

AGE DETERMINATION OF *NOTOTHENIA GIBBERIFRONS* FROM THE SOUTH SHETLAND ISLANDS, ANTARCTIC PENINSULA SUBAREA (SUBAREA 48.1)

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Abstract

Age determination was carried out on *Notothenia gibberifrons* specimens collected at two localities near the South Shetland Islands (Low I. and Potter Cove, 25 De Mayo/King George I.). Samples consisted of small and medium sized fish (total length - 14.8-38 cm). Otolith and scale readings have been compared in 19 Potter Cove specimens. In some cases scale readings gave a result of one year more. This could arise from the difficulty in differentiating between false and annual checks in scales. Age determination by otolith cross sections proved to be the most reliable method. Mean length data at age presented here for Low I. specimens were compared with previous published values. This confirmed that fish from the Antarctic Peninsula Subarea are smaller than those in the same age group around South Georgia. Likewise, our values are lower than the ones reported previously for specimens of South Bay, Palmer Archipelago. Possible reasons for these differences are discussed. It is expected that the Otoliths/Scales/Bones Exchange System established by CCAMLR will help to eliminate discrepancies in age and growth studies of Antarctic fish.

Résumé

La détermination de l'âge a été effectuée sur des spécimens de *Notothenia gibberifrons* rassemblés à deux emplacements près des îles Shetland du Sud (Low Island et Potter Cove, île 25 De Mayo/du Roi George). Les échantillons consistaient en poissons de taille petite et moyenne (longueur totale - 14.8-38 cm). Les lectures d'otolithes et d'écaillés ont été comparées pour 19 spécimens provenant de Potter Cove. Dans quelques cas, les lectures d'écaillés ont donné un résultat d'un an de plus. Ceci pourrait résulter de la difficulté de différencier entre les quadrillages faux et annuels sur les écaillés. La détermination de l'âge au moyen de section transversale s'est montrée la méthode la plus fiable. Les données sur la taille moyenne par âge présentées ici sur les spécimens provenant de Low I. ont été comparées avec des valeurs publiées antérieurement. Ceci a confirmé que les poissons de la sous-zone de la péninsule antarctique sont plus petits que ceux de la même groupe d'âge autour de la Géorgie du Sud. De même, nos valeurs sont plus basses que celles déclarées antérieurement pour des spécimens de South Bay, archipel Palmer. Les causes possibles de ces différences sont discutées. Il est attendu

que le Système d'échange d'otolithes/écailles/os établi par la CCAMLR aidera à éliminera les écarts dans les études sur l'âge et la croissance des poissons antarctiques.

Резюме

Проводилось определение возраста *Notothenia gibberifrons* по образцам, собранным на двух участках района Южных Шетландских островов (о-в Лоу и бухта Поттер, о-в Кинг-Джордж). Образцы состояли из рыб маленького и среднего размера (абсолютная длина 14,8-38 см.). Было проведено сравнение отолитов и чешуи по 19 образцам из бухты Поттер. По некоторым из них данные по чешуе дали завышенный возраст - на один год больше. Это могло случиться в связи с тем, что в чешуе трудно отличить настоящую годовую отметку от обманной. Определение возраста по поперечному разрезу отолитов оказалось наиболее надежным методом. Было проведено сравнение представленных здесь величин средних длин по возрастам для образцов района о-ва Лоу с опубликованными раньше данными. Это подтвердило, что рыбы подрайона Антарктического полуострова меньше, чем рыбы той же возрастной группы, обитающие вокруг Южной Георгии. Подобно этому, полученные нами величины меньше известных ранее величин - для образцов из залива Саут-Бей, архипелаг Палмер Обсуждаются возможные причины этих расхождений. Ожидается, что учрежденная АНТКОМом Система обмена образцами отолитов/чешуи/костей поможет устранить расхождения в работах по возрасту и росту антарктических рыб.

