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Inter-Laboratory Ageing Exchange of Atlantic Mackerel (*Scomber scombrus*) Otoliths for the 2009 Transboundary Resources Assessment Committee Assessment

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ABSTRACT

An inter-laboratory exchange was undertaken to compare the production ages for Atlantic mackerel (*Scomber scombrus*) from two ageing laboratories, the Northeast Fisheries Science Center (NEFSC) in Woods Hole (Massachusetts), United States and the Maurice Lamontagne Institute (MLI) in Mont-Joli (Québec), Canada. The two laboratories exchanged a total of 200 whole otoliths from the 2008 commercial fishery; half of these samples were from the Canadian fishery and half from the United States fishery. Both laboratories conducted ageing of this species in support of the 2009 benchmark mackerel assessment by the Transboundary Resources Assessment Committee (TRAC).

Results were presented in terms of percentage agreement, total coefficient of variation (CV), age bias plots, and age-frequency tables. For United States samples, the results were 92% agreement and a CV of 1.06%. Canadian samples yielded 96% agreement and a CV of 0.50%. These high levels of precision indicate that age determinations are comparable between MLI and NEFSC.

After the exchange, there was a change in the NEFSC mackerel age reader. The new age reader completed two tests of intra-reader precision, with good results (98–100% agreement; 0.00–0.26% CV). This indicates that the change in age reader should not affect the continuity of age data for the TRAC assessment.

RÉSUMÉ

Dans le but de comparer la détermination de l'âge chez le maquereau bleu (*Scomber scombrus*), un échange a été réalisé entre deux laboratoires de lecture, le Northeast Fisheries Science Center (NEFSC) de Woods Hole (Massachusetts) des États-Unis et l'Institut Maurice-Lamontagne (IML) de Mont-Joli (Québec), Canada. Les deux laboratoires ont échangé un total de 200 otolithes de la pêche commerciale de 2008 ; la moitié de ces échantillons était de la pêche canadienne et l'autre moitié de la pêche américaine. Les deux laboratoires ont réalisé des déterminations d'âge en support à l'évaluation en 2009 du maquereau par le Comité d'évaluation des ressources transfrontalières (CERT).

Les résultats sont présentés en termes de pourcentage de concordance, de coefficient total de variation (CV), de graphiques du biais des âges et des tableaux de fréquences d'âge. Pour les échantillons des États-Unis, les résultats ont été de 92 % de concordance avec un CV de 1,06 %. Le pourcentage de concordance pour les échantillons canadiens a atteint 96 % avec un CV de 0,50 %. Ces hauts niveaux de précision indiquent que les déterminations d'âge sont comparables entre l'IML et le NEFSC.

Suite à l'échange, il y a eu un changement de lecteur d'âge au NEFSC. Le nouveau lecteur d'âge a complété deux tests de précision intra-lecteur avec de bons résultats (98–100 % de concordance; 0,00–0,26 % CV). Ceci indique que ce changement de lecteur d'âge ne devrait pas affecter la continuité des données d'âge pour l'évaluation du CERT.

INTRODUCTION

The annual Transboundary Resources Assessment Committee (TRAC) is a joint effort by the United States (U.S.) and Canada to assess fish populations that occur in national waters of both countries. This committee has considered haddock, cod, and yellowtail flounder for many years. In 2009, Atlantic mackerel (*Scomber scombrus*) will be considered for the first time, in a benchmark assessment. Mackerel are highly migratory and are managed as a unit stock between the mid-Atlantic Bight and the Canadian Maritimes (Québec, Newfoundland, and Labrador), encompassing the Northwest Atlantic Fisheries Organization (NAFO) Subareas 2−6.

Production ages for mackerel are regularly determined by established methods, in order to support stock assessments. This ageing effort occurs both at the Maurice Lamontagne Institute (MLI), part of Fisheries and Oceans Canada, and the Northeast Fisheries Science Center (NEFSC), part of the U.S. National Marine Fisheries Service. The two laboratories conduct age determinations independently on samples collected by each nation.

