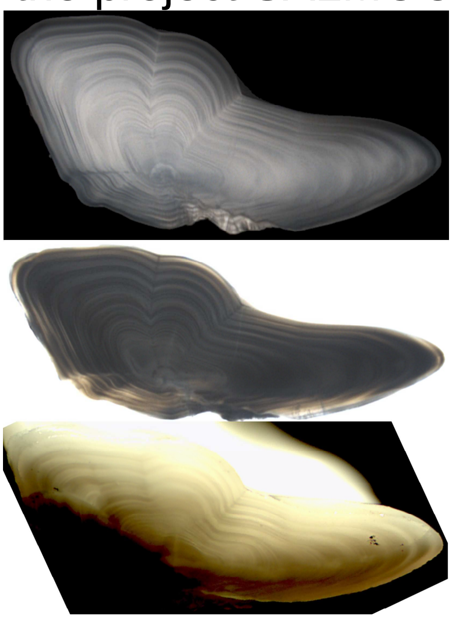
Kélig Mahé, Ifremer, Ressources Halieutiques, Boulogne sur mer
Philippe Schwab, Institut Maurice Lamontagne
Charlie Hiscock, Northwest Atlantic, Fisheries Center, St John's
Gus Cossitt, Northwest Atlantic, Fisheries Center, St John's
Daniel Briand, Ifremer, Ressources Halieutiques, Saint Pierre et Miquelon
Herlé Goraguer, Ifremer, Ressources Halieutiques, Saint Pierre et Miquelon

2012

Age determination of Atlantic cod (*Gadus morhua*): 2012 Workshop between Canada and France on cod otoliths

Final report of the project SALMOCODAGE



Financed by
the French Ministry of the Overseas and the territorial Council of Saint Pierre et Miquelon

Age determination of Atlantic cod (*Gadus morhua*): 2012 Workshop between Canada and France on cod otoliths

Rapport final du contrat SALMOCODAGE
Ministère Français de l'Outre-Mer

Ifremer

septembre 2012

Abstract

France and Canada have been working closely together for numerous years under the governance of The Northwest Atlantic Fisheries Organisation (NAFO) that regulates fisheries in the Northwest Atlantic. This workshop was the first step to achieve greater agreement in the estimation of age from calcified pieces between the scientific experts from those 2 countries. The goal of this project is to realize a calibration of the estimation of ages from cod (*Gadus morhua*) between France and Canada in order to optimize the precision of the data supplied by those countries for stock assessment purposes. There has been in the past an internal workshop for Atlantic Canada in 1997 on ageing fish and numerous workshops for Northeast Atlantic, more precisely for the Baltic and North sea under the governance of the International Council for the Exploration of the Sea (ICES).

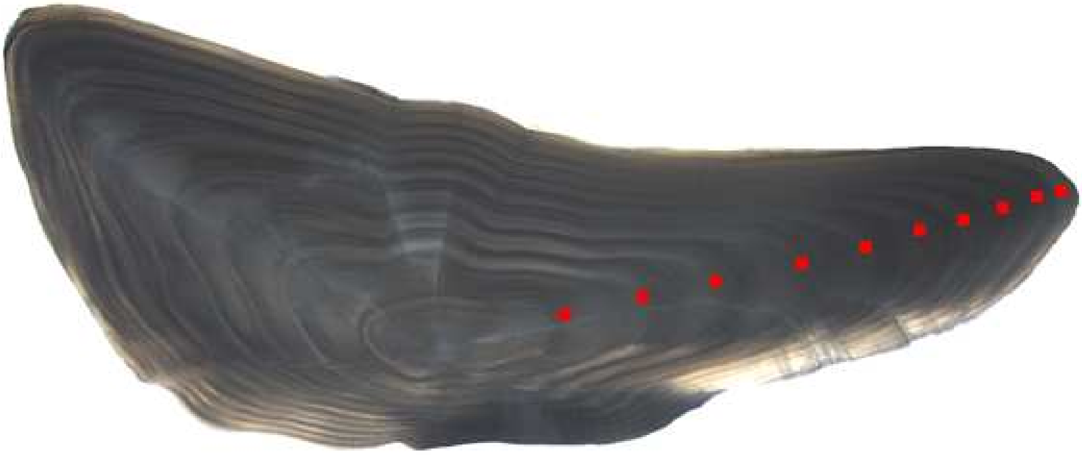
This workshop has been organized in St-Pierre et Miquelon from 10 to 14 September 2012 and regrouped 6 scientists from IFREMER (France) and the Department of Fisheries and Oceans (DFO). This meeting was subsidized by the Ministry of Overseas (France) and the Territorial Council of St-Pierre et Miquelon. Prior to this workshop a sample of 451 otoliths and otolith images has been interpreted independently by 3 French and 3 Canadian readers. The sample consisted of 2 samples from the 3Ps NAFO area (Research survey and commercial) and 1 sample from the 3Pn, 4RS NAFO area (from various sources). Two different methods were used to age the otoliths, one using images from sliced otoliths (France) and one using broken (or cut) otoliths (Canada). Both methods used transmitted light.

Results from the different sets of calcified pieces showed some differences. The set of cod otoliths from research vessel in 3Ps presented the higher percentage agreement (83%). Of the 236 otoliths, 112 were read with 100% agreement (47.5%). Modal age of these fish was comprised between 1 and 13 years with the mean at 4 years. The second set with high percent agreement was composed by cod otoliths from commercial vessels of the same area (3Ps) (71.7%). Of the 115 otoliths, 24 were read with 100% percentage agreement (21%). These fish were older than those from the research vessel. The mean modal age was 6 years (range from 4 to 11). The other set of cod otoliths showed a percentage agreement of 69%. This set was composed of fish both commercial and research vessels from the 3Pn, 4RS area. Of the 100 otoliths, only 7 were read with 100% percentage agreement (7%). Difference in precision could be due to the number of readers (8 for set 3 and only 4 for set 1), the composition of the samples (set 1 was composed of fish younger than other sets) and also of the sampling area.

During this workshop it has been be noted that there was certainty of bias among readings from the 3 sets of cod otoliths. Moreover, there is certainty of bias between 2 readings from different methods from the same reader (example: readers 1 and 2 of the set from commercial and research vessels coming from the 3Pn, 4RS areas). The position of the first ring was identified as an important source of bias. Some measurements were taken on otolith images with 100% agreement from TNPC software in order to determine distances between *nucleus* and the settling check, and also from the *nucleus* to the two first growth rings. Distance analysis will provide tools to identify mismatches between readings and/or readers. The second important source of bias was the difference in the edge interpretation during July and August. When Canadian readers identify the edge with small opaque zone (which is not continuous around the edge), then

the last translucent ring is considered as growth ring. In contrary, for the French readers, it is not a growth ring. Ages assigned by the Canadian personnel are generally one year greater than those of participants from France for those months.

Therefore, in order to reduce those biases, a guideline on reading methods was presented and a database of reference otolith images was started (where 100% agreement was reached).



3Pn, 4RS cod otolith, 65 cm, October 2011, gillnet sentinel fishery.

This first Franco-Canadian meeting on age estimation has identified sources of biases and helped to reduce them. It also produced reference documents common to France and Canada for cod in the Northwest Atlantic. However some differences persist, mainly on the otoliths sampled in July and August and this could be part of future studies.

Introduction

Estimating the age of fish is one of the most important elements in the study of the population group dynamics. It provides the basis for the calculations necessary to know the growth, the mortality, the recruitment and other fundamental parameters of the fish population. Accurate determination of fish age leads to an improved quality of management advice.

During the first exchange between Canadians and French readers, differences were observed. In particular, ages assigned by Canadian personnel generally being one-year greater than those of participants from France (Healey *et al*., 2011).

In 2012, a new exchange of 451 cod otoliths with 3 sets from Northwest Atlantic Fisheries (3Pn, 4RS and 3Ps areas) was studied. During this workshop, the results of reading comparisons were presented to identify the sources of bias. Guidelines of age interpretation of cod otoliths from Northwest Atlantic Fisheries and reference collection of otoliths were begun.

This meeting was subsidized by the ministry of overseas in France and the Territorial Council of Saint-Pierre and Miquelon.

1. Preparation methods of cod otoliths

1.1. Canada, Northwest Atlantic Fisheries Centre in St.John's

At the Northwest Atlantic Fisheries Centre (NAFC) in St.John's, the otolith is scored and broken across the *sulcus acusticus* at the collum (Fig. 1).

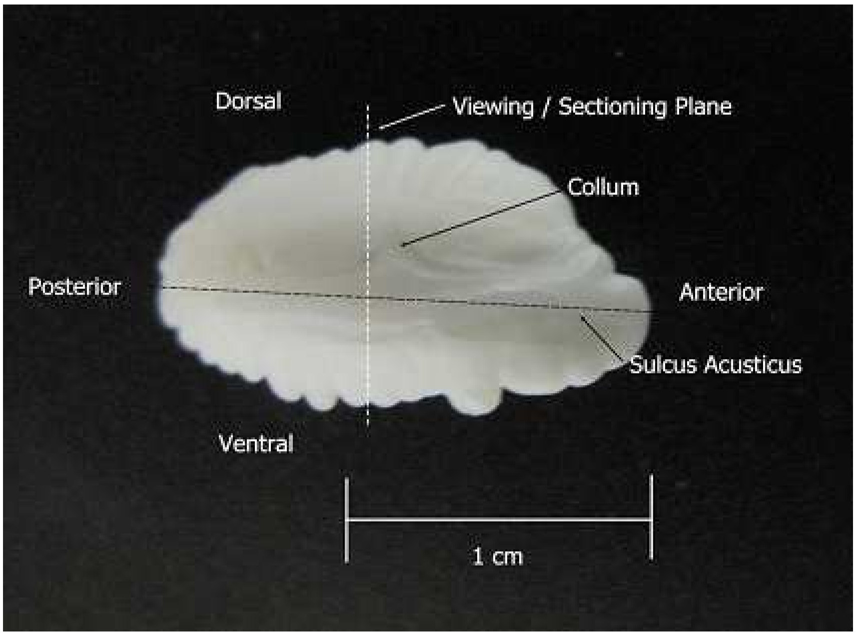


Figure 1: Sectioning plane of cod otolith applied in the Northwest Atlantic Fisheries Centre (NAFC) in St.John's (*In* Healey *et al*., 2011).

The otolith is viewed under transmitted light using Leica™ stereoscopic microscope at 12.5x magnification using either alcohol or Kodak™ Photo-Flo 200 solution, to change the refractive index of the otolith surface (i.e. reduce glare and increase visibility). The surface of the cut/broken otolith is shaded using a scalpel blade to ensure no reflected light from the transmitted light source obscures the view of the annuli. Occasionally the cut surface of the otolith is lightly sanded to provide a smooth viewing surface. Either the hyaline or opaque zones (under transmitted light) are used to determine age, according to reader preference.

1.2. Canada, Institut Maurice Lamontagne in Mont-Joli

The technique employed for preparation and viewing of the otoliths at DFO's Quebec lab is similar to that of NAFC, as the ageing knowledge was transferred from the St. John's lab to Mont-Joli lab in the mid-1980s.
The otolith is cut through the *nucleus* (using the collum as a landmark), perpendicular to the *sulcus acusticus* (Fig. 1), using an Isomet low speed saw with a high concentration diamond wafering blade. The surface is then sanded using the side of the wafering blade (Fig. 2).

