Northeast Fisheries Science Center Reference Document 11-16

Proceedings of the Pollock Ageing Workshop 13 – 14 July 2010, Boothbay Harbor, Maine

by William J. Duffy, W. Eric Gross, Cecil Nelson, and Sarah Emery

September 2011

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11-12 In preparation.

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INTRODUCTION

Pollock (*Pollachius virens*) is a highly migratory, schooling, amphiboreal gadoid ranging from Labrador to Georges Bank. However, it is most commonly found on the southwestern Scotian shelf and the Gulf of Maine. Pollock can reach lengths up to 130 cm and weigh up to 16 kg (Penttila et al. 1988). Pollock start maturing at 4 years old and can reach ages in excess of 20; there are no differences in growth rates between sexes (Penttila et al. 1988).

Initial ageing studies for pollock began in the middle 1950's and early 1960's using scales (Hoberman and Jensen 1962). Currently, pollock are aged by viewing sectioned otoliths, using a dissecting microscope, under reflected light. Age determinations are made by counting translucent rings from nucleus to the edge of the otolith (Penttila et al. 1988). Using the otolith as an ageing structure was validated by Steele (1963) who used otolith marginal increment analysis and later was confirmed by Neilson (2003) using mark-recapture.

The most recent pollock stock assessment (SAW 50) was conducted in June, 2010 (NEFSC 2010). Historically both Canadian and US survey age data was used because the stock overlapped between countries. The stock assessment model was updated for this assessment which included U.S. commercial age data. For this latest assessment, only U.S. age data was used because the stock definition was "refined" to coincide with the Canadian / U.S. boundary (NEFSC 2010). However, to account for the possibility of a combined U.S./Canada stock assessment in the future it became necessary to review the ageing practices between the two labs.

Prior to the assessment (Early May 2010), ageing material was exchanged between the Canadian Department of Fisheries and Oceans (DFO) Biological Station in St Andrews, New Brunswick, Canada and the Northeast Fisheries Science Center (NEFSC) laboratory in Woods Hole, MA, U.S.A. One motivation for holding the exchange was that ageing responsibilities for pollock at both the DFO and NEFSC has recently changed hands, and it was important to develop a working relationship between the new age readers in the event that a joint assessment is performed in the future (The current approach has separate assessments for Canadian and U.S. management units).

The results of this Canada/U.S. ageing exchange suggested that there were systematic differences in the methods used to age pollock between the two laboratories. Therefore, an ageing workshop was conducted to discuss the results of this exchange. This workshop took place in Boothbay Harbor, ME, U.S.A., at Maine's Department of Marine Resources (DMR) during July 13–14, 2010. Attendees included representatives from DFO, DMR, and NEFSC (Table 1). The objectives of the workshop were to:

1. Reconcile the differences between age readers in the exchange.
2. Review standard ageing methods between the two laboratories.
3. Demonstrate improvements in within and between reader agreement as a result of the workshop.

This report describes the results of both the exchange and the workshop, and offers recommendations for future collaboration.

METHODS

Between May and June 2010, the ageing laboratories in St. Andrews and Woods Hole exchanged otolith samples from pollock. Each laboratory supplied otolith samples from both their survey and commercial fisheries: the U.S. supplied 50 spring commercial samples and 50

autumn survey samples; Canada supplied 85 commercial samples and 58 summer survey samples. The primary pollock age reader at each laboratory viewed the exchanged samples.

From the resulting ages, the precision between the two age readers was assessed with percent agreement and age-bias plots (Campana et al. 1995). Also, a Bowker's test of symmetry (Bowker 1948) was used to test for systematic differences between readers.

During the workshop, both agreements and disagreements from the exchange were discussed. Otolith images were taken from both the US and Canadian survey and commercial samples using a digital camera and viewed using imaging software, loaded into Power Point® and viewed using a projector. This enabled discussion between the primary age readers from each laboratory on these disagreements. After an initial discussion between primary age readers, comments were opened to all workshop participants.

