TRENDS IN RELATIVE ABUNDANCE OF FJORD *NOTOTHENIA ROSSII*, *GOBIONOTOTHEN GIBBERIFRONS* AND *NOTOTHENIA CORIICEPS* AT POTTER COVE, SOUTH SHETLAND ISLANDS, AFTER COMMERCIAL FISHING IN THE AREA

E.R. Barrera-Oro*, E.R. Marschoff and R.J. Casaux
Instituto Antártico Argentino, División Biología
Cerrito 1248, 1010 Buenos Aires, Argentina

* Also: Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia'
División Ictiología, Angel Gallardo 470, C1405DJR Buenos Aires, Argentina

Abstract

Monitoring of demersal fish at inshore sites of the South Shetland Islands has continued at Potter Cove from 1991 to 1999, and at Harmony Cove, Nelson Island, in the austral summer of 1995/96. Still evident is the decline in trammel-net catches of fjord-dwelling *Notothenia rossii* and *Gobionotothen gibberifrons* in relation to the non-commercially fished *Notothenia coriiceps*, which was previously reported for the period 1983–1990. A trend of increasing *N. rossii* catches was observed, but the levels of relative abundance of this species and *G. gibberifrons* are well below those found in the early 1980s. These results are supported by our knowledge about the diet of the piscivorous Antarctic shag (*Phalacrocorax bransfieldensis*) in the South Shetland–Antarctic Peninsula area in this decade. The decrease in recruitment to the inshore sub-populations of *N. rossii* and *G. gibberifrons* over the last 16 years was most probably caused by the offshore commercial fishery in the area in the late 1970s. This interpretation is consistent with historical information on offshore commercial fishing and with the results of scientific surveys in the area.

Résumé

Le contrôle des poissons démersaux des sites côtiers des îles Shetland du Sud s'est poursuivi à l'anse Potter de 1991 à 1999 et à l'anse Harmony, à l'île Nelson, pendant l'été austral 1995/96. Le déclin de *Notothenia rossii* et de *Gobionotothen gibberifrons* des fjords par rapport à *Notothenia corriiceps*, espèce ne faisant pas l'objet de pêche commerciale, déjà signalé pour la période de 1983–1990, est toujours apparent dans les captures au trémail. Les captures de *N. rossii* ont tendance à augmenter mais l'abondance relative de cette espèce et de *G. gibberifrons* reste bien inférieure à celle du début des années 80. Notre connaissance du régime alimentaire du cormoran antarctique (*Phalacrocorax bransfieldensis*) piscivore de la région des îles Shetland du Sud et de la péninsule antarctique cette décennie conforte ces résultats. La baisse du recrutement dans les sous-populations côtières de *N. rossii* et de *G. gibberifrons* au cours des 16 dernières années résulte très vraisemblablement de la pêche commerciale hauturière menée dans cette région à la fin des années 70. Cette interprétation concorde avec les informations que l'on détient sur la pêche commerciale hauturière et avec les résultats des campagnes d'évaluation de cette région.

Резюме

Мониторинг демерсальных рыб на прибрежных участках Южных Шетландских о-вов проводился с 1991 по 1999 г. в бухте Поттер, завершая 16-летний период непрерывных наблюдений, а также австральным летом 1995/96 г. в бухте Гармони, о-в Нельсон. При использовании многостенных сетей все еще заметно сокращение уловов обитающих в фиордах *Notothenia rossii* и *Gobionotothen gibberifrons* по сравнению с не вылавливавшейся коммерчески *Notothenia coriiceps*, о чем уже сообщалось для периода 1983–1990 гг. Была отмечена тенденция к увеличению уловов *N. rossii*, однако уровни относительной численности этого вида и *G. gibberifrons* значительно ниже, чем наблюдавшиеся в начале 1980-х гг. Эти результаты также подкрепляются нашими данными о рационе рыбоядного антарктического баклана (*Phalacrocorax bransfieldensis*) в районе Южных

Шетландских о-вов – Антарктического п-ова за эти 10 лет. Сокращение пополнения прибрежных субпопуляций *N. rossii* и *G. gibberifrons* на протяжении последних 16 лет было скорее всего вызвано коммерческим промыслом в открытом море, проводившимся в этом районе в конце 1970-х гг. Такое объяснение согласуется с ретроспективными данными по коммерческому промыслу в открытом море, а также с результатами научных съемок в этом районе.

Resumen

El monitoreo de peces demersales en aguas costeras de las islas Shetland del Sur ha continuado en Caleta Potter desde 1991 a 1999 y en Caleta Armonía, isla Nelson, en el verano austral de 1995/96. En las capturas con redes de transmallo aún es evidente la disminución de las especies *Notothenia rossii* y *Gobionotothen gibberifrons*, ya notificada para el período 1983–1990, en comparación con la especie *Notothenia coriiceps*, que no ha sido explotada comercialmente. Se ha observado un aumento en las capturas de *N. rossii*, pero los niveles de abundancia relativa de esta especie y de *G. gibberifrons* están muy por debajo de los niveles observados a principio de la década de los 80. Estos resultados concuerdan con nuestro conocimiento sobre la dieta del cormorán antártico piscívoro (*Phalacrocorax bransfieldensis*) en el área de las islas Shetland del Sur y la Península Antártica en esta década. Es muy probable que la disminución del reclutamiento en las subpoblaciones costeras de *N. rossii* y *G. Gibberifrons* durante los últimos 16 años se haya debido a la pesquería comercial realizada costas afuera en el área a fines de los años 70. Esta interpretación es consecuente con los datos históricos sobre la pesquería comercial y con los resultados de las prospecciones científicas realizadas en el área.