Figure 2: Cutting the cod otolith in Maurice Lamontagne institute (Canada, *In* Schwab, 2012).

The longest part of the otolith is placed in modelling clay and then viewed under a Leica™ stereoscopic microscope at 15x magnification using fiber optic transmitted light. Alcohol is applied to the otolith surface to change the refractive index (i.e. reduce glare and increase visibility). The surface of the cut otolith is shaded using a pick to ensure no reflected light from the transmitted light source obscures the view of the annuli (Fig. 3).

Figure 3: Reading set-up at the Maurice Lamontagne institute (Canada, *In* Schwab, 2012).

1.3. France

The approach of the IFREMER institute in Boulogne sur Mer is to embed otoliths in polyester resin and then section these transversely at the otolith *nucleus* with a high speed saw (Brillant 250TM, ATM society; Fig. 4). For each otolith, 2 to 3 sections are created with an average thickness of 0.3 mm.

Figure 4: Inclusion of cod otoliths in resin and after they are cut by semi-automatic machine in Ifremer institute (France; *In* Mahé *et al*., 2009).

Age estimation is carried out with TNPC software, a program which has been developed within IFREMER. TNPC (Traitement Numérique des Pièces Calcifiées, www.tnpc.fr) computer-assisted age and growth estimation is used routinely for acquiring and interpreting the growth structures and their storage (Fig. 5).

Figure 5: Computer assisted system for estimating age and growth (*In* Mahé *et al*., 2009).

2. Samples

There are 3 samples from Northwest Atlantic Fisheries (NAFO, Fig. 6; Tab. 1) :

1. Commercial sample from 3Ps
2. Research vessel sample from 3Ps
3. Commercial and research vessel sample from 3Pn, 4RS

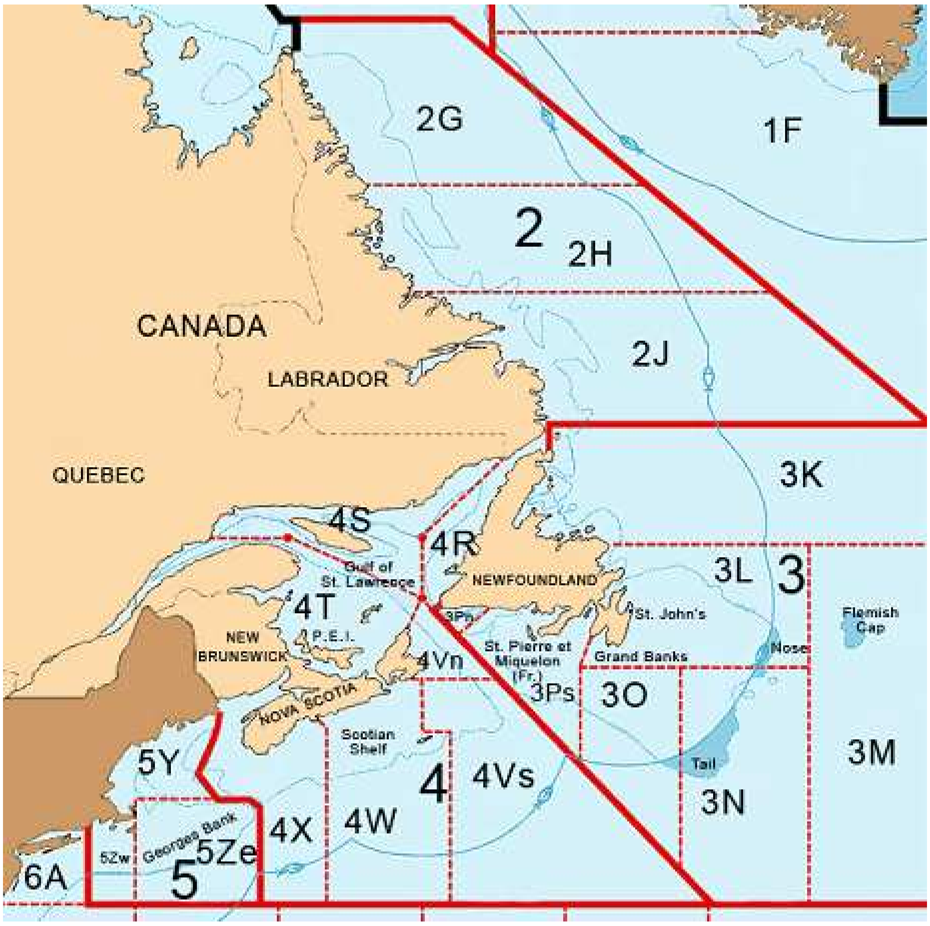


Figure 6: Map of Northwest Atlantic Fisheries Management Divisions.

Table 1: General information of the samplings.

Number of sample		1	2	3
Area of Catch		3Ps	3Ps	3Pn, 4RS
Sample		Research vessel	Commercial	Research vessel & Commercial
Month of catch		4, 5	1, 2, 3	4, 6, 7, 8, 9, 10
Number		236	115	100
Total length (mm)	Mean	38.69	69.89	57.65
	Standard Deviation	11.71	7.44	15.30

3. Results of reading

During these exchanges and workshop, the samples used were not validated, therefore the « true age » is not known. In this way, the work group evaluates the precision of age estimation between readers but not the accuracy (Secor *et al*., 1995; Panfili *et al*., 2002; ICES, 2007) (Fig. 7).

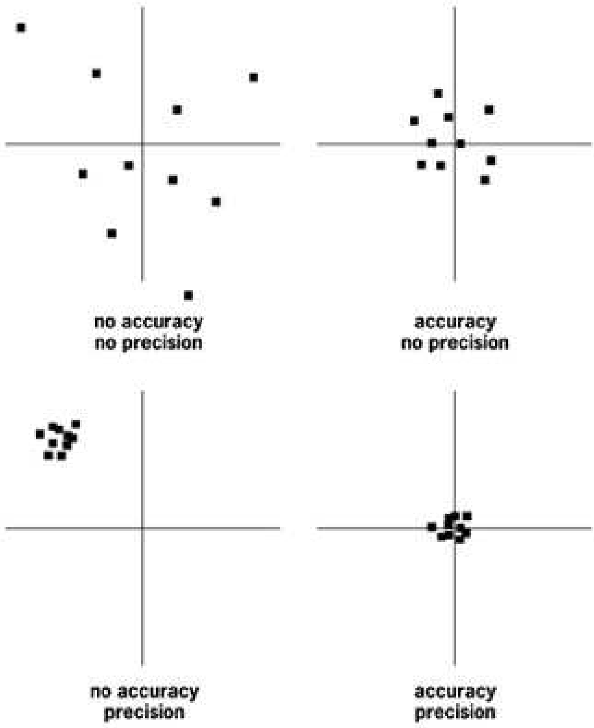


Figure 7: Accuracy[1] and precision[2] in the sclerochronological studies. The age estimation results (black boxes) are marked in relation to the true age value (intersection of axes X and Y). The accuracy corresponds to the proximity to the real value whereas the precision corresponds to the proximity of repeated measures (*In* Panfili *et al*., 2002).

The spreadsheet (Eltink, 2000) was used 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, with percentage agreement, mean age and precision coefficient of variation defined as:

- 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).

[1] In 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, 2007).

[2] Precision is defined as the variability in the age readings. The precision's errors in age readings are better described by the coefficient of variation (CV) by age group. This measure of precision is independent of the closeness to the true age (ICES, 2007).

During the exchange in 2012, the readings were taken by 6 readers (Tab. 2).

Table 2: List of the readers participated to the cod exchange.

Name	Country	Institute
Philippe Schwab	Canada	Institut Maurice-Lamontagne
Charlie Hiscock Gus Cossitt	Canada	Fisheries and Oceans (St John's)
Jean Louis Dufour Jérôme Félix Romain Elleboode	France	Ifremer

3.1. Precision

Mean precision of age estimation for individual fish were percent agreement to modal age and Coefficient of Variation (CV) (Tab. 3). Results among sets of calcified pieces showed some differences. The set of cod otoliths from research vessel in 3Ps presented the higher percentage agreement (83% ; Tab. 3). On 236 otoliths, 112 were read with 100% agreement (47.5%) and thus a CV of 0%. Modal age of these fish was comprised between 1 and 13 years with the mean at 4 years. The second set with high percent agreement was composed of cod otoliths from commercial vessels of the same area (3Ps) (71.7% ; Tab. 3). On 115 otoliths, 24 were read with 100% percentage agreement (21%). These fish were older than those from the research vessel. The mean modal age was 6 years (range from 4 to 11).
The other set of cod otoliths showed a percentage agreement of 69%. This set was composed by fish both commercial and research vessels from 3Pn, 4RS areas. On 100 otoliths, only 7 were read with 100% percentage agreement (7%).
Difference in precision could be due to the number of readers (8 for set 3 and only 4 for set 1), the composition of the samples (set 1 was composed by fish younger than other sets) and also to the sampling area.

Table 3: Percent agreement and Coefficient of Variation (range) and number of readers for each set of cod images.

	1	2	3
Number of readers	4	5	8
% of Agreement	83 (50-100)	71.7 (40-100)	69 (38-100)
CV	7.8 (0-43)	8.2 (0-24)	7.9 (0-36)
Mean modal age	5	6	7

3.2. Relative bias (Accuracy)

The minimal requirement for age reading's consistency is 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 estimated 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 ($p<0.01$)).
The tables 4, 5 and 6 showed these analyses for the 3 sets of cod otoliths coming from different areas and from different vessels (commercial/research).

Table 4: Inter-reader bias test and reader against modal age bias test for the set from research vessels coming from 3Ps area.

	Reader 1	Reader 2	Reader 3	Reader 4
Reader 1				
Reader 3	**			
Reader 4	–	**		
Reader 4	–	**	*	
MODAL age	–	**	–	–

Table 5: Inter-reader bias test and reader against modal age bias test for the set from commercial vessels coming from 3Ps area.

	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5
Reader 1					
Reader 2	**				
Reader 3	**	**			
Reader 4	**	**	**		
Reader 5	**	**	**	*	
MODAL age	–	**	*	**	**

Table 6: Inter-reader bias test and reader against modal age bias test for the set from commercial and research vessels coming from 3Pn, 4RS areas.

	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 7	Reader 8
Reader 1								
Reader 2	–							
Reader 3	**	**						
Reader 4	**	**	–					
Reader 5	**	**	**	**				
Reader 6	–	–	**	**	**			
Reader 7	*	–	**	**	**	–		
Reader 8	**	**	**	**	**	**	**	
MODAL age	**	**	**	**	**	**	**	**

It should be noted that there was certainty of bias among readings from 3 sets of cod otoliths. Moreover, there is certainty of bias between 2 readings from different methods from the same reader (exemple: readers 1 and 2 of the set from commercial and research vessels coming from the 3Pn, 4RS area).

4. Sources of bias

4.1. Position of the first ring

During this workshop, the position of the first ring was identified as an important source of bias. Measurements were taken only on otolith images with 100% agreement from TNPC software, in order to determine distances between *nucleus* and the settling check, and also from the *nucleus* to the two first growth rings on both axes (Fig. 8).

