A DECLINING TREND IN THE ABUNDANCE OF *NOTOTHENIA ROSSII MARMORATA* AND *NOTOTHENIA GIBBERIFRONS* OBSERVED IN FJORDS IN TWO SITES IN THE SOUTH SHETLAND ISLANDS

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Abstract

A declining trend observed in the abundance of *Notothenia rossii marmorata* and *Notothenia gibberifrons* in fjords in two sites in the South Shetland Islands (Subarea 48.1), is analyzed by a nested ANOVA and demonstrated as significant. The material for the current study was obtained with trammel nets at Potter Cove, King George/25 de Mayo I., over a period of eight years from 1983 to 1990 and in waters around Half-Moon I., Moon Bay, in 1989. The analysis was based on the proportion of catches of the abovementioned species in relation to *Notothenia neglecta*, a species with similar ecological habits in the fjords. Since sampling by this method did not utilize a consistent amount of effort between years, the analysis made use of standardized catch data by expressing the catches of *N. rossii* and *N. gibberifrons* in proportion to the catches of *N. neglecta*. A similar declining trend had been reported in the 1960s and 1970s for neighbouring sites in the South Shetland Islands. This phenomenon might be explained as a consequence of the depletion of the stocks due to commercial exploitation in the area in the early 1980s.

Résumé

La tendance au déclin observée dans l'abondance des espèces *Notothenia rossii marmorata* et *Notothenia gibberifrons* dans les fjords de deux sites des îles Shetland du Sud, fait l'objet d'une analyse par emboîtements ANOVA et se révèle significative. Le matériel étudié a été obtenu par filets trémails à Potter Cove, île du Roi George/25 de Mayo, sur une période de huit ans, entre 1983 et 1990 et dans les eaux entourant l'île Half-Moon, baie Moon, en 1989. L'analyse était basée sur la proportion de captures des espèces mentionnées par rapport à *Notothenia neglecta*, une espèce aux habitudes écologiques similaires dans les fjords. L'échantillonnage par cette méthode ne nécessitant pas une valeur constante d'effort entre années, l'analyse a utilisé des données de capture standardisées en exprimant les captures de *N. rossii* et de *N. gibberifrons* proportionnellement aux captures de *N. neglecta*. Une pareille tendance à la baisse a déjà été signalée dans les années 60 et 70, en des sites proches, dans les îles Shetland du Sud. Le présent phénomène peut être expliqué comme étant une conséquence du déclin des stocks dû à l'exploitation commerciale dans cette région depuis le début des années 80.

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Резюме

Посредством гнездового анализа (ANOVA) была проанализирована и, в итоге, признана значительной тенденция к сокращению численности фиордовой рыбы видов *Notothenia rossii marmorata* и *Notothenia gibberifrons* на двух участках в районе Южных Шетландских островов (Подрайон 48.1). Использованные в настоящем исследовании данные были получены с помощью многостенных сетей в бухте Поттер-Коув острова Кинг-Джордж на протяжении восьми лет с 1983 по 1990 гг. и в водах вокруг острова Хаф-Мун в заливе Мун-Бей в 1989 г. Анализ был основан на процентном отношении уловов вышеупомянутых видов к уловам вида *Notothenia neglecta*, обладающего сходными экологическими характеристиками. Поскольку при таком сборе проб промысловое усилие изменяется из года в год, при анализе использовались стандартизированные данные по уловам, выраженные как процентное отношение уловов *N. rossii* и *N. gibberifrons* к уловам *N. neglecta*. В 1960-х и 1970-х годах были получены сведения о существовании подобных тенденций к сокращению запасов на близлежащих участках Южных Шетландских островов. Причиной данного явления в этом районе может быть истощение этих запасов в результате коммерческого промысла в начале 1980-х годов.

