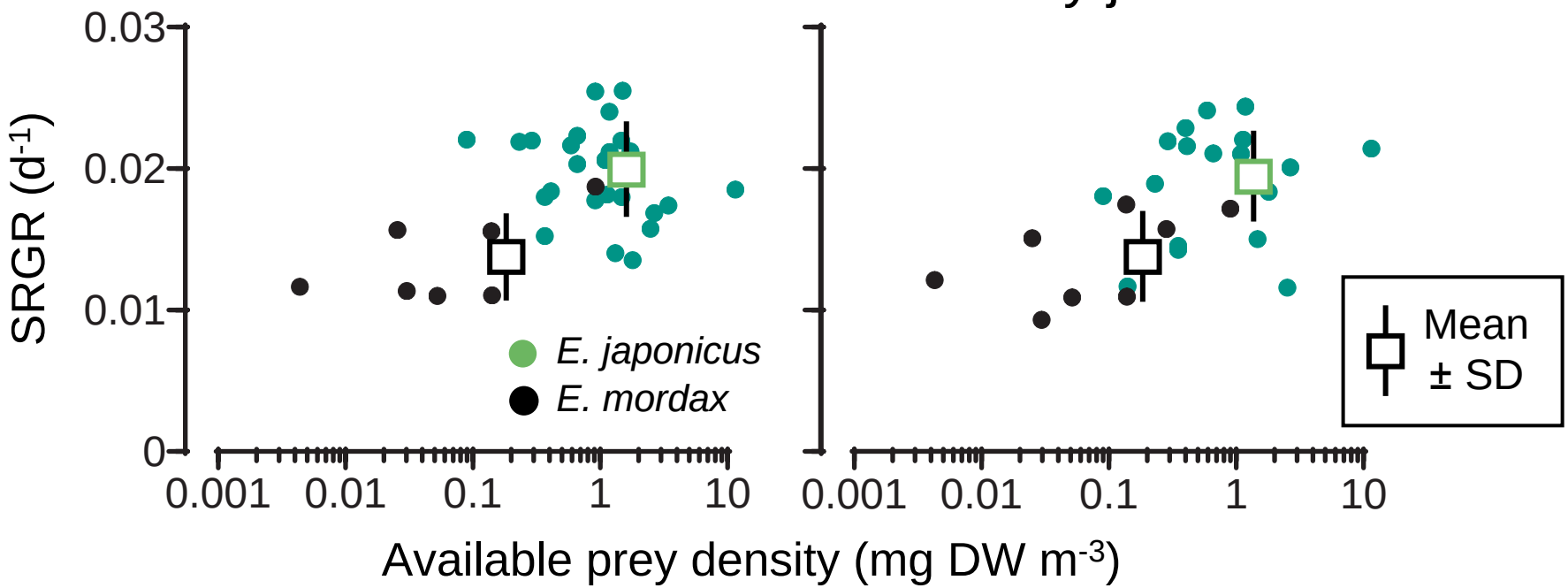
Prosome width
200-600 μm
(Uotani 1985)

Zooplankton collection

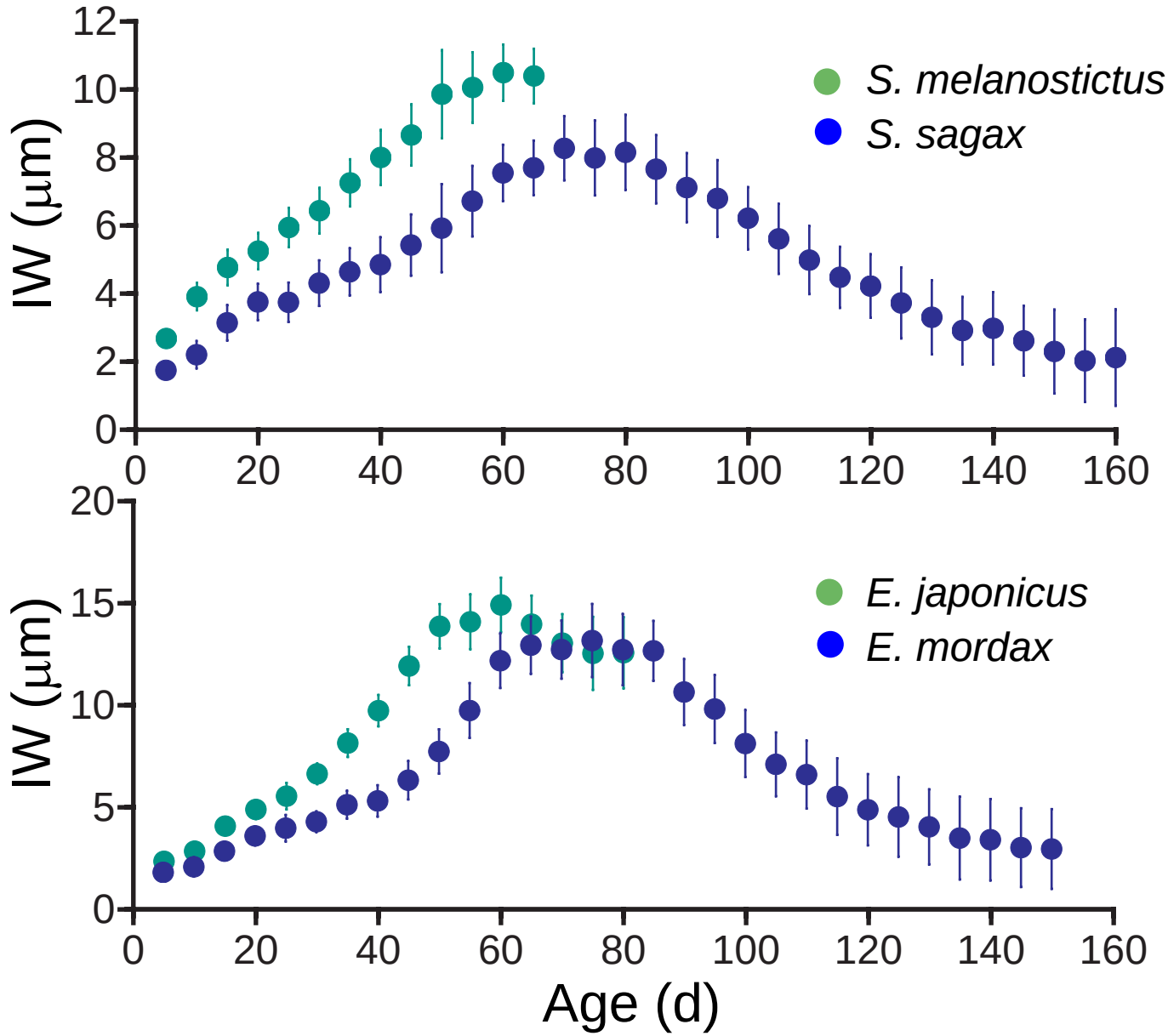
	KOTW	OR/WA
Mesh	335 μm	200, 335 μm
Depth	150 m	100 m

Late larva

Early juvenile



Increment width (IW) at age of 60-80 mm SL fish



Conclusions

- Somatic and otolith growth rates of *Sardinops* and *Engraulis* were faster in the KOTW than in the CCT
- We were unable to separate temperature and food effects on *Sardinops* growth rates
- SRGR of *E. japonicus* was faster than *E. mordax* in the SST range for 13-21°C
- Slower SRGR of *E. mordax* off Oregon/Washington was caused by lower concentration of available copepod

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