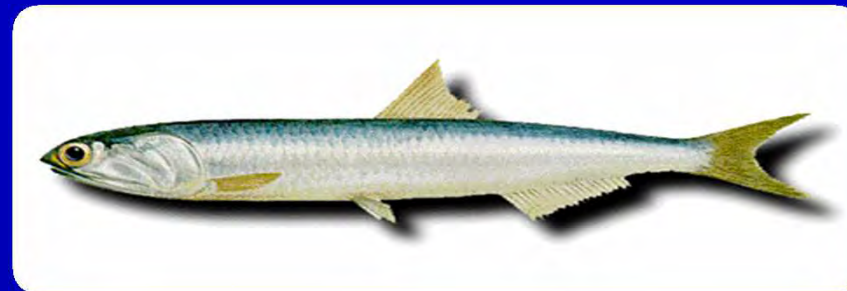


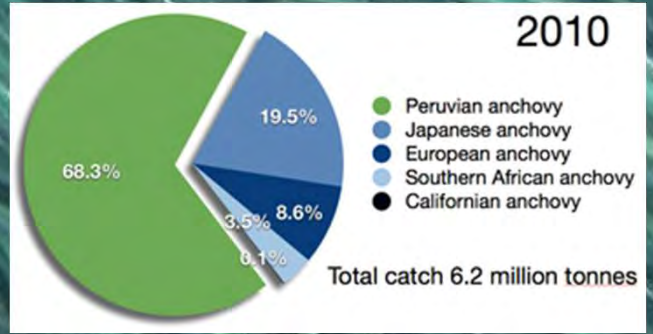
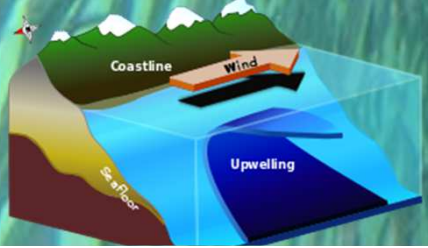
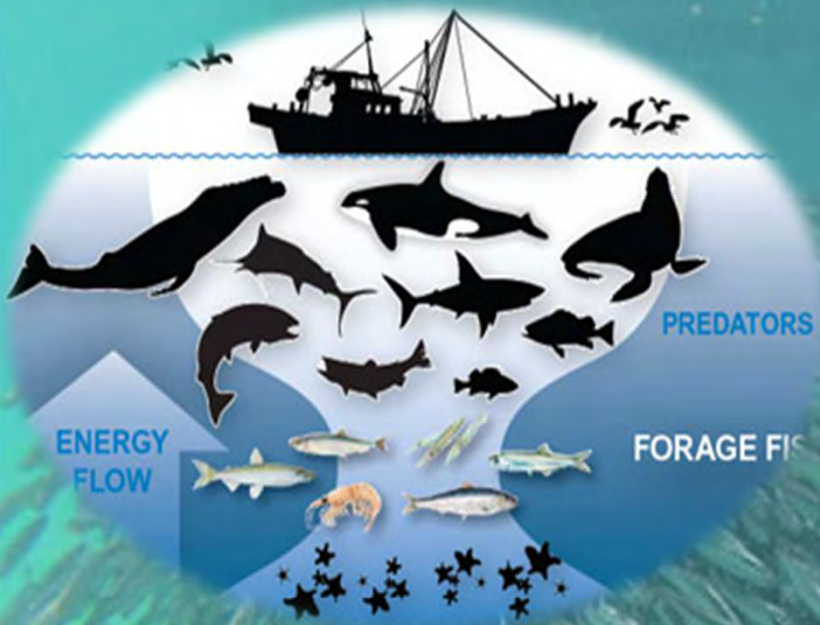


Fast growth and early age-at-recruitment of the anchovy (*Engraulis ringens*): Evidence from interannual monitoring of otolith microstructure in northern Chile

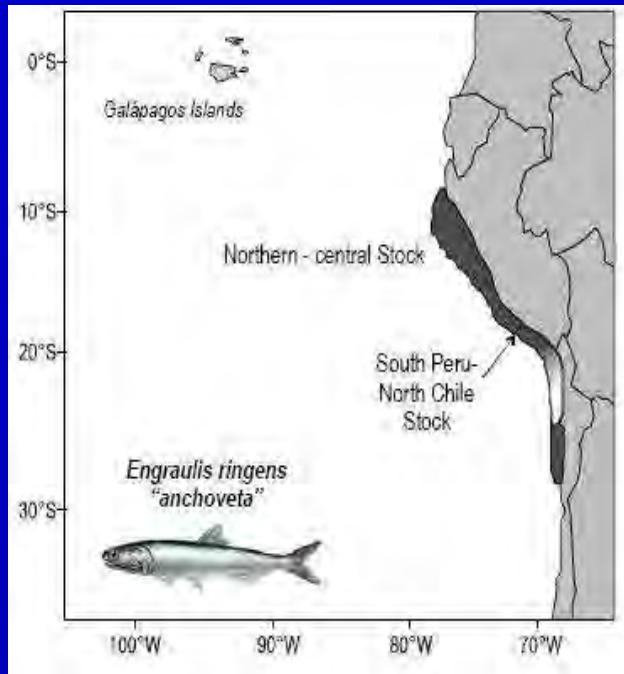
Guido Plaza & Francisco Cerna

*Escuela de Ciencias del Mar, Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile
División de Investigación Pesquera ; Instituto de Fomento Pesquero (IFOP)*





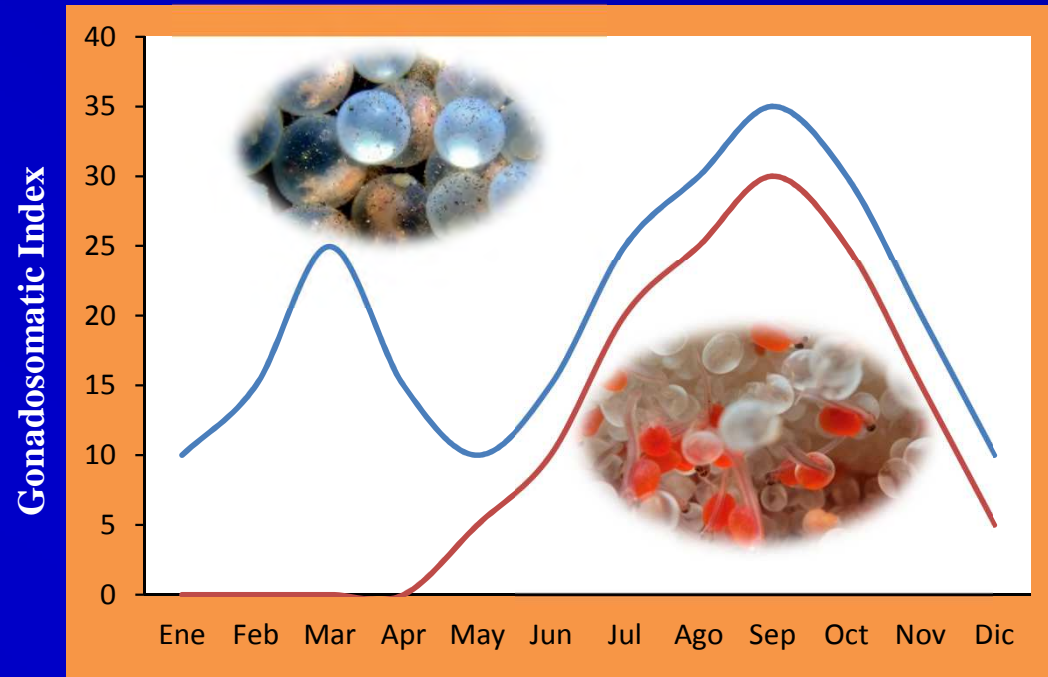
CURRENT WORK IN THE PERUVIAN ANCHOVY



(Chirinos de Vildoso & Chúman
1968; Aguayo 1980)

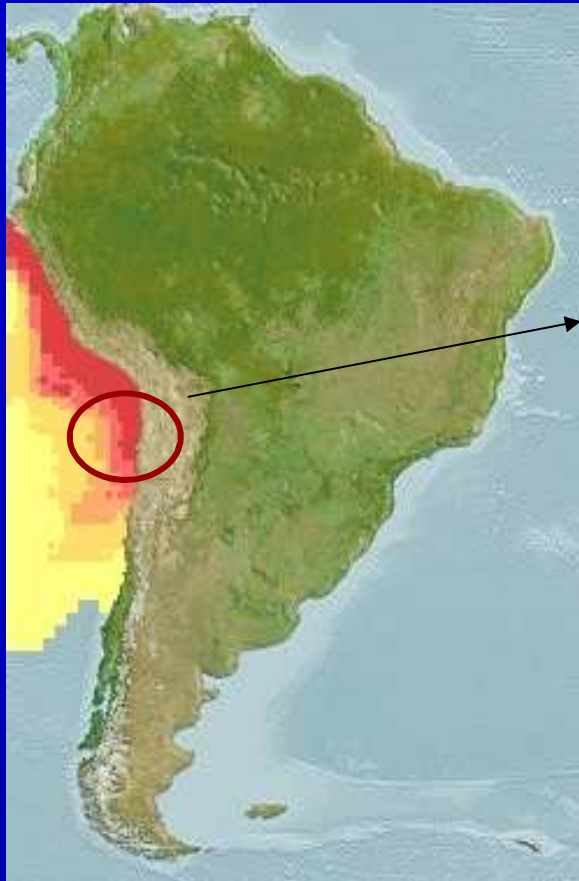


Short-living: 4-5 years
Maximum Length : 18-20 cm



Recruitment pulses all year
around

CURRENT WORK IN THE PERUVIAN ANCHOVY

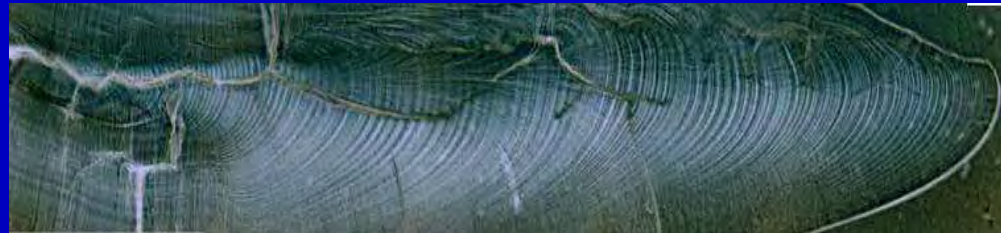


Several early life history traits are still unknown for this species

2009: Line of research in age-at-recruitment and growth patterns at the daily level for juveniles and adults of this species in northern Chile



