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Report on workshop on hake otolith age reading

Vigo, 23-27 June, 1997

by

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1. INTRODUCTION

One of the objectives of the EC Study Contract No. 95/038 "Biological Studies of Demersal Fish (BIOSDEF) was to improve the North-eastern Atlantic hake (*M. merluccius)* growth knowledge (in the Northern and Southern stocks). For this purpose, among other tasks, an ageing workshop for hake from ICES Division VIIIc and IXa was planned to standardise the methodology used in the different Laboratories in order to achieve agreement in the age determination of hake among the countries involved in the exploitation of shared stocks. The present workshop try to evaluate the results of the otolith exchange started in 1995 between Portugal and Spain. Moreover, attempt to identify the differences in the age determination among readers and to agree ageing criteria based on the discussion on otolith interpretation among readers.

The otolith exchange was later extended to more readers involved in hake Stock Assessment.

Reasons for conducting this age reading Workshop:

- Great commercial importance of this species for both translated in catch value and related economics, for Spain, France and Portugal among others.

- The Growth of European hake from Atlantic waters using different methods has been widely studied to improve the knowledge on the formation of rings in the otoliths (Hickling, 1939; Bagenal, 1954, M Bussy, 1966; Robles et al. 1975; Decamps and Labastie, 1978; Iglesias and Dery, 1981; Goñi, 1983; Goñi and Piñeiro, 1988; Guichet, 1988; Piñeiro and Hunt, 1989; Piñeiro and Pereiro, 1993, Piñeiro and Meixide, 1994). Nevertheless, not reliable method of growth interpretation has been found yet.

- Several International ad-hoc working groups have been devoted to otolith age reading (Anon. 1983, 1984, 1986) without a standard criteria of otolith interpretation.

- In recent years the ICES Working Group on Assessment of Southern Shelf Demersal Stocks, has applied numerical methods (Kimura- Chikuni, Hoening, etc.) To the annual length distribution of catches in order to obtain a catch at age matrix for VPA. However, the W.G. considers the results of these methods, an approximation to the true age composition of the catches.

- The **"**Workshop on Sampling Strategies for Age and Maturity, (Anon. 1994)" concluded that it was necessary to convene a specific workshop on age determination when the results of the stock assessment research suggest inconsistencies in the data or whenever new inexperienced staff becomes involved with those age determinations. .

- A previous otolith exchange, conducted in 1994 between France and Spain demonstrated a poor level of agreement between the only two readers who provide the age estimations to the W.G. stock on Piñeiro and Meixide, W.D., ICES 1994).

- The principal conclusion of all meetings and studies on this subject is that the interpretation of the growth pattern of European hake is too complex. Consequently, this fact affects both, Northern and Southern Stocks.

- Due to the difficulties in the age determination, hake has been considered by EFAN, (European Fish Ageing Network) both as a priority and a case study. Recently a very complete review of hake ageing problems was presented to the EFAN plenary ("Review on the European hake age determination and validation problems". B. Morales-Nin. Brest. May. 1997).

For all these reasons one of the objectives of the E.C. Study Project 95/038 “Biological studies of demersal fish” was to conduct an age reading workshop in order to standardise a criteria for ageing hake otoliths.

2. OBJECTIVES OF THE WORKSHOP

- Analyse and discuss the results of the age determination exchange in order to know the problems of hake reading.
- Elaborate an ageing criteria based on agreement between readers

3. PARTICIPANTS

The workshop was held in Vigo (Spain), from 23-27 June 1997 and the participants were:

Afonso Mª H. , IPIMAR, Lisboa, Portugal
Arego S., AZTI, Sukarrieta, Spain
Bellail R., IFREMER, Lorient, France
Casas M., IEO, Vigo, Spain
Labastie J., IFREMER, La Rochelle, France
Loureiro I., IEO, Vigo, Spain
Lucio P., AZTI, Sukarrieta, Spain
Marecos L., IPIMAR, Lisboa, Portugal
Meixide M., IEO, Vigo, Spain
Pereda P., IEO, Santander, Spain, (2 days)
Piñeiro C. , IEO, Vigo, Spain, (Chairperson)
Sainza M., IEO, Vigo, Spain
Trujillo V., IEO, Vigo, Spain

4. REVIEW OF HAKE BIOLOGY:

4.1. Distribution

As it is described by Casey and Pereiro (1995), European hake (*M. merluccius)* is widely distributed in the North-east Atlantic. Its range extends from the western coast of Norway and the waters south of Iceland , (62 º N) to the coast of Mauritania at about 21ºN. The distribution of European hake also extends eastwards into the North Sea, Skagerrat and Kattegat, and into the Mediterranean. The main densities are located in the North-east Atlantic, from the British Isles to Gibraltar (Figure 1).

European hake is found at depths ranging from about 30 m to more than 500 m over mud-sand and rocky substrates. The distribution pattern of the species show bathymetric differences by age class and certain spatial concentrations of annual classes also occur. The aggregations of recruits of the Northern stock are mainly located in areas of the Celtic Sea/ Bay of Biscay. On the Southern stock recruits aggregate in some areas of the Galician and Cantabrian shelf and South-east off Portugal.

4.2. Reproduction

Spawning of hake in the North-east Atlantic has been studied by several authors. In summary, the results from these studies indicate that spawning takes place over an extended period of time and it occurs earlier in more southern latitudes and progressively later towards the northern. In

fact , it is possible to find mature specimens throughout the year, but prolonged spawning is more evident in males. In Spanish waters the greatest spawning intensity occurs from December to April with a peak between February and March (Pérez and Pereiro, 1985). In Portuguese waters, spawning takes place mainly from December to March.

In relation to the spawning areas, the available studies show that hake migrates to spawn, although the spawning behaviour appears to vary with the latitude. Hickling (1939) and Belloc (1935) observed that mature adults concentrate in deep waters but spawn in shallower waters. Pérez and Pereiro (1985) showed that spawning individuals move from shallow to deep waters to spawn in the shelf edge. This information is confirmed by the commercial fleet behaviour, which is directed to these deep-water aggregations. Information from Portuguese research surveys agree with Hickling (*op. cit.*) and Belloc (*op. cit.*) conclusions (pers. com.).

There is abundant information concerning the length at first maturity of male and female hake in the Northeast Atlantic. Despite the methods used to get this information are not comparable, the values obtained are similar especially for the last decade (Martin, I., 1991). In general the length of the first maturity in females is always significantly greater than in males (Table 1).

4.3. Growth.

The difficulty of interpretation is revealed when the results of studies carried out by several authors. In these studies the age determination is based mainly the alternation of hyaline and opaque zones (rings) in the otoliths or well, on the modal length frequency distribution from surveys and fish commercial samplings. The growth parameters obtained by several authors and areas are summarised in Table 2.

In spite of using several techniques to improve the interpretation of growth rings in the hake otolith, all the researchers involved in growth studies find that the pattern of ring deposition is very complex and consequently difficult to interpret.

The main conclusion from all the research and meetings conducted so far noted that the major difficulties are:

- The location of the first annual ring (annulus)
- The classification of the rings as annual or false ring
- The interpretation of the edge

These difficulties can be related to some accompanying false rings, generally well marked (Figure 2). These can be identified very frequently, either, before, simultaneously or after the *annulus* deposition. Several authors have reported these false rings but there is no coincidence in their number and location (Table 3). This makes very difficult to identify the first annual ring, which, as it was indicated, constitute the most important source of uncertainty in otolith age reading.

All these facts, together with the wide range of length at age estimated given by different authors for European hake (Figure 3) are the current issues on hake age determination.

5. MATERIAL AND METHODS

The otoliths collection exchange conducted during 1995 included 193 otoliths sections from individuals of 16 to 60 cm length, for different seasons of the years 1993 and 1994. Some of them (14) belonged to the Northern Stock, in order to check whether growth pattern in both stocks is different.

Thin cross-sections were obtained using the technique described by Piñeiro et al. (1996). The readers did not have any information about the individual fish except the date of the catch and sex.

During the present workshop a second reading of the same exchange collection was planned. Due to the high time consuming reading it was decided to re-read only 94 otoliths sections. An independent second sample of 31 otolith sections of hake with 15 to 65 cm length, belonged to 1996 and 1997, was also read.

The observation was done mainly with a magnification of X20, using a stereo microscope under reflected light but transmitted light to help the viewing was also utilised . For the discussion of the otolith interpretation criteria, a video camera and monitor was used.

For some fish, both the whole otolith and a section, were observed and discussed in order to compare the identification of the first annual ring in both structures. To know if the readers counted the same rings, it was decided to take radius measurement of the first fifth annual rings in the otolith sections.

The number of readers who participated in ageing was eight at the beginning but the readings of one more reader, who participated in all discussions during workshop, was also included in the results. Although the majority of them were experienced in reading otoliths from other species only two were experts in ageing hake.

During the otoliths exchange, the labels used for readers in the analysis are as follows:

READERS	**ID_OTO**	**READERS**	**ID_OTO**
Jacques Labastie	R1	Isabel Loureiro	R6
Lourdes Marecos	R2	Maria Sainza	R7
Mria. Hortense Afonso	R3	Carmen Gª Piñeiro	R8
Paulino Lucio	R4	Robert Bellail	R9
Susana Arego	R5		

Wherever possible, each reader gave an absolute value to each otolith. Doubtful ages were indicated by the mark “?” after the age, and otoliths which were too difficult to read were assigned only “?”. In general, the criteria used to select not precise ages for the analysis was as follows:

Age : 6-7 => age considered is the smaller, so 6
Age : 6 ? => 6
Age : 6 ? 7 => 7 , It is more sure 7 than 6 ? , so is 7.
Age : ? is excluded from the analysis

The general criteria adopted for ageing each otolith was based on the number of the annual hyaline rings, using the following rules:

Period	Quarter 1	Quarter 2	Quarter 3	Quarter 4
N rings Hyaline edge	age = N	age = N	age = N-1 early winter	age = N-1 early winter
N rings Opaque edge	age = N+1 tardy winter	age = N	age = N	age = N

The otolith reading exchange which preceded this Workshop occurred during 1995 between Spain (IEO, AZTI) and Portugal (IPIMAR). Nevertheless, was later extended to more countries which participate in the W. G. on stock assessment.

The main lines of the work at the Workshop were as follows:

- Reading the exchange collection by the readers joined at the end of exchange.
- To analyse the results of the first otolith exchange.
- To discuss the individual interpretations of the otoliths, reviewing those on which there was a big discrepancy among readers and also those for which the age assigned was the same.
- To conduct a second reading of a sub-sample of the same collection (94 otoliths).
- To analyse the results of the second reading.
- To conduct a third independent reading of a different set of otoliths sample (31 sections), which will provide the basis for determining how well the discussed criteria was applied.
- To establish an age determination criteria on the interpretation of the growth pattern for the first years of the fish life.
- To evaluate the results of the third reading.
- To elaborate the draft of the Report.

The comparison of readings was made using an ad-hoc Excel spreadsheet, described by Eltink, (1994). From each otolith mean age, mode, range and standard deviation have been estimated. The Box-whisker plot was used as an exploratory data analysis that summarises the observations.

Following the recommendation given by "Workshop on Sampling Strategies for Age and Maturity C:M:, 1994", the statistical analysis used consisted in :

- Wilcoxon's rank test, to find out the bias between pair of readers.

- Two measures of agreement: The average percent age error (APE), (Beamish and Fournier,1981), and the mean Coefficient of Variation (V) (Chang, 1982).

The average percent age error (APE), is an index of reading accuracy to compare series of observations, the formula is the following :

$$I\,\% = \frac{100}{n}\sum_{i=1}^{n}\left(\frac{1}{r}\sum_{j=1}^{r}\frac{\left|x_{ij}-\overline{x}_i\right|}{\overline{x}_i}\right)$$

n = number of otoliths
r = number of readings for each otolith.
x_{ij} = the j value of age estimation for the otolith/fin-ray i.
$\overline{x}_i$ = average age calculated for the otolith/fin-ray i.

