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On the Validity of Age Determination of Cod from Canadian Research Vessel

Cruises to Flemish Cap, 1977-85

by

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Introduction

Ages were derived from the inspection of the series of hyaline (winter) and opaque (summer) rings in the cross sections of otoliths. The common presence of additional hyaline zones (checks and splits) complicate the interpretation of age. Zones in the same otolith may also vary in appearance from clear and distinct to weak and diffuse. It is the pleasant task of the age reader to impose a mental pattern upon the distribution of zones so that ages may be determined. To the extent that the zones can be grouped to fit this pattern, age interpretations are consistent; to the extent that the annual zones do in fact follow such a regular pattern, the age reading may be correct.

Age compositions of cod from the Flemish Cap have long been compiled by Soviet and Canadian researchers. The Scientific Council noted (Scientific Council Report, 1985) certain discrepancies between these two series of age compositions. To address this problem, the consistency and accuracy of the Canadian ageing series have been examined.

Methods and materials

Canadian research vessel surveys were made in January-February 1977-1985 to assess the distribution and abundance of groundfish on the Flemish Cap. As part of these investigations, cod (usually the entire catch) were measured from each successful set. Otoliths were taken from the catches of various sets such that up to 25 specimens were taken at each 3 cm length grouping. In the few instances where the entire catch was not measured, the measured length frequency was adjusted by the ratio weight caught/weight measured.

Age determinations were made at the laboratory. Age-length keys were constructed for each survey cruise in order to derive the proportion at age at each 3 cm group. These keys, when applied to the overall measured length frequency, allowed the estimation of age composition and average fork length at each age.

Patterns of year-class composition and of growth

In the length frequencies, a dominant mode often is present and the progression of such modes over the years is consistent with the anticipated growth of cod (Fig. 1). From 1981-1985, for example, a group of cod apparently grew at the rate implied by modes at 10, 22, 37 and 43 cm (Table 1). From Fig. 1, this group of cod has been interpreted from age readings to be comprised primarily of the 1981 year-class. Other strong year-classes were those of 1973 and 1977. Average lengths of these two year-classes each followed a regular pattern (Fig. 2) but the 1977 year-class was consistently larger at ages 5-8 years. Such regularities in the age compositions and growth patterns imply consistency in the age interpretations.

### Progression of modes and implied year-classes

From the length compositions (Fig. 1), modes present in one year may often be followed for several successive years. Six such series are proposed (Table 2); these may constitute six year-classes, A to F. Growth appears to be linear (Fig. 3). When least square regressions are fitted to modal length and year, an estimate may be obtained of the year in which the modal length is closest to zero. For example, year-class A is estimated to have been -0.6 cm in 1981 (Table 3) and is therefore probably the 1981 year-class. The other year-classes are readily identifiable except for year-class E which may be either the 1974 or 1975 year-class.

When the modal lengths of these year-classes are compared with the average lengths of the same year-classes derived from the age samples, the fit is good (Table 4) except for year-class E. This year-class fits the 1974 year-class for the first two modal lengths and the 1975 year-class for the last three modal lengths. It would appear that both year-classes are represented in the series E. From the age composition data, the 1974 year-class at age 5 is located in fact at the poorly defined mode at 49 cm rather than at the mode at 40 cm which locates the 1975 year-class at age 4.

Modes from these year-classes at age 1, either observed or extrapolated (Tables 2,3), are in the range 10-13 cm. From inspection of growth rates of cod larvae on the Flemish Cap in 1981, Anderson (1982) extrapolated the standard length of cod of the 1981 year-class in February 1982 as 11 cm. It seems likely then that year-classes have been accurately identified.

### Consistency in age reading

A blind test was set up consisting of 180 otoliths of which the reader was unaware of the length of the specimen or the year of capture. Ages were determined on 5 occasions spaced about 1 week apart. On each of the 5 occasions, the batch of 180 otoliths was read and the age interpretations were filed; the otoliths were immediately read again and the second set of age determinations filed. Ages were then determined for a third and final time on that occasion. Thus each otolith was read 3 times on each of 5 different occasions for a total of 15 iterations. Ages were not compared by the reader until the whole experiment has been completed and each otolith had been read 15 times.

The years of capture were 1979, 1982 and 1984. When it became apparent that the 1979 readings were not in very close agreement with the original readings determined in 1979, a further blind test was undertaken. Otoliths from the years 1977, 1978 and 1980 were used in a manner similar to that outlined above. In this test, however, time permitted 3 readings of each otolith on only 3 separate occasions for a total of 9 readings of each otolith (Table 5).

Intermediate modes were derived for each group of 3 readings read in a single day. There were 5 such intermediate modes for each otolith in the samples from 1979, 1982 and 1984, and 3 intermediate modes for the years 1977, 1978 and 1980. There were 2 instances where there was no intermediate mode. The mode of the intermediate mode made up a grand mode which was considered the best age. For each year separately and overall the probability of determining the best age was greater than 90 percent (Table 6). Discrepancies were almost always 1 year different from the best age. There may be a slight bias to underread.

If all otolith readings are considered to be independent, best ages derived from the overall mode of all readings are similar to the best ages derived from the mode of the intermediate modes. The probability of determining the best age is slightly lower than before but still above 90 percent (Table 7).

### Comparison of best ages with original ages

Original age readings completed routinely in the year of capture were compared with the best ages derived as the grandmode. Agreement was good for 4 of the 6 samples (Table 8), but at the 70 percent level in 1978 and 1979. When the samples were adjusted to the length frequencies for 1978 and 1979, the agreement between age compositions was only fair. Such variation may perhaps be expected when a small sample of ages are distributed over a wide length range (Table 9). The average lengths were generally in agreement (Fig. 5,6).

#### Effects upon age of location of samples

The selection of otoliths has been made by means of a stratified sampling scheme. Since the length composition varies from fishing set to fishing set, and particularly since the smallest and largest specimens may be taken in only a few fishing sets, there is a tendency to sample rather heavily in the first portion of the survey and more lightly afterwards as the number of otoliths required per cm group are obtained. This haphazard method of sampling has the advantage of assuring otolith samples from all length categories caught during the survey. It has the potential, however, to be biased since most of the otoliths tend to be collected during the first part of the survey and consequently mostly from a restricted area of the bank.