Otolith micro-structure analysis



Hatch date of recruits

Validate the time of formation of the first annulus

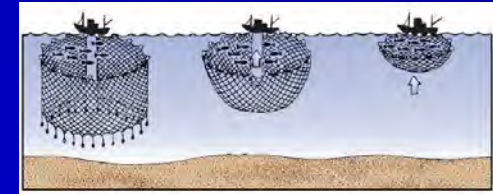
METHODOLOGY



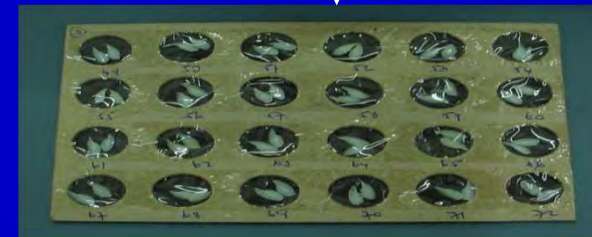
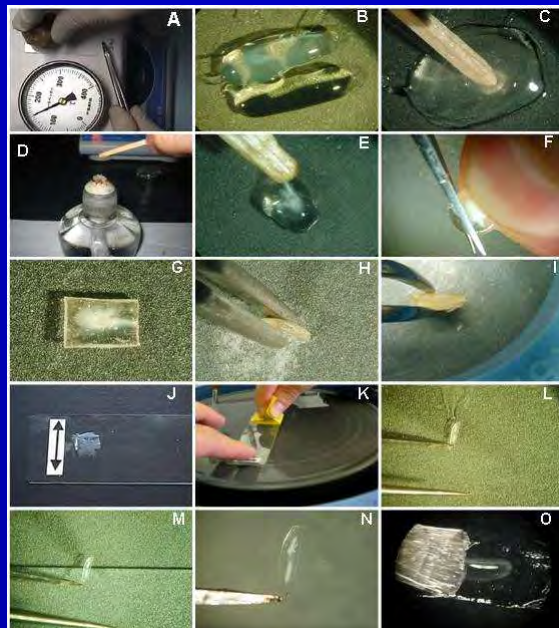
Recruits were collected
from november 2009 to
october 2010



Hydroacoustic surveys
Monitoring of biological
indicators of fishery



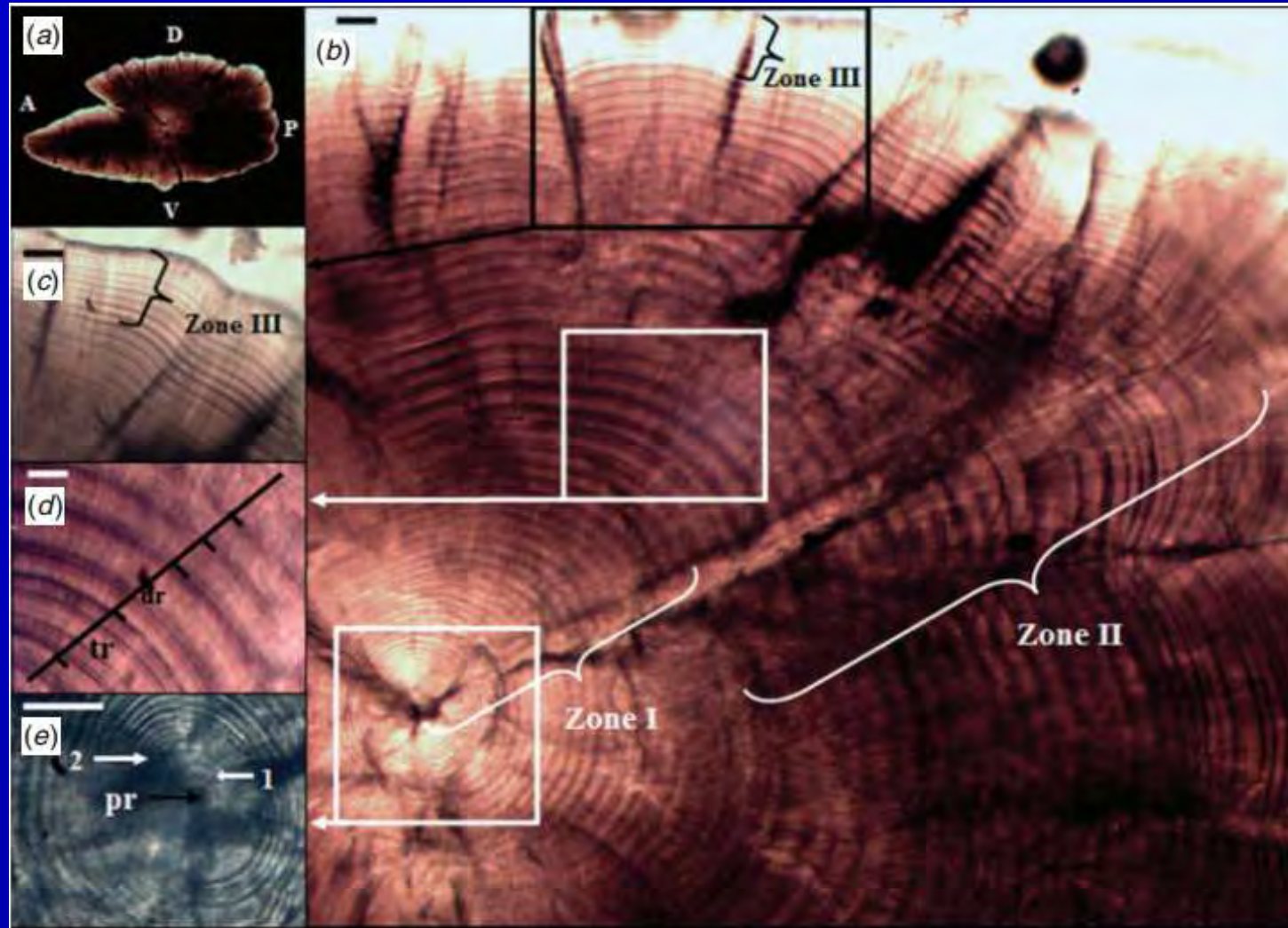
Otolith removal (saggitae)



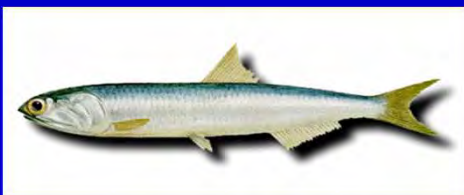
Processed using SGEM

350 otoliths of YOY and 120 of adults
were analyzed

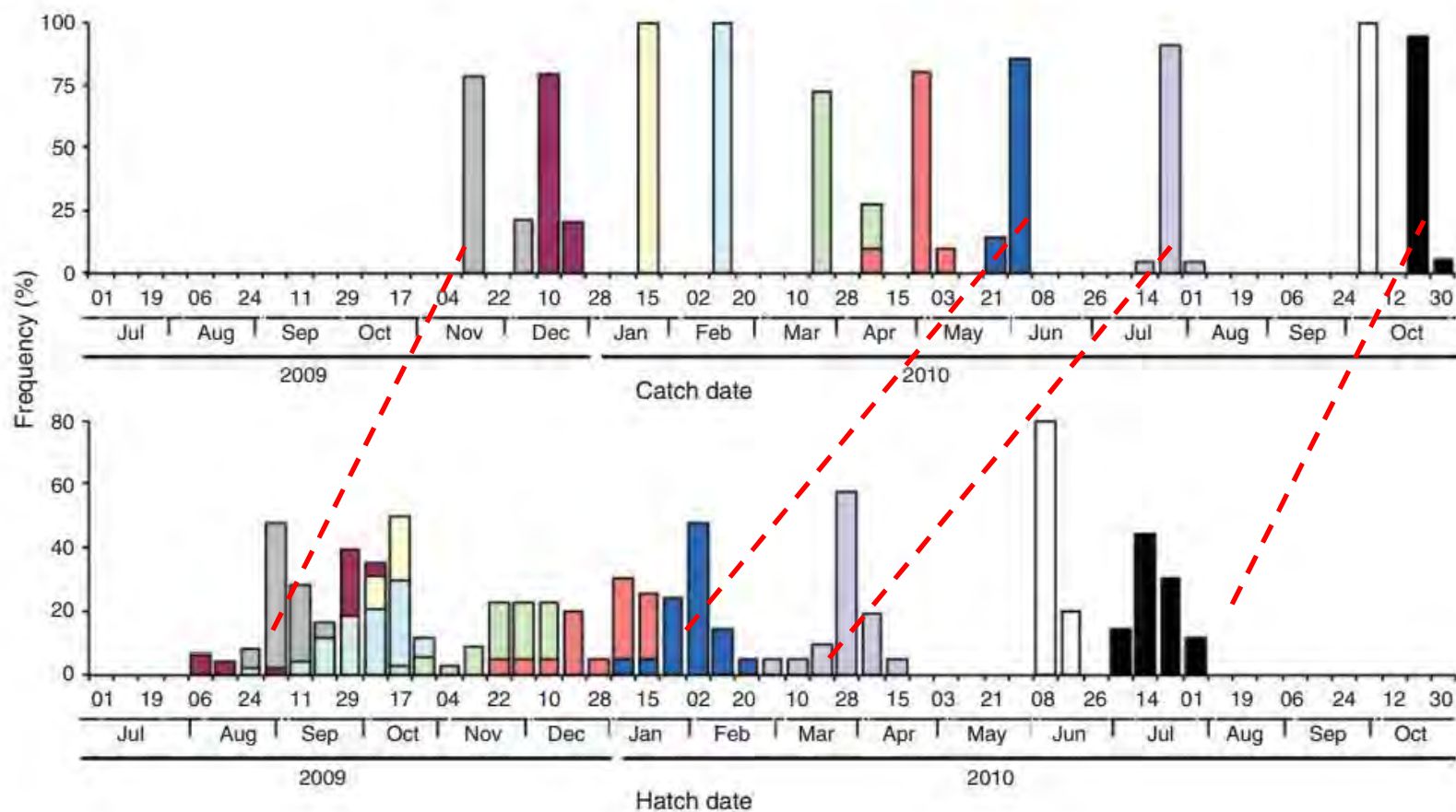
A field study in YOY of *Engraulis ringens* in northern Chile