With production ageing, there is a responsibility to ensure the accuracy and precision of the ages generated (Campana 2001). When two or more laboratories are involved in ageing one fish population, they should do so in a consistent manner so that the age data may be incorporated into a joint stock assessment. The level of inter-laboratory precision may be determined by an exchange of samples, whereby readers from each laboratory both age the same set of fish. The two age readings for each fish are compared in order to calculate precision levels. This data should then be provided to assessment scientists, so that they may consider this potential source of variability within a stock assessment.

Such quality control efforts have been an on-going effort within the framework of the TRAC assessments. For other TRAC species, regular otolith exchanges have occurred since 1986. As this is the first year mackerel will be included in the TRAC, this exchange has been undertaken in order to quantify the level of ageing precision between MLI and NEFSC.

Acceptable levels of inter-laboratory precision are related to various factors, including the fish species, the age readers' experience, and the structure used for age determination. The ageing laboratory at the NEFSC has long considered agreement levels over 80% to be adequate. The total coefficient of variation (CV, Chang 1982), a relatively new approach to measuring agreement, is more reliable as it gives more comparable results between species and structures. Campana (2001) indicated that many ageing laboratories around the world view CVs of below 5% to be acceptable among species of moderate longevity and ageing complexity, such as Atlantic mackerel.

The purpose of this report is to provide the results of the 2009 inter-laboratory exchange for Atlantic mackerel. These results apply to recent production ageing at both labs and for samples aged in preparation for the 2009 TRAC meeting.

DATA AND METHODS

At each laboratory, the primary age reader conducted production ageing of mackerel, following standard ageing methods and criteria (Penttila and Dery 1988). Following standard preparation techniques, whole otoliths were embedded in clear resin prior to ageing. All fish were assigned a January 1st birth-date. During production ageing, the NEFSC age reader had access to data regarding fish length, collection date, and location; the MLI reader only knew the collection date.

After production ageing, samples were selected for inclusion in the exchange such that the combined samples from both countries spanned the entire length distribution of the population. Trays of embedded whole otoliths were exchanged, along with data on collection date and location. Neither production age nor length data were exchanged until after the second reader had completed age determinations for all fish.

Each laboratory selected 100 samples for the exchange from their nation's 2008 commercial fishery. Mackerel for the U.S. portion of the exchange were collected on January 14th (N = 25), March 3rd (N = 25), and March 14th (N = 50) from otter trawlers in the Mid-Atlantic Bight (Division 6A). Canadian samples consisted of fish captured on June 10th (N = 50) and June 12th (N = 50) by the commercial gillnet fishery in Baie des Chaleurs, in the Gulf of St. Lawrence (Division 4T).

Results for each exercise are presented in terms of percent agreement, CV, age-bias plots, and age-frequency tables (Campana et al. 1995, Campana 2001). Age-bias plots show the average age attained by the NEFSC age reader versus the MLI reader's age; this is not meant to indicate that either reader was expected to be more accurate. Age-frequency tables compare the numbers of fish at each age for each age reader.

If two ages were not assigned to a fish for any reason (N = 1), the fish was excluded from calculation of precision measures. No effort was made to change production ages in cases where the second age differed.

RESULTS AND DISCUSSION

A total of 199 fish were aged by both laboratories, with high levels of precision. Samples from the U.S. had 91.9% agreement and a CV of 1.06% (Figure 1). Canadian samples yielded 96.0% agreement and a CV of 0.50% (Figure 2). Between both sets of samples, only 12 fish had ages which were disagreed upon; eleven of these ages were agreed upon within one year. The one fish that had an age difference of three years (Figure 1) was the largest fish (40 cm) in the exchange. In this case, the NEFSC reader had access to length data while ageing and assigned the higher age.

No bias was apparent in either test, and good agreement was achieved for up to age-9 fish. No tests of symmetry were applied, because high levels of agreement render such tests unnecessary (Hoenig et al. 1995, FBP 2008).