Keywords: trends in fish abundance, Antarctic fish, impact of commercial fishing, South Shetland Islands, Nototheniidae, CCAMLR

INTRODUCTION

Commercial exploitation of finfish in Antarctica started at the end of the 1960s. The fishery was developed mainly in offshore waters around South Georgia, the South Orkney and South Shetland Islands in the Atlantic Ocean sector, and around the Kerguelen Islands in the Indian Ocean sector. The fishery has resulted in the stocks of many species becoming seriously depleted. For example, until 1992 the marbled rockcod (*Notothenia rossii*) stock at South Georgia was estimated to be less than 5% of the original stock size in 1969 (Kock, 1992). Since the inception of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), conservation measures have been adopted in order to assist the recovery of these species by banning directed fisheries and establishing stringent by-catch limits.

Commercial fishing in the South Shetland Islands–Antarctic Peninsula (FAO Statistical Subarea 48.1) region started in 1978/79. A total of 87 139 tonnes of finfish was caught until 1989/90 (Kock, 1992). Heavy fishing was carried out on the northern coasts of the northernmost island, Elephant Island, from 1978 to 1980, but catches from other islands and from the tip of the Antarctic Peninsula have also been reported (CCAMLR, 1990). *N. rossii* and the mackerel icefish (*Champsocephalus gunnari*) were the target species, constituting 47.5 and 22.1% of the total catch respectively. The humped rockcod (*Gobionotothen gibberifrons*) was also targeted in a directed fishery, but it was mainly taken in significant quantities as by-catch (4 151 tonnes) (Kock, 1992). Subarea 48.1 has been closed to all finfishing since the 1990/91 season.

Young specimens of *N. rossii* and *G. gibberifrons* inhabit neritic waters. This part of the population was studied at two sites of the South Shetland Islands: Potter Cove (King George Island) and Moon Bay (Livingston Island); samples from these areas were obtained using trammel nets (Barrera-Oro and Marschoff, 1990). This type of gear is easily operated in shallow waters, where the fish are effectively inaccessible to trawlers. As this is a passive sampling device, catching of fish depends mainly on fish activity. Therefore, changes in the population are expected to be reflected by the catches. Over a period of eight years (1983–1990) a decrease in the stocks of juvenile *N. rossii* and *G. gibberifrons* was demonstrated, whereas the stock of black rockcod (*Notothenia coriiceps*), a non-commercially fished species with similar ecological habits in the fjords, did not show the same decline. This finding is supported by our studies on the diet of the Antarctic shag (*Phalacrocorax bransfieldensis*) in the same area. The decline of the fish species mentioned was explained as a reduction in recruitment due to the severe depletion of the reproductive stock (Barrera-Oro and Marschoff, 1990).

Monitoring of pre-recruit fish by means of trammel nets was previously carried out by Duhamel (1990) in the Morbihan Gulf, Kerguelen Islands. He reported a reduction in catches of juvenile *N. rossii* inshore as being caused by the depletion of the offshore reproductive stock by the commercial fishery. Further monitoring showed a continuous recovery of the juvenile stock from 1984 to 1988, after the closure of the fishery (Duhamel, 1989).

Our fish monitoring program in neighbouring sites at the South Shetland Islands has continued since 1991 up to the present at Potter Cove – thus completing a continuous sampling period of 16 years – and in the austral summer of 1995/96 at Harmony Cove, Nelson Island. We present here an updated analysis of the observed variations in relative abundance of fjord-dwelling *N. rossii*, *G. gibberifrons* and *N. coriiceps* in trammel net catches at these locations. This analysis is complemented with data on the availability of the relevant fish species taken from studies of predator–prey interactions between *P. bransfieldensis* and inshore demersal fish of the South Shetland Islands–Antarctic Peninsula region.

MATERIAL AND METHODS

Samples were collected at two locations of the South Shetland Islands: Potter Cove (PC), King George Island, close to the scientific station Jubany (62°14'S and 58°40'W) from 1991 to 1999, and Harmony Cove (HC), Nelson Island (62°18'S and 59°14'W) from November 1995 to February 1996 (Figure 1). Much of this material was used in studies of fish occurring in the area (reviewed in Barrera-Oro and Casaux, 1998). Data from around 6 300 specimens (6 100 from PC and 200 from HC) of *N. coriiceps*, *N. rossii* and *G. gibberifrons* (the last species was not recorded at HC) caught in 609 trammel nets (597 from PC and 12 from HC) are included in this paper. Trammel nets (length 25, 35 and 50 m; width 1.5 m; inner mesh 2.5 cm; outer mesh 12 cm) were set on the bottom at depths from 5 to 50 m. Soak time ranged from 6 to 96 hours. The procedure used, as well as the biotic components and abiotic features of PC, are described in Casaux et al. (1990). Total length (TL) to the nearest mm and sex were recorded. Present data on the relative abundance of the fish species in the catches were combined with those obtained between 1983 and 1990 at PC, which were partially analysed by Barrera-Oro and Marschoff (1990). In view of the known deeper distribution of *G. gibberifrons*, we have only considered hauls made below 17 m for this species.