A field study in YOY of *Engraulis ringens* in northern Chile



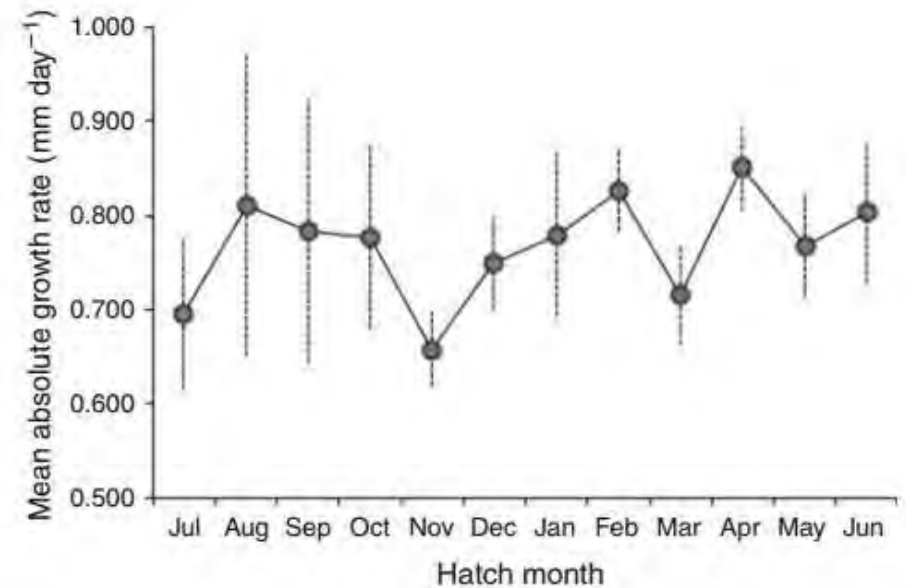
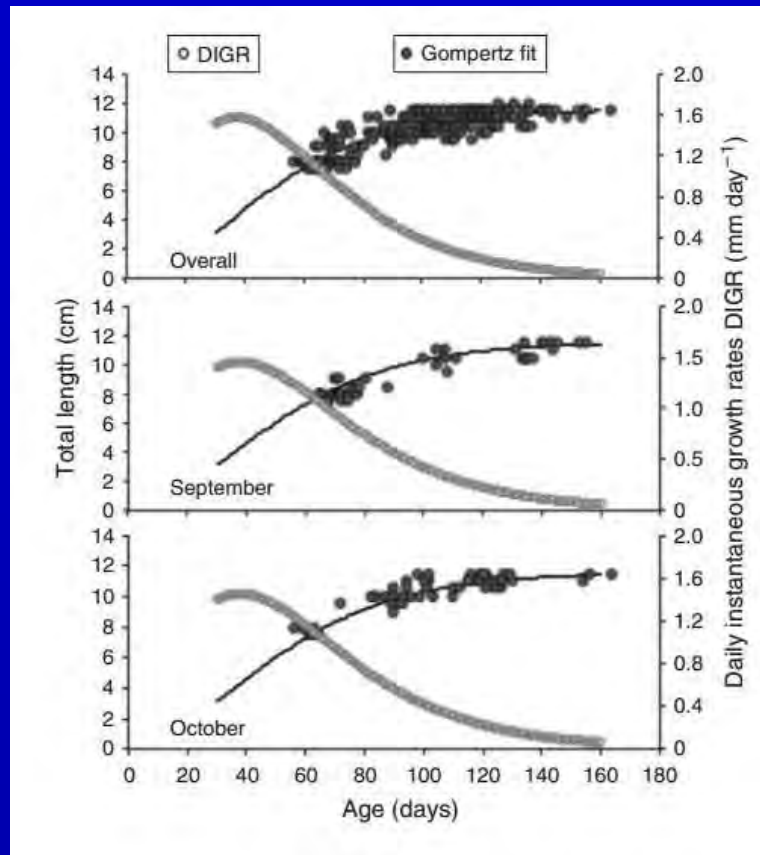
A very fast growth and a very early age-at-recruitment (4-5 months) of juveniles collected



A field study in YOY of *Engraulis ringens* in northern Chile (200-2010)

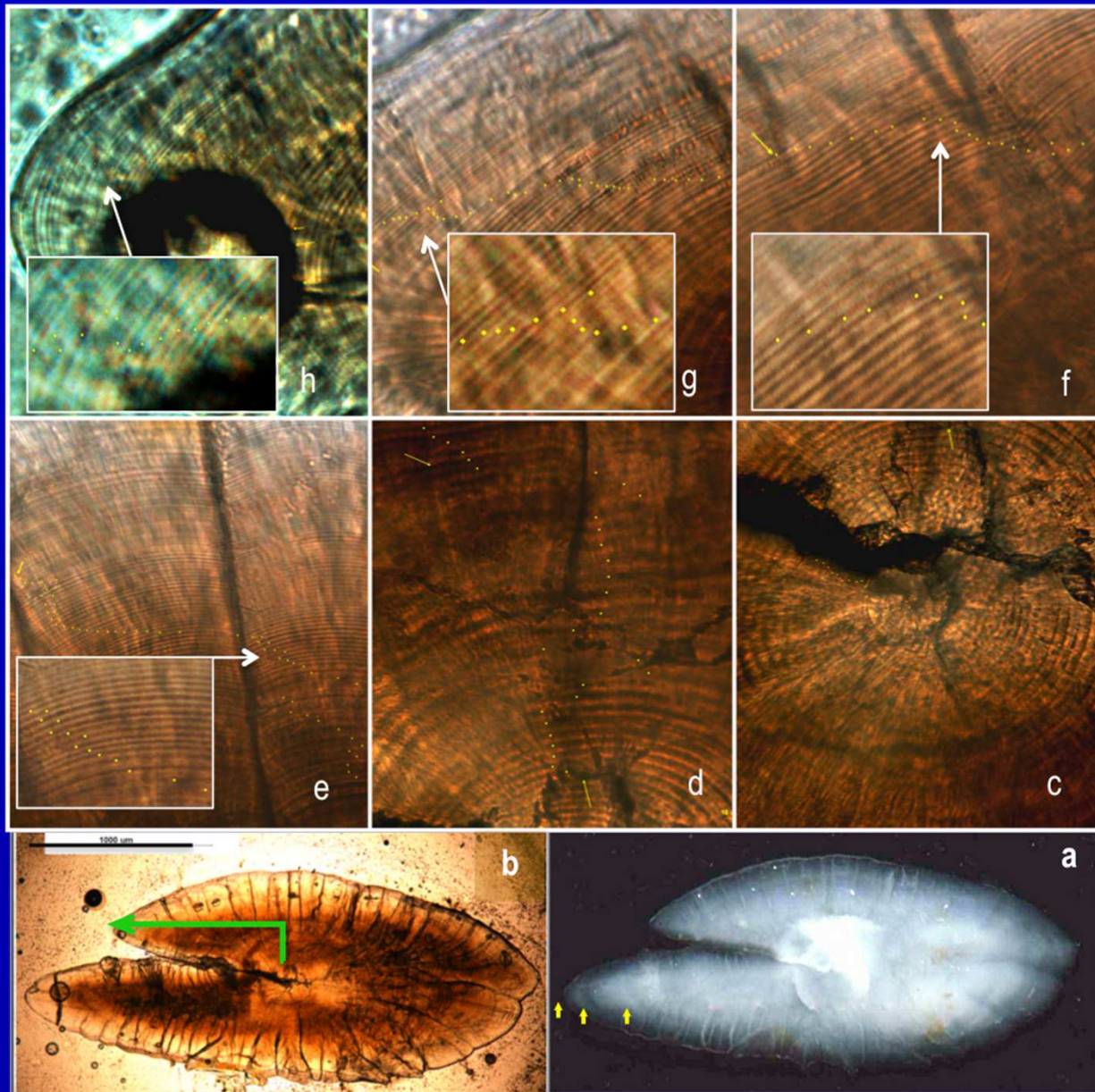
Cohort	L_{∞}	α	X_0	TL at X_0	DIGR at X_0	R^2
Global	11.55	0.04	37.18	4.25	1.57	0.74
September	12.11	0.02	29.49	4.46	0.98	0.88
October	11.60	0.03	33.75	4.27	1.45	0.87

Growth rates at the inflexion point close to 1 at about the onset of the second month of life



$$AGR = (TL - e) \div \text{age}$$

PROBLEM



**Anchovy-northern
Chile**

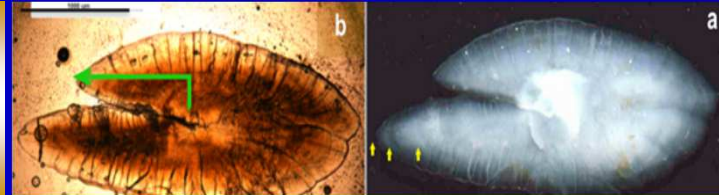


**14 cm LT, 2 year old
through annuli
counting**



**204 days using
otolith micro-
structure**

A comparison between the
micro and macro-structure in
adult fishes



Length	Month	Catch date	Hatch date	Daily Age	Age Group
12.5	Apr	09-04-2010	12-09-2009	209	1
13.0	May	09-04-2010	16-08-2009	236	1
13.0	Jun	09-04-2010	21-08-2009	231	1
13.0	Jul	09-04-2010	20-09-2009	201	1
13.5	Aug	09-04-2010	31-10-2009	160	1.5
13.5	Sep	09-04-2010	29-09-2009	192	1.5
12.0	Feb	02-02-2010	06-09-2009	149	0.5
12.0	Mar	08-03-2010	18-09-2009	171	1
13.5	Apr	20-04-2010	28-09-2009	204	1.5
16.0	May	04-05-2010	17-08-2009	260	2.5
13.5	May	19-05-2010	14-10-2009	217	1.5
17.5	Sep	23-09-2010	01-12-2009	296	2.5
15.0	May	17-05-2010	16-07-2009	305	1.5

THE FAST-GROWING HYPOTHESIS



WORKSHOP



2 INTERNATIONAL EXPERTS

VALIDATION



PERIODICITY OF FORMATION

Validation of the periodicity of formation of primary micro-increments and macro-rings of growth in otolith of the anchoveta *Engraulis ringens* in northern Chile

20° 19' S; 70° 26'

Under natural conditions of photoperiod (20° S) and temperature

After 2 weeks of acclimatization 150 fish were fed twice-a-day with fractionated pellets with low lipid content for marine fishes (5812 Biomarine 2 mm)