The coefficient of Variation (V) is, like above mentioned APE, considered more appropriate to compare ages than the conventional percent of agreement technique, because both incorporate the average year class of fish.

- Bias plots average age, $^{+-}$2 standard deviation, of each age reader and all age readers are plotted against modal age, considered as referential age.

6. RESULTS AND DISCUSSION

6.1 Age readings

The readings of the 193 otoliths exchanged by reader with the basic information concerning each otolith (sample number, month of the capture, fish length, sex) are summarised in Tables 4-6. The first reading of the first sample was done with personal criteria by reader.

The Box-Whisker plot is particularly useful in order to know and compare the distribution of the otoliths readings by reader. Initially, the age readings of all readers are quite different (Figure 4.1a). There are mainly three groups: first one, include the majority of readers and the median value of estimated age is around 3, second one, include two readers which the median values are smaller and the third one which age reading is overestimated (median =7). As it is shown in the Figures 4.1b,c, the main sources of discrepancy are the location of the first annual ring and consequently the second one.

However, once the discussion of interpretation criteria started, the differences among readers decrease. Thus, in the second reading the majority of age readings are similar with a median value around 3 (Figure 4.2 a). The discussion of the criteria was useful as is demonstrated in Figures 4.2b, c, where are shown the measurements of the first and second annual ring considered by all readers.

In the new second sample, a consensus criteria was employed and the results are quite similar (Figure 4.3 a). In comparison with second reading, the improvement here is less important than it was expected. There are two factors, which can affect on it: the reading memory in the second reading of the first sample and the small amount of otolith (31) of the second sample.

The location of the first annual ring seems to be more clear than before for all readers (Figure 4.3 b).

The results of Wilcoxon's test between readers are shown in Table 7. As can be seen there is a clear bias between most readers in the first reading. Only in two combinations of readers there was no significant bias. After discussion on the differences and similarities in age interpretations, the ageing agreement improved. Then the bias decrease so in seven combinations of readers, there was no significant bias.

In the second sample reading, the results indicate the ageing agreement improved even further, thus from nine readers in ten combinations there was no significant bias.

The average percent of error (APE) was calculated using the readings of all readers and also using the readings of those readers are routinely involved in age determination of hake. The values obtained for these are lower than for all readers, due to their experience. The coefficient of Variation (V) decrease after discussion, reached values of 26.3 for all readers and 15.9 for the experienced readers (Table 8). In general, reading accuracy was better as more readings and discussions were done.

By modal age are presented the average age recorded, 2(±) standard deviation, and number of age readings by reader and of all readers (Table 9.1-3). The age bias plots of each reader with respect to the modal age and all readers combined are shown in the Figures 5.1-3. These plots permit the identification of which readers are biased and at what ages.

Bias plots of the first reading show great variability (Figures 5.1), above all, reader 1 tends to underestimate all ages, readers 5 and 8 tend to underestimate ages older than 3. However readers 4 and 6 tend to overestimate all ages in general. In the second reading, after discussion, the variability decreased considerably, the most bias reader is 4, who tends to overestimate ages up to 1.

In the second sample reading, the bias increased lightly, probably due to the small numbers of otoliths in this collection (31). Reader 4 tends to overestimate all ages. The most bias is in ages older than two and in general, all readers seem to have fewer problems in ageing young fish of 0,1 and 2 years.

A good improvement in the age readings between sample 1 of the Otolith Exchange and the Workshop sample 2 is demonstrated. The results are expected to improve further in the future as more readers gain more experience reading hake otoliths and more knowledge on the relation otolith-behaviour of hake is achieved.

6.2 Age determination criteria:

- **Description of the criteria:**

The criteria for the hake age determination is as follows:

As on other species, a set of an opaque and hyaline zone corresponds to one annual growth zone "annulus".

The 1st of January is conventionally adopted as hake "birthday". So if an otolith is collected from a fish captured during the first half of the year, the age group assigned will correspond to the number of annual rings (hyaline) present. On the other hand, if the otolith is removed from a fish caught during the second half of the year, the age group assigned will correspond to the number of hyaline zones formed less one (see table section 5).

There are generally three checks, which appear in the otolith central area and are formed during the first year of life. As was indicated before, these "false rings" are reported by several authors who related them with "larval" (the first), and "pelagic" (the second) life phases and the third one, "demersal", with recruitment of fish to the bottom of the sea.

It is also recognised the presence of a very frequent hyaline ring, usually well marked that often occurs simultaneously with the first annual ring or between the first and second ones (Goñi and Piñeiro, 1988; Piñeiro and Hunt, 1989). This might be caused by feeding changes and may be useful as a reference zone to start the counting.

- **Determination criteria for the First annulus:**

The correct interpretation of the first "annulus" is one of the more critical features of precise ageing of any species. Hake growth during the first year of life is characterised by the occurrence of different check rings, probably related with the physiological and environmental events that make difficult the location of the first annual ring (Figure 3).

As in other species (ICES, CM 1997, G: 1) to help on this, the readers should have the knowledge of catch date and also the fish length. Also measurement of the "larval", "pelagic"

and "demersal" rings taken with an ocular micrometer (X20 magnification) are recommended to be used as a general guideline for the determination of the first annual ring.

It was admitted as a first conclusion that the first annual ring (winter ring) appears after the check called "demersal" ring or may be co-incident with it. The relative position of this annual ring could be related with the duration of the spawning season (Piñeiro and Hunt, 1989).

- **Determination criteria for the Second annulus:**

It was agreed, as a conclusion, that the growth between the first and the second year of life, is large in comparison with the rest of the increments and very often, in this zone appears a strong marked ring that could be related to some event of the fish life cycle. This check appears around 1.5 mm from the nucleus of the otolith section (X20 magnification). As is described by Piñeiro, 1993, this ring is not an annual ring but it may be co-incident with first or second winter ring. The group agreed to use this check as a reference ring when the reading is undertaken.

- **Interpretation of the edge (marginal growth):**

The interpretation of the edge is difficult; however, a correct interpretation of the type of growth at the otolith edge is necessary to assign the appropriate year class. New growth at the edge use to be related to the time of the year fish was caught. For hake otolith, the edge seems do not follow, strictly, the expected pattern of hyaline in winter and opaque in summer. Hyaline edge appears very frequently along the year, suggesting a high incidence of false rings associated with summer. Nevertheless, in order to assign the age year class in agreement, the edge interpretation follows the pattern mentioned before, in material and methods.

7. CONCLUSIONS

1. An otolith interpretation criteria was agreed for the first three ages of hake. However, it was considered, that this workshop, is one step further to achieve a consensus ageing criteria for all ages in hake otolith.

2. A reference factor is necessary to start with the counting of rings: two or three checks before the first annual ring. Thus, the location of the first winter ring is now more clear for the majority of the readers.

3. Based on the difficulty of growth pattern interpretation, the knowledge of length still is a help to achieve a better interpretation in a big percentage of otoliths.

4. The interpretation of the otolith edge type is very complex due to the high frequency of occurrence hyaline edges during the whole year.

5. There was no evidence of different growth pattern between otoliths from Northern and Southern Stock.

6. The central position of the otolith cut is essential for a better reading.

7. The inclusion of otoliths in glycerine before cutting, clarify the ring structure of the otoliths and that makes to improve the interpretation of growth pattern.

8. The experience of the readers improves the agreement.

9. Poor quality of otolith due to the manipulation during the exchange limits the ageing agreement.

10. The workshop participants agreed that the co-operation among countries concerned is essential to solve the ageing problems encountered in this workshop and need to be intensified in order to involve readers from countries that participate in the W. G. on stock assessment.

8. RECOMMENDATIONS

1. Due to the complex growth pattern of hake otoliths, it is necessary to devote more readers for ageing, at least, two by country in order to obtain a consensus for age estimation.

2. A regular exchange of reading otolith is considered necessary, for the purpose of checking the precision of all readers involved in age determination.

3. In order to continue the work started in this workshop and to review the agreement between readers, it is necessary to carry out another workshop next year after a previous otolith collection exchange, ideally with the participation of other countries involved in stock assessment. The exchange will include samples of different areas from Northern and Southern stocks.

4. The preparation of an "age determination guide" is recommended to assist the individual reader in the correct interpretation. This "guide" should include photographs of reference otolith sections.

5. Is strongly necessary to conduct more studies based on the life history events of the fish in order to identify the occurrence of some characteristic hyaline rings (checks), very well marked in the otoliths and its relation with hake behaviour.

6. Some effort should be devoted to explore alternative techniques to validate the estimation of age (tagging, microchemistry, etc.). This recommendation requires a dedicated project on this matter.

In other words, a big effort from the countries involved in Stock assessment on hake is necessary to develop a consensus interpretation criteria for all ages, in order to obtain more reliable age estimations for hake.

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Table 1.- Parameters of Length at first maturity in hake of several areas by differents authors (Martin, I.C.M./G: 54, 1991).

MALES

Área	Reference	Data	Period	L50	L75-L50	Number	Range	Value of A
Mediterranean	Larrañeta 1970	Market sampling		24,3				
IXa	Anon 1982	Portuguese survey	March/June 1980, 1981	33				
	Anon 1983	Iden	April/March 1980 to 1983	32				
	Anon 1986	Iden	June 1983	31,6		2252		
	Iden	Iden	June 1984	28,6		199		
	Anon 1988	Iden	Feb/March 1987	27,5		1254		
IXa	Anon 1986	Spanish data	Quarters 1,2,3 1981	37		428		
	Iden	Iden	Quarters 1,2 1982	36,5		207		
	Iden	Iden		32,5		162		
	Iden	Iden	Quarters 1, 2 1984	37		176		
	Iden	Iden	Quarters 1, 2 1985	32		176		
VIIIc-IXa	Pérez 1981	Market samp+survey	All Quarters 19 May 1980-	39		1539	25-65	
VIIIc-IXa	Anon 1982	Spanish data	All Quarters 1980-1981	39				
VIIIc-IXa	Pérez 1985	Market samp+survey	All Quarters 1980-1982	35-39		1865	25-65	
VIIIc-IXa	Anon1986	Spanish data	Quarters 2,3,4 1980	39,5		1230		
VIII	Present work	Market samples	Jan to May 1987-1990	37,7	4,8	1129	20-62	35,2
VIII	Meriel-B. 1966	Frech surveys	April, May 1965-1966	36-37				
VII+VIIIa	Anon 1986	English surveys	1983-1986	38,4	11,2	854	`12-85	34,9
VII+VIIIa	Anon 1990	Iden	March, Dec. 1987-1989	33,15	6,37*			

* (estimated from the figure provided by the author)

FEMALES

Área	Reference	Data	Period	L50	L75-L50	Number	Range	Value of A
Mediterranean	Larrañeta 1970	Market sampling		32,2				
IXa	Monteiro 1965	Market sampling	Quarters 2,3 1959	57,7	8,4	20-23	40-86	115,87
IXa	Anon 1982	Portuguese survey	April/March 1980 to 1983	49				
IXa	Anon 1983	Iden	June 1983	49		453		
IXa	Anon 1986	Iden	June 1984	55,5		271		
IXa	Iden	Iden	Feb/March 1987	58		874		
IXa	Anon 1988	Port. Surv.+market	Surv. 1986 and Fe-Mar 19	51		874		
IXa	Anon 1986	Spanish data	Quarters 1,2,3 1981	49,5		285		
IXa	Iden	Iden	Quarters 1, 2 1982	47		190		
IXa	Iden	Iden	Quarters 1, 2 1983	46		141		
IXa	Iden	Iden	Quarters 1, 2 1984	45		320		
IXa	Iden	Iden	Quarters 1, 2 1985	47		263		
VIIIc-IXa	Pérez 1981	Marquet samp+survey	All Quarters 19 May 1980	56		922	25-75	
VIIIc-IXa	Anon 1982	Spanish market samp.	All Quarters 1980-81	56				
VIIIc-IXa	Pérez 1985	Marquet samp+surveys	All Quarters 1980	58		832	25-75	
VIIIc-IXa	Anon 1986	Spanish data	Quarters 2,3,4 1980	58		832		
VIII	Present work	Marquet samples	Jan to May 1987-1990	50,5	7	1013	20-75	43,3
VIII	Meriel-B. 1966	Frech surveys	April, May 1965-1966	54-57*				
VII+VIIIa	Anon 1986	English surveys	1983-1986	50,4	8,9	781	`12-85	19,65
VII+VIIIa	Anon 1990	Iden	March, Dec. 1987-1989	59,18	5			

* (estimated from the figure provided by the author)

SEXES COMBINED

Área	Reference	Data	Period	L50	L75-L50	Number	Range	Value of A
IXa	Anon. 1987	Portugrese Surveys	1982-1984	39				
VIII	Present Work	Market samples	Jan to May 1987-1990	41,4	8,1	2142	20-75	130,84
VII+VIIIa	Anon. 1986	English Surveys	1983-1986	43,3	12,5	1635	12-85	35,96
VII+VIIIa	Anon. 1990	Idem	March-Dec. 1987-1989	39,98	13,6			

Table 2.- Growth parameters of European hake, estimated by several authors.

