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Report of the Workshop on Age Reading of Roundnose Grenadier (WKARRG)

4–7 September 2007

Boulogne sur mer, France

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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Contents

Executive summary

Knowledge of the biology and stock structure of the North Atlantic Roundnose grenadier were reviewed and discussed. There is no direct validation of the age estimation for Roundnose grenadier. Nevertheless, Gordon and Swan carried out an indirect validation with marginal increment analysis for the young fish.

France presented national sampling, processing and age determination methods. Ifremer determines ages from the sectioning method because all samples are old adults of more than 30 years old.

Results from an exchange experiment were presented. Altogether 66 fish of sectioned otoliths had been read on the slides and on images by 7 persons. All images were annotated. The overall agreement for sectioned otoliths agreement was very low with 30.2 % (CV=10.4%).

After extensive discussions, a re-reading of 40 sectioned samples from the exchange programme was done. The percentage agreement was higher in the re-reading compared to the original readings in both sets of otoliths (38.1% compared to 30.2%). Results indicate a higher consistency among readers than obtained prior to the workshop.

A first draft of an international manual for age determination of Roundnose grenadier was discussed during the meeting. It was agreed that the objective of the manual is to provide quality assurance among and within national laboratories.

It was recommended that sectioning of otoliths should be used for the age determination of Roundnose grenadier. It is recognized that among readers random differences with respect to interpretations and age estimate errors will always exist. The occurrence of such differences may only be reduced through frequent otolith exchanges and comparative readings.

1 Terms of Reference

2006/2/ACFM36 A **Workshop on Age Reading of Roundnose Grenadier** [WKARRG] (Chair: Kelig Mahe, France) will be established and will take place in Boulogne sur Mer, France for 4 days in 2007 to:

a) Review when and how the age reading technique was validated;

b) Review the sample processing techniques of the different age reading laboratories and try to standardise the processing techniques of calcified structures;

c) Agreement on age determination criteria (e.g. date of birth 1st of January, one annual growth zone consists of one opaque and one translucent zone);

d) Discuss disagreements in age reading results from the sets of the calcified structures read during the exchange and at the workshop and try to agree on the age reading method;

e) Determine at the end of the workshop the precision in age reading and the relative bias (if possible the absolute bias);

f) Estimate improvement in age reading concerning precision and bias by comparing exchange set and the last set at the workshop;

g) Prepare a manual for age reading (date of birth, interpretation of rings and edges, period of opaque and translucent ring formation);

h) Recommend on how to improve the age reading quality.

WKARRG will report to ACFM, RMC and PGCCDBS by 20 September 2007.

Supporting Information

PRIORITY:	
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	An exchange of roundnose grenadier otoliths was scheduled in 2005 and France was asked to organize the final age calibration workshop in 2006 (see PGCCDBS reports).
RESOURCE REQUIREMENTS:	The otoliths exchange is running since June 2006 between Spain, Faeroe Islands, Scotland and France. Due to delay to prepare the reference calcified pieces and digitised images set, it is assumed that the final workshop cannot take place before the end of 2006. Experts involved in this task emphasize the difficulties of age reading for that species, the need to meet together to solve them, and are unanimous to ask for the organization of the final workshop at the beginning of 2007.
PARTICIPANTS:	Spain, France, UK Scotland and Faeroe Islands age readers
SECRETARIAT FACILITIES:	
FINANCIAL:	The final age calibration wokshop was eligible under the 2006 DCR exercise. If the worksop is postponed in 2007, and to ensure wide attendance of relevant experts, additional funding will be required, preferably through the EU, e.g. by making attendance to the Workshop eligible under the 2007 DCR.
LINKAGES TO ADVISORY COMMITTEES:	
LINKAGES TO OTHER COMMITTEES OR GROUPS:	
LINKAGES TO OTHER ORGANIZATIONS:	There is a direct link with the EU DCR

2 Participants and agenda

Seven national representatives from four countries (Faroe Islands, France, Spain, UK Scotland) participated in the exchange and six from two countries (France and Spain) participated in this workshop.

Name	Country	Experience level
Kélig Mahé	France	*Chair*
Pascal Lorance	France	*member of WGDEEP (Working Group on the Biology and Assessment of Deep-sea Fisheries Resources)*
Esther Román Marcote	Spain	No reader of Roundnose grenadier Experienced - A reader of Greenland halibut and cod otoliths since 1996 annually, also a reader of haddock, pollock, roughhead grenadier and splendid alfonsino.
Wilfried Louis	France	Intermediate reader of roundnose grenadier (3 years experience)
Arnold Henriksen	Faroe Islands	No experience in grenadier reading. Very experienced in most other commmercial species in Faroese waters including demersal (cod, haddock, saithe, ling, blue ling and others) and pelagic species (herring, blue whiting and others). Unfortunately he has retired now after being our principal age reader since 1965, but he is still acting as a consultant.
Romain Elleboode	France	Beginner of roundnose grenadier (1 years experience) - A reader of north sea and english channel plaice and sole, english channel and mediterranean sea striped red mullet (2 years experience).
Jean Louis Dufour	France	No reader of Roundnose grenadier Experience - north sea cod (24 years experience, 300 per year), north sea whiting (24 years experience, 2500 per year, 2 workshops), north sea haddock (20 years experience, 400 per year), north sea saithe (10 years experience, 2500 per year), north sea norway pout (5 years experience, 200 per year) and mediterranean hake (4 years experience, 500 per year)
Lis Larsen	Faroe Islands	No experience in grenadier reading. Is a beginner (2 years) in reading the same species as Arnold and is intended to be our principal age reader.
Gordon Henderson	UK Scotland	No reader of Roundnose grenadier Experience in most other commmercial species

Participants' affiliations and e-mail addresses are given in Annex 1.

The workshop was held in Boulogne sur mer, France 4–7 September, 2007. The adopted agenda is presented in Annex 2.

3 Biology and stock units of Roundnose grenadier

The Roundnose grenadier (*Coryphaenoides rupestris* ; Gunnerus, 1765) is widely distributed in the North Atlantic. Its area stretches from Norway to northwest Africa in the east to the Canadian-Greenland coasts and the Gulf of Mexico in the west, and from Iceland in the north to the areas south of the Azores in the south (Parr, 1946; Andriyashev, 1954; Leim & Scott 1966; Zilanov *et al.*, 1970; Geistdoerfer, 1977; Gordon, 1978; Parin *et al.*, 1985; Pshenichny *et al.*, 1986; Sauskan, 1988; Eliassen, 1983).

It occurs at 180–2200 m depth (Haedrich & Merrett, 1988; Cohen *et al.*, 1990; Swan & Gordon, 2001). On the slopes of the Rockall Trough, the species is also a major species of the slope ecosystem and it is often the dominant species of the Fish assemblage at depths from 750 to 1750 m (Gordon & Duncan, 1985; Merrett *et al.*, 1991; Gordon & Bergstad, 1992; Lorance, 1998). To the north and west of the British Isles, it is most abundant at about 800–1000 m (Ehrich, 1983; Magnusson & Magnusson, 1996) or slightly deeper (Reinert, 1995). The density and abundance of roundnose grenadier appears to decrease quickly at depths greater than about 1800 m. It is much less dominant to the southwest of Ireland (Gordon & Swan, 1996). The species is also distributed in the Skagerrak (Bergstad, 1990) where its depth distribution is restricted to the upper part of the depth range observed in the open ocean.

The juvenile and adult roundnose grenadier feed mainly on benthopelagic prey comprising copepods and swimming decapods (shrimps) with also some mysids, euphausiids, amphipods, cephalopod mollusc and small fish (Du Buit, 1978; Mauchline & Gordon, 1984).

Reproductive area stretches from Iceland to 38°N on the MAR and from Central Norway to the Bay of Biscay in the European waters (Kelly *et al.*, 1996 and 1997; Shibanov, 1997; Allain, 2001; Vinnichenko *et al.*, 2004). In the Skagerrak, available information indicates that roundnose grenadier spawn in the late autumn (Bergstad, 1990). Eggs (diameter 2.4 to 2.6 mm), postlarvae and pelagic juveniles have been caught with plankton nets from 150 to 550 m. The newly hatched larvae appear very primitive and the pelagic phase is extensive. The mean size of larvae, assumed to belong to the same cohort sampled repeatedly in the same year, increased from February to October, when they attained a demersal way of life (Bergstad & Gordon, 1994). Thus the pelagic phase might last for almost a full year. This could result in dispersal of the pelagic stages over long distances, but dispersal studies have not been conducted. To the west of the British Isles, females with maturing ovaries have been observed from February to December but they were more abundant from May to October, and spawning appears to extend at least from May to November (Kelly *et al*., 1996; Allain, 1999 and 2001). Studies in Icelandic waters indicate all year-round spawning, with no obvious peaks (Magnússon *et al*., 2000). There appear thus to be differences in the timing of spawning between areas, perhaps reflecting varying environmental conditions.

Roundnose grenadier is a batch spawner with a fecundity of 4000–70 000 oocytes per batch (Allain, 2001). To the West of the British Isles and in the Skaggerak females reach first maturity at 11.5–12.5 cm pre-anal fin length (PAFL) and 9–14 years (Bergstad, 1990; Kelly *et al.*, 1996, 1997; Allain, 2001).

The stock structure of this species is hypothetical (see Atkinson (1995) for a review of debates about stock structure). Previous studies have detected genetic differentiation in at least parts of the species range and indicating the presence of distinct populations within the species (Logvinenko *et al.*, 1983; Dushchenko, 1989). There is no direct evidence of long distance migration made by adult fish in the high seas.

The current perception is the existence of three major adult stock units in the ICES area. Based on what is believed to be a natural topographical restriction to the dispersal of all life stages, the Wyville-Thomson Sill may separate populations further south on the banks and slopes off the British Isles and Europe from those distributed to the north along Norway and in the Skagerrak. Distinct populations may occur in Norwegian fjords due to the presence of shallow sills. Considering the general circulation in the North Atlantic, populations from the Icelandic slope and the Mid-Atlantic Ridge may be separated from those distributed to the west of the British Isles. It has been postulated that a single population occurs in all the areas south of the Faroese slopes, including also the slopes around the Rockall Trough and the Rockall and Hatton Banks. There is a lack of knowledge concerning the distribution and dispersal of the eggs and larval stages, except in the Skagerrak (Bergstad & Gordon, 1994), and so the biological basis for this hypothetical population structure must await the results from future studies of genetics and otolith microchemistry (Lorance *et al*., in press). As a consequence, ICES WGDEEP dealt with three stocks of roundnose grenadier in the NE Atlantic:

- Skagerrak (IIIa)
- The Faroe-Hatton area, Celtic sea (Divisions Vb and XIIb, Subareas VI, VII)
- On the MAR (Divisions Xb, XIIc, Subdivisions Va1, XIIa1, XIVb1)

4 Review of the age reading technique validation (ToRa)

Roundnose grenadier has been aged by counting the rings in otoliths and scales (Savvatimskiy, 1971; 1972; Koch, 1976; Borrmann, 1978; Bridger, 1978; Gordon, 1978; Savvatimskiy *et al.*, 1978, Kosswig, 1981; 1983; 1984; 1986; 1989; Eliassen, 1986; Magnússon, 1986; 1987; Danke, 1987; Bergstad, 1990; Dupouy & Kergoat, 1992; Kelly *et al.*, 1997; Draganik *et al.*, 1998; Allain, 1999). Age estimation with scales was higher for younger fish, but considerably lower than otolith age for older fish (Bergstad, 1990). Just as whole otoliths of roundnose grenadier can be read only for very small individuals (Kelly *et al.*, 1997).

There has been is no direct validation[1] of the age estimation for Roundnose grenadier.

Nevertheless, Gordon and Swan (Gordon *et al.*, 1996; Gordon & Swan, 1996; Gordon and Swan, 2001) carried out an indirect validation with marginal increment analysis. Based on the examination of the growing edge of otoliths from juvenile fish they concluded that rings in the otoliths were formed annually. The broader, opaque zones[2] which are generally considered to represent the growth phase were dominant from August to March. The thinner, translucent zones[3] were dominant from April to July. Compared to shelf species where it occurs in spring and summer, the deposition of opaque material in roundnose grenadier otoliths is delayed by 3–4 months (Gordon and Swan, 2001). These authors considered this was due to food availability because at depth, the period of maximum growth of roundnose grenadier prey might be delayed as a result of the seasonal delay in the increase in the temperature of the upper water column (0±500 m), where some of this prey may live for part of their life cycle. In turn, the food supply to these organisms, which ultimately depends on surface production, will take longer to become available in deep water.

1 The process of estimating the accuracy of an age estimation method. The concept of validation is one of degree and should not be considered in absolute terms. If the method involves counting zones, then part of the validation process involves confirming the temporal significance of the zones being counted. Validation of an age estimation procedure indicates that the method is sound and based on fact (*In* Panfili *et al.*, 2002).

2 A zone that restricts the passage of light in comparison with a translucent zone. The term is a relative one because a zone is determined to be opaque on the basis of the appearance of adjacent zones in the otolith (see translucent zone). In untreated otoliths under transmitted light, the opaque zone appears dark and the translucent zone appears bright. Under reflected light the opaque zone appears bright and the translucent zone appears dark. An absolute value for the optical density of such a zone is not implied (*In* Panfili *et al.*, 2002).

3 A zone that allows the passage of greater quantities of light than an opaque zone. The term is a relative one because a zone is determined to be translucent on the basis of the appearance of adjacent zones in the structure (see opaque zone). An absolute value for the optical density of such a zone is not implied. In untreated calcified structures under transmitted light, the translucent zone appears bright and the opaque zone appears dark. Under reflected light the translucent zone appears dark and the opaque zone appears bright. The term "hyaline" has been used, but "translucent" is preferable (*In* Panfili *et al.*, 2002).

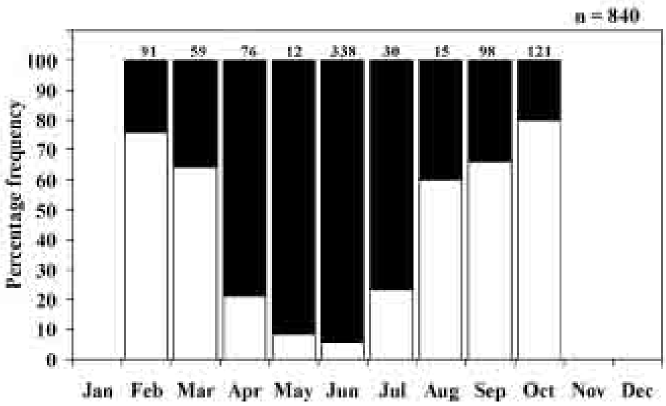


Figure 1: The percentage of otoliths with translucent (indicated by black shading) or opaque edges in different months (≤ five fish per month excluded) (*In* Swan & Gordon, 2001).