RESULTS

A total of 243 otoliths were available for the ageing exchange, although 16 were later evaluated as low quality and not used to calculate agreement (Tables 2-5). Levels of agreement ranged between 40 and 71 percent, with systematic differences in the ages (Tables 6–9). Bowker's tests for all four sample sets were significant ($P < 0.05$; Tables 6–9). The U.S. age reader usually had higher ages than the Canadian age reader (Tables 6–9), with the exception of the U.S. survey samples, where the Canadian age reader had a tendency to have higher ages (Table 7).

Ten samples from the Canadian survey where disagreements occurred were discussed. Of these, five were changed to the U.S. age, four remain unresolved, and one was omitted (Table 10). A total of five otoliths where disagreements occurred were discussed from the U.S. commercial and survey samples. Two of these ages were changed to the Canadian age, two were unresolved, and one remained the same (Table 10).

DISCUSSION

During the workshop, we identified a number of issues that caused the differences in age determination between the two primary age readers, including whether to count the edge, microscope technique, and the location of the first annulus.

First, there were some issues as to whether counting the edge of the otolith was appropriate. One of the concerns with respect to counting edge material is that the Canadian Scotian Shelf survey takes place in July, and most pollock from that area already have a completely formed opaque edge (Steele 1963), where as pollock in the Gulf of Maine start laying down their annulus between March and April (which coincides with NEFSC's spring bottom trawl survey) and in the summer months have very little opaque area on the edge of their otoliths (Penttila et al. 1988). Such a difference in biological timing and dates of collection between the two areas could result in differences in the interpretation of age, based on each reader's notion of the amount of opaque material on the edge expected before another year should be counted.

For example, Figure 1 shows an otolith from a 36 cm pollock caught on the Canadian survey. The Canadian age reader assigned this fish an age of 2, while the U.S. reader assigned it an age of 3. The age was unresolved during the workshop. The U.S. age reader noted enough opaque area after the last visible annulus to count it as an annual ring, whereas the Canadian reader did not count the edge.

Interpreting the difference between a false annulus and true annulus was also an area of concern. During the workshop there were a number of occasions were the Canadian age reader interpreted the fourth annulus as a false annulus. A sample where this issue affected age interpretation is shown in Figure 2. The Canadian age reader originally aged this otolith from a 69 cm pollock, as a 7-year-old, while the U.S. age reader aged it as an 8-year-old. After some discussion, it was agreed that the fourth annulus was a true annulus and that the fish was 8 years old. The intensity of the opaque area before and after the translucent area is a good indicator when trying to determine if a translucent zone is a true annulus.

Optic standardization was another issue raised in the workshop. It is standard practice for the Canadian age reader to view an otolith under a single magnification without modification. During the workshop, this issue was raised while interpreting the edge of some otoliths. This was also an issue which effected the Canadian age reader's interpretation of the fourth annulus. The U.S. age reader is not limited to one magnification, but will adjust the magnification, especially when there is difficulty viewing the edge of an otolith. This issue was a factor in the discussion of the sample depicted in figure 1. Raising the magnification allowed the age readers to see more opaque material after the formation of the annulus, thus allowing it to be counted as a full year.

Finally, the location of the first annulus was another issue where disagreements arose. Figure 3 shows an otolith from a 70 cm pollock where, the Canadian age reader had an age of 6, whereas the U.S. age reader had an age of 7. The disagreement lay in interpretation of the location of the first annulus. After discussion, there was agreement that the fish was 7 years old. It was agreed that the first annulus can often be identified by its irregular ("cauliflower") shape and by the presence of a thin settling check near the nucleus (Figure 3).

CONCLUSIONS AND RECOMMENDATIONS

This pollock ageing workshop helped to examine and reconcile differences in ageing between the NEFSC and DFO. If the NEFSC is going to use both U.S. and Canadian age data in future stock assessments for pollock, consistency in age interpretation for both laboratories would be required for any analysis (i.e. for combined Canada/U.S stock assessment).

