RESULTS OF THE CCAMLR ANTARCTIC FISH OTOLITHS/SCALES/BONES EXCHANGE SYSTEM

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Abstract

An exchange system was established among Members of CCAMLR to compare age determinations for the same species among different laboratories. Four species were included in the exchange: *Notothenia rossii, Champsocephalus gunnari, Notothenia gibberifrons* and *Pleuragramma antarcticum.* The level of agreement in age determination was highest for scales of juvenile *N. rossii* and for otoliths of juvenile *C. gunnari* from South Georgia and lowest for scales of adult *N. rossii* and *N. gibberifrons* and otoliths of *P. antarcticum.* Agreement between otoliths and scales of individual *N. gibberifrons* was in the order of 50%. There was little indication that agreement between experienced investigators was higher than between experienced and less experienced ones.

Résumé

Un système d'échange a été établi parmi les Membres de la CCAMLR afin de comparer la détermination de l'âge d'une même espèce effectuée par des laboratoires différents. Quatre espèces sont comprises dans ce système d'échange: *Notothenia rossii, Champsocephalus gunnari, Notothenia gibberifrons* et *Pleuragramma antarcticum.* Le niveau de conformité de détermination de l'âge le plus élevé concernait les écailles de *N. rossii* juvénile et les otolithes de *C. gunnari* juvénile de la Géorgie du Sud. L'écart le plus important concernait les écailles de *N. rossii* et *N. gibberifrons* adultes, et les otolithes de *P. antarcticum.* La conformité entre les otolithes et les écailles d'individus de *N. gibberifrons* était de l'ordre de 50%. Il n'est pas vraiment évident que la conformité parmi les chercheurs expérimentés ait été plus élevée qu'entre les chercheurs moins expérimentés et ceux qui l'étaient.

Резюме

Членами АНТКОМа была создана система обмена информацией по определению возраста одного и того же вида рыбы в различных лабораториях. Эта система охватывала четыре вида: *Notothenia rossii, Champsocephalus gunnari, Notothenia gibberifrons* и *Pleuragramma antarcticum.* Согласованность результатов была наивысшей при определении возраста молоди *N. rossii* по чешуе и молоди *C. gunnari* по отолитам для района Южной Георгии, тогда как результаты определения возраста по чешуе у половозрелых особей *N. rossii* и *N. gibberifrons*, а также по отолитам *P. antarcticum* имели меньшую степень согласованности. Данные, полученные в результате исследования отолитов отдельных особей *N. gibberifrons* в

50% случаев совпадают с данными, полученными в результате исследований чешуи отдельных особей этого же вида. Не существует значительных свидетельств того, что результаты анализа, проведенного опытными лаборантами, совпадают в большем количестве случаев, чем результаты анализа, выполненного более и менее опытными исследователями.

Resumen

Un sistema de intercambio se estableció entre los Miembros de la CCRVMA para comparar las determinaciones de edad para la misma especie entre los diferentes laboratorios. Cuatro especies fueron incluidas en el intercambio: *Notothenia rossii, Champsocephalus gunnari, Notothenia gibberifrons* y *Pleuragramma antarticum*. El nivel de acuerdo fue alto en relación a la determinación de edad concerniendo las escamas de *N. rossii* juvenil y los otolitos de *C. gunnari* juvenil proveniente de Georgia del Sur. Sin embargo no hubo tanto acuerdo acerca de las escamas de *N. rossii* y *N. gibberifrons* adultos y los otolitos de *P. antarticum*. Acuerdo entre otolitos y escamas de *N. gibberifrons* individuales fue del orden del 50%. Hubo poca indicación de que acuerdo entre los investigadores más experimentados fuese más alto que aquel entre investigadores más y menos experimentados.

1. INTRODUCTION

Following a recommendation of the CCAMLR Fish Age Determination Workshop held in Moscow from 14 to 19 July 1986 (SC-CAMLR-VII/BG/41), an exchange system was established among Members of CCAMLR to examine otoliths, scales and bones of selected species of Antarctic fish. Samples were kindly provided by the USSR, United Kingdom and Argentina. Laboratories of the following Members took part in the exchange: USSR , Poland, German Democratic Republic, Federal Republic of Germany, United Kingdom, Spain, Argentina and Australia. Reports on the progress of the exchange were submitted to the Scientific Committee of CCAMLR in 1987 (SC-CAMLR-VI/BG/26 Rev. 1) and 1988 (WG-FSA-88/30).

The exchange was terminated before 1 August 1989 despite only five of the six samples available having been circulated among all interested Members. The status of one sample is unknown at present.

2. MATERIAL AND METHODS

The following samples were made available for the exchange:

(i) Scales of adult *Notothenia rossii* from South Georgia and the South Shetland Islands (Table 1) mounted on microscopic slides. Sample size: 46. Six slides sent were broken during mailing, therefore only 40 specimens could be included in the exchange. Samples covered the length range of 39 to 70 cm. Sources: VNIRO, AtlantNIRO (USSR).

(ii) Scales of juvenile *N. rossii* from Potter Cove (South Shetland Islands) (Table 2) mounted on microscopic slides. Sample size: 50. Specimens of 23.5 to 44.3 cm length were available. Source: Instituto Antártico Argentino (Argentina).

(iii) Scales of *Notothenia gibberifrons* from South Georgia and the South Shetland Islands (Table 3). Sample size: 58. Five slides were broken during transportation, therefore only 53 specimens could be included in the exchange. Length of the specimens ranged from 10.9 to 46.2 cm. Sources: VNIRO, AtlantNIRO (USSR).

(iv) Scales and otoliths of *N. gibberifrons* from South Georgia (Table 4). Sample size: 81. Otoliths were prepared according to the Bedford method; scales were in vials, but were mounted on microscopic slides by the Convener in the course of the exchange. Both otoliths and scales of 57 specimens were available. Samples covered the length range of 7.7 to 43.2 cm. Source: British Antarctic Survey (UK).

(v) Otoliths of *Champsocephalus gunnari* from South Georgia, the South Orkney Islands and South Shetland Islands (Table 5). Sample size: 70. Four otoliths were lost during transportation, therefore only 66 otoliths were available for the exchange. Specimens of 7.3 to 48.7 (57.5) cm in length were present in the sample. Sources: VNIRO, AtlantNIRO (USSR).

(vi) Otoliths of *Pleuragramma antarcticum* from the Mawson Sea (East Antarctic) (Table 6). Sample size: 50. Two otoliths were broken during transportation, therefore only 48 otoliths were included in the exchange. Size of specimens ranged from 12.4 to 20.6 cm. Source: YugNIRO (AzcherNIRO) (USSR).

Techniques used in various laboratories for ageing Antarctic fish were described in

SC-CAMLR-VII/BG/41 and in various scientific publications. These methods are summarized below:

(i) *Notothenia rossii*: Scales and otoliths were used to age *N. rossii*. Checks observed on both structures were validated to form annuli (scales: Sherbich, 1975; Freytag, 1980; otoliths: Burchett, 1983). Due to the delicacy of the otoliths and the amount of time taken to extract and prepare them, scales are commonly used in most laboratories for routine age determination. Scales located just below the lateral line under the pectoral fin were found to be most suitable for ageing. Scales are usually cleaned by soaking them in 10% ammonia (VNIRO, AtlantNIRO) or in a soap solution (Sea Fisheries Institute, Hamburg) and then mounted wet between two microscopic slides. Scales are then examined with a binocular microscope using transmitted light and various magnifications. Otoliths are prepared in two ways: either 'cracked and charred' (Möller Christensen, 1964) or sectioned after being embedded in polyester resin (Bedford, 1983).

(ii) *Notothenia gibberifrons*: This species is routinely aged by scales prepared similarly to those of *N. rossii* (Boronin and Frolkina, 1976; Skora, 1980; Kompowski, 1983) and by sections of the first ventral fin ray (GDR: Hoffmann, 1982), as described by Gubsch (1980) for *Chaenocephalus aceratus*. Occasionally otolith sections have been used for ageing (North et al., 1980; Clasing et al., 1985). However, so far only the first three to four annuli on scales have been tentatively validated by plotting polymodal curves of the total number of sclerites versus fish age (Boronin and Frolkina, 1976).

(iii) *Champsocephalus gunnari*: Channichthyids lack scales. Routine age determinations are carried out using otoliths (whole otoliths: Kock, 1981; Frolkina unpubl.; cracked: Sosinski, 1981; sections: Kochkin, 1985), vertebrae (Kochkin, 1985) and sections of the first ventral fin ray (Gubsch, 1982). Whole otoliths are kept in alcohol (Frolkina, unpubl.) or glycerine (Kock, 1981). For examination they are placed in camphor oil for a maximum of 10 to 15 minutes, otherwise they become opaque (Frolkina, unpubl.). Whole and sectioned otoliths, vertebrae and sections of the first ventral fin ray are examined either via transmitted light (Frolkina, Kochkin) or reflecting light against a black background (Kock, Gubsch, Sosinski). The first two to three annuli identified on whole otoliths have been validated by distinct peaks in ploymodal frequency curves (Kock, 1981; Slosarczyk, 1987).

(iv) *Pleuragramma antarcticum*: Scales, otoliths and coracoid bones were examined for age determination by Gerasimchook. Scales were found to be unsuitable due to the even distribution of sclerites which were impossible to separate into "fast" and "slow" growth zones. The coracoid was also found to be unsuitable and staining with alizarin did not enhance the internal structures. Poor calcification of the skeleton of *P. antarcticum* is the most probable reason for this lack of distinct rings (Gerasimchook in SC-CAMLR-VII/BG/41).

Sagittal otoliths were proved to be suitable for estimating age. Two different techniques are used for age determination.

(i) Otoliths are examined in glycerine via transmitted light. However, otoliths should not be kept for "long periods" in glycerine because this results in the otoliths becoming irreversibly transparent (Gerasimchook, in SC-CAMLR-VII/BG/41).

(ii) A different technique has been used by Hubold and Tomo (1989). They have examined otoliths in glycerine against a black background under reflected light.