As lengths were not available to the second reader during the exchange, the similarity in the distribution of length versus age was noteworthy (see Appendix). The mean lengths-at-age (MLA) were also very similar between the two readers.

The high levels of inter-laboratory precision, along with a lack of bias, indicate that the mackerel age readers at each laboratory are providing comparable age data for the TRAC assessment.

It is recommended that a mackerel exchange be repeated every other year henceforth, as precision levels may change over time. In addition, any time that a change in mackerel age readers occurs, an exchange should be conducted to compare the new reader with more experienced readers.

POSTSCRIPT

After the completion of the exchange, it became necessary for the NEFSC laboratory to change age readers. An age reader on the NEFSC staff was trained to age mackerel using samples from the exchange, as well as samples previously aged at the NEFSC. A consultant with experience ageing mackerel addressed questions that arose during this training. The new age reader then aged NEFSC commercial samples from 2005 through 2008 (inclusive) and portions of the NEFSC survey samples from 2004 and 2006. All samples from 2009 and later will be aged by this person.

Following production ageing, this person re-aged NEFSC samples from the 2009 spring survey (N = 100) and the 2008 commercial fishery (N = 172) to measure intra-reader precision. These exercises revealed good precision, with 97.7% to 100% agreement and CVs of 0.00% to 0.26% (Figures 3–4). A slight bias toward higher ages in the production ages may have existed in the commercial samples, but this was not strong enough to be significant.

These high levels of intra-reader precision and lack of bias indicate that the change in age reader at NEFSC should not affect the continuity of age data for the TRAC assessment. No new exchange was conducted at this point, as the high intra-reader precision indicated that such an exchange was unnecessary.

ACKNOWLEDGMENTS

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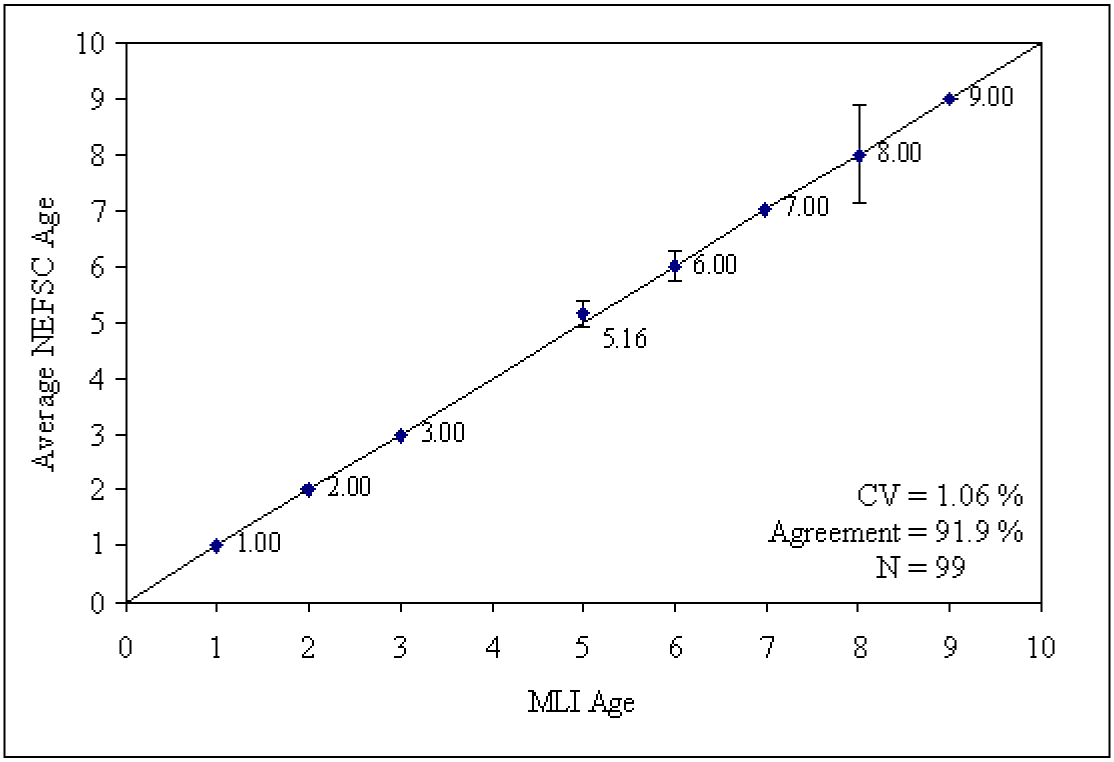
A.