Resumen

Se realizó la determinación de edad en ejemplares de *Notothenia gibberifrons* recolectados de dos localidades en las islas Shetland del Sur (Isla Baja y caleta Potter, isla Rey Jorge). Estas muestras comprendieron peces de tamaño pequeño y mediano (14.8-38 cm de talla total). Se compararon las lecturas otolitos y de escamas en 19 ejemplares Potter. En algunos de ellos las lecturas de escamas resultaron ser un sobrecálculo de la edad del pez por un año. Esto podría ser producto de la dificultad para distinguir entre controles falsos y anuales en las escamas. La determinación de la edad, por medio de cortes transversales de otolitos, demostró ser el método más fehaciente. Se compararon datos de talla promedio por edad aquí presentados para los ejemplares de la isla Baja, con aquellos valores publicados anteriormente. Esto confirmó que los peces de la Subárea de la Península Antártica son más pequeños que aquéllos del mismo grupo de edad en los alrededores de Georgia del Sur. Asimismo, nuestros valores son menores que los informados previamente para

los ejemplares de South Bay archipiélago de Palmer. Se tratan las posibles razones de estas diferencias. Se espera que el Sistema de Intercambio Otolitos/Escalas/Huesos, establecido por CCAMLR, contribuirá a la eliminación de discrepancias en los estudios sobre edad y crecimiento de los Peces Antárticos.



1. INTRODUCTION

Fish age determination is a subject of interest to the compass of CCAMLR. Since 1986 it has been discussed by the Fish Stock Assessment Working Group at the follow-up workshop held in Moscow in July 1986, and at the annual Scientific Committee meetings. As a result of the deliberations an exchange system has been established to examine otoliths, scales and bones of selected species of Antarctic Fish. *Notothenia gibberifrons* was included as one of the commercially most important species .

Up to now several papers have been published on the age and growth of *N. gibberifrons*. Kock et al. (1985) compiled data from different sources on mean total length and mean total weight for each age group of this species caught around South Georgia. Boronin and Frolkina (1976) (quoted in Kock et al. (1985); Shust and Pinskaya (1978) and Skora (quoted in Kock et al. 1985) worked with scales, while Hoffmann (1982) worked with first pelvic fin ray. Later on, Clasing et al. (1985), using otoliths, gave age-length information for a population sampled in South Bay (Palmer Archipelago, Antarctic Peninsula Subarea, Subarea 48.1). Discrepancies among the results of all these studies may arise from the following: different structures/methods used for age determination; different criteria for growth interpretation; growth differences due to geographical or populational variations of the samples. Thus, the aim of this paper is to contribute new data on age and length of *N. gibberifrons* from the South Shetland Islands by means of otolith analysis and emphasize the importance of the exchange system established by CCAMLR to standardize criteria for studying the age and growth of Antarctic fish.

2. METHODS

Samples* were obtained at two localities of South Shetland Is. (Figure 1) according to following detail:

Location	Low Island	Potter Cove (25 De Mayo/King George I.)
Date	January 1985	February-May 1986
Gear	Bottom-trawl (Scientific)	Trammel net
Depth	40-90 m	14-50 m

Fishes from Low I. were caught from the RV *Polar Duke* of the National Science Foundation, USA. For this study, immediately after capture, sagittal otoliths and scales of Potter Cove specimens were extracted, cleaned, dried and stored in paper envelopes until processing. Sex and total length of fishes were recorded.

As observed by Everson (1980), sagittal otoliths of *N. gibberifrons* are too thick for direct examination, therefore a sectioning technique was used. This technique and the equipment used in this work have been described by Tomo and Barrera-Oro (1985). The otoliths of 95 Low I. specimens and 37 Potter Cove specimens were cut in sections of 0.4 mm thickness; otolith cross sections of 82 specimens from the first area and 29 from the second were selected for age determination. Sections were cut in the transverse plane of the otolith, through the nucleus. The remaining parts were also examined. The second sagittal otolith of the pair was sometimes cut in halves, in order to compare the results of their readings with

* The material used in this study was not included in the CCAMLR Antarctic Fish Otolith/Scales/Bones Exchange System.

those obtained from the section of the first otolith. These procedures facilitated the age determination, which was made by direct examination of the growth rings. The counting method was similar to that used by Barrera-Oro and Tomo (1988). The terminology and reading method described by Williams and Bedford (1974) was adopted. The observations were done with a stereomicroscope Wild M 8 with transmitted-light Stand EB, using preferably reflected light against dark background, at magnifications from 8 to 25 x.

