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Validation of age determination from Otoliths for Bay of Biscay anchovy

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1- AZTI, 2- IEO, 3 - IFREMER

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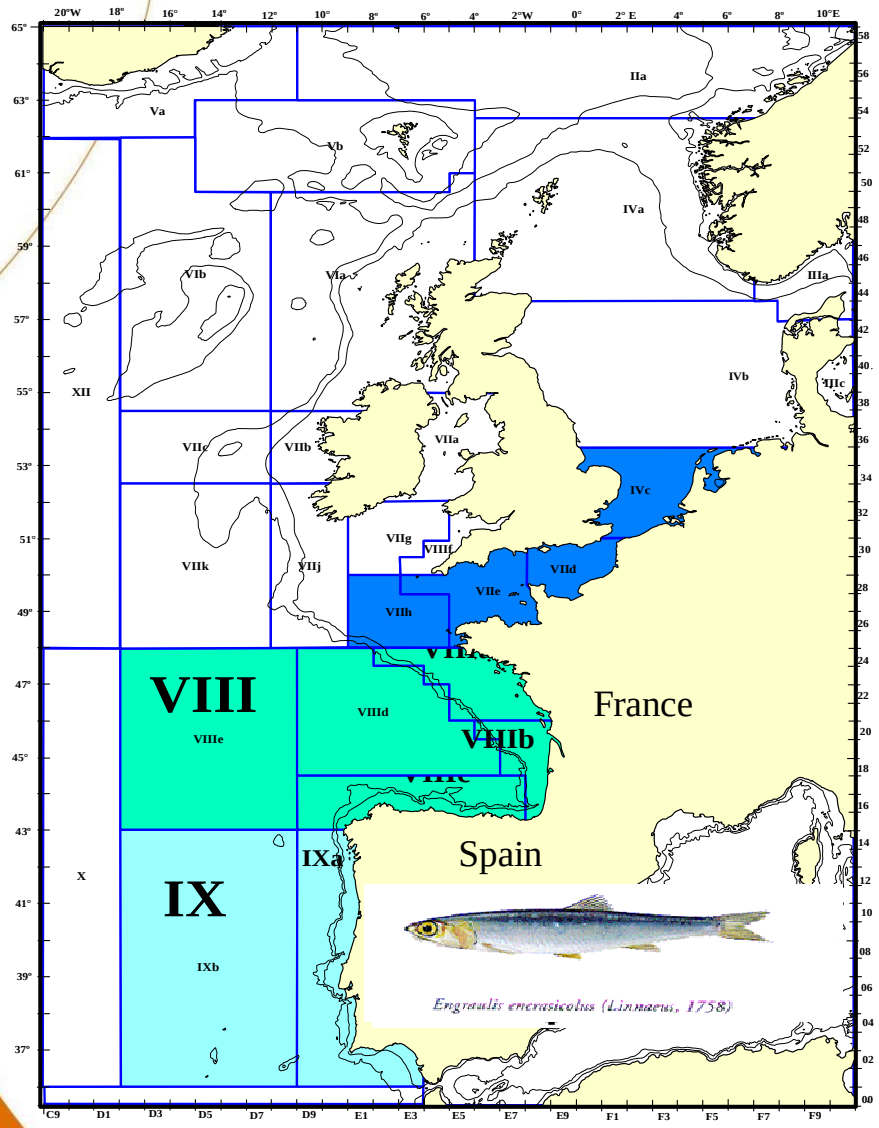
ANCHOVY in Bay of Biscay



Anchovy: Short living species
Fast growth
Full maturity at age 1
Few Age Classes (max 4 y.o.)

High Natural Mortality
Fast decay of Year classes /
Continuous renovation of the Population

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Validation of age determination using otoliths of the European anchovy (*Engraulis encrasicolus* L.) in the Bay of Biscay

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Abstract. Validation of the age determination procedure using otoliths of European anchovy in the Bay of Biscay was achieved by monitoring very strong year-classes in successive spring catches and surveys, as well as the seasonal occurrence of edge types. Historical corroboration of the ageing method was obtained by cross-correlation between successive age groups by year-classes in catches and surveys (1987–2013). Summary annual growth in length is also presented. Yearly annuli consist of a hyaline zone (either single or composite) and a wide opaque zone, disrupted occasionally by some typical checks (mainly at age-0 and age-1 at peak spawning time). Age determination, given a date of capture, requires knowledge of the typical annual growth pattern of otoliths, their seasonal edge formation by ages and the most typical checks. Most opaque growth occurs in summer and is minimal (translucent) in winter. Opaque zone formation begins earlier in younger fish (in spring), and this helps distinguish age-1 from age-2+.

Additional keywords: age estimation, checks, Engraulidae, otolith formation.

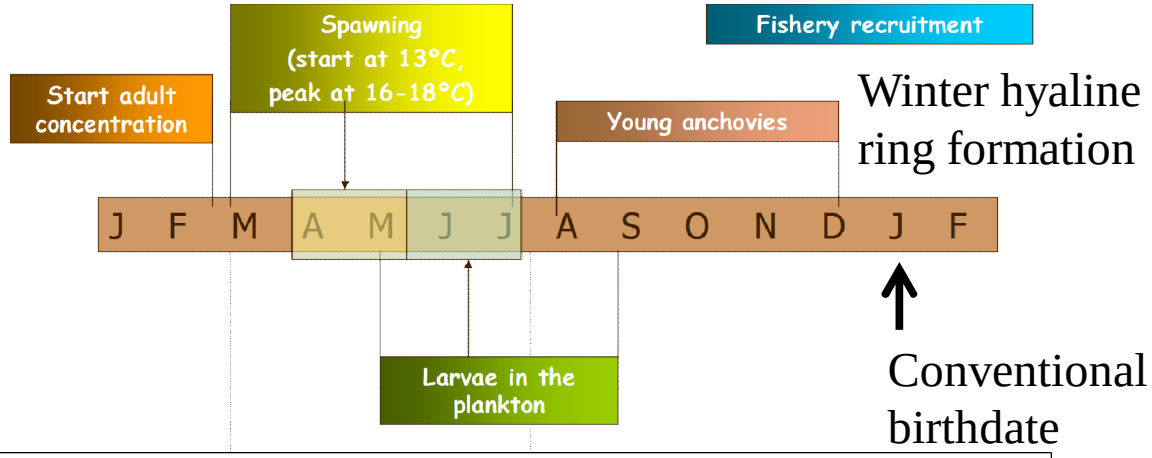
INTRODUCTION & OBJECTIVES

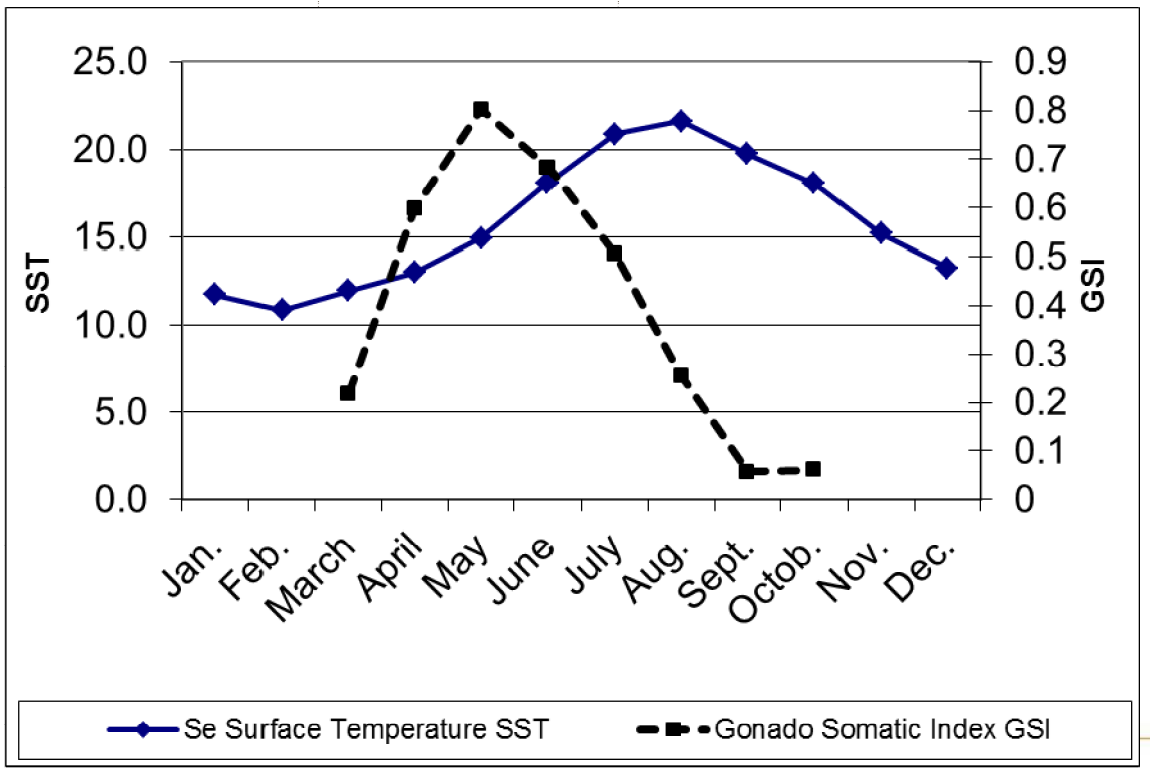
- Accurate Age determination is basic for the study of Population dynamics and for assessments
  - Current assessment based on two age groups Age 1 and Age 2+ (Ibaibarriaga et al. 2008;2011)