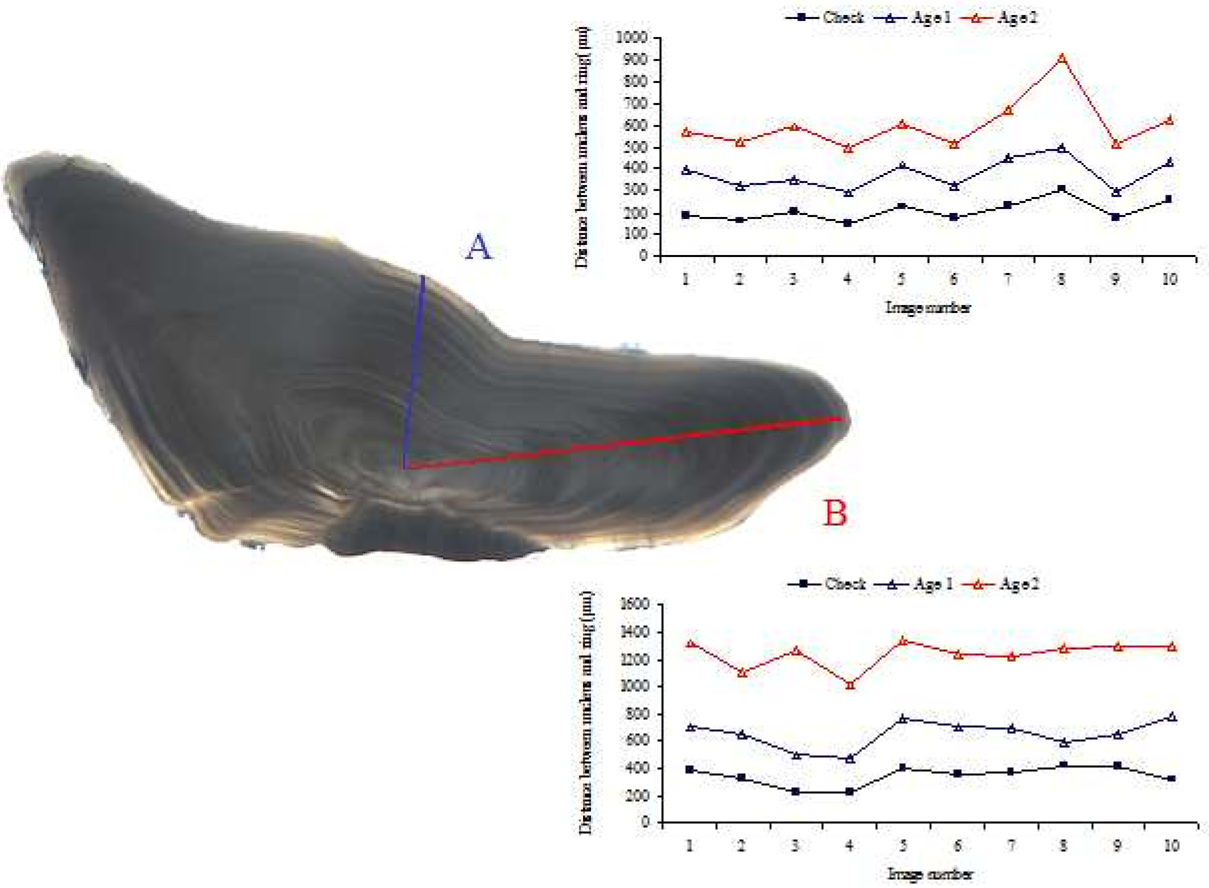


Figure 8: Measurements taken on the 2 principal axes of readings with 100% of agreement from TNPC software. Otolith from 3Pn, 4RS cod.

The check is not observed on all otoliths. It is distinguished by its shape, different from the growth rings (Fig. 9). Its distance from the *nucleus* is shorter on average than the distance from the *nucleus* to the first growth ring (Fig. 8 & 9). Distance analysis will provide tools to identify mismatches between readings and/or readers.

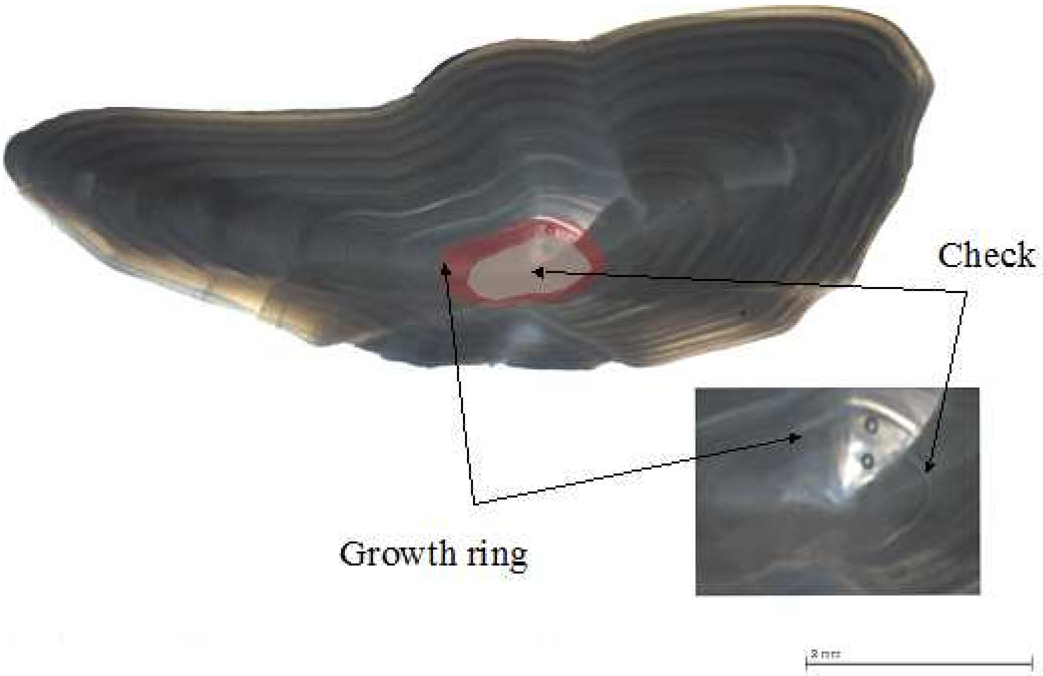


Figure 9: Difference between check and the first growth ring on the cod otolith.

4.2. Edge interpretation during July and August

Differences of edge interpretation were observed only during July and August (Fig. 10 & 11). When Canadian readers identified the edge with a small opaque zone, which is not continous around the edge, the last translucent ring is considered as a growth ring (Fig. 10). In contrast, for the French readers, it is not a growth ring according to the approach shown in figure 11. Ages assigned by Canadian personnel are generally being one-year greater than those of participants from France (Fig. 12).

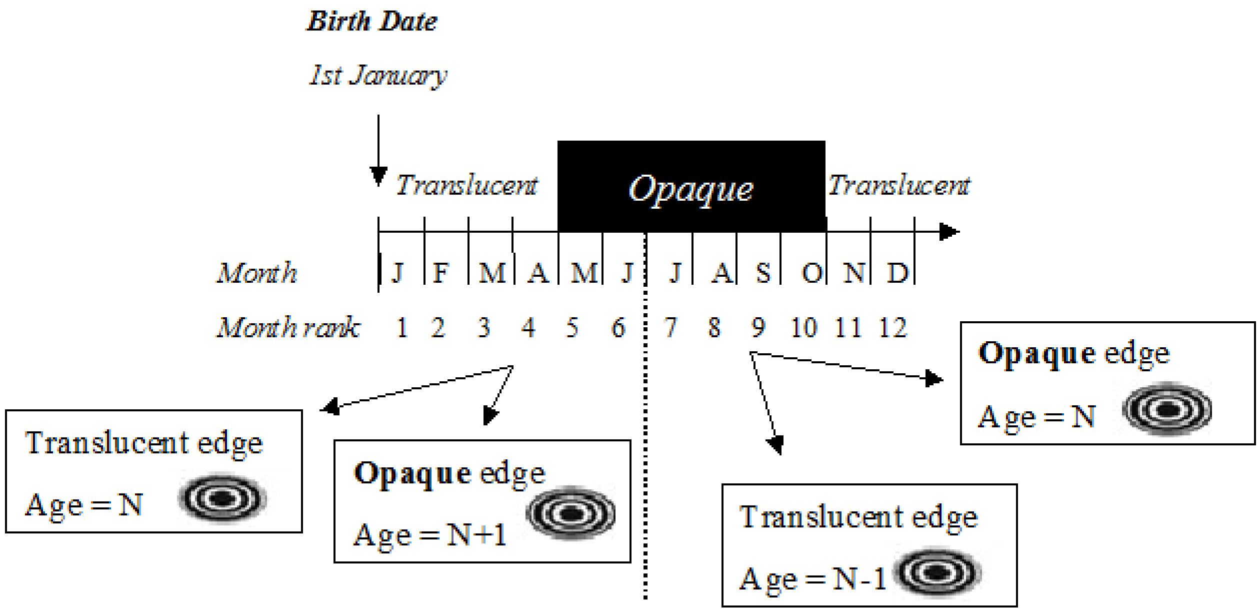


Figure 10: Approach of French readers (From Morales-Nin and Panfili, 2002 ; Mahé *et al.,* 2009) from otolith readings. N is the number of translucent areas. Conventionally, the birth date is fixed at the January 1st for all individuals (Williams and Bedford, 1974).

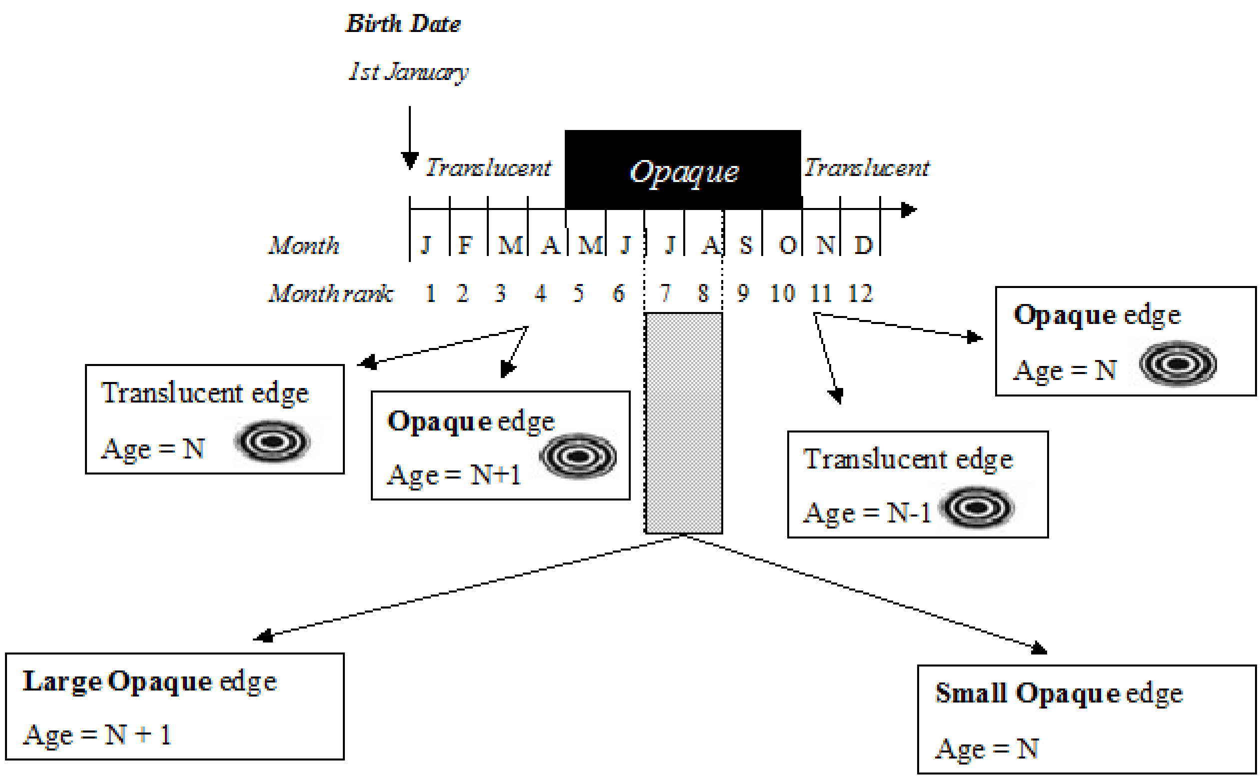


Figure 11: Approach of Canadian readers from otolith readings (From Beanlands, 1997). N is the number of translucent areas. Conventionally, the birth date is fixed at the January 1st for all individuals (Williams and Bedford, 1974).