Since soak time and net size depended on weather conditions and experimental design, fishing effort per haul was highly variable between years and within the same season. Therefore, for analysis, fish abundance was described both as the total number of each species per haul and as standardised numbers of *N. rossii* and *G. gibberifrons* relative to *N. coriiceps* according to:

$$\text{Proportion}(b) = \frac{Nb}{Nc + Nb}$$

where *Nb* is the number of specimens of the species considered (*N. rossii* or *G. gibberifrons*), and *Nc* is the number of specimens of *N. coriiceps*.

We have used *N. coriiceps* as a reference species to obtain an abundance index for *N. rossii* and *G. gibberifrons* because, while these three species show similar ecological habits in the fjords, *N. coriiceps* was not affected by the commercial fishery.

The number of fish per haul and relative abundance were analysed using an ANOVA design, grouping the hauls on a split-year basis. The split-year is defined as the period from 1 May to 30 April next year.

Variance was normalised using the transformations:

$$y = \sqrt{x + 0.5}$$

in the case of numbers per haul and,

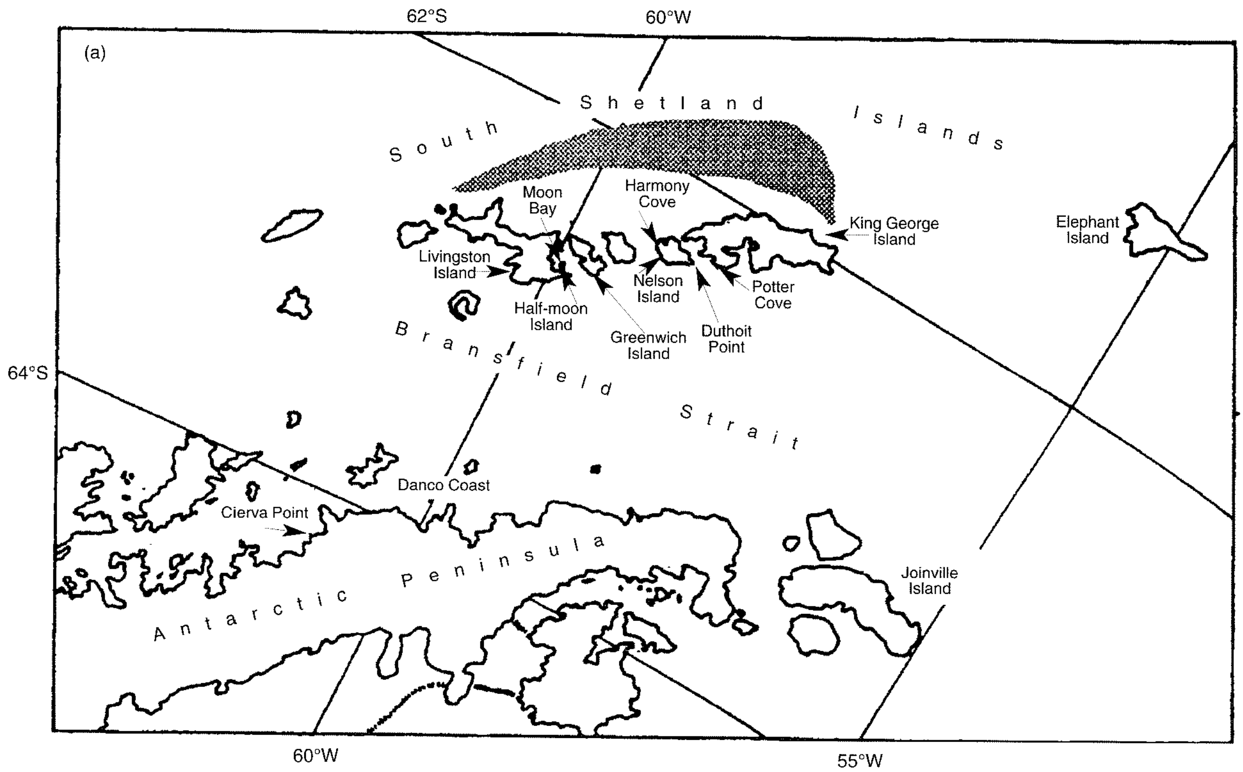
$$y = \arcsin\sqrt{x}$$

for the relative abundance of *N. rossii* and *G. gibberifrons*.

Since interannual variability was highly significant for all species and variables, we fitted a non-parametric model for the relation between abundance and time, according to Härdle (1989), using the Epanenchikov kernel:

$$K(u) = 0.75(1 - u^2),$$

and a bandwidth of 0.15 which yields an effective bandwidth of approximately one year.