Resumen

Se ha utilizado el ANOVA anidado para analizar la disminución observada en la abundancia de *Notothenia rossii marmorata* y *Notothenia gibberifrons* en fiordos situados en dos zonas distintas de las islas Shetland del Sur (Subárea 48.1), concluyéndose que esta disminución es muy marcada. El material de estudio fue recogido mediante redes de trasmallo en Caleta Potter, isla Rey Jorge/25 de Mayo, durante un período de ocho años, de 1983 a 1990 y en las aguas que circundan la isla Media Luna, Bahía Luna, en 1989. El análisis consistió en una comparación de las capturas de las especies mencionadas anteriormente, y *Notothenia neglecta*, especie de hábitos ecológicos similares en los fiordos. Debido a la diferencia anual que existe en el esfuerzo pesquero empleado en la toma de muestras por este método, el análisis utilizó datos estándar de capturas y los expresó como proporción de capturas de *N. rossi* y *N. gibberifrons*, en relación a *N. neglecta*. Una disminución similar se observó en las décadas de los años 60 y 70, en localidades cercanas, en las islas Shetland del Sur. Este fenómeno puede ser interpretado como una consecuencia de la merma en las poblaciones debido a la explotación comercial en el área a principios de los años 80.

1. INTRODUCTION

At the Eighth Meeting of the Scientific Committee the Chilean Delegation reported a recent decline in the abundance of *Notothenia rossii marmorata* and *Notothenia gibberifrons* caught in fjords of South Bay, Doumer I., Palmer Archipelago. Since the implementation by the Instituto Antártico Argentino of routine sampling of fish a similar situation has been observed in neighbouring sites in the South Shetland Islands: Potter Cove (Jubany Station), King George/25 de Mayo I. and Moon Bay (Cámara Station), Livingston I.

This paper presents an analysis on the abundances of fjord *N. rossii marmorata* and *N. gibberifrons* in relation to the abundance of *Notothenia neglecta*, a species with similar ecological habits. Comparisons with earlier data taken from the literature, are also made.

2. METHODS

Samples were obtained using trammel nets (length 25, 35 and 50m; width 1.5m; mesh 2.5cm) at Potter Cove from 1983 to 1990 and in waters around Half Moon I. (Moon Bay, Livingston I.) in 1989 (Figure 1. A). At Potter Cove, the net was always located in the same site (Figure 1. B) at depths from 5 to 50m. The same procedure was followed at Moon Bay, covering a depth range from 5 to 35m.

Since sampling was not aimed at monitoring the abundance of fjord-fish, fishing effort was not controlled, with the result that various yields were obtained per haul (Figure 2). Potter Cove data from 1990 were obtained as part of an ecological study requiring continuous sampling with a limited fishing period for each net. All sampled fish were used for other studies (Barrera-Oro, 1989; Casaux *et al.*, 1990; Barrera-Oro and Casaux, 1990) where morphometric and meristic data, sex, maturity stages, ages and stomach contents were determined.

In order to have a measure of abundance of *N. rossii marmorata* and *N. gibberifrons* standardized for all samples, the proportion of these species in relation to *N. neglecta* was calculated as follows:

$$\text{Proportion(b)} = \frac{Nb}{Nn + Nb} \qquad (1)$$

where **Nb** is the number of specimens of the species considered (*N. rossii marmorata* or *N. gibberifrons*), and
Nn is the number of specimens of *N. neglecta.*

Differences between years have been tested with a nested ANOVA design (Table 1A) using the arcsin of the square root transformation, which is recommended for the analysis of proportions (Sokal and Rohlf, 1981). Data from Half Moon I. obtained in 1989 are presented in Table 1B.

As the trammel net is a passive sampling device, catches depend on fish activity. Our assumption is that changes in population sizes will be reflected in proportional changes in catches.

