An Acad Bras Cienc (2023) 95(4): e20200735 DOI 10.1590/0001-3765202320200735
Anais da Academia Brasileira de Ciências | *Annals of the Brazilian Academy of Sciences*
Printed ISSN 0001-3765 I Online ISSN 1678-2690
www.scielo.br/aabc | www.fb.com/aabcjournal

ECOSYSTEMS

Species composition and assemblage analysis of fishes caught as bycatch by the Patagonian shrimp fishery in the southwest Atlantic

MARÍA EVA GÓNGORA, JULIAN RUIBAL NÚÑEZ, PABLO DANIEL COCHIA & NELSON DARÍO BOVCON

Abstract: Bottom trawl fishing is the most used worldwide gear generating large amounts of discards due to bycatch of a variety of species. Shrimp fisheries are recognized for their high incidence in global discards. In waters of Patagonia Argentina (43°S - 47°S) an industrial shrimp fishery of high economic value is developed whose target species is the Patagonian shrimp *Pleoticus muelleri*. The information presented in this study comprises a period of 12 years (2003-2014) and it was gathered by the On-board Observer Program. The Program collects information of all species captured in the fishing fleets. The data analyzed corresponds to the double-rigged otter trawler fleet and the coastal fleet. The fish bycatch composition was characterized in both fleets and the frequencies of occurrence of species and the assemblage areas were analyzed. A total of 101 fish species were identified (59 families) of which 69 were bony fishes, 29 cartilaginous fishes and three species of jawless fishes. The assemblages described correspond to coastal and deep waters, and they are integrated by temperate and subtropical species pointing out the area as an ecotonal zone.

Key words: bycatch, fish associations, *Pleoticus muelleri*, San Jorge gulf, Southwest Atlantic.

INTRODUCTION

Bycatch is defined as all those non-target captured organisms in a fishery that are discarded dead or severely injured and they will die post-release (Hall et al. 2017). Bycatch is one of the most ubiquitous and crippling challenges worlwide (Kelleher 2008, Hasting et al. 2017). The drive to ecosystem-based fisheries management (FAO 2003) has made it more imperative to understand bycatch in fisheries as a factor contributing to the destabilization of oceanic communities (Hall et al. 2017).

Despite advances in this area, there is still a marked lack of quantitative information on bycatches and discard rates (Kelleher 2008). Even, the extent and degree of the global impact of fisheries on marine biodiversity remains poorly understood and highly contentious (Dulvy et al. 2014). Moreover, studies on bycatch provide an opportunity to characterize the fish composition of a region and they allowed determining possible associations or “species assemblages” defined as geographical areas that are characterized by a particular species composition relatively homogeneous and persistent.

Bycatch is a problem in most of the world’s fisheries. Worldwide, shrimp and prawn trawl fisheries have been questioned (Gillett 2008, Kelleher 2008). Though the problem is wider in tropical and subtropical fisheries, temperate and cold-water fisheries are also recognized for their ecological impact on commercial fish species which are target of other fisheries, particularly the bycatch of juvenile of these species (Gillett 2008).

In Argentina, there is a shrimp fishery sustained by the species *Pleoticus muelleri*. This species of temperate waters is distributed from Espirito Santo, Brazil (20ºS), to Río Gallegos, Argentina (51ºS) (Boschi 1997). Throughout its distribution range several fisheries exploit this resource but the Patagonian stock is the only that sustains a large-scale industrial fishery. This fishery contributes nearly 95% of the shrimp landings in Argentina (Fischbach et al. 2006). It has reached 250.000 tons in 2018 with an uninterrupted growing trend since 2006 (De la Garza & Moriondo Danovaro 2019).

Three different types of fleet are involved in this Patagonian shrimp fishery: (1) a double-rigged otter trawler fleet composed of between 80 and 90 freezer vessels with a length between 24 and 54 m; (2) a coastal fleet composed of 40 vessels with a length of up to 21 m; and (3) a high-seas ice trawler fleet greater than 21 m in length.

In recent years, the latter fleet has increased the number of vessels (Fischbach & Bertuche 2017). The double-rigged otter trawler fleet operates in the San Jorge Gulf and adjacent waters in the Closed Area of Juvenile Hake *Merluccius hubbsi* authorized for this fishery. The coastal fleet operates mainly on the coast of Chubut Province up to 12 miles in provincial jurisdictional waters and less frequently in adjacent waters in the Closed Area of Juvenile Hake where it overlaps with the double-rigged otter trawler fleet (Fig. 1). The high-seas ice trawler fleet when heads for shrimp it operates

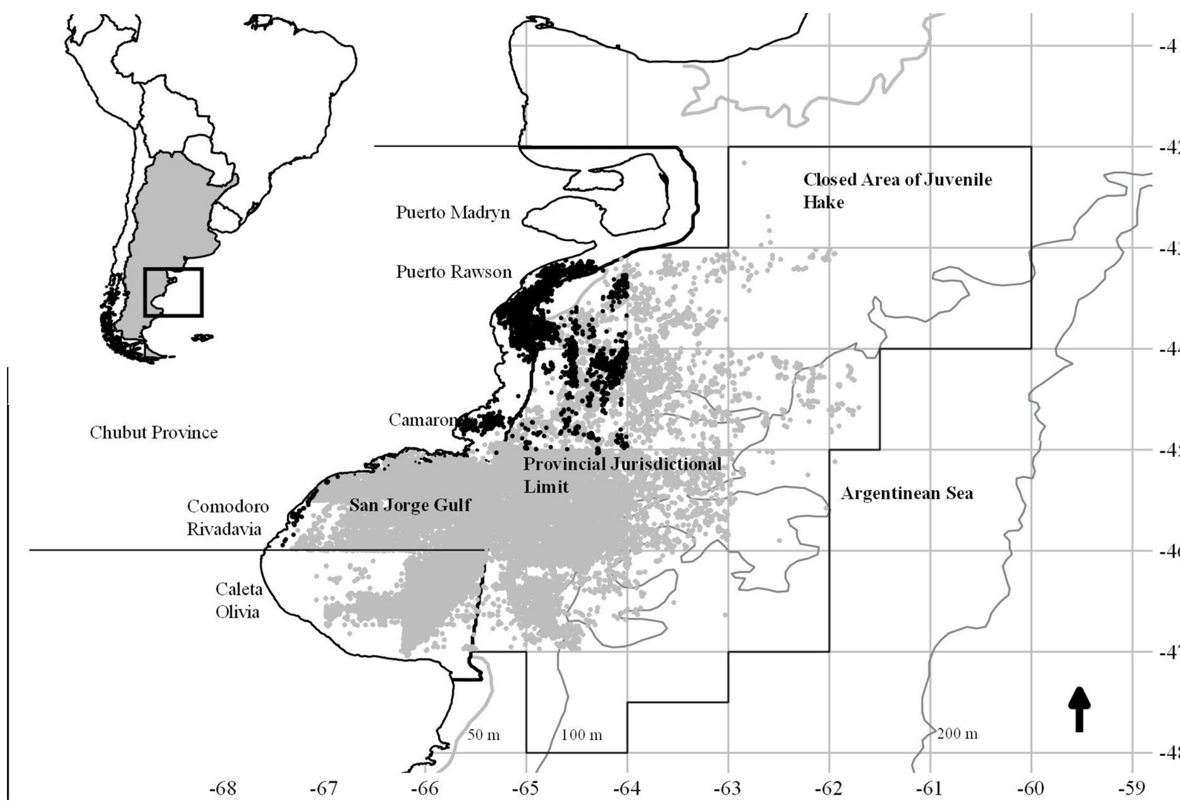

Figure 1. Distribution of hauls analyzed during the period 2005-2014 corresponding to the double-rigged otter trawler fleet (gray dots) and the coastal fleet (black dots). The coastal waters in the provincial jurisdictional limit, the San Jorge Gulf and the Closed Area of Juvenile Hake are indicated.

in the same areas as the double-rigged otter trawler fleet (Góngora et al. 2012). Each fleet when operates to shrimp used two shrimp nets, one for each outrigger.

In the double-rigged otter trawler fleet there is a bycatch description of fishes from 2003 to 2008 (Góngora et al. 2009, Góngora 2011) but in the coastal fleet there is a description of the bycatch of cartilaginous fishes from 2005 to 2014 without reference the bony fish group (Ruibal Nuñez et al. 2016). In the high-seas ice trawler fleet there is a comparative description of the bycatch when this fleet headed for shrimp and hake, and it includes years from 2003 to 2012 (Bovcon et al. 2013) but new data has not been collected in this fleet since then.

Even though fish bycatch composition in the Patagonian shrimp *Pleoticus muelleri* fishery was determined for this region of Patagonia and 42 new fish species for the ichthyological fauna of the San Jorge Gulf and adjacent waters were recorded (Góngora et al. 2009, Bovcon et al. 2011, 2013, 2016, 2017, Cochia et al. 2016), the present study (i) updates the data of the species caught as bycatch in the double-rigged otter trawler fleet, (ii) completes the bycatch description of the fish species caught in the coastal fleet, adding both bony fishes and cartilaginous fishes, and (iii) assesses fish assemblage areas in the shrimp fishery zone.

MATERIALS AND METHODS

Hauls data collected by the On-board Observers Program belonging to the Secretariat of Fisheries of Chubut province were used. For each fishing haul, information about type of vessel, observer, date, depth and position (latitude and longitude) was recorded. Fishing hauls between years 2003 and 2014 from both the fishing hauls between the years 2003 and 2014 of the double-rigged otter trawler frozen fleet and the iced-coastal fleet were included in the analysis. Both fleets use a double-rigged otter trawler with similar features but with dimensions that are appropriate to the length of the fleet type. In order to reduce errors due to hauls data loading, the base was filtered and those incomplete or problematical records were eliminated. The result was a database with 52.583 fishing hauls corresponding to depths ranging from 3 to 127 m (Table I).

The description of the species was made considering all the years, while for the fish assemblage analysis the method used allowed to analyze the bycatch composition per year. The fishing hauls in the coastal waters of Chubut province corresponded to the iced-coastal fleet which operates mainly from September to April during the spring-summer season. The iced-costal fleet also operates in the Closed Area of Juvenile Hake between May and September but the fishing effort is lower than the effort made by this fleet in coastal waters. In the San Jorge Gulf and Closed Area of Juvenile Hake the fishing hauls corresponded to the double-rigged otter

Table I. Number of hauls observed per year and type of fleet of the On-board Observers Program of Chubut Province in the period 2003 to 2014.

Year	Coastal fleet	Double-rigged otter trawler fleet
2003	32	4595
2004	45	5359
2005	150	2979
2006	229	2773
2007	774	3012
2008	650	5979
2009	404	7154
2010	396	5843
2011	586	4409
2012	621	1642
2013	796	1160
2014	1003	1992

trawler frozen fleet and the operational season is from February to November. In 2003 and 2005 the fleet operated during December and January but then a summer closure was successfully implemented and the operational fishing was banned for this fleet in the San Jorge Gulf from November.

Description of the fish bycatch composition

All the species of fishes caught as bycatch by the fleets were identified during the period analyzed. The frequency of occurrence (FO) of the species *i* per type of fleet was calculated from the following relation:

$$FO_i\% = \frac{n_i}{N} \times 100$$

where n_i is the number of hauls where the species *i* was identified and N is the total number of hauls. The species were classified in the following categories according to their incidence in catches (Solervicens 1973): a) *constant species*, with a catch frequency of occurrence of about 50% or more; b) *accessory species*, with catch frequencies between 25% and 50%; and c) *accidental species*, with less than 25% of frequency.

