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Short Communication

By-catch composition of the Patagonian scallop fishery: the fishes

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ABSTRACT. An inventory of 24 fish species incidentally caught by the Patagonian scallop fleet in the SW Atlantic Ocean is provided for the first time. The most frequent species were *Psammobatis* spp. (81.4%), *Bathyraja brachyurops* (75.1%), *B. macloviana* (73.5%), *Patagonotothen ramsayi* (66.1%), *Merluccius hubbsi* (53.7%) and *B. albomaculata* (50.3%). Many of the recorded chondrichthyes are considered vulnerable or endangered species. The number of taxa (fishes + invertebrates) that conforms the by-catch of the fishery was increased and updated to nearly 200 species.

Keywords: *Bathyraja*, by-catch, scallop fishery, discards, *Patagonotothen ramsayi*, southwestern Atlantic Ocean.

Composición de la captura incidental en la pesquería de vieira patagónica: los peces

RESUMEN. Este estudio presenta por primera vez un inventario con 24 especies de peces registradas en la captura incidental de la pesca de la vieira patagónica en el Océano Atlántico sudoccidental por la flota pesquera comercial. Las especies más frecuentes fueron *Psammobatis* spp. (81,4%), *Bathyraja brachyurops* (75,1%), *B. macloviana* (73,5%), *Patagonotothen ramsayi* (66,1%), *Merluccius hubbsi* (53,7%) y *B. albomaculata* (50,3%). Muchos de los condrictios registrados se encuentran actualmente considerados como especies vulnerables o en peligro. El número de taxa (peces + invertebrados) que conforman la captura incidental de esta pesquería se incrementó y actualizó con estos resultados a aproximadamente 200 especies.

Palabras clave: *Bathyraja*, captura incidental, pesquería de vieira, descarte, *Patagonotothen ramsayi*, Atlántico sudoccidental.

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Studies in scallop fisheries by-catch worldwide are mainly focused on invertebrate species identification, predator-prey interactions, epibiotic relationships, damage level related with the action of gears on the bottom and survival or recovery of different taxa. However, the information about by-catch of fishes in these fisheries is scarce or mainly included in technical reports (*e.g.* Schwartz & Porter, 1977; Fuller *et al*., 1998; Harrington *et al*., 2005).

The Patagonian scallop *Zygochlamys patagonica* (King, 1832) fishery in Argentina started in 1996, after the discovery of potentially important commercial beds along the shelf break frontal area in the Argentine Sea (Lasta & Bremec, 1998). The main fishing grounds of this species are located along the 100 m isobath, between 36º43'S and 48º30'S (B.O. 21/07/06 PESCA, Res. 9/2006, Consejo Federal Pesquero). The commercial fleet is equipped with non-selective bottom otter trawls with booms. Since the beginning of the fishery, the identification of invertebrate by-catch and the monitoring of the benthic community associated with the Patagonian scallop fishing grounds were done (*e.g.*, Bremec & Lasta, 2002; Schejter & Bremec, 2007; Schejter *et al*.,

2008). The source of data for the majority of these studies were the annual research surveys, developed onboard the Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP) research vessels. Additionally, trends of biomass of the main invertebrate groups were also estimated using the information from commercial fleet tows provided by the INIDEP Observers Program (Escolar *et al*., 2009). Some information about fishes caught during fishing activities has been reported by observers in the internal technical report presented at the end of each fishing cruise. In these reports all fishes caught during operations of the Patagonian scallop commercial fleet were released to sea almost immediately after the trawl retrieval (Morsan *et al*., 2011). In general, fishes were reported as negligible in the by-catch of the *Z. patagonica* fishery, as the relative biomass in areas of dense aggregations of scallops is low (Fig. 1). However, studies referring to the state of the art regarding the different fish species caught in this scallop fishery are lacking. In this contribution we present the fish species inventory and the frequency of occurrence of fish species incidentally caught by the Patagonian scallop fishery.