Radiometric validation of age was carried out for the closely related Pacific Grenadier, *Coryphaenoides acrolepis* where it confirmed the ages estimated derived from the assumption that growth increments read on otolith sections were annual (Andrews *et al.*, 1999).

Therefore, both the indirect validation based on the deposition of the marginal increment in juvenile roundnose grenadier and the radiometric validation obtained for the pacific grenadier *Coryphaenoides acrolepis*, indicate that growth rings seen on the otoliths are annual. However, in the roundnose grenadier, formal validation of this annual periodicity has been carried out for juveniles only.

Andrews, A.H., Cailliet, G.M., Coale, K.H., 1999. Age and growth of the Pacific grenadier (*Coryphaenoides acrolepis*) with age estimate validation using an improved radiometric ageing technique. *Can. J. Fish. Aquat. Sci.*, 56, 8, 1339–1350.

Figure 2: Otolith pictures for young roundnose grenadier. whole otolith by incident light, the bar indicates a scale of 1 mm (*In* Swan & Gordon, 2001).

5 Review of national sampling, processing, processing and age determination, (ToRb)

5.1 France

5.1.1 Sampling

Following the EU Data Collection Regulation samples are taken from commercial landings and data collected on age and length (pre-anal fin length, cm).

The measure of pre-anal fin length from commercial landings is very difficult because the fish are often damaged. Thus, there is a considerable bias on this parameter.

All data comes from divisions CIEM Vb, VI and VII.

Table 1: Number of the aged fish per year at the Ifremer laboratory in Boulogne sur mer (France).

2001	2002	2003	2004	2005	2006
1000	611	661	724	480	520

5.1.2 Preparation of otoliths

Both sagittae otoliths are removed using of a pair of tweezers. Otoliths are cleaned on a wet tissue and stored dry in paper bags. Data on sampling data and location and fish size are recorded. Each otolith is weighed.

For roundnose grenadier otoliths, sectioning is required because otoliths of adult fish are thick and internal structure which cannot be observed in whole otoliths. All the otoliths are mounted in polyester translucide resin and transverse sections passing through the nucleus are cut as described by Bedford (1983) with low-speed saw (Buehler Isomet) with a diamond blade. The result is a approximately 0.2 mm thick section.

This technique starting from a fine cut (0.2 mm) requires 6 times longer than a cut usually used for the other species (0.35 mm).

5.1.3 Interpretation of otoliths

The section is viewed with a binocular using transmitted light at a magnification up to 20. Age determination is made by counting annulii (one opaque and one translucent zone) on dorso-ventral axis or on proximal region.

5.2 Spain

Following the EU Data Collection Regulation samples are taken from research and commercial surveys and data collected on age and length (pre-anal fin length, cm). All data are obtained in the NAFO Area (Divs. 3LMNO) and Hatton Bank Area (ICES XII &VIb). Roundnose grenadier otoliths are only collected in Hatton Bank.

5.3 Faroe Islands

The Faroese Fisheries Laboratory doesn’t collect age data for roundnose grenadier and roundnose grenadier is at present not included in the regular sampling scheme of commercial catches. There were some experimental deep sea fisheries in the 1980–1990s where cpue, length and weight were sampled and length and weight are also registered in our R/V surveys. All fishing vessels deep-sea species are obliged to keep logbooks with information on haul positions, depth, catch and effort.

5.4 UK Scotland

The UK Scotland laboratory (Marlab) doesn't collect the age data for roundnose grenadier.

6 An otolith weight model of roundnose grenadier age

A study on commercial catches for the years 2002 to 2005 was carried out with 2520 fish. The total weight of the two otoliths of each individual fish was weighed with a precision to the nearest 0.0001 g.

Several models were fit with the explanatory variable (otolith weight, fish length and year).

The preliminary observations of a relationship between otoliths weight and age showed a strong correlation coefficient. The otolith weight seems to be a good predictor of the age estimated with 3.6 years of average deviation (P. Lorance, unpublished data).

This preliminary analysis must be confirmed but these first results could make it possible to limit the number of slides preparations which is a very long technique.

It would also be interesting to test the otolith surface as predictor of the estimated age.

7 Agreement on age determination criteria (ToRc)

7.1 Date of birth and annuli

Date of birth is set to the 1st of January as convention. One annuli consists of one opaque and one translucent zone. For the age estimation, we count the translucent zones.

7.2 Interpretation of a first ring

The distance between the nucleus and the end of the first translucent ring was measured by all readers. The results show very little differences from one reader to another. The distance between the first ring and the nucleus is on average 1.68275±0.21423 mm (min: 1.12 mm; max: 2.0755 mm) with 40 otoliths.

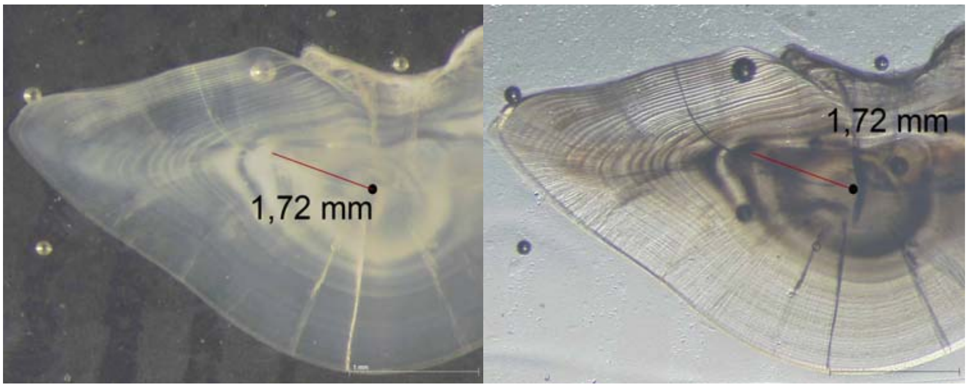


Figure 3: Image of sectioned otolith (fish with pre-anal fin length to 16.5 cm; n°13). Digitised image with reflected light (A) and transmitted light (B). Black point represente the nucleus and the other tip of the red line shows the end of the first ring.

The first ring is detected with reflected or transmitted light without any difference.

To help to place the first ring, it is possible to use the grey scale along the radial because the first important peak symbolizes the medium of the first ring. The difference in contrast is more marked as the transmitted light allows a better discrimination of the first ring.

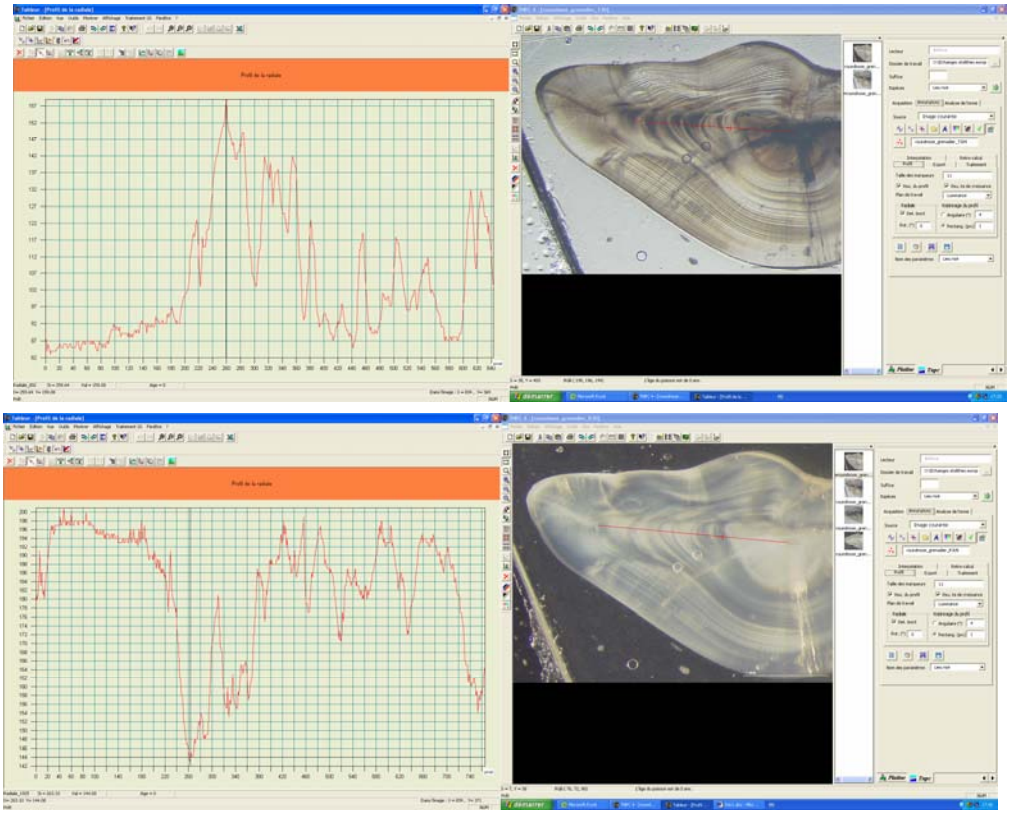


Figure 4: Image of sectioned otolith (fish n°30) with the grey scale along the radial (by software TNPC). Digitised image with transmitted light (A) and reflected light (B).

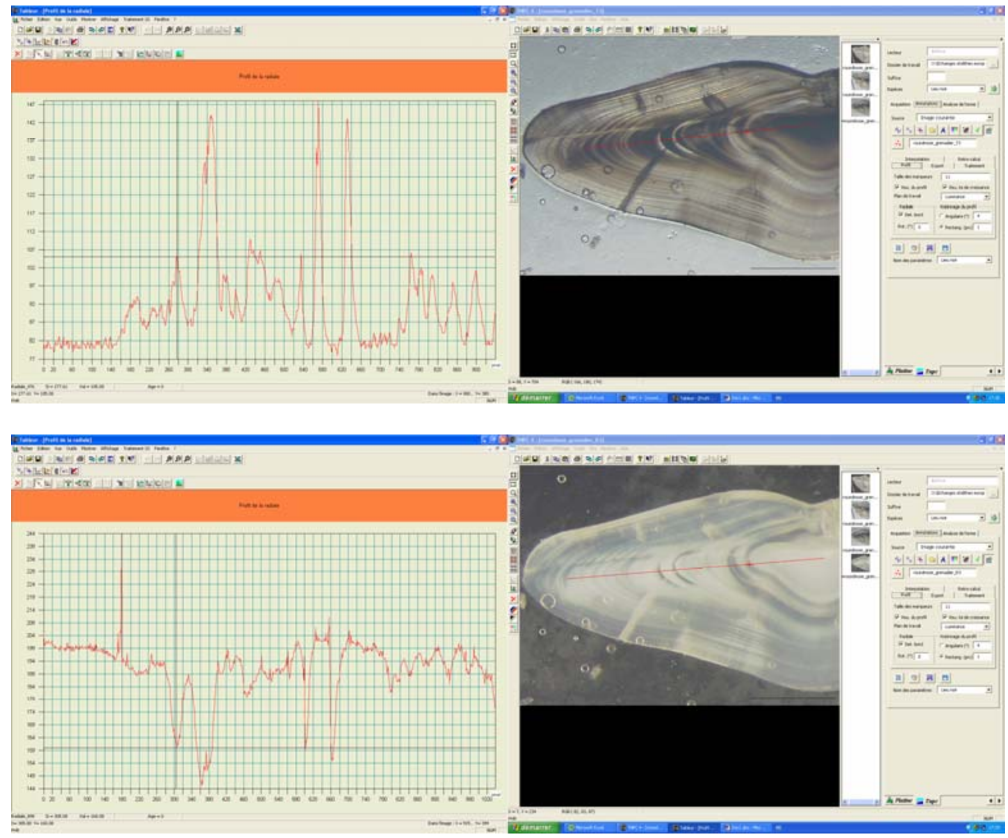


Figure 5: Image of sectioned otolith (fish n°3) with the grey scale along the radial (by software TNPC).Digitised image with transmitted light (A) and reflected light (B).

8 Results of roundnose grenadier otoliths exchange

8.1 Exchange collection

The exchange of otolith samples was started in February 2006. Among the contacted countries, four wished to take part in this exercise (Spain, France, UK Scotland and Faeroe Islands). The otoliths samples (44 fish) were prepared by the Ifremer laboratory (France). The sampled fish were taken by the Ifremer laboratory from 2005 commercial landings (divisions CIEM Vb, VI and VII). Each otolith was mounted in black polyester resin and transverse sections passing through the nucleus.

The slides with datasheets and protocol were distributed from one institute to another (in the following order: France, Spain, Faeroe Islands and UK Scotland) and the results were sent to the coordinator. After this exercice, the Ifremer laboratory made two digitised images (transmitted and reflected light) for the 44 otoliths already read and it added 20 new otoliths.

Thus, the second exchange collection consisted of 66 digitised images by transmitted light and 66 digitised images by reflected light. Each reader chose a mode of light to annotate the images.

Readers were asked to email age readings and post a CD of annotated images to the exchange coordinator.

8.2 Results of the exchange

The first set with the slides was read by six readers from four Institutes and the second set with the digitised images was read by five readers from three Institutes.

The spreadsheet (Eltink, 2000) was completed according to the instructions contained in Guidelines and Tools for Age Reading Comparisons by Eltink *et al.* (2000). Modal ages were calculated for each otolith read, along with percentage agreement, mean age and precision coefficient of variation with as a definition (for each otolith):

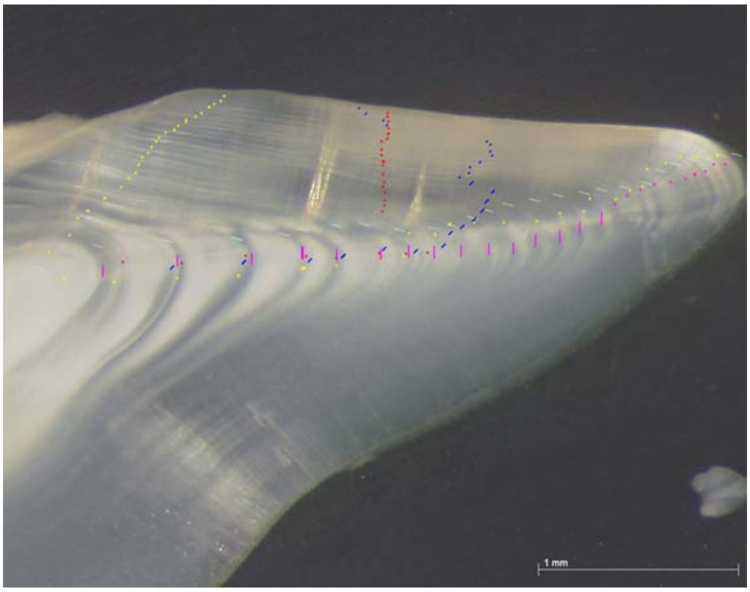
- percentage agreement = 100x(no. of readers agreeing with modal age/total no. of readers).
- precision c. v. = 100x(standard deviation of age readings/mean of age readings).