It was recommended that future ageing exchanges take place on an annual basis between the two laboratories in order to prevent discrepancies. It was also recommended that ageing workshops be conducted every few years to discuss the results of these exchanges.

Furthermore, a reference collection should be created from a combination of Canadian and U.S. age samples. These ages should be corroborated by both the Canadian and U.S. age reader, perhaps from exchange samples. The reference collection could be used to train new age readers, and it would allow age readers to test themselves before starting to age new age samples as a measure of ageing accuracy.

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Table 1. Pollock ageing workshop participants, July 13th and 14th 2010.

Name	Affiliation
Heath Stone	Fisheries and Oceans Canada---St Andrews Biological Station
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Table 2. Exchange results from Canadian commercial samples collected (June –September 2009).

ID Number	Length (cm)	CAN AGE	US AGE	ID Number	Length (cm)	CAN AGE	US AGE
8841	59	5	5	9465	66	6	6
8842	62	5	5	9466	70	6	6
8843	50	3	3	9467	73	7	8
8844	59	6	7	9468	73	7	8
8845	59	5	5	9469	69	6	7
8846	56	6	6	9470	70	7	7
8847	61	5	5	9471	72	7	9
8848	54	4	4	9472	53	3	3
8849	64	5	6	9473	55	4	4
8850	72	6	7	9474	78	8	8
8851	60	5	6	9475	75	N/A	8
8852	55	5	6	9476	78	7	8
8853	52	3	3	9477	78	8	8
8854	52	3	3	9478	75	7	7
8855	68	N/A	6	9479	51	3	3
8856	69	7	8	9631	57	3	3
8857	64	6	7	9632	50	3	3
8858	43	3	3	9633	55	4	4
8859	53	5	5	9634	62	5	5
8860	63	3	4	9635	57	4	4
8861	67	6	8	9636	62	5	5
8862	48	3	3	9637	49	3	3
8863	71	8	10	9638	48	3	3
8864	48	3	3	9639	53	3	3
8865	66	5	6	9640	60	5	5
8866	77	8	11	9641	55	5	5
8867	70	7	8	9642	52	3	3
8868	47	4	4	9643	58	4	4
8869	46	3	3	9644	55	4	4
8870	77	N/A	11	9645	53	3	3
8871	47	3	3	9646	47	3	3
9451	64	6	6	9647	46	3	3
9452	59	5	5	9648	47	3	3
9453	61	5	6	9649	65	6	8
9454	59	4	4	9650	63	6	6
9455	75	7	8	9651	71	7	7
9456	65	6	6	9652	71	7	9
9457	56	4	4	9653	63	5	5
9458	58	5	5	9654	67	N/A	5
9459	62	6	6	9655	44	3	3
9460	67	7	8	9656	44	3	3
9461	65	6	6	9657	67	7	8
9462	61	6	6				
9463	56	4	4				
9464	68	6	6				

N/A = not aged

Table 3. Exchange results from Canadian survey samples NED2009027 collected July 2009.

ID Number	Length (cm)	CAN AGE	US AGE	ID Number	Length (cm)	CAN AGE	US AGE
133	67	6	7	163	73	N/A	6
134	57	4	4	164	60	4	4
135	68	6	8	165	67	6	6
136	56	4	4	166	66	6	6
137	60	6	6	167	57	5	5
138	60	4	4	168	75	7	8
139	47	3	3	169	69	7	8
140	41	3	3	170	81	7	7
141	52	4	4	171	80	7	8
142	60	6	6	172	78	6	8
143	64	6	6	173	61	5	5
144	62	6	6	174	56	5	4
145	31`	2	2	175	59	4	4
146	68	6	6	176	74	7	7
147	69	7	8	177	48	3	3
148	36	2	3	178	68	7	8
149	34	2	2	179	55	6	7
150	31	2	2	180	62	5	5
151	86	8	10	181	54	4	4
152	77	6	7	182	53	3	4
153	59	5	5	183	52	4	4
154	64	5	5	184	50	3	3
155	65	5	5	185	79	6	7
156	76	7	7	186	51	4	4
157	72	6	8	187	60	5	5
158	71	7	7	188	62	5	5
159	70	6	7	189	76	N/A	7
160	58	4	4	190	58	4	5
161	63	6	6	191	70	6	8
162	77	7	7				

NA = Not Aged

Table 4. Exchange results from US commercial samples collected in spring 2009.