Authors	***Area***	***k***	***l***	**Method**
HICKLING (1933)	Southwest of Ireland	0.087	128.6	Otoliths
BIRTWISTLE & LEWIS (1925)	Notheast of Ireland	0.078	245.8	Otoliths and scales
BAGENAL (1954) " "	Clyde "	0.71 0.204	126.4 125.9	Petersen Otoliths
MERIEL- BUSSY (1968)	Gulf of Biscay	0.059	171.8	Otoliths
GUICHET et al (1973) " " " " " " (1974) " " "	Notheast of Ireland " " " " " " " " "	0.069 0.07 0.024 0.087	124.0 124.0 268.2 123.7	Otoliths, males " females " males " females
ROBLES et al (1975)	ICES VIIIc and IX a	0.07	125.4	Otoliths
DESCAMPS et LABASTIE (1978) " " "	Gulf of Biscay " " "	0.154 0.096	81,4 117.7	Otoliths, males “ females
IGLESIAS & DERY (1981) " " " " " "	ICES VIIIc and IX a " "	0.06 0.15 0.06	99.9 63.4 99.8	Otoliths " males " females
GOÑI (1983) " "	Marroco " "	0.064 0.067 0.065	110 100 110	Otoliths " males " females
PIÑEIRO (1991)	ICES VIIIc and IXa	0.08	100	Otoliths
GUICHET & LABASTIE (1993)	VII y VIIIab	0.08	127.5	Otoliths

Table 3 False rings distances (bakcalculated) observed in hake otoliths, before the first annual ring, by authors.

Author	***Area***	False rings
Decamps and Labastie,1978	Gulf of Biscay	7, 12 cm
Iglesias and Dery, 1981	ICES VIIIc and IX a	3 rings before 12 cm and one after
Goñi, 1983	North West of Africa	2, 4, 7, 10 cm
Goñi and Piñeiro, 1988	ICES VIIIc and IX a	3, 5 , 9 cm
Piñeiro and Hunt, 1989	ICES VIIIc and IX a	4, 7 , 9 , 12 cm
Piñeiro and Pereiro, 1993	ICES VIIIc and IX a	One translucent band : 7-10 cm

Table 4.- First readings by reader of the hake otolith exhange. (*)=QUARTER (I, II, III, IV)

Cod oto	Stock	Month/Q *	Sex	Length	AgeR1	AgeR2	AgeR3	AgeR4	AgeR5	AgeR6	AgeR7	AgeR8
1	S.S	10	2	52	5	7	6	8	2	8	6	7
2	S.S	10	2	37	2	3	2	4	2	6	2	2
3	N.S.	3	3	23	2	2	1	3	1	2	2	2
4	S.S.	10	2	31	2	3	3	2	3	8	3	2
5	S.S.	10	2	44	5	7	6	7	2	9	7	7
6	S.S.	10	1	20	1	0		1	2	1	1	0
7	N.S.	3	2	34	3	4	4	5	3	7	3	3
8	N.S.	3	2	32	3	3	3	3	3	8	3	3
9	N.S.	3	2	28	2	2	2	3	3	5	2	2
10	S.S.	10	2	45	4	6	6	5	4	9	5	7
11	S.S.	10	2	46	4	6	6	5	3	5	5	4
12	N.S.	3	3	18	0	1	1	1	1	2	0	1
13	N.S.	3	1	33	3	3	3	4	3	4	3	3
14	S.S.	10	1	40	3	4	4	4	2	6	3	4
15	S.S.	10	2	45	3	5	5	5	4	8	4	4
16	S.S.	10	1	26	1	3	3	3	3	4	2	2
17	N.S.	3	2	32	3	4	4	4	4	5	4	3
18	S.S.	10	2	44	2	5	5	6	4	8	5	5
19	S.S.	10	2	52	3	7	7	7	4	6	6	7
20	S.S.	10	2	37	2	4	3	4	3	6	2	4
21	N.S.	3	1	27	1	2	2	2	2	8	1	2
22	S.S.	9	1	49	3	5	5	7	5	6	6	6
23	S.S.	9	1	34	2	2	2	4	4	6	2	2
24	S.S.	9	2	46	3	6	6	7	2	9	4	4
25	S.S.	9	1	42	3	5	5	6	4	8	4	5
26	S.S.	9	1	49	4	7	7	9	4	9	6	6
27	S.S.	9	1	42	2	4	5	7	4	9	3	5
28	S.S.	9	1	34	2	3	3	3	4	6	2	2
29	N.S.	3	3	20	2	1	1	2	1	3	1	1
30	S.S.	10	1	55	5	8	6	10	3	9	6	7
31	N.S.	3	2	21	0	1	1	2	3	3	1	1
32	S.S.	10	2	31	2	3	3	5	3	8	3	3
33	N.S.	3	2	19	1	1	1	2	1	2	0	1
34	S.S.	9	1	55	4	7	6	10	4	7	6	7
35	S.S.	9	2	28	1	2	2	3	3	3	2	2
36	S.S.	10	3	16	0	0	0	0	1	0	0	0
37	N.S.	3	3	25	1	0	1	3	3	5	1	1
38	S.S.	10	1	40	4	7	5	9	4	10	6	7
39	N.S.	3	2	33	1	2	2	4	3	5	3	3
40	N.S.	3	2	34	1	3	3	4	2	6	3	4
127	S.S.	5	2	26		1	2	2	2	5	2	2
128	S.S.	5	2	26		1	2	2	2	5	2	2
129	S.S.	5	2	26		2	2	2	3	6	2	2
130	S.S.	5	2	26		2	2	2	2	6	2	2
131	S.S.	5	2	26		2	2	2	2	7	2	2
132	S.S.	5	2	26	1	2	2	2	2	5	2	2
133	S.S.	5	2	27	1	2	2	2	2	5	2	2
134	S.S.	5	2	27		2	2	2	2	7	2	2
135	S.S.	5	2	27	1	2	2	2	2	7	2	2
136	S.S.	5	2	27	1	2	2	2	2	7	2	2
137	S.S.	5	2	27	1	2	2	3	3	4	2	2
138	S.S.	5	2	27	1	2	2	2	2	6	2	2
139	S.S.	5	2	27	1	2	2	2	2	5	2	2
140	S.S.	5	2	27		2	2	2	3	7	2	2
141	S.S.	5	2	27	1	2	2	2	3	7	2	2
142	S.S.	5	2	27	1	2	2	3	3	5	2	2
143	S.S.	5	2	27	1	2	2	2	2	5	2	2
144	S.S.	5	2	27	1	2	2	2	2	4	2	2
145	S.S.	5	2	28	1	2	2	2	2		2	2
146	S.S.	5	2	28	1	2	2	3	3		2	2
147	S.S.	5	2	28	1	2	2	3	2		2	2
148	S.S.	5	2	28	1	2	2	3	2		2	2
149	S.S.	5	2	28	1	3	3	3	2		2	2
150	S.S.	5	2	29	1	2	2	3	4		2	2
151	S.S.	5	2	29	1	3	3	2	3		2	2
152	S.S.	5	2	29		3	3	3	2		2	3
153	S.S.	5	2	29	1	3	3	2	2		3	3
154	S.S.	5	2	29	2	3	3	3	4		3	3
155	S.S.	5	2	30	1	2	2	2	3		3	3
156	S.S.	5	2	30	1	2	2	3	3		3	3
157	S.S.	5	2	30	1	2	2	2	2		3	3
158	S.S.	5	2	30	1	2	2	2	2		3	3
159	S.S.	5	2	30	2	2	2	3	3		3	3
160	S.S.	5	2	30	1	2	2	2	3		3	3
161	S.S.	5	2	30	1	2	2	3	2		3	3
162	S.S.	5	2	31	1	3	3	3	5		3	3
163	S.S.	5	2	31		3	3	4	4		3	2
164	S.S.	5	2	31	1	2	3	3	2		2	2
165	S.S.	5	2	31	1	2	2	4	2		3	2
166	S.S.	5	2	31	1	3	3	4	3		3	2
167	S.S.	5	2	32	1	3	3	5	5		3	3
168	S.S.	5	2	32	1	3	2	5	3		3	2
169	S.S.	5	2	32	1	3	3	4	3		3	3
170	S.S.	5	2	32	2	3	3	4	4		3	3
171	S.S.	5	2	33	1	2	2	4	3		2	3
172	S.S.	5	2	33	1	3	3	5	2		3	3
173	S.S.	5	2	33	1	3	2	4	3		3	3
174	S.S.	5	2	34	2	3	3	4	3		4	3
175	S.S.	5	2	35	2	3	3	5	5		4	3
176	S.S.	5	2	37	3	3	3	5	4		4	3
177	S.S.	5	2	37	2	3	4	5	3		3	3
178	S.S.	5	2	50	3	5	5	5	4		6	4
179	S.S.	5	2	53	4	7	7	8	4		7	6
180	S.S.	5	2	18	0	1	1	1	1		1	1
1064	S.S.	IV	1	23	0	1	1	2	2	2	2	1
1124	S.S.	IV	1	24	0	1	1	2	2	2	2	1

Table 5.- Second readings by reader of the hake otolith exchange.