Trammel nets of different length and different sampling periods were used in the study. Nevertheless, as the location of nets was kept constant, the same fraction of the population was sampled over the years. The resultant increase in variance was dealt with by the nesting observations. It forms part of the error term. As variations between hauls are considered as replicates within months, the sum of squares due to the possible changes in fishing gears and sampling periods are used for the comparison of the higher levels. Thus, the effect will be a decrease in the power of the test.

3. RESULTS AND DISCUSSION

As expected, all *N. rossii marmorata* specimens collected were juvenile. *N. gibberifrons* individuals were mainly juvenile, with a limited number of adults. This catch composition, found at a water depth of 5 to 50 m, is in agreement with the known pattern of depth distribution of *N. gibberifrons*.

Figure 3 shows the yearly total catches of *N. rossii marmorata* and *N. gibberifrons* at Potter Cove, expressed as proportions (Equation 1). An overall declining trend is evident for both species, and its significance is demonstrated by the ANOVA results (Table 2).

Published information on fjord-fish taken at similar depths in sites close to Potter Cove and Moon Bay contain data on accumulated catches for non-comparable periods. To make these data comparable with ours, we calculated from them the proportion of catches of *N. rossii marmorata* and *N. gibberifrons* in relation to *N. neglecta*, with the following results: 0.12 *N. rossii marmorata* and 0.044 *N. gibberifrons* in summer 1965/66 at Moon Bay (Bellisio, 1967); 0.38 *N. rossii marmorata* in December 1969 at Fildes Bay, King George I. and 0.48 *N. rossii marmorata* in January 1971 at Discovery Bay, Greenwich I. (Moreno and Bahamonde, 1975); 0.43 *N. rossii marmorata* in summer 1979/80 at Admiralty Bay, King George I. (Linkovski *et al.*, 1983).

It should be noted that data from Fildes Bay and Discovery Bay were obtained by hook and line gears, while at Admiralty Bay gill nets were used. For Half Moon I., combined catches of hook and line gears and trammel nets were reported.

Although this information is not fully comparable in significance tests, it is clear that before 1980 the proportion of *N. rossii marmorata* was well above the starting point of our series at Potter Cove (1983). Around Half Moon I., the proportion of *N. rossii marmorata* obtained by Bellisio (1967) in 1965/66 is three times greater than in 1989 (0.038). In this year, there was not a single capture of *N. gibberifrons*, while a proportion of 0.044 was obtained for this species in 1965/66.

The data series obtained at Potter Cove seems to start after the onset of a declining trend (Figure 2). In this area the abundances of *N. rossii marmorata* and *N. gibberifrons* attained a minimum during 1985/86. The six to seven years preceding this were characterized by commercial catches in the Antarctic Peninsula, Subarea 48.1 (Kock, 1986; Nast *et.al.*, 1988; Tiedtke and Kock, 1989). This decline was demonstrated as highly significant ($P<0.001$). Considering that *N. neglecta* has been not commercially exploited it is reasonable to attribute the recent low abundances of juvenile *N. rossii marmorata* and *N. gibberifrons* to the depletion of the stocks in the area. If so, the phenomenon should affect a wide geographical region, a fact confirmed by the Chilean Delegation's comment on South Bay.

This decrease, implies that in future years recruitment to the commercial fisheries will be low, and recovery to levels close to maximum sustainable yield (MSY) might well take more than two or three decades.

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Table 1: Summary of specimens of each species caught at A) Potter Cove and B) Moon Bay.

A)