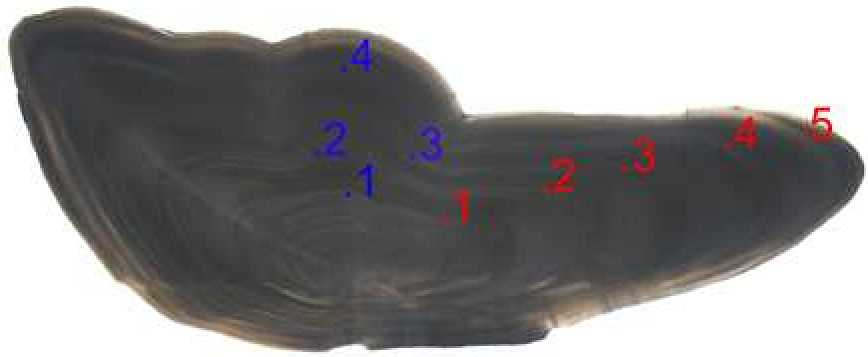


Figure 12: Cod otolith from 3Ps caught on July 23 with the French reading (blue points) and the Canadian reading (red points).

4.3. Other bias

The presence of a check before the first growth ring and the edge interpretation during July and August were the most common biases in interpretation of cod otoliths in the Northwestern Atlantic. However, there are other biases less important :

- The French and Canadian methods of interpreting the otoliths are different and each reader has more difficulty reading the otolith with the other preparation. Also, for the same reader, there is a bias between readings from the 2 preparations.
- It is important to know the biological information and the area of fisheries. By measuring the distances between the *nucleus* and the first two growth rings of otoliths from the 3Pn, 4RS area and from the 3Ps area (Tab. 7), there are differences of otolith growth due to a different somatic growth. They are 2 close stocks but their growth is different.

Table 7: Distance (mean±SD ; µm) between *nucleus* and growth rings on the large and the small axes on the otolith from different fisheries areas (3Pn, 4RS and 3Ps).

		3Pn, 4RS	3Ps	3Pn, 4RS	3Ps
		Growth ring 1		Growth ring 2	
Large axis	Mean	648	1002	1236	1978
	SD	102	188	104	316
Small axis	Mean	377	455	601	781
	SD	72	81	121	114

- In some images, there are split growth rings formed in the opaque zone (Fig. 13). This problem can cause overestimation of age.

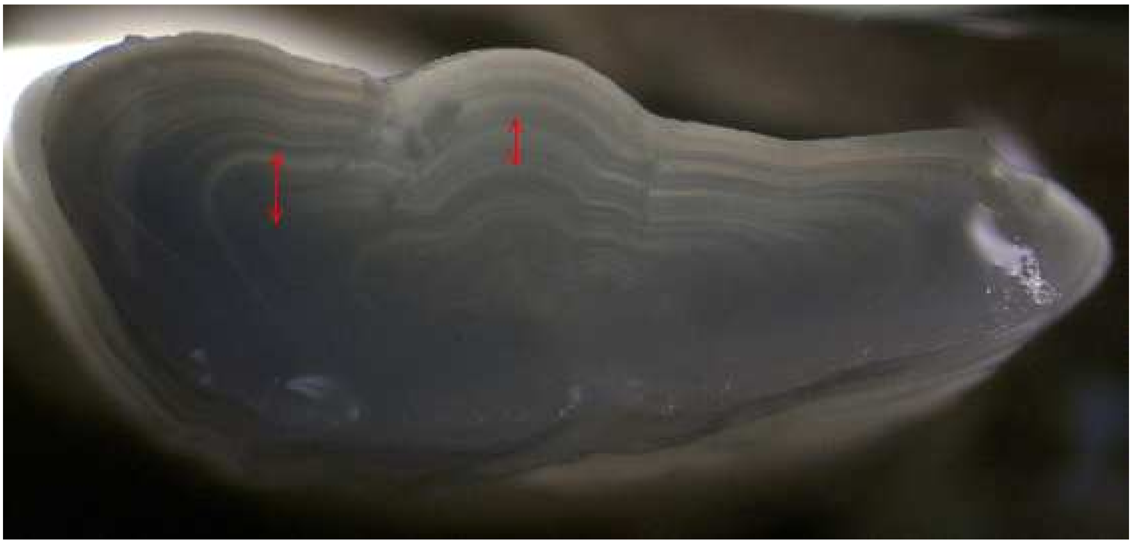


Figure 13: Cod otolith from 3Ps which shows a split in the growth ring (red arrow).

5. Guidelines for age interpretation

- The purpose for determining the age of a fish sample is to understand the age structure of that stock. The yearly growth is represented by an annulus consisting of one opaque and one translucent (hyaline) zone (see Terminology for ageing, Fig. 14).

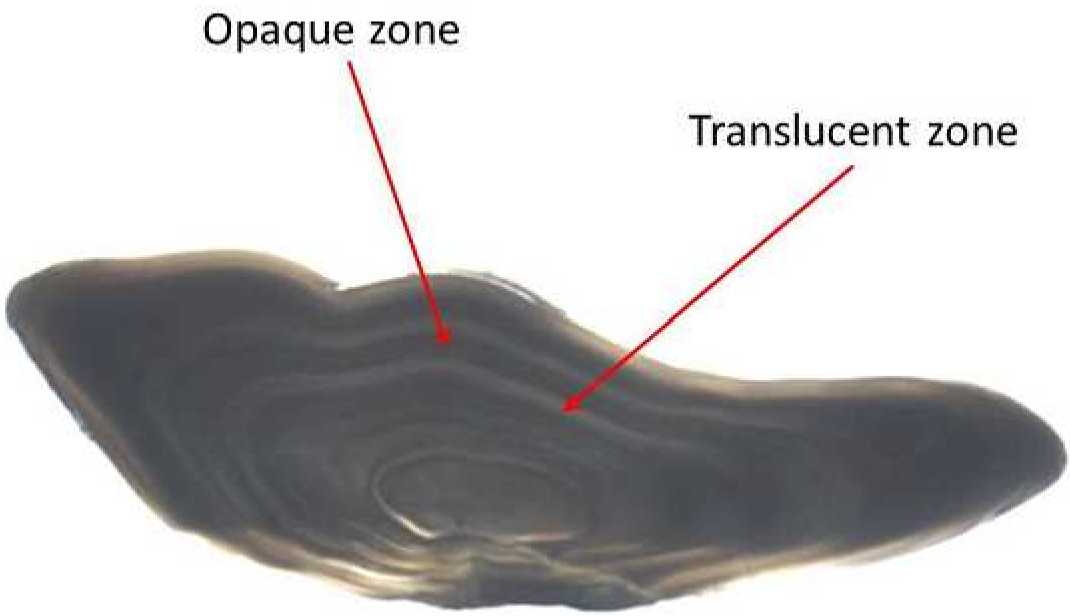


Figure 14 Cod otolith showing opaque and translucent zones.

- The readers used three different methods for cutting and mounting the otoliths for ageing. Each method proved to be equally valid and allowed for a good view of the annuli. It is important for each reader to use the standard procedures as outlined by the working group in his or her laboratory.

- The date of capture must be known in order to successfully interpret the edge. For assessment purposes, January 1st is considered as the birthdate, so a year is added for fish caught from January 1st to the period in the spring or summer when the opaque ring begins to show.

- It is important that the microscope magnification be standardized within a lab to avoid the introduction of a bias.

- When ageing, the convex side of the otolith faces away from the reader and transmitted light is used to count the hyaline zones. There are two prefered axes used to count the age. One axis runs straight up the middle and another out to the long axis. If both counts are the same then the age is considered reliable. If not then the reader may have to move the otolith around to find the best zone to read. This can be aided by manipulating the light and slightly changing the shading. The blind zone should be avoided as the annuli here are too closely packed and often there is physical damage due to the cut (Fig. 15) .

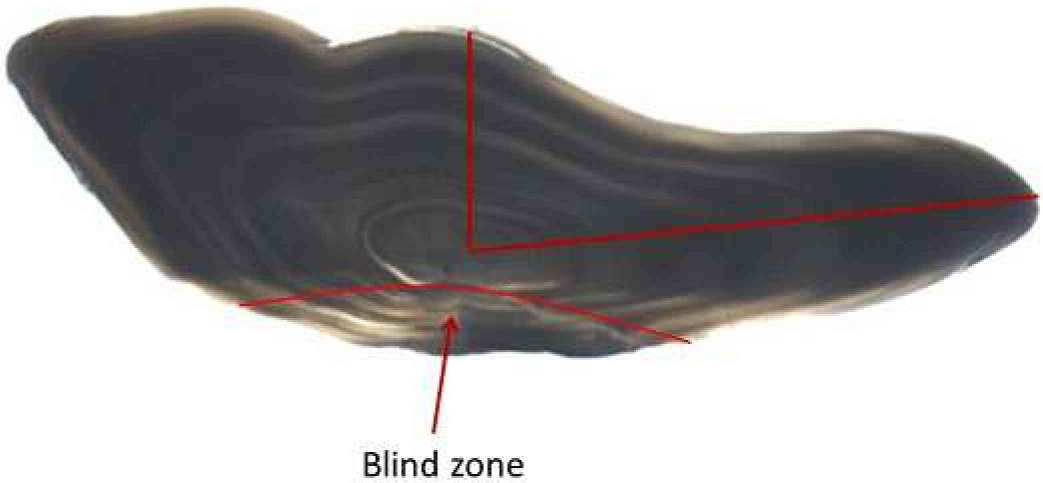
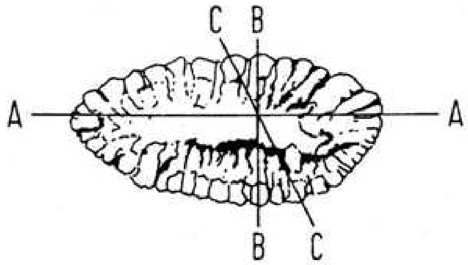
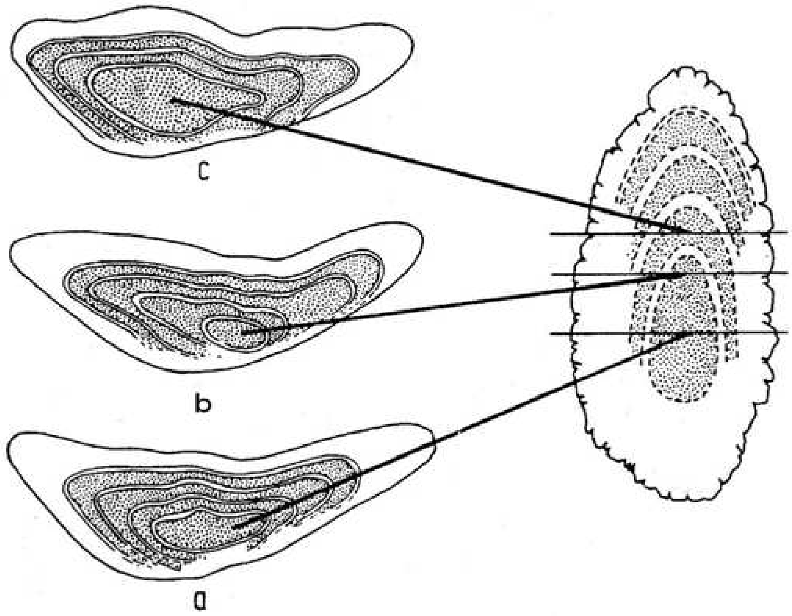