Fishery pair-seine wessel

**31 July 31,
2011**



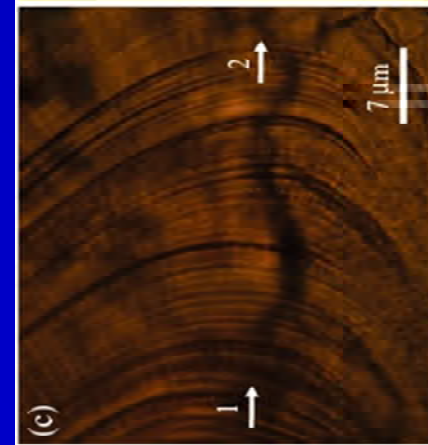
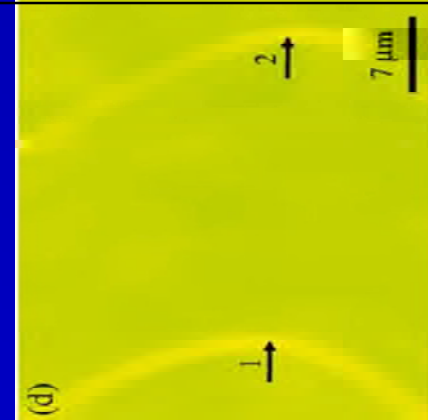
MARKING PROCEDURES



Alizarin Red S
(ARS)



oxytetracycline
hydrochloride
(OTC)



Marker (mg l ⁻¹)	N ₁	Date ₁	N ₂	Date ₂	Time (h)	Elapsed days	Number of increment marks between immersion dates		
							Mean ± s.d.	Range	c.v.
ARS (25)	50	08-10-11	41	16-11-11	6	38	37.82 ± 1.02	36–41	2.64
OTC (200)	50	08-10-11	39	24-11-11	10	46	45.61 ± 1.31	42–49	2.83

A generation of juveniles of known age

STRESS POST-CAPTURE



spontaneous spawning



Floating and fertilized eggs



Incubation (70 Lt)



55 hrs at 14,5 °C



80% (eclosi3n)



52 days after eclosion early juveniles were transferred to a rearing tank



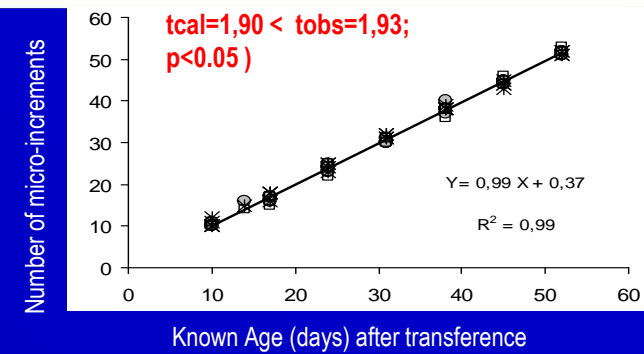
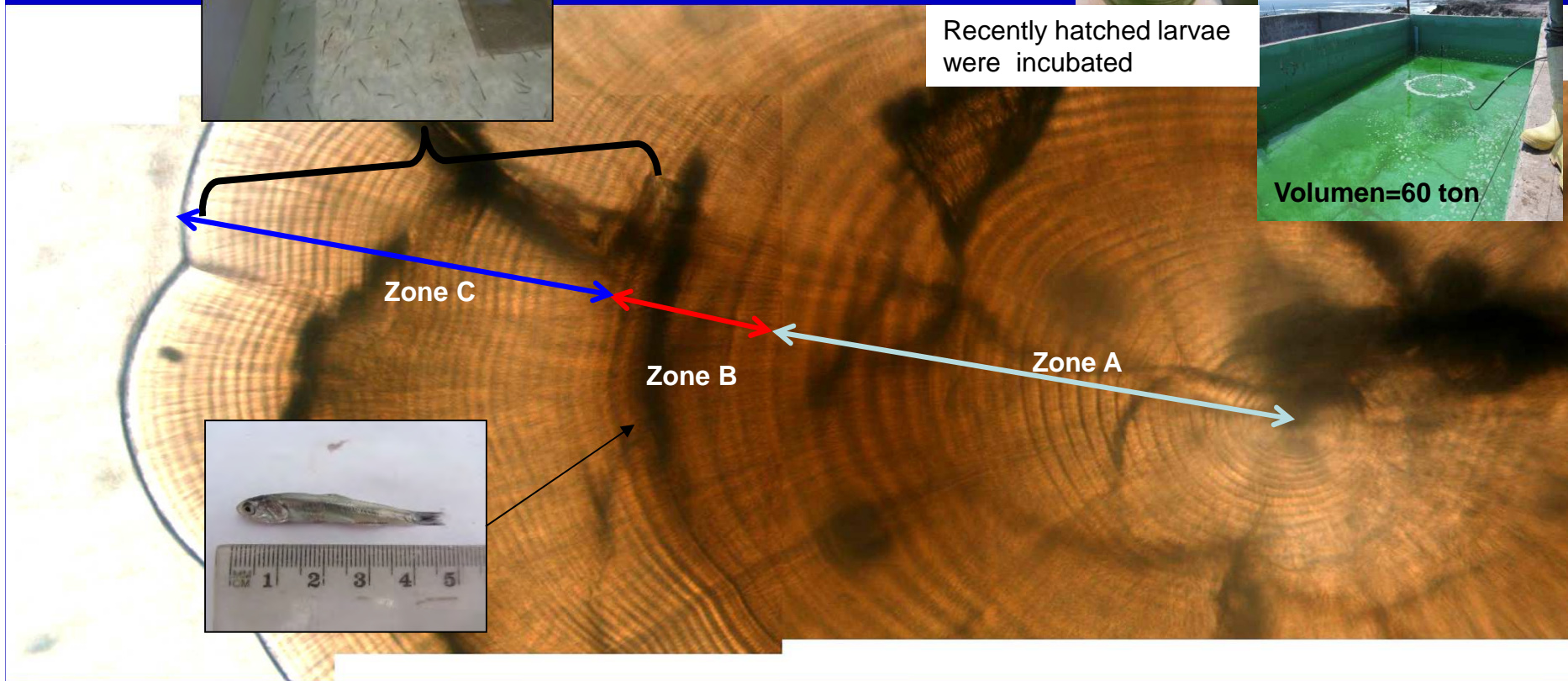
Recently hatched larvae were incubated



Larvae were transferred to an artificial nutrient-enriched system

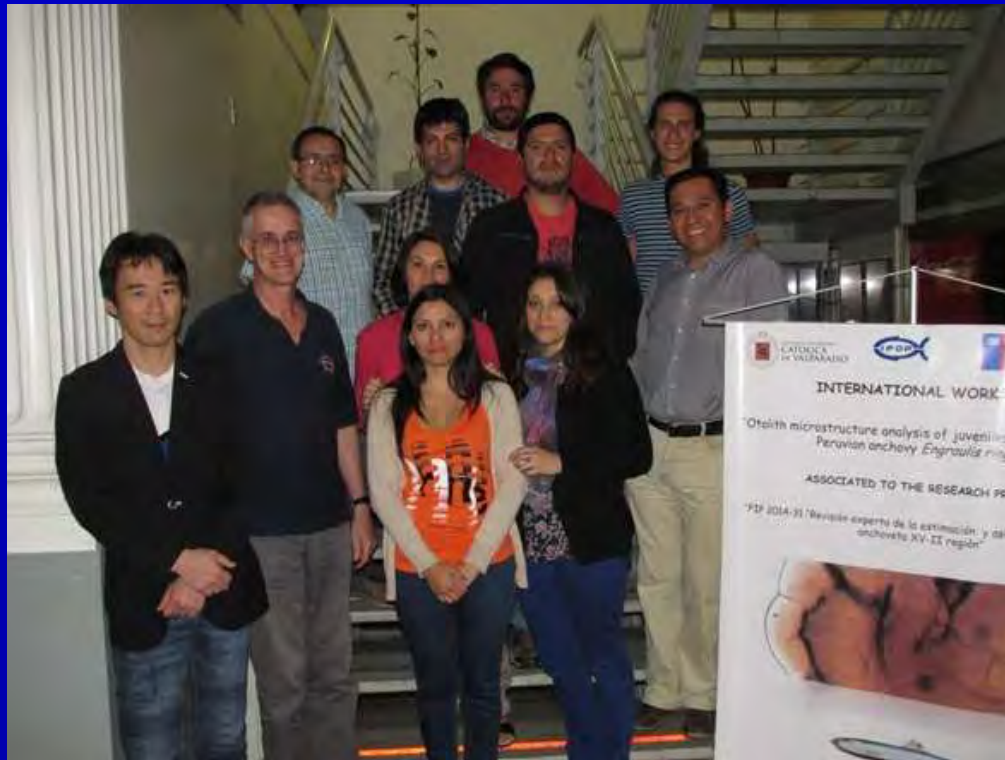


Volumen=60 ton



¿To what extent the high somatic growth reported for this species could be influenced by methodological procedures, associated to either the preparation of otoliths for examination of daily micro-structure or the interpretation of primary micro-increments, or both?

WORKSHOP "Expert review of the estimation and age assignment of the anchovy in XV-II regions"



Workshop (December 2015; Valparaíso; Chile)



Participation of international expert to review methodological procedures

International experts



Dr. **Steven Campana**

32 year at Bedford Institute of Oceanography

Profesor at University of Islandia.

A pioneer and a world expert in the development of methodologies for the determination of age using calcified structures at both annual and daily levels.



