GRENADIERS (PISCES, MACROURIDAE) OF THE SOUTHWEST ATLANTIC OCEAN: BIOLOGIC AND FISHERY ASPECTS*

by

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RESUMEN

Granaderos (Pisces, Macrouridae) del Océano Atlántico Sudoccidental: aspectos biológicos y pesqueros. Varias especies de granadero se distribuyen en el Océano Atlántico Sudoccidental. *Macrourus carinatus* y *Caelorinchus fasciatus* son las que se identifican con mayor frecuencia en las capturas comerciales y en campañas de investigación. Estas especies de peces bentopelágicos se relacionan con aguas subantárticas y habitan entre los 36° S y 59° S, a profundidades superiores a los 200 m y en alta mar. Durante las campañas llevadas a cabo a bordo de buques de investigación pesquera argentinos, *M. carinatus* estuvo presente en el 4% de los arrastres realizados. Las mayores densidades (> 17 t mn^{-2}), que se obtuvieron entre los 360-380 m de profundidad, a 39° S, disminuyeron significativamente hacia el sur. *C. fasciatus* se capturó en el 6% del total de los lances de pesca realizados; las más altas densidades (15-35 t mn^{-2}) se obtuvieron a partir de los 200 m de profundidad, al sur de los 52° S. La dificultad para identificarlos a simple vista hace que en las estadísticas pesqueras las especies se presenten agrupadas como "granaderos". Sin embargo, en muchos casos, los observadores científicos a bordo de buques comerciales los reconocen debidamente y proporcionan valiosa información para respaldar los datos recopilados. Los granaderos constituyen la captura incidental de pesquerías importantes cuyos principales caladeros se sitúan al sur de los 52° S. Históricamente, distintos países participaron de la pesquería que muestra dos períodos de evolución. En el primero, la explotación, realizada esencialmente por buques de la ex Unión Soviética, alcanzó un máximo de 31.000 t en 1984. En el segundo, la flota argentina capturó un máximo de 10.000 t en 2000. En la actualidad, los buques arrastreros congeladores y factoría obtienen el 88% de las capturas y los palangreros el 10% del total.

SUMMARY

Several grenadier species distribute in the Southwest Atlantic Ocean. *Macrourus carinatus* and *Caelorinchus fasciatus* are more frequently identified in commercial catches and during research cruises. Those benthopelagic fishes, related to subantarctic waters, inhabit at depths beyond 200 m and in high seas, between 36° S-59° S. During the surveys carried out on board of Argentinean research vessels, *M. carinatus* was present in 4% of the trawls performed. The highest densities (>17 t nm^{-2}), obtained between 360-380 m depth, at 39° S, decreased significantly southwards. *C. fasciatus* was caught in 6% of the total trawls and the highest densities (15-35 t nm^{-2}) were found at depths beyond

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200 m, south of 52° S. Due to the difficulty encountered to identify them, in fishing statistics they are grouped as "Grenadiers". Nevertheless, in many cases, the correct identification by scientific observers on board of commercial vessels provides useful information to support the data gathered. Grenadiers are caught as by-catch in important fisheries that have the main fishing grounds south of 52° S. Historically, different countries participated in the fishery that shows two evolution periods. In the first, exploitation carried out mainly by vessels from the former USSR reached a maximum of 31,000 t in 1984. In the second, the Argentine fleet caught up to 10,000 t in 2000. At present, freezer and factory trawlers obtain 88% of the catches and longliners 10% of the total.

Key words: Grenadiers, *Caelorinchus fasciatus*, *Macrourus carinatus*, Southwest Atlantic Ocean, fishery.
Palabras clave: Granaderos, *Caelorinchus fasciatus*, *Macrourus carinatus*, Océano Atlántico Sudoccidental, pesquería.

INTRODUCTION

Grenadiers or rattails that inhabit the Southwest Atlantic Ocean belong to the Macrourinae Subfamily that comprises the largest number of species of the Macrouridae Family and the Gadiformes Order (Cohen *et al*., 1990; Jorgensen, 1996). Since the beginning of the XXth Century, scientists have classified them under a large variety of names that results in synonymies that create confusion at the time of searching into databases. Nevertheless, *Macrourus* and *Caelorinchus* genera are well represented. According to synonymies, two species are frequently identified: *Macrourus carinatus* and *Caelorinchus fasciatus* (Nelson, 2006) commonly known as bigeye grenadier ("granadero grande") and banded whiptail ("granadero chico"), respectively. Although those benthopelagic species (Cohen *et al*., 1990; Gordon, 2003) are related to the Malvinas Current in the continental shelf and to slope waters and high seas areas down to 1,200 m, distribution boundaries are difficult to establish because the region off the continental shelf is not frequently studied.

Grenadier catches are not considered important because there are no large schools or concentrations to be exploited with high commercial benefits. They constitute the by-catch of factory vessels that declare them under the same common name, regardless of the species.

The aim of this paper is to describe the current state of knowledge about the biologic and fishery aspects of the grenadier species that inhabit the Southwest Atlantic Ocean.

MATERIALS AND METHODS

The information, derived from research cruises and data of commercial statistics and on board scientific observers programmes led to analyze biologic and fishery aspects.

A total of 67,950 individuals caught by trawlers and longliners were sampled during the 2000-2006 period.

The results of 46 research cruises carried out during different seasons between 1978 and 2006 were analyzed. The surveys, that covered the area between 34° S-55° S up to 1,500 m (Table 1) consisted of bottom trawls on board of Japanese, German and Argentine research vessels that allowed to obtain biologic information and to assess finfish and chondrichthyes species biomass. The Japanese RV "Shinkai Maru" and German RV "Walther Herwig" operated during 1978 and 1979, respectively. The objective of the research cruises was to explore the area to obtain data on catches to assess the species biomass. During the 1992-2006 period the area was explored and the main finfish and chondrichthyes species assessed on board of Argentine research vessels "Dr. Eduardo L. Holmberg" and "Capitán Oca Balda". The information gathered was used to establish the geographic distribution of the two species.