The first two annuli identified by both techniques have been validated by comparing them with prominent peaks in length frequency compositions which are supposed to represent the first two age classes (Gerasimchook, pers. comm.; Hubold and Tomo, 1989).

Analysis of the results of the otoliths/scales/bones exchange was mainly based on the level of agreement either among all investigators or within pairs of investigators. Agreement, however, was not only assumed when 'readers' estimated the same age (e.g. 5 and 5) but also when one of the investigators only gave an approximation (e.g. 5 and 5/6 or 5?). It is obvious that this should lead to an increase of 'positive' results. Agreement among all of the investigators was evaluated under two provisions:

(i) full agreement; and
(ii) full agreement or deviations of not more than one year.

The 'birthday' of Antarctic fish is commonly accepted as 1 July. However, one reader (Barrera-Oro, Argentina) took 1 October as the 'birthday' for *N. rossii* as annuli in its scales were observed as incomplete before that date.

3. RESULTS

3.1 *Notothenia rossii* (Adults)

Results of ageing are set out in Table 1. Three of the four investigators (1, 3 and 4) were experienced in determining the age of the species; one investigator (2) was less experienced.

Age classes 4 to 12/13 were identified from the sample.

Full agreement among all readers: 0
Full agreement among experienced readers: 0

The following table demonstrates the agreement (in %) among all of the investigators:

	Reader	Full Agreement (%) 1	2	3	4
Full agreement/ deviation = 1 year (%)	1	X	29.0	28.2	10.3
	2	76.3	X	48.7	35.1
	3	81.1	89.2	X	59.9
	4	66.7	88.5	84.2	X

With the exception of readers 2 and 4, full agreement between two readers was usually much less than 50%. If one allows for a deviation of one year, agreement among most readers was more than 80%. Deviations were more common as length (= age) of fish increased.

Although true age of the specimens was not known, some investigators (2, and 4) tend to attribute higher ages to the specimens than others, irrespective of the length of the specimens (Figures 1 and 2).

3.2 *Notothenia rossii* (Juvenile)

Results of age determinations are set out in Table 2. Two of the three investigators (1 and 2) were experienced and one (3) was less experienced. Age classes 3 to 7 were identified from the samples.

Full agreement among all readers:	37	(74.0%)
Full agreement among experienced readers:	39	(78.0%)
Full agreement or deviation of not more than one year among all readers:	50	(100%)

The following table indicates that agreement between two readers was in the order of 80%. Agreement could have been even higher if 'reader' 1 had not used 1 October as the 'birthday' instead of 1 July. Except in one case, however, no deviation of more than one year was observed.

		Full Agreement (%)		
	Reader	1	2	3
Full agreement/ deviation = 1 year (%)	1	X	78.0	84.0
	2	100.0	X	80.0
	3	100.0	98.0	X

3.3 *Notothenia gibberifrons*

Results of age determinations from scales only are given in Table 3. Three investigators were experienced (1, 4 and 5) and two (2 and 3) had less experienced with the species. Age classes 1 to 14/15 were identified from the samples.

Full agreement among all readers:	0	
Full agreement or deviation of not more than one year among readers:	1	(2.4%)

The following table demonstrates that the level of agreement between two readers was approximately 25%, except in experienced readers when it was 38.0%. Even allowing for one year of deviation among readers, agreement did not reach more than 50 to 60%.

		Full Agreement (%)				
	Reader	1	2	3	4	5
Full agreement/ deviation = 1 year (%)	1	X	24.4	22.9	38.0	12.0
	2	60.0	X	26.2	25.6	7.0
	3	54.2	47.6	X	16.7	6.0
	4	71.2	50.0	55.3	X	20.4
	5	32.0	11.6	24.4	46.9	X

Less experienced readers tended to attribute higher ages to the specimens than did experienced investigators, irrespective of the fish length (Figures 3 and 4).

Results of ageings on a second set of samples containing scales and otoliths are set out in Table 4. Age classes 1 to 15 were identified from the samples.

Comparison of age determination from scales did not reveal results substantially different from those described for the first set. Analysis is therefore confined to a comparison of age determinations from both otoliths and scales. However only three of the five investigators examined both structures. Two (4 and 5) were experienced and one (2) was less experienced.

Full agreement between ages determined from otoliths and scales was observed in 45.5% (reader 2), 52.6% (5) and 67.3% (4) of the samples respectively. One of the investigators (5) attributed generally (87%) higher ages to scales compared to otoliths of the same specimens, whereas the other two did not.

3.4 *Champsocephalus gunnari*

Results of comparative age determinations are given in Table 5. Two of the investigators were experienced (1 and 3), one was experienced in ageing *C. gunnari* by fin ray sections but not by otoliths (2) and one was less experienced. Age classes 0 to 9 were identified from the samples.

Full agreement among all investigators: (Agreement, however, was mostly confined to age classes 0 and 1 and then substantially decreased).	18.0%
Full agreement or deviation of not more than one year:	72.1%

Agreement was mostly confined to the first three age classes (0 to 2).

The following table demonstrates that agreement was highest between readers 2 and 3 (62.3%).

		Full Agreement (%)			
	Reader	1	2	3	4
Full agreement/ deviation = 1 year (%)	1	X	40.6	46.8	41.0
	2	73.4	X	62.3	39.7
	3	78.7	88.3	X	46.3
	4	82.3	91.1	94.2	X

Agreement between pairs of experienced readers and among less experienced readers (except 2 and 3) did not differ considerably.

Readers 1 and 4 tended to attribute higher ages to fish of the same size more so than did readers 2 and 3. This was consistent in all three populations of *C. gunnari* for which material was available (Figures 5 to 7).

3.5 *Pleuragramma antarcticum*

Results of ageings are shown in Table 6. Three investigators (1, 2 and 3) were experienced with the species and one was (4) less experienced. Age classes 2 to 12 were identified from the sample.

Full agreement among experienced readers existed in 20.8% of all samples. Allowing for one year of deviation, agreement increased to 52.1%.

The following table demonstrates the agreement between pairs of readers.

		Full Agreement (%)			
	Reader	1	2	3	4
Full agreement/ deviation = 1 year (%)	1	X	26.2	37.5	4.2
	2	76.2	X	34.2	26.8
	3	78.7	65.9	X	11.1
	4	43.5	42.5	33.3	X

The same difference among experienced and less experienced readers as indicated above is also evident from this table. Less experienced investigators attributed generally lower ages to fish of the same size than did experienced readers (Figure 8).

4. DISCUSSION

Since the beginning of the 1970s, many studies on age and growth of Antarctic fish have been published. Most of them deal with commercially exploited nototheniids and channichthyids. The first comparative age determinations were carried out during two ageing workshops of the BIOMASS Working Group on Antarctic Fish Biology in 1979 and 1982 (Anon, 1980 and 1982).

Results, however, in particular those obtained during the second workshop are not directly comparable to the CCAMLR otoliths/scales/bones exchange as other species (*Dissostichus eleginoides, Nototheniops larseni, Notothenia squamifrons*) were included.

As in fish from temperate waters, otoliths and scales are widely used for ageing Antarctic fish (Kock, Duhamel and Hureau, 1985). Except for cross sections of the first ventral fin ray (Gubsch, 1980; Hoffmann, 1982), other bony structures (vertebrae, coracoid, cleithrum, operculum and hypural) proved to be less successful for the identification of annuli. However, age determination is still far from being reliable and considerable differences exist between findings of different authors for one species. This is clearly underlined by the results of the CCAMLR Age Determination Workshop in Moscow in 1986 and findings of the CCAMLR otoliths/scales/bones exchange.

Agreement among investigators was high for scales of juvenile *N. rossii* from coastal waters of the South Shetland Islands and for otoliths of juvenile *C. gunnari* from South Georgia (age class 0 to 1). Agreement decreased in this species, however, from age class 2 onwards. Agreement was lowest for scales of adult *Notothenia rossii marmorata* and *N. gibberifrons* and otoliths of *P. antarcticum*. Agreement between otoliths and scales of individual *N. gibberifrons* varied from 45.5 to 67.3% depending on the investigator. One of the experienced investigators (5) of *N. gibberifrons* otoliths and scales tended to attribute higher ages to scales compared to otoliths, whereas the other two did not. This may indicate

that scales which are subject to replacement and resorption do not necessarily exhibit more 'checks' which would mislead investigators into attributing a higher age to them *per se* (at least in *N. gibberifrons*).

There was little indication that agreement among experienced readers was higher than among experienced and less experienced investigators.

One important reason for the observed low level of agreement among readers of most species is likely to be associated with the scarcity of validation studies in Antarctic fish. Validation of the first age classes is usually carried out using three methods.

(i) Correlation of checks on otoliths and scales with prominent peaks in length frequency compositions.

(ii) Estimation of the onset of scale formation and deduction of age classes from frequency histograms of the number of sclerites.

(iii) Validation of 'checks' as being annual by means of counting daily increments.

Length frequency distributions have been used in *C. gunnari* and other icefish species to validate age classes 0 to 2 successfully (Kock, 1981; Slosarczyk, 1987). This seems to have been generally accepted and was largely confirmed by the results of the exchange. A similar approach was used in *P. antarcticum* from the Weddell Sea (Hubold and Tomo, 1989). Unfortunately, samples of this species used in the exchange did not contain small specimens representing the first age classes.

The first age classes of *N. rossii* and *N. gibberifrons* have been derived from frequency histograms of the number of sclerites (Sherbich, 1975; Freytag, 1980; Boronin and Frolkina, 1976) without, however, estimating the onset of scale formation. Freytag's results (1980) exhibit remarkably good agreement with Burchett's findings (1983) on *N. rossii* otoliths.

Daily ring counts of one of the species involved in the exchange have so far only been carried out for *N. rossii* and *C. gunnari* (Radtke, SC-CAMLR-VI/BG/43). Findings on *N. rossii* agree well with Freytag's (1980) and Burchett's (1983) results, but counts for *C. gunnari* indicate much higher ages in fish of the same size than those estimated by traditional methods.