The FO was also calculated by depth ranges considering both the double-rigged otter trawler fleet and the coastal fleet as a whole. The depth ranges were categorized as follows: 0-30 m, 30-60 m, 60-90 m, and more than 90 m. The FO by depth ranges was calculated as:

$$FO_{i,d}\% = \frac{n_{i,e}}{Ne} \times 100$$

where n_i is the number of hauls where the species *i* was identified in the depth range d, and N is the total number of hauls in the depth range e considering both fleets.

Fish assemblage analysis

Fishing hauls were grouped into grid of 6' latitude by 6' longitude (11 km by 11 km) without classified by type of fleet since the aim was to identify the fish assemblages that overlap with the Patagonian shrimp fishery. From the number of records by species in each rectangle per year an absolute frequency matrix was obtained. From this matrix, a relative frequency matrix was calculated by dividing the count of hauls a species was captured in by the total number of hauls made in each grid (site) and each year. Only the species observed with a frequency higher than 1% were included in the analysis (Gauch 1989, Legendre & Legendre 1998, Stobutzki et al. 2003) and the grid (sites) with less than five hauls in each year were discarded.

For describing the fish assemblages and determine areas with similar species composition a Multiple Factorial Analysis (MFA) was used. This method allowed ordering the areas according to the present species in each year. MFA was developed by Escofier & Pagès (1992) and is a factorial method adapted for treatment of multiple tables that allows simultaneous analysis of several groups of variables measured on the same set of individuals. Thus, it balances the influence of each group (weighting). The objects that intervened in the analysis were: (1) the grid or sites (individuals), (2) the species (variables) and (3) the years (groups). The data variability was quantified using the concept of inertia (Pelletier & Ferraris 2000).

The group analysis was carried out through (a) the eigenvalues of the global analysis and (b) the relations between the global analysis factors and the groups based on: (i) the R Vector (RV) coefficients as a measure of similarity between groups and (ii) the correlation coefficients between the partial factors of each group and the MFA global factors. The RV coefficients can take values between 0 (no relation between the variables of the two groups considered) and 1 (total relation). Dimensions 1-2 and 3-4 obtained from MFA were selected to perform a k-means classification algorithm (Hartigan & Wong 1979). The distribution of the sites was graphed by the MFA and the k-means method allowed classified those sites into groups.

The analyses were performed with FactoMineR (Lê et al. 2008) and vegan (Oksanen et al. 2017) packages of R program version 3.4.1 (R Development Core Team 2017). The assemblage areas were represented from maps generated with the Quantum GIS program version 2.18.12.

RESULTS

Description of the fish bycatch composition

One hundred one species of fishes corresponding to 59 families were identified: 69 species of bony fishes (Osteichthyes); 29 species of cartilaginous fishes (Chondrichthyes); and three species of jawless fishes (Agnatha) (Table II). Ninety-nine species of fishes were recorded in the double-rigged otter trawler fleet whereas in the coastal fleet 80 species were recorded. Twelve species were recorded in a single year: the rainbow trout *Oncorhynchus mykiss* (2005); *Dules auriga* (2006); atlantic saury *Scomberesox scombroides* (2007); telescope fish *Mendosoma lineatum* (2012); black southern cod *Patagonotothen tessellata* (2014); the flounder *Achiropsetta* sp. (2009); the southern hake *Merluccius australis* (2008); the white sea catfish *Genidens barbus* (2013); patagonian moray cod *Muraenolepis orangiensis* (2005); bluntonose sixgill shark *Hexanchus griseus* (2006); the multispine skate *Bathyraja multispinis*; and the Magellan skate *Bathyraja magellanica* (2014). The rest of the species were recorded in more than one year.

In the double-rigged otter trawler fleet six species were constants while in the coastal fleet four species were constants (more than 50% of frequency). The argentinean common hake *Merluccius hubbsi* (97% of frequency in the double-rigged otter trawler fleet and 79% of frequency in the coastal fleet) and the southwest atlantic butterfish *Stromateus brasiliensis* (54% in the double-rigged otter trawler fleet and 66% in the coastal fleet) were constant species in both fleets. The longtail southern cod *Patagonotothen ramsayi* (75%), the pink cusk-eel *Genypterus blacodes* (62%), the yellownose skate *Zearaja brevicaudata* (55%) and the apron ray *Discopyge tschudii* (53%) were constant species in the double-rigged otter trawler fleet; whereas, in the coastal fleet the elephantfish *Callorhinchus callorynchus* (55%) and the paperfish *Nemadactylus bergi* (53%) were constant species (Table III).

Four species in the double-rigged otter trawler fleet and seven species in the coastal fleet were observed with a frequency between 25% and 50% (accessory species). In the double-rigged otter trawler fleet, the shortfin sandskate *Psammobatis normani* (36%), the flounder *Xystreurys rasile* (34%), the smallnose fanskate *Sympterygia bonapartii* (29%) and the *C. callorynchus* (29%) were recorded in this range of frequency; whereas, in the coastal fleet, the argentinean sea bass *Acanthistius patachonicus* (46%), the brazilian flathead *Percophis brasiliensis* (45%), *D. tschudii* (42%), *X. rasile* (40%), the parona leatherjacket *Parona signata* (31%), the flounder *Paralichthys isosceles* (31%) and the argentinean anchovy *Engraulis anchoita* (29%) were recorded between these frequencies.

Most of the species were observed with frequencies less or equal to 25%. Ninety-four accidental species in the double-rigged otter trawler fleet (95% of the species) and 69 accidental species in the coastal fleet (86% of the species) were recorded. Among these species, the narrowmouth catshark

Table II. Taxonomic list of fish species caught as bycatch by the double-rigged otter trawler fleet and the coastal fleet during the period 2003 to 2014.

AGNATHA	
Myxini	Batrachoidiformes
Myxiniformes	Batrachoididae
Myxinidae	***Triathalassothia argentina*** Berg, 1897 (toadfish)
Myxine australis Jenyns, 1842 (hagfish)	***Porichthys porossisimus*** (Cuvier, 1829)
Notomyxine tridentiger Garman, 1899 (hagfish)	Atheriniformes
Cephalaspidomorphi	Atherinopsidae
Petromyzontiformes	***Odontesthes platensis*** (Berg, 1895) (silverside)
Geotriidae	***Odontesthes smitti*** Lahille, 1929 (silverside)
Geotria australis Gray, 1851 (pouched lamprey)	Scorpaeniformes
CHONDRICHTHYES	Sebastidae
Elasmobranchii	***Sebastes oculatus*** Cuvier, 1833 (Patagonian redfish)
Hexanchiformes	Congiopodidae
Hexanchidae	***Congiopodus peruvianus*** (Cuvier, 1829) (horsefish)
Notorhynchus cepedianus (Perón, 1807) (broadnose sevengill shark) ***Hexanchus griseus*** (Bonnaterre, 1788) (bluntonose sixgill shark)	Triglidae ***Prionotus nudigula*** Ginsburg, 1950 (red searobin)
Carcharhiniformes	Agonidae
Carcharhinidae	***Agonopsis chiloensis*** (Jenyns, 1842) (snailfish)
Prionace glauca (Linné, 1758) (blue shark)	Perciformes
Scyliorhinidae	Polyprionidae
Schroederichthys bivius Müller y Henle, 1841 (narrowmouthed catshark)	***Polyprion americanus*** Bloch y Schneider, 1801 (wreckfish)
Triakidae	Serranidae
Mustelus schmitti Springer, 1939 (narrownose smooth-hound)	***Acanthistius patachonicus*** (Jenyns, 1842) (Argentinean sea bass)
Galeorhinus galeus Linné, 1758 (tope shark)	***Dules auriga*** Cuvier, 1829 (cocherito)
Squaliformes	Carangidae
Squalidae	***Parona signata*** (Jenyns, 1842) (Parona leatherjacket)
Squalus acanthias Linné, 1758 (picked dogfish)	***Selene setapinnis*** (Mitchill, 1815) (Atlantic moonfish)
Squalus lobularis Jordan y Snyder, 1903 (shortspine spurdog)	***Trachurus lathami*** Nichols, 1920 (rough scad)
Squatiniformes	Sparidae
Squatinidae	***Diplodus argenteus*** (Valenciennes, 1830) (South American silver porgy)
Squatina guggenheim (Marini, 1930) (angular angel shark)	***Pagrus pagrus*** Linné, 1758 (red porgy)
Torpediniformes	Bramidae
Torpedinidae	***Brama brama*** (Bonnaterre, 1788) (Atlantic pomfret)

Table II. Continuation.

Tetronarce puelcha Lahille, 1926 (Argentinean torpedo)	Sciaenidae
Narcinidae	***Cynoscion guatucupa*** (Cuvier, 1829) (stripped weakfish)
Discopyge tschudii Heckel, 1846 (apron ray)	***Micropogonias furnieri*** (Desmarest, 1823) (whitemouth croaker)
Rajiformes	Cheilodactylidae
Rajidae	***Nemadactylus bergi*** (Norman, 1937) (castaneta)
Atlantoraja castelnaui Miranda Ribeiro, 1907 (spotback skate)	Mullidae
Atlantoraja cyclophora Regan, 1903 (eyespot skate)	***Mullus argentinae*** Hubbs & Marini, 1933 (Argentinean goatfish)
Zearaja bevicauda (Marini 1933) (yellownose skate)	Zoarcidae
Dipturus trachyderma (Krefft y Stehmann, 1975) (roughskin skate)	***Austrolycus laticinctus*** (Berg, 1895) (eelpout)
Dipturus argentinensis Díaz de Astarloa, Mabragaña, Hanner & Figueroa, 2008 (Argentinean skate)	***Dadyanos insignis*** (Steindachner,1898) (eelpout)
Bathyraja brachyurops (Fowler, 1910) (broadnose skate)	***Iluocoetes fimbriatus*** Jenyns, 1842 (eelpout)
Bathyraja macloviana (Norman, 1913) (Patagonian skate)	Bovichthidae
Bathyraja magellanica (Philippi, 1902) (Magellan skate)	***Cottoperca trigloides*** (Günther, 1881) (channel bull blenny)
Bathyraja multispinis (Norman, 1937) (multispine skate)	***Bovichtus argentinus*** MacDonagh, 1931 (thornfish)
Psammobatis normani McEachran, 1983 (shortfin sandskate)	Nototheniidae
Psammobatis bergi Marini, 1932 (blotched sandskate)	***Notothenia angustata*** Hutton, 1875 (Maori chief)
Psammobatis lentiginosa McEachran, 1983 (freckled sandskate)	***Patagonotothen ramsayi*** (Regan, 1913) (longtail southern cod)
Psammobatis extenta Garman, 1913 (zipper sandskate)	***Patagonotothen tessellata*** **(Richardson, 1845)** Black southern cod
Psammobatis rudis Gunther, 1870 (smallthorn sandskate)	***Patagonotothen sima*** (Richardson, 1845) ***Paranotothenia magellanica*** (Bloch & Schneider, 1801) (Magellanic rockcod)
Sympterygia bonapartii Muller y Henle, 1841 (smallnose fanskate)	Eleginopsidae
Sympterygia acuta Garman, 1878 (bignose fanskate)	***Eleginops maclovinus*** (Valenciennes, 1830) (Patagonian blennie)
Myliobatiformes	Latridae
Myliobatidae	***Mendosoma lineatum*** Guichenot 1848 (telescope fish)
Myliobatis goodei Garman, 1885 (Southern eagle ray)	Percophidae
Holocephalii	***Percophis brasiliensis*** (Quoy y Gaimard, 1824 (Brazilian flathead)
Chimaeriformes	Pinguipedidae
Callorhynchidae	***Pinguipes brasilianus*** Cuvier 1829 (Brazilian sandperch)

Table II. Continuation.