Before reading, scales were placed into a 5% alkaline solution for 36-48 hours. Then, selected scales of each specimen were cleaned mechanically, dried and mounted between microscope slides. Scales of 19 Potter Cove specimens were read. For age determination, the winter rings along the axis from the focus to the anterior margin were counted. The optical equipment used was the same as for the otoliths, but only with transmitted light at magnifications from 12 to 25 x.

After Scherbich (1975), July 1st was taken as the birth date from which the age of fish was calculated.

3. RESULTS

The examination of an otolith cross section under reflected and transmitted lights revealed that hyaline nucleus had an eccentric position. The growth rings could be observed in all the section; however the dorsal area was chosen as the best zone for counting the annuli (Figure 2). For further information about shape and size measurements of otoliths see North et al. (1984); Clasing et al. (1985) and Hecht (1987).

The length distribution (Figure 3) shows that specimens collected from both localities were of small and medium sizes (20.2-38 cm for Low I.; 14.8-35.5 cm for Potter Cove). In Low I. the sex ratio between males and females was 1:1.26 and females were of larger sizes. The amount of material from Potter Cove was insufficient to make a final comparison; however it was observed that fishes taken in the area were smaller (14.8-19.3 cm). This finding is in agreement with the known depth-distribution of the species. Our samples at Low I. were taken offshore, while Potter Cove is a fjord (shallow waters) area where the smallest juveniles of *N. gibberifrons* occur.

Comparative analysis of otolith cross sections and scales of chosen specimens from Potter Cove allowed a simultaneous age determination. Results are presented in Table 1. Both methods gave comparable results, however in some specimens reading of scales indicated one extra year. This finding is discussed below.

Table 2 shows the observed age-length for *N. gibberifrons* from both localities. Potter Cove and Low I. fishes ranged from 4 to 10 years and from 5 to 13 years, respectively. Comparison of mean length at certain age groups suggested similarity in growth; however data from Potter Cove were not enough for full analysis. Mean lengths of females from Low I. were higher than those of corresponding males; more data are needed to make a significant comparison. Few age groups were well represented (6-9 year groups predominated), however, no data were obtained for the first 1-4 year age groups. Therefore, growth curves were not fitted.

4. DISCUSSION

Fishes of larger sizes were absent in our samples (only one specimen from Low I. was of 38 cm while the rest were below 35.5 cm). Data compiled for the last 13 years on length distribution of *N. gibberifrons* for the Antarctic Peninsula (AP) area were considered. According to data of Kelle and Kock (unpublished) (quoted in Kock et al., 1985) and

Hoffmann (1982) for the South Shetland Is. and of Clasing et al. (1985) for South Bay, Palmer Archipelago, the largest specimens ranged from 45 to 52 cm. Fish of such length probably inhabit greater depths than our net could reach (40-90 m) and so this would explain their absence in the samples of Low I. In Potter Cove, fjord fishes from shallower waters were adequately represented by small and medium sizes.

In a qualitative analysis of otoliths, scales and bones (vertebrae-operculum) of *N. gibberifrons*, Kelle (1982) concluded that otoliths and preferably scales are useful for age determination studies of the species. Although Boronin and Frolkina (1976) (quoted in Kelle, 1982) had also indicated scales as the most appropriate structures, difficulties in their interpretation of the *N. gibberifrons* age have been reported. Everson (1980) found inconsistencies between age determined by otoliths and scales (scales indicated 1-2 years less). North et al. (1980) mentioned the difficulty in discriminating splits or false checks from the annual checks (winter checks) as well as in separating checks on the outer edge of old fish scales. In this study a comparison between age determination by means of scales and otolith cross sections of Potter Cove specimens showed general correlation. However, in some specimens scale readings resulted in one extra year (Table 1). This could arise from the difficulties with false checks as mentioned above, which caused age overestimation. Thus, in this work, age determination by otolith cross sections proved to be the most reliable method. Clasing et al. (1985) have already expressed the easiness of age determination of *N. gibberifrons* by otolith "crack and char method".