In some years, more extensive sampling was undertaken to allow an examination of the differences in age-length keys taken from different areas over the bank. The number of samples from the 4 geographical areas on the Flemish Cap formed by the 45° W longitude and the 47° 10' latitude appear to be adequate for age-length keys (Table 10). In addition, adequate age-length keys were constructed from 4 depth zones, namely up to 100 fm, 100-140 fm, 140-200 fm and 200-400 fm.

For each of the years considered, the separate age-length keys were applied to the total length frequency for the entire survey. Separate estimates for age compositions and average lengths for the whole survey area were thus obtained as follows:

- 4 estimates by geographical quadrant
- 4 estimates by depth zone
- 1 estimate from all samples combined.

For depth zone 4, with depths 200-400 fm, small cod tend not to be present in the catches and the age length key would therefore be inadequate to account for the age distribution of small cod taken elsewhere on the bank. In 1978, for example, no cod in the length range 16-31 cm were taken (and therefore no otoliths) in this depth zone. The estimated age composition for this zone therefore lacks the 1661 fish present in the overall length frequency at these length groups.

In general it is evident that age compositions and average lengths at age are very similar regardless of the area sampled (Tables 11-14). There is no reason to suppose, therefore, that such estimates for the period 1977-85 have been biased because of sampling design.

#### Level of agreement in otoliths exchanges

Samples of (usually) 50 otoliths are circulated at the St. John's, laboratory to all cod age readers roughly every month. Sampling details are known to the reader. Modes are derived and percent agreement calculated (Table 15). The level of agreement of best ages and original ages (Table 8) in the present study is consistent with the level of agreement between age readers in the St. John's laboratory.

#### Reference

- ANDERSON, J. T. 1982. Distribution, abundance and growth of cod (*Gadus morhua*) and redfish (*Sebastes* spp.) larvae on Flemish Cap, 1981. NAFO Res. Doc. 82/VI/37.

Table 1. Length compositions of cod taken on the Flemish Cap by Canadian research vessels in winters, 1977-85.

Length (3-cm gp.)	1977	1978	1979	1980	1981	1982	1983	1984	1985
6-8						2			
9-11	1				2	71	18		2
12-14					2	42	29	6	4
15-17	28	1	4	4	2		89	52	3
18-20	92	13	13	30			908	98	46
21-23	137	25	159	64		4	5235	193	164
24-26	321	266	389	71		10	4856	272	222
27-29	259	562	117	55	2	60	1259	393	240
30-32	96	794	39	231	29	162	163	569	282
33-35	74	1071	54	960	216	83	50	818	329
36-38	141	947	166	1389	438	3	99	822	414
39-41	242	670	403	594	329	8	133	568	560
42-44	410	1112	347	119	371	5	264	344	696
45-47	404	1912	299	70	864	18	368	151	684
48-50	332	2055	272	109	998	67	320	57	644
51-53	232	1564	194	165	633	100	145	49	486
54-56	157	1035	228	244	192	108	17	52	314
57-59	118	636	166	228	110	58	22	83	209
60-62	75	408	118	185	156	46	47	90	98
63-65	47	310	69	179	174	57	94	79	45
66-68	17	189	65	138	119	20	167	31	22
69-71	8	138	44	83	115	10	135	12	20
72-74	11	73	22	83	64	7	64	8	34
75-77	17	38	16	51	40	11	36	22	35
78-80	14	21	11	52	31	18	28	30	20
81-83	5	21	10	42	33	8	24	48	8
84-86	14	24	4	24	27	10	14	38	7
87-89	9	25	4	14	20	4	6	25	9
90-92	3	14	1	10	17	2	3	13	9
93-95	3	8	4	4	23	2	6	16	5
96-98		6	2	2	7	8	5	5	4
99-101	2	8	4		7	6	3	6	2
102-104	1	13	6	2	2	3	3	3	
105-107		4	2	1	3	5	5	3	1
108-110		5	1	1	1	2	3	3	3
111-113		7	3	2		1	1	1	5
114-116	1	2	1		1		1	2	1
117-119	1	1	1	2			1	1	
120-122	2	1	3	1					2
123-125		3	2						
126-128									
129-131			2					1	
132-134							1		
Total	3274	13982	3245	5209	5208	1022	14622	4964	5629
Av. length	41.88	46.34	44.40	44.20	50.05	45.54	27.81	38.46	43.68

Table 2. Modal lengths in the research length frequencies of cod from Canadian surveys, 1979-85 on the Flemish Cap.

Year	Year-class					
	A	B	C	D	E	F
1977					25	43
1978					34	49
1979				25	40	55
1980			25	37	55	73
1981		13	37	49	64	82
1982	10	31	55	64		
1983	22	46	67			
1984	37	61				
1985	43	76				
Slope	11.4	15.6	14.4	12.9	9.9	10.2
Intercept	-22584	-30889	-28488	-25505	-19548	-20125
R	.988	.999	.997	.998	.990	.978
N	4	5	4	4	5	5

Table 3. Predicted length in various years for assumed year-classes of cod.

Year	Year-class					
	A	B	C	D	E	F
1972						-10.6
1973						-.40
1974					-5.4	9.8
1975					4.5	
1976				-14.6		
1977			-19.2	-1.7		
1978			-4.8	11.20		
1979		-16.6	9.6			
1980	-12.0	-1.0				
1981	-.60	14.6				
1982	10.8					
Year-class	1981	1980	1978	1977	1974 1975	1973

Table 4. Comparison of modal lengths from length frequencies and average lengths from age determinations of various year-classes of cod.

Age	Year-class													
	1973		1974		1975		1977		1978		1980		1981	
	M	A	M	A	M	A	M	A	M	A	M	A	M	A
1											13	13.0	10	11.0
2					25	20.0	25	24.5	25	22.8	31	31.0	22	23.6
3			25	26.0	34	27.9	37	36.1	37	37.6	46	44.0	37	35.3
4	43	44.6	34	35.2	40	40.5	49	48.0	55	52.3	61	58.2	43	45.9
5	49	48.4	40	45.6	55	54.3	64	60.9	67	66.4	76	69.4		
6	55	56.3	55	59.5	64	62.5								
7	73	69.5	64	66.4										
8	82	75.6												

Table 5. Materials for the age consistency test.