Callorhinchus callorynchus Linné 1758 (elephantfish)	***Pseudopercis semifasciata*** (Cuvier, 1829) (Argentinean sandperch)
OSTEICHTHYES	Trichiuridae
Anguiliformes	***Trichiurus lepturus*** Linné, 1758 (largehead hairtail)
Congridae	Scombridae
Bassanago albescens (Barnard, 1923) (hairy conger)	***Scomber colias*** Gmelin, 1789 (Atlantic chub mackerel)
Conger orbignyanus Valenciennes, 1847 (Argentinean conger)	***Sarda sarda*** (Bloch, 1793) (Atlantic bonito)
Clupeiformes	Gempylidae
Clupeidae	***Thyrsitops lepidopoides*** (Cuvier, 1832) (white snake mackerel)
Ramnogaster arcuata (Jenyns, 1842) (Jenyns's sprat)	Centrolophidae
Sprattus fueguensis (Jenyns, 1842) (Falkland sprat)	***Seriolella porosa*** Guichenot, 1848 (choicy ruff)
Engraulidae	Pomatomidae
Engraulis anchoita Hubbs y Marini, 1935 (Argentinean anchovy)	***Pomatomus saltatrix*** (Linné, 1758) (bluefish)
Gadiformes	Stromateidae
Moridae	***Stromateus brasiliensis*** Fowler, 1906 (Southwest Atlantic butterfish)
Salilota australis Günther, 1878 (tadpole codling)	Zeiformes
Phycidae	Oreosomatidae
Urophycis brasiliensis Kaup, 1858 (Brazilian codling)	***Allocyttus verrucosus*** (Gilchrist, 1906) (warty dory)
Merlucciidae	Zeidae
Merluccius hubbsi Marini, 1933 (Argentinean hake)	***Zenopsis conchifer*** (Lowe, 1858) (Silvery John dory)
Merluccius australis (Hutton, 1872) (Southern hake)	
Macruronidae	Pleuronectiformes
Macruronus novaezelandiae **(Hector, 1871) (Patagonian grenadier)**	Paralichthyidae
Muraenolepididae	***Xystreurys rasile*** (Jordan, 1890) (flounder)
Muraenolepis orangiensis Vaillant, 1888 (Patagonian moray cod)	***Paralichthys isosceles*** Jordan, 1891 (flounder)
Ophidiformes	***Paralichthys patagonicus*** Jordan, 1889 (Patagonian flounder)
Ophidiidae	Pleuronectidae
Genypterus blacodes Schnaider, 1801 (pink cusk-eel)	***Oncopterus darwini*** Steindachner, 1875 (remo flounder)
Genypterus brasiliensis Regan, 1903 (cusk-eel)	Achiropsettidae
Raneya brasiliensis (Miranda Ribeiro, 1903) (banded cusk-eel)	***Achiropsetta*** sp. Norman, 1930
Salmoniformes	Syngnathiformes

Table II. Continuation.

Salmonidae ***Oncorhynchus mykiss*** (Walbaum, 1792) (rainbow trout)	Syngnathidae
Lophiiformes	***Leptonotus blainvilleanus*** (Eydoux y Gervais, 1837) (Deep-bodied pipefish)
Lophiidae	Siluriformes
Lophius gastrophysus Miranda Ribeiro, 1915 (Blackfin goosefish	Ariidae
	Genidens barbus (Lacepéde, 1803) (white sea catfish)
	Beloniformes
	Scomberesocidae
	Scomberesox scombroides (Richardson, 1843) (atlantic saury)

Schroederichthys bivius (25%), the horsefish *Congiopodus peruvianus* (23%), the flounder *Paralichthys isosceles* (21%), *N. bergi* (21%), the picked dogfish *Squalus acanthias* (19%) and the choicy ruff *Seriolella porosa* (13%) standed out in the double-rigged otter trawler fleet; while the Patagonian flounder *Paralichthys patagonicus* (21%), the argentinean sandperch *Pseudopercis semifasciata* (20%), the brazilian sandperch *Pinguipes brasilianus* (20%), *S. porosa* (17%), *P. ramsayi* (17%), the narrownose smoothhound *Mustelus schmitti* (15%) and *S. bonapartii* (13%) standed out in the coastal fleet (Table III).

In the double-rigged otter trawler fleet these species are discarded entirely while in the coastal fleet some species of bony and cartilaginous fishes are landed (*A. patachonicus*, *P. semifasciata*, *M. hubbsi*, *P. isosceles*, *P. patagonicus*, *X. rasile*, *P. signata*, the atlantic chub mackerel *Scomber colias*, the tope shark *Galeorhinus galeus*, *M. schmitti*, the angular angel shark *Squatina guggenheim*, *C. callorynchus*, *Z. brevicaudata* and *S. acanthias*), but most of these landings are not recorded by the vessel captain or by the fishing inspectors and they are difficult to quantify. The landings are fated for personal consumption or they integrate the non-formal fish market in the region.

From the analysis of the depth range distribution of the species it is observed that most of them showed a wide bathymetric distribution. The species that presented the highest FO in all the bathymetric strata were *M. hubbsi*, with high values of FO as depth increased, and *S. brasiliensis*, with low values of FO as depth increased (Table III). The depth range distribution analysis showed that species are distributed in three groups: (1) coastal species that present a decrease in their values of FO as depth is higher, such as *C. callorynchus*, *N. bergi*, *P. brasiliensis*, *A. patachonicus*, *P. signata*, *E. anchoita*, *P. brasilianus*, *P. semifasciata*, *S. porosa*, *M. schmitti*, *Triathalassothia argentina*; (2) a deep-sea group species with high values of FO as depth increased where highest values of these frequencies are recorded at depths greater than 60 m. This group is represented by the species *D. tschudii*, *S. acanthias*, *P. ramsayi*, *P. normani*, *Z. brevicaudata*, *C. peruvianus*, *S. bonapartii*; (3) species that are distributed homogeneously throughout all the bathymetric strata, such as *X. rasile*, *P. isósceles*, *Agonopsis chiloensis*, *Raneya brasiliensis* (Table III).

Table III. **Frequency of occurrence of each fish species caught as bycatch in both the double-rigged otter trawler fleet and the coastal fleet. Also, it is shown the frequency of occurrence by depth ranges without categorized per fleet.**

Species	**FO Coastal Fleet**	**FO double-rigged otter trawler fleet**	**FO Depth 0 -30 m**	**FO Depth 30 - 60 m**	**FO Depth 60- 90 m**	**FO Depth + 90 m**
Merluccius hubbsi	79.44	96.59	69.40	79.21	98.78	99.48
Stromateus brasiliensis	65.88	54.46	72.14	62.10	56.37	40.72
Callorhinchus callorynchus	54.68	29.45	69.96	54.50	29.21	11.97
Nemadactylus bergi	53.06	21.55	72.11	57.56	18.59	7.88
Acanthistius patachonicus	45.85	10.40	23.73	27.26	13.41	3.49
Percophis brasiliensis	45.04	6.29	30.07	30.47	6.71	3.25
Discopyge tschudii	42.84	53.04	29.91	36.08	57.32	49.55
Xystreurys rasile	40.26	33.64	26.34	30.01	36.17	32.98
Paralichthys isosceles	30.95	20.57	15.27	23.08	22.69	18.71
Parona signata	30.39	7.65	23.91	20.53	8.19	4.65
Engraulis anchoita	28.61	11.31	32.56	31.33	10.84	1.10
Paralichthys patagonicus	21.32	8.61	13.34	12.71	9.61	8.09
Pinguipes brasilianus	20.30	1.18	5.47	13.46	1.84	0.45
Pseudopercis semifasciata	20.19	6.61	11.54	15.51	7.82	1.85
Patagonotothen ramsayi	17.50	74.55	23.79	24.98	76.40	85.64
Seriorella porosa	16.09	13.66	23.73	22.46	13.47	5.00
Mustelus schmitti	14.44	6.35	18.59	10.50	6.22	4.42
Sympterygia bonapartii	13.74	29.01	18.19	17.65	29.90	27.51
Raneya brasiliensis	12.66	11.45	7.56	10.64	13.21	6.68
Squalus acanthias	11.57	18.75	4.35	7.38	17.98	32.10
Psammobatis normani	11.52	36.23	12.94	13.76	37.46	40.42
Zearaja chilensis	10.39	55.22	9.33	14.26	56.95	66.79
Congiopodus peruvianus	9.32	23.04	9.67	14.28	21.74	31.51
Odontesthes smitti	7.47	7.93	43.91	26.09	3.06	0.051
Genypterus blacodes	6.17	62.40	6.84	16.02	63.46	77.05
Triathalassothia argentina	5.17	0.59	1.34	3.96	0.73	0.28
Galeorhinus galeus	5.15	4.35	7.90	11.33	3.49	1.69
Agonopsis chiloensis	5.10	7.35	4.20	5.14	8.30	4.51
Squatina guggenheim	4.89	1.15	3.86	3.48	1.19	0.703
Cynoscion guatucupa	3.61	0.12	3.54	1.49	0.14	0.013
Ramnogaster arcuata	3.39	0.11	2.11	2.07	0.13	

Table III. Continuation.

Myliobatis goodei	2.37	1.00	5.53	2.15	0.77	0.19
Eleginops maclovinus	2.36	4.58	19.62	9.93	2.78	0.60
Schroederichthys bivius	2.13	24.59	1.49	1.44	22.72	44.88
Oncopterus darwini	1.97	0.40	4.63	1.16	0.21	0.05
Genypterus brasiliensis	1.92	7.53	0.81	1.88	7.39	11.39
Sebastes oculatus	1.60	8.28	2.61	2.11	9.10	7.08
Bathyraja macloviana	1.48	5.24	1.87	1.00	5.34	6.85
Myxine australis	1.41	2.13	0.34	0.55	2.54	1.73
Psammobatis lentiginosa	1.35	1.97	1.03	0.62	2.08	2.51
Conger orbignyanus	1.18	0.18	0.12	1.00	0.19	0.24
Dipturus trachyderma	1.06	4.71	2.05	2.18	4.61	5.63
Pomatomus saltatrix	0.91	0.72	2.55	2.07	0.49	0.038
Atlantoraja castelnaui	0.90	0.19	1.62	0.78	0.094	0.064
Scomber colias	0.86	0.97	0.68	1.17	1.15	0.064
Psammobatis bergi	0.83	0.12	0.47	0.52	0.13	0.13
Cottoperca trigloides	0.81	11.27	2.77	2.47	11.41	13.63
Psammobatis rudis	0.81	2.95	1.43	1.20	2.62	4.94
Thyrsitops lepidopoides	0.76	0.61	3.30	1.84	0.30	
Psammobatis extenta	0.69	2.22	0.65	0.66	2.32	2.51
Trachurus lathami	0.62	0.066	0.75	0.49	0.03	
Squalus lobularis	0.55	0.73	0.34	0.33	0.73	1.09
Diplodus argenteus	0.51	0.44	0.59	0.57	0.51	0.026
Atlantoraja cyclophora	0.51	0.23	0.47	1.08	0.12	0.13
Bathyraja brachyurops	0.49	1.83	0.19	0.73	1.85	2.34
Salilota australis	0.37	11.60	1.80	2.85	11.39	15.51
Sympterygia acuta	0.33	0.026	0.28	0.21	0.01	0.064
Polyprion americanus	0.23	0.75	1.00	0.71	0.76	0.27
Prionotus nudigula	0.23	0.61	0.22	0.59	0.52	0.91
Macruronus magellanicus	0.18	0.90	0.031	0.095	0.94	1.20
Austrolycus laticinctus	0.18	0.13	0.22	0.063	0.16	0.051
Notorynchus cepedianus	0.12	0.20	0.68	0.62	0.12	
Odontesthes platensis	0.12	0.006	0.062	0.11	0.003	
Micropogonias furnieri	0.088	0.055	0.22	0.095	0.043	0.038
Leptonotus blainvilleanus	0.070	0.71	0.81	3.34	0.27	0.026

Table III. Continuation.