Level 1 (years)	Level 2 (months)	Number of Replicates	Number of Specimens Caught in Each Replicate		
			N. neglecta	*N. rossii*	*N. gibberifrons*
1983	April	7	2,12,16,15 2,1,4	4,6,9,5,0 0,3	Not recorded
	May	9	6,5,11,3,6 6,5,2,8	7,3,2,8,0 0,3,2,6	
	June	3	13,17,32	4,2,2	
	October	1	39	2	
	November	3	26,2,0	1,16,2	
1984	January	5	35,11,18,15 13	16,4,4,5,5	
	February	2	3,12	1,2	
	March	2	26,31	13,15	
	April	6	10,36,5,24 5,19	2,5,2,5,2 1	
	October	2	21,20	11,10	
	November	2	10,25	1,3	
	December	3	28,16,25	11,4,6	
1985	April	5	5,11,8,14,24	0,1,3,7,3	1,8,16,1,3
	May	5	10,14,28,7 31	0,6,3,4,2	11,13,3,15 13
	August	3	56,8,25	4,0,1	2,14,0
	September	3	41,15,21	0,0,2	3,0,13
	October	1	9	0	1
1986	February	3	27,20,8	9,2,2	3,4,1
	March	4	16,40,34,27	0,0,3,2	1,14,1,2
	April	6	34,29,27,33 32,11	0,2,1,0,0,1	1,4,0,3,0,1
	May	2	28,25	4,0	2,0
	December	5	37,14,11,29 20	4,0,1,0,3	1,0,0,0,0

Table 1A) (continued)

Level 1 (years)	Level 2 (months)	Number of Replicates	Number of Specimens Caught in Each Replicate		
			N. neglecta	*N. rossii*	*N. gibberifrons*
1987	January	2	35,12	2,2	0,0
	February	3	6,17,22	1,1,0	0,0,0
	March	3	23,37,18	0,0,0	0,0,0
	April	4	27,33,48,31	0,0,2,0	1,0,1,1
	May	2	12,26	1,3	0,0
	November	1	70	6	0
	December	4	2,26,21,44	0,0,2,1	0,0,0,0
1988	January	3	18,51,13	1,1,0	0,0,0
	October	2	7,48	6,0	0,2
	November	2	21,9	4,0	0,0
	December	2	23,33	0,0	0,0
1990	January	10	26,5,25,16,7 9,2,7,21,5	0,0,1,0,0 0,0,1,1,0	0,0,1,0,0 0,0,0,2,0

B)

Year	Month	Number of Replicates	Number of Specimens Caught in Each Replicate		
			N. neglecta	*N. rossii*	*N. gibberifrons*
1989	January	2	57,52	2,1	0,0
	February	1	95	5	0

Table 2: ANOVA of proportions of *N. gibberifrons* and *N. rossii marmorata* using the arcsin of square root transformation.

a) *N. rossii marmorata*

Source (Level)	DF	Sum of Squares	Mean Square	F	Probability	Percentage of Variance
Years	6	11908.306	1984.718	8.7007	0.00003	34.4055
Months	27	6158.961	228.110	1.2654	0.20592	5.0655
(Error)	86	15503.397	180.272			60.5291

b) *N. gibberifrons*

Source (Level)	DF	Sum of Squares	Mean Square	F	Probability	Percentage of Variance
Years	4	8458.203	2114.551	15.3911	0.00002	54.0275
Months	17	2335.601	137.388	1.3514	0.19897	4.8200
(Error)	53	5388.212	101.664			41.1525