During 2010, the research surveys of the Patagonian *scallop* were conducted onboard scallopers: FV "Atlantic Surf I" (July 26-30, between 39º48'-37º19'S and 56º17'-54º53'W, in a depth range of 71-141 m) and FV "Miss Tide" (March 23-31, between 42º55'S-45º00'S and 59º07'-60º20'W, in a depth range of 95-138 m). The former survey fished with an otter bottom trawl with booms, with an horizontal opening of 22 m and mesh size of 120 mm, while the latter used a 22 m horizontal opening net and 140 mm mesh size, with 100 mm internal mesh size. Sampling design obeyed to *Z. patagonica* biomass evaluation purposes. On each sampling site, trawling activity was conducted for 10 min at an average speed of 4 knots. This is the standard procedure not only for monitoring cruises, but also during routine fishing of the scallopers (*e.g.*, Ciocco *et al*., 2006). Once the capture was on the deck and the invertebrate subsamples for ecological studies were taken, we computed the presence of the different fish species (Chondrichtyes and Osteichthyes) retained in 123 sites in the northern area and in 54 sites in the southern area (Fig. 2). Identification of Chondrichtyes species was done using keys and characters mentioned in Cousseau *et al*. (2007) and San Martín (2010). Osteichthyes species in the catch were identified after Cosseau *et al*. (2007). Flatfishes' identification was done following Rico & Lagos (2009). We estimated presence (%) in the total sampling area and species richness. Pearson correlations were computed to study the relationship of species richness with depth. Kruskal-Wallis test, combined with a Dunn's methods, was applied to compare species richness among degrees of latitude (Sokal & Rohlf, 1995).