Block number	ID number	Length (cm)	US AGE	CAN AGE
PL0297	C1	48	4	4
PL0297	C2	49	4	3
PL0297	C3	50	4	4
PL0297	C4	51	4	5
PL0297	C5	52	4	5
PL0297	C6	53	5	5
PL0297	C7	54	4	4
PL0297	C8	55	5	5
PL0297	D1	56	4	4
PL0297	D2	57	5	5
PL0297	D3	58	5	5
PL0297	D4	59	6	6
PL0297	D5	60	6	6
PL0297	D6	61	7	6
PL0297	D7	62	7	6
PL0297	E1	63	7	7
PL0297	E2	64	6	5
PL0297	E3	65	7	7
PL0297	E4	66	8	N/A
PL0297	E5	67	7	7
PL0297	E6	68	7	7
PL0297	E7	69	7	7
PL0298	C1	70	6	6
PL0298	C2	70	9	8
PL0298	C3	71	7	6
PL0298	C4	71	8	6
PL0298	C5	72	7	6
PL0298	C6	72	9	9
PL0298	C7	73	9	N/A
PL0298	D1	73	7	6
PL0298	D2	73	8	7
PL0298	D3	74	10	N/A
PL0298	D4	74	8	7
PL0298	D5	75	9	8
PL0298	D6	77	7	N/A
PL0300	C1	80	8	6
PL0300	C2	81	9	8
PL0300	C3	82	9	9
PL0300	C4	83	10	8
PL0300	C5	84	10	N/A
PL0300	C6	85	9	8
PL0300	C7	86	10	7
PL0300	D1	88	10	8
PL0300	D2	89	10	8
PL0300	D3	90	10	N/A
PL0300	D4	91	9	8
PL0300	D5	92	14	13
PL0300	D6	94	12	8
PL0301	D6	96	14	12
PL0301	D7	100	12	11

N/A = Not aged

Table 5. Exchange results from US survey samples collected during the fall bottom trawl survey in October 2009.

Block number	ID number	Length (cm)	US AGE	CAN AGE
PL0032	A1	67	6	6
PL0032	A2	43	2	2
PL0032	A3	56	4	4
PL0032	A4	80	9	8
PL0032	A5	77	7	8
PL0032	A6	81	9	9
PL0032	A7	29	1	2
PL0032	A8	30	1	2
PL0032	A9	67	6	6
PL0032	B1	65	6	6
PL0032	B2	31	1	2
PL0032	B3	52	4	4
PL0032	B4	30	1	2
PL0032	B5	59	6	6
PL0032	B6	14	0	1
PL0032	B7	31	2	2
PL0032	B8	31	2	2
PL0032	B9	59	6	6
PL0032	B10	71	7	N/A
PL0032	B11	51	5	5
PL0032	C1	68	6	6
PL0032	C2	53	4	4
PL0032	C3	36	2	2
PL0032	C4	31	1	1
PL0032	C5	69	6	6
PL0032	C6	72	6	6
PL0032	C7	69	6	7
PL0032	C8	61	6	6
PL0032	C9	71	6	7
PL0032	C10	41	2	3
PL0032	D1	54	3	3
PL0032	D2	34	1	2
PL0032	D3	33	1	2
PL0032	D4	30	1	2
PL0032	D5	59	5	5
PL0032	D6	49	5	N/A
PL0032	D7	66	4	5
PL0032	D8	61	6	6
PL0032	D9	66	6	6
PL0032	D10	75	6	N/A
PL0032	F1	69	6	6
PL0032	F2	64	6	N/A
PL0032	F3	79	7	8
PL0032	F4	25	1	1
PL0032	F5	30	1	2
PL0032	F6	32	1	2
PL0032	F7	24	1	1
PL0032	F8	87	8	10
PL0032	F9	81	7	8
PL0032	F10	81	7	N/A

N/A = Not Aged

Table 6. Number of pollock assigned by the NEFSC and DFO to various age classes from US commercial samples collected in the spring of 2008. Even though the DFO ages are listed first, it does not indicate that either age is more reliable.