It is obvious that there is still a need to carry out additional validation studies, in particular on exploited nototheniids, to identify the first annuli more precisely. This may be one way to establish more reliable age determinations in exploited Antarctic fish species. Validation studies should be extended to otoliths which are not subject to replacement and resorption as scales are. Priority should be given to compare age determinations from both structures as has been attempted for *N. gibberifrons* in the exchange.

As commonly observed in age determinations of temperate water fish, agreement among investigators generally decreased with increasing size of the fish. This problem is likely to remain unresolved in the near future. However, further validation studies and the increase in knowledge of the biology of a particular species may reduce that problem. Comparative age determinations on a workshop basis which should be combined with an extensive discussion on the life history of a species may in the future better help to attribute the 'best'* age to a specimen. Establishing additional exchange schemes are unlikely to give more reliable estimates than those obtained during the first exchange.

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* The 'best' age is not necessarily the true age nor is it the majority 'reading' nor the mean of the exchange 'readings'.

The assessment of the state of Antarctic fish stocks within CCAMLR is largely based on age-dependent models. Prerequisites are reliable age determinations. It is evident from the results both of the Age Determination Workshop in Moscow and the otoliths/scales/bones exchange that 'readings' among investigators are not compatible. Age-dependent models should thus be based on age/length keys from one source only to avoid the introduction of additional systematic errors.

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Table 1: Age readings of *Notothenia rossii* scales from South Georgia and the South Shetland Islands.

No.	Length (cm)	Weight (g)	Sex	Maturity Stage	Age Readings 1	2	3	4
South Georgia, November 1971, Source: VNIRO								
1	70.0	5030	M	2	10	12?	nr	13
2	39.5	670	M	1	4+	4	4	5
3	67.0	3740	F	2/3	9	11	10?	12
4	66.0	3280	F	2/3	8	9	10?	12/13
5	53.5	1920	M	2	6	7	6/7	7
6	65.5	3540	M	2	9	10	9/10	12
7	67.0	4130	F	2/3	9	10	10	12
8	57.0	2500	M	2	8	8	8/9	9
9	66.0	3680	F	2/3	8	10	9?	12
10	67.0	3930	F	2/3	9	11	10/11	11
11	66.5	3490	F	2/3	8	-	10	10
12	62.0	3210	F	2/3	9	-	9	10
South Georgia, 1977, Source: VNIRO								
1	56.0	2620	M	3/4	8	-	-	-
2	51.0	1450	M	3/4	7	6	6	6
3	54.0	1980	F	3/4	8	-	-	-
4	53.0	2360	F	3/4	8	-	-	-
5	51.0	1630	M	3/4	7	6	6	7
South Georgia, 1986, Source: AtlantNIRO								
1	41.0	1050	-	-	4+	4	6	5
2	42.0	1100	-	-	4+	5	5/6?	6
3	43.0	1300	-	-	5+	6	6	6
4	42.0	1300	-	-	5+	6	6	6
5	42.0	1300	-	-	5+	5	6	6
6	41.0	1200	-	-	4+	5	5/6?	5
7	42.0	1650	-	-	4+	5	6	5
8	48.0	1340	-	-	4+	6	6	6
9	58.0	2360	-	-	6+	8	8/9	nr
10	56.0	2180	-	-	6+	7	7/8	9
South Shetland Islands, November 1979, Source: VNIRO								
1	38.5	540	F	2	6	5	4	5
2	45.0	1120	F	2	7	6	7	7
3	49.0	1290	M	3	7	-	-	-
4	44.0	920	F	2	7	-	-	-
5	45.5	990	M	2/3	6	-	-	-
6	46.5	1250	F	5	8	7	8	8
7	46.0	1130	M	3	9	7	8/9	8
8	44.0	990	F	2	9	7	9	7
9	40.0	890	M	2	8	6	8	7

Table 1 (continued)

No.	Length (cm)	Weight (g)	Sex	Maturity Stage	Age Readings 1	2	3	4
South Shetland Islands, November 1986, Source: AtlantNIRO								
1	41.0	860	-	-	5+	5	6	6
2	48.0	1600	-	-	6+	7	8	8
3	48.0	1450	-	-	6+	6	6/7	7
4	46.0	1350	-	-	6+	6	7	7
5	42.0	1070	-	-	5+	6	6	6
6	52.0	2070	-	-	7+	7	9	8
7	45.0	1200	-	-	6+	6	7	7
8	47.0	1610	-	-	7+	7	8	7
9	42.0	1010	-	-	5+	6	6	6
10	39.0	930	-	-	5+	5	6	6

Age readings, source:

1: VNIRO and AtlantNIRO (USSR) respectively
2: U. Hoffman (GDR)
3: E. Barrera-Oro (ARG)
4: K.-H. Kock (FRG)

- not available, lost
n r not readable

Table 2: Age readings of juvenile *Notothenia rossii* scales from King George Island (South Shetland Islands). Source: Instituto Antártico Argentino.

No.	Capt.	Length (cm)	Weight (g)	Sex	Maturity Stage	Age Readings 1	2	3
1	10/05/83	30.0	-	M	-	4	4	4
2	13/05/83	33.5	-	F	-	4	4	4
3	16/05/83	23.5	-	M	-	3	3	3
4	19/05/83	28.5	-	M	-	3	3	3
5	19/05/83	33.5	-	M	-	5	6	4
6	23/05/83	25.7	-	F	-	3	3	3
7	27/05/83	24.4	-	M	-	3	3	3
8	04/06/83	31.3	-	M	-	4	4	4
9	04/06/83	30.2	-	F	-	4	4	4
10	04/06/83	36.5	-	F	-	5	5	5
11	08/06/83	24.8	-	M	-	3	3	3
12	08/06/83	32.7	-	M	-	5	5	4
13	17/11/83	26.6	-	F	-	3	3	4
14	17/11/83	35.0	-	M	-	5	4	5
15	17/11/83	37.5	-	M	-	6	5	6

Table 2 (continued)

No.	Capt.	Length (cm)	Weight (g)	Sex	Maturity Stage	Age Readings 1	2	3
16	21/11/83	36.6	-	F	-	6	6	6
17	21/11/83	33.9	-	F	-	5	5	5
18	11/04/85	44.3	1118	M	-	6	6	6
19	18/04/85	38.9	665	M	2	5	5	5
20	25/04/85	37.0	635	F	1	5	5	5
21	25/04/85	36.5	592	M	1	5	5	5
22	25/04/85	35.5	570	M	1	5	5	5
23	14/05/85	37.4	757	F	1	5	5	5
24	14/05/85	36.8	597	M	1	5	5	5
25	17/05/85	26.7	258	M	1	3	3	3
26	20/05/85	37.7	727	F	2	5	5	5
27	07/08/85	36.6	606	F	2	5	6	5
28	07/08/85	39.1	818	M	2	6	6	6
29	23/08/85	37.0	673	M	1	5	6	6
30	08/09/85	37.6	658	F	2	5	6	6
31	20/09/85	38.0	617	F	2	5	6	6
32	20/11/85	38.0	656	M	1	6	6	6
33	25/12/85	43.0	879	M	2	7	6	6
34	25/12/85	37.6	739	M	1	6	6	6
35	04/01/86	40.5	952	F	2	6	6	6
36	04/01/86	30.0	392	F	1	4	4	4
37	04/01/86	35.5	576	M	1	6	6	5
38	04/01/86	39.6	728	M	2	6	6	6
39	04/01/86	37.3	654	M	1	6	6	6
40	04/01/86	37.9	714	M	1	6	6	6
41	08/02/86	40.0	824	F	-	6	6	6
42	08/02/86	37.9	770	M	3	6	6	6
43	08/02/86	38.9	803	F	2	6	5	6
44	08/02/86	40.5	830	F	2	6	6	6
45	03/04/86	42.1	1030	F	2	6	6	6
46	07/05/86	38.9	697	M	2	6	5	6
47	07/05/86	38.6	804	F	2	6	5	6
48	06/12/86	23.8	153	F	1	3	3	3
49	06/12/86	23.0	126	F	1	3	3	3
50	29/12/86	24.2	165	F	1	3	3	3

Age readings, source:

1: E. Barrera-Oro (ARG)
2: K.-H. Kock (FRG)
3: U. Hoffman (GDR)

Table 3: Age readings of *Notothenia gibberifrons* scales from South Georgia and the South Shetland Islands.

No.	Length (cm)	Weight (g)	Sex	Maturity Stage	Age Readings 1	2	3	4	5
South Georgia, March 1985, Source: VNIRO									
1	42.0	740	F	3	11	11/12	9	10	9
2	33.0	355	M	2	7(8)	nr	nr	6	5
3	36.0	500	F	3	8+	nr	7	6	6
4	37.0	460	M	3	11	12/13	10	11	9
5	41.0	650	M	3	10	nr	9	9	8
6	34.0	480	M	3	10	10/11	13	12	7
7	40.0	610	M	3	11	11	9	9	9
8	36.0	500	M	3	10	11	10	9	8
9	40.0	470	F	2	9	nr	9	8	8
10	38.0	530	M	3	9	9/10	9	9	7
South Georgia, September 1986, Source: AtlantNIRO									
1	11.3	8	-	-	1	1	3	1	1
2	10.9	7	-	-	1	1	3	1	1
3	28.7	200	-	-	6	6	6	4	-
4	21.8	70	-	-	4	nr	5	2	-
5	24.0	98	-	-	4	nr	nr	2	3
6	20.6	55	-	-	3	3/4	7	3	3
7	19.0	42	-	-	2	3/4	5	2	-
8	37.0	450	-	-	8	9/10	10	7	7
9	33.0	400	-	-	7	8	10	8	5
10	39.0	650	-	-	9	-	-	-	-
11	31.0	340	-	-	7	7	9	5	5
12	37.0	540	-	-	9	9	11	9	7
13	45.0	960	-	-	11	13/14	11	12	11
14	46.0	1100	-	-	13	14	14	14	11
15	43.0	830	-	-	14	-	-	-	-
16	46.2	1050	-	-	13	-	-	-	-
17	41.8	790	-	-	8	10/11	nr	11	9
South Shetland Islands, March 1985, Source: VNIRO									
1	22.5	100	M	1	4+	5/6	6	4	4
2	36.0	430	F	2	9+	12	8	8	7
3	34.5	350	M	2	8+	10/11	9	8	6
4	39.0	580	F	3	10(9)	-	-	-	-
5	26.0	145	F	1	5+	7	7	6	4
6	30.5	255	F	1	7(8)	9	7	8	5
7	40.0	650	M	3	11	14/15	10	11	8
8	32.0	245	M	1	8+	9/10	8	8	6
9	43.5	740	F	3	12	14	11	10?	10
10	29.0	215	F	2	8+	9	7	8	6
11	28.0	180	F	1	6+	-	-	-	-
12	30.0	220	M	1	7+	9/10	8	7	5