	1977	1978	1979	1980	1982	1984
Number of otoliths	60	60	60	60	60	60
Number of readings	540	540	900	540	900	900
Number of intermediate modes	179 <sup>a</sup>	179 <sup>a</sup>	300	180	300	300

<sup>a</sup>Mode indeterminate for one specimen.

Table 6. Anomalies of modal readings from the grand mode.

Modal age	-2	-1	0	1	2	3	Total	% Agree
A. All years								
1			10				10	
2			68	2			70	
3		10	206	4			220	
4		5	236	4			245	
5		11	240	5		1	257	
6	1	6	219	1			227	
7	1	9	185	5	1		201	
8		2	64	2			68	
9		2	74	3			79	
10			36				36	
11	2		23				25	
Total	4	45	1361	26	1	1	1438	95
B. 1977								
2			3				3	
3		3	32	1			36	
4			29	1			30	
5		2	22				24	
6			37	1			38	
7		2	22				24	
8							-	
9			12				12	
10			12				12	
Total		7	169	3			179	94
C. 1978								
2			6				6	
3		1	38				39	
4		1	38				39	
5			27	1		1	29	
6		5	22				27	
7			21				21	
8			9				9	
9			-				-	
10			9				9	
Total		7	170	1		1	179	95
D. 1979								
2			24	1			25	
3		2	46	2			50	
4		1	59				60	
5			25				25	
6	1		84				85	
7		3	20	2			25	
8			13	2			15	
9			5				5	
10			-				-	
11			10				10	
Total	1	6	286	7			300	95

Table 6. Cont'd.

Modal age	-2	-1	0	1	2	3	Total	% Agree
E. 1980								
2			6				6	
3			30				30	
4		2	18	1			21	
5		2	36	1			39	
6		1	26				27	
7	1	1	34				36	
8		2	7				9	
9			11	1			12	
Total	1	8	168	3			180	93
F. 1982								
1			10				10	
2			19	1			20	
3		4	26				30	
4			45				45	
5		2	67	1			70	
6			5				5	
7		1	41	2	1		45	
8			25				25	
9		2	37	1			40	
10			5				5	
11	2		3				5	
Total	2	9	283	5	1		300	94
G. 1984								
2			10				10	
3			34	1			35	
4		1	47	2			50	
5		5	63	2			70	
6			45				45	
7		2	47	1			50	
8			10				10	
9			9	1			10	
10			10				10	
11			10				10	
Total		8	275	7			300	92

Table 7. Anomalies of readings from the overall mode.

Modal age	-2	-1	0	1	2	3	Total	% Agree
<b>A. All years</b>								
1			30				30	
2			216	18			234	
3		32	594	18	1		645	
4		20	675	22			717	
5		55	705	27	2	3	792	
6	2	17	636	18	2		675	
7	3	36	535	25	3	1	603	
8		8	186	10			204	
9		10	212	15			237	
10			108				108	
11	2	3	68	2			75	
Total	7	181	3965	155	8	4	4320	92
<b>B. 1977</b>								
2			9				9	
3		12	92	4			108	
4		1	79	1			81	
5		12	68	1			81	
6			106	10	1		117	
7		7	63	2			72	
8			-				-	
9			36				36	
10			36				36	
Total		32	489	18	1		540	91
<b>C. 1978</b>								
2			23	4			27	
3		3	105				108	
4		4	113				117	
5		1	85	8	2	3	99	
6		12	58	2			72	
7		1	62				63	
8		1	25	1			27	
9			-				-	
10			27				27	
Total		22	498	15	2	3	540	92
<b>D. 1979</b>								
2			73	2			75	
3		8	136	5	1		150	
4		4	171	5			180	
5		4	71				75	
6	2		247	6			255	
7		11	58	6			75	
8			38	7			45	
9			14	1			15	
10			-				-	
11			30				30	
Total	2	27	838	32	1		900	93



Table 7. Cont'd.

Modal age	-2	-1	0	1	2	3	Total	% Agree
E. 1980								
2			18				18	
3			95	4			99	
4		5	46	3			54	
5		9	104	4			117	
6		5	76				81	
7	3	4	101				108	
8		6	21				27	
9			33	3			36	
Total	3	29	494	14			540	91
F. 1982								
1			30				30	
2			63	12			75	
3		7	66	2			75	
4			134	1			135	
5		7	196	7			210	
6			15				15	
7		4	117	10	3	1	135	
8		1	72	2			75	
9		10	104	6			120	
10			15				15	
11	2	3	9		1		15	
Total	2	32	821	40	4	1	900	91
G. 1984								
2			30				30	
3		2	100	3			105	
4		6	132	12			150	
5		22	181	7			210	
6			134		1		135	
7		9	134	7			150	
8			30				30	
9			25	5			30	
10			30				30	
11			29		1		30	
Total		39	825	34	2		900	92

Table 8. Agreement of original age readings with the grand mode.

Year	Number agreed	Number over	Number under	Total	% Agreed	% Over	% Under	Total
1977	51	5	4	60	85	8	7	100
1978	44	15	1	60	73	25	2	100
1979	42	18	-	60	70	30	-	100
1980	54	3	3	60	90	5	5	100
1982	51	4	5	60	85	7	8	100
1984	51	2	7	60	85	3	12	100
Total	293	47	20	360	81	13	6	100

Table 9. Age compositions and average lengths at age from overall length frequencies and age-length keys of 60 otoliths each.

Age	Age composition				Average length			
	Mode 1978	Original 1978	Mode 1979	Original 1979	Mode 1978	Original 1978	Mode 1979	Original 1979
2	13	13	467	259	19.0	19.0	25.5	25.0
3	1439	1439	219	326	29.2	29.2	35.2	27.9
4	3427	1973	1060	782	37.1	35.2	43.1	41.1
5	2583	3771	329	708	54.5	48.3	45.1	45.8
6	507	701	764	507	64.2	61.8	56.9	56.3
7	57	107	109	360	86.6	80.7	61.4	58.7
8	17	27	8	4	89.2	87.3	96.3	88.0
9	-	20	1	8	-	89.8	91.0	92.5
10	20	12	-	1	96.4	102.0	-	91.0
11			3	4			112.0	104.5
12				1				112.0
	8063	8063	2960	2960				

Table 10. Sampling by geographical area and depth zone for certain years.