The combined results on the one hand slides and other hand of the digitised images are presented in the Annex 3. Table 3.1 contains the sample information and the input data of the age readings by reader. It should be noted that the first otoliths (n°1–43) were read according to two processes' (slides then images) and only the images were read for the following otoliths (n°44–63).

Readers are assigned numbers in accordance with their experience levels. The Guus Eltink spreadsheet is set up in such a way that the most experienced reader must be positioned in the left most column with less experienced on the right. In the case of a possible tie on two modal ages from a group of readers, the most experienced reader's determination of the age will take precedence. The modal age was calculated from readers 1 to 7 (four readers) as these were considered the most experienced of the group. Three readers are not included in the modal age because for the Faroe Islands, one is a beginner and the two others (J-L Dufour and G Henderson) are experienced readers for others species (example: the cod) but do not work on roundnose grenadier. For each reader, we separated the reading on the slides and on the digitised images from same otolith.

Percentage agreement ranged from 0% to 80% with an average of 30.2%. Of the 64 otoliths, 7 were read with at least 50% agreement and, 2 of these were read with 80% agreement.

A)



B)

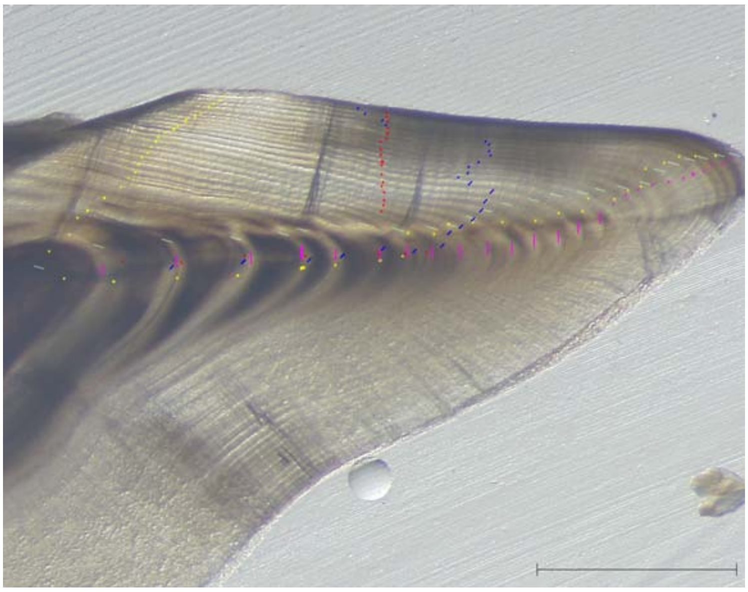


Figure 6: Otolith n°53 (percent agreement : 80%; CV: 2%). Digitised image with reflected light (A) and transmitted light (B).

A)

B)

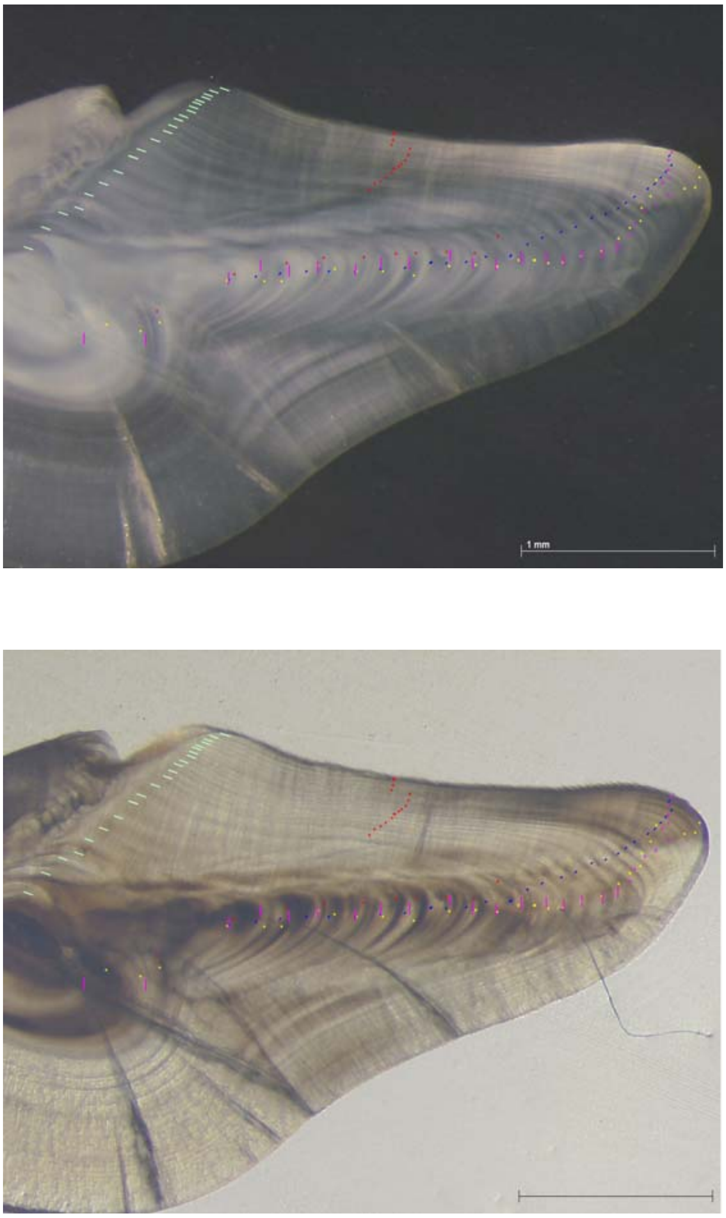
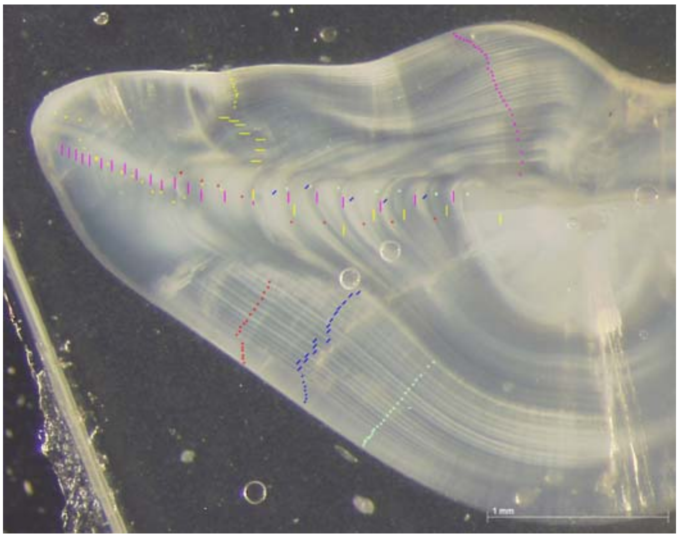


Figure 7: Otolith n°59 (percent agreement: 80%; CV: 2%). Digitised image with reflected light (A) and transmitted light (B).

It should be noted at this point though, that not all readers read all otoliths. The precision CV ranged from 2% (corresponding to 80% agreement in readings) to 28% with an average of 12.5%.

In Table 3.1, it is important to note that the otoliths, which appear to be difficult for age reading, are indicated with a high CV and a low percent agreement. These are the otoliths n° 6, 8, 18, 16, 30, 40, 41, 43, 54 and 62.

A)



B)

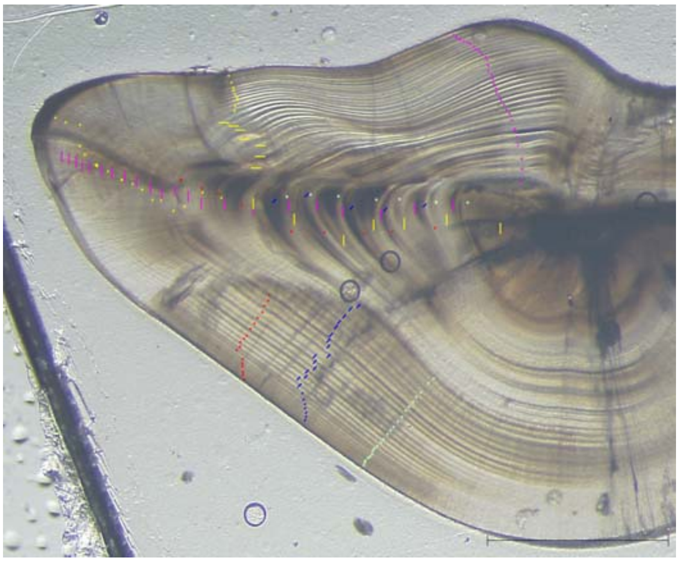


Figure 8: Otolith n°30 (percent agreement: 10%; CV: 24%). Digitised image with reflected light (A) and transmitted light (B).

Table 3.2 examines the readings of individuals at each modal age and summarises the number of otoliths read, the precision CV, percentage agreement and relative bias of each reader. Among sampled fish, these are only the old individuals with a modal age ranging from 19 to 46 years.

The coefficient of variation (CV) table shows the precision[4] in age reading by modal age, by age reader and all readers combined. With the precision (CV) of all readers combined, it is clear that precision tends to decrease with older ages. It should be noted that among the confirmed readers, the percentage agreement range between 37.5 and 54%. If reader 1 has very similar results between the slides and the images, there are important differences for the two other readers on a same otolith (Annex 4). The percentage agreement is much lower for the beginner readers. Figure 3.2 is a graphical representation of the coefficient of variation and percentage agreement.

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4 Precision is defined as the variability in the age readings. The precision errors in age readings are best described by the coefficient of variation (CV) by age group. This measure of precision is independent of the closeness to the true age (ICES, 2007b).

The relative biais[5] table shows the accuracy[6] in age reading by modal age, by age reader and all readers combined. The relative bias table demonstrates the difference between the mean age for each age group and the modal for each age group. It can be seen that experienced readers (readers 1, 3, 6, 8 and 10) show little relative bias, once again affirming their consistency. Two readers (Readers 5 and 9) belonging to the same laboratory show a very low percentage agreement and relative bias (-6.4 and -3.89) being explained by a tendency to underestimate a lot of the time. Figure 3.1 is a graphical representation of the relative bias table. The data for each reader which is plotted in Figure 3.1 is derived from Table 3.2. In these age bias plots any deviation of the points from the solid line indicates a bias when the reader's age estimates are compared with the modal age. (Points above and below the line indicate a positive and negative bias, respectively) The vertical bars are drawn plus and minus two standard deviations from the mean age. Short bars indicate consistency of reading at a given modal age.

In the overall ranking table, Readers 1, 3 and 6 are ranked in the top three positions for CV, percentage agreement and relative bias. These three readers are from France and Spain.

Figure 3.3 shows the distribution of the age reading errors in percentage by Modal age as observed from the whole group of age readers in an age reading comparison to Modal age. Figure 3.4 shows the relative bias by modal age as estimated by all age readers combined.

The minimal requirement for age reading consistency is the absence of bias among readers and through time. The hypothesis of an absence of bias between two readers or between a reader and the modal age estimates can be tested non-parametrically with a one-sample Wilcoxon signed rank test. This table shows inter-reader bias test and reader against modal age bias test (-: no sign of bias (p>0.05); *: possibility of bias (0.01<p<0.05); **: certainty of bias (p<0.01)).

	Spain ER-S Reader 1	Spain ER-I Reader 2	France WL-S Reader 3	France WL-I Reader 4	Faroe AH-S Reader 5	France RE-S Reader 6	France RE-I Reader 7	France JLD-I Reader 8	Faroe LL-S Reader 9	Scotland GH-S Reader 10	Scotland GH-I Reader 11
Reader 1											
Reader 2	–										
Reader 3	*	*									
Reader 4	**	**	–								
Reader 5	**	**	**	**							
Reader 6	**	**	**	**	**						
Reader 7	–	–	–	*	**	**					
Reader 8	–	–	–	*	**	**	**				
Reader 9	**	**	**	**	–	**	**	**			
Reader 10	**	**	*	*	**	*	**	**	*		
Reader 11	–	–	–	**	**	**	**	**	**	**	
MODAL	*	**	–	–	**	**	–	–	**	**	–

It should be noted that there are strong inter-reader and reader against modal age bias. Readers 3, 4, 7, 8 and 11 show no sign of reader against modal age bias.

5 In the absence of calcified structures of known age, the age readings can be compared to modal age, which is defined as the age determined for an individual structure for which most of the readers have a preference. Relative bias can be defined as a systematic over- or underestimation of age compared to the modal age. The age reading comparisons to modal age provide a low estimate of relative bias compared to absolute bias, when most readers have a similar serious bias in age reading (ICES, 2007b).

6 Accuracy is defined as the closeness of a measured value to its true value. The bias quantifies the degree of accuracy. We distinguish 2 types of bias: absolute bias and relative bias (ICES, 2007b).

9 Consistency among and within age determination experts

The results of the exchange revealed a low level of agreement and precision (high coefficient of variation) in relation to modal age.

For the same reader, there can be important differences between the reading on the slides and the image. For one reader, the explanation accounts for the magnification used. With a high magnification, finer structure become visible on the otolith, if those are counted old ages are estimated. With a binocular (magnification: 16), only macro-structures are visible and the images seems appropriate to estimate the age of roundnose grenadier.