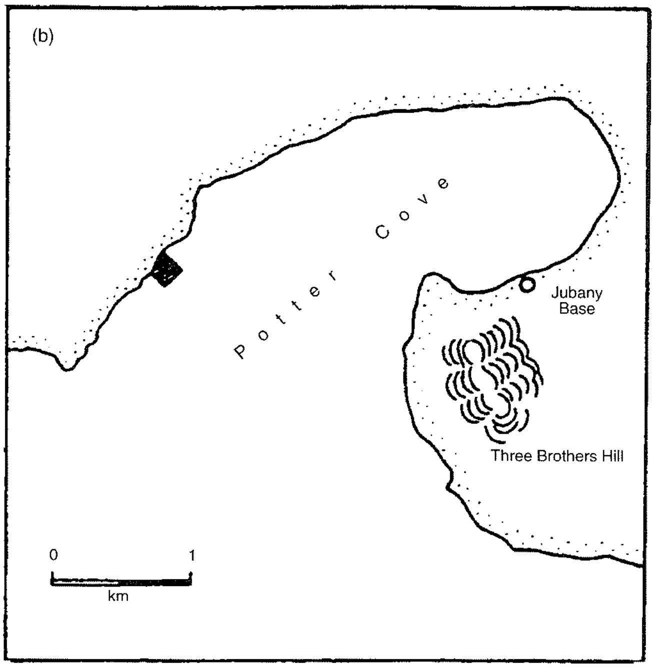


Figure 1: (a) The South Shetland Islands–Antarctic Peninsula region showing the locations considered in this study. The offshore, bottom-trawled area has been shaded.

(b) The sampling area at Potter Cove.

Table 1: Results of the ANOVAs performed on total and relative catches of fish at Potter Cove.

Source	Sum of Squares	DOF	Mean Square	*F*	*P*
(a) *Notothenia rossii*, total catches					
Years	16.9939	15	1.13293	15.8671	<0.00001
Error	41.4126	580	0.0714		
(b) *Gobionotothen gibberifrons*, total catches					
Years	8.5908	12	0.7159	26.107	<0.00001
Error	7.5959	277	0.02742		
(c) *Notothenia coriiceps*, total catches					
Years	18.0094	15	1.20062	9.3905	<0.00001
Error	74.156	580	0.12786		
(d) *Notothenia rossii*, relative catches					
Years	32 892.9816	15	2 192.865	7.2324	<0.00001
Error	175 249.7339	578	303.2002		
(e) *Gobionotothen gibberifrons*, relative catches					
Years	13 450.9726	12	1 120.914	16.6973	<0.00001
Error	18 595.426	277	67.1315		

In this study, we have reworked the data from PC for the period 1983–1990 using the same methodology used for the period 1991–1999. This allowed us to obtain non-parametric regressions and ANOVAs for the whole sampling period from 1983 to 1999.

RESULTS AND DISCUSSION

We analysed the historical data obtained at PC (from 1983 to 1999) and recent data from HC. The length composition of *N. coriiceps* (12.2–58.6 cm at PC; 15.6–50.5 cm at HC) includes immature and mature adult specimens (Casaux et al., 1990). As expected, all fjord-dwelling *N. rossii* specimens collected (15.5–47.2 cm at PC; 19.2–30.1 cm at HC) were juvenile (Barrera-Oro and Casaux, 1992). The length range of *G. gibberifrons* (13–35.5 cm) caught at PC (no catches at HC) indicates the presence of mainly small and medium-size specimens. This finding is in agreement with the known depth distribution of the species. Potter Cove is a fjord area (shallow waters), where the smallest *G. gibberifrons* juveniles occur (Barrera-Oro, 1988). While *N. coriiceps* and *N. rossii* were found at all the depths sampled, *G. gibberifrons* was very scarce in the upper layers, down to at least 15 m. The variation of length composition with depth of *N. coriiceps*, *N. rossii* and *G. gibberifrons* is generally similar in inshore locations of the South Shetland Islands area, i.e. Admiralty Bay (Skora, 1993) and Fildes Bay (Moreno and Bahamonde, 1975), and Discovery Bay on Greenwich Island (Moreno and Bahamonde, 1975). The abovementioned sites, together with PC, are located in the King George Island area.

Results of the ANOVAs performed on total and relative catches taken at PC are shown in Table 1. Split-year (1 May to 30 April) means of total catches per haul are presented in Figure 2, along with the non-parametric fit of the regression of the number of fish per haul for a particular date. Relative catches are presented in Figure 3. At HC, total catches per haul of *N. coriiceps* and *N. rossii* were 15.58 and 0.92 specimens respectively; the relative catch of *N. rossii* was 0.048.

A previous study, conducted at PC from 1983 to 1990, reported a significant declining trend in the observed catches of *N. rossii* and *G. gibberifrons* relative to those of *N. coriiceps* (Barrera-Oro and Marschoff, 1990). Data taken from literature for other locations at the South Shetland Islands (Moon Bay at Livingston Island, Fildes Bay, Admiralty Bay and Discovery Bay) over a comparable period, which were reworked in the above study, showed a similar decline in the abundance of *N. rossii* and *G. gibberifrons*.