Figure 15: Cod otolith showing the 2 main axes for reading and the blind zone.

- Some otoliths prove to be very difficult to interpret and the age is reached with uncertainty. These otoliths should be discarded from the sample. Some otoliths are crystalized and these are also rejected from the sample. It is possible to use either the right or the left otolith. Only one otolith is cut unless it is unreadable, if so then the other one is cut and mounted. It is very important to ensure the otolith is cut through the *nucleus* to avoid misinterpretation of the age (Fig. 16).



Three possible sections through a cod otolith:
A-A longitudinal; B-B lateral; C-C diagonal.



The varying appearance of the ring structure of a cod otolith when broken.

(a) through the centre of the nucleus
(b) through one end of the nucleus
(c) missing the nucleus completely

Figure 16: The importance of cutting the otolith through the *nucleus* (Williams & Bedford, 1974).

- Most ageing labs have reference collections of otoliths and images from different exchanges and workshops. Readers should read selections of these samples after prolonged periods of reading inactivity.

- The interpretation of the first annulus can be made difficult by the presence of a check which may give the reader a false impression of a year inside the first true year’s growth. The shape of the check (settling ring) is usually atypical from the other annuli. It is more oval. The use of measurements on otoliths can be helpful in identifying the position of the settling check. Checks can be seen in later years but these can be easily spotted and rarely cause problems for experienced readers.

6. Terminology for ageing

This terminology was taken from various cod ageing workshops (Beanlands, 1997 ; ICES, 1994, 1997, 1999, 2000, 2004, 2005, 2006, 2008) :

Annual growth zone: one opaque and one hyaline zone constitute a typical growth zone.

Checks: Narrow hyaline zone that fonns within the opaque zone. These zones should not be included in the age estimation. More than one check per year may be formed, especially in the first opaque growth zone.

Edge of otolith (zone at the edge of otolith): Opaque or hyaline (narrow or wide) zone on the edge of otolith. The amount and type of growth on the edge is related to the life cycle of the fish.

Hyaline (translucent) zone: A growth zone that allows a better passage of light. On the surface of broken otoliths and slices under reflected light, the hyaline zone appears dark, in transmitted light it appears bright (light).

Nucleus**:** The hypothetical or real origin of the otolith; synonymous with focus or core.

Opaque zone: A growth zone that restricts the passage of light. On the surface of broken otoliths and slices under reflected light the opaque zone appears white, under transmitted light it appears dark. The opaque zones on otoliths of cod in the Eastern Baltic are formed in the period of intensive feeding.

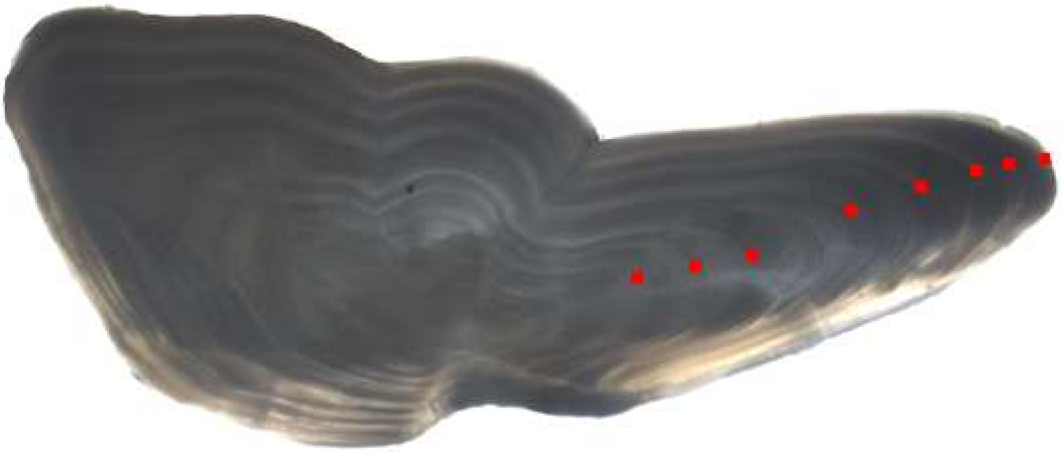
Transmitted light: Light that passes through the otolith, or from the side of a broken otolith if the surface is shadowed.

Sulcus acousticus: The groove passes on the inner surface of an otolith with a bend under the otolith center.

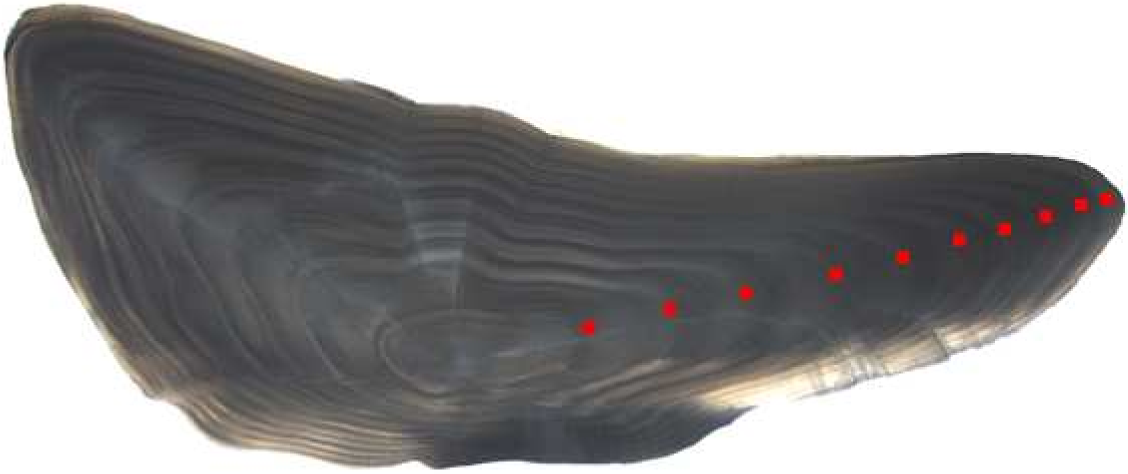
7. Reference collection of otoliths

7.1. Area 3Pn, 4RS

3Pn, 4RS cod otolith, 22 cm, August 2011, research survey.



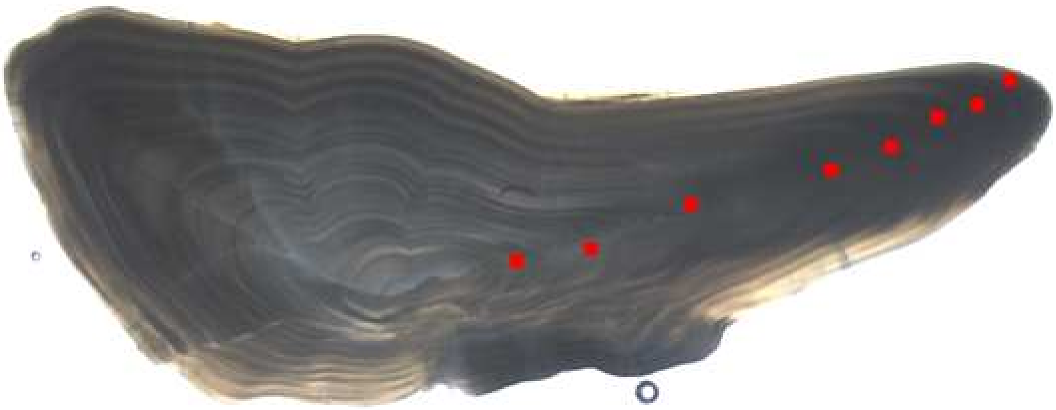
3Pn, 4RS cod otolith, 69 cm, April 2011, longline sentinel fishery.



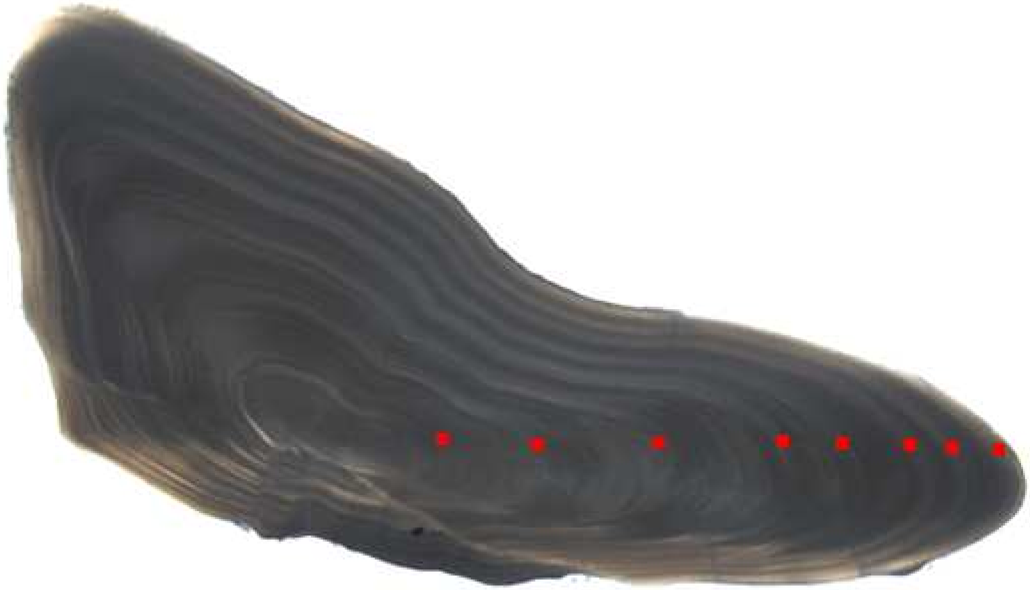
3Pn, 4RS cod otolith, 65 cm, October 2011, gillnet sentinel fishery.