Sprattus fueguensis	0.070	0.15	0.59	0.30	0.10	0.013
Dadyanos insignis	0.053	0.18	0.25	0.08	0.18	0.13
Mullus argentinae	0.053	0.12	0.093	0.11	0.11	0.13
Urophycis brasiliensis	0.035	1.60	2.21	7.57	0.55	0.13
Genidens barbus	0.035		0.062			
Brama brama	0.018	0.42		0.27	0.40	0.50
Iluocoetes fimbriatus	0.018	0.38		0.11	0.32	0.75
Sarda sarda	0.018	0.02		0.032	0.020	
Zenopsis conchifer	0.018	0.011	0.031	0.047	0.006	
Dules auriga	0.018	0.006		0.016	0.003	0.026
Selene setapinnis	0.018	0.002	0.031	0.016		
Zapteryx brevirostri	0.018			0.016		
Myxinidae		3.23	0.81	0.52	3.63	2.24
Notomyxine tridentiger		2.86	0.65	0.73	2.93	3.09
Dipturus argentinensis		0.294		0.016	0.26	0.58
Zoarcidae		0.122		0.047	0.12	0.14
Bassanago albescens		0.109	0.09	0.016	0.074	0.27
Prionace glauca		0.092	0.25	0.36	0.034	
Tetronarce puelcha		0.092			0.10	0.10
Notothenia angustata		0.032			0.040	0.013
Geotria australis		0.023		0.079	0.017	
Paranotothenia magellanica		0.021	0.031		0.023	0.013
Bovichtus argentinus		0.015			0.020	
Pagrus pagrus		0.013		0.016	0.014	
Allocytus verrucosus		0.009			0.011	
Trichiurus lepturus		0.009	0.031	0.016	0.006	
Bathyraja magellanica		0.004				0.026
Bathyraja multispinis		0.002				0.013
Merluccius australis		0.002			0.003	
Oncorhynchus mykiss		0.002			0.003	
Hexanchus griseus		0.002			0.003	
Lophius gastrophysus		0.002			0.003	
Mendosoma lineatum		0.002			0.003	
Scomberesox scombroides		0.002			0.003	

Fish assemblage analysis

The relative frequency matrix to analyze the association of fish species and areas was 754 individuals (sites or grid), 791 variables (species per year) and 12 groups (years). Species that were not recorded in one year were not included in the analysis since the MFA method does not allow to the variable the same values (zeros values): 51 species in 2003, 52 species in 2004; 61 species in 2005; 68 species in 2006, 70 species in 2007 and 2008; 72 species in 2009; 71 species in 2010, 69 in 2011; 68 species in 2012; 71 species in 2013; and 68 species in 2014. The matrix "site x species x year" was 596.414 grid, of which 88.5% resulted with zero values, i.e. the species was not recorded in that site and year.

The percentage of inertia explained by the first axis or factor was 4,85% and the second axis was 4% (Table IV). According to Escofier & Pagès (1992), these percentages must be considered respect to the size of the table. For example, a value of 10% is weak if the table has 10 variables and it is a strong value if the table has 100 variables. In this analysis, the table contains 791 variables, which would indicate the model is acceptable.

The first four factors were analyzed and their eigenvalues were higher than 1. They explained an important part of the total inertia. The first eigenvalue was not close to the number of years and it meant that the first factor was not common to the set of years. It only represented an important direction of inertia in some of the years. The RV coefficients (relation between groups) were between 0.04 and 0.21 and these values indicated differences among years since relations between them were low. The years 2012 to 2014 showed the lower RV coefficients with all years, except between them, and the highest RV coefficients were observed between 2006 and 2011 (Table V).

Years 2012, 2013 and 2014 presented a different grouping respect the years 2003 to 2011. Years 2012 to 2014 had a greatest contribution to dimension 2, and even to dimension 3 and 4. Years 2003 to 2010 presented the highest correlation with dimension 1, and the year 2011 with dimension 2 and 3 (Table VI). Year 2005 did not present a preponderant correlation with any of the factors and it was separated from the two groups of years described before (Fig. 2). During this year the shrimp abundance was low for the double-rigged otter trawler fleet and it operated mainly in the northern area of the San Jorge Gulf. During years 2003 to 2011, the double-rigged otter trawler fleet operated both in the San Jorge Gulf and the Closed Area of Juvenile Hake. From 2011 this fleet concentrated its fishing operation in the Closed Area of Juvenile Hake and the coastal fleet increased its participation in the fishery. The central area of the San Jorge Gulf is not represented in years 2012, 2013 and 2014.

The grouping of the sites is based on the set of variables (species) of all years considered in the present study. The distribution formed

Table IV. Eigenvalues, percentage of inertia explained (variance explained) and percentage of cumulative inertia (cumulative variance) of the first five factors of the global analysis of the MFA.

Factors	Eigenvalues	% inertia explained	% cumulative inertia
Factor 1	3.986	4.851	4.851
Factor 2	3.292	4.007	8.858
Factor 3	1.791	2.181	11.039
Factor 4	1.635	1.991	13.030
Factor 5	1.254	1.527	14.558

by factors 1 and 2 of the sites that contributed to the model in a percentage higher than 0.2% is showed in Figure 3. Three groups were defined with the k-means methodology: the coastal waters of the Chubut province and the northern areas of the San Jorge Gulf (Group 1); the bordering areas with the northern of the San Jorge Gulf and the central-eastern area of the San Jorge Gulf (Group 2); and the Closed Area of Juvenile Hake (Group 3). The areas included in Group 1 have a mean depth of 40.3 m ± 15.0 m; the sites of Group 2 are characterized by a depth of 56.5 m ± 12.7 m; and Group 3 reaches a depth of 96.6 m ± 9.0 m (some of the sites for this group were in coastal waters and were not considered in the analysis).

Species (variables) that characterized Group 1 and whose contribution to factors 1 and 2 was higher than 0.4% were: *C. callorynchus* (2010-2014); *N. bergi* (2006-2014); the yellowtail silverside *Odontesthes smitti* (2005-2014); *E. anchoita* (2005-2014); *S. porosa* (2009, 2011-2013); *P. brasiliensis* (2007, 2011, 2012); and *S. brasiliensis* (2012-2014). The species *P. signata* (2011, 2013) and the patagonian blennie *Eleginops maclovinus* (2013, 2014) characterized the area in two of the years included in the analysis (Fig. 4).

Group 2 was characterized by *M. hubbsi* (2003, 2004, 2005-2011), *P. ramsayi* (2003, 2004, 2006-2011), *Z. brevicaudata* (2003, 2004, 2006-2011), *G. blacodes* (2003, 2004, 2006-2011), *X. rasile* (2006-2010), *P. normani* (2003, 2004, 2006, 2007, 2010), *D. tschudii* (2003, 2004, 2006-2010), *S. bonapartii* (2004, 2006-2008), *S bivius* (2008-2010), *C. callorynchus* (2006-2009), *S. brasiliensis* (2004-2011) and the tadpole codling *Salilota australis* (2010, 2011). Group 3 was characterized by *S. acanthias (2014), S. bivius (2014), C. peruvianus (2014), M. hubbsi (2013), M. schmitti (2013), S. brasiliensis (2014), A. patachonicus (2013), X. rasile (2013,2014) and P. brasiliensis (2013, 2014)*. As this group was represented mainly by species in a year (2014) and sites were distanced from each other it was not considered (Fig. 4).

Figure 5 shows the distribution formed by factors 3 and 4 of the sites that contributed to the model in a percentage higher than 0.4%. Four groups were observed. Factors 3 and 4 separated the area formed in Group 1 by factors

Table V. **RV coefficients between groups (years) of the MFA.**

Groups	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2003	1.000	0.118	0.090	0.142	0.118	0.124	0.157	0.184	0.131	0.048	0.069	0.057
2004	0.118	1.000	0.085	0.116	0.185	0.129	0.132	0.095	0.071	0.066	0.041	0.069
2005	0.090	0.085	1.000	0.081	0.092	0.073	0.108	0.072	0.070	0.051	0.085	0.062
2006	0.142	0.116	0.081	1.000	0.191	0.162	0.203	0.136	0.145	0.097	0.080	0.069
2007	0.118	0.185	0.092	0.191	1.000	0.198	0.201	0.150	0.129	0.095	0.092	0.090
2008	0.124	0.129	0.073	0.162	0.198	1.000	0.174	0.156	0.132	0.081	0.096	0.088
2009	0.157	0.132	0.108	0.203	0.201	0.174	1.000	0.158	0.160	0.094	0.101	0.077
2010	0.184	0.095	0.072	0.136	0.150	0.156	0.158	1.000	0.194	0.093	0.069	0.084
2011	0.131	0.071	0.070	0.145	0.129	0.132	0.160	0.194	1.000	0.145	0.123	0.107
2012	0.048	0.066	0.051	0.097	0.095	0.081	0.094	0.093	0.145	1.000	0.115	0.129
2013	0.069	0.041	0.085	0.080	0.092	0.096	0.101	0.069	0.123	0.115	1.000	0.150
2014	0.057	0.069	0.062	0.069	0.090	0.088	0.077	0.084	0.107	0.129	0.150	1.000
MFA	0.415	0.396	0.353	0.465	0.487	0.461	0.491	0.453	0.474	0.396	0.401	0.399

1 and 2 and they distinguished the coastal zone of Chubut province (Group A) and the northern of the San Jorge Gulf, particularly the Quintano area (Group B). Other group was distinguished in the central-western of the San Jorge Gulf (Group C) and it was not presented in dimensions 1 and 2. In this group, the k-means methodology adds two sites of Bahía Camarones that are further away geographically than the central-western sites of San Jorge Gulf. A fourth group comprised the Closed Area of Juvenile Hake (Group D). This latter group presented a strong contribution to factors 3 and 4, unlike factors 1 and 2 respect to Group 4. Group A present a mean depth of 46.8 ± 11.4 m while the area corresponding to Group B is characterized by a mean depth of 37.0 m ± 20.7 m. The sites that integrated Group C has a mean depth of 68.0 m ± 11.0 m. Group D is characterized by a depth of 70.7 m ± 11.0 m, similar to depth of Group C.

Group A was characterized in dimensions 3 and 4 by a reef fish assemblage: *A. patachonicus* (2007, 2008-2014); *P. brasiliensis* (2004 to 2008, 2010-2014); *P. brasilianus* (2006-2013); and *P. semifasciata* (2010, 2012). Furthermore, this group was composed of *P. signata* (2011, 2012, 2014), *M. schmitti* (2012, 2014), *P. patagonicus* (2010, 2011) and the toadfish *T. argentina* (2007, 2012) (Fig. 6).

The species described in Group B were characterized in Group 1. These species were: *O. smitti* (2006-2014); *N. bergi* (2003, 2006); and *E. maclovinus* (2008, 2013, 2014). They had a higher contribution in dimensions 1 and 2; therefore, these species were better represented in Group 1. Sites of Group C were characterized by an assemblage composed of species in 2004: *C. callorynchus*; *E. maclovinus*; *N. bergi*; *C. peruvianus*; *G. blacodes*; the cusk-eel *Genypterus brasiliensis*; *M. hubbsi*; *P. ramsayi*; the red searobin *Prionotus nudigula*; *S. brasiliensis*; *S. bivius*; *P. normani*; and *Z. brevicaudata*. The species *S. bonapartii* was the only that was present in two years (2004, 2007). As this group was characterized by one year it was not considered. The central-western areas of the San Jorge Gulf are not well represented in all years (Fig. 6).