- Validation of the Age determination from otoliths was stablished in late eighties and early nineties at AZTI (Uriarte ms.) being improved with discussion during exchanges and workshops.
  - Presented in several workshops (1998 / 2002 /2006 / 2009) for anchovy age reading in Southeast Europe

- **OBJECTIVES of this presentation**
  - Summarize the Age Validation originally carried out for anchovy in BoB
  - Posterior (later) verification of the method up 2014
  - Current method of age determination (practice, prior knowledge and difficulties)
  - Summary of the annual growth in length

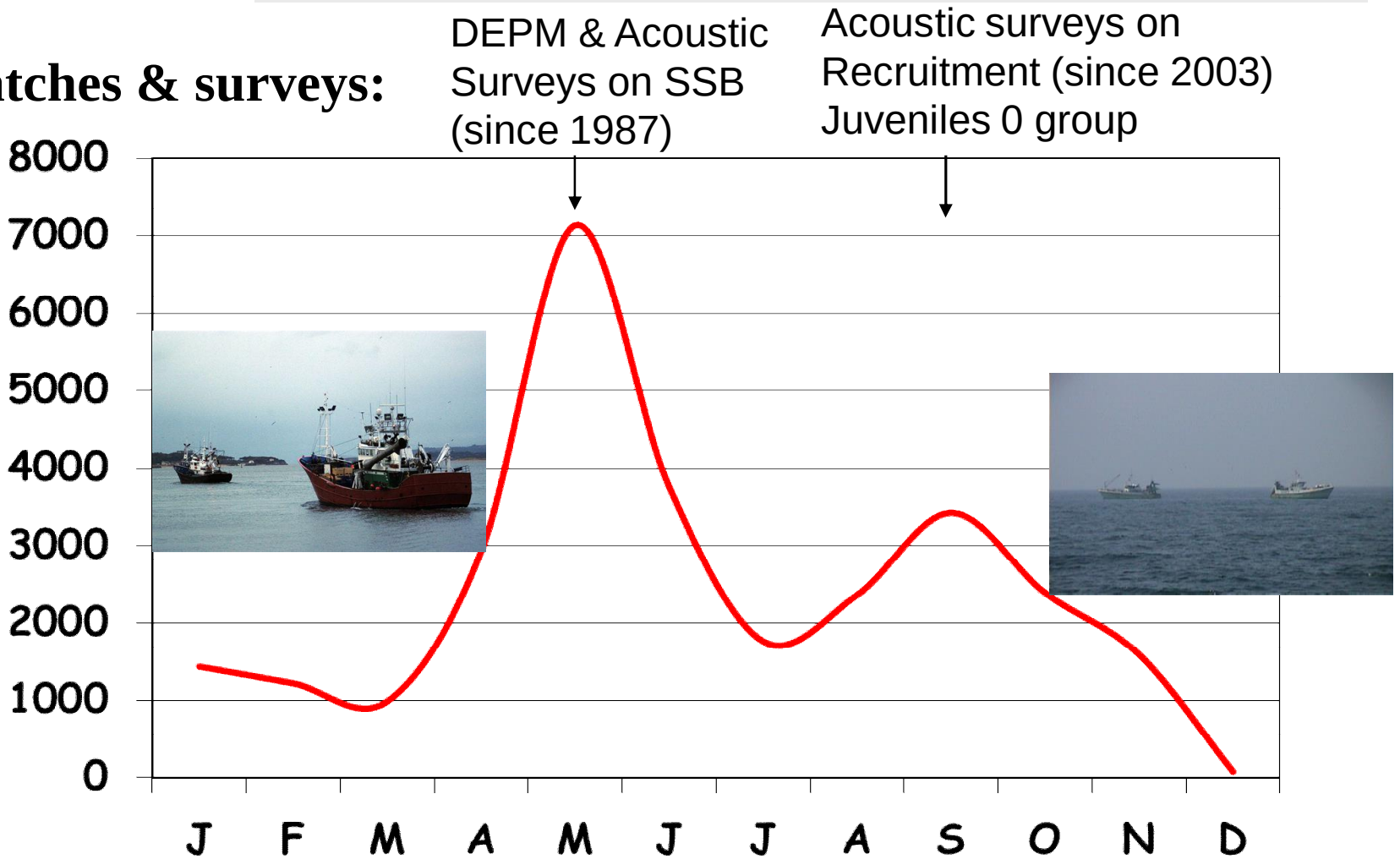
Anchovy Life cycle





The fishery and monitoring system

Catches & surveys:



METHODS

- Original Validation:
  - Monitoring of the Progression of strong year classes both in catches and surveys: The 1982 and 1989 year classes
  - Marginal Increment formation throughout the year by age classes

- Material:
  - Biological sampling (with otoliths) between 1984-2014
    - Extra original analysis on the subset 1984 – 1992 : 233 samples (7533 otoliths)

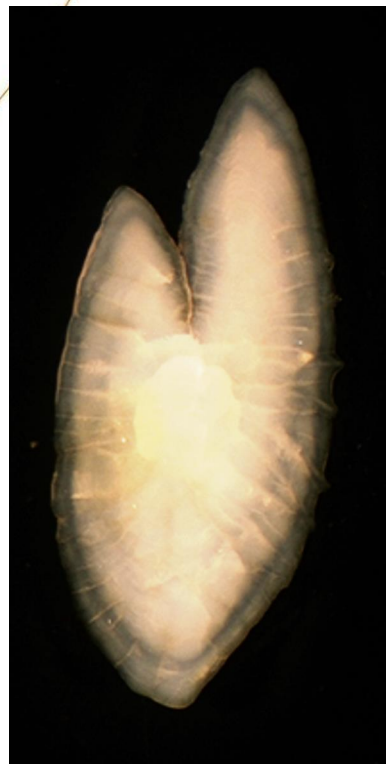
	Months												
Otoliths	1	2	3	4	5	6	7	8	9	10	11	12	Total
Age 0	0	0	0	0	0	0	0	1	95	259	327	78	760
Age 1	87	0	435	541	1048	908	308	177	242	6	16	6	3774
Age 2	6	0	205	483	805	375	132	61	25	5	11	0	2108
Age 3+	0	0	149	271	266	116	69	1	17	0	2	0	891
Totals	93	0	789	1295	2119	1399	509	240	379	270	356	84	7533
Samples	3	0	22	40	64	40	17	11	12	9	12	3	233

  - Surveys for SSB and Population estimates 1983-2014 (Acoustic and DEPM)
    - And the Juveniles acoustic survey started in 2003