The observed hyaline nucleus in otoliths of *N. gibberifrons* from South Shetland Is. was also reported by Clasing et al. (1985) for specimens from South Bay, South Georgia and South Orkneys Is. According to this publication, hatching of larvae occurs during the Antarctic winter; that is to say, a non favourable season of the year. The populations of *N. gibberifrons* from South Bay and South Georgia would reach sexual maturity at 6.7 years of age (Clasing et al., 1988).

Table 3 shows a comparison of mean total lengths data by age, between South Georgia (compiled by Kock et al. 1985) and AP specimens of *N. gibberifrons*. Mean lengths data have been calculated from the total length annuli number keys published in Clasing et al. (1985). The limited number of Potter Cove fishes has not been included in this comparison. For the South Georgia area, the reported data on age determination are well comparable in age groups up to 9 years except the data of Skora (quoted in Kock et al., 1985) due to discrepancies for fishes larger than 40 cm (Kock et al. 1985). Difficulties with checks, particularly in old fish might explain different results of authors working with scales. Length data at each age group clearly show a slower growth of fishes from the AP (Table 3). Colder waters at higher latitudes seem to be responsible for such a decrease in growth, as it was also observed by Clasing et al. (1985). Variations between the results obtained from South Georgia and AP specimens may also be in part explained by the different structures and methods used for age determination. Clasing et al. (1985) also used otoliths for the age readings and their samples (South Bay) were collected at nearly the same places as ours (Low I.). Nevertheless, they reported higher mean length values than those presented here (Table 3). Presumably, interpretation criteria used were different. Results of Skora (quoted in Kock et al. 1985) from scale analysis of South Georgia specimens, are similar to ours (Table 3). As it was mentioned, more than one reason might explain differences in the results of age and growth studies of a fish species.

The Otolith/Scales/Bones Exchange System established by CCAMLR seems to be the adequate way of eliminating discrepancies in this subject.

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Table 1: Comparison of age determined from otolith cross section (ot) and scales (s) in *Notothernia gibberifrons* specimens from Potter Cove, 25 De Mayo/King George Island. Age in years; total length in cm.

Specimen No.	MALES			FEMALES		
	Total Length	ot	Age s	Total Length	ot	Age s
1	20.6	5	5 / 6	18.6	4	4 / 5
2	23	6	6	20.3	5	6
3	29.3	9	10	22.9	5	6
4	29.4	8	9	24.2	6	5
5	31	10	10	24.7	6	6
6	31.6	10	11	25.1	6	6
7				25.6	7	7
8				29.9	9	9
9				30.1	9	10
10				31.2	9	9
11				31.7	10	9 / 10
12				32.3	10	10
13				33.2	10	11

Table 2: Age-length observed values for each age group in male and female *Notothenia gibberifrons* from Low Island and Potter Cove. Age in years; range and mean length in cm.

Age group	LOW ISLAND						POTTER COVE					
	MALES			FEMALES			MALES			FEMALES		
	N	Range	Mean length	N	Range	Mean length	N	Range	Mean length	N	Range	Mean length
4										3	18.6-19.3	19
5	1	-	20.2	4	22.3-23.2	22.75	3	19.4-21.5	20.5	2	20.3-22.9	21.6
6	3	22.8-24.8	24.07	5	24.6-26.4	25.14	1	-	23	3	24.2-25.1	24.67
7	8	24.9-27.8	26.51	12	24.9-30.9	27.05				1		25.6
8	9	25.9-29.8	27.91	21	26.3-32.3	28.79						
9	9	29.1-33.8	30.62	4	29.9-34.9	31.88	2	29.3-29.4	29.35	6	29-35.5	30.8
10	3	30.4-33.9	32.13				3	31-31.6	31.2	5	30.1-33.2	32
11	2	30.4-38	34.2									
12												
13	1		32.5									
	+ 36			+ 46			+ 9			+ 20		

Table 3: Mean length (cm) data according to age (years) of *Notothenia gibberifrons* for different authors in different zones. The type of structure used for age determination is specified. Sample numbers are indicated in parenthesis, when less than five.