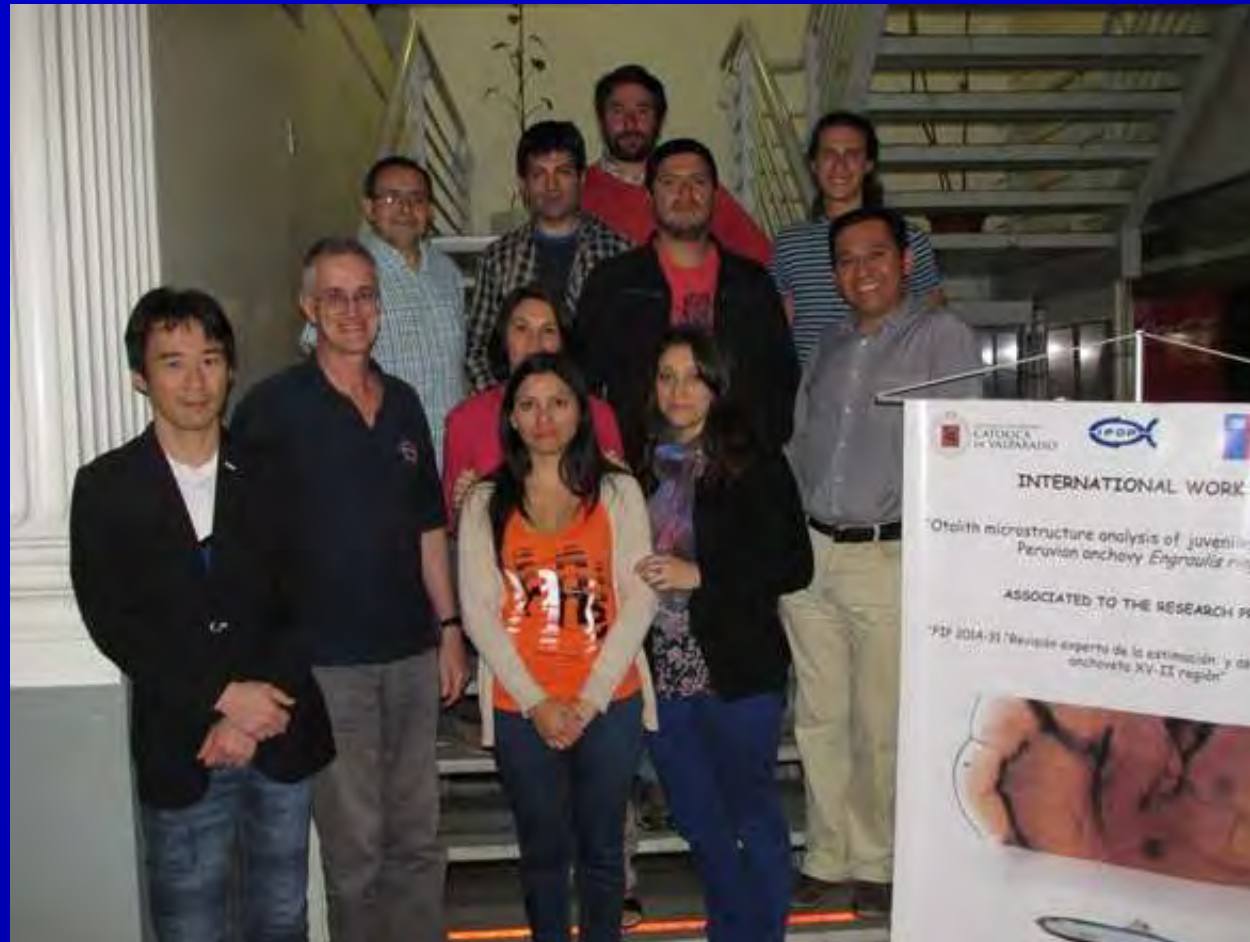
Dr. **Akinori Takasuka**

National Institute of Fisheries Science of Japan.

He has led studies associated with the growth survival paradigm in the early stages of teleost fishes and he has experience in early growth of anchovy species as well.

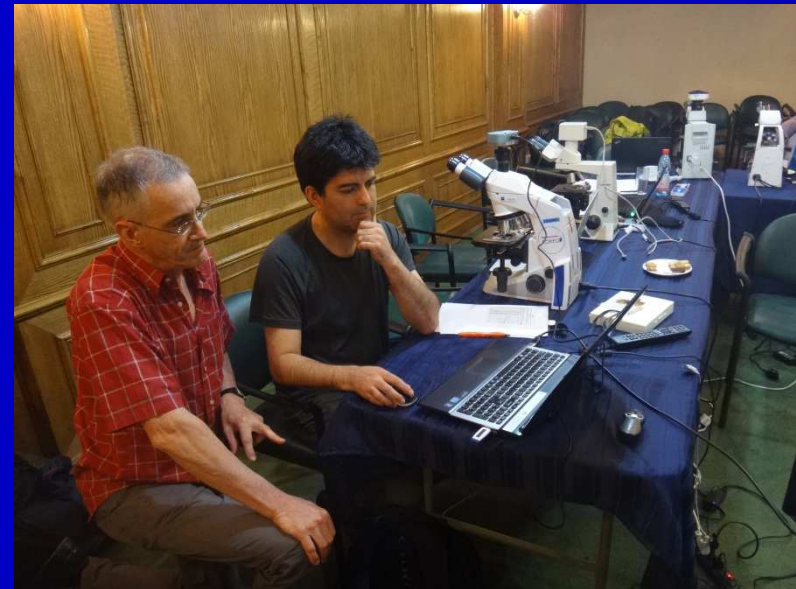
WORKSHOP

Otolith microstructure analysis of juveniles and adults of the Peruvian anchovy *Engraulis ringens*

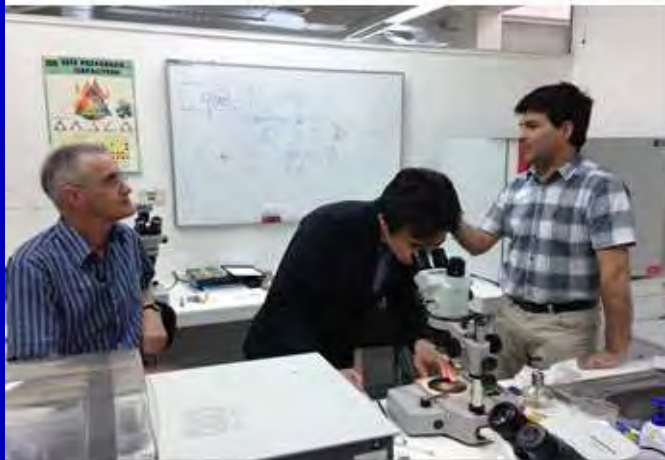


OBJETIVE

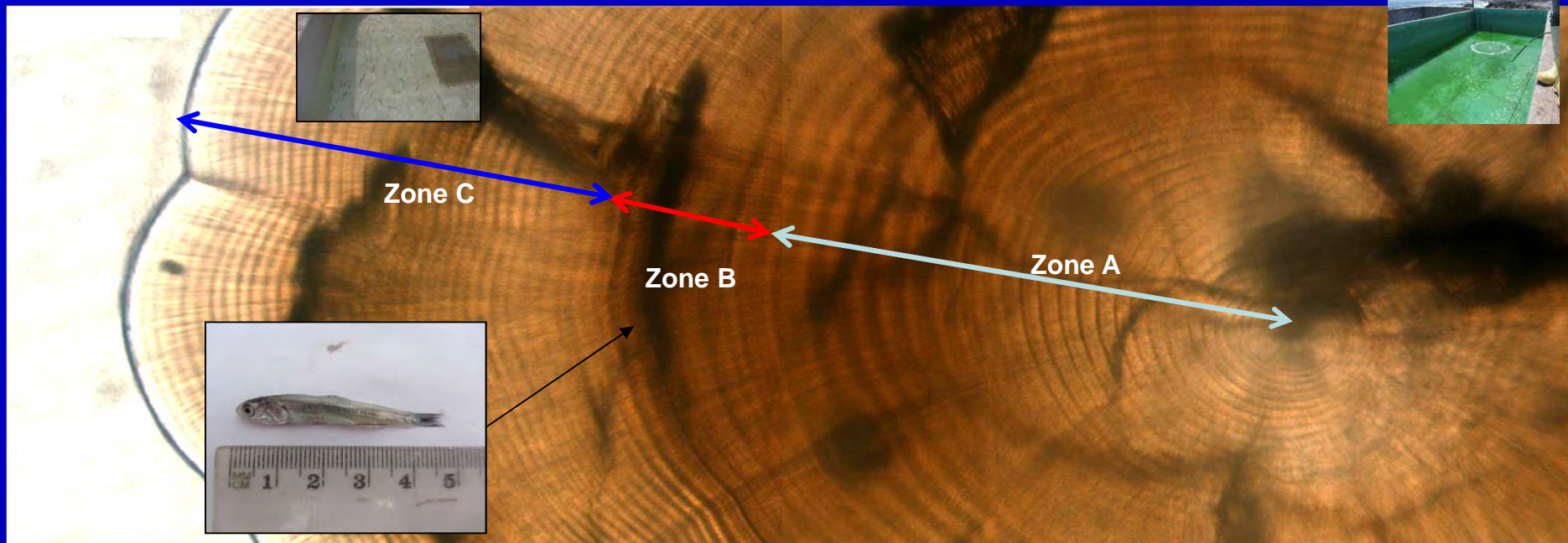
To provide a laboratory-based platform to revise, analyze and discuss the criteria of identification of primary-micro increments in otoliths of juveniles and adults of the Peruvian anchovy *Engraulis ringens*, collected in both field research and produced under rearing conditions, as part of the development of the previous research projects “FIP 2009-17” and “SUBPESCA 4728-31 LP 11”.



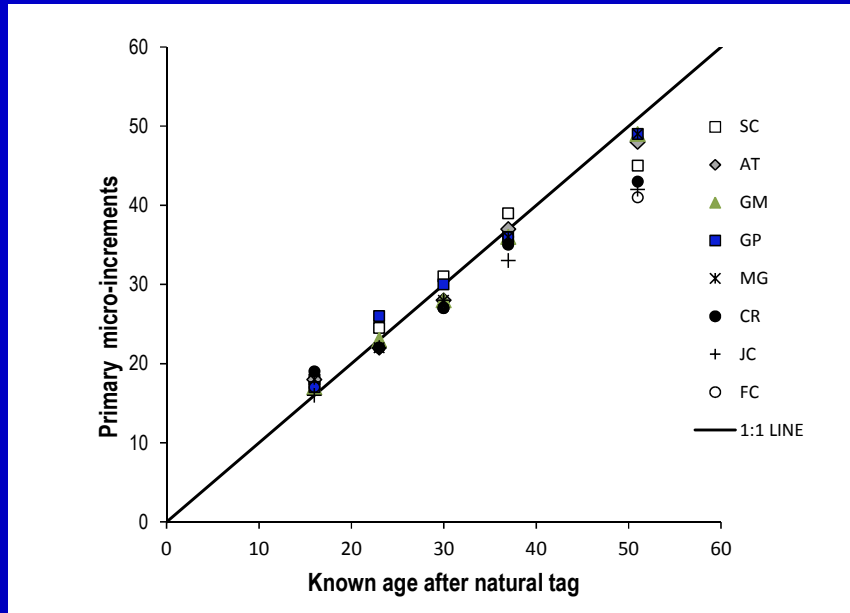
Preparation of otoliths for micro-structure analysis