The biologic information obtained during the

Argentine cruises included total and preanal length distribution and total individual weight data. The stomach content of 193 *M. carinatus* and 146 *C. fasciatus* individuals was examined. The data were obtained during the 1994 and 2006 summer cruises and the 1993 winter cruise. Stomachs were preserved and analyzed in the laboratory to study the diet and trophic relation. Preys in the stomach content were identified up to the lowest possible taxonomic level and frequency of occurrence (%F) and weight percentage (%W) estimated. Stomachs with evidence of regurgitation were not included in the analysis. The trophic spectra of both species were described and the trophic level (TL) of both grenadiers species was calculated as:

$$TL = 1 + \left(\sum_{j=1}^{n} W_j \times TL_j \right)$$

where: W_j is the percentage in weight and TL_j the trophic level of the *j* prey.

Table 1. List of research cruises included in the analysis carried out in the Southwest Atlantic Ocean. SM: RV "Shinkai Maru", WH: RV "Walter Herwig", EH: RV "Dr. Eduardo L. Holmberg", OB: RV "Capitán Oca Balda".

Tabla 1. Lista de campañas de investigación incluidas en el análisis realizado en el Océano Atlántico Sudoccidental. SM: BIP "Shinkai Maru", WH: BIP "Walter Herwig", EH: BIP "Dr. Eduardo L. Holmberg", OB: BIP "Capitán Oca Balda".

Research vessel	Season	Year	Number of trawls	Range of latitude		Maximum depth (m)
SM	autumn	1978	79	36° 58'	54° 59'	750
SM	autumn	1978	76	39° 30'	54° 00'	1,222
SM	autumn	1978	59	36° 30'	42° 31'	831
SM	winter	1978	91	36° 30'	54° 42'	1,033
SM	winter	1978	53	38° 53'	51° 34'	940
SM	spring	1978	87	36° 29'	46° 31'	325
SM	summer	1978	39	42° 26'	46° 30'	385
SM	summer	1978-1979	83	36° 29'	54° 40'	847
SM	summer	1979	71	39° 18'	54° 19'	700
SM	autumn	1979	70	43° 28'	51° 32'	295
WH	autumn	1978	106	40° 02'	54° 39'	995
WH	autumn	1978	97	40° 16'	53° 27'	1,500
WH	winter	1978	103	35° 24'	54° 27'	1,010
WH	winter	1978	119	40° 42'	54° 57'	840
WH	spring	1978	108	35° 53'	54° 10'	868
WH	spring	1978	119	36° 01'	54° 52'	914
EH	summer	1992	139	45° 04'	53° 60'	280
EH	summer	1993	136	45° 01'	52° 37'	300
EH	autumn	1993	34	50° 17'	55° 04'	360
EH	winter	1993	91	48° 11'	55° 07'	418
EH	spring	1997	179	34° 46'	47° 51'	440
EH	winter	1998	76	45° 03'	47° 36'	405
EH	summer	2000	132	45° 27'	54° 24'	356
EH	summer	2001	163	45° 02'	54° 24'	394
EH	summer	2002	99	45° 02'	50° 44'	391

Table 1. Continued.
Tabla 1. Continuación.

Research vessel	Season	Year	Number of trawls	Range of latitude		Maximum depth (m)
EH	winter	2003	85	34° 46’	40° 60’	224
EH	summer	2004	165	45° 04’	54° 24’	385
EH	autumn	2004	65	37° 01’	42° 54’	386
EH	summer	2005	154	45° 04’	54° 20’	399
EH	summer	2006	164	45° 04’	54° 24’	403
OB	summer	1994	195	45° 01’	54° 19’	650
OB	spring	1994	102	45° 19’	55° 07’	510
OB	summer	1995	152	45° 01’	55° 03’	409
OB	summer	1995	152	45° 01’	55° 03’	409
OB	spring	1995	17	52° 26’	54° 23’	608
OB	spring	1995	37	52° 26’	54° 55’	637
OB	summer	1996	88	45° 01’	50° 44’	333
OB	autumn	1996	89	37° 00’	43°54’	401
OB	winter	1996	65	34° 56’	39° 24’	363
OB	summer	1997	138	45° 01’	54° 21’	386
OB	summer	1998	175	45° 02’	54°24’	385
OB/EH	winter/spring	1999	247	34° 46’	47° 50’	440
OB/EH	autumn/spring	2000	249	34° 46’	47° 50’	440
OB/EH	spring	2001	93	34° 46’	40° 59’	353
OB/EH	winter/spring	2004	86	34° 46’	40° 59’	235
OB/EH	winter	2005	128	41° 14’	47° 52’	150

RESULTS AND DISCUSSION

Geographic distribution

In the Southwest Atlantic Ocean (SAO) grenadiers distribute on the continental shelf and slope waters between 36° S-55° S. Scientists such as Günther (1880) identified a large number of genera and species on the Patagonian shelf and slope in the late 1800’s.

According to Cousseau (1993) the species present in the area were summarized and reorganized as follows (*included in this paper):

Cynomacrurus piriei Dollo, 1909
Coelorhynchus marinii Hubbs, 1934 (?)
**Caelorinchus fasciatus* (Günther, 1878)
Coelorhynchus kayomaru Arai and Iwamoto, 1979
Coryphaenoides subserrulatus Makushok, 1976
Coryphaenoides (*Lionurus*) *filicauda* Günther, 1887
Macrourus holotrachys (Günther, 1878)
**Macrourus carinatus* (Günther, 1878)
Macrourus withsoni (Günther, 1878)

Angelescu and Prenski (1987) included the Macrouridae Family, that belongs to the demersal-benthic community, in the Deep Water Shelf-