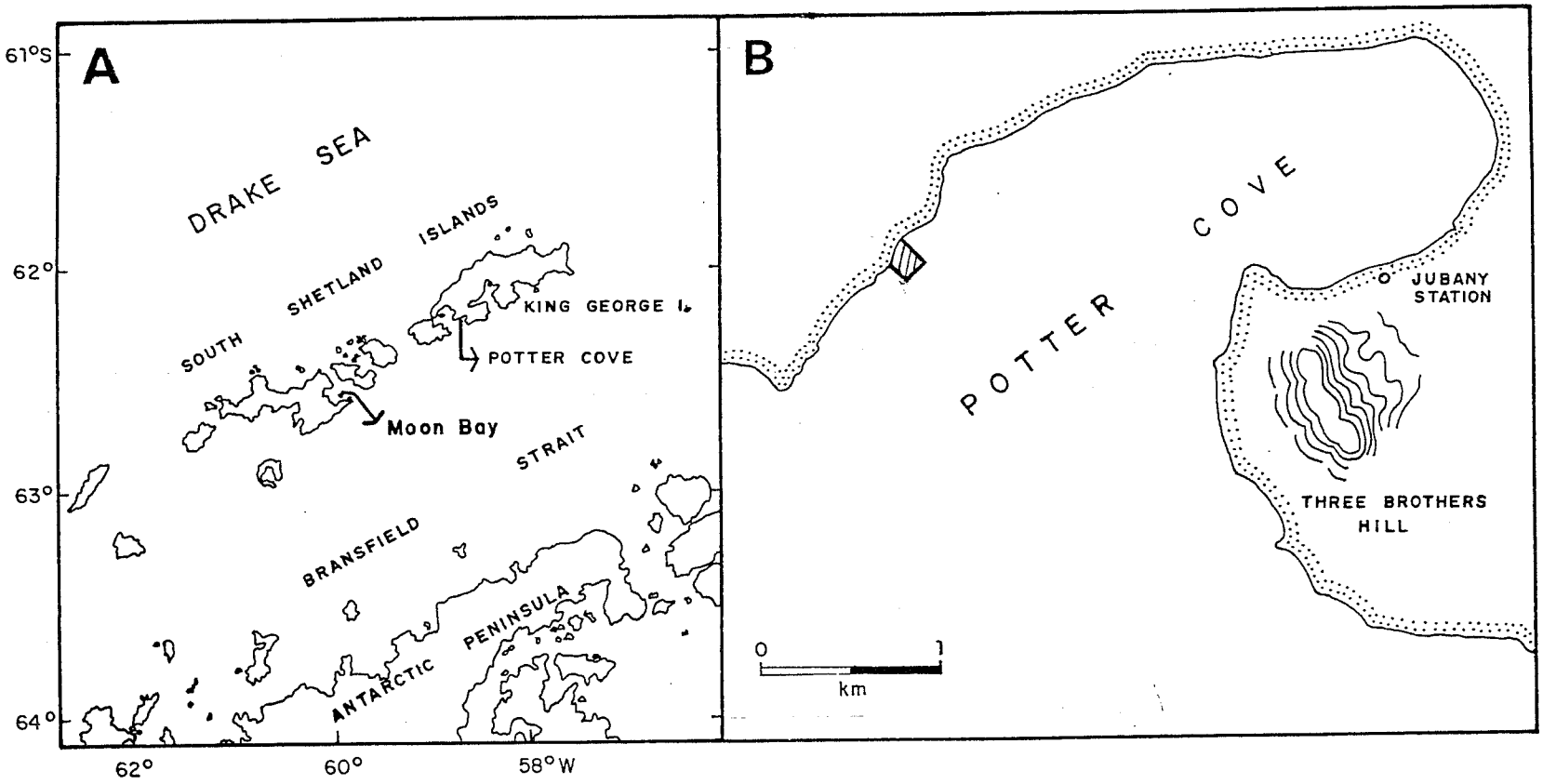

Figure 1: Location of sampling sites: (A) Moon Bay, (B) Potter Cove.