Age group	SOUTH GEORGIA					ANTARCTIC PENINSULA					
	Boronin and Frolkina 1976 Scales		Shust and Pinskaya 1978 Scales			Hoffman 1982 Pelvic fin ray	Skora Scales	South Bay Clasing et al 1985 Otoliths		Low Island This paper Otoliths	
	♂	♀	♂	♀	♂+♀		♂	♀	♂	♀	
1			8.4	8	8.2						
2			14.9	14.7	14.8						
3	21.5	22.9	20.5	20	20.2	21.7	21				
4	25.7	25.6	25.8	25.5	25.6	27.1	22.3				
5	29.5	29.1	29.5	29.6	29.5	30.6	23.2			20.2(1) 2.7 (4)	
6	33.5	33.7	32.8	32.5	32.6	34.4	25.3			24 (3) 25.1	
7	35.9	36.4	35.6	35.1	35.3	37.8	26.8	31 (1)	30 (2)	26.5 27	
8	38.4	38.8	38.7	38.1	38.4	39.6	29.3	31.4	32.8	27.9 28.8	
9	40.6	41.4	41.4	41.3	41.3	40.3	33.2	32.6	35.2	30.6 31.9(4)	
10	41.7	42.6	43.5	43.7	43.6	43	35.2	33.6	37	32.1(3)	
11	43.1	43.6	45.7	46	45.7	43.8	36.3	35.5	35.8	34.2(2)	
12	43.3	44.6	47.1	47.5	47.3	44	37.6	37.5	38		
13	44.4	44.9	48	49.1	48.5		39	37.2	39.4	32.5(1)	
14	45.4	45.3	49.5	50.5	50		40	40 (1)	39.8		
15	46.1	46.3					41.3				
16	46.7	47.2					41				
17	47.5	48.4						41.5(1)	45 (1)		
18	49.1	48.5									
19								43 (1)			