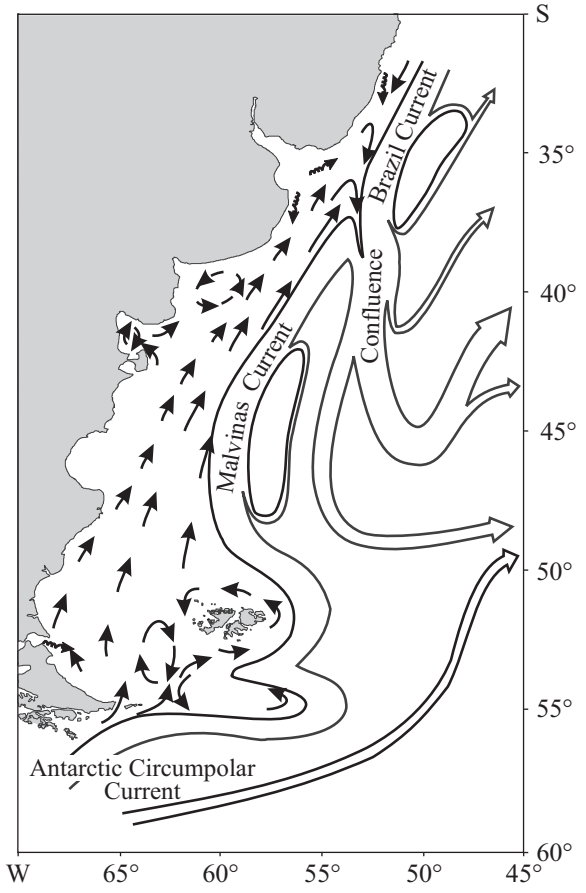


Figure 1. Water circulation scheme over the Argentine continental shelf and slope. Redrawn from Piola and Rivas (1997).

Figura 1. Esquema de la circulación del agua sobre la plataforma y el talud continental de la Argentina. Tomado de Piola y Rivas (1997).

Break Assemblage limited by the 35° S-55° S and the 220-2,300 m isobaths. The group comprises species with euribathic and stenothermic behavior. As observed in the species from the Northern Hemisphere, Macrouridae inhabits, in general, waters of high salinity and low temperature (Jorgensen, 1996; Murúa *et al*., 2005). It was found that, *M. carinatus* and *C. fasciatus*, the grenadier species studied in this paper, inhabit the Malvinas current of subantarctic origin, of high salinity and low range of temperature (Figure 1) (Bianchi *et al*., 1982; Guerrero and Piola, 1997).

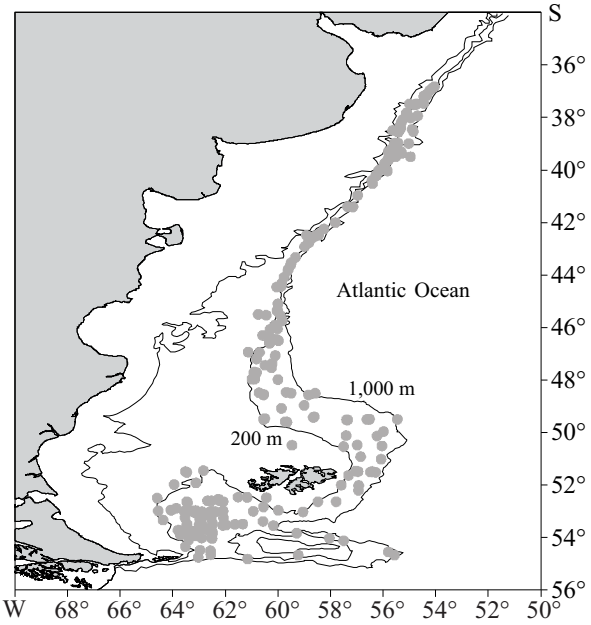


Figure 2. Geographic distribution of *M. carinatus* in the Southwest Atlantic Ocean.

Figura 2. Distribución geográfica de M. carinatus en el Océano Atlántico Sudoccidental.

M. carinatus is present between 36° S-55° S (Figure 2). The bathymetric distribution suggests that the species would inhabit extremely deep waters and be caught from 95 m to 1,200 m in areas associated to the middle and outer shelf. Like other species of the genus, it would reach even deeper areas (Murúa *et al*., 2005) not usually sampled during research cruises (Wöhler *et al*., 1999). Laptikhovsky (2005) mentions that it would be caught up to 1,770 m around Malvinas Islands.

The highest concentrations (>100 t nm^{-2}) of the species, that prefers cold waters ranging 2 °C-7 °C, were found between 480-825 m and 2.1 °C-4 °C. Bigeye grenadier would concentrate in cool and deep waters and disperse in warmer and shallower areas where the lowest density values are shown (Figure 3). There was no correlation between depth and latitude and the highest densities were found at deep waters north of 40° S (Figure 4).

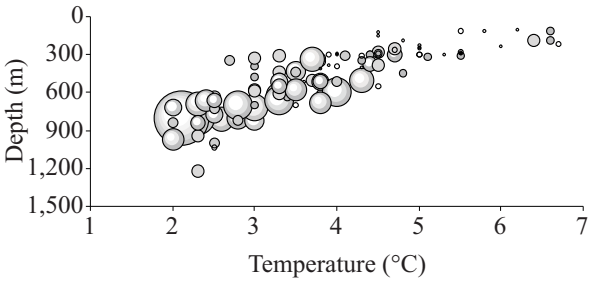


Figure 3. *M. carinatus* density values (t nm^{-2}) in relation to bathymetry and temperature.
Figura 3. Valores de densidad (t mn^{-2}) de M. carinatus en relación a la batimetría y a la temperatura.

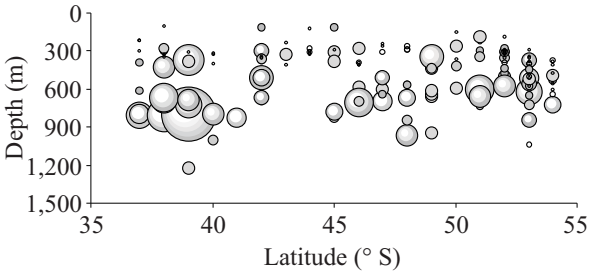


Figure 4. *M. carinatus* density values (t nm^{-2}) in relation to bathymetry and latitude.
Figura 4. Valores de densidad (t mn^{-2}) de M. carinatus en relación a la batimetría y a la latitud.

Although with low frequency of occurrence, *C. fasciatus* also shows a wide distribution and occupies areas similar to *M. carinatus*, mainly between 45° S-50° S and to the east of Malvinas Islands (Figure 5).

The species inhabits waters between 2.5 °C-6.5 °C where a wide range of depth is observed. The weak relation found between temperature and density shows that *C. fasciatus* tends to move to shallower waters as temperature increases. The highest densities were found between 230 m and 530 m at 4 °C (Figure 6). Schools, that reached 40 t per square mile, were smaller than those of *M. carinatus*.