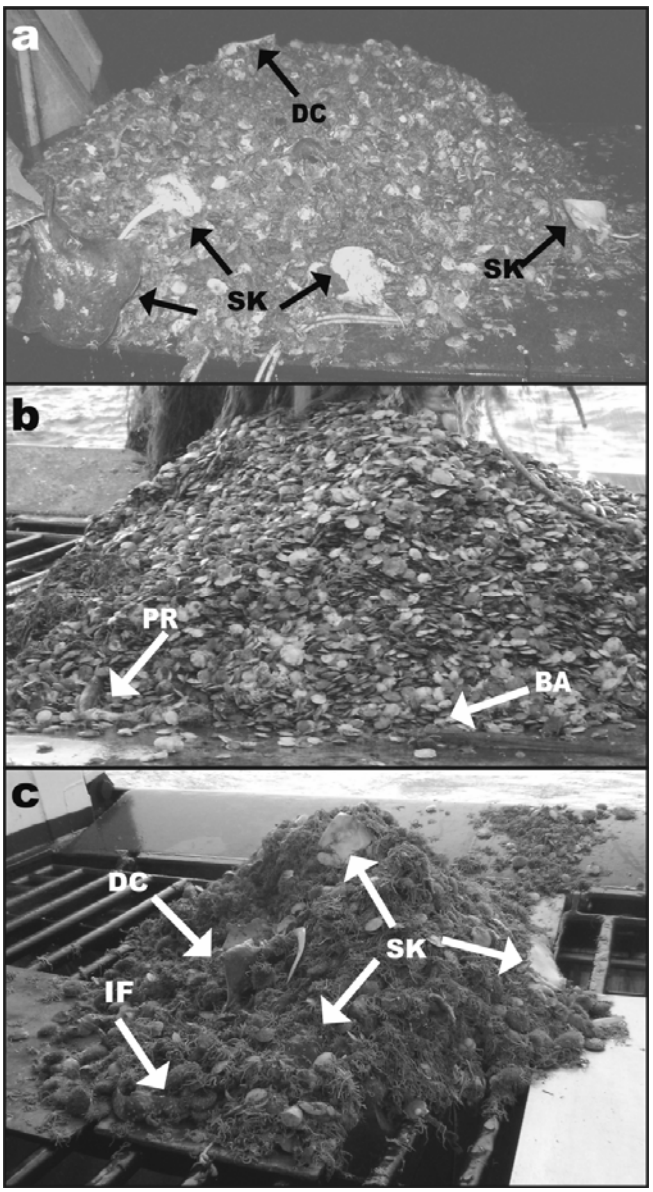

Figure 1. Captures in *Zygochlamys patagonica* fishery. a,b) Fishing grounds with dense aggregations of scallops, c) border area. DC: *Dipturus chilensis*, SK: skates, BA: *Bassanago albescens*, PR: *Patagonotothen ramsayi*, IF: *Iluocoetes fimbriatus*.

Figura 1. Capturas en la pesquería de vieira patagónica. a,b) áreas de bancos de pesca con altas densidades de vieira, c) área de borde de banco. DC: *Dipturus chilensis*, SK: rayas, BA: *Bassanago albescens*, PR: *Patagonotothen ramsayi*, IF: *Iluocoetes fimbriatus*.

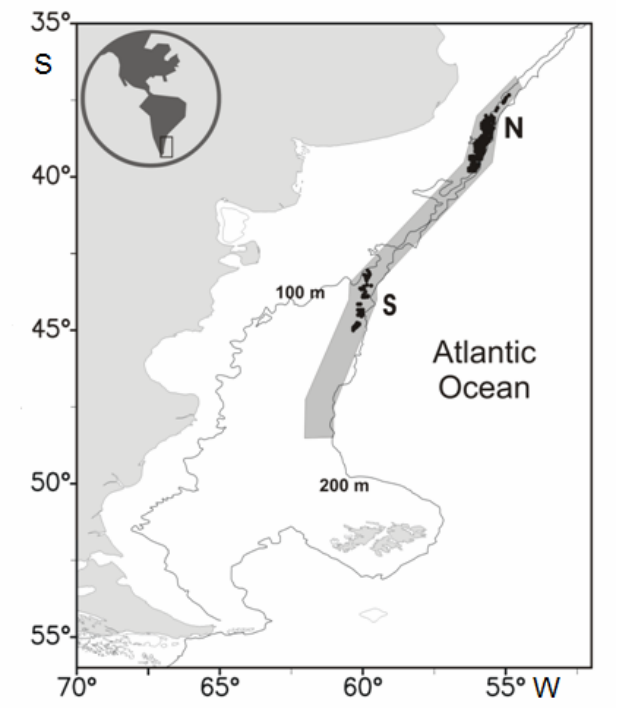

Figure 2. *Zygochlamys patagonica* fishing grounds area in the SW Atlantic Ocean (shaded area). Black circles correspond to sampling sites. N and S correspond to "Northern" and "Southern" areas compared in the study. The small map (top-left) shows the location of the study area in America.

Figura 2. Áreas de pesca de *Zygochlamys patagonica* en el Océano Atlántico sudoccidental (área sombreada en gris). Las indicaciones de N y S corresponden a las áreas mencionadas como "Norte" y "Sur" en este estudio. El mapa pequeño (arriba a la izquierda) muestra la ubicación del área de estudio en América.

A total of 24 fish species (13 Chondrichthyes and 11 Osteichthyes) were identified in the 177 sampling sites (Table 1), all of them comprised in their known distributional ranges mentioned in Cousseau & Perrota (2004). Species richness ranged between 0 and 11 by site and was higher in the northern area ($H_{(3, 170)}$ = 35.737; $P < 0.001$) (Fig. 3), a pattern already observed for Chondrichthyes by Lucifora *et al*. (2012). No relationship between species richness and depth was found (r = -0.04; $P = 0.61$).