Year	By quadrant				By depth zone				Total otoliths	Total measurements
	1	2	3	4	1	2	3	4		
1978	443	460	515	465	384	617	582	300	1883	13982
1983	1513	872	654	728	570	1543	1591	63	3767	14622
1984	965	515	901	974	206	792	1951	406	3355	4967
1985	1278	198	1131	1633	204	1206	1875	955	4240	5631

Table 11. Age composition of cod on the Flemish Cap and average length at age by geographical area and depth zone for the year 1978.

Age	I	II	III	IV	Total	I	II	III	IV	Total
A. Geographical area										
1	-	18	26	13	18	19.52	20.47	19.00	19.00	19.50
2	1101	1120	744	728	920	28.04	28.46	27.36	27.36	27.88
3	2852	2807	2524	3251	2852	35.85	36.00	33.90	34.86	35.16
4	8551	8101	6744	8254	7888	49.11	48.51	46.92	48.88	48.40
5	1347	1759	3732	1535	2116	61.54	60.47	55.32	60.84	58.30
6	46	72	108	97	85	81.88	79.29	73.22	80.29	77.70
7	22	36	36	32	33	89.30	88.43	84.84	87.71	87.32
8	13	4	16	5	12	101.03	112.00	88.48	85.00	94.50
9	13	29	29	18	28	103.94	99.42	94.28	88.68	95.94
10	6	14	9	11	13	110.77	101.15	98.90	91.74	101.21
11	-	-	-	-	3	-	124.00	103.00	-	110.52
12	-	2	4	4	6	97.57	105.01	123.32	-	110.29
13	11	5	4	-	2	-	116.19	112.73	112.00	115.00
14	-	4	8	7	7	-	115.00	-	115.00	115.00
15	-	-	1	-	1	-	-	103.00	-	103.00
>15	-	-	2	-	1	-	-	-	-	103.00
Total	13960	13979	13974	13951	13982					

B. Depth zone

Age	I	II	III	IV	Total	I	II	III	IV	Total
A. Geographical area										
1	21	16	16	16	19.87	19.61	19.61	19.61	19.61	19.61
2	1102	952	705	705	28.38	27.81	27.81	27.55	27.55	27.81
3	2975	3180	2680	1684	35.89	35.72	34.24	34.24	35.75	35.75
4	7868	7123	8760	7804	48.75	48.51	48.24	47.90	47.90	47.90
5	1855	2470	1644	2654	59.96	57.52	58.52	56.49	56.49	56.49
6	78	124	87	92	82.94	70.48	81.60	82.27	82.27	82.27
7	21	32	30	14	86.79	88.55	84.99	84.50	84.50	84.50
8	8	12	9	-	107.04	91.44	89.33	-	-	89.33
9	22	32	26	21	96.21	90.28	100.13	101.87	101.87	101.87
10	7	17	14	-	105.05	97.39	102.12	-	-	102.12
11	6	2	-	-	108.85	103.00	-	-	-	103.00
12	4	13	-	-	103.00	109.22	-	-	-	109.22
13	8	3	7	-	113.12	113.77	112.00	-	-	112.00
14	1	-	-	-	115.00	-	-	-	-	115.00
15	-	-	-	-	-	-	-	-	-	-
>15	-	2	-	-	103.00	-	-	-	-	103.00
Total	13976	13979	13961	12269						

Table 12. Age composition of cod on the Flemish Cap and average length at age by geographical area and depth zone for the year 1983.

Age	I	II	III	IV	All	I	II	III	IV	All
A. Geographical Area										
0	47	63	57	47	52	12.15	12.91	12.59	11.85	12.37
1	12430	12293	12536	12455	12420	23.61	23.57	23.68	23.62	23.61
2	1447	1374	1306	1407	1427	44.09	42.06	45.03	44.54	43.95
3	41	217	44	34	58	53.38	49.65	52.17	50.23	50.96
4	488	428	355	393	417	67.22	66.10	65.69	65.91	66.37
5	107	154	244	218	171	75.44	71.72	71.20	73.14	72.50
6	10	8	11	-	8	74.37	78.82	73.14	-	76.37
7	8	37	6	21	15	82.00	82.34	84.48	80.49	82.19
8	3	17	11	-	12	91.00	79.24	83.24	-	83.71
9	19	13	40	14	42	93.05	107.15	90.73	101.50	94.79
10	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-
15	-	1	-	-	1	-	133.00	-	-	133.00
>15	-	1	-	-	1	-	118.00	-	-	118.00
Total	14599	14606	14610							

B. Depth Zones

Age	I	II	III	IV	Total	I	II	III	IV	Total
A. Geographical Area										
0	80	50	26	-	13.57	12.22	13.00	-	-	13.00
1	12482	12403	12434	11403	23.65	23.61	23.60	24.07	24.07	23.65
2	1246	1364	1455	1158	44.89	43.31	44.21	44.92	44.92	44.89
3	104	130	40	73	47.74	49.72	54.67	52.00	52.00	47.74
4	477	504	353	266	65.19	66.81	66.52	62.51	62.51	65.19
5	140	104	229	232	72.80	74.98	71.88	71.81	71.81	72.80
6	9	17	5	-	79.10	73.62	77.23	-	-	79.10
7	33	14	11	8	81.38	85.00	83.16	82.00	82.00	81.38
8	18	9	8	6	78.97	89.00	84.84	76.00	76.00	78.97
9	18	9	33	74	104.33	104.00	93.48	86.66	86.66	104.33
10	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-
15	1	-	-	-	133.00	-	-	-	-	133.00
>15	1	-	-	-	118.00	-	-	-	-	118.00
Total	14611	14603	14595	13220						

Table 13. Age composition of cod on the Flemish Cap and average length at age by geographical area and depth zone for the year 1984.