C. fasciatus was more frequent between 52° S and 55° S, to the north and west of Burdwood Bank that could be, then, considered as the main distribution area (Figure 7).

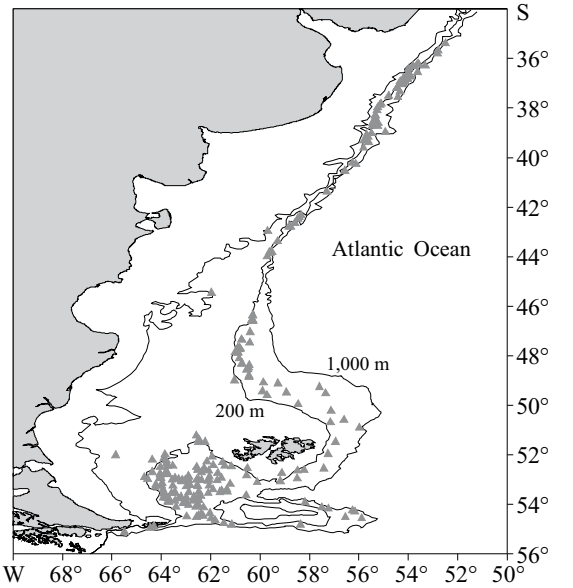


Figure 5. Geographic distribution of *C. fasciatus* in the Southwest Atlantic Ocean.
Figura 5. Distribución geográfica de C. fasciatus en el Océano Atlántico Sudoccidental.

Size and weight

Although *M. carinatus* length distribution ranged 31-92 cm TL, the most frequent sizes found were 51-62 cm TL (4-5%) (Figure 8). The notorious absence of small specimens suggests that juveniles would inhabit in different areas or at different depths or have a different behavior than adults.

C. fasciatus showed a total length range narrower than *M. carinatus* (12-40 cm TL) (Figure 9). The most frequent sizes of 13% of the specimens were 27-32 cm TL.

In both species, mainly *M. carinatus*, males were smaller than females.

The length-weight relation of both species showed parameter values similar to other gadiform species although those fitted using banded whiptail length-weight data did not show a high correlation value. Bigeye grenadier maximum weight was 4,260 g and corresponded to a 92 cm TL specimen (Figure 10); for banded whiptail it

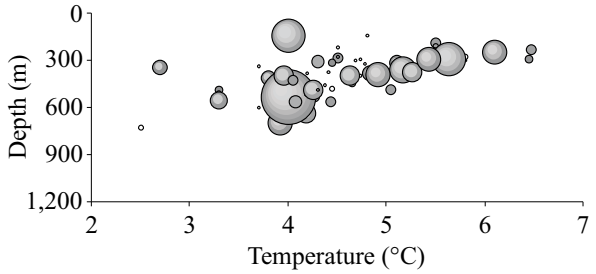


Figure 6. *C. fasciatus* density values (t nm^{-2}) in relation to bathymetry and temperature.
Figura 6. Valores de densidad (t mn^{-2}) de C. fasciatus en relación a la batimetría y a la temperatura.

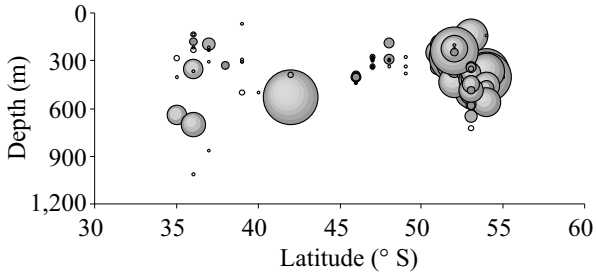


Figure 7. *C. fasciatus* density values (t nm^{-2}) in relation to bathymetry and latitude.
Figura 7. Valores de densidad (t mn^{-2}) de C. fasciatus en relación a la batimetría y a la latitud.

was 260 g and corresponded to a 39 cm TL specimen (Figure 11).

Total length (TL) and preanal length (PL) relation for both sexes combined was highly correlated (R^2 = 0.9347), mainly in the case of *M. carinatus* (Figure 12). Specimens included in the analysis ranged 9-32 cm PL and 32-92 cm TL.

C. fasciatus specimens ranged 3-13 cm PL and 12-40 cm TL. The relation obtained for both sexes combined was fitted to a linear regression with a lower determination index (R^2 = 0.7973) than expected (Figure 13).

Trophic ecology

The trophic information obtained did not allow to make a seasonal analysis; therefore, results should be considered as a general view of the

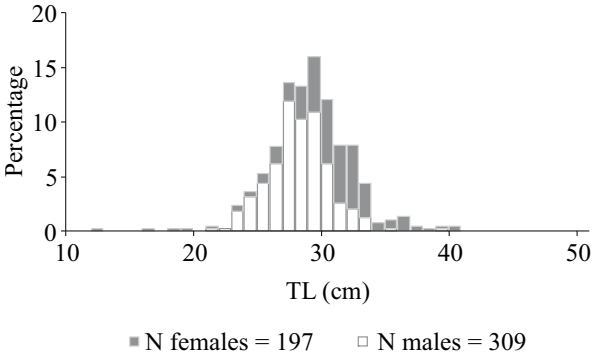


Figure 9. *C. fasciatus* length frequency distribution per sex.
Figura 9. Distribución de frecuencia de longitud por sexo correspondiente a C. fasciatus.

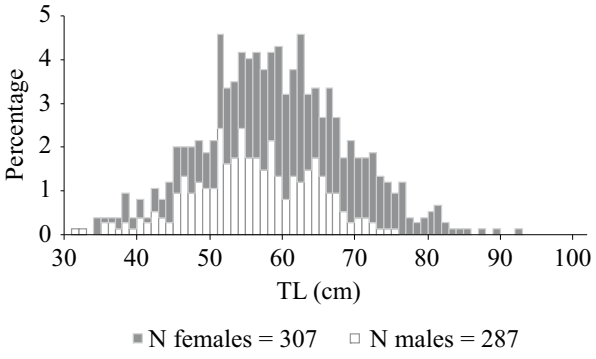


Figure 8. *M. carinatus* length frequency distribution per sex.
Figura 8. Distribución de frecuencia de longitud por sexo correspondiente a M. carinatus.