Group D was characterized by *P. normani* (2003, 2011-2014), *P. ramsayi* (2003, 2011-2014), *P. isosceles* (2011, 2012, 2014), *S. brasiliensis* (2012-2014), the banded cusk-eel *R. brasiliensis* (2011,

Table VI. Contribution of groups to the global factors of the MFA.

Groups	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
2003	10.054	5.179	2.866	6.816	5.889
2004	8.546	3.139	16.704	3.012	15.456
2005	5.337	4.941	4.197	3.237	3.309
2006	12.222	6.524	3.462	4.404	4.502
2007	13.067	7.559	3.364	5.381	6.918
2008	10.247	8.940	2.710	6.199	5.273
2009	11.835	10.453	3.990	4.254	4.922
2010	11.471	5.813	3.587	8.583	6.293
2011	8.706	10.638	17.806	8.559	11.628
2012	3.547	8.938	21.766	11.162	6.952
2013	2.120	16.588	4.195	19.259	8.573
2014	2.847	11.288	15.353	19.135	20.286

2012), *S. bonapartii* (2013, 2014) and a group of species that appeared in the period 2011 to 2014: *S. acanthias*; *S. bivius*; *D. tschudii*; *Z. brevicaudata*; *X. rasile*; *C. peruvianus*; *M. hubbsi*; *G. blacodes*; and the channel bull blenny *Cottoperca trigloides*. Many of these species characterized the central-eastern area of the San Jorge Gulf (Group 3) in dimensions 1 and 2 but during the years 2003 to 2010 (Fig. 6).

Groups 1 and B were considered as an area (Group 1B). Groups A and 1B corresponded to coastal assemblage areas; Group 2 corresponded to San Jorge Gulf assemblage areas; and Group D corresponded to a deep-water assemblage area of the Closed Area of Juvenile Hake. Table VII summarized the years in which the species characterized each assemblage.

DISCUSSION

The bycatch of fishes in the Patagonian shrimp *P. muelleri* fishery is composed of 101 species corresponding to 59 families: 69 species of bony fishes, 29 species of cartilaginous fishes and three species of jawless fishes. This work extends and updates the number of fish species recorded in the region respect to previous studies in this fishery (Pettovello 1999, Roux et al. 2007, Cedrola et al. 2004, Góngora et al. 2009, Góngora 2011, Bovcon et al. 2013). The double-rigged otter trawler fleet captures a higher number of fish species than the coastal fleet (99 and 80, respectively). The number of species recorded in the double-rigged otter trawler fleet is higher than that reported to date by Góngora (2011), who identified a total of 81 species in the catches of this fleet (54 bony fishes and 25 cartilaginous fishes). The difference in the number of species between the coastal fleet and the double-rigged otter trawler fleet is due to rare species observed infrequently in the hauls of the latter fleet.

The ichthyological fauna caught as bycatch in the shrimp fisheries is variable among regions. This difference is remarkable in the number of bony fishes and cartilaginous fishes. In northern of Australia and the Torres Strait 329 species of bony fishes and 25 species of cartilaginous fishes have been recorded in the bycatches of the shrimp fishery (Stobutzki et al. 2001); on the coast of Israel in the Mediterranean Sea 124 species of bony fishes and seven species of cartilaginous fishes were recorded (Dor Edelist et al. 2011); in the southern and southeast coast of Brazil 91 species of bony fishes were identified (Vianna & Almeida 2005); in Celestun Lagoon,

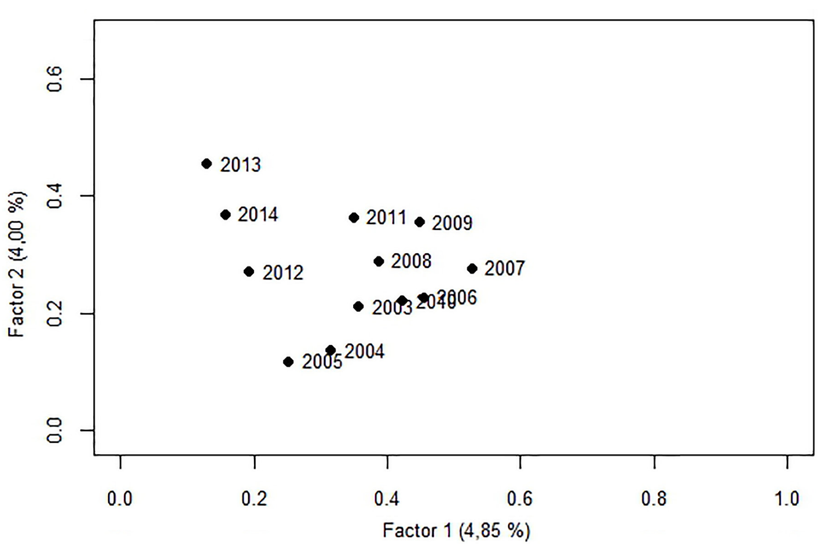

Figure 2. Representation of the groups (years) in the MFA.

Gulf of Mexico, 41 species of bony fishes were reported (Poot Salazar et al. 2009); and in the Sea of Marmara, in Turkey, 25 species of bony fishes and three species of cartilaginous fishes were recorded in the bycatches (Zengin & Akyol 2009). The Patagonian shrimp fishery described herein presents a considerable number of fish species caught as bycatch, in particular the cartilaginous fishes.

Of the three species of jawless fishes, the pouched lamprey *G. australis* and the hagfish *Notomixine tridentiger* are recorded only in the double-rigged otter trawler fleet. The species *G. australis* was not registered by Góngora et al. (2009) and it is incorporated herein. Eight species of cartilaginous fishes not reported previously in the bycatch of the double-rigged otter trawler frozen fleet were incorporated on the list of this bycatch fleet: *H. griseus*; the zipper sandskate *Psammobatis extenta*, the blotched sandskate *Psammobatis bergi*, the bignose fanskate *Sympterygia acuta*, the spotback skate *Atlantorraja castelnaui*, the multispine skate *Bathyraja multispinis*; the Magellan skate *Bathyraja magellanica*; and the argentinean skate *Dipturus argentinensis*. While *H. griseus*, the blue shark *Prionace glauca*, *B. multispinis*, *B. magellanica*, *D. argentinensis* and argentinean torpedo *Tetronarce puelcha* are not recorded in the iced-coastal fleet bycatch. These six species were also not recorded by Ruibal Núñez et al. (2016), who identified 23 species of cartilaginous fishes in the bycatch of the iced-coastal fleet.

Sixteen species of bony fishes not reported previously in the bycatch of both fleets are incorporated on the list of records: the Jenyns's

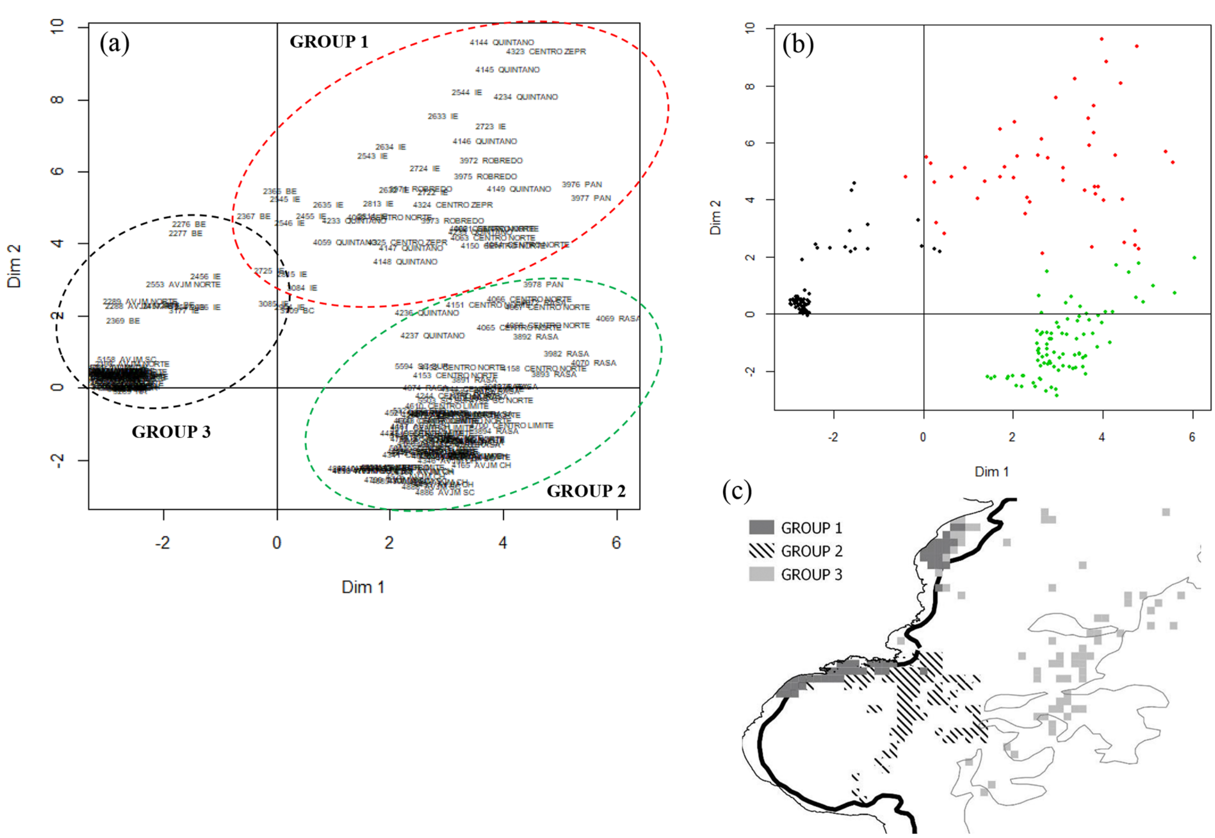

Figure 3. Global analysis that contribute to factors 1 and 2 of the AFM: (a) areas (sites), (b) k-means classification of the sites by groups, and (c) geographic location of the assemblages.

sprat *Ramnogaster arcuate*; the atlantic moonfish *Selene setapinnis*; the silvery john dory *Zenopsis conchifer*; the thornfish *Bovichtus argentinus*; the southern hake *Merluccius australis*; the white snake mackerel *Thyrsitops lepidopoides*; the silverside *Odontesthes platensis*; atlantic saury *Scomberesox scombroides;* telescope fish *Mendosoma lineatum;* black southern cod *Patagonotothen tessellata*; *Patagonotothen sima,* patagonian moray cod *Muraenolepis orangiensis;* the flounder *Achiropsetta* sp.; *O. darwini*, *Dules auriga* and the white sea catfish *Genidens barbus*. These species were not described by Góngora (2011) in the double-rigged otter trawler fleet neither recorded by Bovcon et al. (2013) in the bycatch of the high-seas ice trawler fleet.

Of all bony fish species mentioned in this work, sixteen of them are present only in the double-rigged otter trawler frozen fleet but in a low bycatch frequency: the warty dory *Allocyttus verrucosus*; the hairy conger *Bassanago albescens*; *B. argentinus*; *M. australis*; the maori chief *Notothenia angustata*; the Magellanic rockcod *Paranotothenia magellanica*; *M. lineatum*; *O. mykiss*; the red porgy *Pagrus pagrus*; *P. tessellata*; *M. orangiensis*; *S. scombroides*; *Achiropsetta* sp.; *S. setapinnis* and *Trichiurus lepturus*. Only *G. barbus* is recorded in the iced-coastal fleet. The fish species reported by Bovcon et al. (2013) in the high-seas ice trawler fleet are included in the present work.