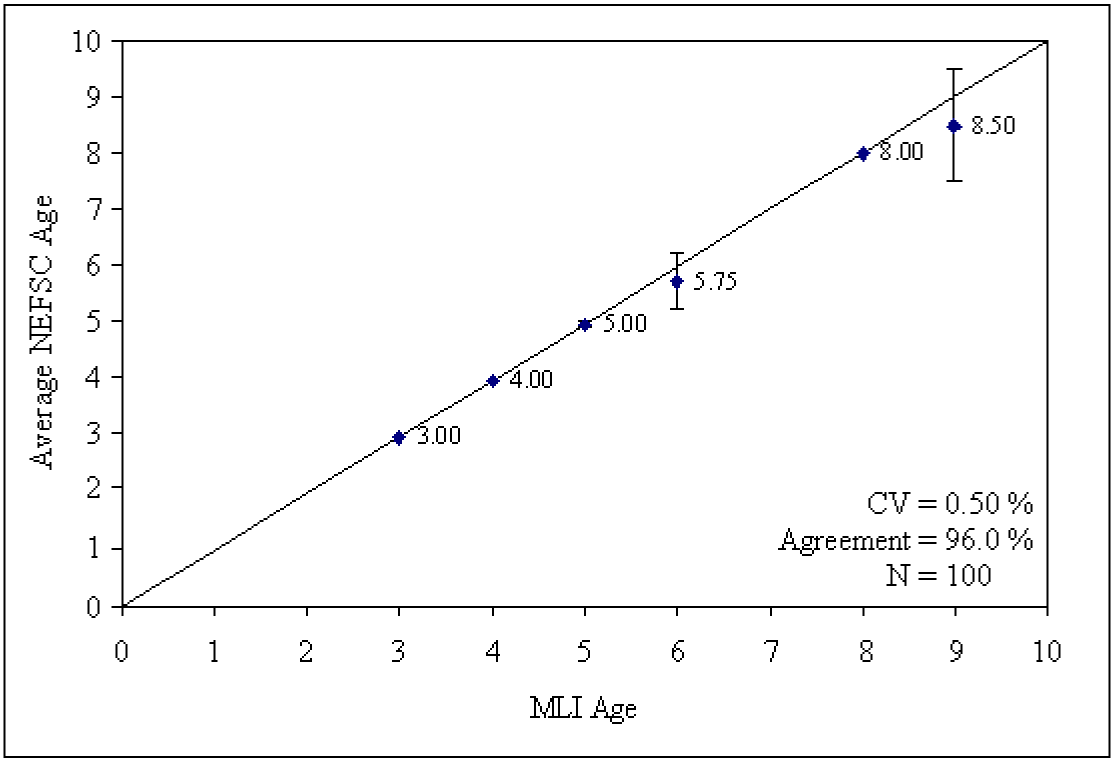
B.

Age (MLI)	Age (NEFSC) 1	2	3	4	5	6	7	8	9	Total
1	24									24
2		18								18
3			8							8
4										
5					23	1		1		25
6					1	8	1			10
7							3			3
8							2	1	2	5
9									6	6
Total	24	18	8		24	9	6	2	8	99

DIFFERENCE				
-1	0	+1	+2	+3
3	91	4	0	1

Figure 1. Results of MLI/NEFSC mackerel exchange using fish from the first quarter of 2008 U.S. commercial samples. The NEFSC reader conducted production ageing for these samples. Figure is for comparison purposes only; it is not meant to indicate one set of ages is more accurate than the other. (A) Age-bias plot, showing the average age attained by the NEFSC age reader versus the ages attained by the MLI age reader. Error bars indicate 95% confidence intervals. (B) Age-frequency table, showing each reader's ages. Numbers in boxes along the main diagonal indicate where both readers were in agreement. Numbers above this diagonal indicate fish that were given higher ages by the NEFSC age reader; those below the diagonal indicate higher ages by the MLI age reader. The inset shows the frequency of differences in age assignment; positive differences indicate a higher age by the NEFSC reader, while negative differences indicate a higher age given by the MLI age reader.