Table 3 (continued)

No.	Length (cm)	Weight (g)	Sex	Maturity Stage	Age Readings 1	2	3	4	5
South Shetland Islands, March 1985, Source: VNIRO (continued)									
13	39.0	760	F	3	11	nr	9	9	7
14	33.0	350	F	2	9+	11	9	11	6
15	28.5	220	F	1	6(7)	8	8	6	4
16	36.0	440	M	3	8+	13	nr	10	8
17	38.0	610	F	3	9+	13/14	9	11/12	8
South Shetland Islands, November 1986, Source: AtlantNIRO									
1	29.0	230	-	-	7	8/9	9	7	5
2	28.0	220	-	-	7	9	9	6	4
3	27.0	180	-	-	6	8	9	6	5
4	30.0	260	-	-	7	9	11	-	5
5	24.0	140	-	-	5	6/7	8	5	4
6	36.0	520	-	-	8	12	10	8	7
7	37.0	440	-	-	8	nr	10	9	7
8	33.0	350	-	-	9	9/10	10	9	6
9	38.0	625	-	-	9	12	10	11	7
10	35.0	420	-	-	9	10/11	11	9	7
11	40.0	670	-	-	10	11/12	10	9	8
12	41.0	710	-	-	10	11	11	9	8
13	42.0	820	-	-	12	13	nr	10	9
14	41.0	810	-	-	11	12/13	11	11/12	9

Age readings, source:

1. VNIRO and AtlantNIRO (USSR) respectively
2. E. Barrera-Oro (ARG)
3. M.T. Garcia Santamaria, E. Balguerias Guerra (SP)
4. R. Coggan, M.G. White (UK)
5. U. Hoffman (GDR)

Table 4: Age readings of *Notothenia gibberifrons* otoliths and scales from South Georgia.

Source: British Antarctic Survey (UK)									
No.	Length (cm)	Weight (g)	Sex	Maturity Stage	Age Readings (otoliths/scales) 1	2	3	4	5
88 20 80	39.5	610	F	2	9/-	12/12	-/7	10/9	8/10
20 81	35.6	400	M	1	12/-	10/nr	-/7	9/10	9/10
24,65	43.2	870	F	1	10/-	13/-	-	13/-	-
24 66	33.7	350	M	1	6/-	10/7	-	7/-	6/7
24 80	41.8	720	M	2	7/-	13/10	-/8	10/10	10/11-12
24 82	34.0	350	M	1	5/-	11/10	-/6	8/8	8/9
27 63	35.2	390	M	-	6/-	11/-	-	9/-	9/-
88 49 68	26.0	132	M	2	4/-	7/-	-	5/-	5/-
83	39.0	660	M	2	7/-	11/11	-/8	9/9	9/9
84	40.0	690	F	2/3	7-6/-	12/12	-/8	11/10	9/10
85	40.2	620	M	2	8-7/-	12/12	-/9	11/10	9/10
86	34.5	350	M	1	6/-	9/10	-/6	7/7	6-7/8
87	20.3	70	M	1	4/-	5/6	-/3	4/4	3/3-4
88 60 80	36.5	?	?	?	7/-	10/10	-/6	8/8	7/7-8
81	36.5	475	F	2	6/-	10/10	-/6	?/7	7/7
82	34.5	375	F	1	6-7/-	10/10	-/6	7/7	6/7
83	38.5	550	F	1	7/-	12/11	-/7	8/9	9/9
84	37.5	500	F	2	7/-	-/11	-/7	8/8?	8/10
85	31.0	255	F	1	5/-	9/11	-	6/6	6/6
86	30.0	245	F	1	6/-	8/8	-/5	6/6	5/6
87	30.5	252	F	1	7/-	11/11	-/6	7/6	6/7
88	30.5	236	F	1	9/-	9/9	-/5	7/6	6(5?)/6
89	25.8	210	M	1	7-6/-	8/7	-/4	5/5	5/5
90	23.3	95	M	1	6-8/-	7/7	-/4	4/4	4/4(3?)
88 60 91	23.0	90	M	1	6/-	7/7	-/3	4/4	4/3
92	24.2	120	F	1	(3)/-	-/6	-/4	?/4	3(2?)/4
93	22.2	85	F	1	4/-	6/6	-/3	4/4	3/3
94	22.5	83	F	1	4-7/-	5/6	-/3	4/4	4/4(5?)
15 B 1-1	20.8	64	F	1	3/-	7/-	-/3	4/4	3/5?
1-2	21.5	80	F	1	4/-	6/-	-/3	4/4	3/4?
1-3	30.0	270	F	2	8/-	7/-	-/5	7/6	6/6(7?)
1-4	18.3	37	F	1	?/-	6/-	-/12	4/3	2/3?
15 B 1-5	39.1	560	-	-	11/-	13/-	-	10/-	11/1-
1-6	38.3	520	F	2	9/-	10/-	-/7	9/9	9/(10?)9
1-7	38.0	590	F	1	11/-	10/-	-/7	8/9	9/(10?)9
1-8	40.9	650	M	2	10/-	14/-	-	10/-	9/11
1-9	35.8	530	F	2	11/-	11/-	-/7	8/10	8/10(11?)
1-10	22.4	84	F	1	6/-	7/-	-/3	5/5	(6?)7/3(4?)
89 44 41	19.8	47	F	1	4/-	7/6	-/3	4/4	3/3
42	18.0	42	F	1	4/-	7/7	-/2	4/3	(2?)3/(2?)3
43	16.3	26	F	1	4/-	6/6	-/2	3/3	2/2(3?)
66	31.3	270	F	2	9/-	10/10	-/6	6/6	7/-
68	41.5	770	M	2	13/-	14/11	-/10	11/11	(11?)12/11
69	42.4	850	F	2	13/-	15/15	-/9	11/10	11/11
70	33.2	360	M	1/2	7/-	11/12	-/6	7/8	7/8
71	38.8	540	F	2	9/-	10/11	-/7	8/8	9/9
72	41.3	770	M	2	9/-	12/10	-/8	11/11	10/12
73	35.8	450	F	2	8-9/-	10/11	-/7	8/9	8/(8?)9

Table 4 (continued)

No.	Length (cm)	Weight (g)	Sex	Maturity Stage	Age Readings (otoliths/scales) 1	2	3	4	5
89 44 74	27.0	155	F	1	8/-	8/-	-/4	5/5	5/5
75	25.5	122	M	1	4/-	6/7	-/4	5/4	5/5
76	18.2	41	M	1	3/-	5/6	-/3	4/4	4/3(4?)
77	12.6	11	F	1	2/-	5/4	-/2	2/2	?/?
78	12.3	11	F	1	2/-	4/4	-/1	2/2	2/2
89 45 51	22.0	80	-	1	5/-	6/-	-	4/-	(4?)3/-
52	17.1	32	-	1	3/-	5/-	-	3/-	3/-
53	13.7	16	-	1	3/-	4/-	-	2/-	2/-
54	14.5	20	F	1	3/-	5/-	-	3/-	2-3/-
61	12.2	11	-	1	2/-	3/-	-	2/-	2/-
62	7.7	2	-	1	?/-	2/-	-	1/-	1/-
89 46 38	14.4	21	-	1	2/-	4/-	-	3/-	3/-
39	13.7	19	M	1	3/-	4/-	-	3/-	3/-
40	13.7	17	M	1	3/-	5/-	-	3/-	3/-
41	11.6	10	M	1	2/-	3/-	-	2/-	(3?)2/-
42	12.9	16	M	1	2/-	-/-	-	2/-	2/-
45	43.6	750	F	2	12/-	12/-	-	12/-	12/-
76	43.1	1010	M	3	14/-	12/-	-	12/-	12/-
77	37.8	?	F	1	9-10/-	10/-	-	9/-	(9?)10/-
79	32.9	325	F	1	8-7/-	9/-	-	8/-	8/-
80	23.7	110	F	1	4/-	5/-	-	5/-	5?/-
81	17.6	36	-	1	3-4/-	4/-	-	3/-	3/-
82	14.8	20	-	1	3/-	4/-	-	3/-	3/-
96	40.0	665	F	2	10/-	11/9	-/8	10/10	10/9
97	21.1	64	M	1	4/-	6/6	-/3	4/4	4(5?)/4(5?)
98	31.8	300	M	1/2	7-6/-	8/8	-/5	6/6	6/6
99	23.1	79	M	1	4	5/5	-/3	4/4	4/(3?)4
89 47 00	36.3	450	M	2	8/-	11/9	-/7	8/8	9/8(9?)
01	30.1	219	F	1	6/-	8/-	-/5	6/6	6(5?)/5(6?)
02	39.2	600	M	2	9/-	10/9	-/8	9/9	9(10?)/9
03	31.8	288	F	2	7/-	9/10	-/5	7/7	7/6
04	36.7	490	M	2	9/-	11/10	-/7	9/9	7/8
05	12.0	11	F	1	2-3/-	5/4	-/1	2/2	?/1(2?)

Age readings, source:

1. R. Coggan (UK)
2. M.T. Garcia Santamaria
   E. Balguerias Guerra
   M.E. Quintero Perez (SP)
3. U. Hoffmann (GDR)
4. K.-H. Kock (FRG)
5. K. Skora (POL)

Table 5: Age readings of *Champsocephalus gunnari* otoliths from South Georgia, the South Orkney Islands and South Shetland Islands.