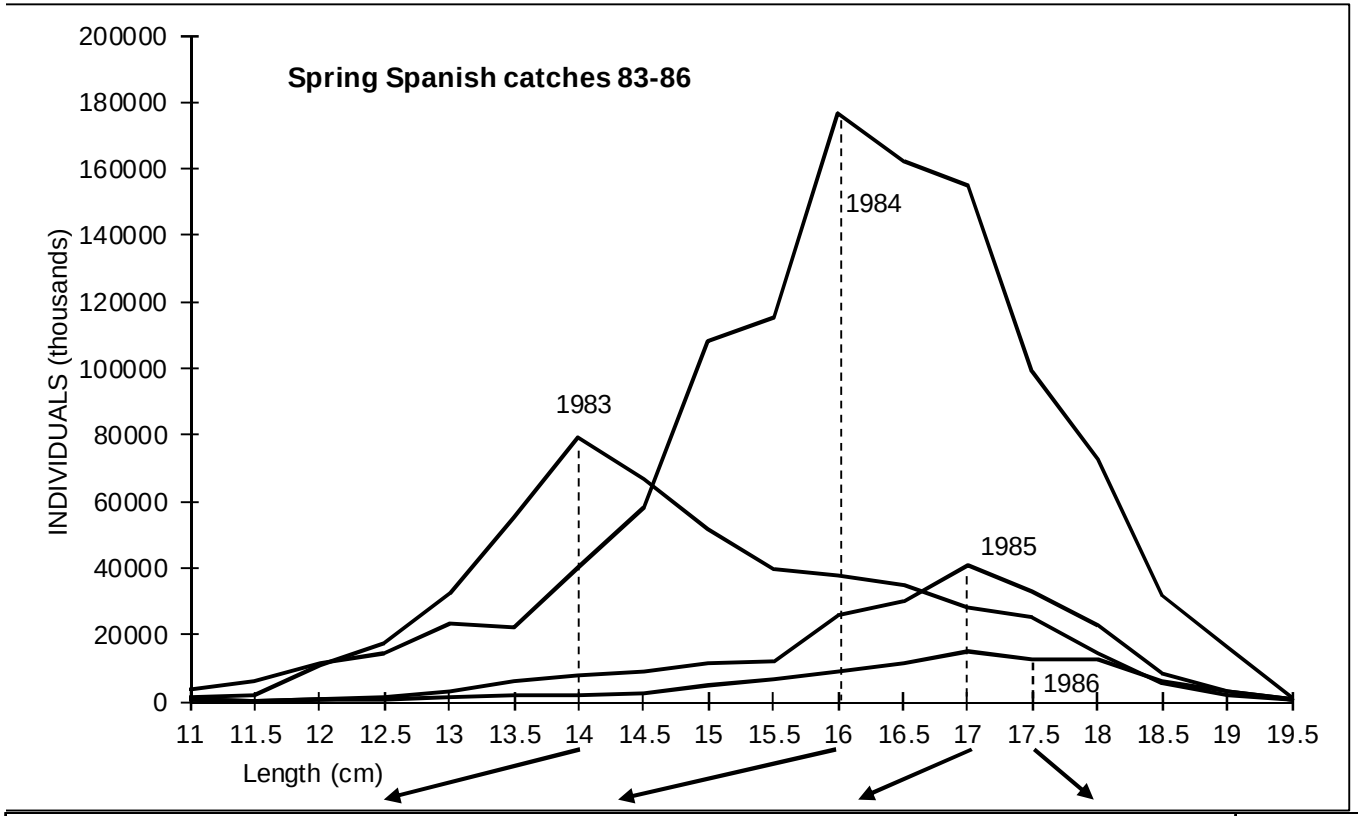
  - Length distribution of catches and age compositions with the proposed method

- Later verifications (complete series): Correlation between sucessive age classes abundances in catches and population estimates.

Typical Otolith types in Spring (April + May)

Type I	Type II	Type III	Type IV
			
Single annulus + Opaque edge On// Ow	Single annulus + Very Wide opaque band + Hialine edge Hn/ Hw	Two annulus + Wide opaque band + Hialine edge Hn/ Hw	Three annulus + Wide opaque band + Hialine edge Hn/ Hw

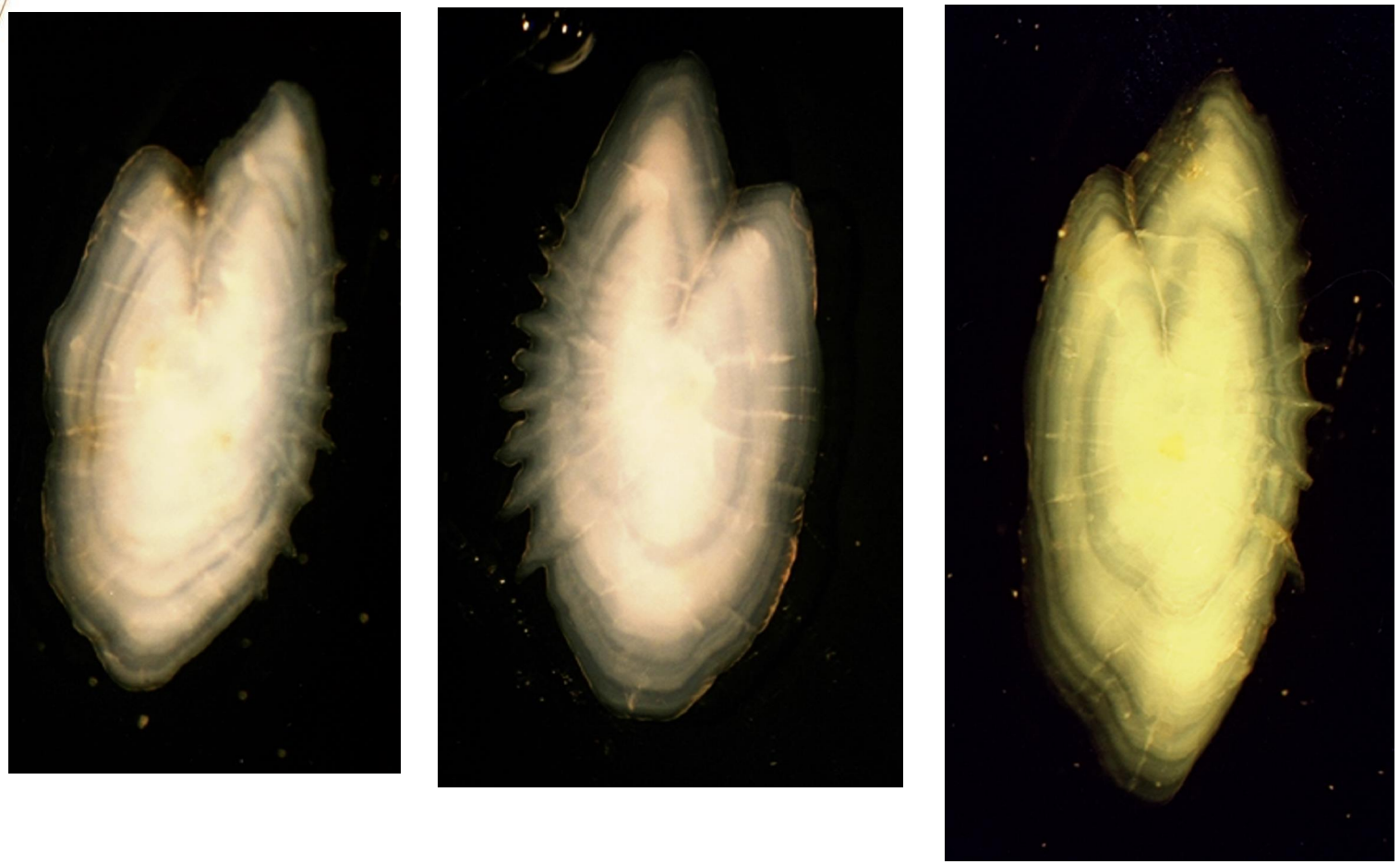
Validation 1: Progression of the 1982 cohort in Catches



Otoliths	Type I	Type II	Type III	Type IV	Total
1983 (*)	*64.4%*	*29.7%*	*5.9%*	*(*)*	*100%*
1984	12.8%	78.0%	8.8%	0.4%	100%
1985	11.8%	32.0%	54.9%	1.3%	100%
1986	17.6%	32.3%	26.3%	23.8%	100%
Conclusion	Age 1	Age 2	Age 3	Age 4	0

(*) IN 1983 There was no biological sampling and proportions by ages were inferred from length distributions (Uriarte & Astudillo 1987) with a 3+

The Old fishes from the 1982 Cohort: A Clear Growth Pattern

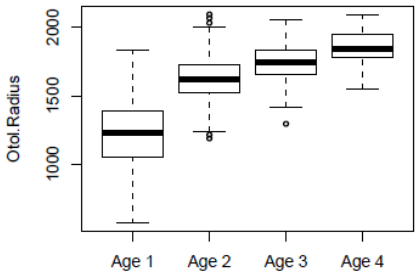


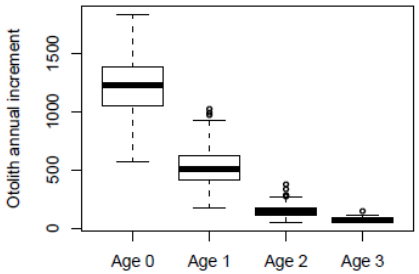
Typical otoliths of ages 3 (1985), 4 (86) and 5 (87) at spring time:

➔ Readers should know the expected annual growth pattern by ages (and most likely checks)

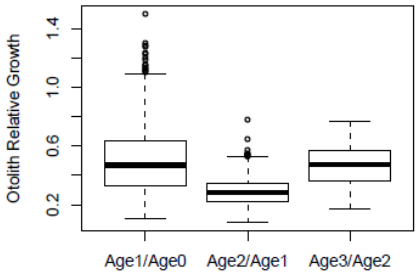
Quantification of otolith growth

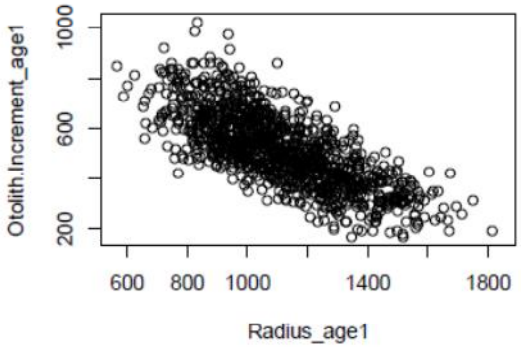
Measures of annual increments (annulus)