A.



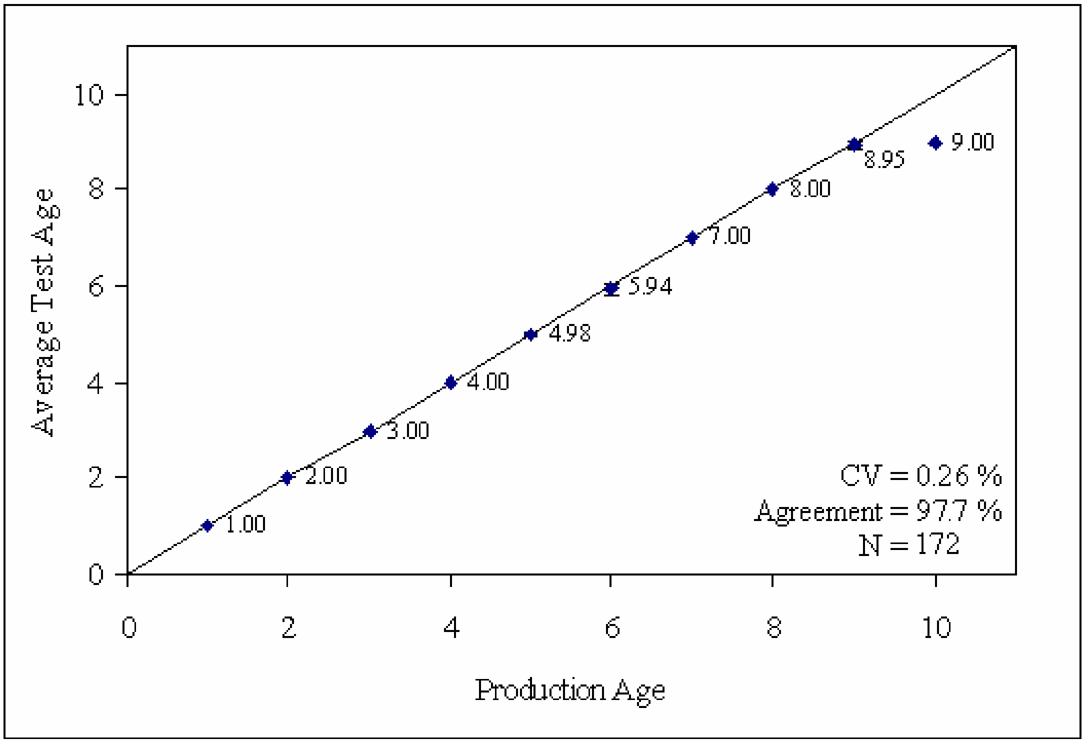
B.

Age (MLI)	Age (NEFSC) 1	2	3	4	5	6	7	8	9	Total
1										
2										
3			4							4
4				31						31
5				1	56	1				58
6					1	3				4
7										
8								1		1
9								1	1	2
Total			4	32	57	4		2	1	100

DIFFERENCE -1	0	+1
3	96	1

Figure 2. Results of MLI/NEFSC mackerel exchange using fish from the second quarter of 2008 Canadian commercial samples. The MLI reader conducted production ageing for these samples. Figure is for comparison purposes only; it is not meant to indicate one set of ages is more accurate than the other. (A) Age-bias plot, showing the average age attained by the NEFSC age reader versus the ages attained by the MLI age reader. Error bars indicate 95% confidence intervals. (B) Age-frequency table, showing each reader's ages. Numbers in boxes along the main diagonal indicate where both readers were in agreement. Numbers above this diagonal indicate fish that were given higher ages by the NEFSC age reader; those below the diagonal indicate higher ages by the MLI age reader. The inset shows the frequency of differences in age assignment; positive differences indicate a higher age by the NEFSC reader, while negative differences indicate a higher age given by the MLI age reader.