Of the recorded species, 24 were not cited for these latitudes in Patagonia: *T. puelcha*; *A. castelnaui*; the eyespot skate *Atlantoraja cyclophora*; *P. bergi*; *P. extenta*; *S. acuta*; the argentinean conger *Conger orbignyanus*; the brazilian codling *Urophycis brasiliensis*; *P.*

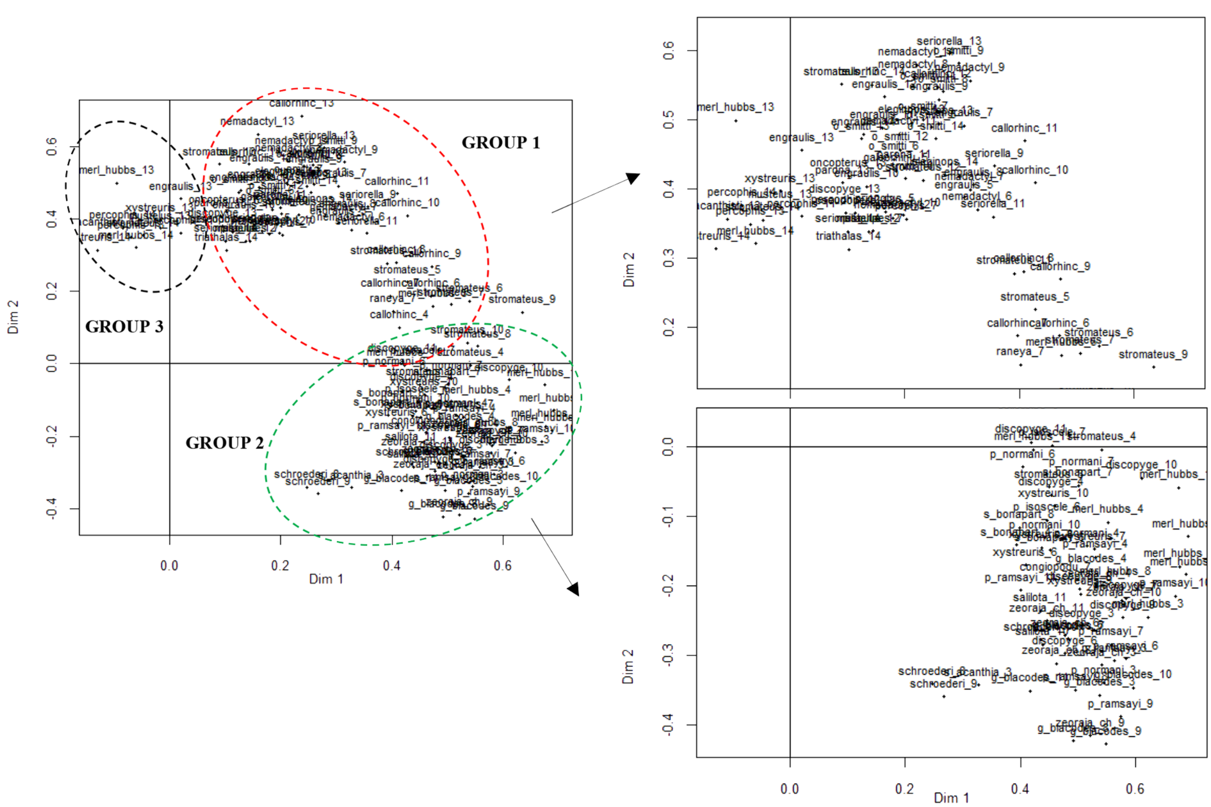

Figure 4. Representation of the variables (species) that contribute to factors 1 and 2 of the AFM. The graph has been magnified to visualize the species in the assemblages.

nudigula; *D. auriga*; the rough scad *Trachurus lathami*; the south american silver porgy *Diplodus argenteus*; *P. pagrus*; the stripped weakfish *Cynoscion guatucupa*; the whitemouth croaker *Micropogonias furnieri*; the argentinean goatfish *Mullus argentinae*; *T. lepturus*; the atlantic bonito *Sarda sarda*; the Patagonian flounder *Paralichthys patagonicus*; *S. setapinnis*; *L. gastrophysus*; *S. scombroides*; *M. lineatum*; and the remo flounder *Oncopterus darwini*. These records correspond to temperate-warm waters species whose range of distribution was extended southward (Bovcon et al. 2011, 2016, Góngora et al. 2009), with the exception of *M. lineatum*, which is a species that lives in cold temperate and sub-Antarctic waters of southern oceans (Bovcon et al. 2017). In the case of *L gastrophysus* it is a deep-water species that was first recorded in coastal waters (Cochia et al. 2016). The species *S. scombroides*, *M. lineatum*, *D. auriga* and *S. setapinnis* were recorded in a single year. The remaining species were recorded in two or more years and their presence in the bycatch are not random encounters but they are species that inhabit these waters.

The species with the highest frequencies in the bycatch were also reported in previous studies as constant species in the catches with values of frequencies higher than 50% (Góngora et al. 2009, Góngora 2011, Bovcon et al. 2013, Ruibal Núñez et al. 2016). Other group of species present frequencies between 25% and 50% but most of the species are observed with frequencies below than 25%.

In the present work 30 species of fishes associated with four assemblage areas are

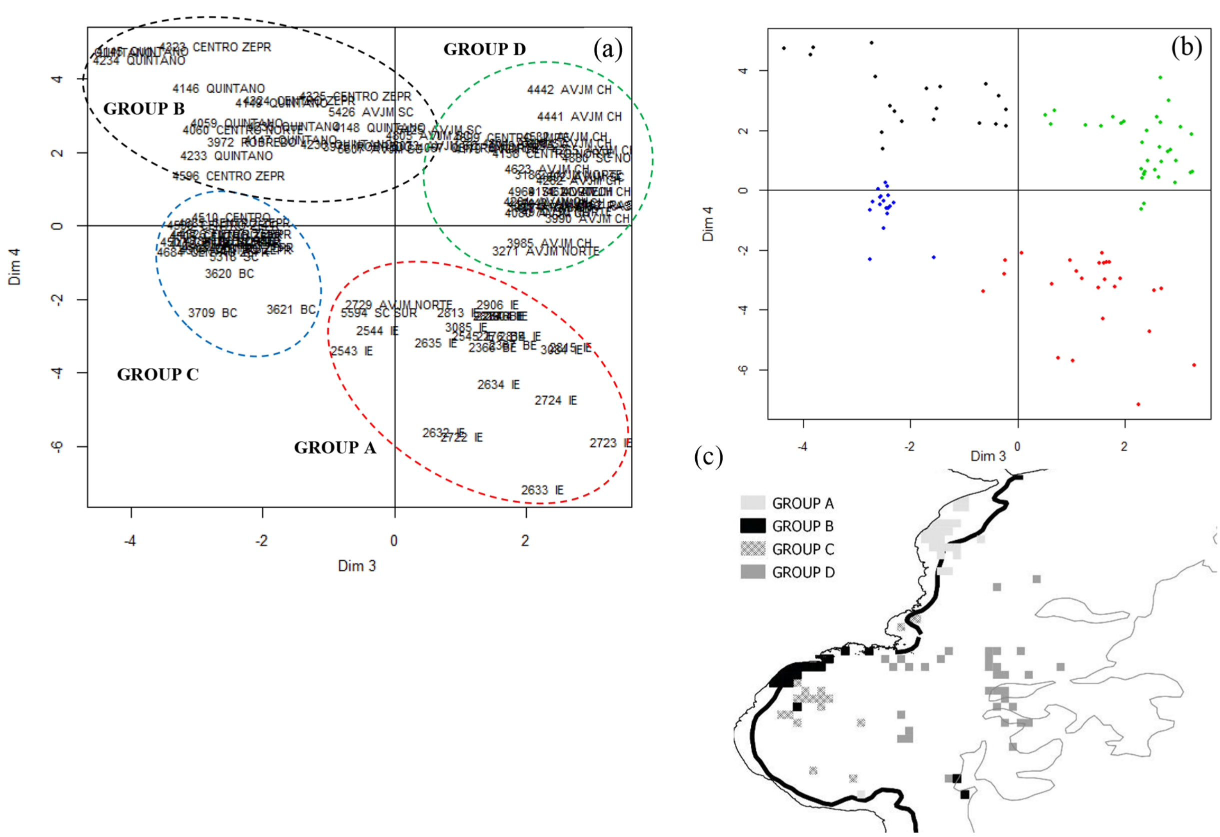

Figure 5. Global analysis that contribute to factors 3 and 4 of the AFM: (a) areas (sites), (b) k-means classification of the sites by groups, and (c) geographic location of the assemblages.

recorded. These areas have clear spatial patterns that differ in their extension and geographical location. In coastal waters of Chubut Province and the northern areas of the San Jorge Gulf two assemblages are located. In the bordering areas with the northern of San Jorge Gulf and in the central-eastern area of the San Jorge Gulf an assemblage is distinguished. In waters of national jurisdiction, a deeper-water assemblage is located whose extension includes the Closed Area of Juvenile Hake.

The northern of the San Jorge Gulf and the coastal areas of Chubut Province are characterized by a fish association determined by the presence of *C. callorynchus*, the silverside *O. smitti*, *N. bergi*, *E. anchoita*, *S. porosa*, *P. brasiliensis*, *S. brasiliensis*, *E. maclovinus*, *P. signata*. The northern of the San Jorge Gulf is an area with a high diversity and biological productivity, and for its environmental importance, a protected area of 750 km^2 was created in 2009 that extends from the coastline to one nautical mile. Though its priority has been the protection of birds and marine mammals, it is also a breeding area for fish and crustacean species (Yorio 2009).

In the coastal waters of Chubut Province, a second assemblage is distinguished and characterized by a group of species corresponding to rocky reef fishes (*A. patachonicus*, *P. brasiliensis*, *P. brasilianus*, *P. signata*, *P. semifasciata*, *M. schmitti*, *P. patagonicus* and *T. argentina*). This grouping was cited for the northern Patagonian gulfs Nuevo and San José, and for the San Jorge Gulf (Galvan et al. 2009). The description of this assemblage shows a continuity of these species between the gulfs and the coastal areas of Chubut.