- Greatest growth at age 0.
- Growth at age 1 is about 50% at age 0.
- At age 2, G reduces to ~29% (CV = 33%) of that achieved at age 1.
- At ages 3+, opaque growth still diminishes but to a lesser extent,
- Negative correlation between growth at age 0 and increments at age 1
  - Compensatory growth



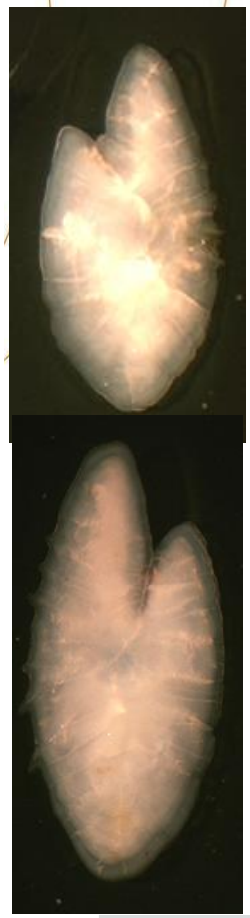


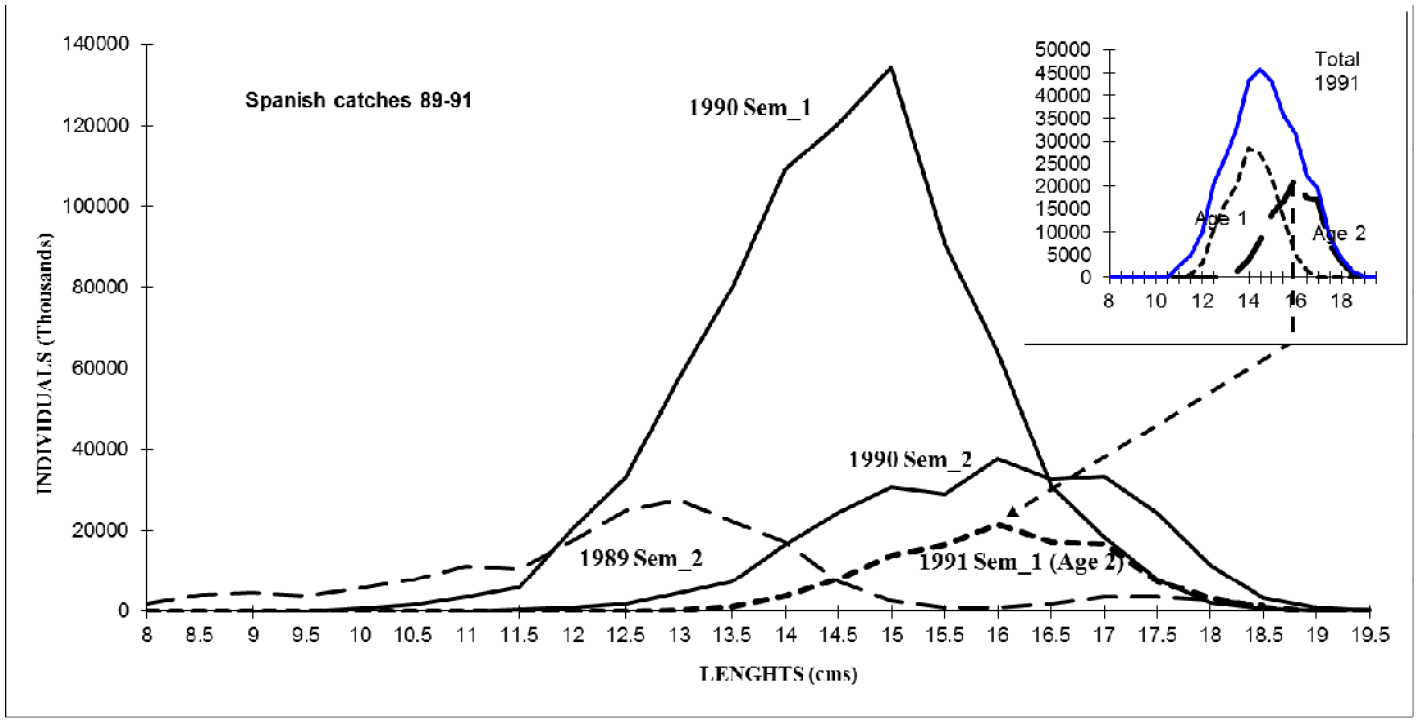
Verifying : Most recent Year Class (2010)

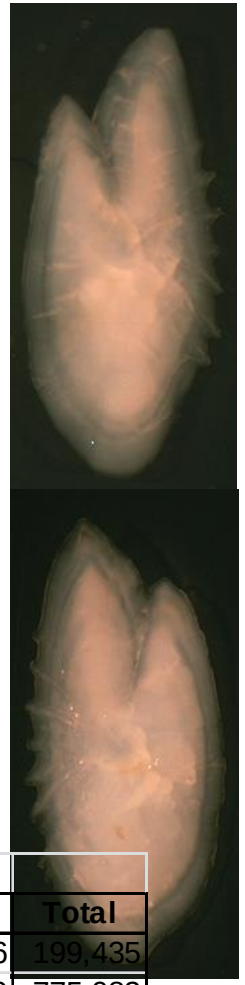
09/2010 04/2011 04/2012 04/2013 04/2014

➔ Similar growth pattern observed in recent year classes

Validation 2: Seasonal Progression of the 1989 cohort in Catches (from age 0 to 2)