Cod oto	Stock	Month	Sex	Length	AgeR1	AgeR2	AgeR3	AgeR4	AgeR5	AgeR6	AgeR7	AgeR8
1	S.S	10	2	52	7	7	5	8	6	5	6	6
2	S.S	10	2	37	2	3	2	2	3	2	3	3
3	N.S.	3	3	23	1	2	1	1	2	2	2	2
4	S.S.	10	2	31	3	3	3	4	4	4	4	3
5	S.S.	10	2	44	5	6	6	6	5	6	6	4
6	S.S.	10	1	20	1	1	0	1	1	1	1	1
7	N.S.	3	2	34	3	3	3	5	4	3	4	3
8	N.S.	3	2	32	2	3	3	4	3	3	4	3
9	N.S.	3	2	28	1	2	2	4	3	2	3	2
10	S.S.	10	2	45	5	4	6	7	5	6	5	5
11	S.S.	10	2	46	7	4	5	9	5	5	6	5
12	N.S.	3	3	18	1	1	1	1	1	0	0	1
13	N.S.	3	1	33	3	3	3	5	4	3	4	3
14	S.S.	10	1	40	5	3	4	8	4	4	4	4
15	S.S.	10	2	45	4	4	4	6	5	5	5	4
16	S.S.	10	1	26	3	2	2	3	3	2	2	2
17	N.S.	3	2	32	4	3	3	6	3	4	4	3
18	S.S.	10	2	44	5	4	5	8	5	5	5	4
19	S.S.	10	2	52	5	5	6	8	6	5	6	6
20	S.S.	10	2	37	4	3	3	5	4	2	3	3
21	N.S.	3	1	27	4	3	2	5	4	3	2	2
22	S.S.	9	1	49	5	5	5	9	4	4	6	5
23	S.S.	9	1	34	2	2	2	4	3	2	3	2
24	S.S.	9	2	46	4	4	5	8	5	6	5	4
25	S.S.	9	1	42	5	5	5	7	5	4	6	5
26	S.S.	9	1	49	5	5	5	8	5	4	6	6
27	S.S.	9	1	42	5	5	5	9	5	4	5	6
28	S.S.	9	1	34	3	2	2	4	3	3	3	2
29	N.S.	3	3	20	2	2	1	1	2	2	1	2
30	S.S.	10	1	55	10	8	6	10	7	6	7	7
31	N.S.	3	2	21	1	1	1	1	2	1	1	1
32	S.S.	10	2	31	3	3	3	4	4	4	3	3
33	N.S.	3	2	19	1	1	1	1	1	0	1	1
34	S.S.	9	1	55	8	5	6	9	7	5	8	7
35	S.S.	9	2	28	2	2	2	3	3	3	2	2
36	S.S.	10	3	16	0	0	0	0	0	0	0	0
37	N.S.	3	3	25	2	2	1	3	3	3	2	
38	S.S.	10	1	40	6	6	5	8	5	6	7	6
39	N.S.	3	2	33	3	2	2	4	4	3	4	3
40	N.S.	3	2	34	3	3	3	4	5	3	4	3
127	S.S.	5	2	26	2	2	2	2	2	2	2	2
128	S.S.	5	2	26	2	2	2	2	2	2	2	2
129	S.S.	5	2	26	2	2	2	2	2	2	2	2
130	S.S.	5	2	26	2	2	2	2	2	2	2	2
131	S.S.	5	2	26	2	2	2	2	2	3	2	2
132	S.S.	5	2	26	2	3	2	2	3	2	2	2
133	S.S.	5	2	27	2	2	2	2	2	3	2	2
134	S.S.	5	2	27	2	2	2	2	2	3	2	2
135	S.S.	5	2	27	2	2	3	2	3	3	2	2
136	S.S.	5	2	27	2	2	2	2	2	2	2	2
137	S.S.	5	2	27	3	2	2	3	2	2	2	2
138	S.S.	5	2	27	2	2	2	2	2	2	2	2
139	S.S.	5	2	27	2	2	2	2	2	2	2	2
140	S.S.	5	2	27	2	3	2	3	3	2	2	2
141	S.S.	5	2	27	2	3	3	3	3	2	2	2
142	S.S.	5	2	27	2	3	2	3	3	2	2	2
143	S.S.	5	2	27	2	3	2	2	2	3	2	2
144	S.S.	5	2	27	2	3	2	2	2	3	2	2
145	S.S.	5	2	28	2	2	2	3	2	2	2	2
146	S.S.	5	2	28	3	3	3	3	2	3	2	2
147	S.S.	5	2	28	3	3	3	3	3	3	2	2
148	S.S.	5	2	28	2	3	2	3	2	3	2	2
149	S.S.	5	2	28	3	3	2	3	3	3	2	2
150	S.S.	5	2	29	3	3	2	3	3	3	2	2
151	S.S.	5	2	29	3	2	2	5	3	3	2	3
152	S.S.	5	2	29	3	2	3	3	3	3	2	2
153	S.S.	5	2	29	3	3	3	3	3	4	3	2
154	S.S.	5	2	29	3	3	3	3	3	4	3	2
155	S.S.	5	2	30	3	3	3	3	2	3	3	2
156	S.S.	5	2	30	3	2	3	3	3	3	2	2
157	S.S.	5	2	30	3	3	3	4	2	3	2	2
158	S.S.	5	2	30	3	3	3	3	2	3	2	2
159	S.S.	5	2	30	3	3	3	4	2	3	3	2
160	S.S.	5	2	30	4	3	3	3	2	4	2	2
161	S.S.	5	2	30	4	3	3	3	2	3	3	3
162	S.S.	5	2	31	3	3	3	3	3	3	2	2
163	S.S.	5	2	31	3	3	3	4	3	3	2	2
164	S.S.	5	2	31	3	3	3	3	2	3	2	2
165	S.S.	5	2	31	3	3	2	3	2	3	2	2
166	S.S.	5	2	31	4	3	2	3	3	4	3	2
167	S.S.	5	2	32	4	3	3	4	3	4	3	2
168	S.S.	5	2	32	4	3	3	4	3	4	3	2
169	S.S.	5	2	32	4	3	3	4	3	3	3	2
170	S.S.	5	2	32	3	3	3	3	3	4	3	2
171	S.S.	5	2	33	4	3	3	3	3	3	2	2
172	S.S.	5	2	33	4	3	3	4	3	4	3	3
173	S.S.	5	2	33	4	3	2	4	3	3	3	2
174	S.S.	5	2	34	4	3	3	4	4	5	3	
175	S.S.	5	2	35	4	3	3	4	4	5	4	
176	S.S.	5	2	37	4	3	3	5	4	4	4	3
177	S.S.	5	2	37	5	3	3	5	4	5	4	3
178	S.S.	5	2	50	6	6	4	5	4	6	5	4
179	S.S.	5	2	53	7	6	6	6	5	7	6	6
180	S.S.	5	2	18	1	1	1	1	1	0	1	1

Table 6.- Second sample. Readings by reader of the hake otolith.

Cod oto	Stock	Month	Sex	Talla	Age R1	Age R2	Age R3	Age R4	Age R5	Age R6	Age R7	Age R8	Age R9
70	S.S.	3	2	18	2	1	1	3	1	1	1	1	
12	S.S.	3	1	20	2	1	1	2	1	1	1	1	
49	S.S.	3	2	22	2	2	2	3	3	3	2	2	
6	S.S.	3	2	24	2	2	2	4	3	3	2	2	2
57	S.S.	3	2	25	2		2	4	3	2	2	2	2
75	S.S.	3	2	29	3	2	2	4	4	3	4	3	3
3	S.S.	3	2	31	3	3	2	4	5	3	3	3	3
90	S.S.	3	1	33	3	3	3	4	4	3	3	2	3
98	S.S.	3	2	37	4	4	4	5	6	4	5	4	4
118	S.S.	3	1	38	5	4	3	5	5	4	5	3	3
4004	S.S.	2	3	41	5	4	3	6	5	4	4	3	3
2542	S.S.	3	1	44	5	4	5	7	6	5	5	5	3
2503	S.S.	3	1	47	4	5	6	7	5	4	5	5	3
2574	S.S.	3	1	49	6	5	4	7	5	6	5	6	4
2579	S.S.	3	2	52	6	5	4	7	6	6	6	6	3
4046	S.S.	2	3	54	5	5	5	8	6	6	7	7	6
4075	S.S.	4	2	40	5	4	4	7	6	5	5	5	5
703	S.S.	6	1	43	5	4	4	6	6	5	5	4	4
6266	S.S.	10	2	17	1	0	1	1	1	0	1	1	0
6061	S.S.	10	1	19	1	1	1	1	1	1	1	1	1
5337	S.S.	10	1	21	2	2	1	2	4	1	2	1	1
6004	S.S.	10	2	24	2	1	1	3	3	3	2	2	3
6641	S.S.	10	2	25	2	2	2	4	3	3	2	2	2
6080	S.S.	10	1	28	3	2	2	3	3	2	2	1	1
6102	S.S.	10	2	30	4	3	3	3	4	4	4	2	4
5412	S.S.	10	2	33	4	4	4	4	4	3	4	3	2
5279	S.S.	10	1	37	3	3	3	6	4	4	3	3	3
6180	S.S.	10	1	39	3	4	4	5	5	5	4	3	4
5207	S.S.	10	2	52	5	3	3	5	6	3	5	4	2
6193	S.S.	10	2	53	6	3	3	5	5	3	5	4	2

Table 7.- Wilcoxson´s test for first and second readings, and second sample reading

First reading

	R1	R2	R3	R4	R5	R6	R7	R8
R1		**	**	**	**	**	**	**
R2	**		**	**	**	**	ns	**
R3	**	**		**	**	**	**	**
R4	**	**	**		**	**	**	**
R5	**	**	**	**		**	**	ns
R6	**	**	**	**	**		**	**
R7	**	ns	**	**	**	**		**
R8	**	**	**	**	ns	**	**	

Second reading

	R1	R2	R3	R4	R5	R6	R7	R8
R1		**	**	**	ns	ns	*	**
R2	**		*	**	ns	*	ns	**
R3	**	*		**	**	**	*	*
R4	**	**	**		**	**	**	**
R5	ns	ns	**	**		ns	ns	**
R6	ns	*	**	**	ns		ns	**
R7	*	ns	*	**	ns	ns		**
R8	**	**	*	**	**	**	**	

Second sample

	R1	R2	R3	R4	R5	R6	R7	R8	R9
R1		**	**	**	**	ns	ns	*	**
R2	**		ns	**	**	**	**	ns	ns
R3	**	ns		**	**	**	**	ns	ns
R4	**	**	**		*	**	**	**	**
R5	**	**	**	*		**	**	**	**
R6	ns	**	**	**	**		ns	ns	**
R7	ns	**	**	**	**	ns		**	**
R8	*	ns	ns	**	**	ns	**		ns
R9	**	ns	ns	**	**	**	**	ns	

ns: no sign of bias ($p > 0.05$)
*: possibility of bias ($0.01 < p < 0.05$)
**: certainty of bias ($p < 0.01$)

Table 8.- Indices of Beamish and Fournier (APE) and Coeffcient of Variation (V). First and second reading of the first sample and second sample reading .

	APE	V	n
All Readers$_{1st\ reading}$ (%)	35.0	50.0	192
Readers 1&8$_{1st\ reading}$ (%)	27.9	39.5	183
All Readers$_{2nd\ reading}$ (%)	16.2	21.1	95
Readers 1&8$_{2^{nd}\ reading}$ (%)	11.2	16.0	90
All Readers$_{2nd\ sample}$ (%)*	20.5	26.3	31
Readers 1&8$_{2^{nd}\ sample}$ (%)	11.3	15.9	31

* with 9 readers
APE = average percent error .
V = mean Coefficient of Variation.