No.	Length (cm)	Weight (g)	Sex	Maturity Stage	Age Readings 1	2	3	4
South Georgia, Source: VNIRO, AtlantNIRO								
1	7.3	1.1	-	1	0+	0	0	0
2	7.5	1.3	-	1	0+	0	0	0
3	9.0	2.5	-	1	0+	0	0	0
4	18.4	34	-	1	1+	1	1	1
5	20.7	49.2	M	2	1+	1	1	2
6	20.7	49.5	F	2	1+	1	1	2
7	20.8	51.2	M	2	1+	1	1	2
8	22.0	63	M	1	1+	2	2	2
9	27.8	117	M	3	2+	2	2	2
10	28.1	136	M	3/4	2+	2	2	2
11	28.5	118	F	2	2+	2	?	2
12	30.5	165	F	3	3+	3	2	-
13	30.5	186	M	2	3+	3	2	3
14	34.0	276	M	3/4	3+	3	2	?
15	34.5	276	F	3/4	4+	3	3	3
16	36.0	287	F	2/3	4+	3	4	4
17	36.0	307	M	3	4+	4	4	4
18	36.2	344	M	3/4	4+	4	5	4
19	39.6	374	M	2/3	5+	4	?	4
20	40.5	475	M	3/4	5+	-	-	-
21	42.6	450	F	3/4	5+	4	5	5
22	48.7	915	M	3	7+	5	9	-
23	50.5	870	M	3	8+	-	-	-
24	57.5	1720	F	3	11+	-	-	-
South Georgia, December 1984, Source: VNIRO, AtlantNIRO								
1	25.1	90	M	-	3	2	2	3
2	37.4	363	M	-	6	3	4	4
3	37.1	346	F	-	6	3	?	4
4	29.2	175	F	-	4	3	2	3
5	33.2	264	F	-	5	3	3	3
Shag Rocks, October 1985, Source: VNIRO, AtlantNIRO								
6	13.3	12.1	M	-	1	?	?	2
7	24.8	91.6	F	-	3	2	2	3
8	30.0	174.0	M	-	4	3	4	3
9	21.6	66.5	M	-	3	2	2	3
10	13.5	11.2	F	-	1	1	1	2
11	25.1	86.6	F	-	3	-	2	3
12	13.9	10.1	F	-	1	1	1	2
13	22.2	59.7	F	-	3	2	2	2
14	28.9	114.0	M	-	4	2	3?	3
15	15.2	17.8	M	-	1	1	1	2

Table 5 (continued)

No.	Length (cm)	Weight (g)	Sex	Maturity Stage	Age Readings 1	2	3	4
South Orkney Islands, March 1978, Source: VNIRO, AtlantNIRO								
1	13.5	10	-	1	1+	1	1	1+
2	20.5	50	F	2	2+	2	2	2+
3	22.0	60	-	1	2+	2	2	3
4	22.0	60	F	2/3	3+	2	2	2
5	24.0	70	M	2	3+	3	3	2
6	25.0	90	F	3	3+	3	3	2+
7	26.5	100	F	3	4+	3	3	3/4
8	27.0	110	M	3	4+	3	3	3
9	27.0	100	F	2	4+	3	3	3
10	28.0	110	M	2	4+	3	3	4+
11	28.0	120	M	2	5+	3	3	4+
12	30.0	160	M	2	5+	3	3	4
13	30.5	140	F	3	5+	3	3	4
14	33.0	230	F	3	6+	4	4	3+
South Shetland Islands, March 1985, Source: VNIRO, AtlantNIRO								
1	29.5	165	F	2	3+	3	3	3
2	30.5	165	M	2	3+	2	3	3+
3	34.2	-	M	3	4+	3	4	4
4	34.3	-	F	3	4+	4	4	7
5	36.2	-	F	3	5+	-	-	5
6	36.5	260	F	2	5+	4	5	7
7	40.0	450	F	2	5+	3	4	6
8	40.0	500	M	3	5+	4	5	6
9	41.0	740	M	2	5+	5	5	6
10	47.3	-	M	3/4	7+	>5	8	?
11	47.5	940	F	4	7+	7	7	6+
12	51.5	980	M	4	8+	>6	?	6+

Age readings, source:

1. VNIRO and AtlantNIRO (USSR)
2. G. Gubsch (GDR)
3. J. Sosinski (POL)
4. R. Coggan/M. White (UK)

Table 6: Age readings of *Pleuragramma antarcticum* otoliths from Mawson Sea, March 1984.

Source: AzcherNIRO								
No.	Length (cm)	Weight (g)	Sex	Maturity Stage	Age Readings 1	2	3	4
1	19.3	66.0	F	-	7	9	9	6/7
2	18.2	51.0	F	-	7	5	8	5
3	19.8	80.0	F	-	9	9	7	7
4	18.6	60.0	F	-	8(7)	8	8	6/7
5	16.6	45.0	M	-	7	8	7	5
6	19.1	64.0	F	-	7	?	7	6?
7	17.4	58.0	M	-	7	8	6	6
8	18.4	74.0	M	-	8	9	9	7
9	20.1	90.0	F	-	8	9	9	6/7
10	18.7	74.0	F	-	9(10)	?	9?	5/6
11	19.2	80.0	F	-	7	8	10	5?
12	18.4	70.0	F	-	8	8	9	5/6
13	16.8	49.0	M	-	7	8	8	5
14	18.0	69.0	F	-	7	?	7	5
15	19.6	93.0	F	-	9	10	9	6/7
16	17.2	58.0	F	-	7	9	8	4/5
17	17.8	68.0	F	-	7	7	7	4/5
18	17.3	67.0	M	-	8	6	8	5/6
19	20.6	99.0	F	-	8	7	9	6/7
20	16.9	42.0	M	-	6(7)	?	7?	5
21	16.6	50.0	M	-	6	7	7	4/5
22	14.2	26.0	M	-	5	4	5	3/4
23	15.5	34.0	F	-	5	4	5	?
24	16.6	40.0	F	-	6	4-5	7	4
25	16.0	44.0	M	-	7(6)	7	7	4
26	15.0	30.0	F	-	5	5	5	3/4
27	15.4	38.0	F	-	5(6)	6	5	4
28	16.0	34.0	M	-	5	5?	7	4
29	15.5	32.0	F	-	5	5	5	3
30	14.5	24.0	M	-	5	-	-	-
31	20.5	89.0	F	-	9	7	8	7
32	14.5	26.0	F	-	5	?	7	3/4
33	20.5	80.0	F	-	10?	7	8	6/7
34	14.5	25.0	F	-	5	4	5	4
35	13.4	21.2	F	-	5	3	4	3
36	13.4	22.0	M	-	5	3	4	4
37	12.4	15.0	M	-	4	2-3	-	2/3
38	13.9	18.7	F	-	4	4	4	-
39	12.6	16.5	F	-	4	3	3	2
40	13.6	19.9	F	-	5	-	-	-
41	13.5	21.5	M	-	5	4	6	3
42	19.4	69.8	F	-	8	9	7?	5/6
43	19.3	73.0	M	-	7	12	9	7
44	17.8	56.0	F	-	7	9	7	5

Table 6 (continued)

No.	Length (cm)	Weight (g)	Sex	Maturity Stage	Age Readings 1	2	3	4
45	17.1	52.5	M	-	7	?	5	5/6
46	16.5	44.5	M	-	7	8	5	5
47	15.9	38.9	F	-	6	6	6	4
48	13.8	20.3	M	-	5	5	6	3
49	13.6	18.5	F	-	5	4	4	2
50	18.1	46.8	F	-	6	5	8	5

Age readings, source:

1. V.V. Gerasimchook (USSR)
2. G. Hubold (FRG)
3. R. Williams (AUS)
4. E. Barrera-Oro (ARG)

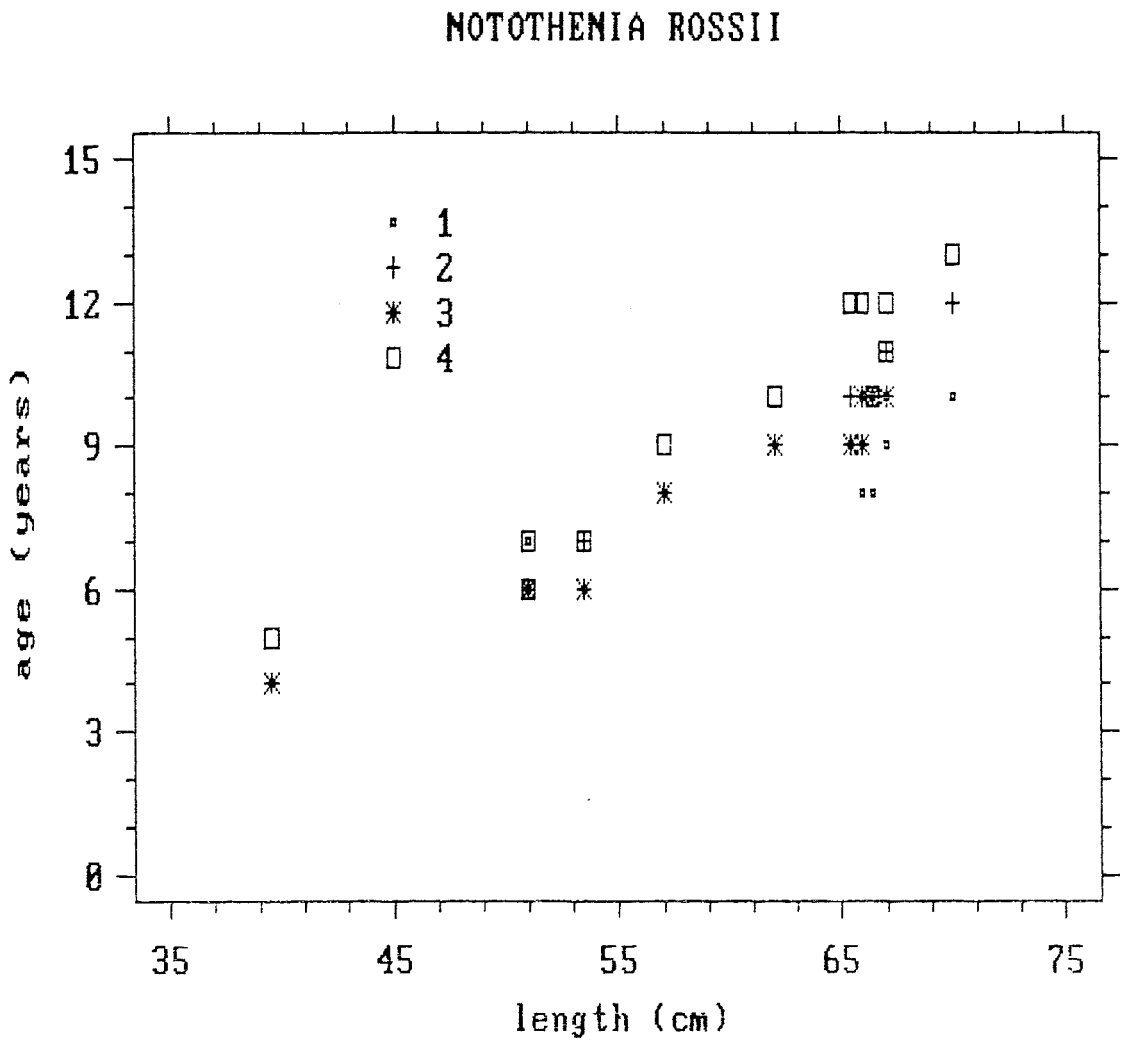

Figure 1: Length versus age plot from comparative age determinations on scales of *Notothenia rossii* from South Georgia. Collected 1971, 1977 by VNIRO (USSR). For readers 1-4 see footnote to Table 1.

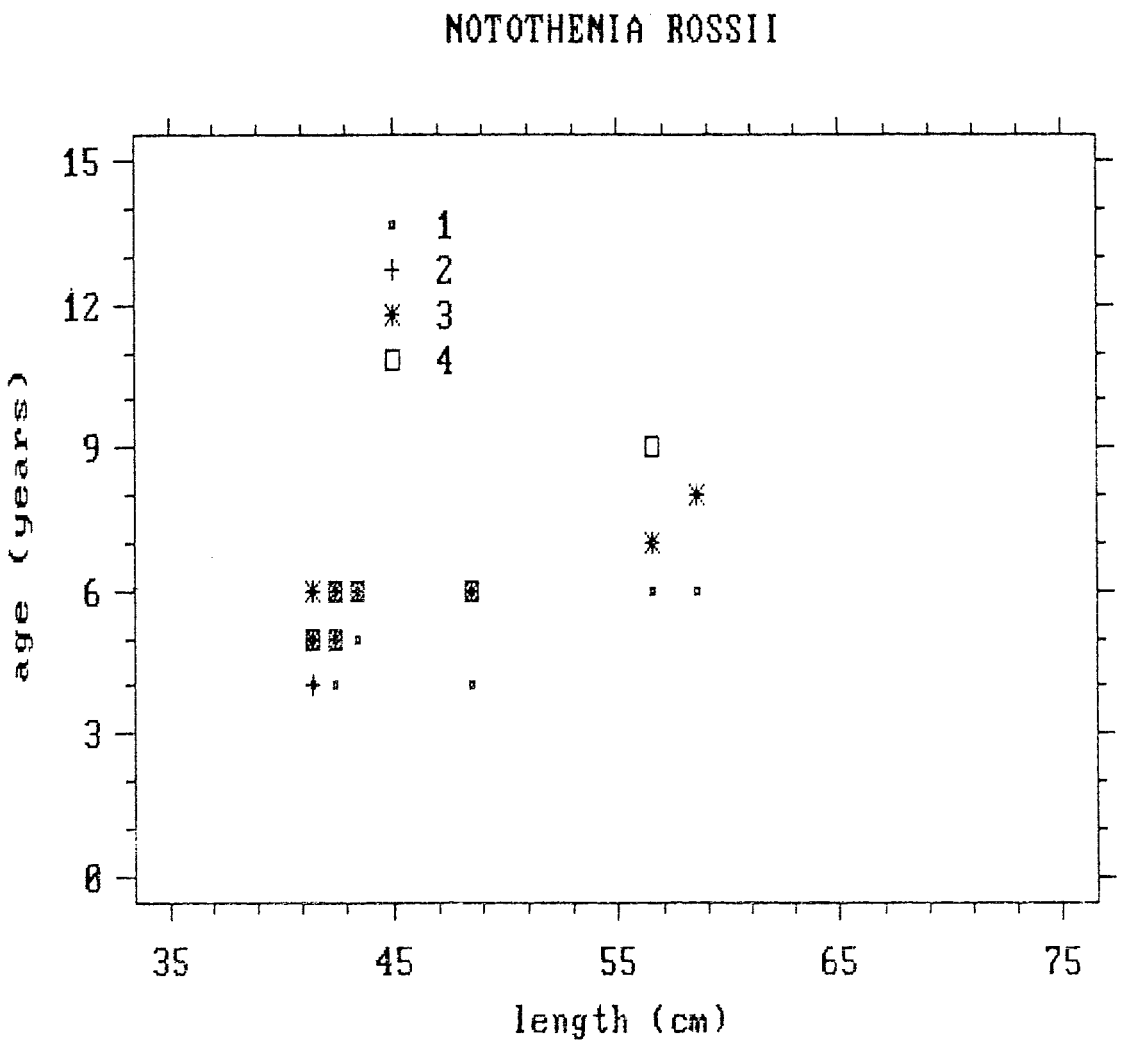

Figure 2: Length versus age plot from comparative age determinations on scales of *Notothenia rossii* from South Georgia. Collected 1986 by AtlantNIRO (USSR). For readers 1-4 see footnote to Table 1.

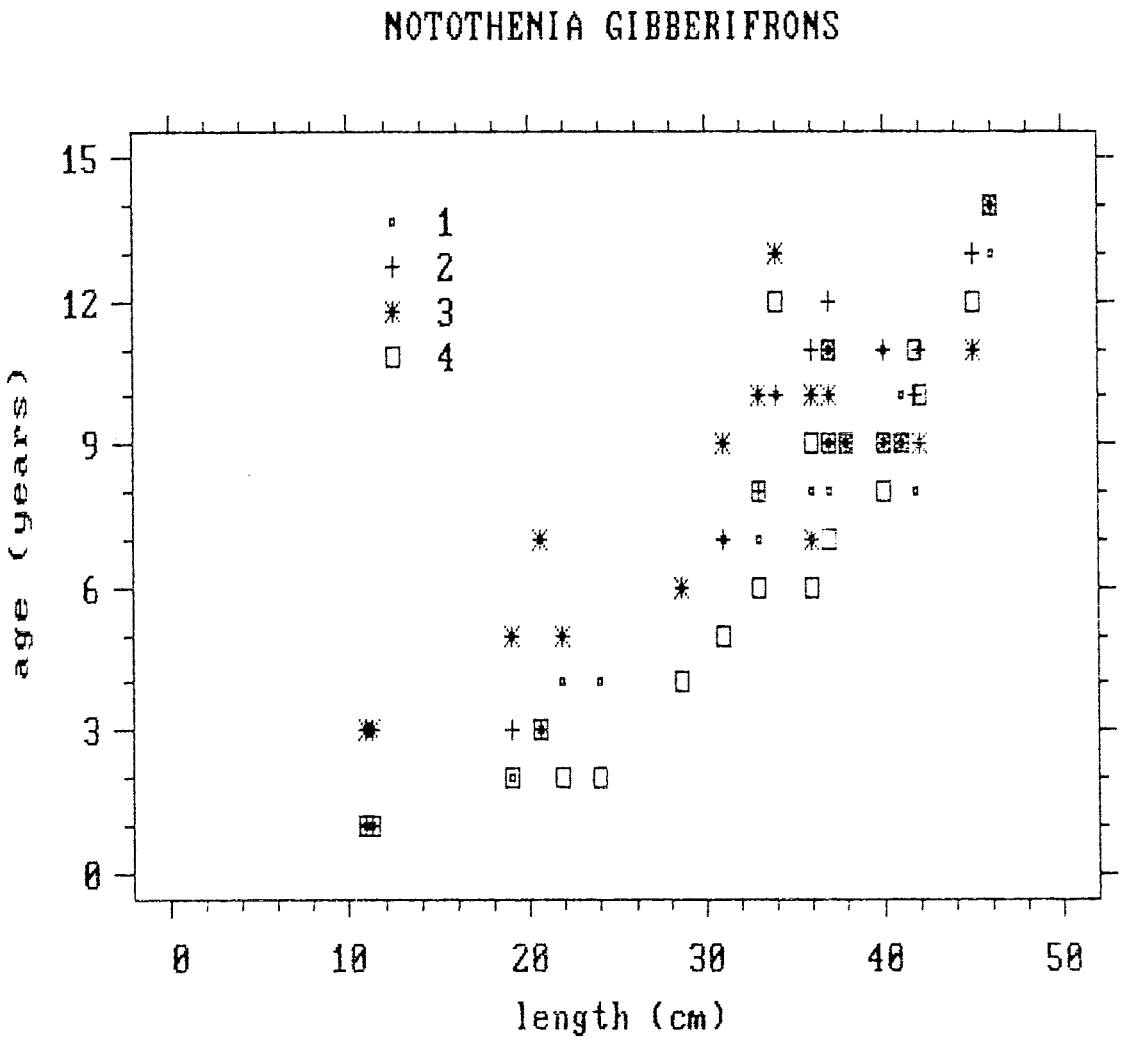

Figure 3: Length versus age plot from comparative age determinations on scales of *Notothenia gibberifrons* from South Georgia. (Data of reader 5 have not been included due to submission after deadline). Collected 1985, 1986 by VNIRO and AtlantNIRO (USSR).
For readers 1-4 see footnote to Table 3.