The estimated relative abundance of *N. rossii* declined from 29% in March 1983 to 3% in April 1991. Likewise, the relative abundance of *G. gibberifrons* declined from 19% in March 1985 to 0.2% in January 1989 (Figure 3). Subsequently, *N. rossii* increased to 8% in 1998 and to 14% in 1999, while *G. gibberifrons* remained at the same low level (Figure 3). Although fishing effort was not kept constant throughout the whole sampling period of 16 years, the number of specimens per haul of *N. rossii* and *G. gibberifrons* shows a similar pattern (Figure 2).

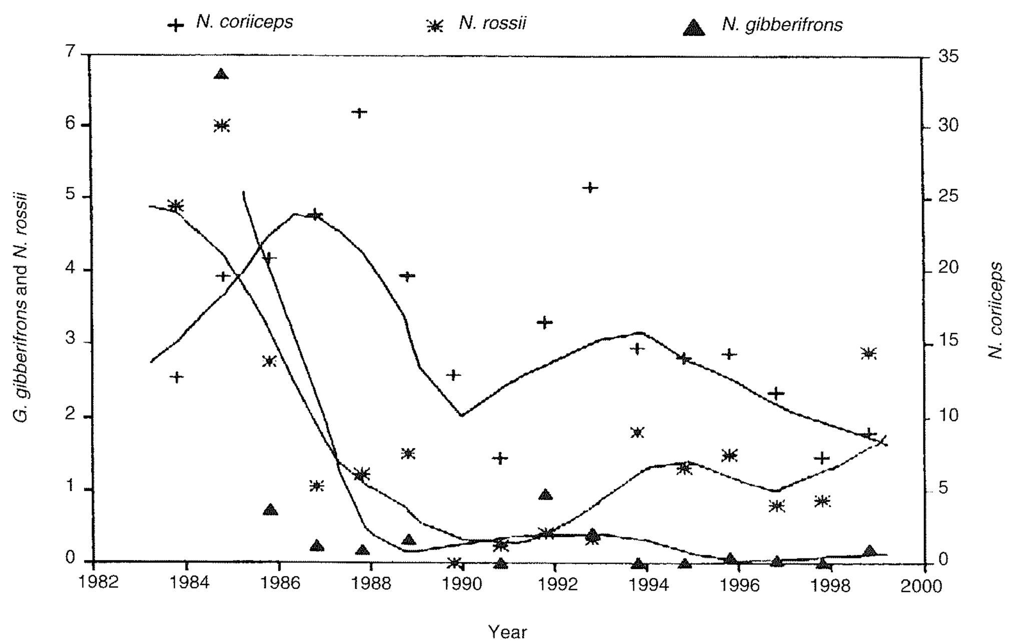


Figure 2: Expected catches (number of fish) of *Notothenia rossii, Gobionotothen gibberifrons* and *Notothenia coriiceps* as functions of catch date (Epanenchikov kernel, bandwidth = 0.15), together with the observed split-year mean values. Annual marks correspond to 1 January each year.

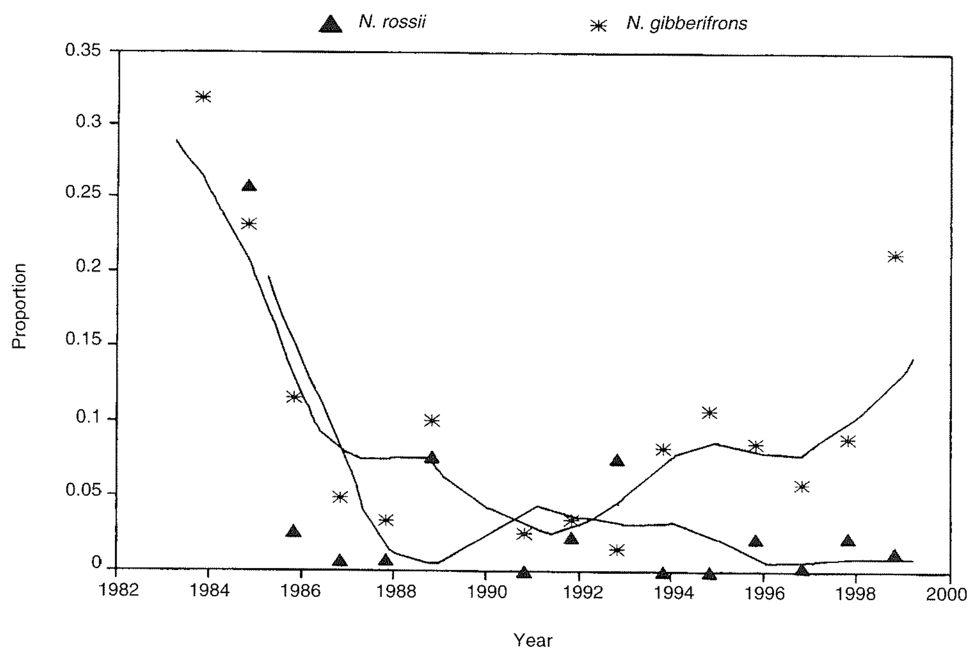


Figure 3: Expected catches of *Notothenia rossii* and *Gobionotothen gibberifrons* relative to the catches of *Notothenia coriiceps* as functions of catch date (Epanenchikov kernel, bandwidth = 0.15), together with the observed split-year mean values. Annual marks correspond to 1 January each year.