Age	I	II	III	IV	All	I	II	III	IV	All
A. Geographical Area										
1	9	6	13	13	14.64	13.00	13.00	21.75	14.56	14.64
2	412	427	330	452	21.83	21.52	21.52	35.16	22.04	21.83
3	3889	3817	4005	3862	35.32	35.23	35.23	58.18	35.52	35.32
4	398	480	379	396	58.86	58.43	56.88	66.78	58.50	58.18
5	14	7	16	15	65.95	61.06	66.78	80.07	65.22	65.95
6	68	12	118	101	80.64	80.70	80.71	84.30	80.64	80.64
7	48	-	77	69	85.11	82.00	85.09	88.00	85.11	85.11
8	-	-	2	3	92.31	-	97.00	92.35	92.31	92.31
9	-	5	7	12	95.17	97.00	96.08	95.17	95.17	95.17
10	22	-	14	-	95.29	95.64	95.62	95.29	95.29	95.29
11	1	3	5	31	100.85	118.00	96.83	94.22	100.85	100.85
12	-	-	-	-	109.00	109.00	-	-	109.00	109.00
13	3	-	-	-	103.00	103.00	-	-	103.00	103.00
14	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-
>15	-	-	1	-	130.00	-	130.00	-	-	130.00
	4866	4760	4954	4953	4967					

B. Depth Zone

Age	I	II	III	IV	I	II	III	IV
1	6	7	15	-	13.00	16.00	14.81	-
2	351	363	457	262	21.42	21.55	22.08	23.26
3	3862	3960	3844	3872	34.90	35.27	35.52	35.33
4	447	381	411	382	54.77	58.86	58.38	58.72
5	19	13	15	-	58.00	63.13	69.95	-
6	21	113	122	97	67.39	81.17	80.78	80.64
7	48	91	53	73	82.00	83.58	86.16	82.87
8	-	5	4	-	-	97.00	88.00	-
9	5	6	12	-	97.00	96.00	94.43	-
10	6	10	12	6	100.00	101.00	92.47	76.00
11	-	3	11	45	-	97.17	94.82	96.20
12	3	-	-	-	109.00	-	-	-
13	-	2	-	-	-	103.00	-	-
14	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-
>15	-	-	1	-	-	-	130.00	-
	4768	4954	4958	4737				

Table 14. Age composition of cod on the Flemish Cap and average length at age by geographical area and depth zone for the year 1985.

Age	I	II	III	IV	All	I	II	III	IV	All
A. Geographical Area										
1	2	93	113	4	6	10.00	-	13.00	-	12.00
2	108	1016	996	58	86	21.08	20.51	21.31	19.99	20.71
3	974	3735	4231	1109	1038	29.39	29.05	29.58	29.45	29.41
4	4355	129	224	4223	4269	45.96	45.10	45.78	46.02	45.94
5	135	129	170	173	173	72.84	62.12	66.68	69.75	69.44
6	6	-	10	15	11	76.00	-	76.87	75.75	75.90
7	18	20	11	17	18	89.50	89.01	87.38	87.56	88.85
8	-	15	5	10	15	-	92.34	89.66	88.15	91.37
9	-	-	3	-	1	-	-	94.00	-	94.00
10	-	2	-	4	2	-	112.00	-	97.00	104.50
11	-	-	3	1	4	-	107.50	109.00	106.00	106.75
12	-	1	7	7	5	-	115.00	103.41	111.31	105.90
13	-	2	-	2	2	-	112.00	-	109.00	110.50
14	-	2	-	-	2	-	121.00	-	-	121.00
>15	-	-	-	-	-	-	-	-	-	-
	5597	5017	5607	5615	5631					
B. Depth zone										
1	2	4	62	46	6	10.00	13.00	-	-	-
2	181	75	1123	1087	46	21.44	20.49	20.76	19.00	-
3	988	985	4199	4101	1087	31.39	29.15	29.36	31.02	-
4	4155	4316	179	165	4101	45.72	45.66	46.14	46.05	-
5	84	134	10	11	165	53.98	66.69	69.34	69.85	-
6	-	12	10	11	11	-	76.00	75.82	75.97	-
7	18	9	17	19	19	89.50	91.00	88.97	88.82	-
8	-	3	8	16	16	-	94.00	86.11	92.19	-
9	-	3	-	-	-	-	94.00	-	-	-
10	-	-	4	2	2	-	-	97.00	112.00	-
11	5	-	3	1	1	112.00	-	107.08	100.00	-
12	1	-	7	5	5	115.00	-	105.00	110.07	-
13	-	-	2	2	2	-	-	109.00	112.00	-
14	-	-	-	2	2	-	-	-	121.00	-
>15	-	-	-	-	-	-	-	-	-	-
	5435	5540	5612	5456	5456					

Table 15. Level of agreement between readers and modal age in otolith exchanges at the St. John's laboratory.

Reader	# Exchanges	% Agree	Stand dev.	% Over
A	46	90	6.0	6
B	46	87	8.7	6
C	25	80	10.3	14
D	32	76	9.5	7
E	16	87	8.1	8
F	14	79	13.3	18
Total	179	84	10.2	8
G	3	31	25	