The central-eastern areas of the San Jorge Gulf are mostly characterized by deep-water species between the years 2003 and 2011. The most consistent and well-represented species in these areas are *C. callorynchus*, *S. brasiliensis, M.*

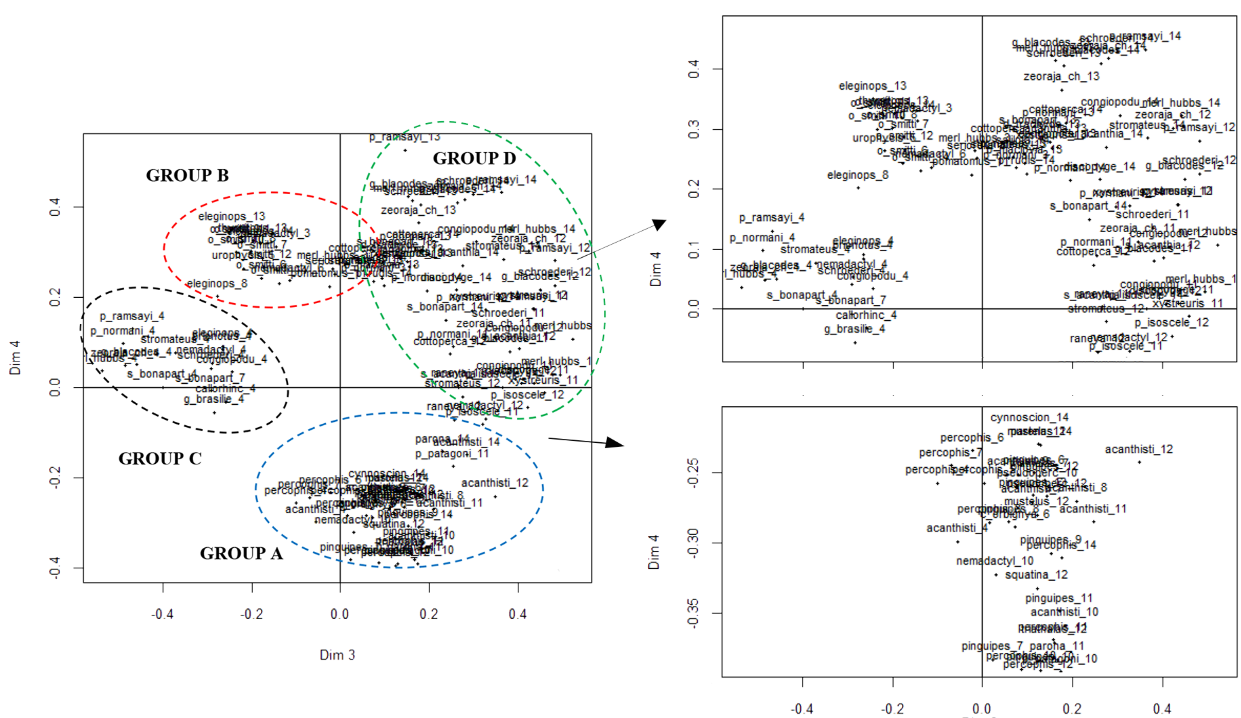

Figure 6. Representation of the variables (species) that contribute to factors 3 and 4 of the AFM. The graph has been magnified to visualize the species in the assemblages.

hubbsi, *P. ramsayi*, *Z. brevicaudata*, *G. blacodes*, *X. rasile*, *P. normani*, *D. tschudii*, *S. bonapartii*, *S. bivius* and *S. australis*. The assemblage in the Closed Area of Juvenile Hake is mainly characterized by an association of species between 2011 and 2014. It is composed mostly by the same deep-water species present in the central-eastern areas of the San Jorge Gulf: *P. ramsayi*, *M. hubbsi*, *Z. brevicaudata*, *G. blacodes*, *S. brasiliensis*, *X. rasile*, *P. normani*, *D. tschudii*, the smallnose fanskate *S. bonapartii* and *S. bivius*; whereas, *P. isosceles*, *C. peruvianus*, *S. acanthias*, the channel bull blenny *C. trigloides* and *R. brasiliensis* are exclusive species of the latter assemblage and they are not reported in association with other areas.

The assemblage in the northern of the San Jorge Gulf was also identified by Góngora (2011) and characterized by coastal species such as *N. bergi*, *E. anchoita*, *O. smitti*, *E. maclovinus*, *C. callorynchus* and *M. schmitti*. Góngora (2011) characterized an assemblage in the southern areas of the San Jorge Gulf that were not grouped in this analysis; however, some of the species cited for that area are those that were grouped in the assemblage of the central-eastern area of the San Jorge Gulf (*G. blacodes*, *P. ramsayi*, *S. bonapartii*, *S. bivius* and *D. tschudii*). Moreover, Bovcon et al. (2013) observed between 2003 and 2012 a grouping in the northern and central area of the gulf with information of bycatches from the high-seas ice trawler fleet. In the coastal region of Chubut Province, Ruibal Núñez et al. (2016) analyzed between 2005 and 2014 the associations of cartilaginous fishes based on the characterization of the bycatch in the coastal fleet that operates in that area. They identified associations of coastal waters species, such as *C. callorynchus*, *M. schmitti* and *S. bonapartii*, and associations of deep-water species, such as *S. bivius*, *S. acanthias*, *Z. brevicaudata* and *P. normani*. These associations reported for the coastal waters of Chubut and the Closed Area of Juvenile Hake are coincident with the assemblages observed herein.

The main pattern of distribution and ecology of marine fishes in the Southwest Atlantic Ocean is related with two zoogeographic provinces: the Magellanic Province with a Patagonian District in the Atlantic; and the Argentinean Province with a northern region (the South Brazilian District) and a southern region (the Bonaerensean District) (Balech 1964, Menni 1983, Balech & Ehrlich 2008). The definition of the provinces is mainly associated to the low temperatures of the waters in the Magellanic Province (sub-Antarctic origin), and to the highest temperatures of the Argentinean Province (subtropical origin) (Menni & Stehmann 2000). The Argentinean Province extends on the submarine shelf between a fluctuating northern limit between 30°S and 32°S (Rio Grande do Sul) and a southern limit that is located in the northern of Patagonia, in a wide range which extends between 42°S and 44°S. The Magellanic Province includes the Patagonian shelf from Cabo de Hornos to 43°S, and it follows northward along the edge of the continental shelf (Balech & Ehrlich 2008). The assemblages described in this work are located in a transition zone (ecotone) between both provinces (43°-46°S) and they are composed by associations of both warm-temperate waters species of the Argentinean Province and temperate-cold waters species of the Magellanic Province that often reach northern latitudes, as previously proposed by Bovcon (2016). Among the species that are associated with warm-temperate waters are *N. bergi*, *A. patachonicus*, *P. brasiliensis*, *P. signata*, *P. semifasciata*, *E. anchoita*, *S. bonapartii* and *M. schmitti*. Among the species that are associated with temperate-cold waters are *S. australis*, *E. maclovinus*, *P. ramsayi*, *Z. brevicaudata*, *S. bivius* and *C. callorynchus*.

Table VII. Assemblage areas formed from factors 1, 2, 3 and 4 of the MFA. Years that species characterized each assemblage are indicated. The species present in a single year.

Assemblage areas	Species	Years
Group 1B (factors 1 and 2; factors 3 and 4). Assemblage located in coastal waters of Chubut Province and the northern areas of the San Jorge Gulf. Mean depth between 37.0 m and 40.3 m.	*Callorhinchus callorynchus* *Odontesthes smitti* *Nemadactylus bergi* *Engraulis anchoíta* *Seriorella porosa* *Percophis brasiliensis* *Stromateus brasiliensis* *Eleginops maclovinus* *Xystreuris rasile* *Parona signata* *Mustelus schmitti* *Merluccius hubbsi*	2010 to 2014 2006 to 2014 2003, 2006 to 2014 2005 to 2014 2009, 2011 to 2013 2007, 2011 to 2014 2012 to 2014 2008, 2013, 2014 2013, 2014 2011, 2013 2012, 2013 2013, 2014
Group A (factors 3 and 4). Assemblage located in coastal waters of Chubut Province. Mean depth of 46.8 m.	Acanthistius patachonicus Percophis brasiliensis Pinguipes brasilianus Pseudopercis semifasciata Parona signata Mustelus schmitti *Paralichthys patagonicus* *Triathalassothia argentina*	2007, 2008 to 2014 2004 to 2008, 2010 to 2014 2006 to 2013 2010, 2012 2011, 2012, 2014 2012, 2014 2010, 2011 2007, 2012
Group 2 (factors 1 and 2). Assemblage located in the bordering areas with the northern of San Jorge Gulf. Mean depth of 55.6 m.	*Callorhinchus callorynchus* *Stromateus brasiliensis* *Merluccius hubbsi*	2006 to 2009 2004 to 2011 2005, 2011
Group 3 (factors 1 and 2). Assemblage located in the central-eastern area of the San Jorge Gulf. Mean depth of 57.0 m.	*Merluccius hubbsi* *Patagonotothen ramsayi* *Zearaja chilensis* *Genypterus blacodes* *Xystreuris rasile* *Psammobatis normani* *Discopyge tschudii* *Sympterygia bonapartii* *Schroederichthys bivius* *Salilota australis*	2003, 2004, 2006 to 2010 2003, 2004, 2006 to 2011 2003, 2004, 2006 to 2011 2003, 2004, 2006 to 2011 2006 to 2010 2003, 2004, 2006, 2007, 2010 2003, 2004, 2006 to 2010 2004, 2006 to 2008 2008 to 2010 2010, 2011
Group E (factors 3 and 4). Deep water assemblage located in the Closed Area of Juvenile Hake. Mean depth of 70.7 m.	*Psammobatis normani* *Patagonotothen ramsayi* *Paralichthys isosceles* *Merluccius hubbsi* *Zearaja chilensis* *Genypterus blacodes* *Schroederichthys bivius* *Congiopodus peruvianus* *Stromateus brasiliensis* *Sympterygia bonapartii* *Squalus acanthias* *Discopyge tschudii* *Xystreuris rasile* *Cottoperca trigloides* *Raneya brasiliensis*	2003, 2011 to 2014 2003, 2011 to 2014 2011, 2012 and 2014 2011 to 2014 2011 to 2014 2011 to 2014 2011 to 2014 2011 to 2014 2012 to 2014 2013, 2014 2011 to 2014 2011 to 2014 2011 to 2014 2011 to 2014 2011, 2012

Further studies are required regarding to the influence of oceanographic variables on the fish species that characterize the assemblage areas. Most studies of demersal fish assemblages on continental shelves have indicated that the main faunal changes occur along the temperature-depth gradient (Menni & Gosztonyi 1982, Menni & López 1984, Mahon & Smith 1989, Magnussen 2002) and a few others along salinity-depth gradients (Pierce & Mahmoudi 2001). Alemany et al. (2013) mention that the main differences in the fish assemblages of the Argentinean Continental Shelf are related to oceanographic characteristics, particularly with temperature and salinity.

The use of the Multiple Factorial Analysis as an exploring method enabled to order the areas according to the species present in each of the years, without considering a unique exploratory analysis that involves all the years. The analysis describes and characterizes the fish species associations that are caught as bycatch in the double-rigged otter trawler frozen fleet and the iced-coastal fleet. The same species assemblages were identified in both fleets in the coastal areas of the Chubut province (where the iced-coastal fleet operates exclusively) and in the north of the San Jorge Gulf (where the double-rigged otter trawler frozen fleet operates exclusively). The proposed analyzes should be complemented with abundance data of the species by fleet since the bycatch rates are different in each fleet. The quantification of the bycatch is a valuable data to assess the real impact of the bycatch since among the species mentioned some of them have conservation issues, such as, the group of cartilaginous fishes (Dulvy et al. 2014) and the rocky reef fishes (Venerus et al. 2014), and others are rare species that could be affected by bycatches in this type of fisheries (Stobutski et al. 2001).

Acknowledgments

This study was made possible thanks to the On-board Observer Program coordinated by the Chubut province Fisheries Secretariat. We acknowledge the invaluable work of on-board observers who gathered the information analyzed in this paper. We special thanks to Dra. Noela Sánchez for her collaboration with the bathymetry data.

REFERENCES

ALEMANY D, IRIBARNE O & ACHA EM. 2013. Effects of a Large-Scale and Offshore Marine Protected Area on the Demersal Fish Assemblage in the Southwest Atlantic. ICES J Mar Sci 70: 123-34.

BALECH E. 1964. Caracteres Biogeográficos de la Argentina y Uruguay. Bol Inst Biol Mar 7: 107-112.

BALECH E & EHRLICH MD. 2008. Esquema biogeográfico del Mar Argentino. Rev Inv y Des Pesq 19: 45-75. Instituto de Investigación y Desarrollo Pesquero (INIDEP), Mar del Plata.

BOSCHI EE. 1997. Las pesquerías de crustáceos decápodos en el litoral de la República Argentina. Inv Mar 25: 19-40.

BOVCON ND. 2016. Evaluación de las pesquerías recreativas costeras de la provincia del Chubut, Argentina: base para su ordenamiento y manejo. [PhD Thesis]. Bariloche: Universidad Nacional del Comahue; 2016. Available from: http://opac.uncoma.edu.ar/cgi-bin/koha/opac-detail.pl?biblionumber=53590.