3Pn, 4RS cod otolith, 49 cm, July 2011, sentinel otter trawl survey.

3Pn, 4RS cod otolith, 38 cm, July 2011, sentinel otter trawl survey.

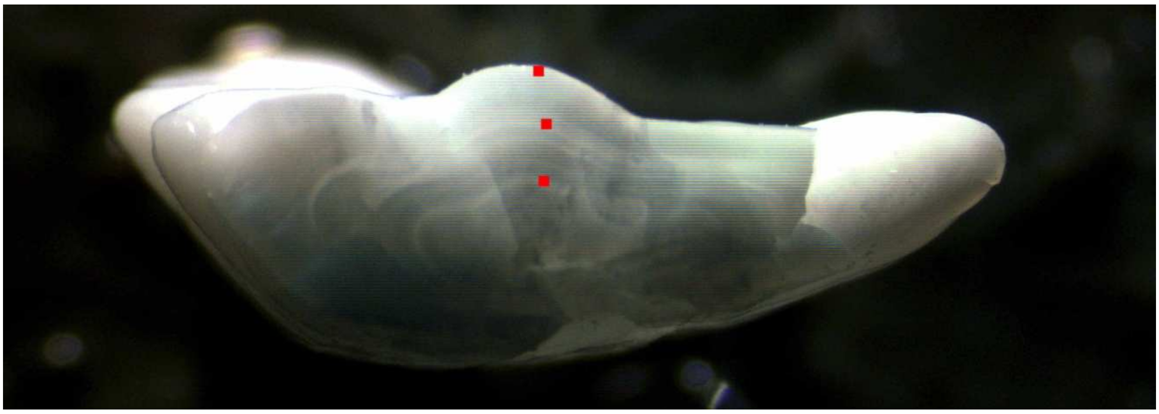


3Pn, 4RS cod otolith, 70 cm, July 2011, sentinel otter trawl survey.

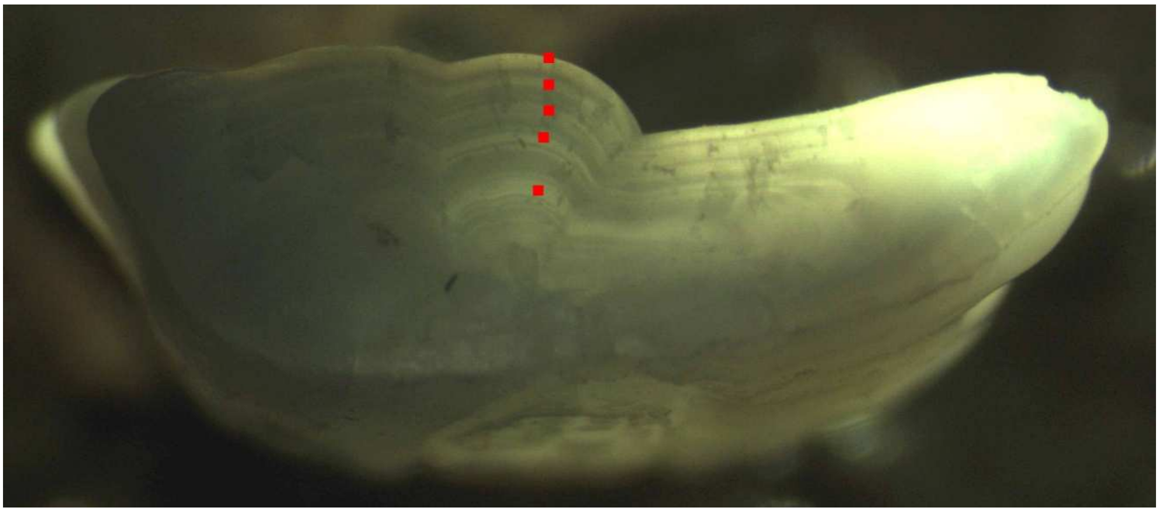


3Pn, 4RS cod otolith, 64 cm, July 2011, longline sentinel fishery.

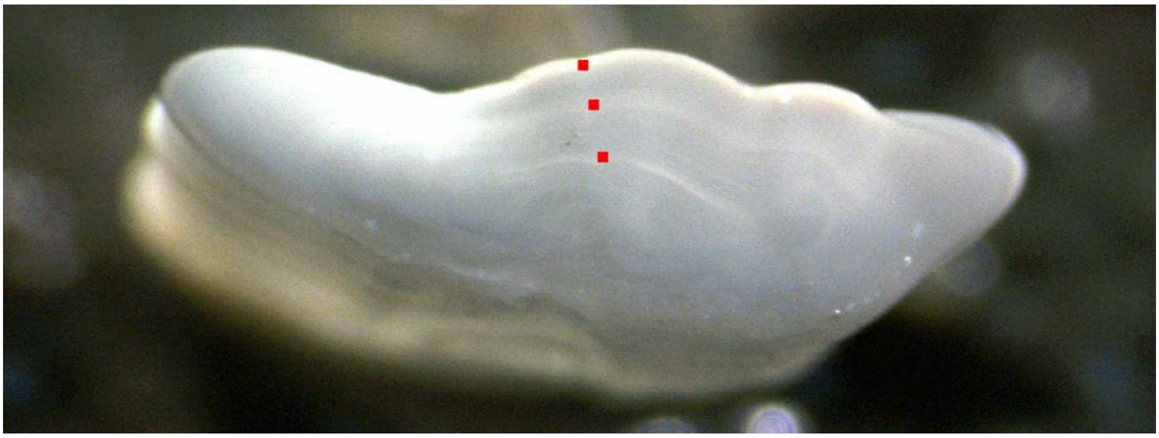
7.2. Area 3Ps



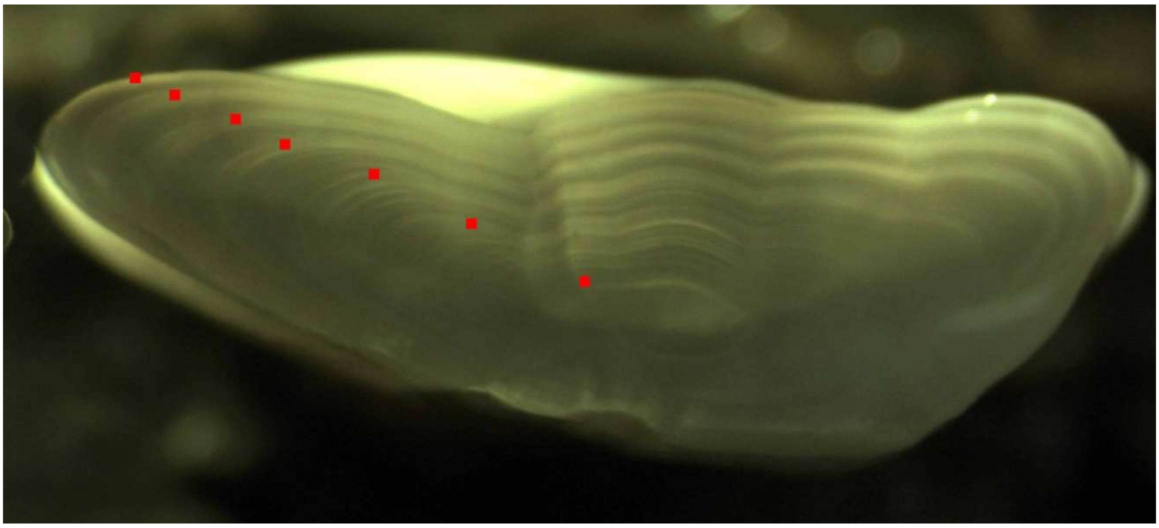
3Ps cod otolith, 34 cm, April 2011, research survey.



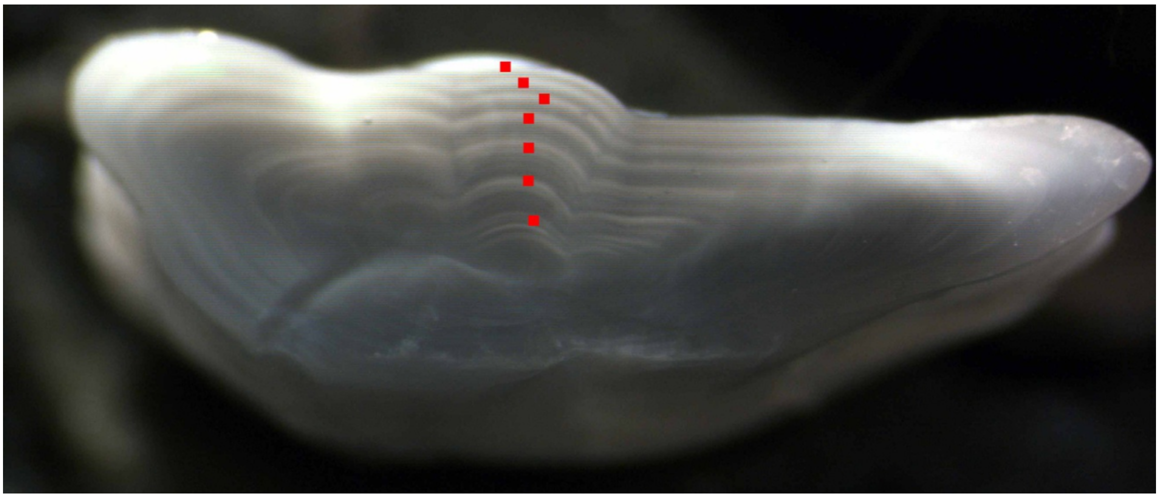
3Ps cod otolith, 39 cm, April 2011, research survey.



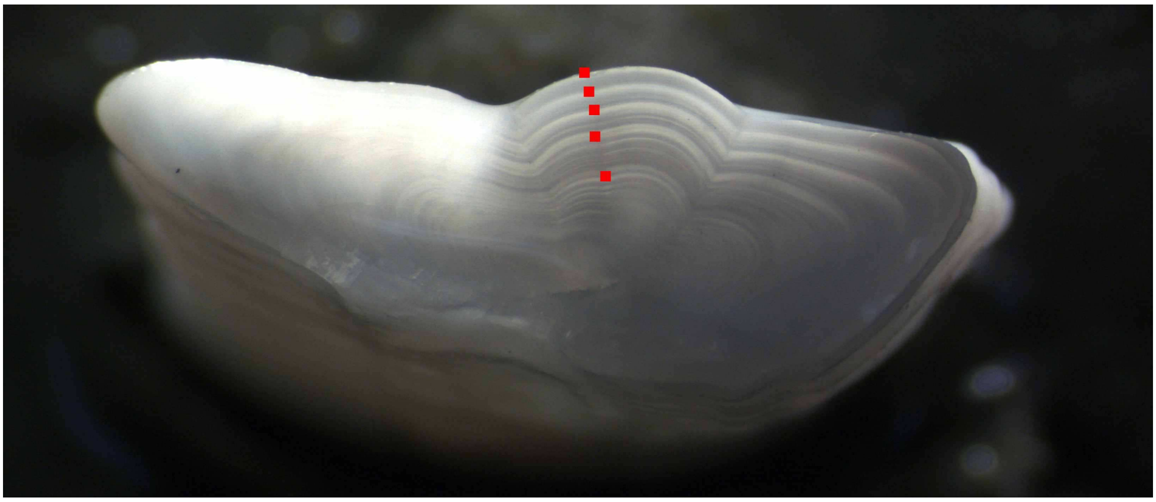
3Ps cod otolith, 32 cm, April 2011, research survey.