The most frequently recorded species were *Bathyraja brachyurops* (75.1%), *B. macloviana* (73.5%), *Patagonotothen ramsayi* (66.1%), *Merluccius hubbsi* (53.7%) and *B. albomaculata* (50.3%) (Table 1). Skates of the genus *Psammobatis* (*P. normani* and *P. rudis*, although not discriminated) were also very frequent in the study area (81.4%). Some species, including the sharks *Schroederichthys*

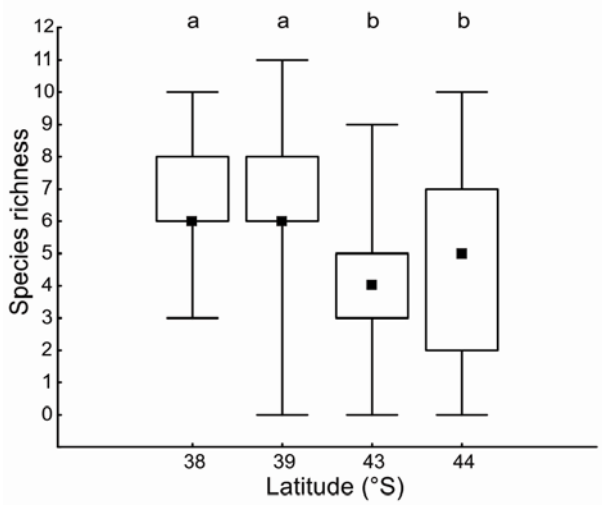

Figure 3. Box-plots show the median (small inner squares), the 25 and 75 percentiles (outer box) and min-max confidence interval (whiskers) of species richness. Letters denote significant differences in medians.

Figura 3. El gráfico de cajas muestra la mediana (cuadrados pequeños internos), los percentiles 25 y 75 (cajas externas) y el intervalo de confianza mínimo-máximo (líneas) de riqueza específica. Las letras marcan diferencias significativas entre las medianas.

bivius and *Squalus acanthias*, the grenadier *Caelorinchus fasciatus*, the flatfish *Xystreurys rasile*, the rockfish *Helicolenus dactylopterus lahillei* and the hawkfish *Cheilodactylus bergi*, were only registered in the northern study area.

It is interesting to point out that the commercial nets do not catch conspicuous quantities of fishes (Morsan *et al*., 2011) (Fig. 1). Notwithstanding, according to IUCN (2011), almost all the Chondrichthyes species registered during this study deserve attention. *Bathyraja griseocauda* corresponds to the category "endangered species", *B. albomaculata*, *Dipturus chilensis* and *Squalus acanthias* are considered "vulnerable species", *B. macloviana*, *B. multispinis* and *B. scaphiops* are considered "near threatened species". *Schroederichthys bivius*, *Psammobatis* spp., *Sympterygia bonapartii* are included in a category "data deficient", which means that the information about these species is inadequate to infer any conclusion. Only *Amblyraja doellojuradoi* and *B. brachyurops* are considered "least concern" species (taxa that have been evaluated against the criteria and do not qualify for critically endangered, endangered, vulnerable or near threatened; they are widespread and abundant taxa) and may not deserve so much attention.

Survival of demersal fishes after being discarded and returned to sea depends on different physiological,

Table 1. Fish species, occurrence frequency and percentage of presence in the Patagonian scallop fishing grounds registered during the present study (N = 177).

Tabla 1. Especies de peces, frecuencia de aparición y porcentaje de presencia en áreas de pesca de vieira patagónica registrados durante este estudio (N = 177).