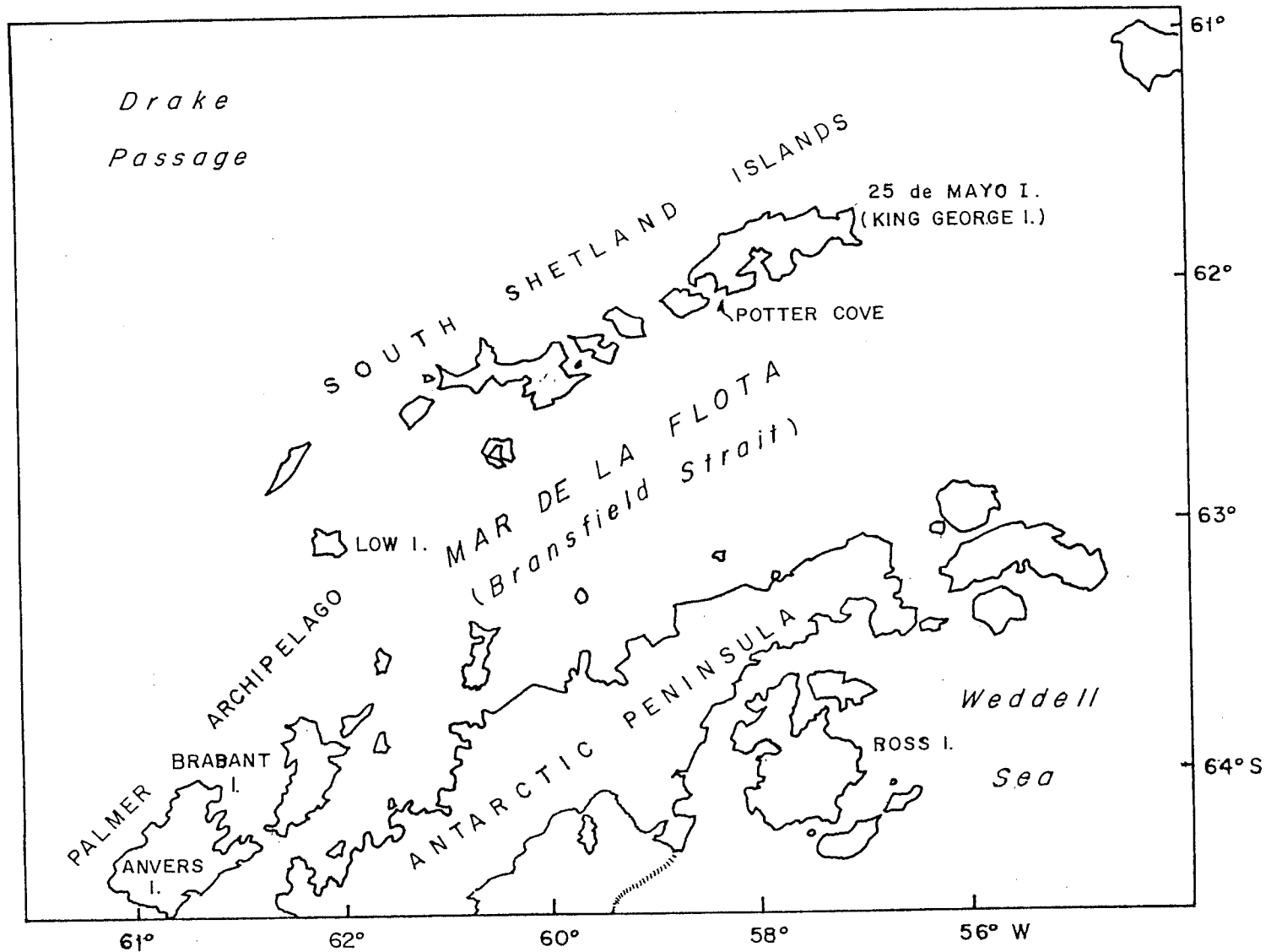


Figure 1: Catch sites of *Notothenia gibberifrons* sampled at two localities of the South Shetland Islands, Antarctic Peninsula Subarea.

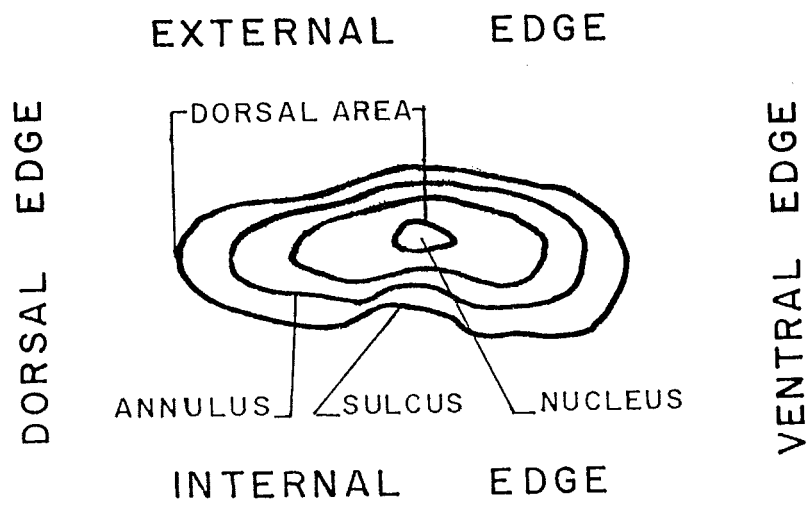


Figure 2: Drawing of an otolith cross section showing the counting area used for *Notothenia gibberifrons*.