A.



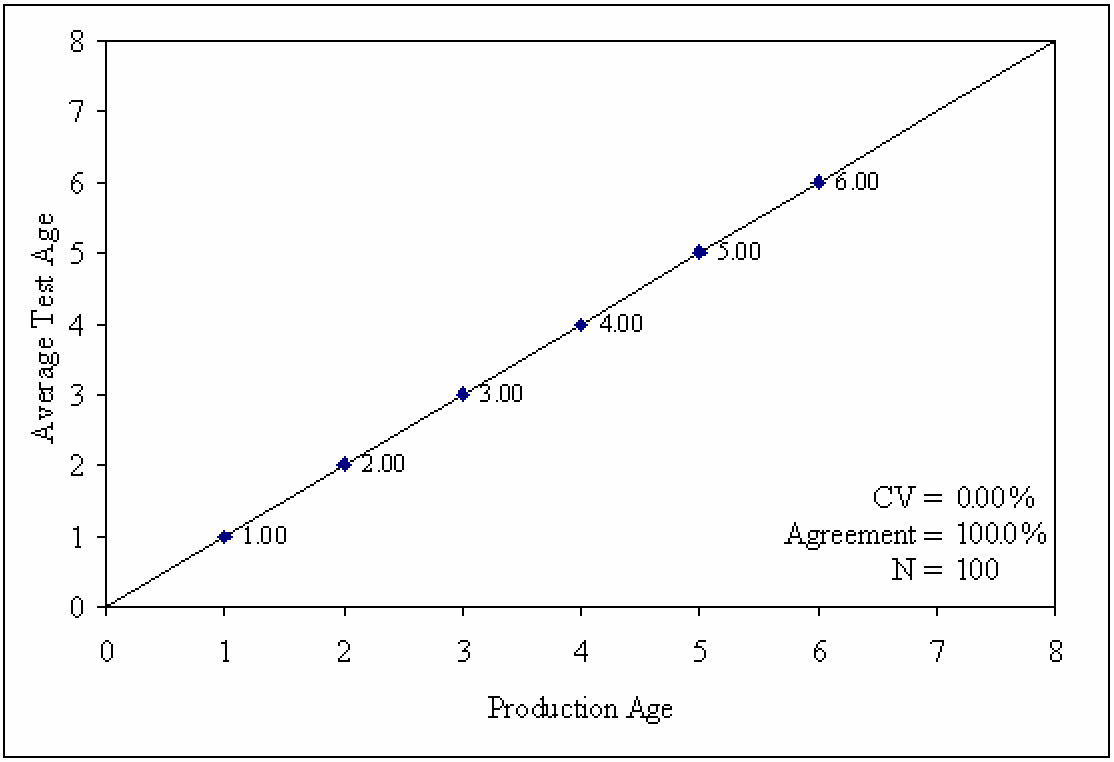
B.

Production Age	Test Age 1	2	3	4	5	6	7	8	9	10	Total
1	24										25
2		5									5
3			33								33
4				21							21
5				1	43						44
6					1	15					16
7							2				2
8								7			7
9								1	18		19
10									1		1
Total	24	5	33	22	44	15	2	8	19		172

DIFFERENCE		
-1	0	+1
4	168	0

Figure 3. Results of intra-reader precision exercise using fish from the 2008 U.S. commercial samples. The new NEFSC reader conducted production ageing for these samples. Figure is for comparison purposes only; it is not meant to indicate one set of ages is more accurate than the other. (A) Age-bias plot, showing the average test age versus the production ages attained by the new NEFSC age reader. Error bars indicate 95% confidence intervals. (B) Age-frequency table, showing both sets of ages. Numbers in boxes along the main diagonal indicate where both ages were in agreement. Numbers above this diagonal indicate fish that were given higher test ages; those below the diagonal indicate higher production ages. The inset shows the frequency of differences in age assignment; positive differences indicate a higher test age, while negative differences indicate a higher production age.