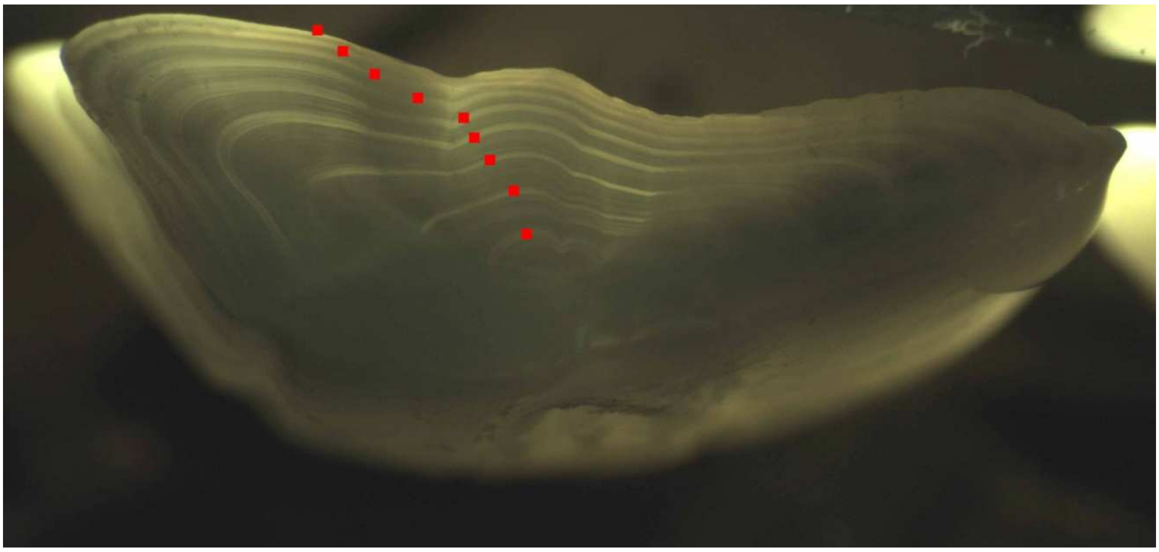
3Ps cod otolith, 54 cm, April 2011, research survey.



3Ps cod otolith, 55 cm, April 2011, research survey.



3Ps cod otolith, 46 cm, April 2011, research survey.



3Ps cod otolith, 69 cm, April 2011, research survey.

References

Beanlands, D., 1997. Inter-regional ageing workshop, Canadian Stock Assessment, Proceedings Series, 97/18, 72 p.

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

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

Healey, B.P., Mahé, K., Cossitt, G., Dufour, J.-L., Felix, J., Hicks, H.F., Hiscock, C. & Schwab, P., 2011. Age determination of Atlantic cod (*Gadus morhua*): Results from an otolith exchange between Canada and France. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/015. iv + 17 p.

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

ICES, 1994. Report of the Workshop on Baltic Cod Age Reading. ICES CM 1994/J:5.

ICES, 1997. Report of the Study Group on Baltic Cod Age Reading. Rostock, Germany, 7–11 October 1996. ICES CM 1997/J:1. 166p.

ICES, 1999. Report of the Study Group on Baltic Cod Age Reading. Charlottenlund, 16–20 November 1998. ICES CM 1999/H:4. 30 p.

ICES, 2000. Report of the Study Group on Baltic Cod Age Reading. Karlskrona, Sweden 27–31 March 2000. ICES CM 2000.H:01.

ICES, 2004. Report of the Study Group on Ageing Issues in Baltic Cod. 11–14 May 2004. Riga, Latvia. ICES CM 2004/ACFM:21 Ref. G, H. 39 p.

ICES, 2005. Report of the Study Group on Ageing Issues in Baltic Cod. 17–20 May 2005. Klaipeda, Lithuania. ICES CM 2005/ACFM:02 Ref. G, H.32 p.

ICES, 2006. Report of the Study Group on Ageing Issues of Baltic Cod (SGABC), 16–19 May 2006, Gdynia, Poland. ICES CM 2006/BCC:08. 45 pp.

ICES, 2008. Report of the Workshop on Age Reading of North Sea Cod (WKARNSC), 5-7 August 2008, Hirsthals, Denmark. ICES CM 2008/ACOM:39. 71 pp.

Mahé, K., Bellail, R., Dufour, J.-L., Boiron-Leroy, A., Dimeet, J., Duhamel, E., Elleboode, R., Felix, J., Grellier, P., Huet, J., Labastie, J., Le Roy, D., Lizaud, O., Manten, M.-L., Martin, S., Metral, L., Nedelec, D., Verin, Y. & Badts, V., 2009.

Synthèse française des procédures d'estimation d'âge / French summary of age estimation procedures. http://archimer.ifremer.fr/doc/00000/7294/

Panfili, J., Pontual, H.(de)., Troadec, H. & Wright, P.J. (eds.), 2002. Manuel de sclérochronologie des poissons. Coédition Ifremer-IRD, 464p.

Schwab, P., 2012. COD AGEING PROTOCOL : Department of Fisheries and Oceans Quebec Region, 3 p.

Williams, T. & Bedford B.C., 1974. The use of otoliths for age determination. In The ageing of fish (Bagenal, T.B., ed.) *In* : T.B. Bagenal (Eds.) Ageing of Fish. *Proceedings of an International Sympopsium. Old WorkingsSurreyEnglandUnwin Brothers*, 114-123.

Annex 1: List of participants

Name	Address	Phone/Fax	Email
Daniel Briand	27 rue de Paris BP 1518 Saint-Pierre 97500 Saint-Pierre et Miquelon France	(0)508412789	Daniel-briand@hotmail.fr
Philippe Schwab	Institut Maurice Lamontagne 850 Route de la Mer Mont-Joli, Québec Canada G5	(418) 775-0626	Philippe.Schwab@dfo-mpo.gc.ca
Charlie Hiscock	Northwest Atlantic Fisheries Center Box 5667 80 East White Hills Road St. John's, NL, A1C5X1 Canada	(709) 772-2061 Fax (709) 772-4105	Charlie.hiscock@dfo-mpo.gc.ca
Gus Cossitt	Northwest Atlantic Fisheries Center Box 5667 80 East White Hills Road St. John's, NL, A1C5X1 Canada	(709) 772-0564 Fax (709) 772-4105	Gus.Cossitt@dfo-mpo.gc.ca
Herlé Goraguer	IFREMER Quai de la L'Alysse BP 4240 97500 Saint Pierre et Miquelon France	Phone (0) 508413083	Herle.Goraguer@ifremer.fr
Kélig Mahé Chair	IFREMER Boulogne-sur-Mer Centre P.O. Box 699 F-62 321 Boulogne Cedex France	Phone +33 321 995602 Fax +33 321 995601	Kelig.Mahe@ifremer.fr

Annex 2: Agenda

Monday 10/09/12

09.00-10.30 : Introduction with the salmon ageing workshop : introduction, logistics, time schedule.
10.30-10.45 : coffee break
10.45-12.00 : Review the results of exchanges
12.00-13.30 : lunch
13.30-16.00 : Review the annotated images of the exchange
16.00-16.15 : coffee break
16.15-18.00 : Review the annotated images of the exchange

Tuesday 11/09/12

09.00-10.30 : Review the annotated images of the exchange
10.30-10.45 : coffee break
10.45-12.00 : Review the annotated images of the exchange
12.00-13.30 : lunch
13.30-16.00 : Review the annotated images of the exchange
16.00-16.15 : coffee break
16.15-18.00 : Review the annotated images of the exchange

Wednesday 12/09/12

09.00-10.30 : Discussion on the disagreement and sources of bias
10.30-10.45 : coffee break
10.45-12.00 : Utilisation of TNPC software to mesure the distances between *nucleus* and check or growth rings
12.00-13.30 : lunch
13.30-16.15 : Guidelines for age interpretation
16.15-16.30 : coffee break
16.30-17.30 : Guidelines for age interpretation

Thursday 13/09/12

09.00-10.30 : Draft report
10.30-10.45 : coffee break
10.45-12.00 : Draft report
12.00-13.30 : lunch
13.30-16.00 : Reference images
16.00-16.15 : coffee break
16.15-18.30 : Draft reports, Recommendations

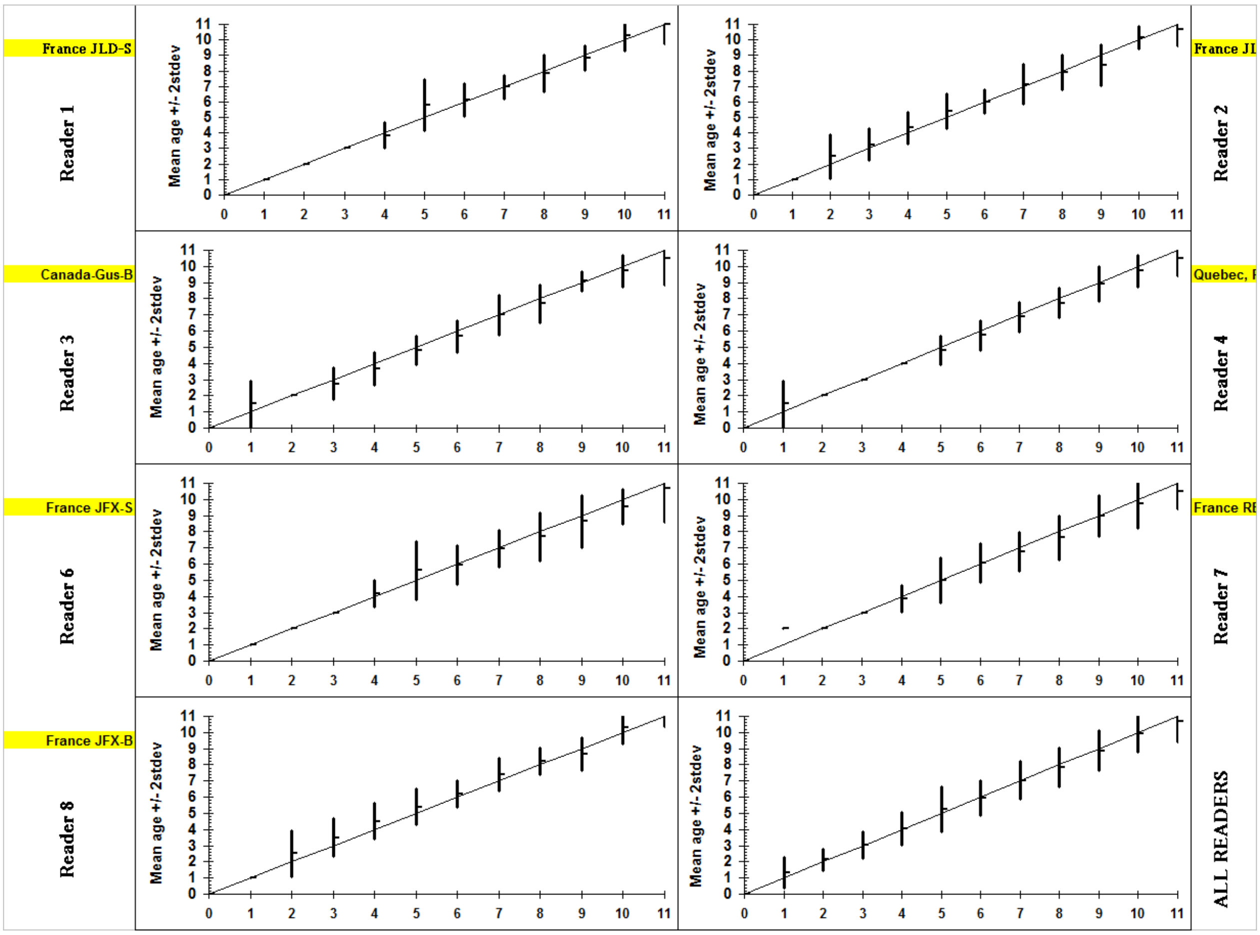
Friday 14/09/12

09.00-10.30 : Draft report
10.30-10.45 : coffee break
10.45-12.00 : Abstract
12.00-13.30 : lunch
13.30-16.00 : Finalisation of the Report