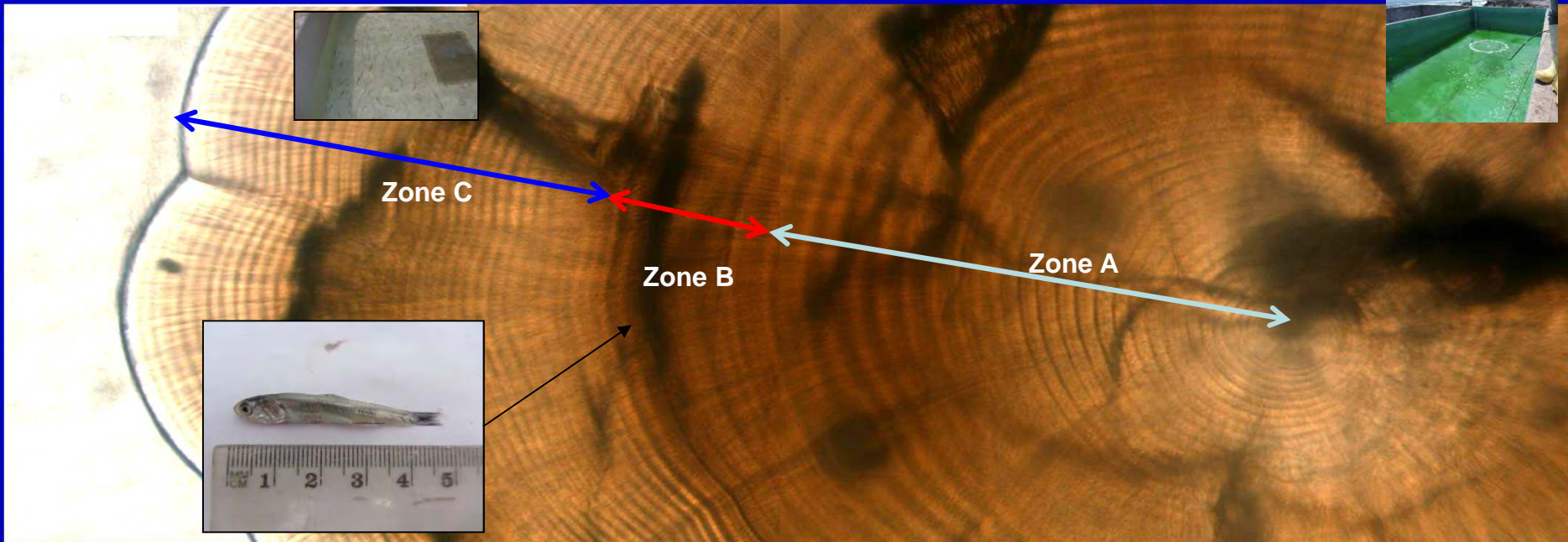


The methods used to prepare the otoliths for microstructural examination were equivalent to those used in the top laboratories around the world, and would not have limited any interpretations

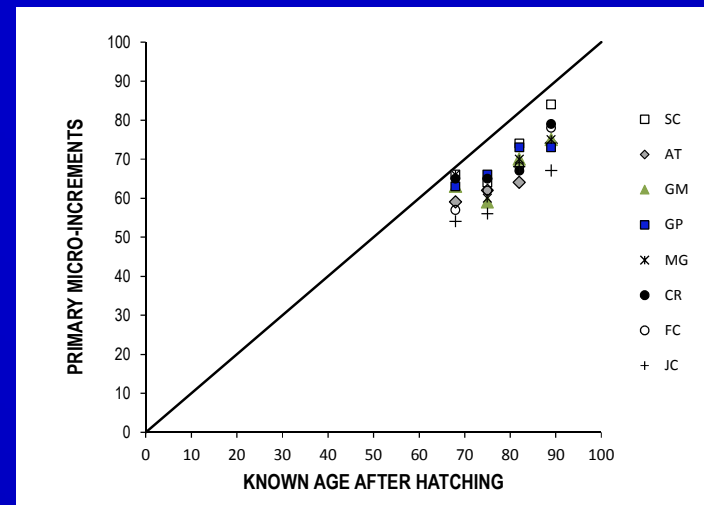


The age estimates for Zone C showed that the workshop participants interpreted the daily growth increments accurately (on average) over a post-check period of 16-51 days, with no appreciable bias and a mean coefficient of variation (CV) of 6.0% and IPAE=4.9



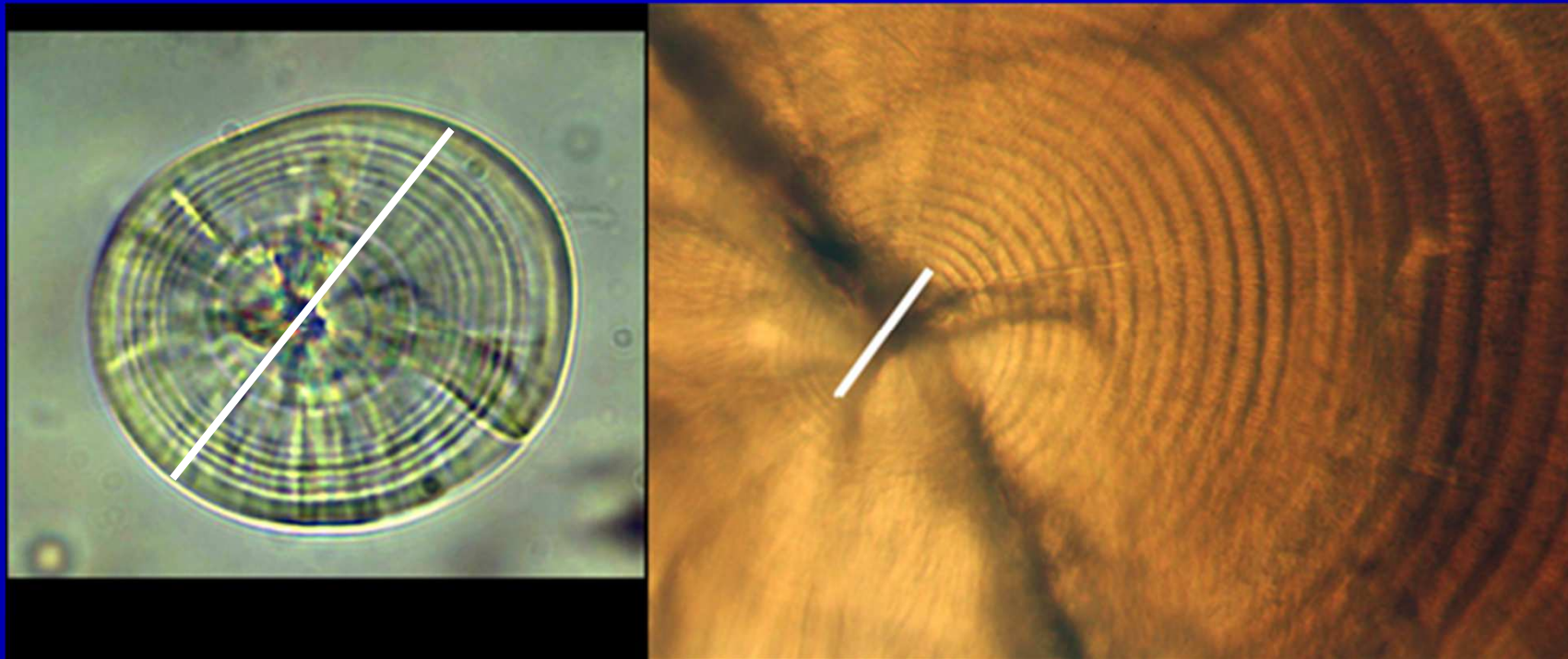


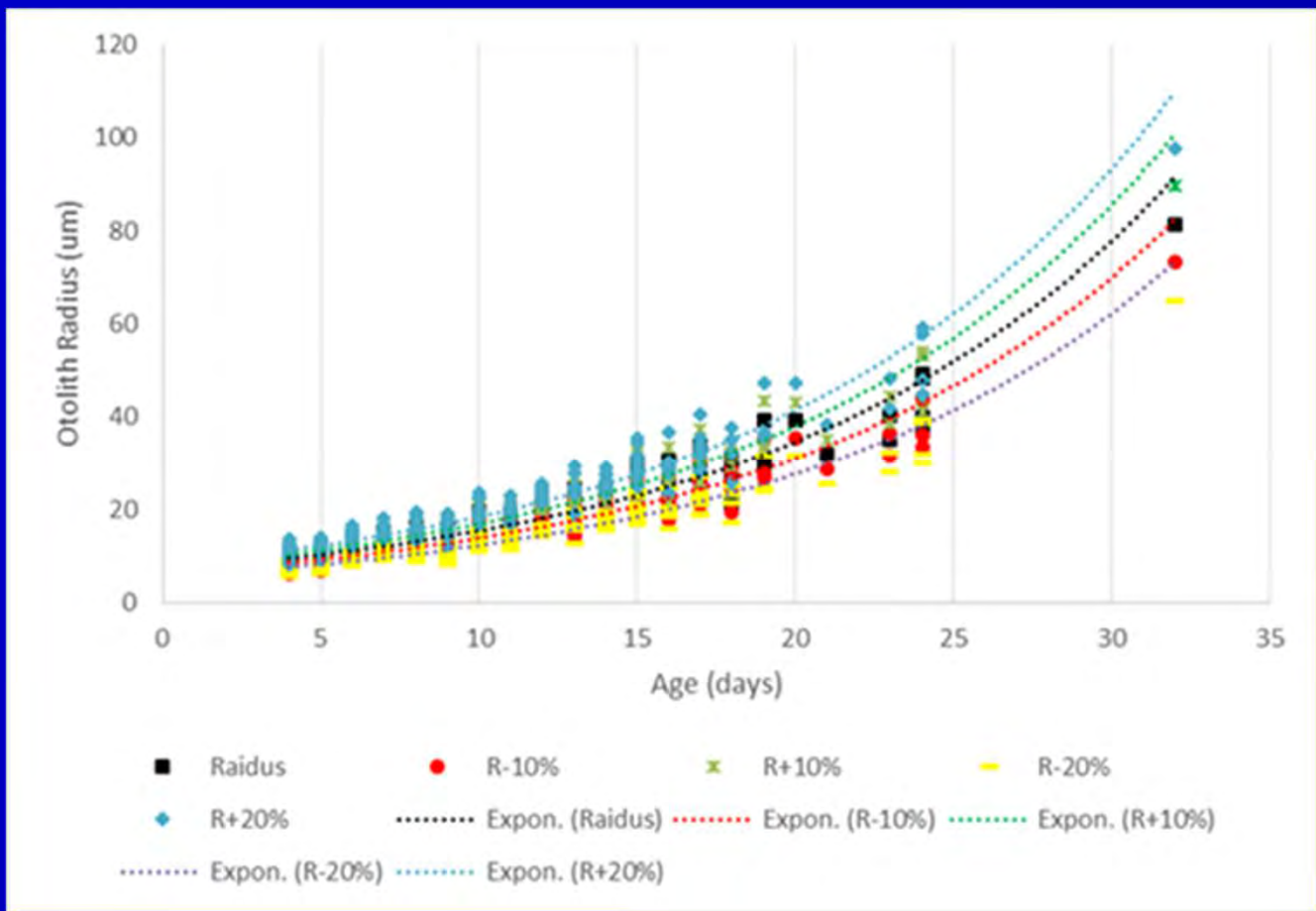
None of the workshop participants correctly estimated the known age (A+B+C)



which are the causes of sub-estimation?