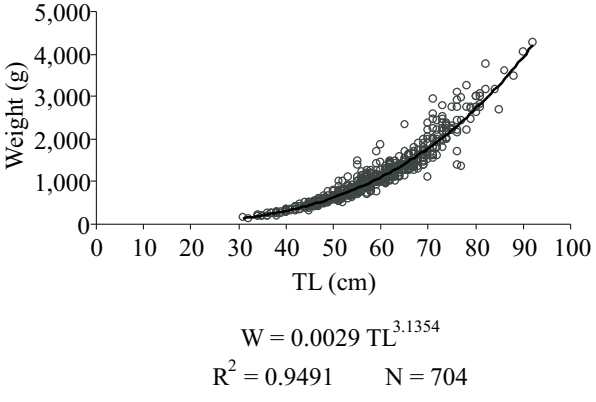
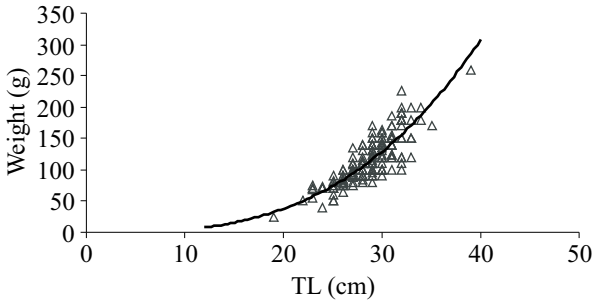
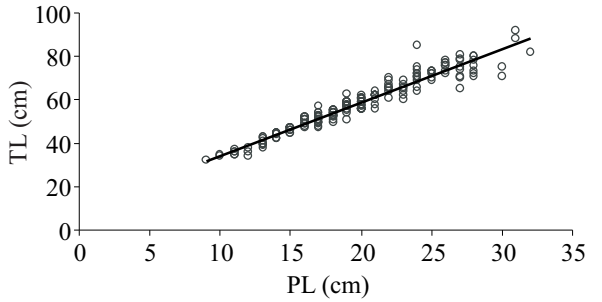


Figure 10. *M. carinatus* length-weight relation.
Figura 10. Relación longitud-peso de M. carinatus.



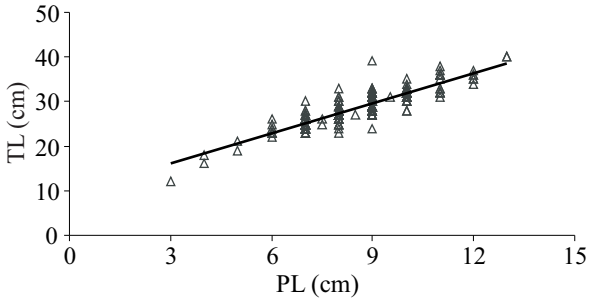
$W = 0.0044\ TL^{3.0251}$ $R^2 = 0.7461$ N = 170

Figure 11. *C. fasciatus* length-weight relation.
Figura 11. Relación longitud-peso de *C. fasciatus*.



TL = 9.8242 + 2.4442 PL $R^2 = 0.9347$ N = 192

Figure 12. *M. carinatus* preanal length (PL)-total length (TL) relation.
Figura 12. Relación longitud preanal (LP)-longitud total (LT) de M. carinatus.



TL = 9.5873 + 2.2318 PL $R^2 = 0.7973$ N = 355

Figure 13. *C. fascinatus* preanal length (PL)-total length (TL) relation.
Figura 13. Relación longitud preanal (LP)-longitud total (LT) de C. fasciatus.

trophic ecology of grenadiers from the SAO. Although *M. carinatus* and *C. fasciatus* preyed upon many organisms of different trophic levels, the most important prey items belonged to the zoobenthic isopods, amphipods, echinoderms, polychaete worms and mysids and nektonic groups (long fin squids, fishes and jelly fishes).

The frequency of occurrence (%F) of each item allowed to determine that *M. carinatus* consumed mainly jelly fishes or salps (Thaliacea) and benthic crustaceans such as isopods. Nevertheless, when the percentage per weight was analyzed, the most important preys were fishes, mainly southern blue whiting (*Micromesistius australis*) and notothenids (*Patagonotothen ramsayii*). Jorgensen (1996) reported similar prey groups from different areas for *M. berglax* and observed, also, a shift in diet in relation to the body size.

C. fasciatus is an omnivorous predator that consumes mainly crustaceans such as amphipods and isopods. However, the wide trophic spectrum comprises other benthic organisms that include polychaeta worms, ophiuroidea and hydrozoa and, occasionally, juveniles and small fishes (notothenids) (Table 2).

In cases where the degree of digestion made it impossible to identify the fish species found in the stomach content, the hard parts of the body and otoliths proved useful to proceed to a correct classification (Table 2 and Figure 14).

The general trophic spectrum of those fishes is similar to that of other grenadier species from different oceans (Geistdoerfer, 1978). Changes in the percentage of prey items were observed in *M. carinatus* from the Indian Ocean. Bigeye grenadier and banded whiptail are opportunistic species that show a very wide feeding spectrum. *M. carinatus* and *C. fasciatus* trophic levels estimated in this paper were 3.6 and 3.2, respectively, slightly lower than for other grenadiers (Froese and Pauly, 2007).

Although long tail hake (*Macruronus magellanicus*), common hake (*Merluccius hubbsi*) and southern blue whiting (*Micromesistius australis*)

Table 2. Preys list of *M. carinatus* and *C. fasciatus* of the Southwest Atlantic Ocean.
Tabla 2. Lista de presas de M. carinatus y C. fasciatus del Océano Atlántico Sudoccidental.