Despite the increasing trend of *N. rossii* catches since 1991, the actual levels of relative abundance of this species and *G. gibberifrons* at PC are well below those found in the early 1980s. During the 16 years of observations the values observed were never comparable with those found at the beginning of the time series. The total catches and relative abundance per haul of *N. rossii* (around 1 and 0.05 specimens respectively) at HC in the austral summer of 1995/96 are in the range of the values obtained for PC (Figures 2 and 3). These results might be interpreted as the outcome of a decline in recruitment to the juvenile fjord populations of *N. rossii* and *G. gibberifrons* observed since the beginning of our sampling program at PC (1983 and 1985 respectively, no data were recorded before these years).

The low relative abundance of *N. rossii* and *G. gibberifrons* in trammel net catches is consistent with the composition of the *P. bransfieldensis* diet in the South Shetland Islands area over a similar period from 1991 to 1998. While the fish species identified in stomach contents and pellets agreed qualitatively and in relative numbers with those regularly taken by trammel nets, *N. rossii* and *G. gibberifrons* were not or were scarcely represented (Casaux and Barrera-Oro, 1993; Coria et al., 1995; Barrera-Oro and Casaux, 1996; Casaux et al., 1998; Favero et al., 1998). Moreover, at the onset of the last decade in waters around the South Orkney Islands – a fishing ground which is likely to still be affected by the commercial fishery (Balguerías, 1989) – *N. rossii* was a frequent prey of *P. bransfieldensis* (Shaw, 1984), but it was not represented in our recent study in that area (Casaux et al., 1997).

Recent information obtained at Cierva Point on the Danco coast, Antarctic Peninsula (Figure 1), indicates that *G. gibberifrons* and *N. coriiceps* constitute, in similar proportions, the main prey of *P. bransfieldensis* (Casaux et al., unpublished data). This probably reflects the high availability of these two species at a site which is far away from the main historical commercial fishing grounds of the South Shetland Islands (Elephant Island and north of Livingston/King George Islands) and the Antarctic Peninsula (Joinville Island).

Historical information on the status of the ichthyofauna in the South Shetland Islands region, obtained from bottom trawl surveys, indicates that until 1978 *N. rossii* and *G. gibberifrons* were the dominant demersal nototheniid species off Elephant Island (Nast et al., 1988). Due to fishing operations in that area, particularly in 1978/79 and 1979/80, the abundance of *N. rossii* in the mid-1980s decreased drastically in comparison to previous years, whereas the stock of *G. gibberifrons*, although also considerably affected, predominated in the bottom fish fauna, mainly down to 250 m (Nast et al., 1988; Skora, 1988; Balguerías, 1989; Tiedtke and Kock, 1989; Gröhsler, 1994). Data reported for the north off Livingston Island in 1981 (Takahashi, 1983) and 1982 (Takahashi and Iwami, 1997), and for Elephant Island in 1981/82 (Kock, 1998; Takahashi and Iwami, 1997) confirm that *N. rossii* and *G. gibberifrons* were at that time already scarce and dominant demersal species respectively. According to the most recent data, this last pattern seems to be still valid in both the Lower South Shetland Islands area (Livingston Island and King George Island) (Jones et al., 1998) and Elephant Island (Kock, 1998; Jones et al., 1998).

The above information shows that, despite the impact of the commercial fishery, *G. gibberifrons* is still the dominant offshore demersal fish species of the whole South Shetland Islands region after 1980. However it is interesting to note the latest data available for the northeast region off King George Island in 1986 (Balguerías, 1989) and 1998 (Jones et al., 1998), close to our main sampling site at PC, on the prevalence of the non-commercially exploited *N. coriiceps* over *G. gibberifrons* in catches down to 200–300 m. *N. coriiceps* has proliferated markedly in inshore waters of the South Shetland Islands over the last 12 to 18 years, in parallel with the decrease of *N. rossii* and *G. gibberifrons* populations (Barrera-Oro and Casaux, 1998). It is probable that during this period *N. coriiceps* encountered progressively less interspecific competition and consequently expanded its trophic and habitat niches.

In PC, the increase of juvenile fjord-dwelling *N. rossii* observed since 1991 could be a sign of recovery in recruitment. The recovery of the offshore population might require a much longer period of high recruitment (Barrera-Oro and Marschoff, 1990). No signs of change in the long period of low abundance of inshore *G. gibberifrons* have been observed.

CONCLUSIONS

The decrease in recruitment to the inshore sub-populations of *N. rossii* and *G. gibberifrons* in the South Shetland Islands in the last 16 years was most probably caused by the offshore commercial fishery in the area in the late 1970s. This interpretation is consistent with historical information on offshore commercial fishing and with the results of scientific surveys in the area.

In trammel net catches, the low relative abundance of *N. rossii* and *G. gibberifrons* compared to that of non-commercially fished *N. coriiceps* is consistent with the results of dietary studies of the piscivorous *P. bransfieldensis* conducted in the South Shetlands area in the 1990s.

