NATURAL MORTALITY OF GREY ROCKCOD (*NOTOTHENIA SQUAMIFRONS*) IN VARIOUS AREAS OF THE INDIAN SECTOR OF THE SOUTHERN OCEAN

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Abstract

The rate of natural mortality of grey rockcod (Notothenia squamifrons) on the Ob and Lena Banks and the Kerguelen Shelf were determined using three independent methods. From the values obtained the means were taken to be the most reliable. These were 0.38, 0.36 and 0.33 for the above areas respectively. These values are comparable with those derived for most notothenioids.

Résumé

Le taux de mortalité naturelle de la bocasse grise (*Notothenia squamifrons*), provenant des hauts-fonds Ob et Léna et du plateau de Kerguelen, a été déterminé selon trois méthodes différentes. A partir des valeurs obtenues, on a supposé que les moyennes étaient les plus fiables. Celles-ci étaient respectivement de 0,38, 0,36 et 0,33 pour les zones mentionnées ci-dessus. Ces valeurs sont comparables à celles provenant de la plupart des *Notothenioidei*.

Резюме

При использовании трех различных методов был определен коэффициент естественной смертности серой нототении *(Notothenia squamifrons)* в районе банок Обь и Лена и шельфа Кергелена. Наиболее надежными были признаны средние величины полученных значений. Для вышеупомянутых районов эти величины составили соответственно 0,38, 0,36 и 0,33. Эти значения сопоставимы со значениями, выведеннными для большинства нототениоидных рыб.

Resumen

El índice de mortalidad natural de la trama gris (*Notothenia squamifrons*) en los Bancos de Ob y de Lena y en la plataforma de Kerguelen, se determinó usando tres métodos independientes. De los valores obtenidos, las medias se tomaron como las más fiables. Estas fueron 0.38, 0.36 y 0.33 para estas áreas, respectivamente. Estos valores son comparables con esos derivados para la mayoría de los peces nototenioídeos.

The rate of natural mortality (M) of grey rockcod (*Notothenia squamifrons*) was determined using three independent methods.

The Rikhter-Efanov method uses the empirical relationship between M and age at maturity for most fish (t_n) where 50 or 70% of a population comprises mature specimens (Babayan et al., 1984). The rate of natural mortality (M) is calculated as

$$M = \frac{1.521}{t_n \cdot 0.720} - 0.155 \qquad (1)$$

Values for t_n (70%) were calculated for each area. For specimens on the Ob and Lena Banks these were 6.6 and 6.2 years respectively, while for the Kerguelen Islands area the value was 8.6 years.

The calculated values of M were found to be the lowest among specimens of the Kerguelen populations (0.17), while the "bank" populations gave higher values (0.24 to 0.25).

In order to compare our data with the results obtained by Duhamel (Kock, Duhamel, Hureau, 1985), age at maturity for most fish was determined for a population with 50% of mature fish. The values of t_n were established to be 5.9, 5.2 and 7.6 years. The value for M in the Kerguelen Islands area is comparable to, although slightly higher than that calculated by the French scientists (0.20 as opposed to 0.18) (Table 1).

The Alverson-Carnee method takes into account the age at which fish biomass reaches its maximum (T). This parameter is calculated according to the age of the oldest group in the catches (T_m), comprising not less than 0.5% of the total sample (Babayan et al., 1984). For an exploited population $T=0.38\ T_m$. For *N. squamifrons* T_m is 15 years (Ob Bank), 14 years (Lena Bank) and 15 years (Kerguelen Islands). In this case the natural mortality rate is 0.35 to 0.39.

The Beverton-Holt method is used for previously unexploited populations. The value of M was determined according to the following formula:

$$M = \frac{K\ (l\infty - l')}{T - l'} \qquad (2)$$

where T = mean length of fish in the catch;
l' = minimum length of fish in the catch;
$l\infty$ = asymptotic length (i.e. maximum length according to Bertalanffy's growth equation);
K = coefficient of growth of the Bertalanffy growth.

This equation was worked out using data on *N. squamifrons* size composition over the first years of exploitation (i.e. 1978 to 1979 for the Ob and Lena Banks and 1969 to 1972 for the Kerguelen Islands). Data on 2 to 15 year old fish were used in calculations.

Depending on the area, values for M varied from 0.46 to 0.52, which is slightly higher than values obtained using the Rikhter-Efanov and Alverson-Carnee methods.