	Macrourus carinatus	*Caelorinchus fasciatus*
Crustacea		
Euphausiacea		x
Amphipods		
Gammarids	x	x
Caprelids		x
Hiperids (*Themisto gaudichaudii*)	x	
Mysidacea	x	
Isopoda		x
Serolis spp.	x	
Cirolana spp.	x	
Idotea spp.	x	
Anthuridae	x	
Polychaeta *Onuphis* sp.	x	x
Ophiuroidea	x	
Hydrozoa	x	
Echiura	x	
Cephalopoda		
Loligo gahi	x	x
Thaliacea		
Salpidae	x	
Pisces		
Osteicthyes		
Micromesistius australis	x	
Iluocoetes fimbriatus	x	
Patagonothotem ramsayi	x	x

are demersal pelagic species, distribution on the continental shelf overlaps with that of grenadiers (Angelescu and Prenski, 1987). Their status in the food web shows that, although in different proportion, they prey over similar items (crustaceans, squid, notothenids), fact that establishes a potential competition (Hixon, 1978). Finally, it should be mentioned that, on occasions, grenadiers become the preys of southern hake (*Merluccius australis*) and patagonian toothfish (*Dissostichus eleginoides*) (García de la Rosa *et al*., 1997), different mammals and deep sharks (*Notorhynchus cepedianus*) (Crespi-Abril *et al*., 2003).

Commercial fishing

As of 1970, when landings started to be declared, a high variability was observed in reports by fleets from different countries that operated on grenadiers with no fishing regulations (Figure 15). The largest catches were registered during the 1983-1987 period when the

Argentine government, through different agreements, allowed vessels from the former Soviet Union to catch the species on the Patagonian shelf, mainly to the northwest of Burdwood Bank and north of Malvinas Islands. Landings, that reached 30,000 t during said period, showed a rapid decline soon after.

Since the mid 90's only Argentine trawlers and longliners have operated on the resource in different areas with landings that average 3,600 t and vary based on the market demands rather than on the status of the stock (Figure 16).

Longliners that target patagonian toothfih (*Dissostichus eleginoides*) –the most valuable resource– operate in waters between 800-1,000 m depth (Martínez *et al*., 2001) and obtain the highest grenadier yields on the continental slope, north of 40° S and south of 54° S, near Burdwood Bank (Figure 17). Catches of the species, that amount to 15% of the annual harvest of the fleet, represent 20% of the landings of the target species (Figure 18).

Trawlers that catch mainly long tail hake (*M. magellanicus*) on the Patagonian shelf (Giussi *et al*., 2004) and common hake (*M. hubbsi*) north of 45° S (Aubone *et al*., 2004) overlap with longliners on the slope north of 43° S and south of 52° S, near Burdwood Bank and the Beagle Channel. The yields obtained by the fleet show that the most important fishing grounds are found

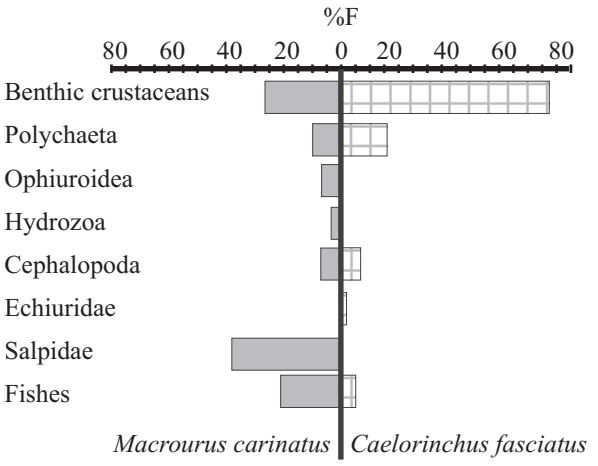


Figure 14. Trophic spectrum in frecuency of percentage of *M. carinatus* and *C. fasciatus* in the Southwest Atlantic Ocean.

Figura 14. Espectro trófico en porcentaje de frecuencia de M. carinatus y C. fasciatus en el Océano Atlántico Sudoccidental.

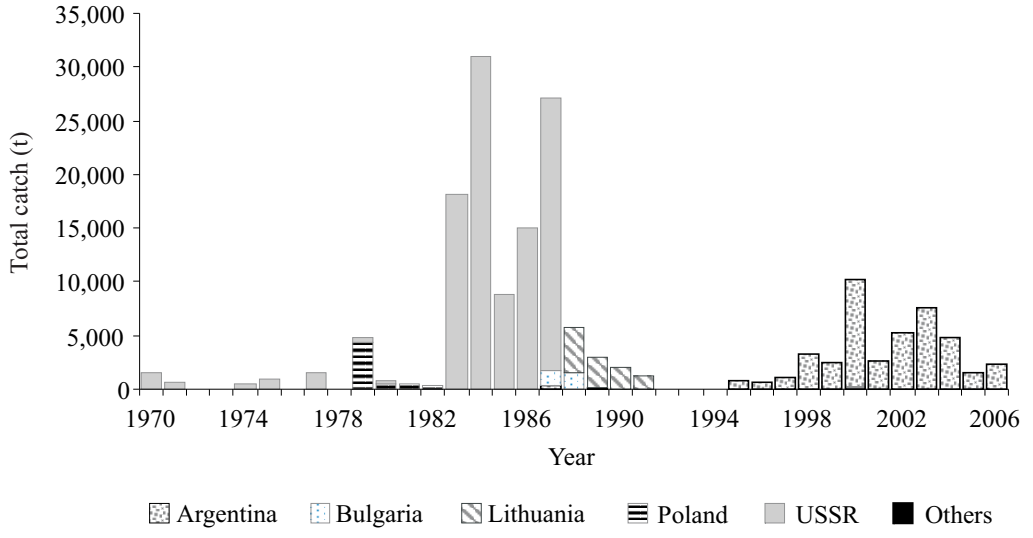


Figure 15. Grenadiers annual landings reported by fleets of different nationalities.

Figura 15. Desembarques anuales de granaderos reportados por flotas de distintas nacionalidades.