In many small pelagic fish species, daily increments appear not to form until well after hatch. For example, Campana et al (1987) demonstrated that increment count underestimated true age in larval herring (*Clupea harengus*) by 15-20 days because the first-formed increments had a width that was less than the resolution limit of a light microscope.





ID	Hatch Date	Catch Date	Known Age	Direct Reading	Digital Reading	Estimated Day (close to core)	Corrected Age
10	04-08-2011	11-10-2011	68	66	64	7,5	71,5
13	04-08-2011	18-10-2011	75	64	62	11	73
18	04-08-2011	25-10-2011	82	74	70	9,5	79,5
23	04-08-2011	01-11-2011	89	84	80	7,5	87,5
34	04-08-2011	15-11-2011	103	90	91	15	106



Actual age = 82
Interpreted age = 72 + 9.5 estimated = 81.5 days

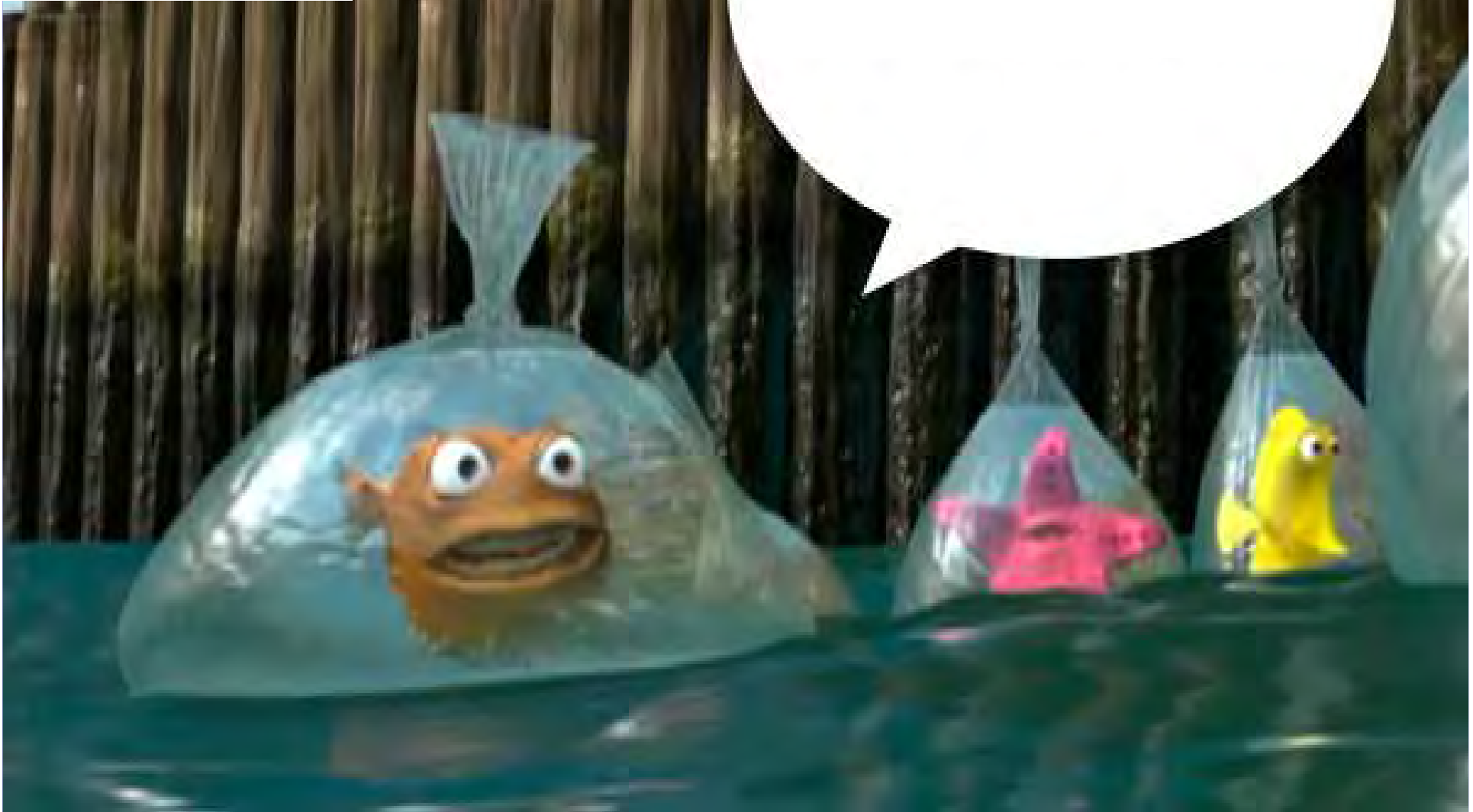
The image shows a cross-section of a biological specimen with concentric rings. A dotted line path starts from the center and moves outwards, following the rings. The path is composed of several segments: a vertical segment, a diagonal segment, and a horizontal segment. The text on the right side of the image provides the actual age and the interpreted age based on the path.

CONCLUSIONS

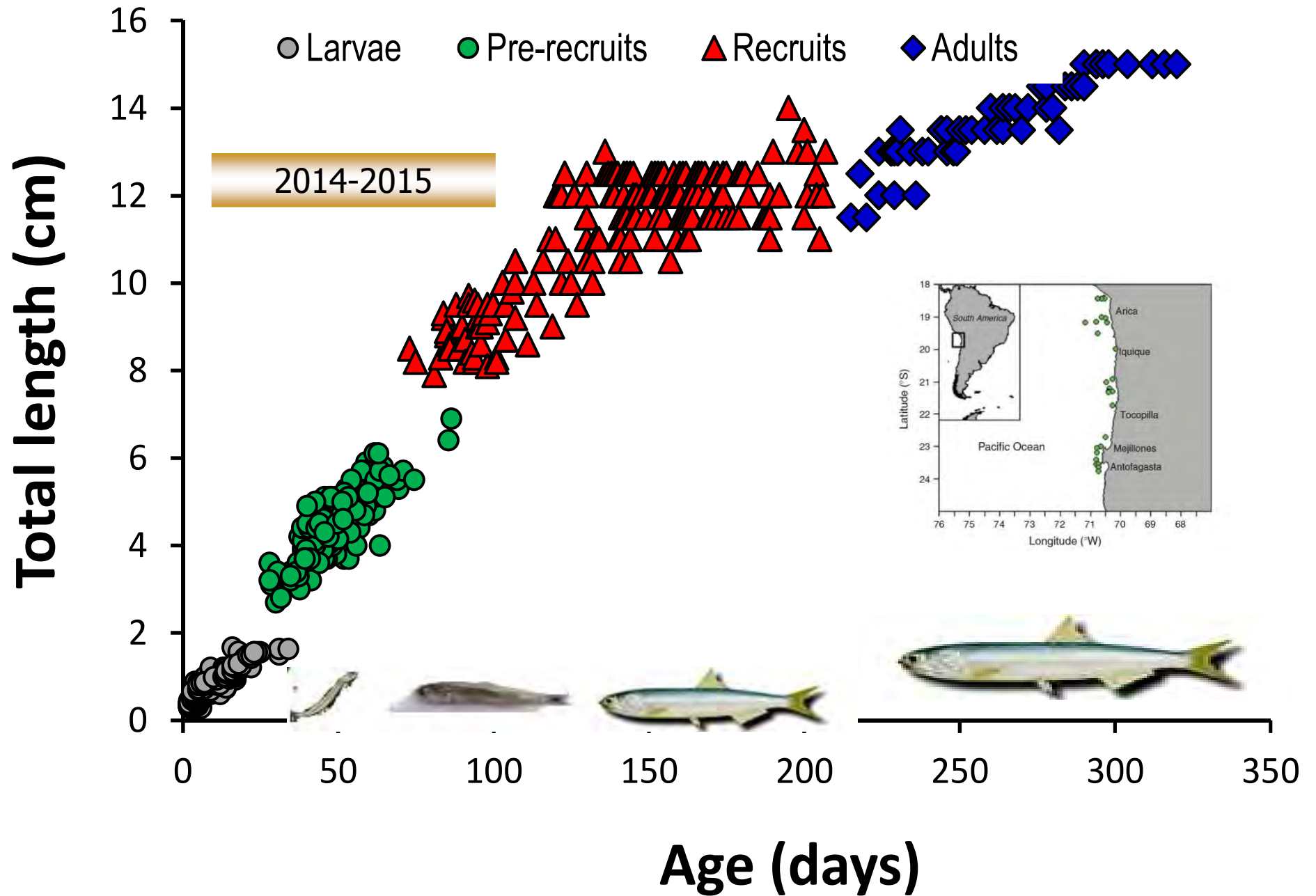
- ❖ The otolith preparation protocol applied by the Chilean researchers produced polished samples of equivalent quality to those developed by expert international laboratories.
- ❖ The workshop review of known-age juvenile anchovy otoliths reared under quasi-natural conditions confirmed that young anchovy could be aged both accurately and precisely using otolith microstructure.
- ❖ Otolith-specific age adjustments of 7-15 days must be made with a known-age age-otolith radius relationship, as has been described for other small pelagic fish species.
- ❖ Wild juvenile anchovy otoliths can be read both accurately and precisely to an age of at least 136 days and a length of about 11.5 mm. There is no doubt about the relative accuracy of the juvenile age determinations.
- ❖ The available evidence suggested that the daily increment sequence provides a more reliable indicator of age than do the presumed annuli, and that the adults are mainly about one year old. However, further research will be required to confirm this.