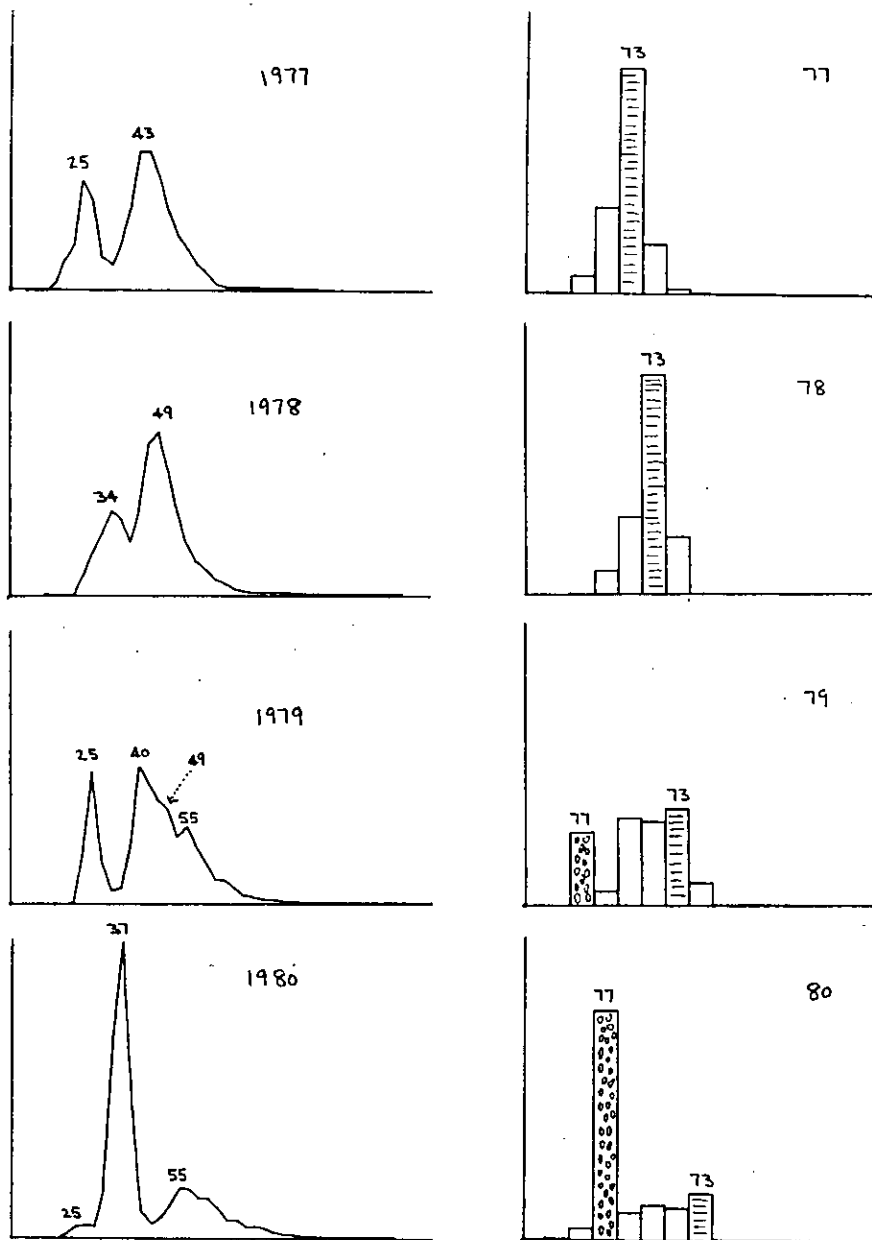


Fig. 1. Length and age frequencies for Flemish Cap cod, 1977-85.

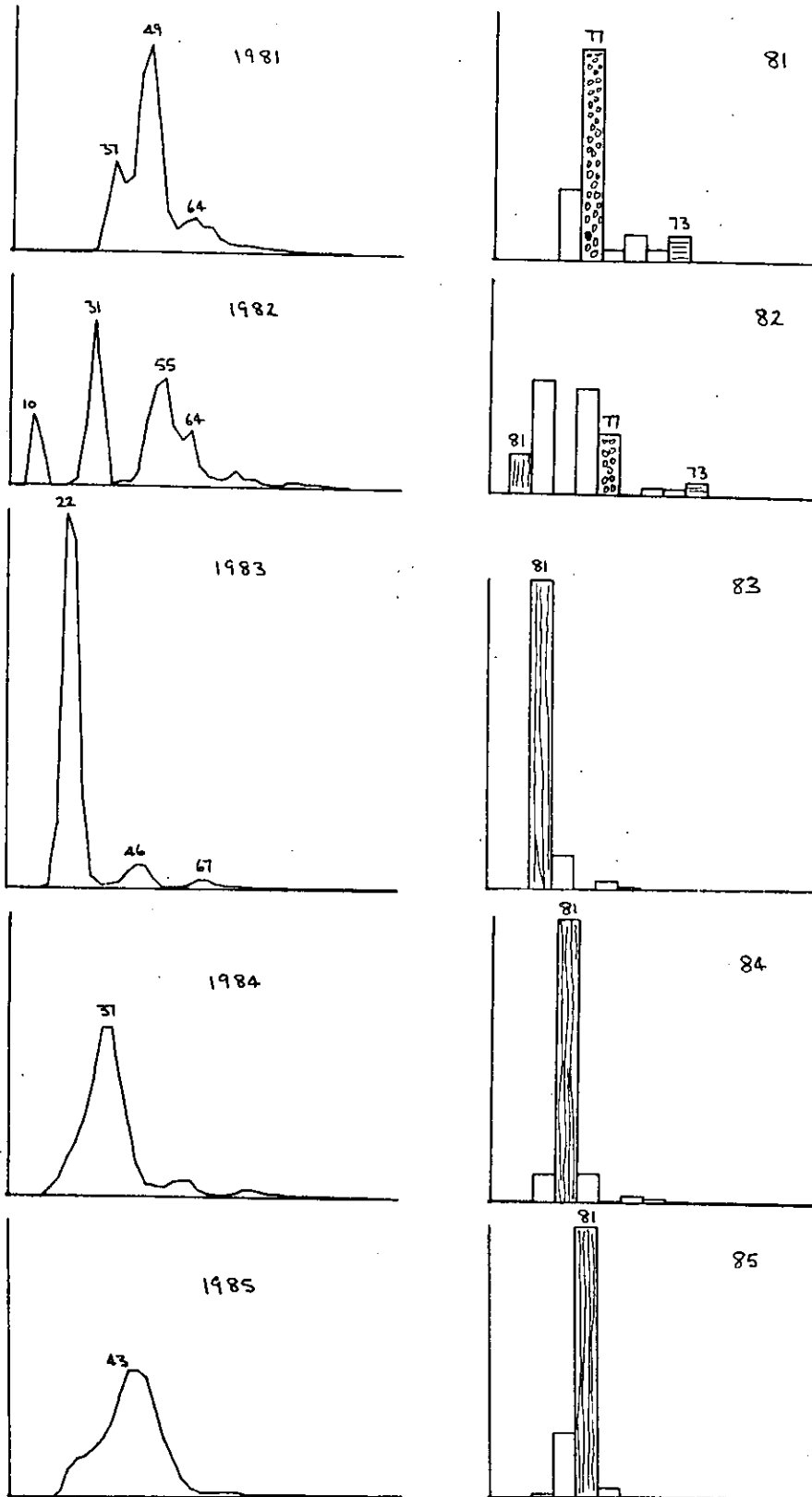


Fig. 1. (Continued)