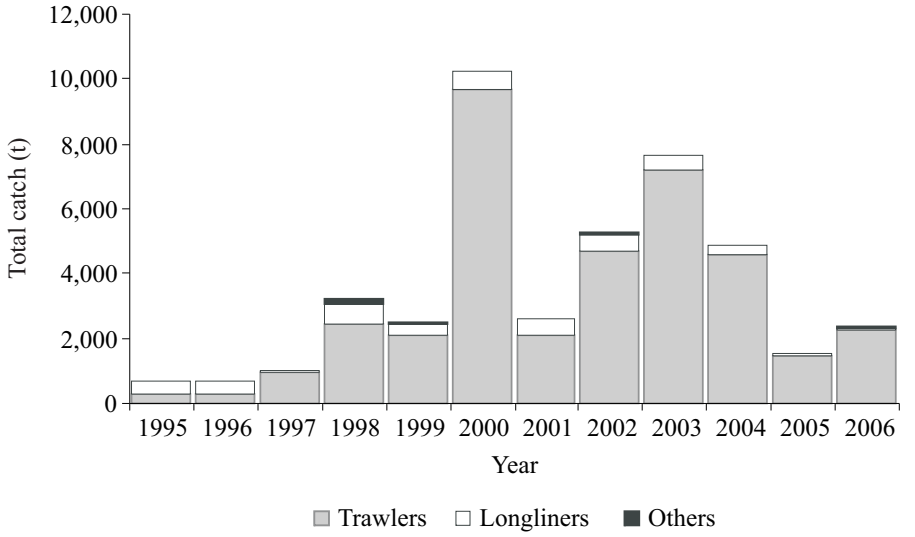


Figure 16. Grenadiers annual landings reported by the Argentine fleet.
Figura 16. Desembarques anuales de granaderos reportados por la flota argentina.

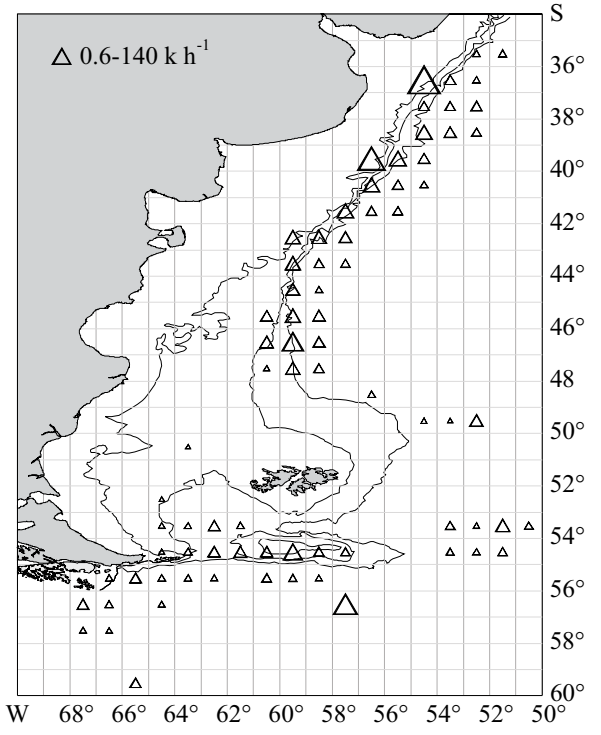


Figure 17. Grenadiers average yields obtained by the longliner fleet.
Figura 17. Rendimientos promedio de granaderos obtenidos por la flota palangrera.

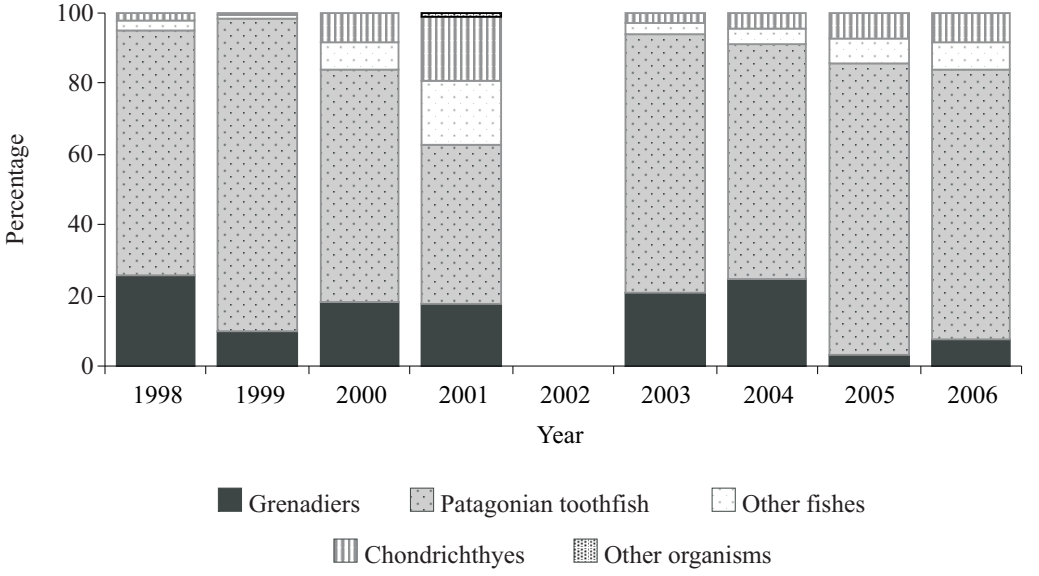


Figure 18. Percentage of grenadiers in longliners catches per year.
Figura 18. Porcentaje de granaderos en las capturas de palangreros por año.

between 53° S-56° S, at depths beyond 200 m (Figure 19). The 3.65 percentage of grenadiers present in the total landings of species caught by trawlers accounts for 4% of the main target species (Figure 20). The total catches declared by both fleets show that grenadiers would be more vulnerable to trawlers.

The length frequency distribution of fish caught by the two fleets was similar (Figure 21) and included two size groups, one of specimens smaller than 40 cm TL and another of individuals larger than 50 cm TL, a bimodal distribution that showed slight differences in the smallest fishes. The largest, caught by longliners, were mostly 32-38 cm TL specimens (up to 11%); individuals of 28 cm TL corresponded to trawlers.

The smallest sizes included banded whiptail adults and bigeye grenadier juveniles. Unfortunately, it was impossible to estimate the proportion in catches because neither fishermen nor scientific observers could identify them properly. The length range caught allowed to include only *M. carinatus* individuals in the second mode of distribution.