The image of an otolith estimated 8 years old (Kelly *et al.*, 1997) was annotated. The age estimated was the same as that published from these authors and it was consistent with validation of young fish age (Gordon *et al.*, 1996):

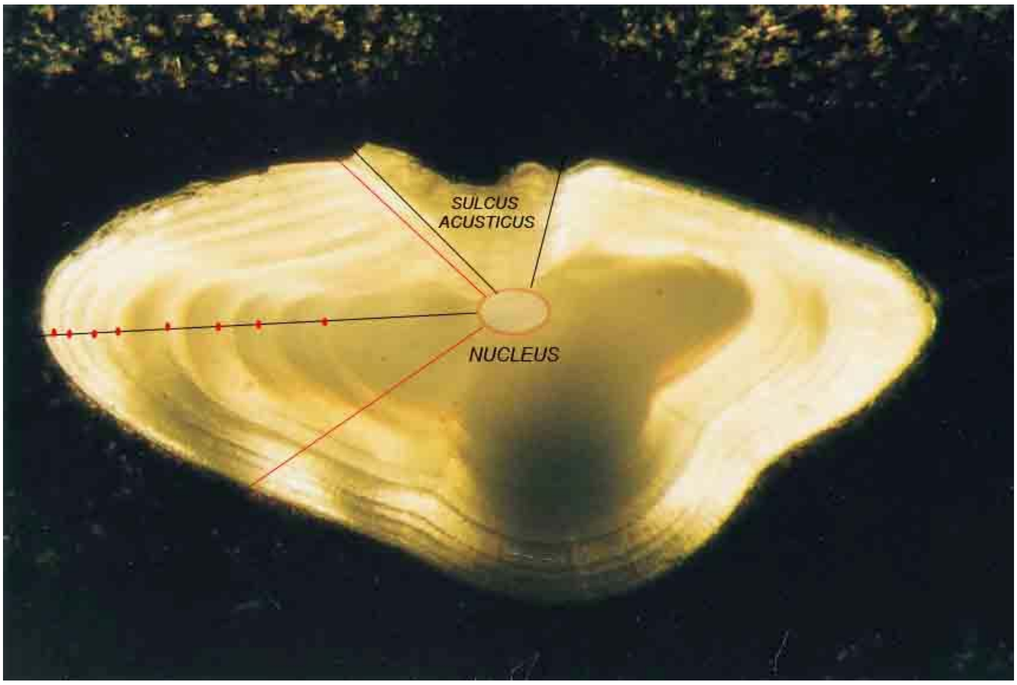

Figure 9: Otolith slide from an immature fish of pre-anus length 5 cm, estimated at age group 8, in transmitted light (*In* Kelly *et al.*, 1997). Reading zone is defined by the two red lines.

Based upon analysis of this image and viewing of other image during the workshop, all readers agreed on the location of the first ring (See 7.2).

Some marks visible on otolith slices, where consider as checks[7], several of those usually occur inside the first ring.

A set of 40 otoliths from the exchange was re-read by all participants during the workshop. The results are presented in the Annex 5.

For readers participating to both, the CVs, percentage agreements and relative bias during the exchange programme and at the end of the workshop showed an overall improvement in percentage agreement from 30.2% to 38,1%, a slight improvement in CV and relative bias (Table 1).

7 A disccontinuity or weak mark in a zone, or in a pattern of opaque and translucent zones. Not a true annulus, though it might appear as one.

Table 1: Comparison of CVs, percentage agreements and relative bias during the otoliths exchange and the workshop for the 4 readers attending the worhskop.

Analysis of the 40 images of otoliths during the exchange					
COEFFICIENT OF VARIATION (CV)					
	Spain ER	France WL	France RE	France JLD	All
Readers	Reader 2	Reader 4	Reader 7	Reader 8	Readers
All ages	3,9%	6,7%	5,5%	7,9%	7,0%
PERCENTAGE AGREEMENT					
	Spain ER	France WL	France RE	France JLD	All
Readers	Reader 2	Reader 4	Reader 7	Reader 8	Readers
All ages	48,7%	42,5%	37,5%	28,9%	30,2%
RELATIVE BIAS					
	Spain ER	France WL	France RE	France JLD	All
Readers	Reader 2	Reader 4	Reader 7	Reader 8	Readers
All ages	0,51	-0,95	-0,30	0,66	-0,03
Workshop re-read of 40 images of otoliths					
COEFFICIENT OF VARIATION (CV)					
	Spain ER	France WL	France RE	France JLD	All
Readers	Reader 1	Reader 2	Reader 3	Reader 4	Readers
All ages	4,5%	4,7%	5,5%	3,0%	6,5%
PERCENTAGE AGREEMENT					
	Spain ER	France WL	France RE	France JLD	All
Readers	Reader 1	Reader 2	Reader 3	Reader 4	Readers
All ages	50,0%	37,5%	20,0%	45,0%	38,1%
RELATIVE BIAS					
	Spain ER	France WL	France RE	France JLD	All
Readers	Reader 1	Reader 2	Reader 3	Reader 4	Readers
All ages	0,75	-0,7	-2,125	0,425	-0,87

10 Towards a manual for age reading of roundnose grenadier (ToRg)

The objective of an international manual is to provide a protocol for age determination of Roundnose grenadier. The manual and regular inter-calibrations will serve as a means to provide quality assurance. The manual will be updated regularly.

10.1 Preparation of otoliths

Several methods of preparation can be employed but for the roundnose grenadier that reach old age, transverse sections passing through the nucleus as described by Bedford (1983) with low-speed saw fitted with a diamond blade (0.2 mm) are required. For young fish (<10 years), whole otolith can be used as there is good agreement between ages estimated from whole otoltihs and thin slices under this size.

10.2 Interpretation of otoliths

To be copied from the WKARRG 2007.

10.3 Storage of otoliths

There are a number of storage methods employed by the various countries that collect otoliths from this stock. They range from the traditional paper bags style to small plastic "self-seal" bags and plastic tubes. Although all of these methods provide for the safe storage of the otolith, it is recommended that paper bags may provide the best alternative.

10.4 Light source and magnification

It is recommended to use the two sources of light: transmitted and reflected light. Magnification should be limited to the range of magnification x10–20. A too high magnification will result in splits being counted as rings.

11 Recommendations (ToRh)

- The Workshop noted that institutes where readers showed a low agreement with the other participants in the exchange may need further training, particularly if some of these readers contribute to age compositions to ICES Assessment WGs.
- Image analysis packages can be used to measure ring growth and construct an annual growth curve as an aid in verifying the age. This method is used by France. However, rings should not be discounted just because they do not follow the expected growth pattern.
- A reference collection of images with high agreement from the exchange should be established.
- Age validation of adult roundnose grenadier should be carried out. Although it does not produce age validation of individual fish, radiometric age estimation as done for the pacific grenadier *Coryphaenoides acrolepis* (Andrews *et al*., 1999) seems to be the most appropriate method to check the consistency of the range of age estimated from visual readings.
- It would be important to estimate bias when measuring the pre-anal fin length from commercial landings.
- It would be necessary to continue to collect information on the otolith weight to identify the accuracy of this predictor of the estimated age. Moreover, the otolith surface could also be a good predictor. Thus, it could be possible to limit the number of reading which is a very long process for this species.
- A second workshop on this species is required with samples of different stocks and several areas within the same presumed stock (the same stock in believed to cover ICES division Vb and XIIb and sub-areas VI and VII) and a range of size taking including the juvenile and the adult fish. For juveniles, readings from whole otolith and thin slices with various thicknesses (0.2 to 0.4 mm) could be compared. For the adults, methods of polishing or staining could be carried out.
- The roundnose grenadier can live up to 70 years old, the precision and the bias of age estimates should be evaluated according to needs' for the assessment.

12 Acknowledgements

This otolith exchange and this workshop were possible through the cooperation and participation of all readers from the four institutes involved and the success of the exchange and the workshop is entirely due to their efforts.

Thanks are due especially to Pascal Lorance, member of WGDEEP, for his presence at the time of the workshop and his help and to Guus Eltink for permission to use his spreadsheet for the analysis.

13 References

Andrews, A.H., Cailliet, G.M., Coale, K.H., 1999. Age and growth of the Pacific grenadier (*Coryphaenoides acrolepis*) with age estimate validation using an improved radiometric ageing technique. Can. J. Fish. Aquat. Sci., 56, 8: 1339–1350.

Alexseev, F. E., 1982. Reproductive cycle, functional structure of the area and intrapopulational differentiation in grenadier *Macrurus rupestris* Gunn. of the Middle Atlantic Ridge. In: the Union Conference on Theory of Formation of Abundance and Rational Exploitation of Commercial Fish Stocks. Theses of papers. Moscow: 73–75.

Allain, V., 1999. Ecologie, biologie et exploitation des populations de poissons profonds de l`Atlantique du nord-est. Thèse de Doctorat de L'Université de Bretagne Occidentale, France.

Allain, V., 2001. Reproductive strategies of three deep-water benthopelagic fishes from the northeast Atlantic Ocean. Fisheries Research, 51: 165–176.

Andriyashev, A. P., 1954. The North seas fish. Moscow. AN USSR, 568.

Atkinson, D. B., 1995. The biology and fishery of roundnose grenadier (*C. rupestris* Gunnerus, 1765) in the north-west Atlantic. *In*: Hopper, A.G. (Ed.), Deep-water Fisheries of the North Atlantic Oceanic Slope. Kluwer Academic Publishers, Netherlands, 51: 112.

Bedford, B.C., 1983. A method for preparing sections of large numbers of otoliths embedded in black polyester resin. J. Cons. Int. Explo. Mer, 41: 4–12.

Bergstad, O. A., 1990. Distribution, population structure, growth and reproduction of the roundnose grenadier *Coryphaenoides rupestris* (Pisces: Macrouridae) in the deep waters of the Skagerrak. Marine Biology, 107: 25–39.

Bergstad, O. A., Gordon, J. D. M., 1994. Deep-water ichthyoplankton of the Skagerrak with special reference to *Coryphaenoides rupestris* Gunnerus, 1765 (Pisces, Macrouridae) and *Argentina silus* (Ascanius, 1775) (Pisces, *Argentinidae*). Sarsia, 79: 33–43.

Borrmann, H., 1978. Stock assessment of roundnose grenadier in the northwest Atlantic. ICNAF Res. Doc. 78/VI/54, 8.

Bridger, J.P., 1978. New deep-water trawling grounds to the west of Britain. Lab. Leafl., MAFF Direct. Fish. Res., Lowestoft. No.41, 40.

Cohen, D. M., Inada, T., Iwamoto, T., Scialabra, N., 1990. Gadiformes fishes of the world (Order Gadiformes). An annotated and illustrated catalogue of cods, hakes, grenadiers and other gadiform fishes known to date. FAO Fisheries Synopsis, N 125, 10: 1–442.

Danke, L., 1987. Some particularities of roundnose grenadier (*Coryphaenoides rupestris* Gunn.) in the North Mid-Atlantic Ridge region. NAFO Scient. Counc. Res. Doc. 87/78, 10.

Draganik, B., Psuty-Lipska, I., Janusz, J., 1998. Ageing of roundnose grenadier (Coryphaenoides rupestris Gunn.) from otoliths. ICES CM 1998/O:49, 21.

Du Buit, M.-H. 1978. Alimentation de quelques poissons téléostéens de profondeur dans la zone du seuil de Wyville Thomson. [The diet of some sea teleost fishes in the Wyville Thomson ridge area]. Oceanologica acta, 1: 129–134.

Dupouy, H., Kergoat, B., 1992. La pêcherie de grenadier de roche (*Coryphaenoides rupestris*) de l'ouest de l'Ecosse: production, mortalité par pêche et rendement par recrue. ICES CM 1992/G:40, 9.

Dushchenko, V. V., 1989. On intraspecific structure of roundnose grenadier (*Coryphaenoides rupestris* G.) from the North Atlantic. Abstract of Biology science kandidat dissertation. M : 22.

Ehrich, S., 1983. On the occurrence of some fish species at the slopes of the Rockall Trough. Arch. FischereiWiss., 33: 105–150.

Eliassen, J. E., 1983. Distribution and abundance of roundnose grenadier (*Coryphaenoides rupestris*, Gadiformes, *Macrouridae*) in northern and mid Norway. ICES C.M.-1983/G:43: 24.

Eliassen, J. E., 1986. Undersùkelser av utbredelse, forekomster og bestandsstruktur av skolest (*Coryphaenoides rupestris* Gunnerus). I. Trùndelag. Fisken Hav., 1: 1–19.

Eltink, A. T. G. W., Newton, A. W., Morgado, C., Santamaria, M. T. G., Modin, J., 2000. Guidelines and Tools for Age Reading. (PDF document version 1.0 October 2000) Internet : http://www.efan.no

Eltink, A. T. G. W., 2000. Age reading comparisons. (MS Excel workbook version 1.0 October 2000) Internet : http://www.efan.no

Geistdoerfer, P., 1977. Contribution a la biologie de *Coryphaenoides rupestris*. Répartition et reproduction dans l'Atlantique nord-est, ICES C.M. 1977/F:45: 6.

Gordon, J. D. M., 1978. Some notes of the biology of the Roundnose Grenadier *Coryphaenoides rupestris* to the west of Scotland, ICES C.M. 1978/G:40: 13.

Gordon, J. D. M., Bergstad, O. A., 1992. Species composition of demersal fish in the Rockall Trough, north-eastern Atlantic, as determined by different trawls. J. mar. biol. Assoc. U. K., 72: 213–230.

Gordon, J. D. M., Duncan, J. A. R., 1985. The ecology of deep-sea benthic and benthopelagic fish on the slopes of the Rockall Trough, northeastern Atlantic. Progress in Oceanography, 15: 37–69.

Gordon, J. D. M., Swan, S. C., 1996. Validation of age readings from otoliths of juvenile roundnose grenadier, *Coryphaenoides rupestris*, a deep-water macrourid fish. Journal of Fish Biology, 49: 289–297.

Gordon, J.D.M., N.R. Merrett, O.A. Bergstad, and S.C. Swan. 1996. A comparison of the deep-water demersal fish assemblages of the Rockall Trough and Porcupine Seabight, eastern north Atlantic: continental slope to rise. Journal of Fish Biology 49, supplement A: 217–238.

Grigoriev, G. V., 1972. On reproduction of roundnose grenadier of the North Atlantic. Trudy PINRO. Murmansk, 28: 107–115.

Haedrich, R. L., Merrett, N. R., 1988. Summary atlas of deep-living demersal fishes in the North Atlantic Basin. J. Nat. Hist., 22: 1325–1362.

ICES, 2007a. Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources. ICES CM 2007/ACFM: 20.

ICES. 2007b. Report of the Planning Group on Commercial Catch, Discards and Biological Sampling (PGCCDBS), 5–9 March 2007, Valetta, Malta. ACFM:09. 115p.

Kelly, C. J., Connolly, P. L., Bracken, J. J., 1996. Maturity, oocyte dynamics and fecundity of the roundnose grenadier from the Rockall Trough. Journal of Fish Biology, 49: 5–17.

Kelly, C. J., Connolly, P. L., Bracken, J. J., 1997. Age estimation, growth, maturity and distribution of the roundnose grenadier from the Rockall Trough. Journal of Fish Biology, 50: 1–17.

Koch, H., 1976. A contribution on the methodics of age determination in roundnose grenadier (*Coryphaenoides rupestris* Gunn.). ICNAF Res. Doc. 76/VI/28: 3.