BOVCON ND, COCHIA PD, GÓNGORA ME & GOSZTONYI AE. 2011. Records of warm-temperate water fishes in central Patagonian coastal waters (Southwestern South Atlantic Ocean). J Appl Ichthyol 27: 832-839.

BOVCON ND, GÓNGORA ME, MARINAO C & GONZÁLEZ-ZEVALLOS D. 2013. Composición de las capturas y descartes generados en la pesca de merluza común *Merluccius hubbsi* y langostino patagónico *Pleoticus muelleri*: un caso de estudio en la flota fresquera de altura el Golfo San Jorge, Chubut, Argentina. Rev Biol Mar y Oc 48: 303-319.

BOVCON ND, COCHIA PD, RUIBAL NÚÑEZ J, ROMERO JJ, VUCICA M & GÓNGORA ME. 2016. Records of Atlantic saury *Scomberesox scombroides* (Richardson 1843) in the Argentinian Sea and its southernmost occurrence in waters off coast of Patagonia in the Southwest Atlantic. J Appl Ichthyol 32: 1239-1242

BOVCON ND, COCHIA PD, RUIBAL NÚÑEZ J, VUCICA M & FIGUEROA D. 2017. Presence of the telescope fish *Mendosoma* *lineatum* in Patagonian waters, a new species in the ichthyological fauna from the south-west Atlantic Ocean. J Fish Biology 9: 1224-1227. doi:10.1111/jfb.13397.

CEDROLA PV, GONZÁLEZ AM & PETTOVELLO AD. 2004. Bycatch or skates (Elasmobranchii: Arhynchobatidae, Rajidae) in the Patagonian red shrimp fishery. Fish Res 71: 141-150.

COCHIA PD, BOVCON ND, RUIBAL NÚÑEZ J, VILLAGRAN L & JEREZ L. 2016. Occurrence of the blackfin goosefish, *Lophius gastrophysus* (Miranda Ribeiro, 1915), in coastal waters of San Jorge Gulf, Patagonia, Argentina. J Appl Ichthyol 32: 1-3.

DE LA GARZA J & MORIONDO DANOVARO PI. 2019. Resumen de la pesquería de langostino (*Pleoticus muelleri*). Temporada 2018. Informe Técnico Interno 10/19. Inst Nac de Inv y Des Pesq (INIDEP), Mar del Plata.

DOR EDELIST OS, DANIEL G, GIL R & SPANIER E. 2011. Spatiotemporal Patterns of Catch and Discards of the Israeli Mediterranean Trawl Fishery in the Early 1990s: Ecological and Conservation Perspectives. Sci Mar 75: 641-652.

DULVY NK ET AL. 2014. Extinction risk and conservation of the world's sharks and rays. eLife 3: 00590. doi: 10.7554/eLife.00590.

ESCOFIER B & PAGÈS J. 1992. Análisis factoriales simples y múltiples. Objetivos, métodos e interpretación. Traducción de: Abascal Fdez. E, Fdez. Aguirre K, Landaluce Calvo MI, Piris Laespada JM, Zárraga Castro A. Universidad del País Vasco.

FAO. 2003. La ordenación pesquera. 2. El Enfoque de ecosistema en la pesca. FAO Orientaciones Técnicas para la Pesca Responsable 4(Suppl. 2), FAO, Roma.

FISCHBACH C, DE LA GARZA J & BERTUCHE D. 2006. La pesquería del langostino patagónico en el período 1991-2005. Informe Técnico Interno 03/06. Inst Nac de Inv y Des Pesq (INIDEP), Mar del Plata.

FISCHBACH C & BERTUCHE D. 2017. Pesquería de langostino Pleoticus muelleri. Temporada 2016. Estadística pesquera a fines de noviembre. Informe Técnico INIDEP 7/17, Mar del Plata, 23 p.

GALVÁN DE, VENERUS LA & IRIGOYEN AJ. 2009. The reef-fish fauna of the Northern Patagonian gulfs of Argentina, Southwestern Atlantic. Open Fish Sci J 2: 90-98.

GAUCH HG. 1989. Multivariate analysis in community ecology. Cambridge University Press.

GILLETT R. 2008. Global study of shrimp fisheries. FAO Fisheries Technical Paper 475. FAO, Roma.

GÓNGORA ME. 2011. Dinámica y manejo de la captura incidental de peces en la pesquería del langostino patagónico *(Pleoticus muelleri)*. Ph.D. Thesis. Universidad Nacional del Comahue, Río Negro, Argentina. Available from: http://opac.uncoma.edu.ar/cgi-bin/koha/opac-detail.pl?biblionumber=36800.

GÓNGORA ME, BOVCON N & COCHIA P. 2009. Ictiofauna capturada incidentalmente en la pesquería de langostino patagónico *Pleoticus muelleri* Bate, 1888 (Solenoceridae). Rev Biol Mar y Oc 44: 583-593.

GÓNGORA ME, GONZÁLEZ-ZEVALLOS D, PETTOVELLO A & MENDÍA L. 2012. Caracterización de las principales pesquerías del golfo San Jorge Patagonia, Argentina. Lat Am J Aquat Res 40: 1-11.

HALL M, GILMAN E, MINAMI H, MITUHASI T & CARRUTHERS E. 2017. Mitigating bycatch in tuna fisheries. Rev Fish Biol Fisher 27: 881-908.

HARTIGAN JA & WONG MA. 1979. Algorithm AS 136: A k-means clustering algorithm. J R Stat Soc C-Appl 28(1): 100-108.

HASTING A, GAINES SD & COSTELLO C. 2017. Marine reserves solve an important bycatch problem in fisheries. PNAS 111 (34): 8297-8934.

KELLEHER K. 2008. Descartes en la pesca de captura marina mundial. FAO Documento Técnico de Pesca 470. FAO, Roma.

LÊ S, JOSSE J & HUSSON F. 2008. FactoMineR: An R package for multivariate analysis. J Stat Softw 25: 1-18.

LEGENDRE P & LEGENDRE L. 1998. Numerical Ecology. Second English Edition. Elsevier.

MAHON R & SMITH RW. 1989. Demersal fish assemblages on the Scotian Shelf, Northwest Atlantic: spatial distribution and persistence. Can J Fish Aquat Sci 46: 134-152.

MAGNUSSEN E. 2002. Demersal fish assemblages of Faroe Bank: species composition, distribution, biomass spectrum and diversity. Mar Ecol Prog Ser 238: 211-225.

MENNI RC. 1983. Los peces en el medio marino. Sigma, Buenos Aires, Argentina.

MENNI RC & GOSZTONYI AE. 1982. Benthic and semidemersal fish associations in the Argentine Sea. Stud Neotrop Fauna E 17: 1-29.

MENNI RC & LÓPEZ HL. 1984. Distributional patterns of Argentine Marine Fishes. Physis, Secc. A 42: 71-85.

MENNI RC & STEHMANN FW. 2000. Distribution, environment and biology of batoid fishes off Argentina, Uruguay and Brazil. A review. Rev Mus Arg Cs Nat 2: 69-109.

OKSANEN AJ ET AL. 2017. Vegan: Community Ecology Package. R package vegan. Versión 2.4-4. Available at: https://cran.r-project.org/web/packages/vegan/index.html.

PELLETIER D & FERRARIS J. 2000. A multivariate approach for defining fishing tactics from commercial catch and effort data. Can J Fish Aquat Sci 57: 51-65.

PETTOVELLO AD. 1999. Bycatch in the Patagonian red shrimp (*Pleoticus muelleri*) fishery. Mar Freshwater Res 50: 123-127.

PIERCE DJ & MAHMOUDI B. 2001. Nearshore fish assemblages along the central west coast of Florida. Bull Mar Sci 68: 243-270.

POOT-SALAZAR A, PÉREZ-CASTAÑEDA R, VEGA-CENDEJAS ME & DEFEO O. 2009. Assessing Patterns of Ichthyofauna Discarded by an Artisanal Shrimp Fishery through Selectivity Experiments in a Coastal Lagoon. Fish Res 97: 155-162.

R DEVELOPMENT CORE TEAM. 2017. *R:* A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at: http://www.R-project.org/.

ROUX A, PIÑERO R & DE LA GARZA J. 2007. Guía para la identificación de la fauna asociada a la pesquería de langostino patagónico. Publicaciones Especiales INIDEP, Mar del Plata, Argentina.

RUIBAL NÚÑEZ J, BOVCON ND, COCHIA PD & GÓNGORA ME. 2016. Bycatch of chondrichthyans in a coastal trawl fishery on Chubut Province coast and adjacent waters, Argentina. J Mar Biol Assoc UK, doi:10.1017/S0025315416001508.

SOLERVICENS J. 1973. Coleópteros del bosque de Quintero. Anales Mus Hist Nat Valp 6: 115-159.

STOBUTZKI IC, JONES P & MILLER M. 2003. A comparison of fish bycatch communities between areas open and closed to prawn trawling in an Australian tropical fishery. ICES J Mar Sci 60: 951-966.

STOBUTZKI I, MILLER M & BREWER D. 2001. Sustainability of Fishery Bycatch: A Process for Assessing Highly Diverse and Numerous Bycatch. Environ Conserv 28: 167-181.

VENERUS LA, IRIGOYEN AJ, GALVÁN DE & PARMA AP. 2014. Spatial dynamics of the Argentine sandperch, *Pseudopercis semifasciata* (Pinguipedidae), in temperate rocky reefs from northern Patagonia, Argentina. Mar Freswater Res 65: 39-49.

VIANNA M & ALMEIDA T. 2005. Bony Fish Bycatch in the Southern Brazil Pink Shrimp (*Farfantepenaeus brasiliensis* and *F. paulensis*) Fishery. Braz Arch Biol Techn 48: 611-23.

YORIO P. 2009. Marine Protected Areas, Spatial Scales, and Governance: Implications for the Conservation of Breeding Seabirds. Conserv Lett 2: 171-178.

ZENGIN M & AKYOL O. 2009. Description of by-Catch Species from the Coastal Shrimp Beam Trawl Fishery in Turkey. J Appl Ichthyol 25: 211-211.

How to cite

GÓNGORA ME, NÚÑEZ JR, COCHIA PD & BOVCON ND. 2023. Species composition and assemblage analysis of fishes caught as bycatch by the Patagonian shrimp fishery in the southwest Atlantic. An Acad Bras Cienc 95: e20200735. DOI 10.1590/0001-3765202320200735.

MARÍA EVA GÓNGORA[1]
https://orcid.org/0000-0001-7234-5217

JULIAN RUIBAL NÚÑEZ[1,2]
https://orcid.org/0000-0003-4015-6467

PABLO DANIEL COCHIA[1]
https://orcid.org/0000-0003-4220-2164

NELSON DARÍO BOVCON[1,3]
https://orcid.org/000-0002-3786-406X

[1]Universidad Nacional de la Patagonia San Juan Bosco, Instituto de Investigación de Hidrobiología, Facultad de Ciencias Naturales y Ciencias de la Salud, Gales 48, Trelew 9100, Chubut, Argentina

[2]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Godoy Cruz 2290, Ciudad Autónoma de Buenos Aires, C1425FQB, Argentina

[3]Centro de Investigación y Transferencia Golfo San Jorge, Ruta 1 Km 4, Comodoro Rivadavia 9005, Chubut, Argentina

Correspondence to: **Nelson Darío Bovcon**
E-mail: nelsonbovcon@hotmail.com

Author contributions

All authors contributed in the building process of the manuscript and made different contributions. General ideas and aims of the work (M.E.G, J.R.N., N.D.B and P.D.C). Data analysis (M.E.G. and J.R.N.).