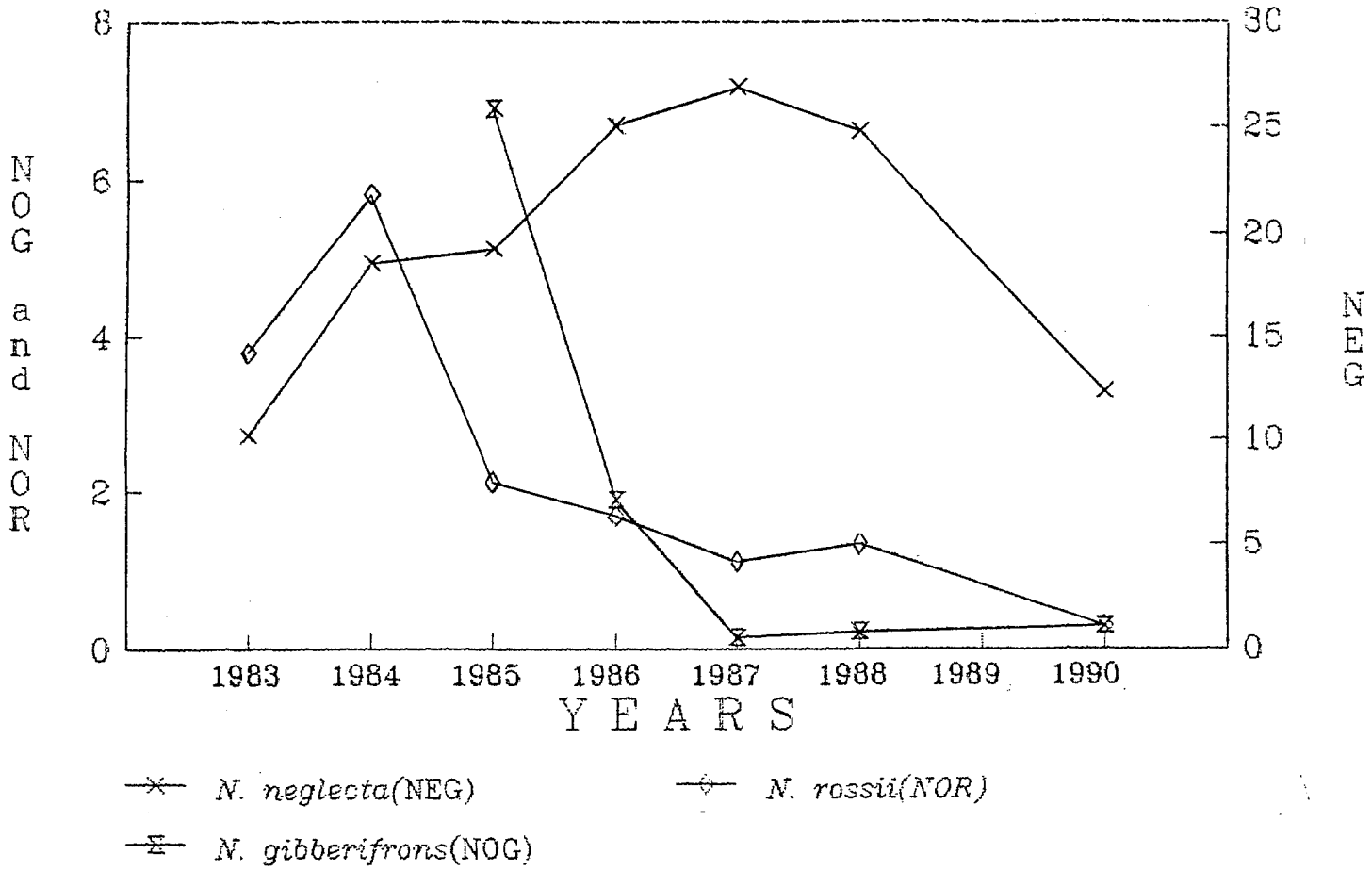

Figure 2: Annual mean catches-per-haul (number of specimens).