Kosswig, K., 1981. Investigations on grenadier fish (*Coryphaenoides rupestris* Gunnerus and *Macrourus berglax* Lacepede) by the Federal Republic of Germany in 1979. Ann. Biol. Copenhague, 36: 190.

Kosswig, K., 1983. Investigations on grenadier fish (*Macrourus berglax* and *Coryphaenoides rupestris*) by the Federal Republic of Germany in 1980. Ann. Biol. Copenhague, 37: 230.

Kosswig, K., 1984. Investigations on grenadier fish (*Macrourus berglax* and *Coryphaenoides rupestris*) by the Federal Republic of Germany in 1981. Ann. Biol. Copenhague, 38: 200.

Kosswig, K., 1986. Investigations on grenadier fish (*Macrourus berglax* and *Coryphaenoides rupestris*) by the Federal Republic of Germany in 1983. Ann. Biol. Copenhague, 40: 176.

Kosswig, K., 1989. Investigations on grenadierfish (*Macrourus berglax* and *Coryphaenoides rupestris*) by the Federal Republic of Germany in 1986 and 1987. Mitt. Inst. Seefisch. Hamburg, 44: 67–70.

Leim, A. H., Scott, W. B., 1966. Fishes of the Atlantic coast of Canada. Ottawa: 220–221.

Logvinenko, B. M., Nefedov, G. N., Massal'skaya, L. M., Polyanskaya, I. B., 1983. A population analysis of rock grenadier based on the genetic polymorphism of non-specific esterases and myogenes. Can Trans Fish Aquat Sci, 5406: 16.

Lorance, P., 1998. Structure du peuplement ichthyologique du talus continental à l'ouest des Iles Britanniques et impact de la pêche. Cybium, 22: 309–331.

Lorance, P., Dupouy H., Allain V., 2001. Assessment of the roundnose grenadier (*Coryphaenoides rupestris*) stock in the Rockall Trough and neighbouring areas (ICES Sub-areas V-VII). Fisheries Research, 51(2-3): 151–163.

Lorance, P., Garren F., Vigneau J., 2001. Age estimations of the roundnose grenadier (*Coryphaenoides rupestris*), effects of uncertainties on ages. NAFO SCR doc.01/123: 15.

Lorance, P., Garren, F., Vigneau, J., 2003. Age estimation of Roundnose Grenadier (*Coryphaenoides rupestris*), effects of uncertainties on ages. J. Northw. Atl. Fish. Sci., 31 : 387–399.

Lorance, P., Bergstad, O.A., Large, P.A., Gordon J.D.M., 2007. Grenadiers of the NE Atlantic - distribution, biology, fisheries and their impacts, and developments in stock assessment and management. American Fisheries Society Books. *In press*.

Magnússon, J. V., 1986. Icelandic investigations on grenadier fish (*Macrourus berglax* and *Coryphaenoides rupestris*) in 1983. Ann. Biol. Copenhague, 40: 176.

Magnússon, J. V., 1987. Grenadier fish in Icelandic waters. NAFO SCR Doc. 87/87, Serial No. N1341: 19.

Magnússon, J. V., Magnússon, J., 1996. The distribution relative abundance and the biology of the deep-sea fishes of the Icelandic slope and Reykjanes ridge. *In*: Hopper, A.G. (Ed.), Deep-water Fisheries of the North Atlantic Oceanic Slope. Kluwer Academic Publishers, Netherlands, 161–199.

Magnússon, J., Magnússon, J. V., Jakobsdottir, K. B., 2000. Deep-sea fishes. Icelandic contributions to the deep-water research project, EC FAIR Project CT 95-0655: 1996–1999.

Mauchline, J., and J.D.M. Gordon. 1984. Diets and bathymetric distributions of the macrourid fish of the Rockall Trough, northeastern Atlantic Ocean. Marine Biology 81: 107–121.

Merrett, N. R., Gordon, J. D. M., Stehmann, M., Haedrich, R. L., 1991. Deep demersal fish assemblage structure in the Porcupine Seabight (eastern North Atlantic): slope sampling by three different trawls compared. J. Mar. Biol. Assoc. UK, 71: 329–358.

Panfili, J., Pontual, H. (de)., Troadec, H., Wright, P. J., 2002. Manual of Fish Sclerochronology. Coédition Ifremer-IRD, 464.

Parin, N. V., Neyman, V. G., Rudyakov, Y. A., 1985. To the problem of waters biological productivity in the High Sea areas of underwater elevations. *In*: Biological grounds of the fishery development of the High Sea areas. Selected papers. Nauka. Moscow, 192–203.

Parr, A. E., 1946. The Macrouridae of the Western North Atlantic and Central American seas. Bull. of the Bingham Oceanogr. Collect. Yale Univers., 1: 1–101.

Pshenichny, B. P., Kotlyar, A. N., Glukhov, A. A., 1986. Fish resources of thalassobathyal Atlantic Ocean. *In*: Biological resources of the Atlantic Ocean. Moscow, Nauka: 230–252.

Reinert, J., 1995. Deep-water resources in Faroese waters to the south, southwest and west of the Faroes a preliminary account. *In*: Hopper, A.G. (Ed.), Deep-water Fisheries of the North Atlantic Oceanic Slope. Kluwer Academic Publishers, Netherlands, 201–225.

Sauskan, V. I., 1988. Commercial fish of the Atlantic ocean. Agropromizdat, Moscow: 165–166.

Savvatimskii, P. I., 1972. The age of the rock grenadier in the northwest Atlantic and a possible influence of fisheries on its population numbers. Proc. Polar Res. Inst. Mar. Fish. Ocean (PINRO), Fisheries Research Board of Canada, Translation Series, 28: 116–127.

Savvatimskiy, P. I., 1971. Determination of the age of grenadiers (order Macruriformes). J. Ichthyol., 11: 397–403.

Savvatimskiy, P. I., Kokh, K., Yernst, P., 1978. Comparison of methods for determining the age of grenadiers (Macruriformes, Pisces) from the northern Atlantic. J. Ichthyol., 17: 324–327.

Savvatimsky, P. I., 1969. Roundnose grenadier of the North Atlantic. PINRO, Murmansk, 72 (in Russian).

Swan, S.C., and J.D.M. Gordon. 2001. A review of age estimation in macrourid fishes with new data on age validation of juveniles. Fisheries Research 51: 177–195.

Shibanov, V. N., 1997. Biological foundation of roundnose grenadier (*Coryphaenoides rupestris* Gunnerus, 1765) fishery in the North Atlantic. Candidate Dissertation in Biological Sciences. Murmansk, PINRO: 156.

Shibanov, V. N., Vinnichenko, V. I., 2007. Biology and fishery of roundnose grenadier (*Coryphaenoides rupestris* Gunnerus 1765) in the North Atlantic, In press.

Vinnichenko, V. I., Khlivnoy, B. N., 2007. New data on distribution of young roundnose grenadier (*Coryphaenoides rupestris*) in the North Atlantic. *In press.*WALTERS, C., 2003. Folly and fantasy in the analysis of spatial catch rate data. Canadian Journal of Fisheries and Aquatic Sciences, 60: 1433–1436.

Vinnichenko, V. I., Khlivnoy, B. N., Orlov, A. M., 2004. Biology and distribution of the deepwater fish on the Northeast Atlantic underwater elevations. Fishery economy. Water biological resources, their condition and use: Obzornaya informacjiya, VNIERH. Moscow. 1: 46.

Zakharov, G. P., Mokanu, I. D., 1970. Distribution and biological characteristics of roundnose grenadier in the Davis Strait in August-September 1969. Reports on PINRO marine research cruises. II cruise of RV “Persey-III”, M: 146–154.

Zilanov, V. K., Troyanovsky, F. M., Shepel, and L. I., 1970. Some biology features, search and fishery characteristics of the roundnose grenadier in the North Atlantic. *In*: Materials of the Northern Basin. Murmansk, 16: 3–21.

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Annex 2: Agenda

- Tuesday, September 4

  09:30–10:00: Opening of meeting, local arrangements (computer, network arrangements)

  10:00–10:30: Review of Terms of Reference, Adoption of Agenda

  10:30–11:00: Coffee

  11:00–12:00: Biology of roundnose grenadier and ToR a

  12:00–13:00: Lunch

  13:00–14:30: Review the sample processing techniques of the different age reading and try to standardise the processing techniques (ToR b)

  14:30–15:00: Presentation: Relationship on fish age and otolith weight (Pascal Lorance)

  15:00–15:30: Break

  15:30–16:00: ToR c

  16:00–18:00: Presentation: results from the exchange program (ToR d)

- Wednesday, September 5

  09:00–10:00: Presentation: images with annotations of all readers

  10:00–10:30: Break

  10:30–12:00: Presentation: images with annotations of all readers

  12:00–13:00: Lunch

  13:00–15:00: Discussion on interpretation from the live images

  15:00–15:30: Break

  15:30–18:00: Discussion

- Thursday, September 6

  09:00–10:00: Re-reading exchange otoliths

  10:00–10:30: Break

  10:30–12:00: Re-reading exchange otoliths

  12:00–13:00: Lunch

  13:00–15:00: Results from re-reading exchange otoliths

  15:00–15:30: Break

  15:30–18:00: ToR e and f

- Friday, September 7

  09:00–10:00: ToR g

  10:00–10:30: Break

  10:30–12:00: ToR h

Annex 3: Detailed results from exchange set

The annex contains results (tables and figures) from the exchange set of slides on roundnose grenadier sectioned otoliths during 2006 and 2007.

Table 3.1

Fish no	Fish length	Sex	Landing month	Spain ER-S Reader 1	Spain ER-I Reader 2	France WL-S Reader 3	France WL-I Reader 4	Faroe AH-S Reader 5	France RE-S Reader 6	France RE-I Reader 7	France JLD-I Reader 8	Faroe LL-S Reader 9	Scotland GH-S Reader 10	Scotland GH-I Reader 11	MODAL age	Percent agreement	Precision CV
1	16	-	5	24	20	20	18	18	19	20	19	17	21	22	20	27%	10%
2	15,5	-	5	25	24	21	23	19	20	26	24	20	25	25	24	18%	11%
3	13	-	4	25	25	26	23	18	22	26	21	18	20	27	25	18%	14%
4	16,5	-	4	27	27	26	26	19	18	24	33	19	22	31	27	18%	20%
5	16	-	6	28	26	29	25	20	21	25	35	23	26	22	25	18%	17%
6	15	-	5	30	32	37	36	18	25	34	30	17	22	30	30	27%	24%
7	19	-	6	29	29	25	30	23	25	28	32	25	24	28	29	18%	10%
8	16	-	5	39	46	46	42	21	36	41	42	22	23	43	46	18%	27%
9	14,5	-	6	25	26	26	26	22	22	23	-	24	24	18	26	30%	11%
10	16,5	-	4	-	-	26	27	19	20	23	21	18	23	29	23	22%	17%
11	15	-	6	25	25	24	25	18	19	26	27	20	24	27	25	27%	13%
12	18	-	1	23	23	21	22	17	19	26	33	15	22	33	23	18%	25%
13	16,5	-	1	24	24	22	24	19	22	25	24	18	23	26	24	36%	11%
14	17	-	1	23	23	22	23	24	23	23	26	22	23	24	23	55%	5%
15	16	-	6	25	24	23	22	21	18	25	25	22	22	27	25	27%	11%
16	15	-	6	25	25	29	31	17	19	21	-	17	13	31	25	20%	28%
17	15	-	6	26	26	24	25	20	21	22	28	22	25	25	26	18%	10%
18	14,5	-	6	28	28	29	28	24	25	25	29	24	23	33	28	27%	11%
19	17	-	6	26	26	25	24	22	23	25	28	23	20	26	26	27%	9%
20	16	-	6	25	25	28	26	21	24	28	25	21	-	26	25	30%	10%
21	15	-	6	23	23	23	22	18	22	25	21	19	-	25	23	30%	10%
22	15,5	-	5	28	28	26	24	17	18	24	21	19	-	30	28	20%	19%
23	17,5	-	5	24	24	25	21	22	25	23	25	22	-	30	25	30%	10%
24	16	-	5	27	29	32	31	24	30	30	36	24	-	33	30	20%	13%
25	18	-	5	26	28	32	20	19	21	28	29	19	-	26	28	20%	19%
26	16	-	6	25	24	23	23	23	23	26	23	22	-	25	23	50%	5%
27	18	-	6	27	28	29	28	22	24	30	28	22	-	29	28	30%	11%
28	17	-	1	24	25	23	25	19	23	25	24	17	-	27	25	30%	13%
29	20	-	5	37	44	42	38	36	37	42	43	35	-	41	37	20%	8%
30	15	-	5	37	31	29	28	17	22	23	31	18	-	27	31	20%	24%
31	14,5	-	6	25	25	25	23	21	22	26	25	21	-	24	25	40%	8%
32	17,5	-	1	22	21	20	19	18	18	22	23	18	-	21	22	20%	9%
33	18	-	4	26	26	25	23	23	23	23	25	22	-	28	23	40%	8%
34	17	-	4	28	28	26	24	20	25	28	31	25	-	29	28	30%	12%
35	16	-	1	24	23	20	19	17	19	19	19	18	-	18	19	40%	11%
36	21	-	1	32	32	32	32	25	29	32	30	23	-	30	32	50%	11%
37	17	-	6	34	30	25	22	22	22	25	27	22	-	24	22	40%	16%
38	16,5	-	1	21	21	20	21	14	19	20	19	15	-	19	21	30%	13%
39	17,5	-	3	31	31	27	27	20	22	29	29	20	-	27	31	20%	16%
40	14	-	6	32	30	26	25	15	26	31	21	17	-	31	26	20%	24%
41	16	-	6	34	32	29	36	16	26	33	33	16	-	29	33	20%	25%
42	18	-	6	33	33	32	34	18	27	33	30	24	-	35	33	30%	18%
43	18	-	1	33	31	28	26	18	24	26	27	17	-	25	26	20%	20%
44	12,5	-	1	-	26	-	24	-	-	24	22	-	-	22	24	40%	7%
45	15	-	1	-	38	-	32	-	-	36	-	-	-	37	35	0%	7%
46	14	-	1	-	31	-	23	-	-	34	32	-	-	32	29	0%	14%
47	15	-	1	-	23	-	30	-	-	24	27	-	-	22	26	0%	13%
48	11	-	1	-	25	-	23	-	-	23	27	-	-	29	23	40%	10%
49	14	-	1	-	28	-	21	-	-	28	27	-	-	24	28	40%	12%
50	16	-	1	-	28	-	25	-	-	28	29	-	-	28	28	60%	5%
51	14,5	-	1	-	26	-	26	-	-	27	26	-	-	23	26	60%	6%
52	14,5	-	1	-	30	-	29	-	-	27	27	-	-	25	27	40%	7%
53	17	-	1	-	26	-	26	-	-	25	26	-	-	26	26	80%	2%
54	12	-	1	-	20	-	19	-	-	18	15	-	-	25	19	20%	19%
55	19,5	-	1	-	22	-	21	-	-	21	20	-	-	19	21	40%	6%
56	13,5	-	1	-	28	-	24	-	-	24	27	-	-	27	24	40%	7%
57	13,5	-	1	-	25	-	27	-	-	28	26	-	-	25	27	20%	5%
58	15	-	1	-	23	-	22	-	-	22	24	-	-	20	22	40%	7%
59	18,5	-	1	-	28	-	28	-	-	30	22	-	-	24	28	40%	12%
59	15,5	-	1	-	27	-	27	-	-	28	27	-	-	27	27	80%	2%
59	13	-	1	-	24	-	21	-	-	27	24	-	-	22	24	40%	10%
61	15	-	1	-	28	-	24	-	-	24	27	-	-	29	24	40%	9%
62	12,5	-	1	-	23	-	25	-	-	26	16	-	-	18	25	20%	20%
63	13	-	1	-	23	-	22	-	-	21	20	-	-	21	22	20%	5%
			Total read	42	63	43	64	43	43	64	61	43	19	64		30,2%	12,5%
			Total NOT read	22	1	21	0	21	21	0	3	21	45	0			

Table 3.2: The number of age readings, the coefficient of variation (CV), the percent agreement and the RELATIVE bias are presented by MODAL age for each age reader and for all readers combined. A weighted mean CV and a weighted mean percent agreement are given by reader and all readers combined. The CV's by MODAL age for each individual age reader and all readers combined indicate the precision in age reading by MODAL age. The weighted mean CV's over all MODAL age groups combined indicate the precision in age reading by reader and for all age readers combined.