Because of the considerable difference in instantaneous natural mortality rates, calculated using various methods, and the absence of objective criteria to choose any one of them, the mean arithmetical value of the estimates obtained may be applicable. In this case the mean values of M are 0.38 (Ob Bank), 0.36 (Lena Bank) and 0.33 (Kerguelen Islands) (Table 1).

Natural mortality was also determined using the Pauly method whereby a relationship between growth parameters and environmental temperature is used. The values of "l" and "w" from Bertalanffy's equation were applied. The values used are characteristic for the near-bottom layer in each of the areas (Table 1). Pauly's formulae were utilized in the calculations (Pauly, 1980):

$$\lg M = -0.0066-0.279\lg l+0.6543\lg K+0.4634\lg T° \quad (3)$$

$$\lg M = -0.2107-0.0828\lg W-0.6757\lg K-0.4634\lg T° \quad (4)$$

These calculations are presented here purely to compare our results with the data obtained by the French scientists (Kock, Duhamel, Hureau, 1985) in respect of the Ob Bank and the Kerguelen Islands. In our opinion, however, the data obtained has no practical application for notothenioid fish for two reasons. First, the dependence worked out by Pauly referred to tropical fish and secondly, in equations (3) and (4), one of the main components is lgT°. However, many species inhabiting the Antarctic near-shelf zone (such as *Pleuragramma antarcticum*, most *Trematomus spp.*, *Channichthyidae* etc.) live in sub-zero temperatures. The impossibility of obtaining a logarithm from a negative number, however, makes the equation mathematically absurd.

A few points must also be made about the applicability of the Rikhter-Efanov method to Antarctic fish. The only variable in the equation (1) is t_m, age at maturity for most fish (70%). This does not take into account primary causes of natural mortality such as ageing, unfavourable abiotic conditions, predation, parasites and illness, changes in food availability. According to Berdichevsky (Berdichevsky et al., 1982), these factors are the main causes of natural mortality. If we calculate M, for example, using the above method for *N. squamifrons* and *Pleuragramma antarcticum* which, like *N. squamifrons* inhabits the Ob and Lena Banks, becomes mature at the age of six, then natural mortality rates will be approximately the same for both species. However, according to Gerasimchook's data (1987), natural mortality rates calculated by the Beverton-Holt method were 1.46 to 1.69 for *P. antarcticum* from coastal Antarctic seas as opposed to 0.46 to 0.52 for *N. squamifrons*. In the author's opinion, the high level of natural mortality (M) of *P. antarcticum* is attributable to a significant pressure of predators.

Therefore, the Rikhter-Efanov method is not always applicable to Antarctic fish in general. However, this method can be used for *N. squamifrons* since predation and the food availability would not appear to have a great impact on natural mortality. This is so because the only predator of adult *N. squamifrons* is the Patagonian toothfish (*Dissostichus eleginoides*) and the food availability largely depends on the topographic features of the banks rather than on other factors. A stable concentration of prey species occurs in areas where bank peaks are within the water gradient zones, formed by water masses of differing quality (Lanin, 1983).

Accepting 0.33 to 0.38 as the most reliable values for M, it may be concluded that the rate of natural mortality of *N. squamifrons* in all three areas is similar and their mean values are comparable with those for the majority of notothenioid fish (Kock, Duhamel, Hureau, 1985; Tankevich, Shlyakhov, 1987; Shlibanov, 1987).

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Table 1: Calculated values of the natural mortality rate (M) of grey rockcod (*Notothenia squamifrons*).

Area	Method							Accepted Mean Value of M
	Rikhter-Efanov		Alverson-Carnee	Beverton-Holt		Pauly		
	M(50%)	M(70%)	M	M	T°	M(I)	M(W)	
Ob Bank	0.27	0.24	0.39	0.52	1.3	0.09	0.08	0.38
Lena Bank	0.31	0.25	0.35	0.47	1.4	0.10	0.10	0.36
Kerguelen Islands	0.20	0.17	0.37	0.46	1.9	0.11	0.10	0.33
Kerguelen Islands (Duhamel, Ozouf-Costaz, 1985)	0.18	-	-		1.9	0.08	-	
Lena Bank (Duhamel, Ozouf-Costaz, 1985)	-	-	-		1.9	0.11	-	

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