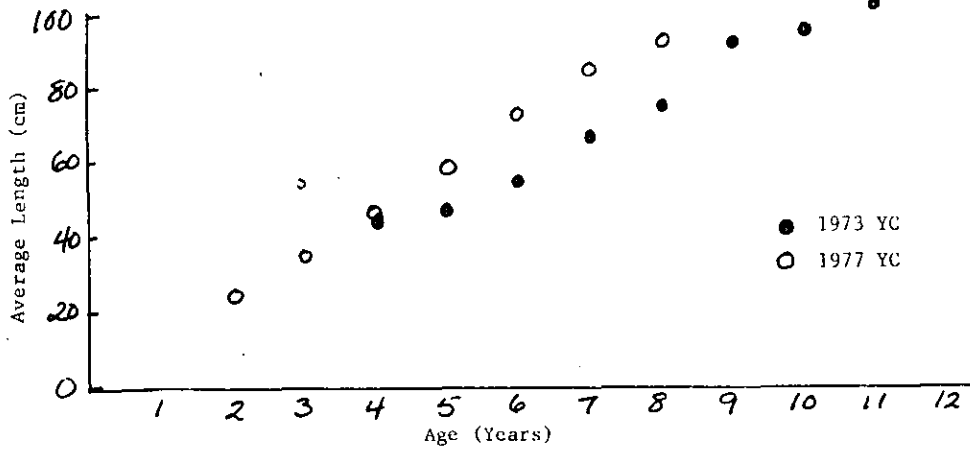


Fig. 2. Average fork length at age for cod of year classes 1973 and 1977 on the Flemish Cap.

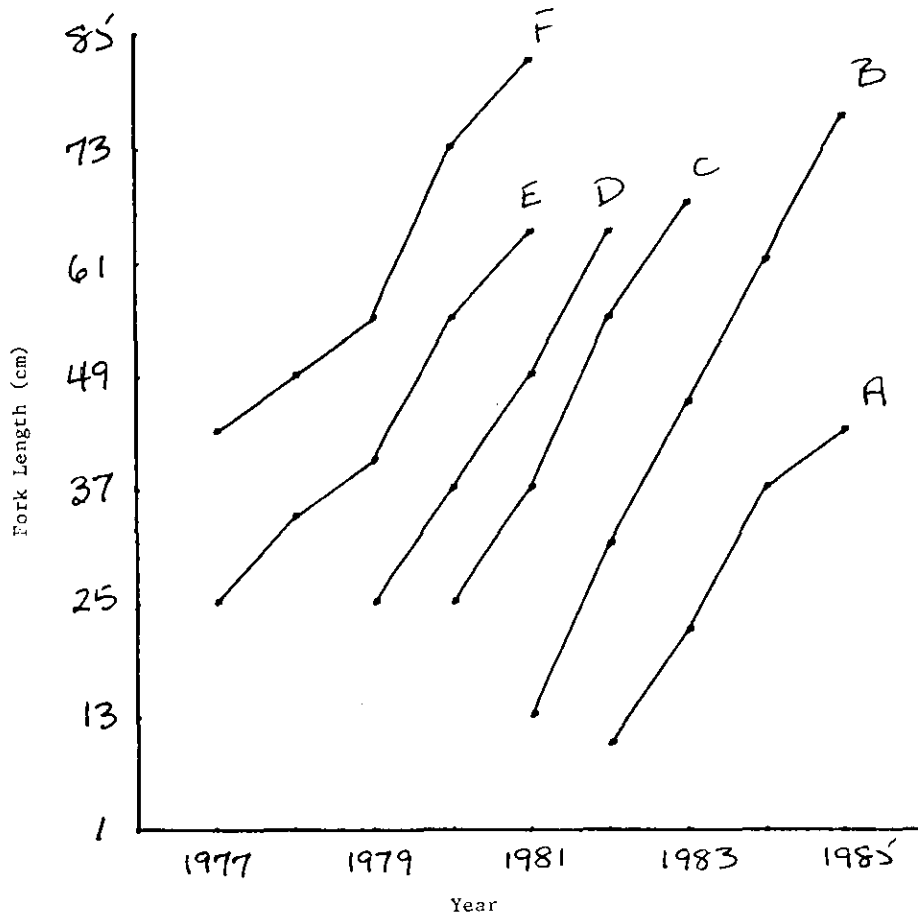


Fig. 3. Average length at age of six presumed year classes of cod on the Flemish Cap.

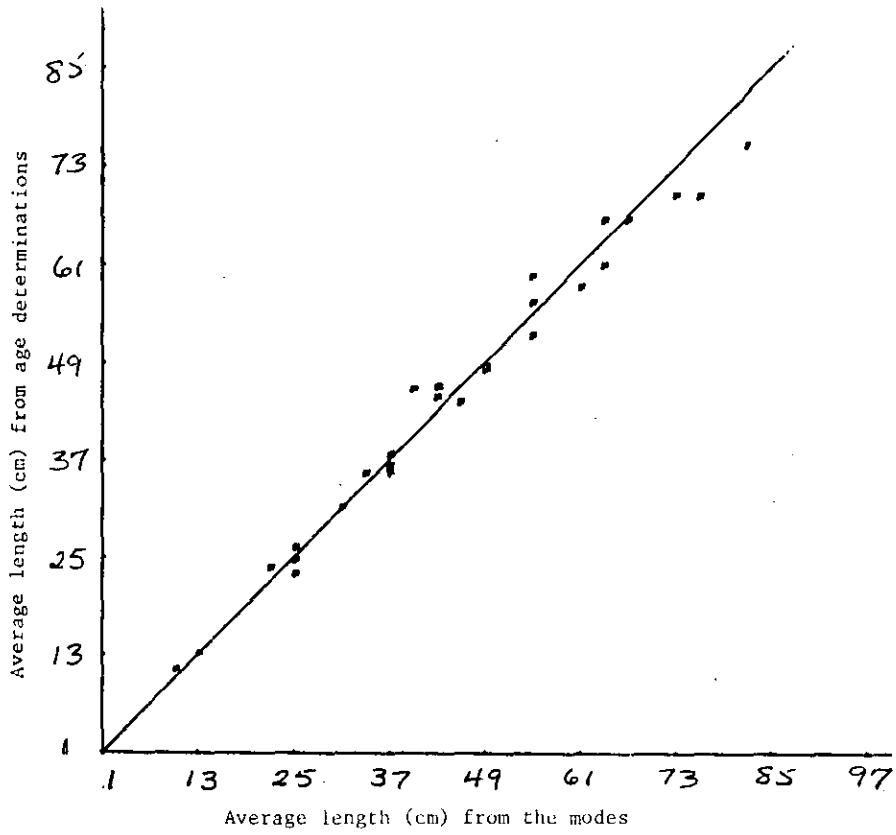


Fig. 4. Comparison of average lengths of certain year classes as derived from modal lengths and from age determinations.