Number of age readings

MODAL	Spain ER-S	Spain ER-I	France WL-S	France WL-I	Faroe AH-S	France RE-S	France RE-I	France JLD-I	Faroe LL-S	Scotland GH-S	Scotland GH-I	
age	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 7	Reader 8	Reader 9	Reader 10	Reader 11	TOTAL
0	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-
19	1	2	1	2	1	1	2	2	1	-	2	**15**
20	1	1	1	1	1	1	1	1	1	1	1	**11**
21	1	2	1	2	1	1	2	2	1	-	2	**15**
22	2	4	2	4	2	2	4	4	2	-	4	**30**
23	6	7	7	8	7	7	8	8	7	4	8	**77**
24	2	6	2	6	2	2	6	6	2	1	6	**41**
25	8	9	8	9	8	8	9	8	8	5	9	**89**
26	5	8	5	8	5	5	8	7	5	3	8	**67**
27	2	4	2	4	2	2	4	4	2	1	4	**31**
28	5	8	5	8	5	5	8	8	5	1	8	**66**
29	2	4	2	4	2	2	4	4	2	1	4	**31**
30	2	2	2	2	2	2	2	2	2	1	2	**21**
31	1	1	1	1	1	1	1	1	1	-	1	**10**
32	1	1	1	1	1	1	1	1	1	-	1	**10**
34	-	-	-	-	-	-	-	-	-	-	-	-
35	-	1	-	1	-	-	1	-	-	-	1	-
36	-	-	-	-	-	-	-	-	-	-	-	-
37	-	-	-	-	-	-	-	-	-	-	-	-
38	-	-	-	-	-	-	-	-	-	-	-	-
39	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-
41	-	-	-	-	-	-	-	-	-	-	-	-
42	1	1	1	1	1	1	1	1	1	-	1	**10**
43	-	-	-	-	-	-	-	-	-	-	-	-
44	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	-	-	-	-	-	-	-	-	-
46	1	1	1	1	1	1	1	1	1	1	1	**11**
0-46	**42**	**63**	**43**	**64**	**43**	**43**	**64**	**61**	**43**	**19**	**64**	**549**

Coefficient of variation (CV)

MODAL	Spain ER-S	Spain ER-I	France WL-S	France WL-I	Faroe AH-S	France RE-S	France RE-I	France JLD-I	Faroe LL-S	Scotland GH-S	Scotland GH-I	ALL
age	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 7	Reader 8	Reader 9	Reader 10	Reader 11	Readers
0	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	10%	-	0%	-	-	4%	17%	-	-	23%	-
20	-	-	-	-	-	-	-	-	-	-	-	-
21	-	3%	-	0%	-	-	3%	4%	-	-	0%	-
22	30%	16%	16%	7%	14%	14%	8%	12%	14%	-	8%	**9,3%**
23	5%	5%	8%	7%	14%	8%	6%	16%	13%	5%	11%	**11,3%**
24	0%	8%	9%	7%	10%	9%	6%	8%	14%	-	13%	**9,0%**
25	5%	3%	10%	10%	8%	10%	7%	22%	12%	24%	15%	**14,8%**
26	13%	10%	6%	7%	15%	8%	11%	9%	16%	12%	15%	**11,8%**
27	22%	9%	8%	3%	8%	14%	10%	11%	4%	-	9%	**12,6%**
28	3%	0%	9%	13%	13%	13%	8%	13%	13%	-	11%	**12,8%**
29	11%	4%	10%	18%	25%	3%	12%	9%	31%	-	10%	**14,2%**
30	7%	7%	10%	11%	20%	13%	9%	13%	24%	-	7%	**18,6%**
31	-	-	-	-	-	-	-	-	-	-	-	-
32	-	-	-	-	-	-	-	-	-	-	-	-
33	-	-	-	-	-	-	-	-	-	-	-	-
34	-	-	-	-	-	-	-	-	-	-	-	-
35	-	-	-	-	-	-	-	-	-	-	-	-
36	-	-	-	-	-	-	-	-	-	-	-	-
37	-	-	-	-	-	-	-	-	-	-	-	-
38	-	-	-	-	-	-	-	-	-	-	-	-
39	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-
41	-	-	-	-	-	-	-	-	-	-	-	-
42	-	-	-	-	-	-	-	-	-	-	-	-
43	-	-	-	-	-	-	-	-	-	-	-	-
44	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	-	-	-	-	-	-	-	-	-
46	-	-	-	-	-	-	-	-	-	-	-	-
0-46	**7,0%**	**5,5%**	**7,3%**	**7,5%**	**10,7%**	**8,2%**	**7,0%**	**11,7%**	**11,8%**	**9,2%**	**10,6%**	**10,4%**
RANKING	**3**	**1**	**4**	**5**	**9**	**6**	**2**	**10**	**11**	**7**	**8**	

Percentage agreement

MODAL	Spain ER-S	Spain ER-I	France WL-S	France WL-I	Faroe AH-S	France RE-S	France RE-I	France JLD-I	Faroe LL-S	Scotland GH-S	Scotland GH-I	
age	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 7	Reader 8	Reader 9	Reader 10	Reader 11	**ALL**
0	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-
19	0%	0%	0%	100%	0%	100%	50%	50%	0%	-	0%	**33%**
20	0%	100%	100%	0%	0%	0%	100%	0%	0%	0%	0%	**27%**
21	100%	50%	0%	100%	0%	0%	50%	0%	0%	-	0%	**33%**
22	50%	0%	0%	75%	50%	50%	50%	0%	50%	-	0%	**30%**
23	50%	43%	29%	63%	29%	43%	50%	13%	0%	50%	0%	**32%**
24	100%	50%	0%	67%	0%	0%	50%	33%	0%	0%	0%	**34%**
25	75%	67%	13%	44%	0%	0%	33%	38%	0%	0%	0%	**26%**
26	40%	63%	40%	50%	0%	20%	13%	29%	0%	0%	25%	**28%**
27	50%	50%	0%	50%	0%	0%	0%	25%	0%	0%	50%	**26%**
28	60%	100%	0%	38%	0%	0%	50%	13%	0%	0%	13%	**30%**
29	50%	25%	50%	25%	0%	0%	0%	0%	0%	0%	25%	**16%**
30	50%	0%	0%	0%	0%	50%	50%	50%	0%	0%	50%	**24%**
31	100%	100%	0%	0%	0%	0%	0%	0%	0%	-	0%	**20%**
32	100%	100%	100%	100%	0%	0%	100%	0%	0%	-	0%	**50%**
33	100%	100%	0%	0%	0%	0%	100%	0%	0%	-	0%	**30%**
34	-	-	-	-	-	-	-	-	-	-	-	-
35	-	0%	-	0%	-	-	0%	-	-	-	0%	-
36	-	-	-	-	-	-	-	-	-	-	-	-
37	-	-	-	-	-	-	-	-	-	-	-	-
38	-	-	-	-	-	-	-	-	-	-	-	-
39	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-
41	-	-	-	-	-	-	-	-	-	-	-	-
42	0%	0%	100%	0%	0%	0%	100%	0%	0%	-	0%	**20%**
43	-	-	-	-	-	-	-	-	-	-	-	-
44	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	-	-	-	-	-	-	-	-	-
46	0%	100%	100%	0%	0%	0%	0%	0%	0%	0%	0%	**18%**
0-46	**57,14%**	**53,97%**	**23,26%**	**48,44%**	**6,98%**	**16,28%**	**37,50%**	**19,67%**	**2,33%**	**10,53%**	**10,94%**	28,23%
RANKING	**7**	**6**	**2**	**5**	**11**	**8**	**1**	**3**	**10**	**9**	**4**	

Relative bias

MODAL	Spain ER-S	Spain ER-I	France WL-S	France WL-I	Faroe AH-S	France RE-S	France RE-I	France JLD-I	Faroe LL-S	Scotland GH-S	Scotland GH-I	
age	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 7	Reader 8	Reader 9	Reader 10	Reader 11	ALL
0	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-
19	5	3	1	0	-2	0	-1	-2	-1	-	3	1
20	4	0	0	-2	-2	-1	0	-1	-3	1	2	0
21	0	1	-1	0	-7	-2	-1	-2	-6	-	-2	-2
22	6	2	1	-1	-2	-2	1	2	-2	-	-1	0
23	1	1	0	0	-3	-2	1	2	-3	0	4	0
24	0	2	-1	-1	-4	-1	1	1	-4	-1	2	0
25	0	0	1	0	-6	-4	0	0	-5	-4	0	-1
26	2	1	0	0	-7	-3	-1	0	-5	-3	-2	-1
27	5	1	1	0	-9	-7	-1	2	-9	-5	1	-1
28	-1	0	0	-3	-8	-5	0	-1	-6	-5	0	-2
29	3	2	-2	1	-10	-4	2	2	-9	-5	-1	-1
30	-2	1	5	4	-9	-3	2	3	-10	-8	2	-1
31	0	0	-4	-4	-11	-9	-2	-2	-11	-	-4	-5
32	0	0	0	0	-7	-3	0	-2	-9	-	-2	-2
33	0	0	-1	1	-15	-6	0	-3	-9	-	2	-3
34	-	-	-	-	-	-	-	-	-	-	-	-
35	-	3	-	-3	-	-	1	-	-	-	2	-
36	-	-	-	-	-	-	-	-	-	-	-	-
37	-	-	-	-	-	-	-	-	-	-	-	-
38	-	-	-	-	-	-	-	-	-	-	-	-
39	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-
41	-	-	-	-	-	-	-	-	-	-	-	-
42	5	2	0	-4	-6	-5	0	1	-7	-	-1	-2
43	-	-	-	-	-	-	-	-	-	-	-	-
44	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	-	-	-	-	-	-	-	-	-
46	-7	0	0	-4	-25	-10	-5	-4	-24	-23	-3	-10
0-46	**1,17**	**0,79**	**0,21**	**-0,63**	**-6,40**	**-3,51**	**0,13**	**0,38**	**-5,98**	**-3,89**	**0,55**	**-2,44**
RANKING	**7**	**6**	**2**	**5**	**11**	**8**	**1**	**3**	**10**	**9**	**4**	

Overall ranking

	Spain ER-S	Spain ER-I	France WL-S	France WL-I	Faroe AH-S	France RE-S	France RE-I	France JLD-I	Faroe LL-S	Scotland GH-S	Scotland GH-I
	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 7	Reader 8	Reader 9	Reader 10	Reader 11
Ranking Coefficient of Variation	3	1	4	5	9	6	2	10	11	7	8
Ranking Percentage Agreement	7	6	2	5	11	8	1	3	10	9	4
Ranking Relative bias	7	6	2	5	11	8	1	3	10	9	4
OVERALL RANKING	**7**	**3**	**2**	**4**	**10**	**8**	**1**	**5**	**10**	**9**	**5**

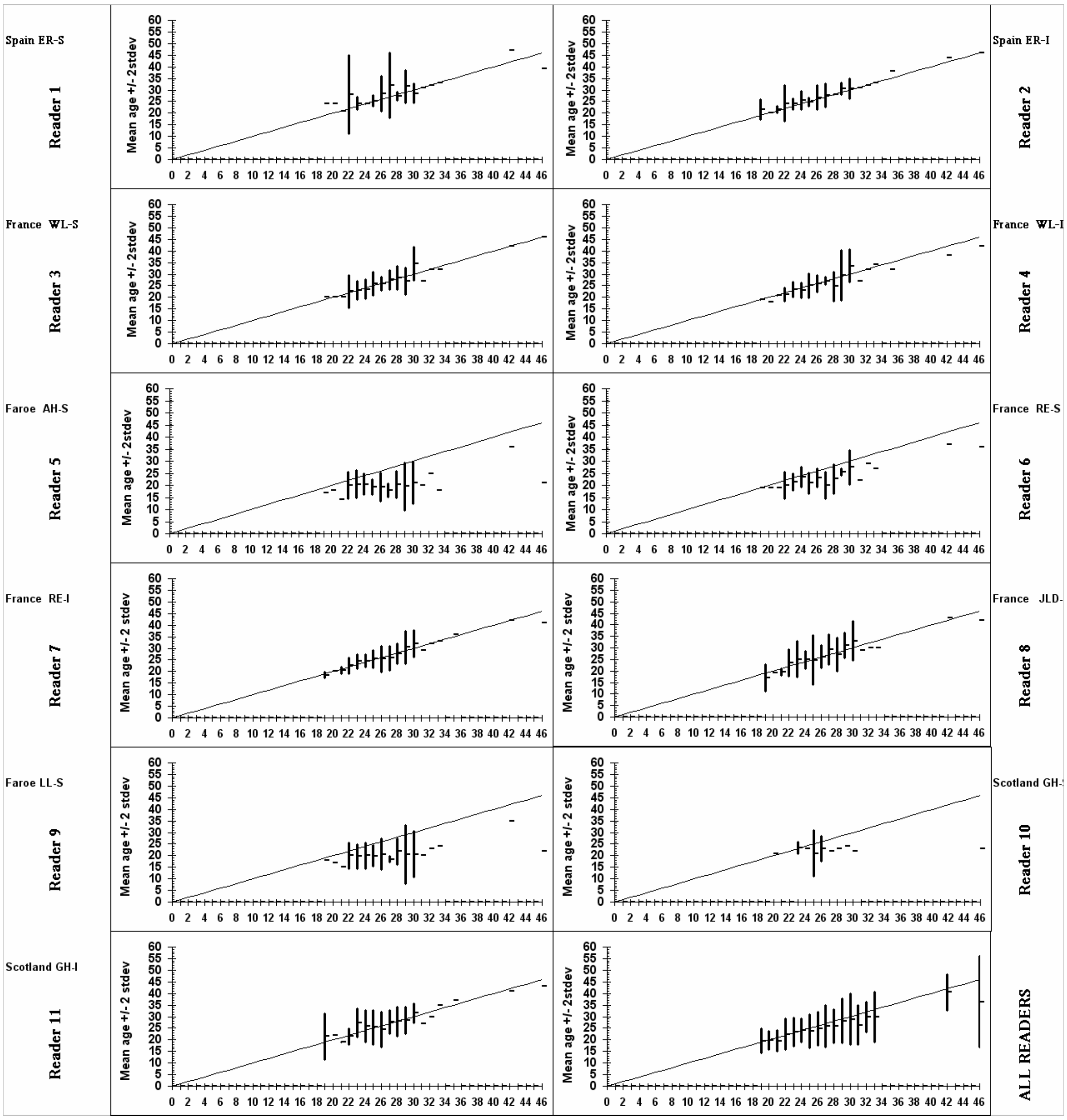


Figure 3.1: In the age bias plots below the mean age recorded +/- 2stdev of each age reader and all readers combined are plotted against the MODAL age. The estimated mean age corresponds to MODAL age, if the estimated mean age is on the 1:1 equilibrium line (solid line). RELATIVE bias is the age difference between estimated mean age and MODAL age.