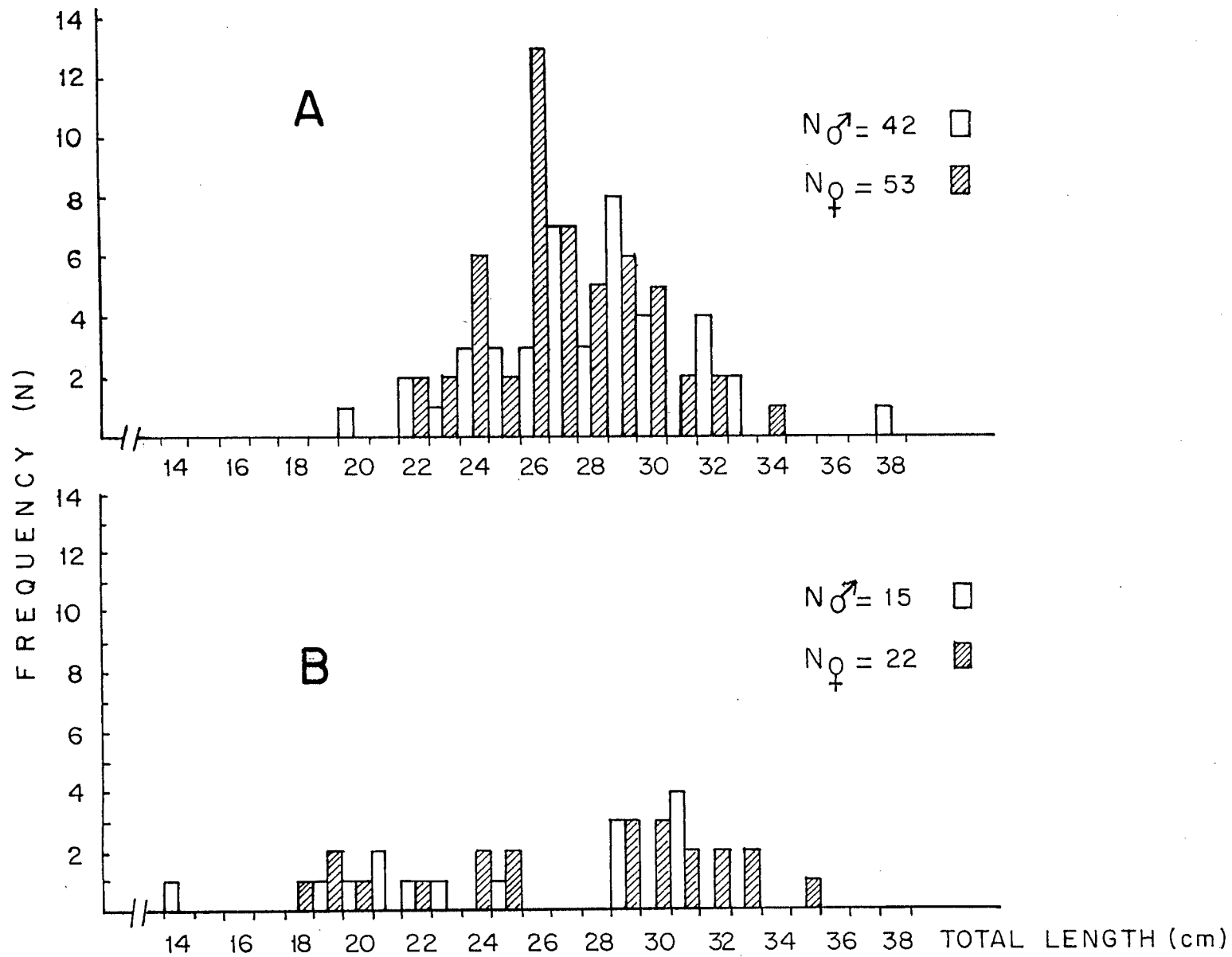


Figure 3: Distribution of length frequencies in *Notothernia gibberifrons*. (A) Specimens from Low Island; (B) Specimens from Potter Cover, 25 de Mayo/King George Island.