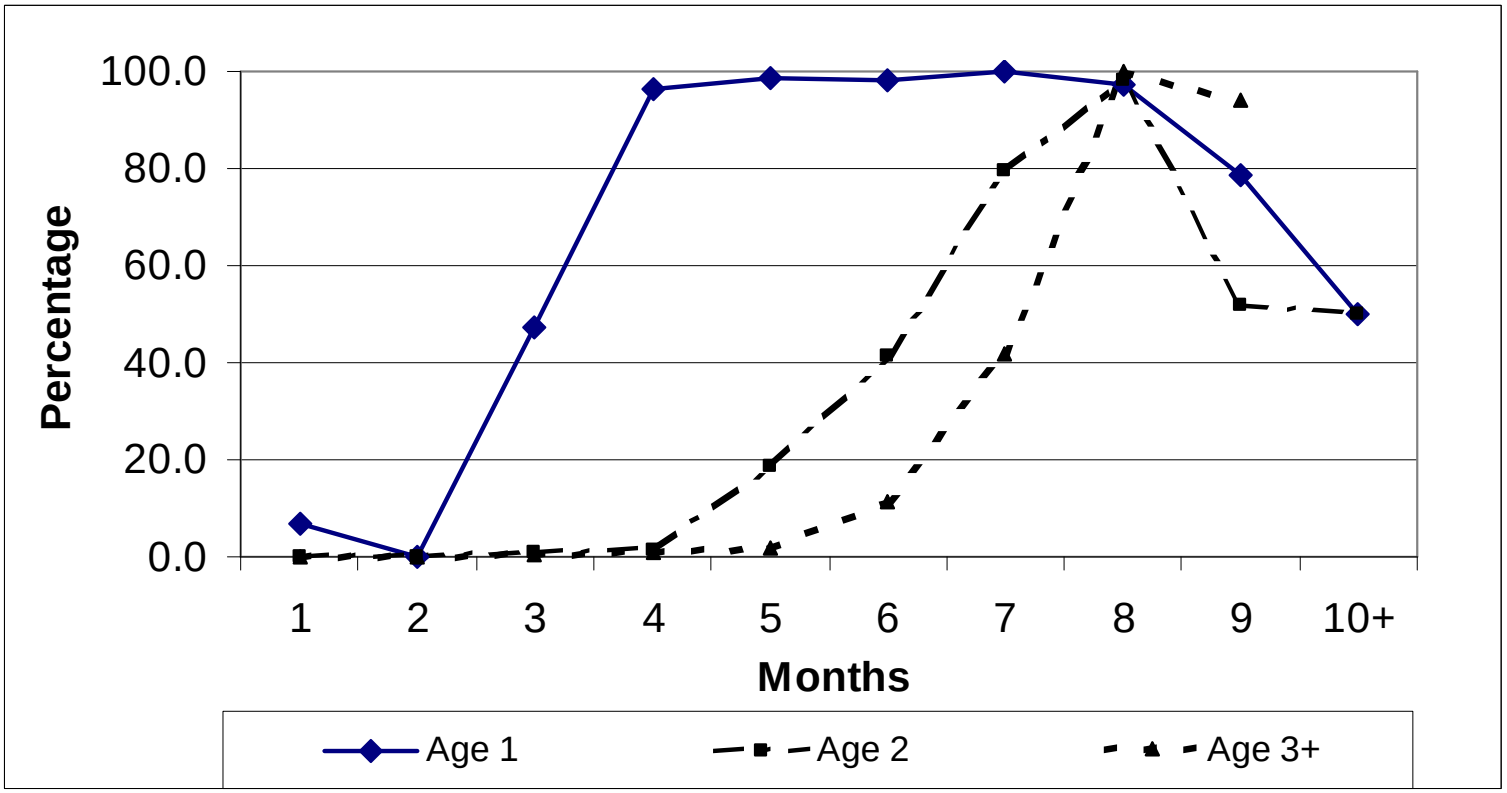


Semester 1 (Sem_1) = 1st half of the year / Sem 2 = 2nd half

➔ Maximum growth in summer time

	French Catches by semestres						Spanish Catches by semestres				
Year	Semestre	Age 0	Age 1	Age 2	Age 3	Total	Age 0	Age 1	Age 2	Age 3	Total
1989	Semestre 2	5,282	13,919	1,290	0	20,492	174,803	13,165	9,481	1,986	199,435
1990	Semestre 1	0	127,949	12,216	36	140,200	0	719,678	47,266	8,139	775,083
1990	Semestre 2	4,985	283,669	32,795	0	321,449	11,999	234,021	43,204	4,999	294,222
1991	Semestre 1	0	113,191	171,293	26,522	311,007	0	210,686	139,327	2,657	352,670

Opaque Edge formation by ages



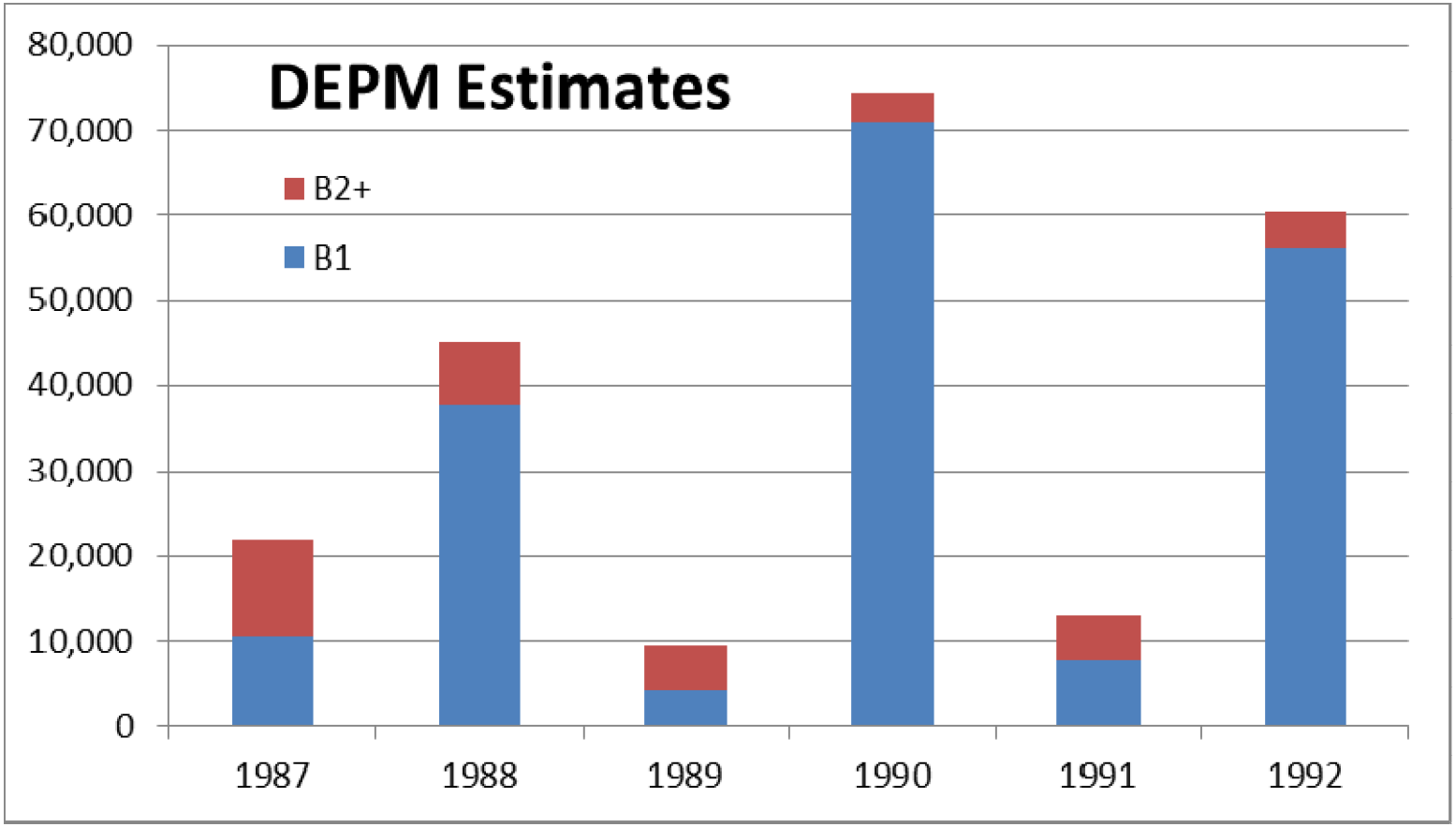
Percentages of otoliths by ages showing an opaque edge

➔ The younger the fish the sooner resumes growth

in Spring age 1 edge is opaque, while it is hyaline for older ages

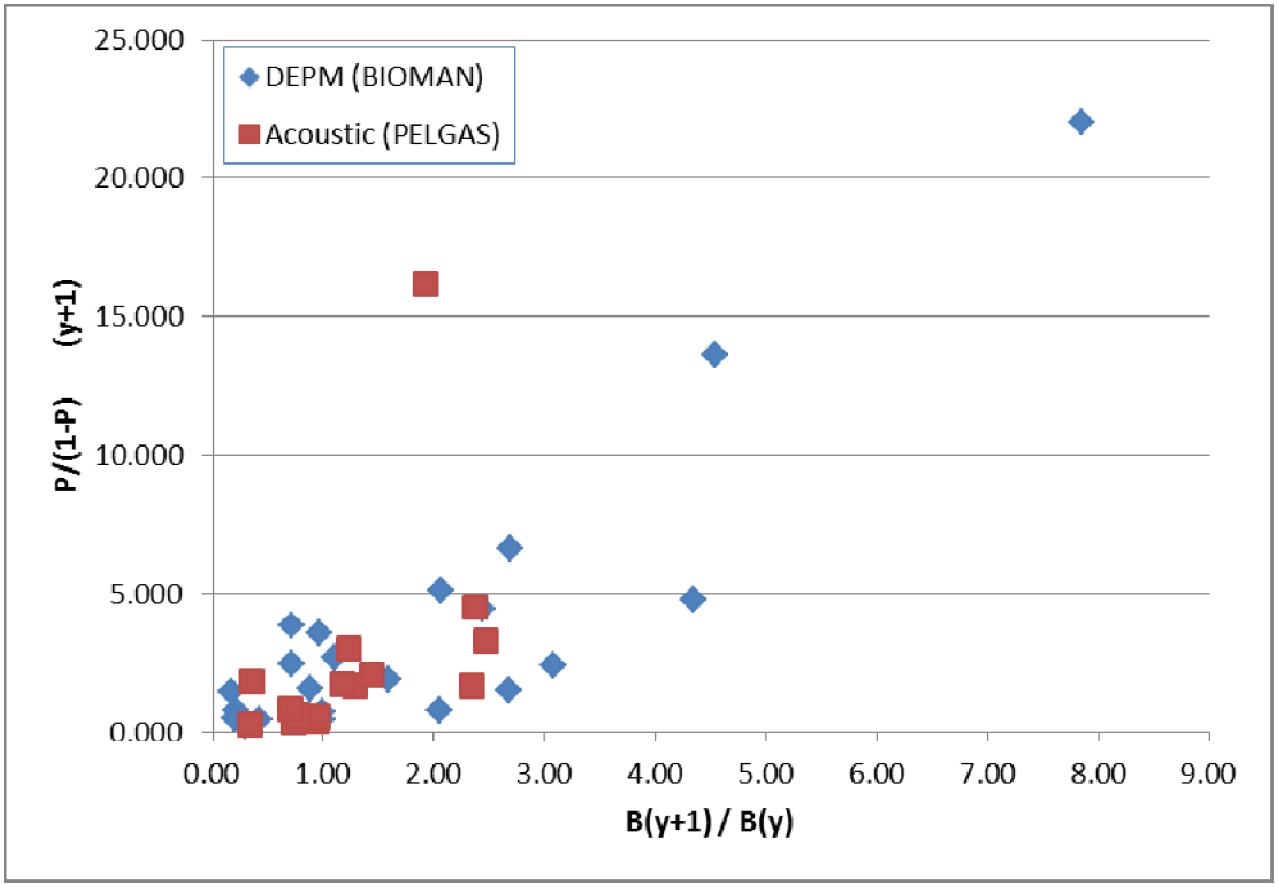
➔ Readers should know a priori the monthly expected type of edge by ages