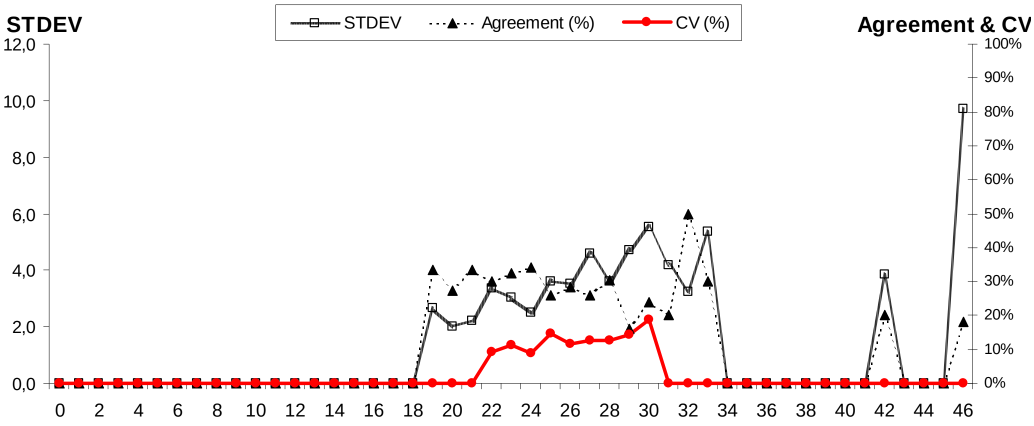


Figure 3.2: The coefficient of variation (CV%) percent agreement and the standard deviation (STDEV) are plotted against MODAL age.

CV is much less age dependent than the standard deviation (STDEV) and the percent agreement. CV is therefore a better index for the precision in age reading. Problems in age reading are indicated by relatively high CV's at age.

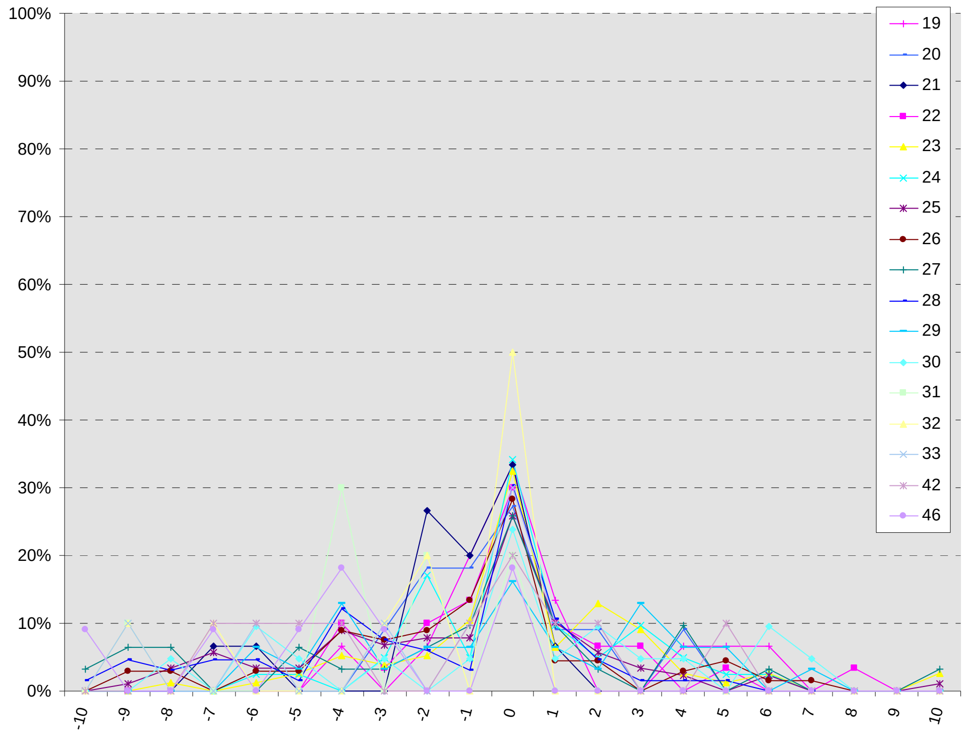


Figure 3.3: The distribution of the age reading errors in percentage by MODAL age as observed from the whole group of age readers in an age reading comparison to MODAL age. The achieved precision in age reading by MODAL age group is shown by the spread of the age readings errors. There appears to be no RELATIVE bias, if the age reading errors are normally distributed. The distributions are skewed, if RELATIVE bias occurs.

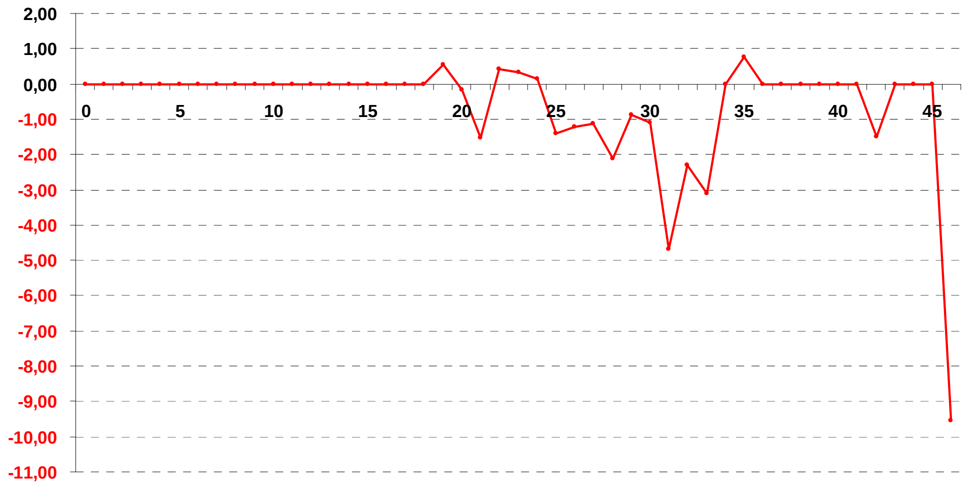
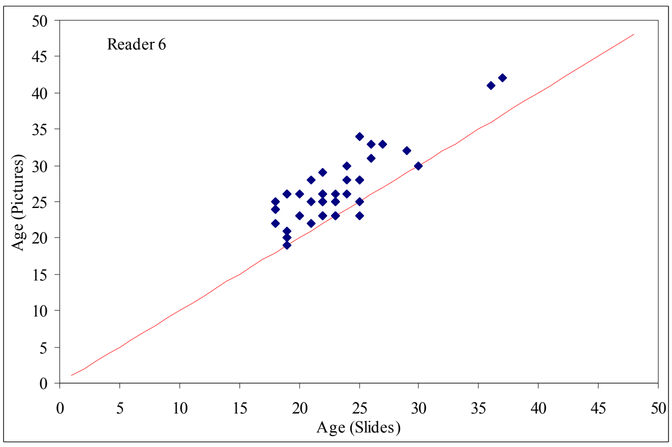


Figure 3.4: The RELATIVE bias by MODAL age as estimated by all age readers combined.

Annex 4: Comparison of the estimated age on a slide and on an image for the same reader



We can notice that if the two readings are very similar for the first reader, there are more differences for the third reader. Lastly, for the sixth reader, the estimated age on the images is higher than that on the slides. This is due primarily to the positioning of the first rings.

Annex 5: Detailed results from workshop set

The annex contains results (tables and figures) from the exchange set of slides on roundnose grenadier sectioned otoliths during 2006 and 2007.

Table 5.1

Sample year	Sample no	Fish no	Fish length	Sex	Landing month	Spain ER Reader 1	France WL Reader 2	France RE Reader 3	France JLD Reader 4	MODAL age	Percent agreement	Precision CV
2006	-	1	16	-	5	20	18	18	20	20	50%	6%
2006	-	2	15,5	-	5	23	24	21	24	24	50%	6%
2006	-	3	13	-	4	23	22	20	21	22	25%	6%
2006	-	4	16,5	-	4	27	26	23	27	27	50%	7%
2006	-	5	16	-	6	26	23	22	24	24	25%	7%
2006	-	6	15	-	5	30	33	29	32	31	0%	6%
2006	-	7	19	-	6	28	25	24	28	28	50%	8%
2006	-	8	16	-	5	42	41	36	42	42	50%	7%
2006	-	9	14,5	-	6	25	25	21	26	25	50%	9%
2006	-	10	16,5	-	4	25	25	21	26	25	50%	9%
2006	-	11	15	-	6	25	26	22	27	25	25%	9%
2006	-	12	18	-	1	24	21	21	24	24	50%	8%
2006	-	13	16,5	-	1	23	22	21	24	23	25%	6%
2006	-	14	17	-	1	23	22	23	25	23	50%	5%
2006	-	15	16	-	6	23	22	19	24	22	25%	10%
2006	-	16	15	-	6	27	30	20	24	25	0%	17%
2006	-	17	15	-	6	25	24	20	26	24	25%	11%
2006	-	18	14,5	-	6	29	26	27	28	28	25%	5%
2006	-	19	17	-	6	25	25	25	24	25	75%	2%
2006	-	20	16	-	6	25	25	23	25	25	75%	4%
2006	-	21	15	-	6	22	22	20	23	22	50%	6%
2006	-	22	15,5	-	5	29	22	22	24	22	50%	14%
2006	-	23	17,5	-	5	26	23	22	25	24	0%	8%
2006	-	24	16	-	5	29	31	25	31	31	50%	10%
2006	-	25	18	-	5	27	20	24	27	27	50%	14%
2006	-	26	16	-	6	25	23	23	25	25	50%	5%
2006	-	27	18	-	6	30	28	29	29	29	50%	3%
2006	-	28	17	-	1	25	24	23	25	25	50%	4%
2006	-	29	20	-	5	42	39	40	40	40	50%	3%
2006	-	30	15	-	5	32	30	29	30	30	50%	4%
2006	-	31	14,5	-	6	24	22	25	25	25	50%	6%
2006	-	32	17,5	-	1	21	19	20	23	21	25%	8%
2006	-	33	18	-	4	28	25	24	25	25	50%	7%
2006	-	34	17	-	4	28	27	28	29	28	50%	3%
2006	-	35	16	-	1	23	20	19	18	20	25%	11%
2006	-	36	21	-	1	31	32	31	32	31	50%	2%
2006	-	37	17	-	6	29	25	24	27	26	0%	8%
2006	-	38	16,5	-	1	20	20	19	19	20	50%	3%
2006	-	39	17,5	-	3	30	27	26	29	28	0%	7%
2006	-	40	14	-	6	31	28	26	30	29	0%	8%
					Total read	40	40	40	40		38,1%	7,0%
					Total NOT read	0	0	0	0			

Table 5.2: The number of age readings, the coefficient of variation (CV), the percent agreement and the RELATIVE bias are presented by MODAL age for each age reader and for all readers combined. A weighted mean CV and a weighted mean percent agreement are given by reader and all readers combined. The CV's by MODAL age for each individual age reader and all readers combined indicate the precision in age reading by MODAL age. The weighted mean CV's over all MODAL age groups combined indicate the precision in age reading by reader and for all age readers combined.