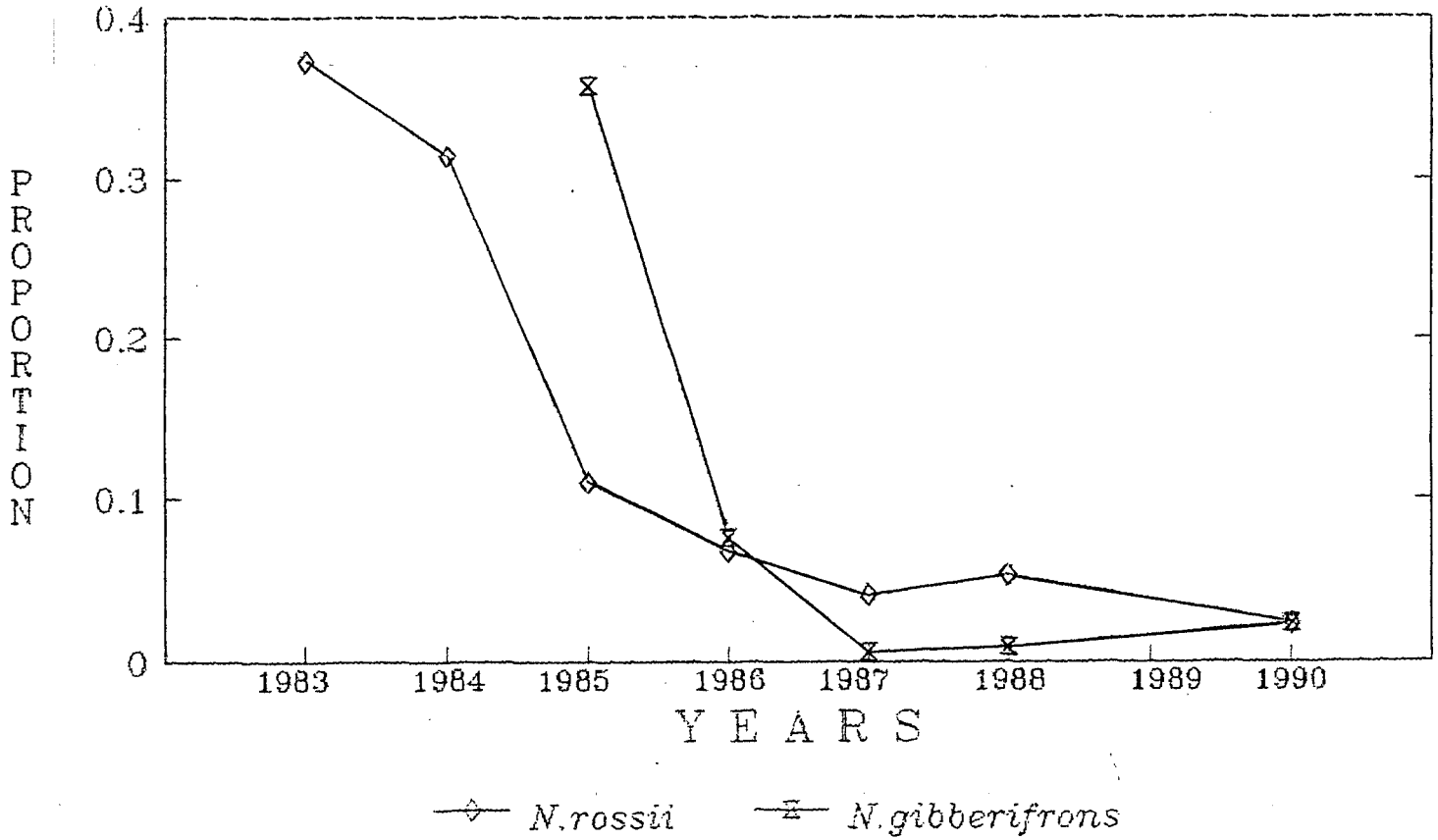

Figure 3: Annual catches of *N. rossii* and *N. gibberifrons* expressed as proportions of *N. neglecta* catches (see text, Equation 1).

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gibberifrons, Potter Cove, Notothenia rossii, trammel nets, South Shetland Islands, isla Media Luna, Notothenia rossii marmorata, iles Shetland du Sud, Notothenia gibberifrons, en, Fildes Bay, Admiralty Bay, Discovery Bay, proportion, Moon Bay, toma de muestras

A declining trend in the abundance of Notothenia rossii marmorata and Notothenia gibberifrons observed in fjords in two sites in the South Shetland Islands