Лéгeндeс дeс тaблeау

- Тaблeау 1 Сoмпaрaйзoн дeс âгeс дeтeрмiнeс пaр eкaмiнaцiй д'унe сeццiйoн тrаnсvеrсaлe дeс oтoлiтeс (ot) eт дeс eцaйллeс (s) дeс спeцiмeнс дe *Notothenia gibberifrons* дe Pottеr Cоvе, îlе 25 dе Mаyо/King Gеorgе. Age eн аnnéеs; lоngueur tоtаlе eн cm.
- Тaблeау 2 Vаlеurs âгeс-lоngueurs оbсervéеs pоur чaquе grоupе d'âгeс dе *Notothenia gibberifrons* mâlеs eт fеmеllеs dе Lоw Islаnd eт Pottеr Cоvе. Age eн аnnéеs; limites eт lоngueur mоyеnnе eн cm.
- Тaблeау 3 Donnéеs sur lоngueur mоyеnnе (cm) pаr rаng d'âгe (аnnéеs) dес *Notothenia gibberifrons* pоur différents аutеurs dаns différentes zоnеs. Le typе dе structurе utilisé pоur lа détermination dе l'âгe еst spécifiéе. Le nоmbre d'échantillons еst indiqué еntre parenthèses, s'il еst inférieure à 5.

Лéгeндeс дeс figures

- Figure 1 Sites dе capture dе *Notothenia gibberifrons* échantillonné à deux еmplacements dес îlеs Shetland du Sud, dаns lа sous-zоnе dе lа péninsulе Antarctique.
- Figure 2 Dessin d'une section transversale d'une otolithe montrant lа zоnе dе dénombrement utilisée pоur lе *Notothenia gibberifrons*.
- Figure 3 Distribution dес fréquences dе longueurs pоur lе *Notothenia gibberifrons*. (A) Spécimens dе Lоw Islаnd; (B) Spécimens dе Pottеr Cоvе, îlе 25 dе Mаyо/King Gеorgе.

Загoлoвки к тaблицам

- Таблица 1 Сравнение возраста, определенного по спилу отолита (ot) и чешуи (s) экземпляров *Notothenia gibberifrons*, найденных в районе залива Поттер Коув, о. Кинг Джордж. Возраст в годах; общая длина в сантиметрах.
- Таблица 2 Полученные путем наблюдения величины соотношения возраст-длина для каждой возрастной группы мужских и женских особей *Notothenia gibberifrons*, с о. Лоу и из залива Поттер.Коув. Возраст в годах; пределы длины и средняя длина в сантиметрах.
- Таблица 3 Данные по средней длине (см) в соответствии с возрастом (годы) *Notothenia gibberifrons*, для разных авторов и в разных зонах. Уточнен тип использованной структуры для определения возраста. В скобках указано количество проб (в случае, если было меньше пяти проб).

Подписи к рисункам

- Рисунок 1 Места выловов *Notothenia gibberifrons*, пробы из которых были взяты в двух районах: у Южных Шетландских островов и у Антарктического полуострова.

- Рисунок 2 Диаграмма спила отолита, в пределах которого производился подсчет годовых колец.
- Рисунок 3 Распределение частот длины у *Notothenia gibberifrons*. (A) Экземпляры с о. Лоу; (B) Экземпляры из залива Поттер Коув, о. Кинг-Джордж.

Encabezamientos de las Tablas

- Tabla 1 Comparación de edades determinadas por el corte transversal de otolitos (ot) y las escamas (s) en ejemplares de *Notothenia gibberifrons* procedentes de la caleta Potter, isla Rey Jorge. Edad en años; tamaño total en cm.
- Tabla 2 Valores observados de edad-tamaño para cada grupo de edad en machos y hembras de *Notothenia gibberifrons* procedentes de la isla Baja y caleta Potter. Edad en años; rango y tamaño medio en cm.
- Tabla 3 Datos de la talla promedio (cm) según la edad (años) de *Notothenia gibberifrons* por diferentes autores en distintas zonas. Se especifica el tipo de estructura utilizada para la determinación de la edad. Los números de la muestra están indicados entre paréntesis, cuando es menos de cinco.

Leyendas de las Figuras

- Figura 1 Sitios de captura de *Notothenia gibberifrons* muestreados en dos localidades de las islas Shetland del Sur, Subárea de la Península Antártica.
- Figura 2 Dibujo de una sección transversal de un otolito mostrando el área de recuento utilizada para *Notothenia gibberifrons*.
- Figura 3 Distribución talla - frecuencia en *Notothenia gibberifrons*. (A) Ejemplares de la isla Baja; (B) Ejemplares de la caleta Potter, isla Rey Jorge.