Number of age readings

MODAL age	Spain ER Reader 1	France WL Reader 2	France RE Reader 3	France JLD Reader 4	TOTAL
0	-	-	-	-	-
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-	-	-	-	-
10	-	-	-	-	-
11	-	-	-	-	-
12	-	-	-	-	-
13	-	-	-	-	-
14	-	-	-	-	-
15	-	-	-	-	-
16	-	-	-	-	-
17	-	-	-	-	-
18	-	-	-	-	-
19	-	-	-	-	-
20	3	3	3	3	12
21	1	1	1	1	4
22	4	4	4	4	16
23	2	2	2	2	8
24	5	5	5	5	20
25	10	10	10	10	40
26	1	1	1	1	4
27	2	2	2	2	8
28	4	4	4	4	16
29	2	2	2	2	8
30	1	1	1	1	4
31	3	3	3	3	12
32	-	-	-	-	-
34	-	-	-	-	-
35	-	-	-	-	-
36	-	-	-	-	-
37	-	-	-	-	-
38	-	-	-	-	-
39	-	-	-	-	-
40	1	1	1	1	4
41	-	-	-	-	-
42	1	1	1	1	4
43	-	-	-	-	-
44	-	-	-	-	-
45	-	-	-	-	-
46	-	-	-	-	-
0-46	40	40	40	40	160

Coefficient of variation (CV)

MODAL age	Spain ER Reader 1	France WL Reader 2	France RE Reader 3	France JLD Reader 4	ALL Readers
0	-	-	-	-	**-**
1	-	-	-	-	**-**
2	-	-	-	-	**-**
3	-	-	-	-	**-**
4	-	-	-	-	**-**
5	-	-	-	-	**-**
6	-	-	-	-	**-**
7	-	-	-	-	**-**
8	-	-	-	-	**-**
9	-	-	-	-	**-**
10	-	-	-	-	**-**
11	-	-	-	-	**-**
12	-	-	-	-	**-**
13	-	-	-	-	**-**
14	-	-	-	-	**-**
15	-	-	-	-	**-**
16	-	-	-	-	**-**
17	-	-	-	-	**-**
18	-	-	-	-	**-**
19	-	-	-	-	**-**
20	8%	6%	3%	5%	**6,6%**
21	-	-	-	-	**-**
22	13%	0%	6%	6%	**8,8%**
23	0%	0%	6%	3%	**5,6%**
24	5%	5%	4%	4%	**7,9%**
25	5%	8%	8%	4%	**7,1%**
26	-	-	-	-	**-**
27	0%	18%	3%	0%	**10,4%**
28	3%	4%	7%	2%	**5,5%**
29	2%	0%	8%	2%	**5,3%**
30	-	-	-	-	**-**
31	3%	3%	11%	2%	**5,8%**
32	-	-	-	-	**-**
33	-	-	-	-	-
34	-	-	-	-	-
35	-	-	-	-	-
36	-	-	-	-	-
37	-	-	-	-	-
38	-	-	-	-	-
39	-	-	-	-	-
40	-	-	-	-	3%
41	-	-	-	-	-
42	-	-	-	-	7%
43	-	-	-	-	-
44	-	-	-	-	**-**
45	-	-	-	-	**-**
46	-	-	-	-	**-**
0-46	**4,5%**	**4,7%**	**5,5%**	**3,0%**	**6,5%**
RANKING	**2**	**3**	**4**	**1**	

Percentage agreement

MODAL age	Spain ER Reader 1	France WL Reader 2	France RE Reader 3	France JLD Reader 4	ALL
0	-	-	-	-	-
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-	-	-	-	-
10	-	-	-	-	-
11	-	-	-	-	-
12	-	-	-	-	-
13	-	-	-	-	-
14	-	-	-	-	-
15	-	-	-	-	-
16	-	-	-	-	-
17	-	-	-	-	-
18	-	-	-	-	-
19	-	-	-	-	-
20	67%	67%	0%	33%	**42%**
21	100%	0%	0%	0%	**25%**
22	25%	100%	25%	0%	**38%**
23	100%	0%	50%	0%	**38%**
24	20%	40%	0%	60%	**30%**
25	70%	50%	20%	50%	**48%**
26	0%	0%	0%	0%	**0%**
27	100%	0%	0%	100%	**50%**
28	50%	0%	25%	50%	**31%**
29	0%	0%	50%	50%	**25%**
30	0%	100%	0%	100%	**50%**
31	33%	33%	33%	33%	**33%**
32	-	-	-	-	-
33	-	-	-	-	-
34	-	-	-	-	-
35	-	-	-	-	-
36	-	-	-	-	-
37	-	-	-	-	-
38	-	-	-	-	-
39	-	-	-	-	-
40	0%	0%	100%	100%	**50%**
41	-	-	-	-	-
42	100%	0%	0%	100%	**50%**
43	-	-	-	-	-
44	-	-	-	-	-
45	-	-	-	-	-
46	-	-	-	-	-
0-46	**50,00%**	**37,50%**	**20,00%**	**45,00%**	**38,13%**
RANKING	**3**	**2**	**4**	**1**	

Relative bias

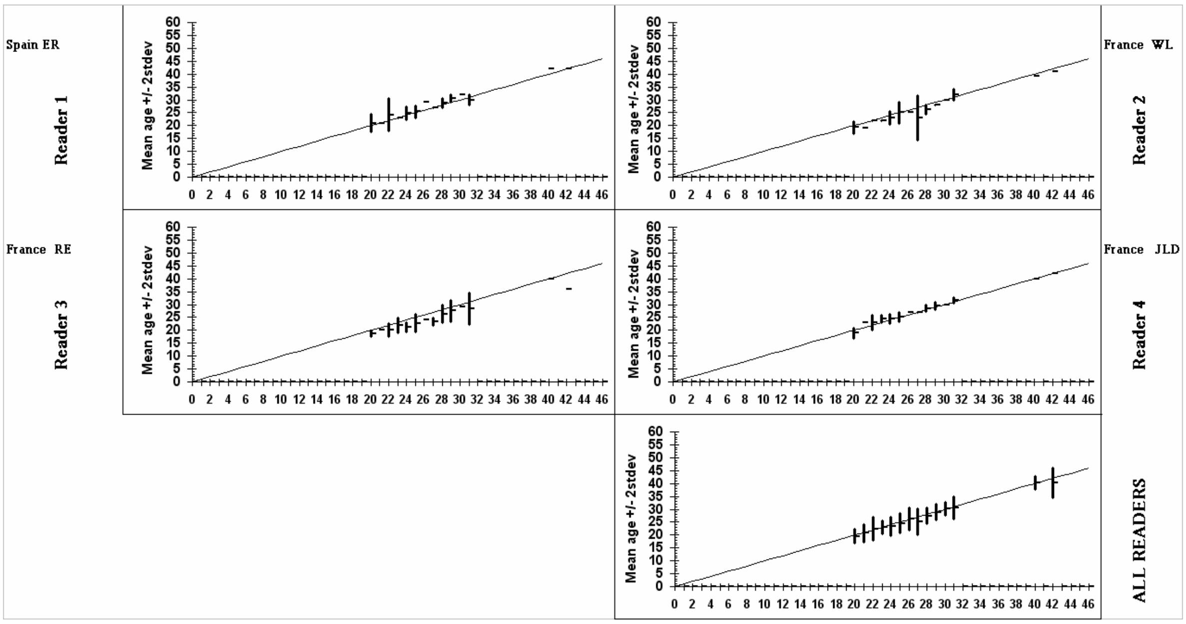
MODAL age	Spain ER Reader 1	France WL Reader 2	France RE Reader 3	France JLD Reader 4	ALL
0	-	-	-	-	-
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-	-	-	-	-
10	-	-	-	-	-
11	-	-	-	-	-
12	-	-	-	-	-
13	-	-	-	-	-
14	-	-	-	-	-
15	-	-	-	-	-
16	-	-	-	-	-
17	-	-	-	-	-
18	-	-	-	-	-
19	-	-	-	-	-
20	1	-1	-1	-1	-1
21	0	-2	-1	2	0
22	2	0	-2	1	0
23	0	-1	-1	2	0
24	1	-1	-3	1	-1
25	0	0	-2	0	0
26	3	-1	-2	1	0
27	0	-4	-4	0	-2
28	1	-2	-2	1	-1
29	2	-1	-2	1	0
30	2	0	-1	0	0
31	-1	1	-3	1	-1
32	-	-	-	-	-
33	-	-	-	-	-
34	-	-	-	-	-
35	-	-	-	-	-
36	-	-	-	-	-
37	-	-	-	-	-
38	-	-	-	-	-
39	-	-	-	-	-
40	2	-1	0	0	0
41	-	-	-	-	-
42	0	-1	-6	0	-2
43	-	-	-	-	-
44	-	-	-	-	-
45	-	-	-	-	-
46	-	-	-	-	-
0-46	**0,75**	**-0,70**	**-2,13**	**0,43**	**-0,87**
RANKING	**3**	**2**	**4**	**1**	

Overall ranking

	Spain ER Reader 1	France WL Reader 2	France RE Reader 3	France JLD Reader 4
Ranking Coefficient of Variation	2	3	4	1
Ranking Percentage Agreement	3	2	4	1
Ranking Relative bias	3	2	4	1
OVERALL RANKING	**3**	**2**	**4**	**1**
Mean Ranking	2,67	2,33	4,00	1,00
absolute value of the bias	0,75	0,70	2,13	0,43

Table 5.3: The minimal requirement for age reading consistency is the absence of bias among readers and through time. The hypothesis of an absence of bias between two readers or between a reader and the modal age estimates can be tested non-parametrically with a one-sample Wilcoxon signed rank test. This table shows inter-reader bias test and reader against modal age bias test (- : no sign of bias (p>0.05); *: possibility of bias (0.01<p<0.05); **: certainty of bias (p<0.01)).

	Spain ER Reader 1	France WL Reader 2	France RE Reader 3	France JLD Reader 4
Reader 1				
Reader 2	**			
Reader 3	**	**		
Reader 4	–	**	**	
MODAL	**	**	**	*



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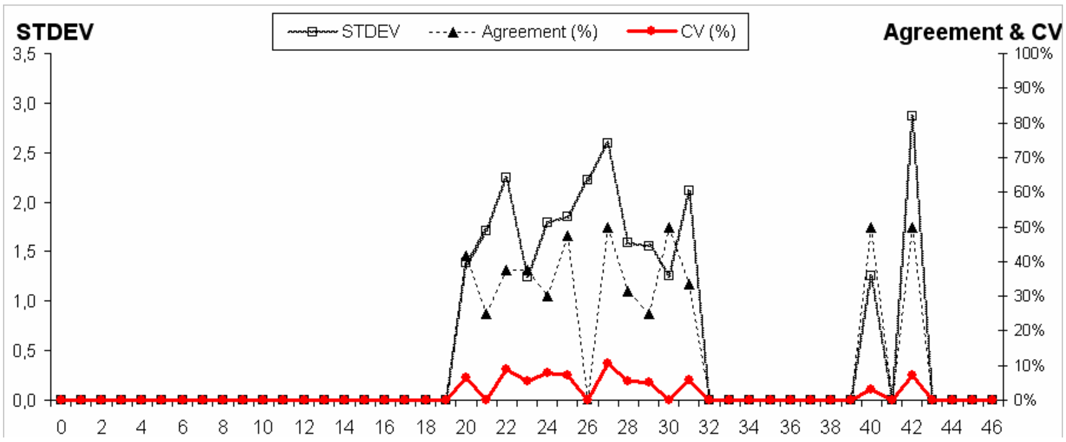

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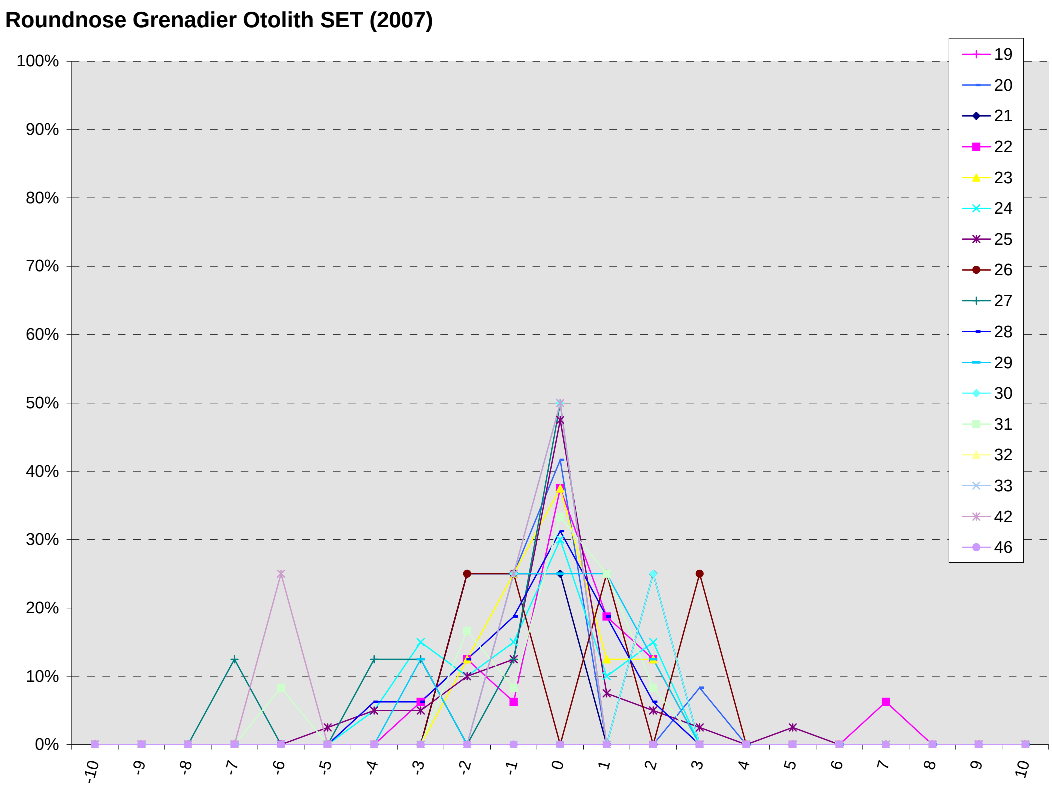

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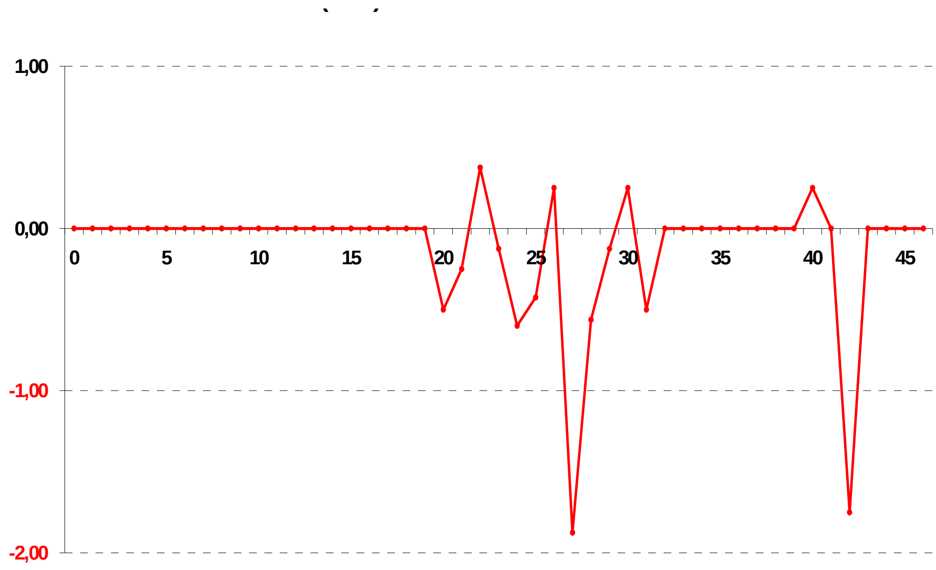

Figure 5.4: The RELATIVE bias by MODAL age as estimated by all age readers combined.