DFO Ages	NEFSC Ages																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0																	
1																	
2																	
3					1												
4					**4**												
5					2	**4**	1										
6							**3**	5	2								
7								**5**	2		1						
8										5	3		1				
9										**2**							
10																	
11													1				
12															1		
13															1		
14																	

Number of Fish: 50
Number aged by readers from both agencies: 44
Percent Agreement: 40.9
Bowkers test: $p = 0.02$

Table 7. Number of pollock assigned by the NEFSC and DFO to various age classes from US Survey samples collected in the fall of 2009. Even though the DFO ages are listed first, it does not indicate that either age is more reliable.

DFO Ages	NEFSC Ages												
	0	1	2	3	4	5	6	7	8	9	10	11	12
0													
1	1	**3**											
2		9	**4**										
3			1	**1**									
4					**3**								
5					1	**2**							
6							**12**						
7							2						
8								3		1			
9										**1**			
10								1					
11													

Number of Fish: 50
Number aged by readers from both agencies: 45
Percent Agreement: 57.8
Bowkers test: $p = 0.01$

Table 8. Number of pollock assigned by the NEFSC and DFO to various age classes from Canadian commercial samples collected June – September 2009. Even though the DFO ages are listed first, it does not indicate that either age is more reliable.

DFO Ages	NEFSC Ages												
	0	1	2	3	4	5	6	7	8	9	10	11	12
0													
1													
2													
3				**22**	1								
4					**10**								
5						**12**	5						
6							**10**	4	2				
7								**3**	8	2			
8									**2**		1	1	
9													
10													
11													
12													

Number of Fish: 87
Number aged by readers from both agencies: 83
Percent Agreement: 71.1
Bowkers test: $p = 0.00$

Table 9. Number of fish assigned by the NEFSC and DFO to various age classes from Canadian survey samples collected during survey cruise NED2009027 (July 2009). Even though the DFO ages are listed first, it does not indicate that either age is more reliable.

DFO Ages	NEFSC Ages												
	0	1	2	3	4	5	6	7	8	9	10	11	12
0													
1													
2			**3**	1									
3				**4**	1								
4					**10**	1							
5					1	**8**							
6							**8**	5	4				
7								**5**	5				
8											1		
9													

Number of Fish: 58
Number aged by readers from both agencies: 57
Percent Agreement: 66.7
Bowkers test: $p = 0.02$

Table 10. Selected otolith disagreements that were discussed by the workshop participants.

	ID	CAN AGE	US AGE	Resolution	Issue
Canadian Samples					
NED20009027	133	6	7	Age 7	4/5 annulus
	147	7	8	Age 8	Edge/1st annulus
	148	2	3	No resolution	Edge
	152	6	7	No resolution	Edge /processing issue
	159	6	7	Age 7	1st annulus
	168	7	8	Age 8	4/5 annulus
	169	7	8	Age 8	4/5 annulus
	135	6	8	Could be 6 or 8, depending on which otolith, agreed to omit	4/5 annulus and 7/8 annulus
	151	8	10	No resolution	"Checky" otolith
	172	6	8	No resolution	4/5 annulus and edge
US Samples					
HB2010709	C2	3	4	Age 3	
	C5	5	4	Age 5	1st annulus
CF2008	F3	8	7	No resolution	2nd /3rd annulus
	F5	2	1	Age 1	Edge
	C9	7	6	No resolution	1st annulus