HAKE EXCHANGE SAMPLE (FIRST READING)

Table 9.1.- **By modal age are presented the average age recorded, 2*stdev and number of age readings by reader and of all readers.**

READER 1

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	0,73	1,14	1,65	1,88	3,00	3,33	4,00	3,00	-	-	-	-	-	-	-
2*stdev	-	1,29	0,90	1,42	2,18	1,41	3,06	1,63	-	-	-	-	-	-	-	-
n	1	11	51	52	16	5	3	4	1	0	0	0	0	0	0	0

READER 2

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	0,88	2,03	3,06	4,00	5,20	7,00	7,00	8,00	-	-	-	-	-	-	-
2*stdev	-	1,28	0,89	1,26	0,00	0,89	2,83	0,00	-	-	-	-	-	-	-	-
n	1	8	36	31	3	5	2	4	1	0	0	0	0	0	0	0

READER 3

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	1,20	2,07	3,11	3,94	5,20	5,67	6,50	7,00	-	-	-	-	-	-	-
2*stdev	-	0,84	0,91	1,45	0,89	0,89	1,15	1,15	-	-	-	-	-	-	-	-
n	1	10	58	53	16	5	3	4	1	0	0	0	0	0	0	0

READER 4

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	1,82	2,78	4,41	5,19	5,60	8,33	8,00	8,00	-	-	-	-	-	-	-
2*stdev	-	1,50	2,22	2,79	3,03	1,10	3,06	2,83	-	-	-	-	-	-	-	-
n	1	11	58	54	16	5	3	4	1	0	0	0	0	0	0	0

READER 5

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	1,00	1,45	2,19	3,09	3,13	3,80	3,33	3,50	4,00	-	-	-	-	-	-	-
2*stdev	-	1,64	1,21	1,61	1,77	0,89	1,15	2,00	-	-	-	-	-	-	-	-
n	1	11	58	54	16	5	3	4	1	0	0	0	0	0	0	0

READER 6

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	3,40	5,94	8,00	8,00	7,75	10,33	7,33	9,00	-	-	-	-	-	-	-
2*stdev	-	3,43	4,34	4,78	4,62	4,12	4,62	3,06	-	-	-	-	-	-	-	-
n	1	10	48	36	16	4	3	3	1	0	0	0	0	0	0	0

READER 7

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	1,27	2,29	3,30	4,13	5,20	6,00	6,50	6,00	-	-	-	-	-	-	-
2*stdev	-	1,81	1,24	1,54	1,91	1,67	0,00	1,15	-	-	-	-	-	-	-	-
n	1	11	58	54	16	5	3	4	1	0	0	0	0	0	0	0

READER 8

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	0,91	2,00	2,72	2,94	4,60	5,00	6,75	5,00	-	-	-	-	-	-	-
2*stdev	-	0,60	0,75	1,06	2,68	1,10	3,46	1,00	-	-	-	-	-	-	-	-
n	1	11	58	54	16	5	3	4	1	0	0	0	0	0	0	0

ALL READERS

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,13	1,46	2,52	3,52	4,17	4,97	6,09	6,16	6,25	-	-	-	-	-	-	-
2*stdev	0,71	2,30	3,19	3,88	4,46	2,96	5,22	3,43	4,24	-	-	-	-	-	-	-
n	8	83	425	388	115	39	23	31	8	0	0	0	0	0	0	0

HAKE EXCHANGE SAMPLE (SECOND READING)

Table 9.2.- **By modal age are presented the average age recorded, 2*stdev and number of age readings by reader and of all readers.**

READER 1

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	1,00	2,08	3,27	4,25	5,29	6,00	10,00	-	-	-	-	-	-	-	-
2*stdev	-	0,00	1,12	1,03	1,00	1,51	2,00	-	-	-	-	-	-	-	-	-
n	1	5	26	33	4	7	5	1	0	0	0	0	0	0	0	0

READER 2

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	1,00	2,27	2,88	3,25	4,57	6,00	8,00	-	-	-	-	-	-	-	-
2*stdev	-	0,00	0,90	0,66	1,00	1,07	1,41	-	-	-	-	-	-	-	-	-
n	1	5	26	33	4	7	5	1	0	0	0	0	0	0	0	0

READER 3

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	0,80	1,96	2,82	3,50	5,14	5,60	6,00	-	-	-	-	-	-	-	-
2*stdev	-	0,89	0,69	0,78	1,15	0,76	1,10	-	-	-	-	-	-	-	-	-
n	1	5	26	33	4	7	5	1	0	0	0	0	0	0	0	0

READER 4

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	1,00	2,46	3,70	5,75	8,14	7,20	10,00	-	-	-	-	-	-	-	-
2*stdev	-	0,00	1,81	1,62	3,42	1,80	2,19	-	-	-	-	-	-	-	-	-
n	1	5	26	33	4	7	5	1	0	0	0	0	0	0	0	0

READER 5

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	1,20	2,38	2,97	4,25	4,86	5,40	7,00	-	-	-	-	-	-	-	-
2*stdev	-	0,89	1,14	1,37	1,00	0,76	1,10	-	-	-	-	-	-	-	-	-
n	1	5	26	33	4	7	5	1	0	0	0	0	0	0	0	0

READER 6

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	0,40	2,35	3,24	4,50	4,57	5,80	6,00	-	-	-	-	-	-	-	-
2*stdev	-	1,10	0,97	1,00	1,15	1,57	1,67	-	-	-	-	-	-	-	-	-
n	1	5	26	33	4	7	5	1	0	0	0	0	0	0	0	0

READER 7

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	0,80	2,04	2,76	4,25	5,57	6,20	7,00	-	-	-	-	-	-	-	-
2*stdev	-	0,89	0,69	1,42	1,00	1,07	0,89	-	-	-	-	-	-	-	-	-
n	1	5	26	33	4	7	5	1	0	0	0	0	0	0	0	0

READER 8

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	1,00	2,00	2,30	3,67	5,14	5,60	7,00	-	-	-	-	-	-	-	-
2*stdev	-	0,00	0,00	0,93	1,15	1,38	1,79	-	-	-	-	-	-	-	-	-
n	1	5	26	33	3	7	5	1	0	0	0	0	0	0	0	0

ALL READERS

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	0,90	2,19	2,99	4,19	5,41	5,98	7,63	-	-	-	-	-	-	-	-
2*stdev	0,00	0,76	1,08	1,37	2,03	2,49	1,78	3,20	-	-	-	-	-	-	-	-
n	8	40	208	264	31	56	40	8	0	0	0	0	0	0	0	0

HAKE (SECOND SAMPLE)

Table 9.3.- **By modal age are presented the average age recorded, 2*stdev and number of age readings by reader and of all readers.**

READER 1

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	-	1,50	2,20	2,80	4,00	4,75	6,00	-	-	-	-	-	-	-	-	-
2*stdev	-	1,15	0,89	0,89	1,41	1,00	-	-	-	-	-	-	-	-	-	-
n	0	4	5	5	5	4	1	0	0	0	0	0	0	0	0	0

READER 2

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	-	0,75	2,00	2,40	3,80	4,25	5,00	-	-	-	-	-	-	-	-	-
2*stdev	-	1,00	0,00	1,79	0,89	1,00	-	-	-	-	-	-	-	-	-	-
n	0	4	4	5	5	4	1	0	0	0	0	0	0	0	0	0

READER 3

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	-	1,00	2,00	2,20	3,80	4,50	4,00	-	-	-	-	-	-	-	-	-
2*stdev	-	0,00	0,00	1,67	0,89	2,58	-	-	-	-	-	-	-	-	-	-
n	0	4	5	5	5	4	1	0	0	0	0	0	0	0	0	0

READER 4

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	-	1,75	3,60	4,20	4,60	6,50	7,00	-	-	-	-	-	-	-	-	-
2*stdev	-	1,91	1,10	2,19	2,28	2,00	-	-	-	-	-	-	-	-	-	-
n	0	4	5	5	5	4	1	0	0	0	0	0	0	0	0	0

READER 5

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	-	1,00	3,00	4,00	5,00	5,50	6,00	-	-	-	-	-	-	-	-	-
2*stdev	-	0,00	0,00	1,41	2,00	1,15	-	-	-	-	-	-	-	-	-	-
n	0	4	5	5	5	4	1	0	0	0	0	0	0	0	0	0

READER 6

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	-	0,75	2,60	3,20	4,20	4,50	6,00	-	-	-	-	-	-	-	-	-
2*stdev	-	1,00	1,10	0,89	1,67	1,15	-	-	-	-	-	-	-	-	-	-
n	0	4	5	5	5	4	1	0	0	0	0	0	0	0	0	0

READER 7

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	-	1,00	2,00	3,00	4,40	5,00	6,00	-	-	-	-	-	-	-	-	-
2*stdev	-	0,00	0,00	1,41	1,10	0,00	-	-	-	-	-	-	-	-	-	-
n	0	4	5	5	5	4	1	0	0	0	0	0	0	0	0	0

READER 8

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	-	1,00	1,80	2,60	3,20	4,50	6,00	-	-	-	-	-	-	-	-	-
2*stdev	-	0,00	0,89	1,10	1,67	2,00	-	-	-	-	-	-	-	-	-	-
n	0	4	5	5	5	4	1	0	0	0	0	0	0	0	0	0

READER 9

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	-	0,50	1,75	3,00	3,60	3,50	3,00	-	-	-	-	-	-	-	-	-
2*stdev	-	1,41	1,00	0,00	1,79	2,00	-	-	-	-	-	-	-	-	-	-
n	0	2	4	5	5	4	1	0	0	0	0	0	0	0	0	0

ALL READERS

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	-	1,06	2,35	3,04	4,07	4,78	5,44	-	-	-	-	-	-	-	-	-
2*stdev	-	1,09	1,37	1,81	1,78	2,14	2,47	-	-	-	-	-	-	-	-	-
n	0	34	43	45	45	36	9	0	0	0	0	0	0	0	0	0

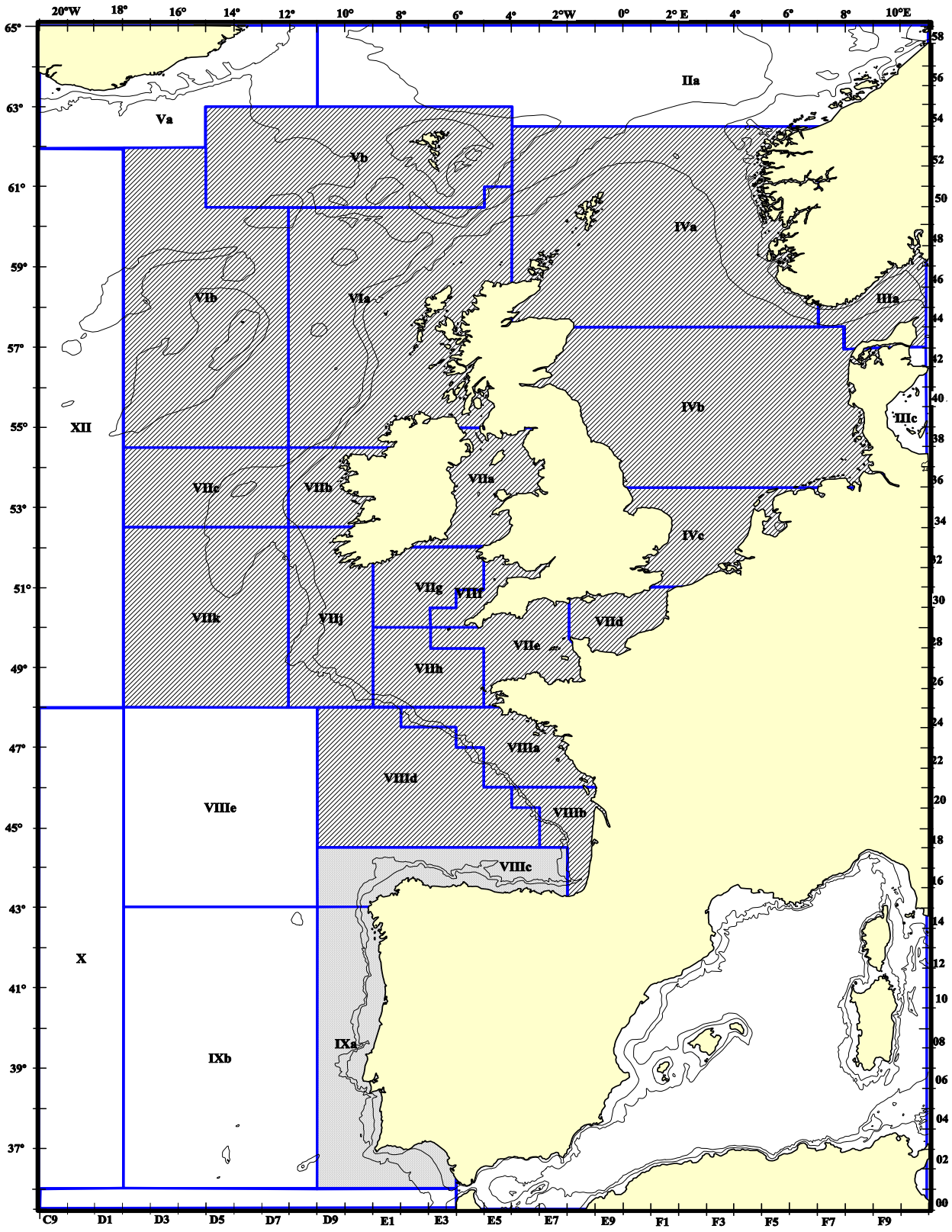


Figure 1.- Distribution of European hake in the Northeast Atlantic, showing both Stocks: North (lines), South (points)