Validation 3: Increases of biomasses in Spring Surveys due to strong recruitments



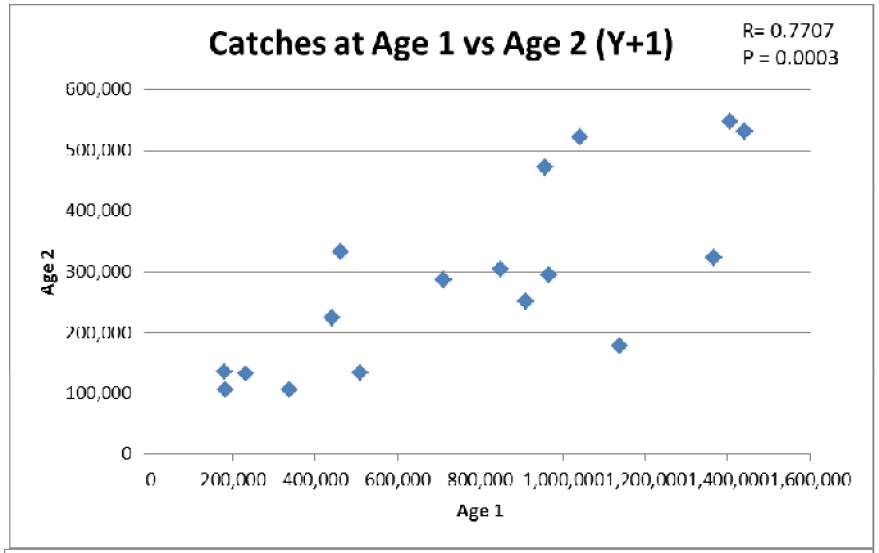
➔ Good determinations of ages 1 and 2+

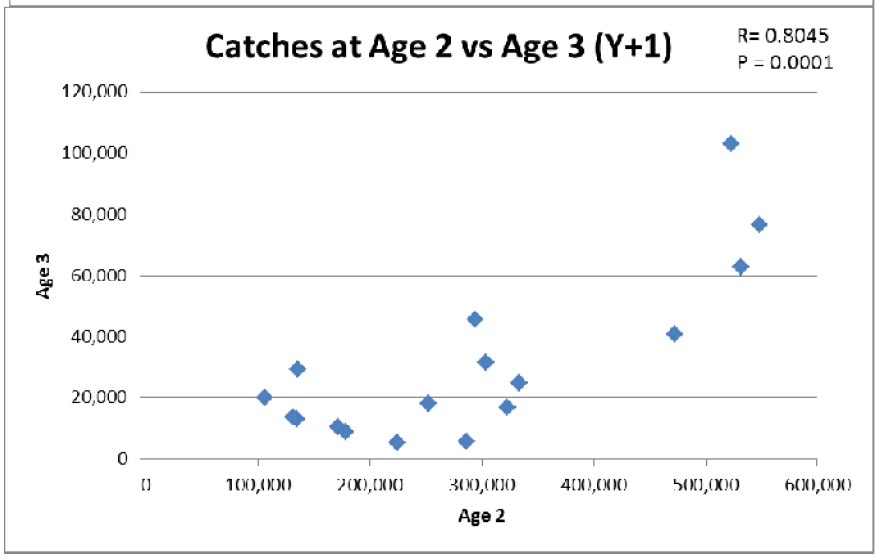
Verifying with complete survey series: Historical relative changes in Biomass over Percentages at age 1



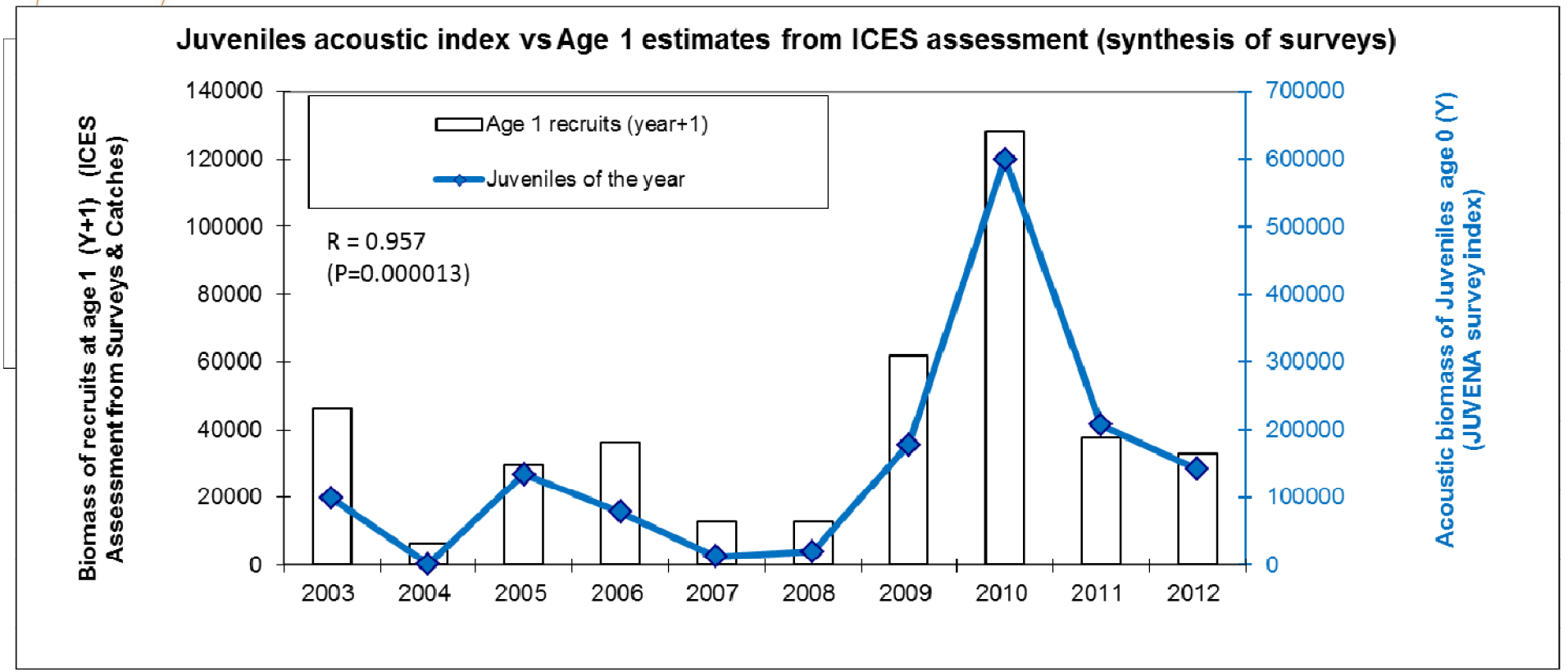
➔ The larger the increase in B the higher P1 R=0.722

Verifying with the international fishery : Correlation of successive age classes in the Catches (1987-2004)