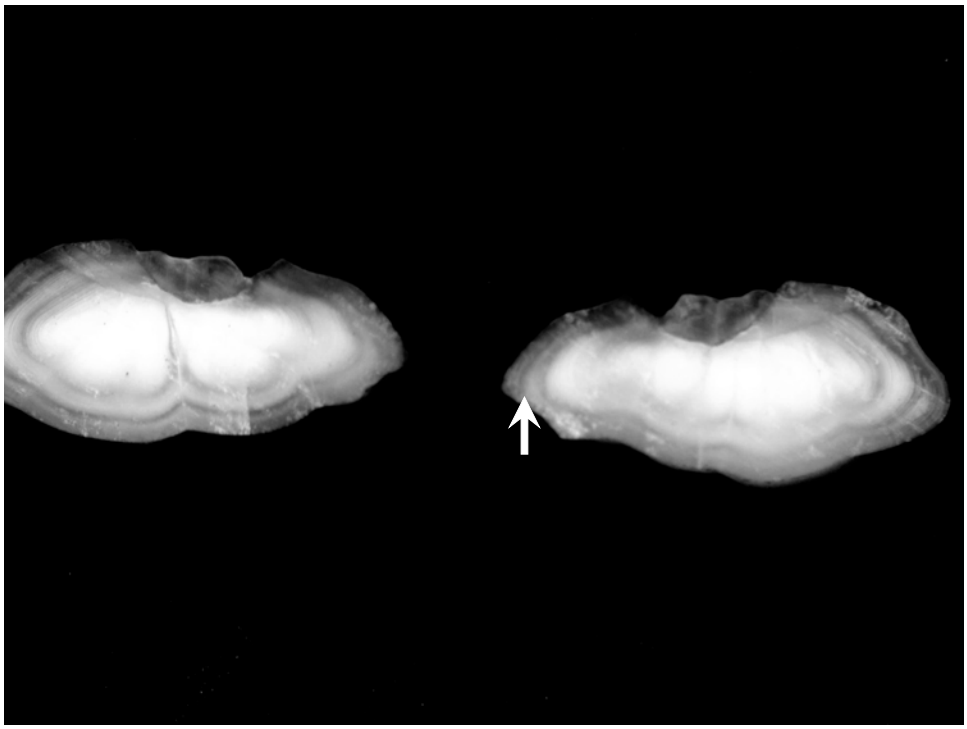

Figure 1. Otoliths from a 36 cm pollock caught on the Canadian survey NED2009027, number 148. The second annulus is shown with an arrow. The Canadian age reader aged it as a 2; the US age reader aged it as a 3. The final age was unresolved.