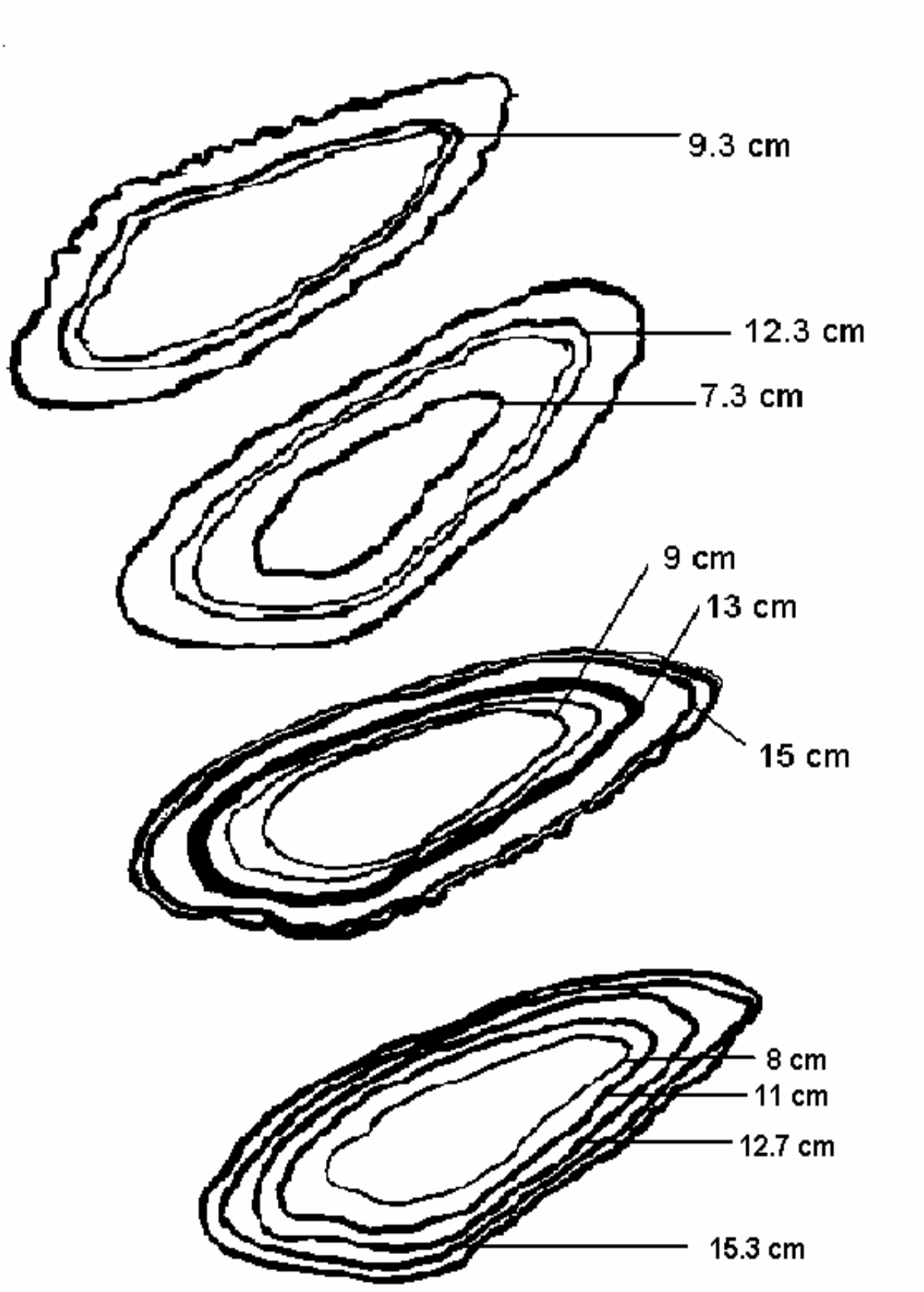


Figure 2. - Different growth patterns from hake otolith belonged to individuals from the same length (16cm) and captured in the same haul of the Survey "Carioca 0989". The measurement of the rings encountered is related with length (backcalculated).

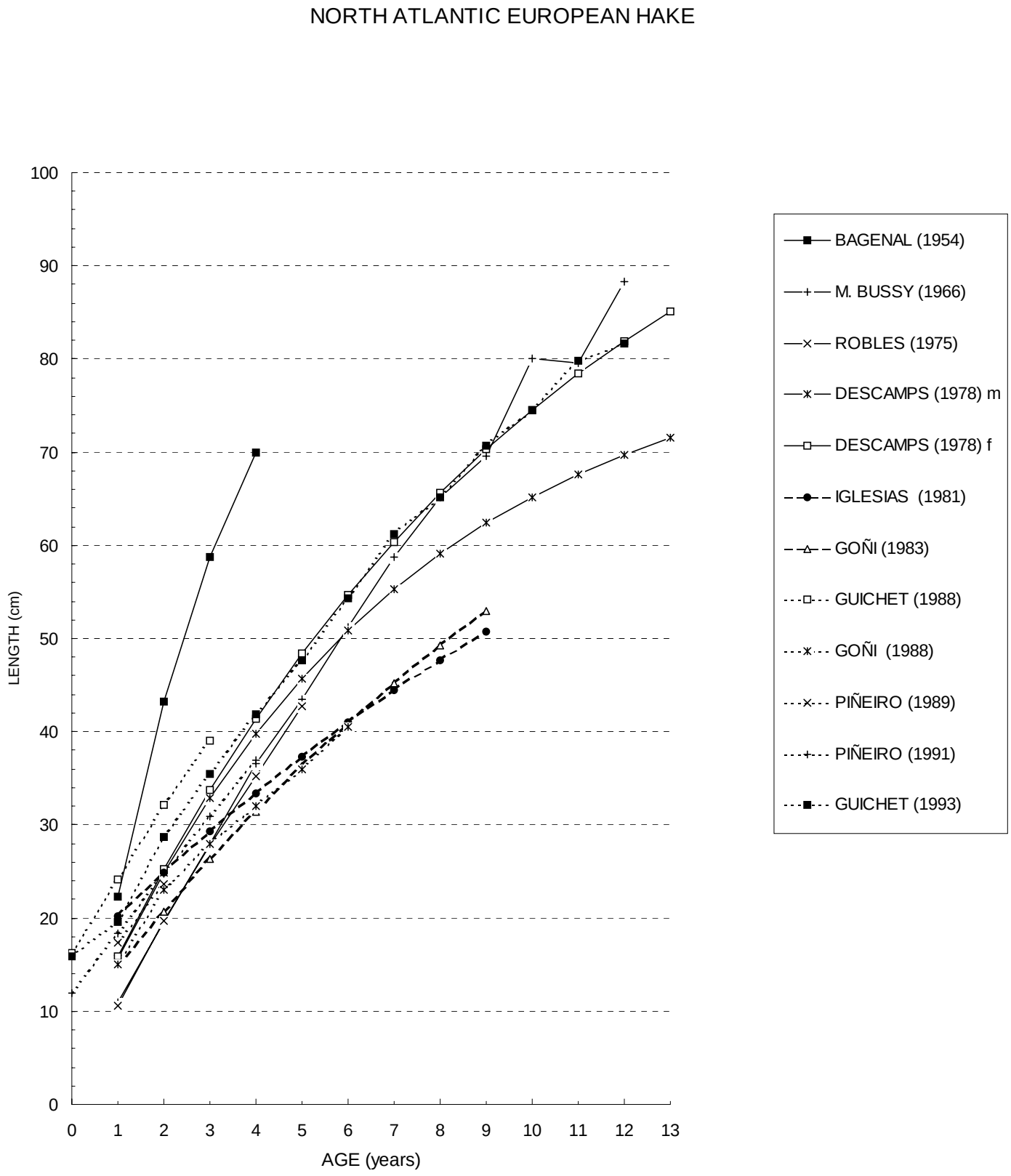
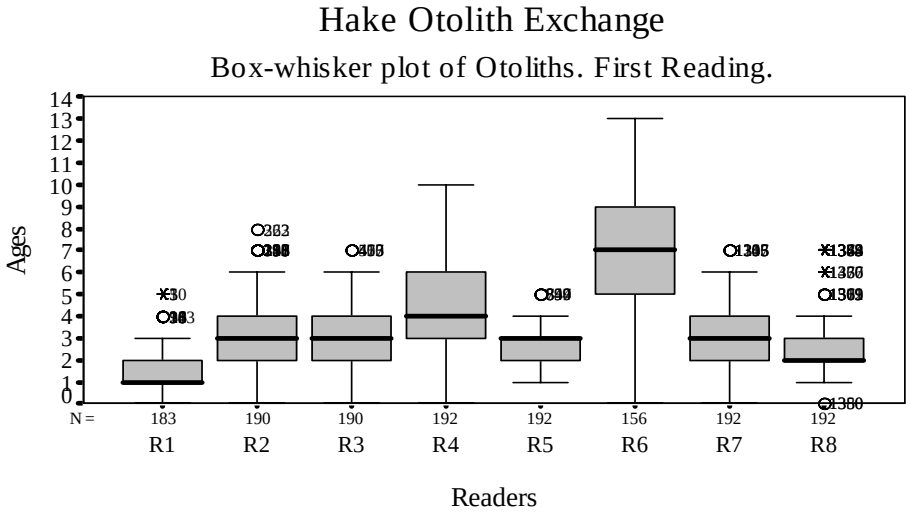
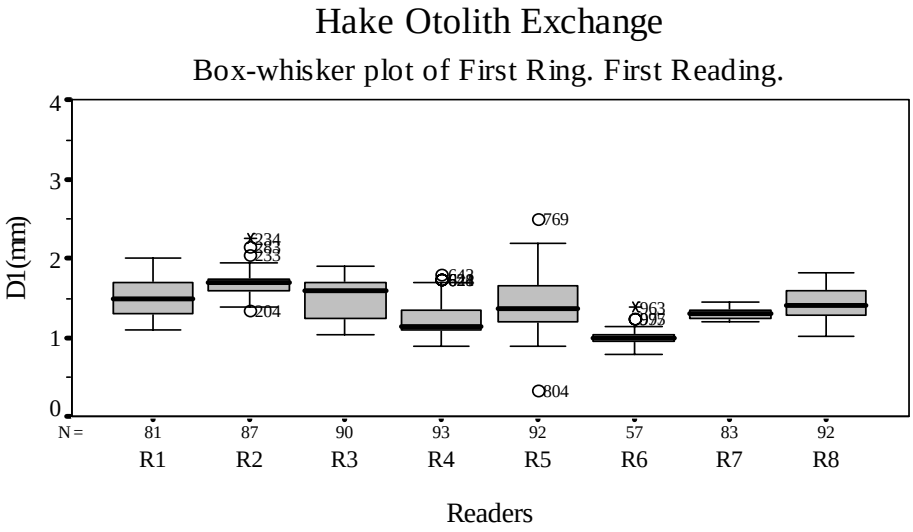