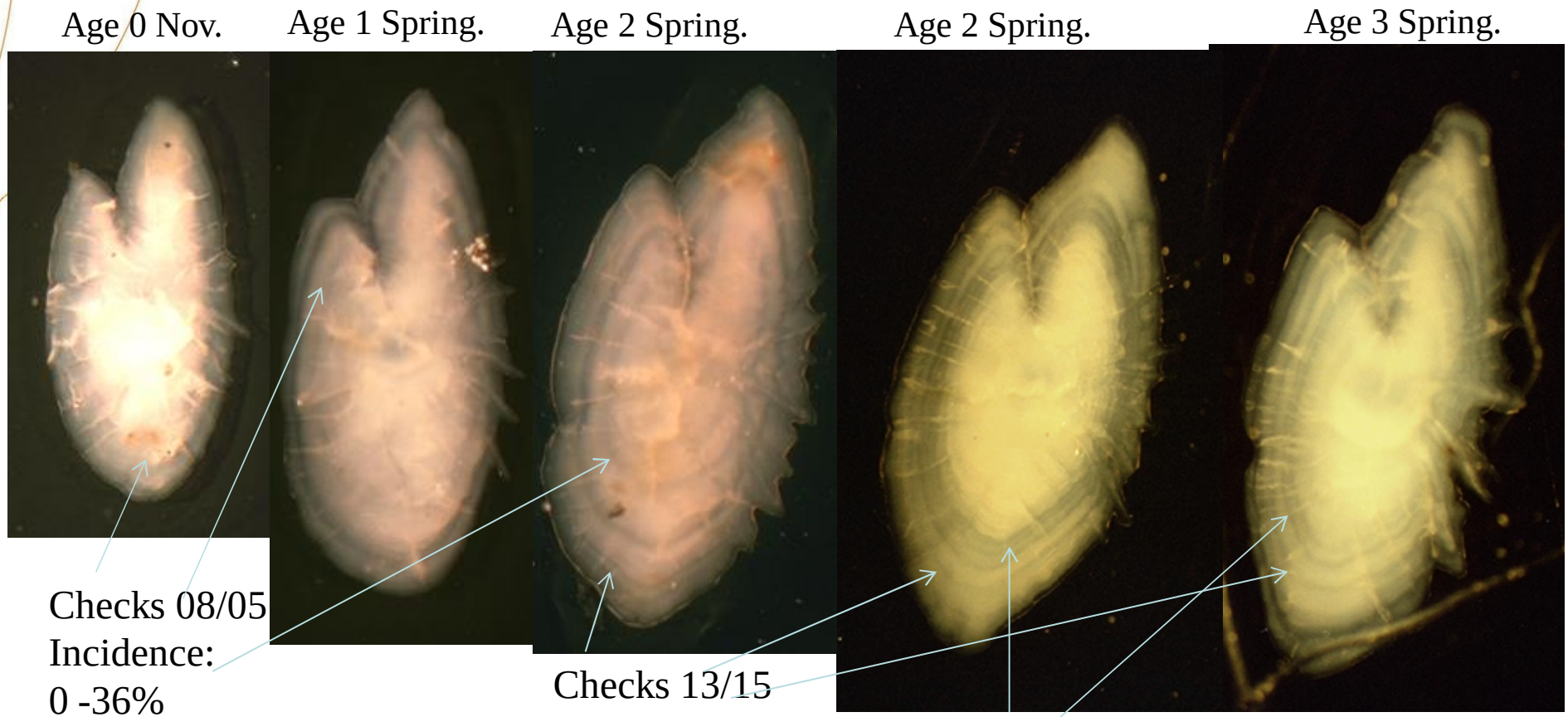
Verifying: Consistency of Age 0 (Y) and Age 1 (Y+1) in Surveys



➔ Consistent survey estimates

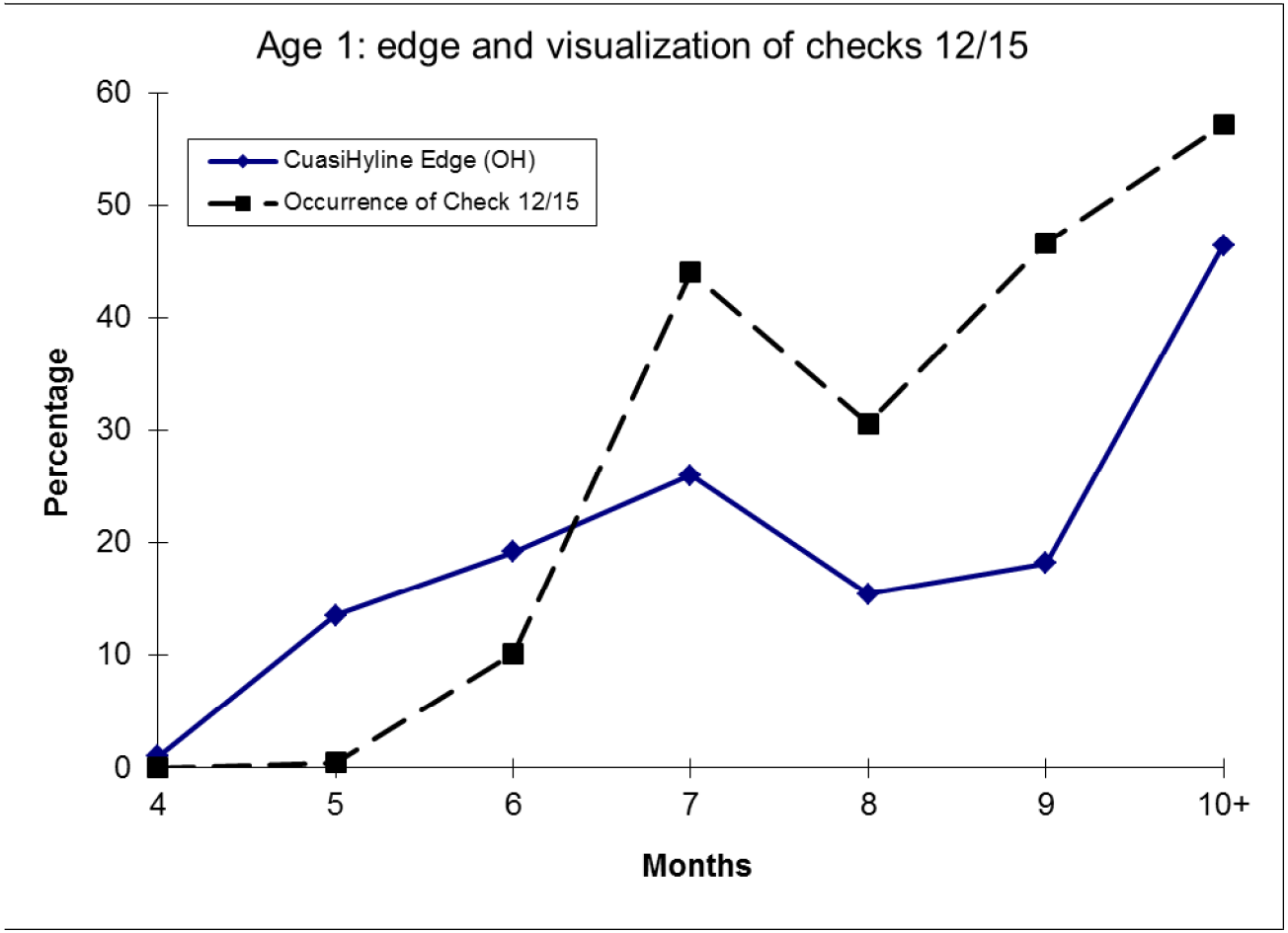
➔ Good Age determinations of ages 0 and 1

Difficulties: Checks



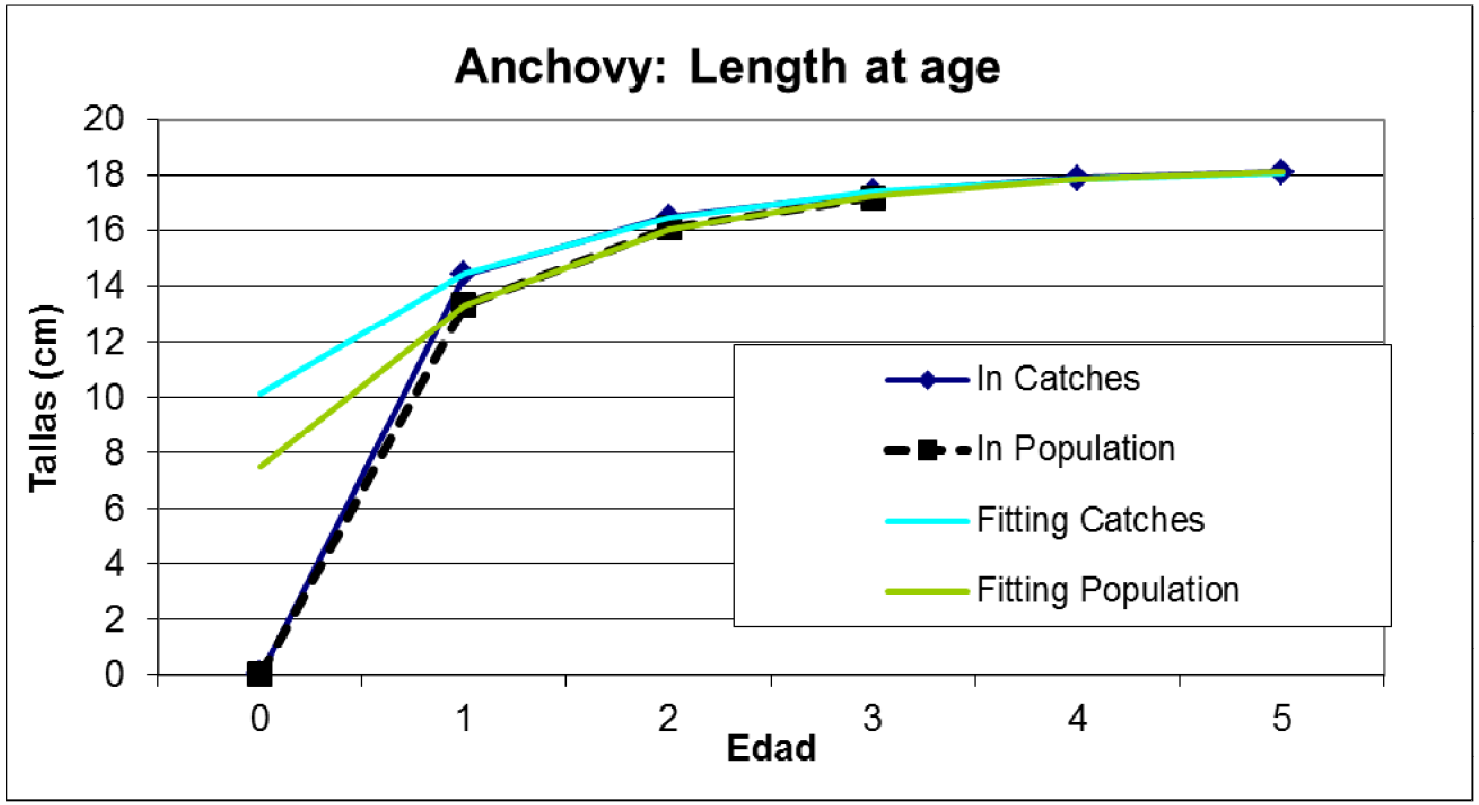
➔ Knowledge of Annual growth pattern and typical cheks is required to avoid missinterpretations and overestimation of ages