Taxa	Frequency	%
Chondrichthyes		
Amblyraja doellojuradoi (Pozzi, 1935)	65	36.7
Bathyraja albomaculata (Norman, 1937)	89	50.3
Bathyraja brachyurops (Fouler, 1910)	133	75.1
Bathyraja griseocauda (Norman, 1937)	12	6.8
Bathyraja macloviana (Norman, 1937)	130	73.4
Bathyraja multispinis (Norman, 1937)	7	3.9
Bathyraja scaphiops (Norman, 1937)	16	9.0
Dipturus chilensis (Guichenot, 1848)	83	46.9
Psammobatis spp. (2 species)	144	81.4
Sympterigia bonapartii Müller & Henle, 1841	1	0.6
Squalus acanthias Linnaeus, 1758	2	1.1
Schroederichthys bivius Müller & Henle, 1838	27	15.3
Osteichthyes		
Bassanago albescens (Barnard, 1923)	21	11.9
Caelorinchus fasciatus (Günther 1878)	2	1.1
Cheilodactylus bergi Norman, 1937	3	1.7
Congiopodus peruvianus (Cuvier, 1829)	20	11.3
Cottoperca gobio (Günther, 1861)	12	6.8
Genypterus blacodes (Forster, 1801)	28	15.8
Helicolenus dactylopterus lahillei Norman, 1937	1	0.6
Iluocoetes fimbriatus Jenyns, 1842	10	5.7
Merluccius hubbsi Marini, 1933	95	53.7
Patagonotothen ramsayi (Regan, 1913)	117	66.1
Xystreurys rasile (Jordan, 1890)	21	11.9

technical or intrinsic specific factors; one of the most basic ones is the presence or absence of a closed swim bladder (Hislop & Hemmings, 1971; Broadhurst *et al*., 2006; Enever *et al*., 2009). Chondrychthyes and some benthic physostomous fishes present a higher survival percentage due to the physiological advantages (Broadhurst *et al*., 2006). Sex, age and size of the fishes are other important factors. Several studies recorded lower survival rates in Chondrichthyes in low-sized (juveniles), or male individuals (Stobutzki *et al*., 2002; Laptikhovsky, 2004). Survival rates after trawling events and discard to the sea are in general unknown for the majority of the species here registered. A few reports of vulnerability and lower survival rates of *Psammobatis normani, P. rudis, Dipturus chilensis, Sympterigia bonapartii, Bathyraja albomaculata, B. brachyurops, B. griseocauda* and *B. macloviana* are given in Laptikhovsky (2004) Cedrola *et al*. (2005) and Quiroz *et al*. (2011).

Tow time, air exposure, manipulation time before release and weight and composition of the capture are important factors influencing survival of the species: a larger catch provokes more compression for the retained organisms, associated with larger damages and mortalities (Laptikhovsky, 2004; Broadhurst *et al*., 2006; Frick *et al*. 2010). Because in the Patagonian scallop fishery the towing time is brief (10 min) and sorting of the total catch is a very fast procedure (Morsan *et al*., 2011), presumably many Chondrichthyes and physostomous fish species could survive. Skates and sharks usually start to swim down into the sea after being released (authors' personal observations), but post-catch mortality due to the attraction of albatrosses and other scavenging birds by trawlers, is unknown.

Some fishes not represented in the present sampling have been occasionally registered in

previous years in North area during research surveys onboard the RV "Capitán Cánepa" (INIDEP), with a different fishing gear (non-selective dredge). For instance, specimens of the electric ray *Discopyge tschudii* Heckel, 1846, the spotback skate *Atlantoraja castelnaui* (Miranda Ribeiro, 1907), the red mullet *Mullus argentinae* Hubbs & Marini, 1933, the Patagonian cod *Salilota autralis* (Günther, 1878), the Argentinean sandperch *Pseudopercis semifasciata* (Cuvier, 1829), the butterfish *Stromateus brasiliensis* Fowler, 1906, the Patagonian redfish *Sebastes oculatus* Valenciennes, 1833 and also some Myxininae, many of them frequent in coastal waters (Cousseau & Perrota, 2004).

Benthic macroinvertebrate richness at *Z. patagonica* fishing grounds (from by-catch samples) is estimated in more than 170 species considering motile and epibiotic species, including new species described in this area (Bremec & Lasta, 2002; Schejter & Bremec, 2007). The results of the present study increase the richness of this benthic habitat with the 24 fish species reported, although possibly many more fish species could be reported in the northern region.

Finally, it must be highlighted the importance of studies regarding by-catch fishes, especially those species considered vulnerable or endangered, for management purposes.

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