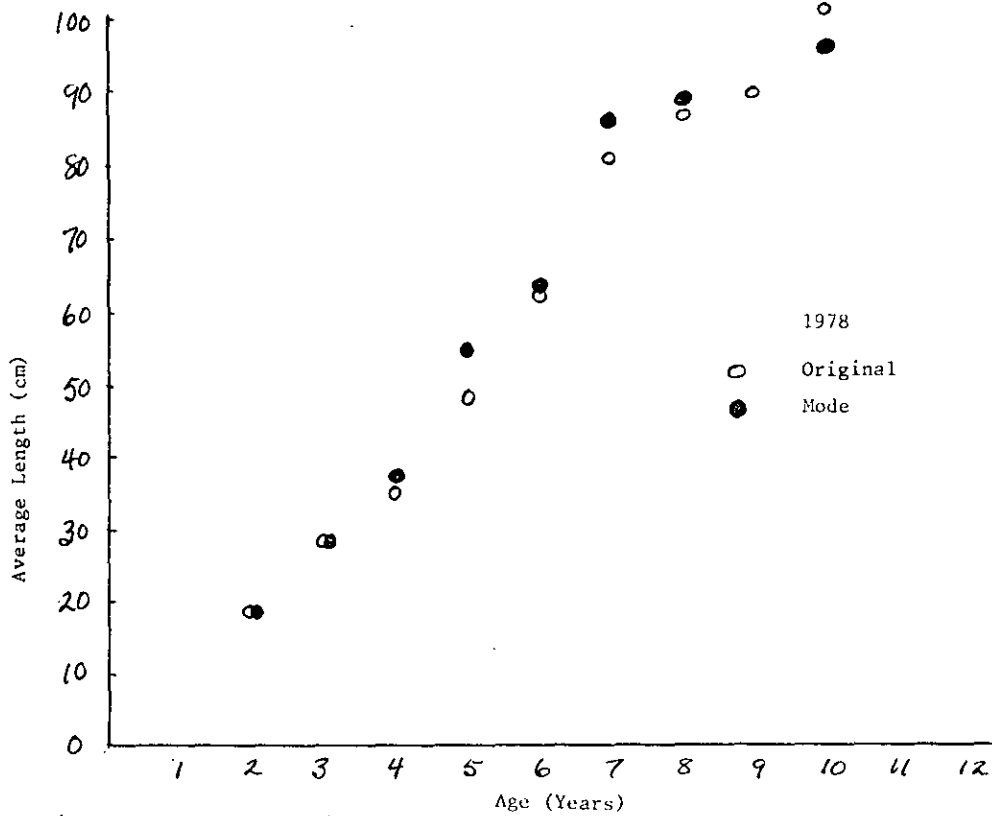


Fig. 5. Average length at age derived from modal ages and from the original ages in 1978.



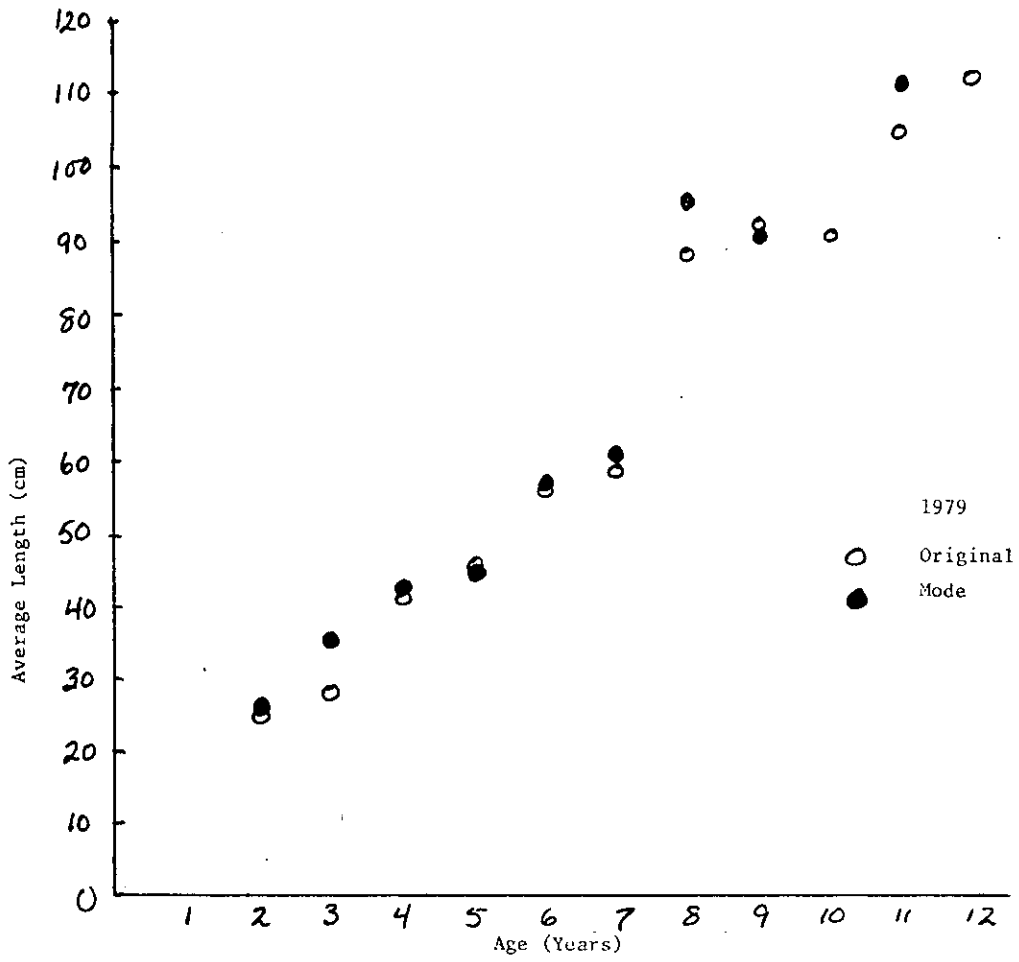


Fig. 6. Average length at age derived from modal ages and from the original ages in 1979.