A.



B.

Production Age	Test Age 1	2	3	4	5	6	7	8	Total
1	49								49
2		29							29
3			7						7
4				12					12
5					1				1
6						2			2
7									
8									
Total	49	29	7	12	1	2			100

DIFFERENCE		
-1	0	+1
0	100	0

Figure 4. Results of intra-reader precision exercise using fish from the 2009 NEFSC spring survey. The new NEFSC reader conducted production ageing for these samples. Figure is for comparison purposes only; it is not meant to indicate one set of ages is more accurate than the other. (A) Age-bias plot, showing the average test age versus the production ages attained by the new NEFSC age reader. Error bars indicate 95% confidence intervals. (B) Age-frequency table, showing both sets of ages. Numbers in boxes along the main diagonal indicate where both ages were in agreement. Numbers above this diagonal indicate fish that were given higher test ages; those below the diagonal indicate higher production ages. The inset shows the frequency of differences in age assignment; positive differences indicate a higher test age, while negative differences indicate a higher production age.

Appendix. Age versus length for fish in the exchange.

A.

Length (cm)	Age (years) 1	2	3	4	5	6	7	8	9	Total
19	3									3
20	8									8
21	8									8
22	5									5
23										0
24										0
25										0
26		4								4
27		3								3
28		9	3							12
29		2	2							4
30			1							1
31			2							2
32										0
33										0
34										0
35										0
36					21	4		1		26
37					3	4	1	3	3	14
38						1	1		3	5
39						1	1	1		3
40					1					1
Total	24	18	8	0	25	10	3	5	6	99
MLA (cm)	*20.6*	*27.5*	*29.3*		*36.3*	*36.9*	*38.0*	*37.2*	*37.5*	

B.

Length (cm)	Age (years) 1	2	3	4	5	6	7	8	9	Total
19	3									3
20	8									8
21	8									8
22	5									5
23										0
24										0
25										0
26		4								4
27		3								3
28		9	3							12
29		2	2							4
30			1							1
31			2							2
32										0
33										0
34										0
35										0
36					20	5	1			26
37					4	2	3	1	4	14
38						1	1		3	5
39						1	1		1	3
40								1		1
Total	24	18	8	0	24	9	6	2	8	99
MLA (cm)	*20.6*	*27.5*	*29.3*		*36.2*	*36.8*	*37.3*	*38.5*	*37.6*	

Figure A1. Age (years) versus fork length (cm) for Atlantic mackerel collected in the first quarter of 2008 in U.S. commercial samples. MLA is the mean length at each age. The NEFSC reader conducted production ageing for these samples. (A) Results for MLI reader. (B) Results for NEFSC reader.

A.

Length (cm)	Age (years) 3	4	5	6	7	8	9	Total
32	2	1						3
33	1	8	9					18
34	1	14	23					38
35		8	19	1				28
36			5	1				6
37			2	2			1	5
38								0
39						1	1	2
Total	4	31	58	4	0	1	2	100
MLA (cm)	*32.8*	*33.9*	*34.4*	*36.3*		*39.0*	*38.0*	

B.

Length (cm)	Age (years) 3	4	5	6	7	8	9	Total
32	2	1						3
33	1	8	9					18
34	1	14	22	1				38
35		9	18	1				28
36			6					6
37			2	2			1	5
38								0
39						2		2
Total	4	32	57	4	0	2	1	100
MLA (cm)	*32.8*	*34.0*	*34.5*	*35.8*		*39.0*	*37.0*	

Figure A2. Age (years) versus fork length (cm) for Atlantic mackerel collected in the second quarter of 2008 in Canadian commercial samples. MLA is the mean length at each age. The MLI reader conducted production ageing for these samples. (A) Results for MLI reader. (B) Results for NEFSC reader.