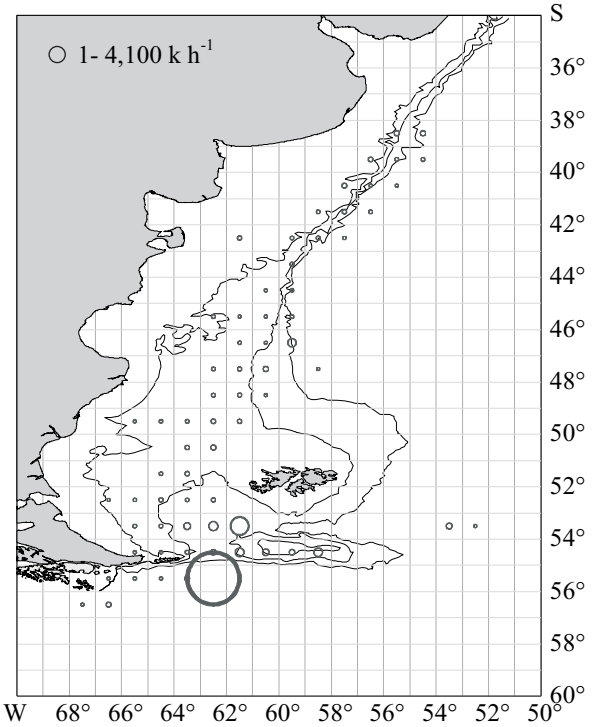


Figure 19. Average yields of grenadier obtained by trawlers.
Figura 19. Rendimientos promedio de granaderos obtenidos por la flota arrastrera.

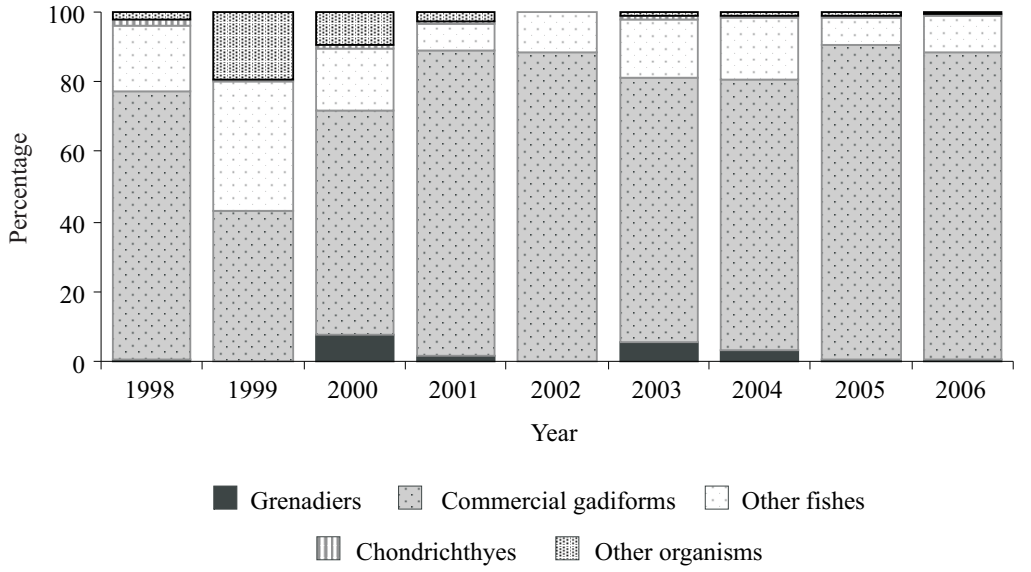


Figure 20. Percentage of grenadiers in trawlers catches per year.
Figura 20. Porcentaje de granaderos presentes en las capturas de arrastreros por año.

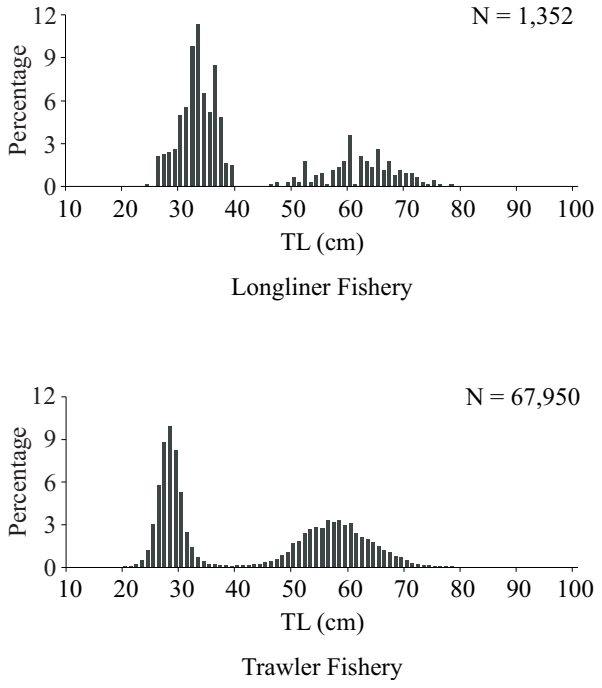


Figure 21. Length frequency distribution of grenadiers per type of fleet.
Figura 21. Distribución de frecuencia de longitud de granaderos por tipo de flota.

Considering the biology of grenadiers, their longevity and moderate growth (van Wijk *et al.*, 1999; Morley *et al.*, 2004), it may be concluded that it would be impossible to keep the mentioned level of catches for a long time if no stock assessment is performed. The strong impact catches have on stocks may put sustainability at risk if no proper regulations are implemented. As both species constitute the by-catch of other important fisheries, the difficulty to establish protection rules in the Southwest Atlantic Ocean makes of it an unregulated fishery. Regulations in the area such as 120 mm mesh span in trawlers and 4 cm round hook in longliners would not be sufficient to protect and sustain grenadier stocks.

As van Wijk *et al.* (1999) suggest and considering the level of knowledge about the species and the difficulty to identify specimens, definition of by-catch rate values for other species such as patagonian toothfish caught in longliners and common hake or long tail hake in trawlers becomes extremely difficult.

A possible solution would be to consider fishing

grounds outside the Argentine EEZ, mainly north of 48° S. The preliminary results obtained in a recent international research cruise show that *M. carinatus* is the most important finfish species caught outside the Argentine EEZ, at depths beyond 500 m (Scarlato and Sánchez, 2008). The absence of protection rules in the area makes it necessary to deepen knowledge as regards catches, wherever they occur, so as to understand the response to pressure exercised on the resource and the role that pressure has on the ecosystem.

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