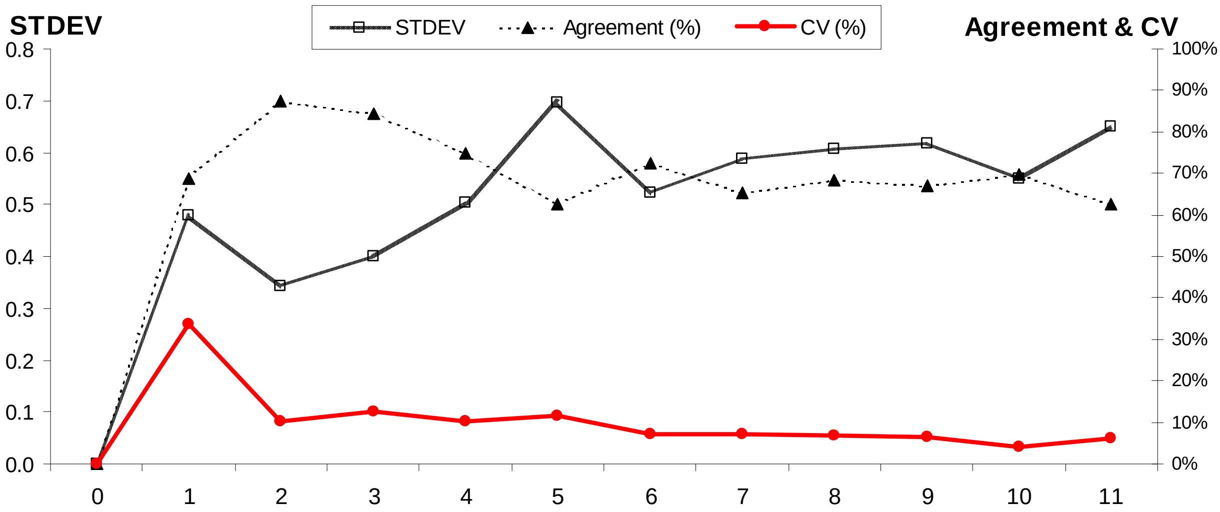
Annex 3 : Results of readings comparaison

Commercial sample from 3Ps

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.

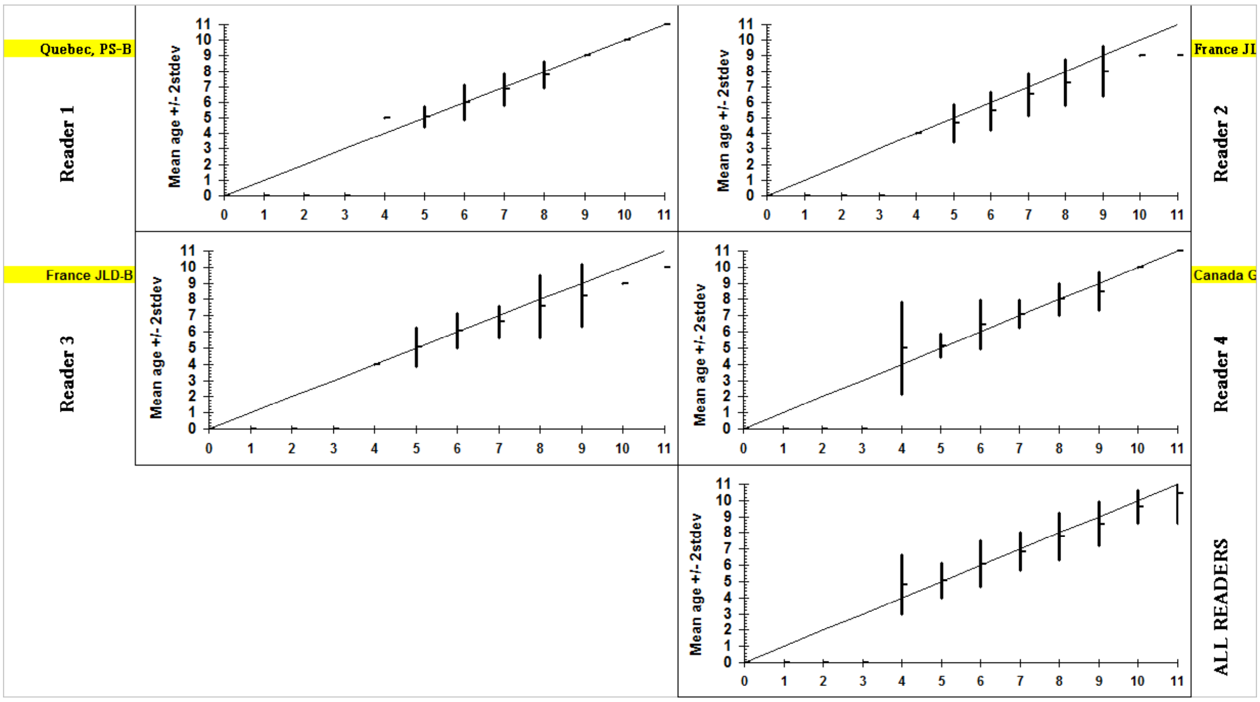


The coefficient of variation (CV%), percent agreement and the standard deviation (STDEV) are plotted against MODAL age. CV is much less age dependent than the standard deviation (STDEV) and the percent agreement. CV is therefore a better index for the precision in age reading. Problems in age reading are indicated by relatively high CV's at age.

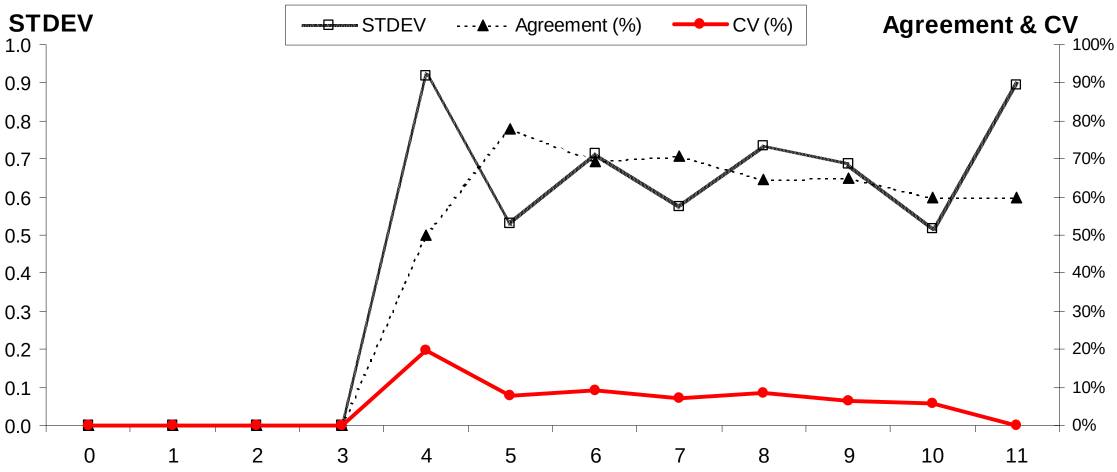


Research vessel sample from 3Ps

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.

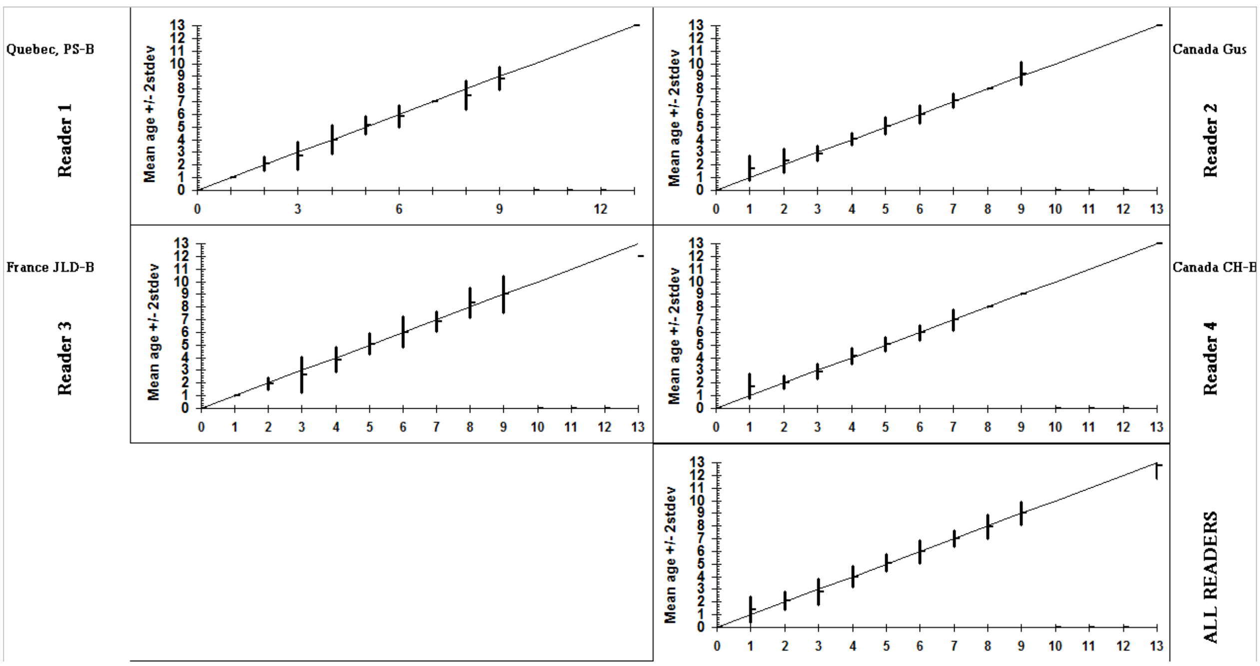


The coefficient of variation (CV%), percent agreement and the standard deviation (STDEV) are plotted against MODAL age. CV is much less age dependent than the standard deviation (STDEV) and the percent agreement. CV is therefore a better index for the precision in age reading. Problems in age reading are indicated by relatively high CV's at age.



Sample from 3Pn, 4RS

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.



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.