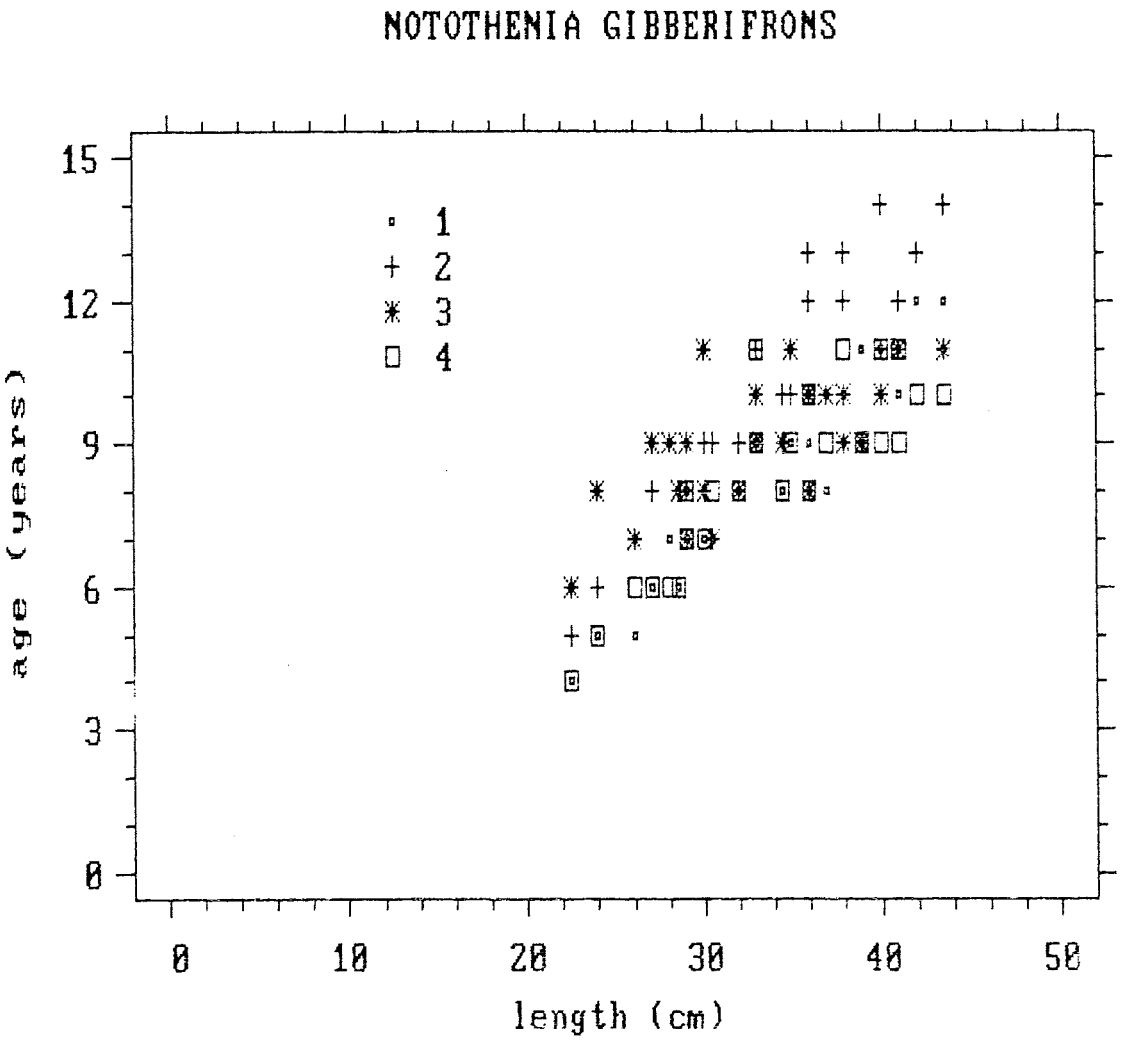

Figure 4: Length versus age plot from comparative age determinations on scales of *Notothenia gibberifrons* from the South Shetland Islands. (Data of reader 5 have not been included due to submission after deadline). Collected 1985, 1986 by VNIRO and AtlantNIRO (USSR).
For readers 1-4 see footnote to Table 3.

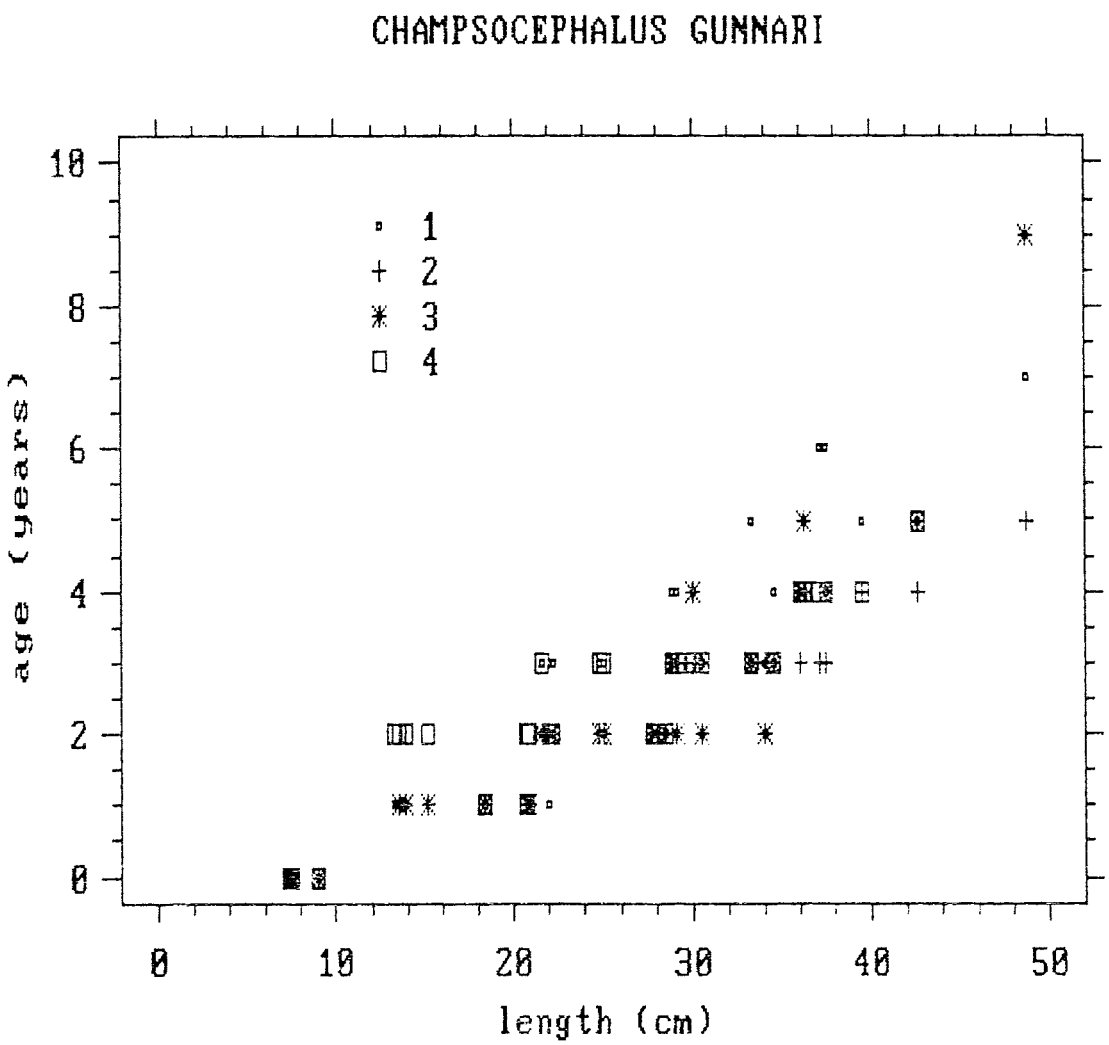

Figure 5: Length versus age plot from comparative age determinations on otoliths of *Champsocephalus gunnari* from South Georgia. Collected by VNIRO and AtlantNIRO (USSR).
For readers 1-4 see footnote to Table 5.