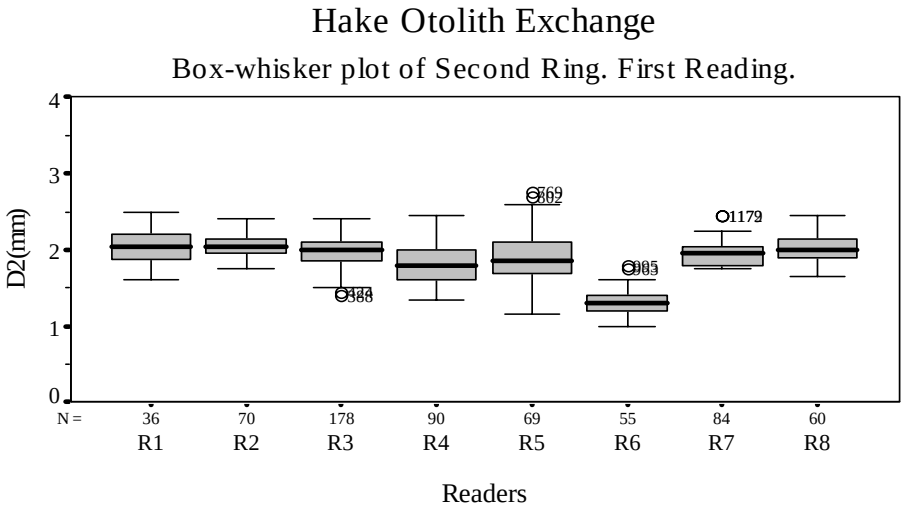
Figure 3.- Mean length at age of hake obtained by several authors.



a)

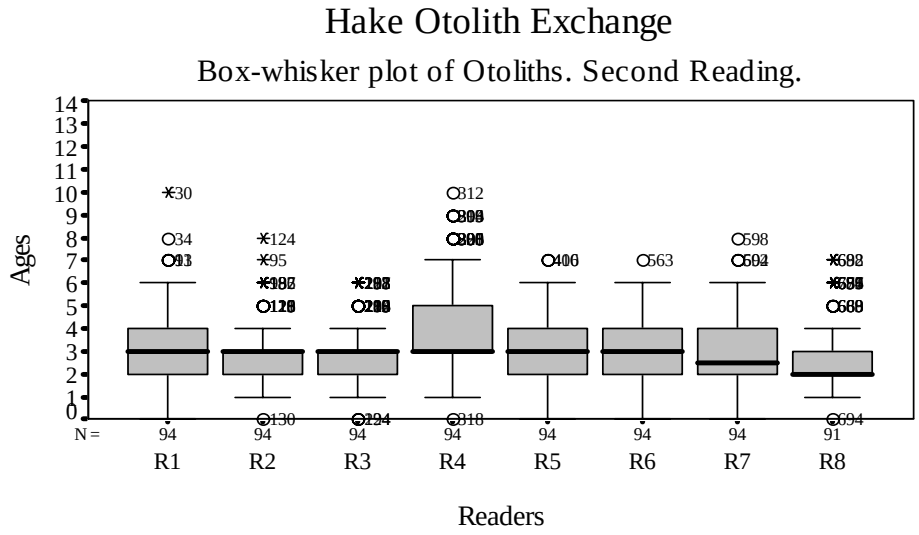


b)

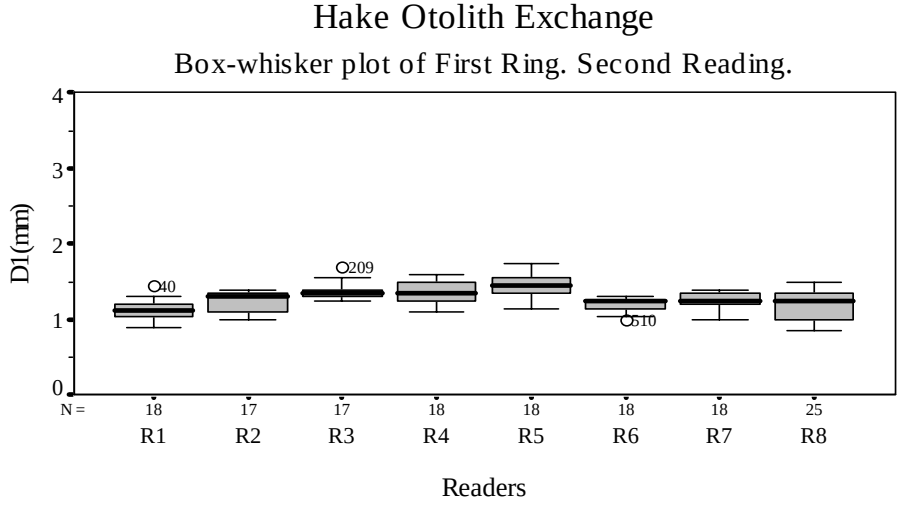


c)

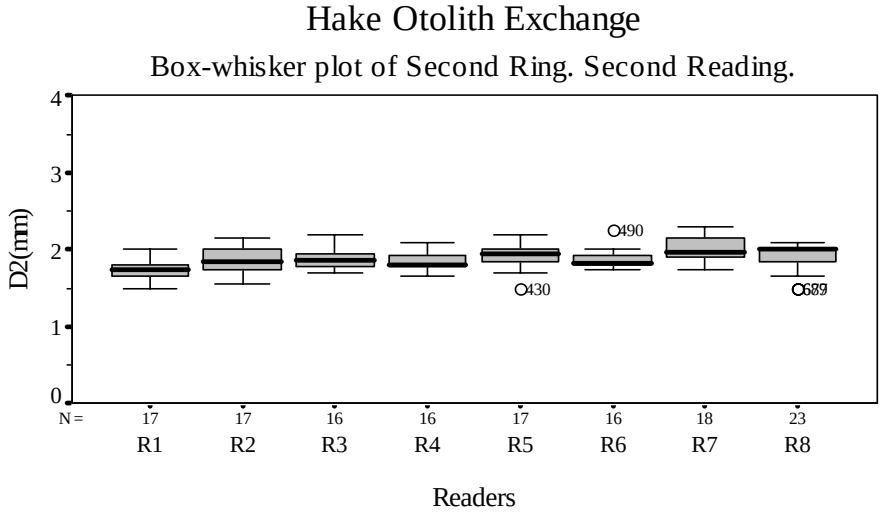
Figure 4.1 Box and Wisker plot for the First reading. Age reading of all readers (a) and distances (D1,D2) for the first two annual rings considered by readers (b,c)



a)

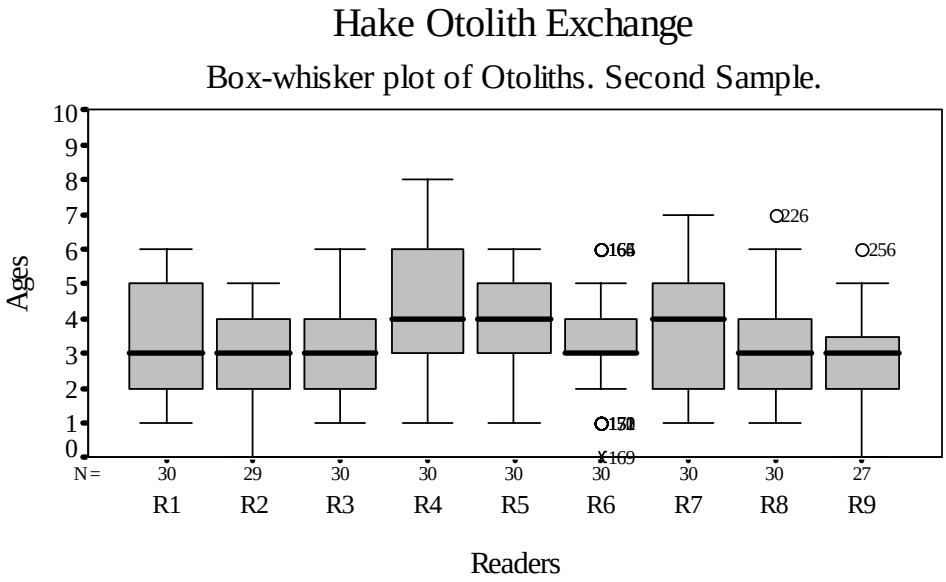


b)

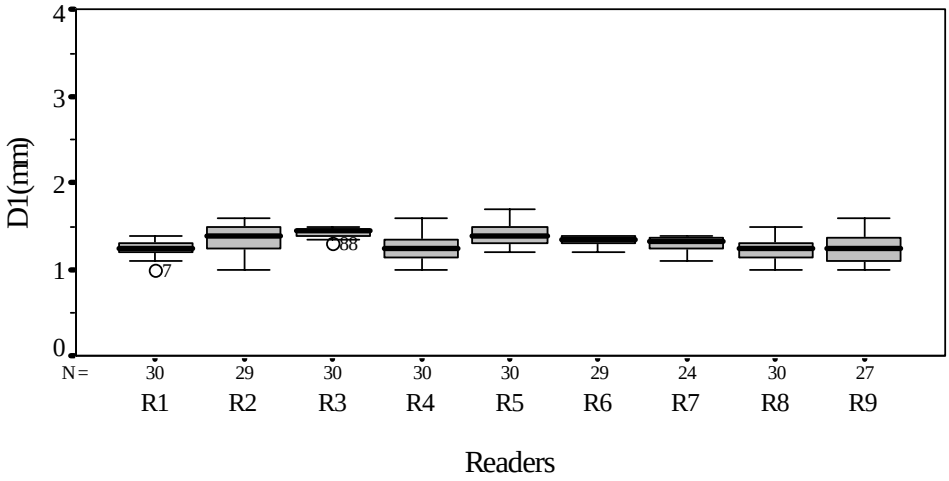


c)

Figure 4.2.- Box and Wisker plot for the Second reading. Age reading of all readers (a) and distances (D1,D2) for the first two annual rings considered by readers (b,c)



a)



b)

Figure 4.3.- Box and Wisker plot for the Third reading. Age reading of all readers (a) and distances (D1) for the first two annual rings considered by readers (b)