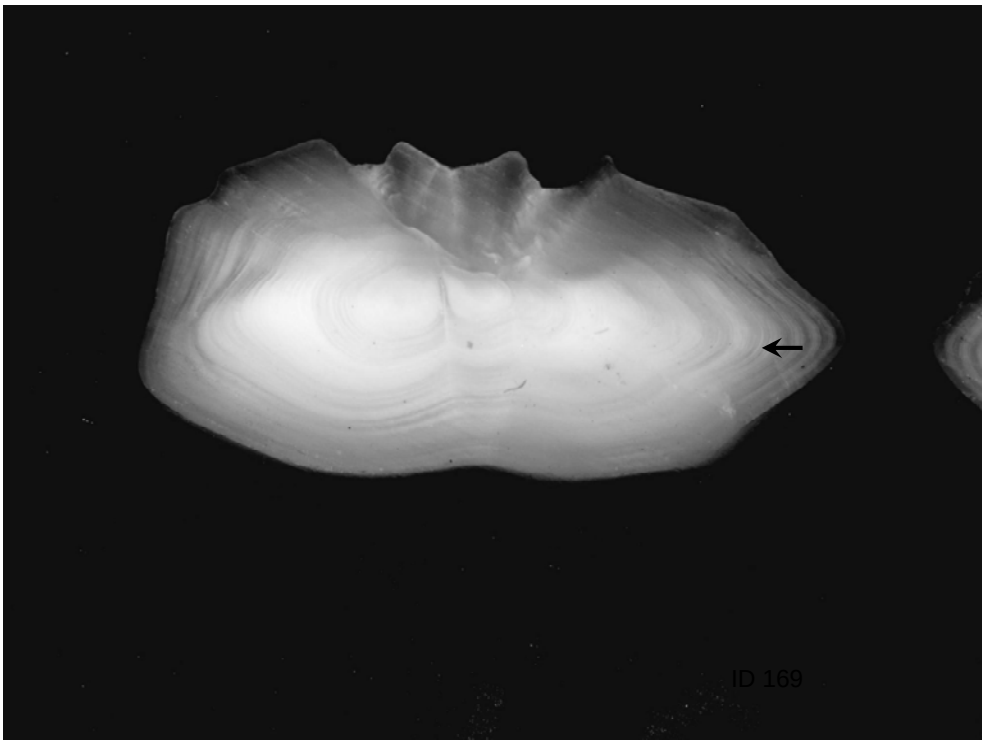

Figure 2. Otolith from a 69 cm pollock caught on the Canadian survey NED2009027, number 169. The fourth annulus is shown with an arrow. The Canadian age reader aged it as a 7; the US age reader aged it as an 8. The age was resolved and changed to an 8.

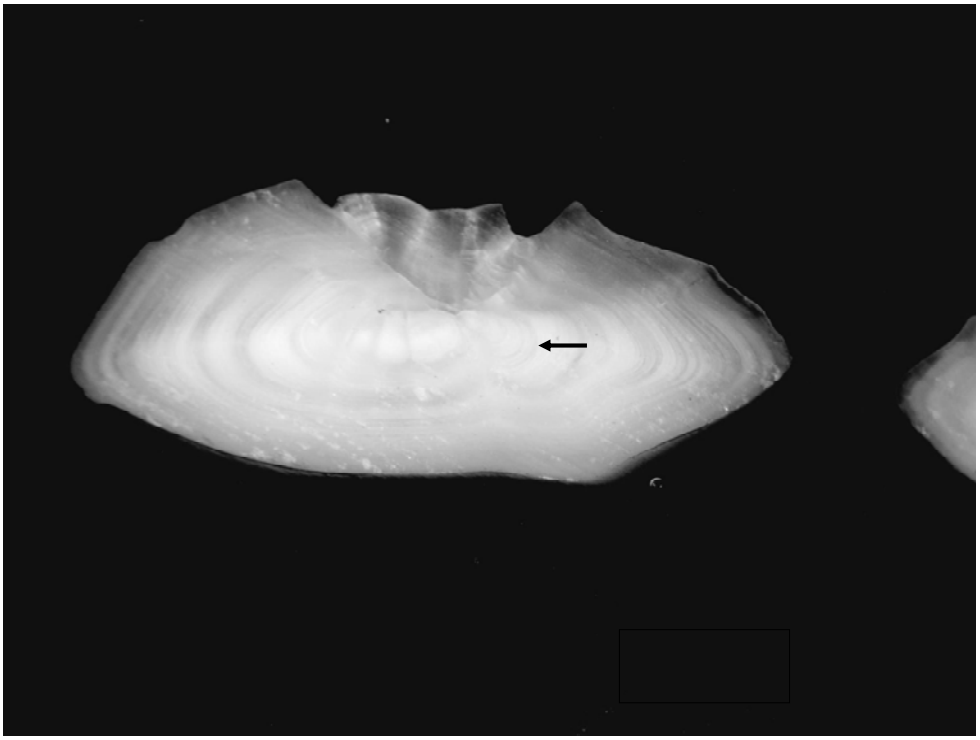

Figure 3. Otolith from a 70 cm pollock caught on the Canadian survey NED2009027, 159. The first annulus is shown with an arrow. The Canadian age reader aged it as a 6; the US age reader aged it as a 7. Based on the cauliflower shape of the first annulus, the age was resolved and changed to a 7.

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