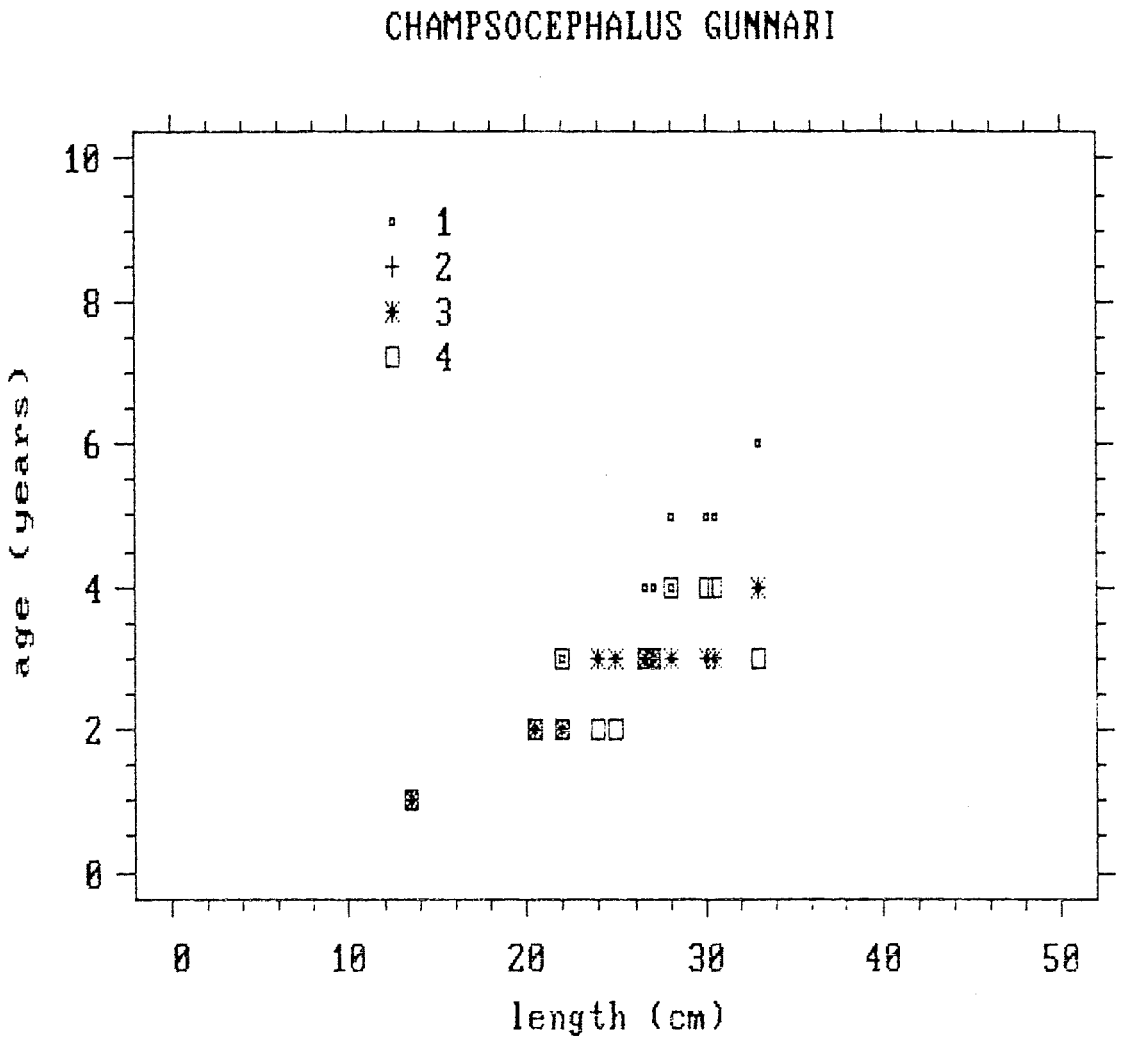

Figure 6: Length versus age plot from comparative age determinations on otoliths of *Champsocephalus gunnari* from the South Orkney Islands. Collected by VNIRO and AtlantNIRO (USSR).
For readers 1-4 see footnote to Table 5.

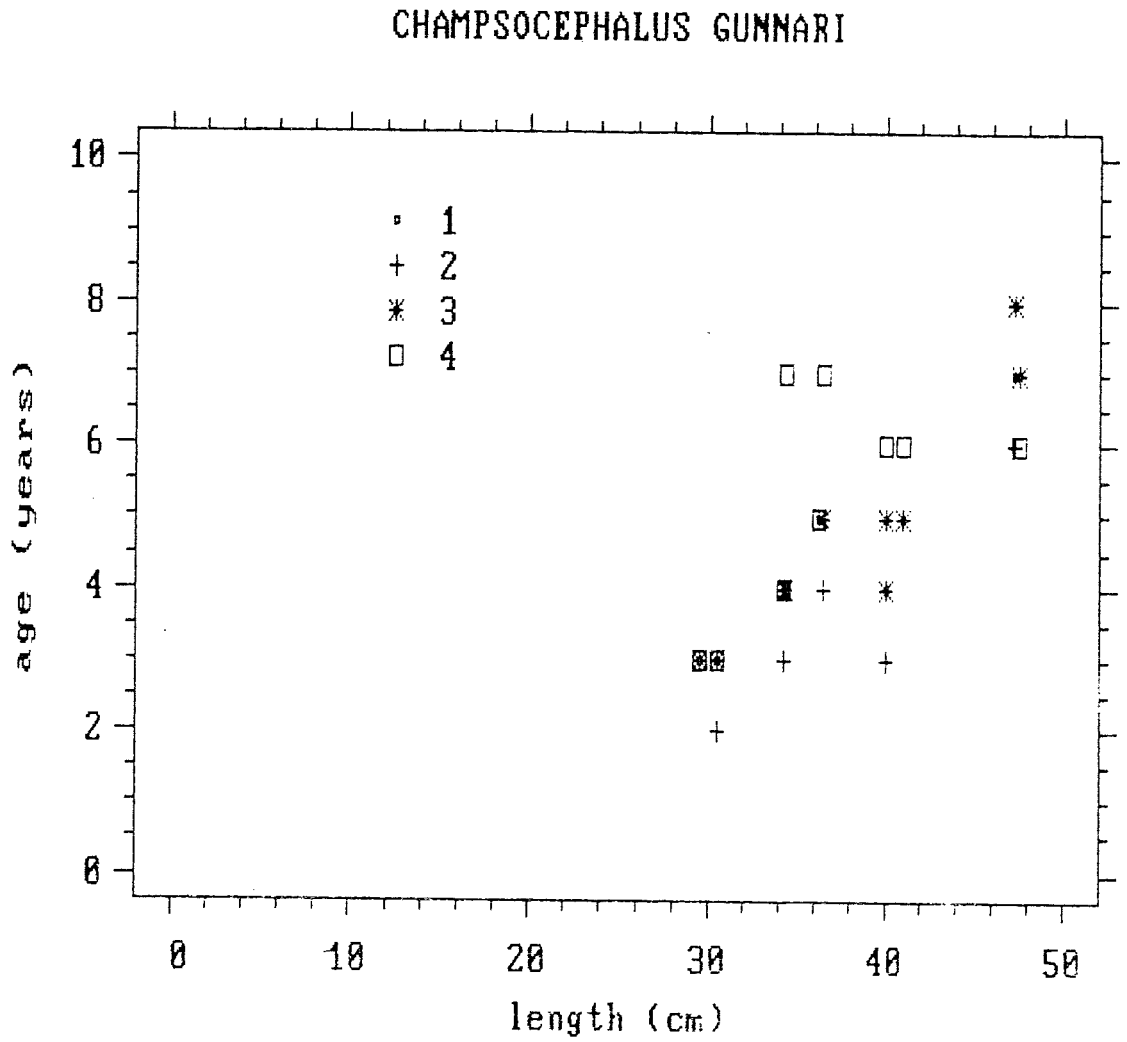

Figure 7: Length versus age plot from comparative age determinations on otoliths of *Champsocephalus gunnari* from the South Shetland Islands. Collected by VNIRO and AtlantNIRO (USSR).
For readers 1-4 see footnote to Table 5.

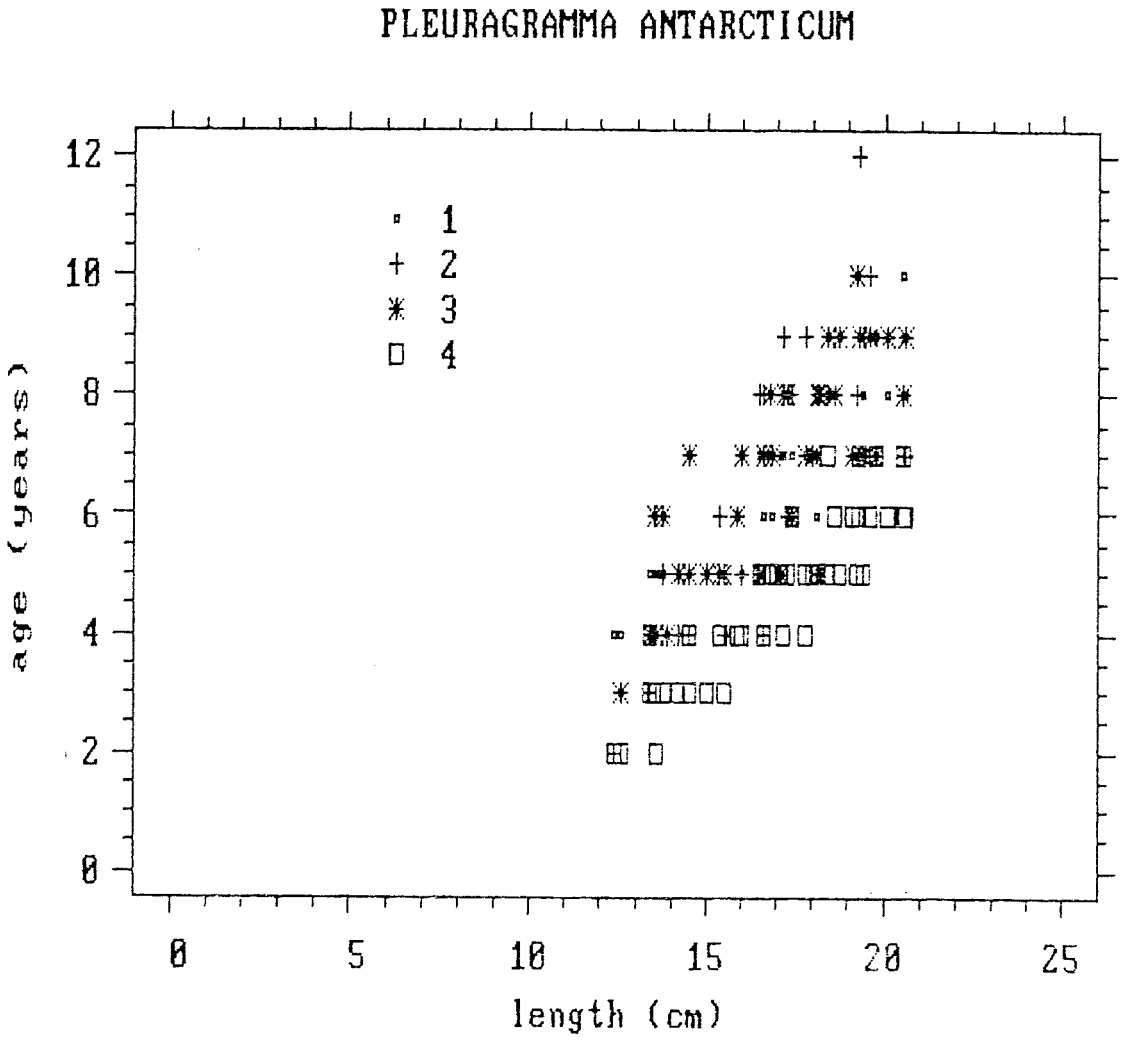

Figure 8: Length versus age plot from comparative age determinations on otoliths of *Pleuragramma antarcticum* from Mawson Sea. Collected by AzcherNIRO (USSR). For readers 1-4 see footnote to Table 6.