ACKNOWLEDGEMENTS

We are grateful to C. Bellisio, M. Favero, A. Thibaud, R. Di Paola and E. Pínola for their cooperation in the fishing tasks. We also thank Luis J. López Abellán and an anonymous referee who critically commented on the manuscript.

REFERENCES

Balguerías, E. 1989. Informe de resultados 'Antártida 8611', Biología pesquera. In: *Resultados de la Campaña 'Antártida 8611'. Publ. Espec., Inst. Esp. Oceanogr.*, 2: 267–483.

Barrera-Oro, E. 1988. Age determination of *Notothenia gibberifrons* from the South Shetland Islands, Antarctic Peninsula subarea (Subarea 48.1). In: *Selected Scientific Papers, 1988 (SC-CAMLR-SSP/5)*, Part II. CCAMLR, Hobart, Australia: 143–160.

Barrera-Oro, E.R. and E.R. Marschoff. 1990. A declining trend in the abundance of *Notothenia rossii marmorata* and *Notothenia gibberifrons* observed in fjords in two sites in the South Shetland Islands. In: *Selected Scientific Papers, 1990 (SC-CAMLR-SSP/7)*. CCAMLR, Hobart, Australia: 263–274.

Barrera-Oro, E.R. and R.J. Casaux. 1992. Age estimation for juvenile *Notothenia rossii* from Potter Cove, South Shetland Islands. *Ant. Sci.*, 4 (2): 131–136.

Barrera-Oro, E.R. and R.J. Casaux. 1996. Fish as diet of the blue-eyed shag, *Phalacrocorax atriceps bransfieldensis* at Half-Moon Island, South Shetland Islands. *Cybium*, 20 (1): 37–45.

Barrera-Oro, E.R. and R.J. Casaux. 1998. Ecology of demersal fish species from Potter Cove. In: Wiencke, C., G.A. Ferreyra, W. Arntz and C. Rinaldi (Eds). *The Potter Cove Coastal Ecosystem, Antarctica. Berichte zur Polarforschung*, 299: 156–167.

Casaux, R.J. and E.R. Barrera-Oro. 1993. The diet of the blue-eyed shag, *Phalacrocorax atriceps bransfieldensis* feeding in the Bransfield Strait. *Ant. Sci.*, 5 (4): 335–338.

Casaux, R.J., A.S. Mazzotta and E.R. Barrera-Oro. 1990. Seasonal aspects of the biology and diet of nearshore nototheniid fish at Potter Cove, South Shetland Islands, Antarctica. *Polar Biol.*, 11: 63–72.

Casaux, R.J., N. Coria and E.R. Barrera-Oro. 1997. Fish in the diet of the Antarctic shag, *Phalacrocorax bransfieldensis* at Laurie Island, South Orkney Islands. *Polar Biol.*, 18: 219–222.

Casaux, R., E.R. Barrera-Oro, N. Coria and A. Carlini. 1998. Fish as prey of birds and mammals at the South Shetland Islands. In: Wiencke, C., G.A. Ferreyra, W. Arntz and C. Rinaldi (Eds). *The Potter Cove Coastal Ecosystem, Antarctica. Berichte zur Polarforschung*, 299: 267–274.

CCAMLR, 1990. *Statistical Bulletin*, Vol. 1 (1970–1979) and Vol. 2 (1980–1989). CCAMLR, Hobart, Australia: 61 pp. and 109 pp.

Coria, N., R. Casaux, M. Favero and P. Silva. 1995. Analysis of the stomach content of the blue-eyed shag *Phalacrocorax atriceps bransfieldensis* at Nelson Island, South Shetland Islands. *Polar Biol.*, 15: 349–352.

Duhamel, G. 1989. Supplementary data on exploited stocks in Division 58.5.1 (Kerguelen). In: *Selected Scientific Papers, 1989 (SC-CAMLR-SSP/6)*. CCAMLR, Hobart, Australia: 147–161.

Favero, F., R.J. Casaux, P. Silva, E.R. Barrera-Oro and N. Coria. 1998. The diet of the Antarctic shag during summer at Nelson Island, Antarctica. *Condor*, 100: 112–118.

Gröhsler, T. 1994. Feeding habits as indicators of ecological niches: investigations of Antarctic fish conducted near Elephant Island in late autumn/winter 1986. *Archive of Fishery and Marine Research*, 42 (1): 17–34.

Härdle, W. 1989. *Applied Nonparametric Regression*. Cambridge University Press, Cambridge: 333 pp.

Jones, C.D., K.-H. Kock and S. Wilhelms. 1998. Results from the 1998 bottom trawl survey of Elephant Island and the lower South Shetland Islands (Subarea 48.1). Document *WG-FSA-98/15.* CCAMLR, Hobart, Australia.

Kock, K.-H. 1989. Reproduction in fish around Elephant Island. *Arch. FischWiss.*, 39 (1): 171–210.

Kock, K.-H. 1992. *Antarctic Fish and Fisheries.* Cambridge University Press, Cambridge: 359 pp.

Kock, K.-H. 1998. Changes in the fish biomass around Elephant Island (Subarea 48.1) from 1976 to 1996. *CCAMLR Science*, 5: 165–189.