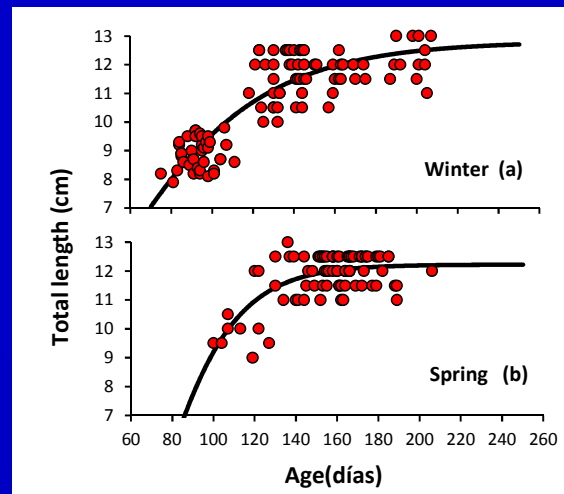
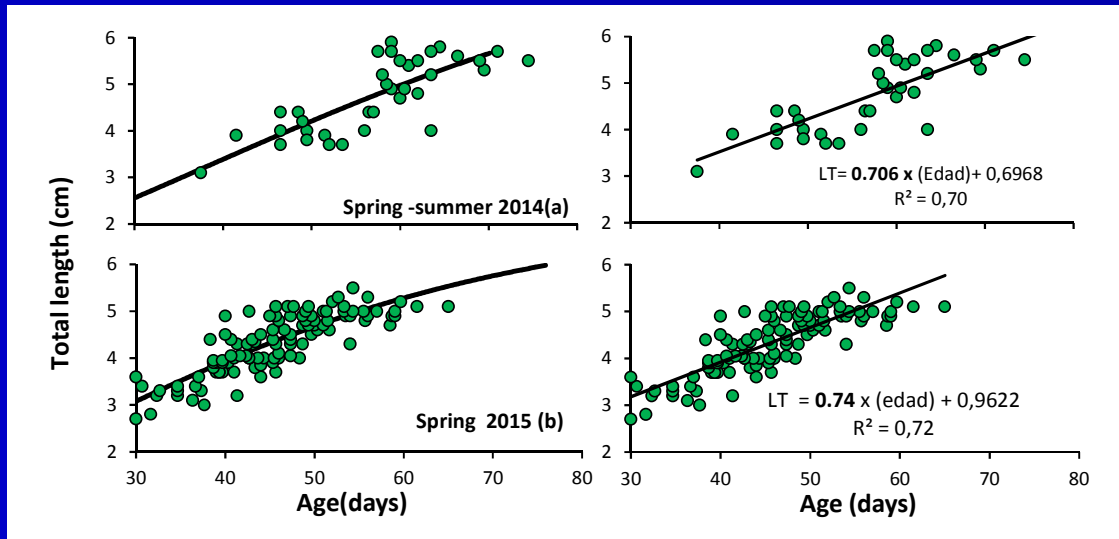
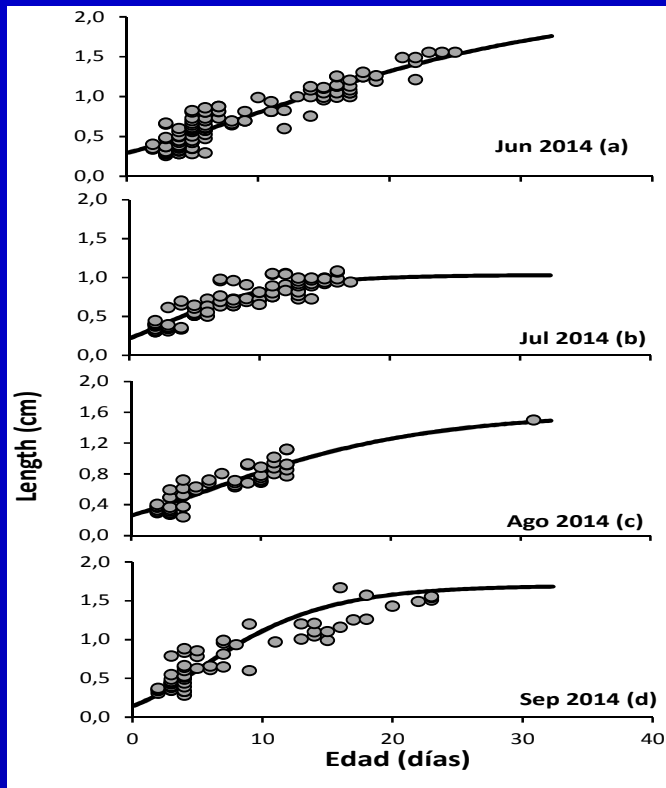


And now what?



An effort have been made to try collect pre-recruits, which are no vulnerable to fishery, including larvae as well in the analysis





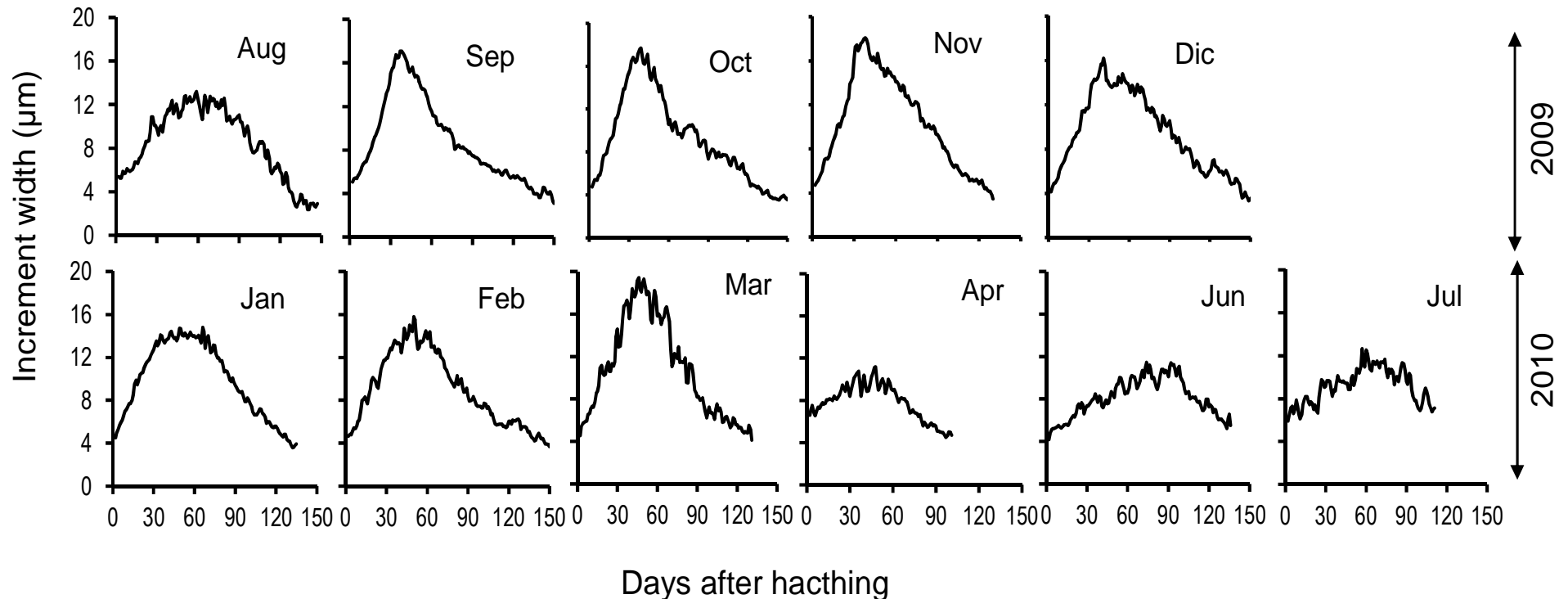
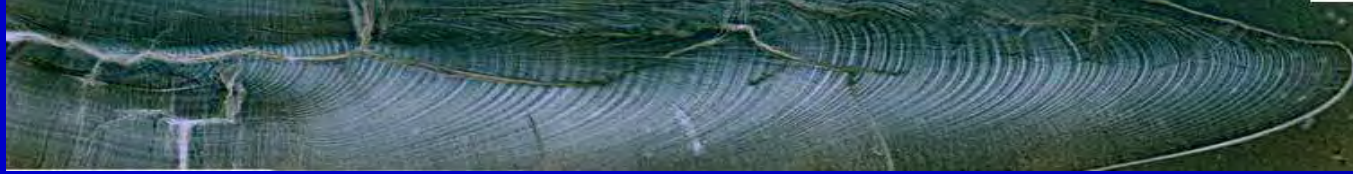
Cohort	$L_{\infty} \pm se$	$g \pm se$	$X_0 \pm es$	$TL at X_0$	$Gr at X_0$	r^2	
Jun	2.18 ± 0.40	0.069 ± 0.015	10.08 ± 2.90	0.802	0.550	0.86	
Jul	1.03 ± 0.06	0.190 ± 0.035	2.35 ± 0.354	0.380	0.720	0.81	
Sep	1.598 ± 0.168	0.104 ± 0.016	5.888 ± 1.11	0.588	0.610	0.84	
Oct	1.697 ± 0.184	0.117 ± 0.026	5.13 ± 1.08	0.624	0.730	0.86	
Global	1.935	0.136	8.036	0.99	0.712	0.056	0.86

Cohort	$L_{\infty} \pm SE$	$G \pm ES$	$X_0 \pm ES$	$TL at X_0$	$Gr at t_0$	r^2	n
Winter	12.81 ± 0.35	0.240 ± 0.004	48.59 ± 5.65	4.712	1.131	0.76	105
Spring	12.23 ± 0.17	0.480 ± 0.013	73.84 ± 8.949	4.497	2.159	0.46	84
Global	12.721 ± 0.218	0.26 ± 0.003	50.03 ± 4.19	4.680	1.217	0.75	199

QUESTIONS AND REMARKS

- ❖ Peruvian anchovy seems to be a species that maximizes a substantive fraction of its growth during the first year of life.
- ❖ What will be the impact of this new scenario of fast growth in the vB growth parameters when using daily age instead the traditional annuli counting?
- ❖ Under the new scenario a great fraction of the catch of a year would be recruits and the high growth would lead to an increase in natural mortality.
- ❖ It is very necessary the new growth scenario are compressively discussed and analyzed in a framework of a complementary study by a group of experts in stock assessment.

Seasonal variability in early growth through the monitoring of increment width profiles



- ❖ Irrespective of seasonality a significant fraction of growth variability seems to occur before the third month of life.
- ❖ It could be interesting to see if such a pattern it is also occurring in other species by revising the literature were increment width profiles at the cohort level is reported.

Thank you very much for you attention!!

Acknowledgments: A. Hernández; P. Poblete; C. Barra; F. Cerna; M. Gómez; C. Machuca; A. Takasuka; M. Landaeta; C. Rodriguez; J. Contreras; U. Cotano; A. Uriarte; G. Moyano; J. Merino; D. Queirolo; S. Campana, G. claramunt; etc.

The funds to attend this symposium were provided by the research grant FONDECYT 11404740