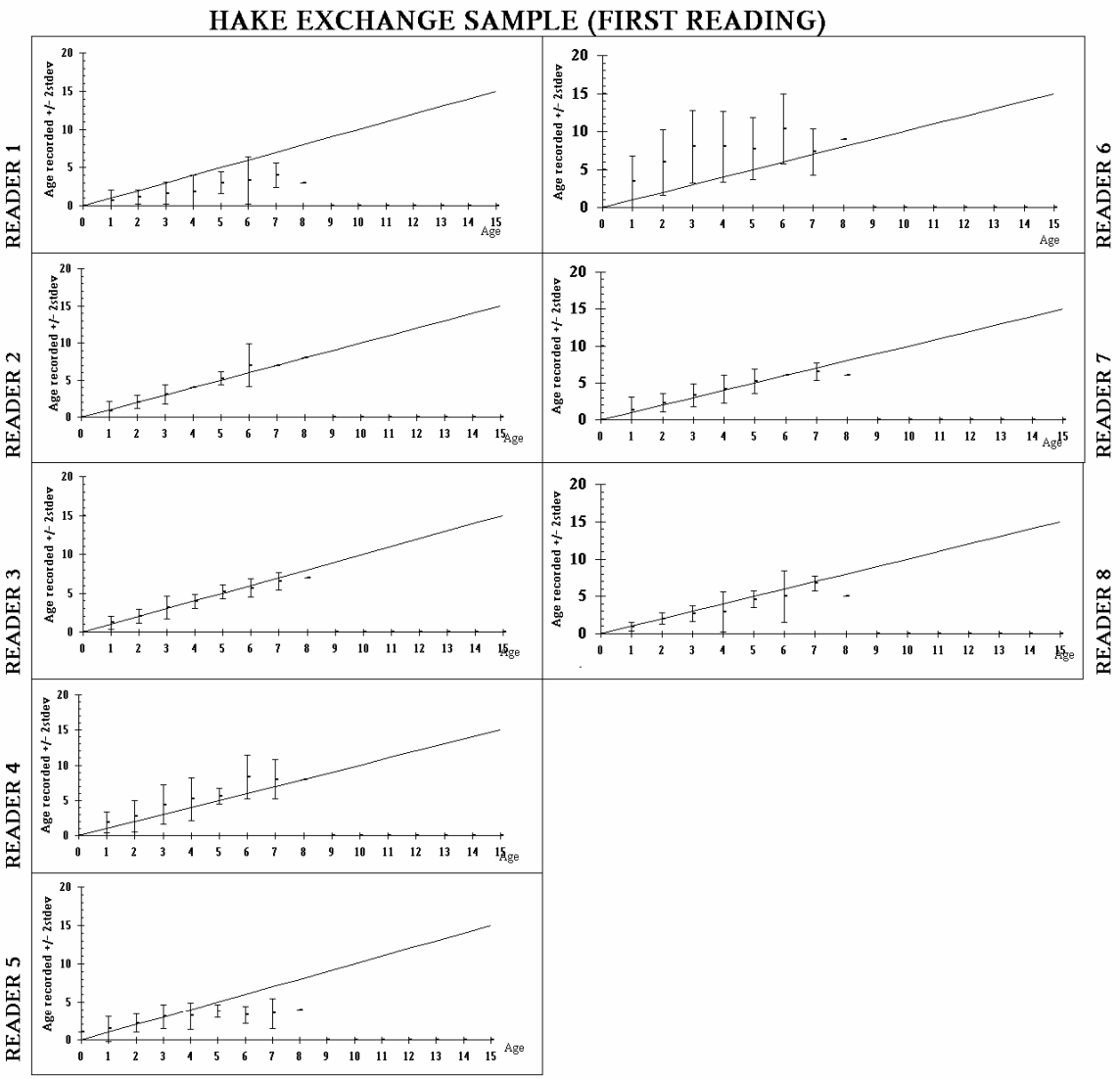


Figure 5.1a In above age bias plots average age +/- 2stdev of each age reader is plotted against modal age.

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,13	1,46	2,52	3,52	4,17	4,97	6,09	6,16	6,25	-	-	-	-	-	-	-
2*stdev	0,71	2,30	3,19	3,88	4,46	2,96	5,22	3,43	4,24	-	-	-	-	-	-	-

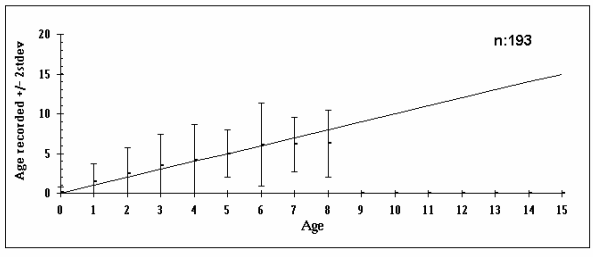


Figure 5.1b.- In above age bias plot average age +/- 2stdev of all age readers is plotted against modal age.

HAKE EXCHANGE SAMPLE (SECOND READING)

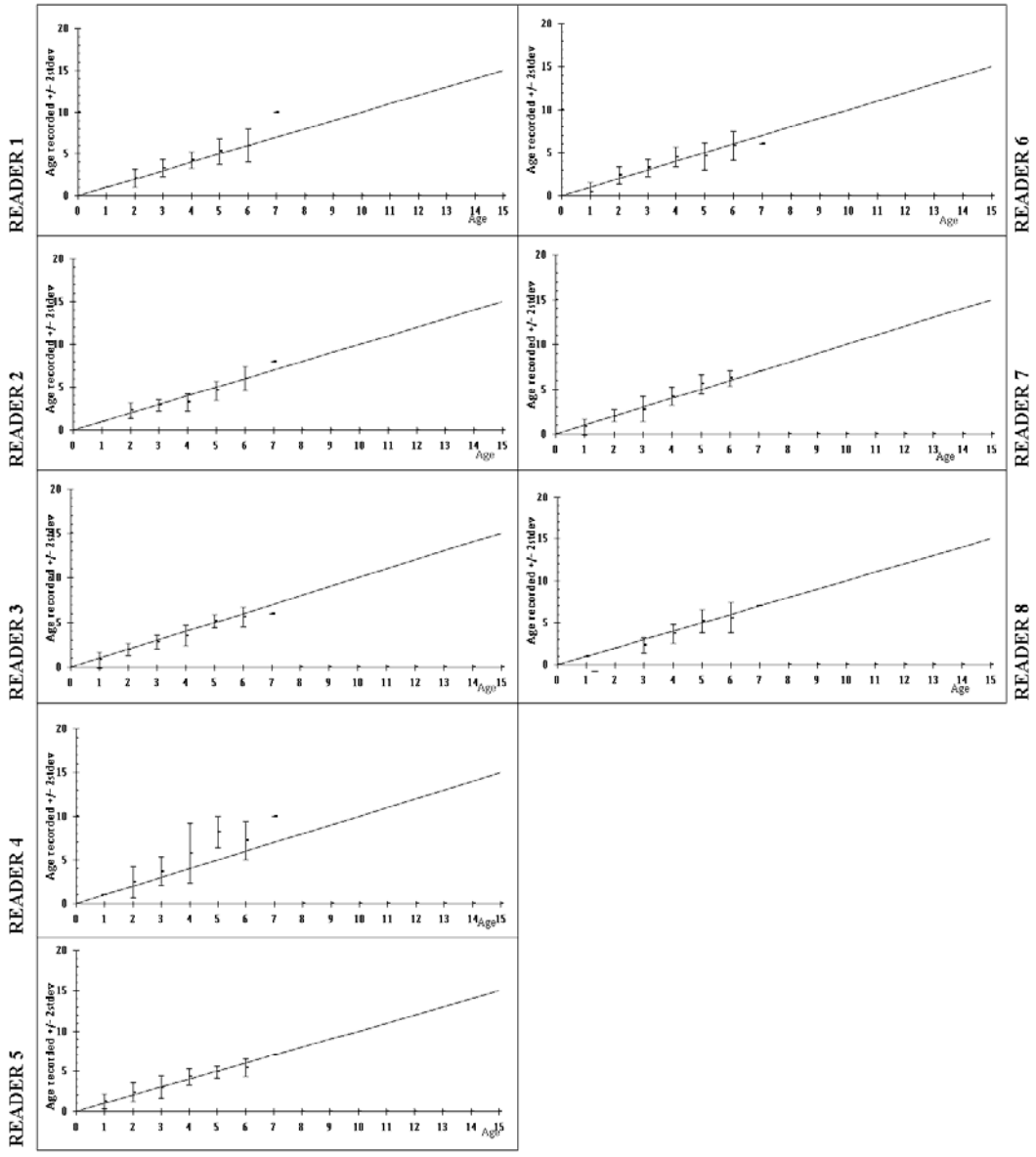


Figure 5.2a.- In above age bias plots average age +/- 2stdev of each age reader is plotted against modal age.

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	0,00	0,90	2,19	2,99	4,19	5,41	5,98	7,63	-	-	-	-	-	-	-	-
2*stdev	0,00	0,76	1,08	1,37	2,03	2,49	1,78	3,20	-	-	-	-	-	-	-	-

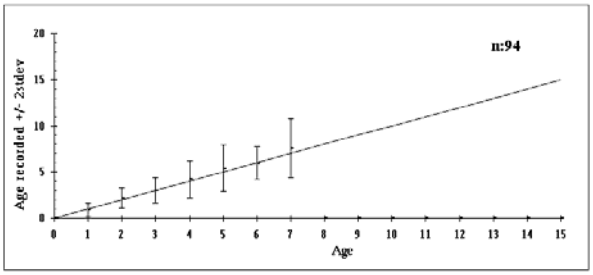


Figure 5.2b.- In above age bias plot average age +/- 2stdev of all age readers is plotted against modal age.

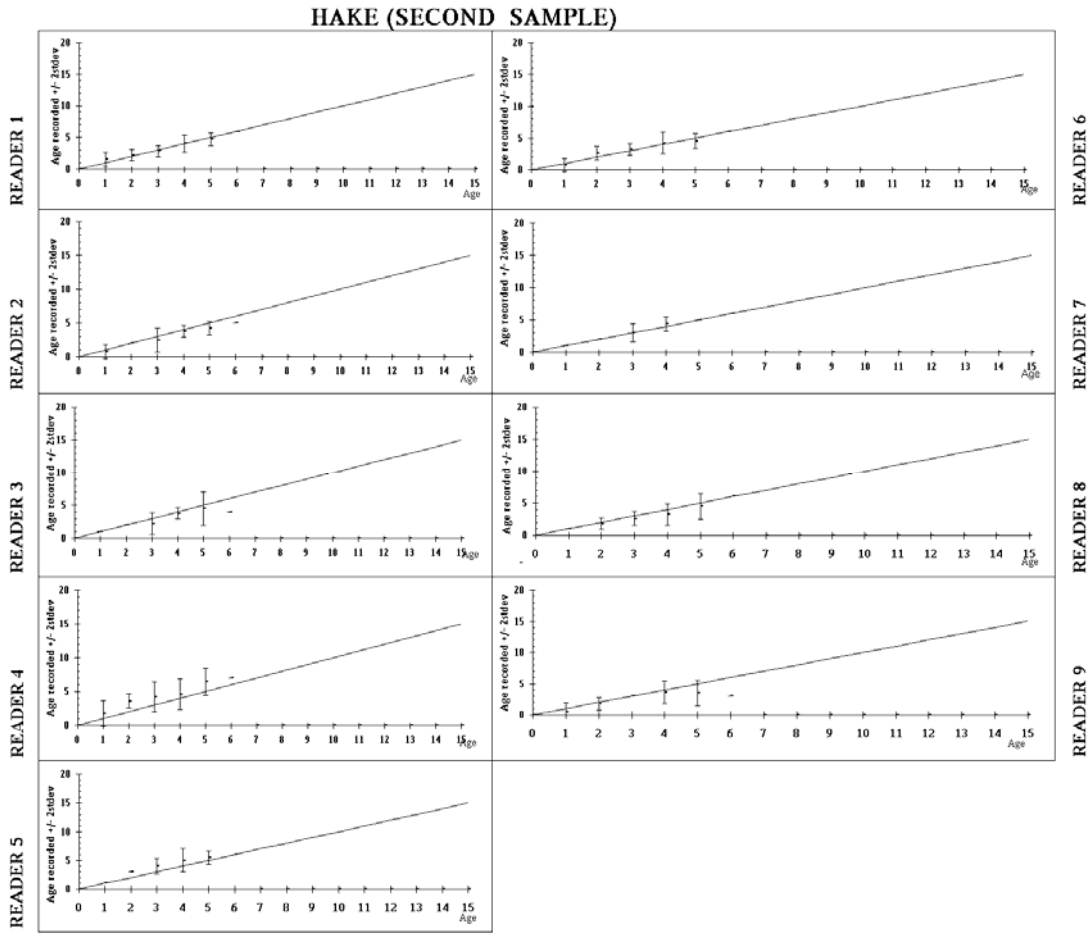


Figure 5.3 In above age bias plots average age +/- 2stdev of each age reader is plotted against modal age.

Modal age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Age recorded	-	1,06	2,35	3,04	4,07	4,78	5,44	-	-	-	-	-	-	-	-	-
2*stdev	-	1,09	1,37	1,81	1,78	2,14	2,47	-	-	-	-	-	-	-	-	-

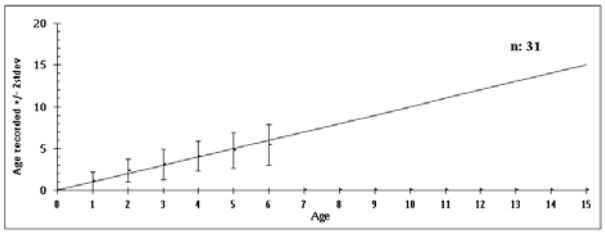


Figure 5.3b.- In above age bias plot average age +/- 2stdev of all age readers is plotted against modal age.