Moreno, C.A. and N. Bahamonde. 1975. Nichos alimentarios y competencia por el alimento entre *Notothenia coriiceps neglecta* Nybelin y *Notothenia rossii marmorata* Fischer en Shetland del Sur, Antártica. *Serie Científica del Instituto Antártico Chileno*, 3: 45–62.

Nast, F., K.-H. Kock, D. Sahrhage, M. Stein and J. Tiedtke. 1988. Hydrography, krill and fish and their possible relationships around Elephant Island. In: Sahrhage, D. (Ed.). *Antarctic Ocean and Resources Variability.* Springer-Verlag, Berlin Heidelberg: 183–198.

Shaw, P. 1984. Factors affecting the breeding performance of the Antarctic blue-eyed shag (*Phalacrocorax atriceps bransfieldensis*). PhD thesis, University of Durham (unpublished).

Skora, K.E. 1988. Benthic fishes of the Elephant Island shelf (Biomass III, October–November 1986 and February 1987). *Pol. Polar Res.*, 9: 385–398.

Skora, K.E. 1993. Fish. In: Rakusa-Suszczewski, S. (Ed.). *The Maritime Antarctic Coastal Ecosystem of Admiralty Bay*. Warsaw: 123–128.

Takahashi, M. 1983. Trophic ecology of demersal fish community north of the South Shetland Islands, with notes on the ecological role of the krill. In: *Memoirs of National Institute of Polar Research*, Special Issue 27: 183–192.

Takahashi, M. and T. Iwami. 1997. The summer diet of demersal fish at the South Shetland Islands. *Ant. Sci.*, 9 (4): 407–413.

Tiedtke, J. E. and K.-H. Kock. 1989. Structure and composition of the demersal fish fauna around Elephant Island. *Arch. FischWiss.*, 39 (1): 143–169.

Liste des tableaux

Tableau 1: Résultat des ANOVA effectuées sur les captures totales et relatives de poisson à l'anse Potter.

Liste des figures

Figure 1: a) Région des îles Shetland du Sud et de la péninsule antarctique indiquant les sites étudiés ici. La région ayant fait l'objet de chalutages de fond, au large, figure en gris.

b) Secteur d'échantillonnage de l'anse Potter.

Figure 2: Captures prévues (en nombre de poissons) de *Notothenia rossii, Gobionotothen gibberifrons* et *Notothenia corriiceps* en fonction de la date de la capture (noyau d'Epanenchikov, largeur de bande = 0,15) avec valeurs moyennes observées de l'année australe. Les marques des années correspondent au 1er janvier de chacune d'elles.

Figure 3: Captures prévues de *Notothenia rossii* et de *Gobionotothen gibberifrons* relativement aux captures de *Notothenia corriiceps* en fonction de la date de capture (noyau d'Epanenchikov, largeur de bande = 0,15) avec valeurs moyennes observées de l'année australe. Les marques des années correspondent au 1er janvier de chacune d'elles.

Список таблиц

Табл. 1: Результаты дисперсионного анализа общих и относительных уловов рыбы в бухте Поттер.

Список рисунков

Рис. 1: (a) Рассматриваемые в статье участки района Южных Шетландских о-вов – Антарктического п-ова. Штриховкой показан район открытого моря, в котором проводилось придонное траление.

(b) Район исследований бухты Поттер.

Рис. 2: Ожидаемый вылов (число особей) *Notothenia rossii, Gobionotothen gibberifrons* и *Notothenia coriiceps*, как функция времени вылова (ядро Епаненчикова, ширина полосы = 0.15), а также наблюдавшиеся средние значения за разбитый год. Деления на оси времени соответствуют 1 января каждого года.

Рис. 3: Ожидаемый вылов *Notothenia rossii* и *Gobionotothen gibberifrons* относительно вылова *Notothenia coriiceps*, как функция времени вылова (ядро Епаненчикова, ширина полосы = 0.15), а также наблюдавшиеся средние значения за разбитый год. Деления на оси времени соответствуют 1 января каждого года.

Lista de las tablas

Tabla 1: Resultados de los ANOVA realizados con los datos de la captura total y de la captura relativa de peces en Potter Cove.

Lista de las figuras

Figura 1: a) Ubicación de las áreas de estudio en la región de las Islas Shetland del Sur y Península Antártica. El área de prospección con arrastres de fondo en alta mar aparece sombreada.

b) El área de muestreo en Potter Cove.

Figura 2: Capturas esperadas (número de peces) de *Notothenia rossii, Gobionotothen gibberifrons* y *Notothenia coriiceps* en función de la fecha de la captura (núcleo de Epanenchikov, ancho de banda = 0,15), junto con los valores observados del promedio por año emergente. Las marcas anuales corresponden al 1° de enero de cada año.

Figura 3: Capturas esperadas de *Notothenia rossii* y *Gobionotothen gibberifrons* en relación a las capturas de *Notothenia coriiceps* en función de la fecha de la captura (núcleo de Epanenchikov, ancho de banda = 0,15), junto con los valores observados del promedio por año emergente. Las marcas anuales corresponden al 1° de enero de cada año.