Check 15: Spawning check?
Check 15 formed in July



➔ Check 12-15: A Likely spawning check

Summary: Resulting Growth



Anchovy	In Catches	In Population
L inf.	18.30	18.3
K	0.75	0.8
t0	1.09	0.7

Summary Conclusions

- The methods is consistent with the population changes in length and biomassess (surveys) as well as in Catches

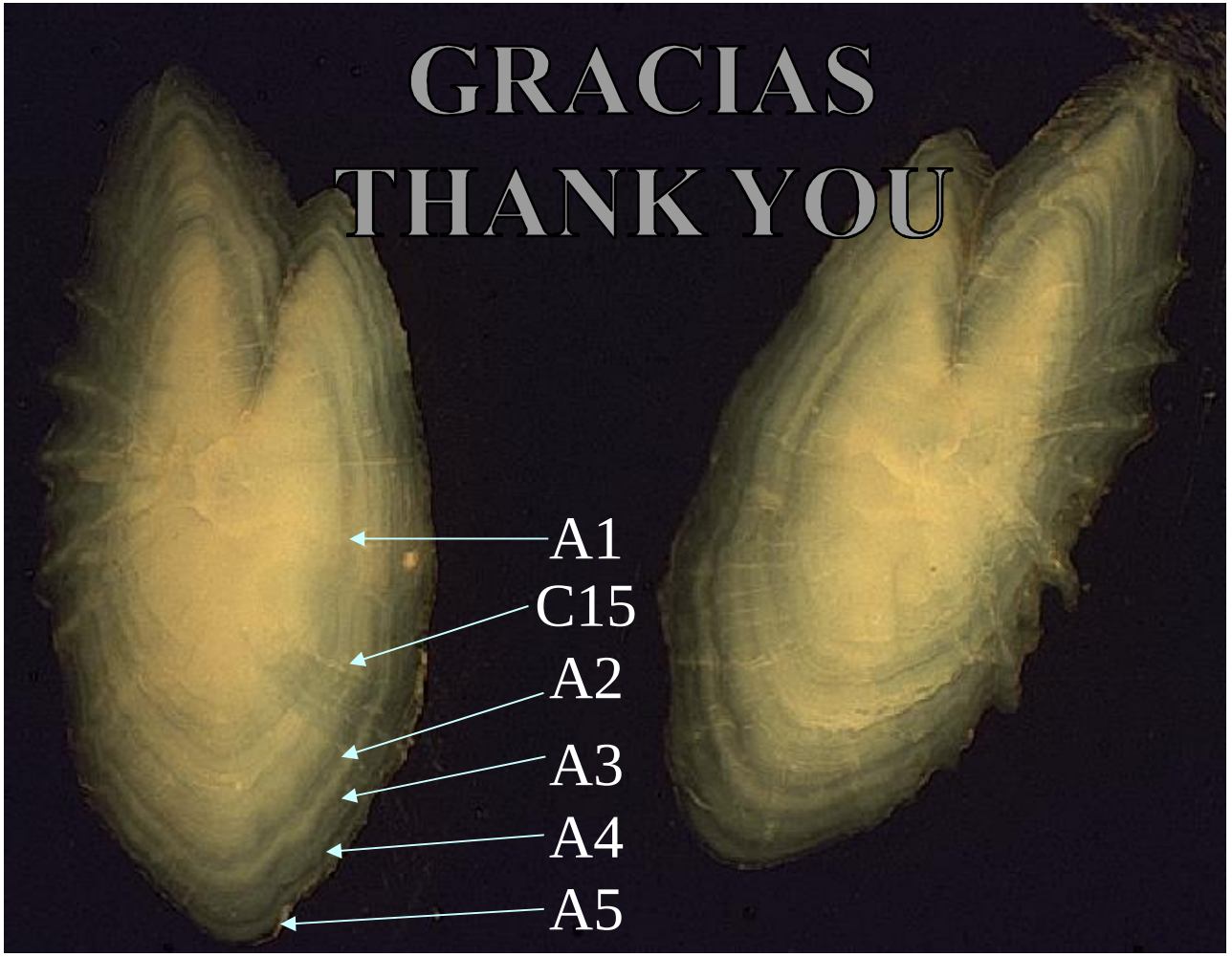
- The age reading method is based on the knowledge of date of capture and:
  - the annual growth pattern of the anchovy otoliths,
    - Criteria of complete growth zones: Age equals the number of complete opaque growth zones corresponding to the expected annual growth pattern of the otolith and excluding the marginal edge development of the year.
  - the seasonal otolith edge formation by ages:
    - maximum otolith opaque growth in summer months,

    The starting time of opaque edge formation changes with ages, being sooner at age 1 than at older ages. Edge should match expectationé

    in Spring: age 1 edge is opaque, while it is hyaline for older ages

  - the most typical checks (C05-08 // C12-15)

END



Aknowledgements: to all institutions supporting the anchovy monitoring
Fisheries Department of the Basque Government
/ Spanish and French Fisheries Department and European Commision

AGEING METHOD

- Typical annual growth of the otoliths is established, by which growth during the first, second and third years of life (corresponding to 0, 1 and 2 years old groups) diminish to about ½ or 1/3 of the growth performed during the previous year of life. Older ages (4 and 5 years old present a rather similar growth to the one experienced at age 3). Figure 5.1.2.1 and 5.1.2.2 present typical otoliths at different ages in spring time showing the typical annual growth described above.

AGEING METHOD

- Seasonal formation of the otolith edge follows that of temperate fishes in the northern hemisphere with maximum otolith growth (opaque white band formation) in summer months, and growth detentions (with hyaline rings) in winter time. However the starting of the white edge during spring time changes with ages, being remarkably sooner at age 1 than at older ages (Figure 5.1.2.3). As a result of this, in spring 1 year old anchovy have typically already started the deposition of the opaque growth band, whereas 2 years old or older fishes have mostly hyaline edges (or at the end of the spring in early formation of the opaque band) (Figure 5.1.2.1).

AGEING METHOD

- Typical checks occur before and after the first winter ring is formed, during age 0 and age 1 of this anchovy. The most typical one is that formed during June/July in many of the one years old anchovy at the peak of their first spawning period, which is considered to be a spawning check (Figure 5.1.2.4). Not all the years, neither all anchovies lay down the same amount of checks and many of them may not show any. The differences between true winter annual ring and the checks can be difficult: Usually checks tend to be weaker or more diffuse than true annual rings and often they are not completely formed all otolith around

CRITERIA FOR AGE DETERMINATION

- **Criteria of complete growth zones** in conformity with the typical annual growth pattern: Age equals the number of complete opaque growth zones corresponding to the expected annual growth pattern of the otoliths and excluding the marginal edge development of the year. In case the number of opaque zones do not correspond with the typical expected annual growth pattern the existence of some checks can be suspected and evaluated.
- **Criteria of the edge** in conformity with the expected seasonal edge growth by age: If the edge of the otolith do not correspond with the expected otolith edge of the age derived from above (a) criteria, then alternative interpretations should be considered (such as presence of checks). This may be relevant for instance to differentiate between ages 1 and older during the first half of the year, etc. In those cases a decision can be taken about the most likely age of the fish or alternatively the otolith can be rejected for age determinations.

Between Readers Precission

- The age reading determination has been presented in workshops with colleagues of the Bay of Biscay area and other neighbour areas of South Europe in 1998 / 2002 / 2006 / 2009

- On average 93% of agreement among readers of the BoB
  - Average CV of 9.2%
- Better agreement for younger ages (0,1) than for olders (2,3, 4)

- More difficulties arise during the growing period of the year (summer): to discriminate between true winter rings from summer and autumn checks