

SYNOPTIC POST FISHERY STRUCTURE OF INVERTEBRATE BYCATCH ASSOCIATED TO *ZYGOCHELAMYS PATAGONICA* FISHING GROUNDS AT THE SOUTHWEST ATLANTIC SHELF-BREAK FRONT (39° S, ARGENTINA)

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ABSTRACT Biological data were collected in a Patagonian scallop fishing ground, between 39° 00' and 39° 50' S and between 87 and 130 m depth. During 2007, we sampled the following stations where the trawling exerted could be precisely determined: 11 locations subjected to continuous fishing effort between 1996 and 2006 (continuous fishing effort, 878 commercial tows) and 12 locations subjected to fishing effort between 1996 and 2002 (interrupted fishing effort, 302 commercial tows). Univariate (species richness, Shannon's diversity index, and Pielou's equitability index) and multivariate analysis, analysis of variance, and Kruskal–Wallis tests were applied to analyze species composition and biomass. This study reflects the significant higher density of sessile taxa (Porifera and the ascidean *Paramolgula gregaria*) and two small ophiuroids (*Ophiacantha vivipara* and *Ophiura lymani*), all of them conspicuous during the exploratory cruises conducted in 1995, in the sites where fishing effort was interrupted 4 y before the sampling in 2007 than in those sites continuously exploited and discusses the results considering previous knowledge on the damage that the process on board scallopers imparts on invertebrates bycatch.

KEY WORDS: bycatch, invertebrates, fishing grounds, Patagonian scallop, SWAO, *Zygochlamys patagonica*

INTRODUCTION

The shelf-break frontal area in the Argentine Sea is one of the most productive ecosystems in the southwest (SW) Atlantic Ocean (Acha et al. 2004). Frontal zones in the Argentine continental shelf are associated with an increased vertical mixing that supply high levels of nutrients in the photic zone even after the spring bloom and promote high surface chlorophyll *a* concentrations; the region supports a high biological production as a consequence of high levels of nutrients and chlorophyll (Carreto et al. 1986). In general, the frontal areas accumulate floating material and also invertebrate larvae (Mann & Lazier 1996); the mentioned one is characterized by the presence of extensive beds of the Patagonian scallop *Zygochlamys patagonica* (King, 1832), a pectinid species exploited by scallopers since 1996 (Lasta & Bremec 1998).

Since the start of the Patagonian scallop fishery in 1996, management regulations were implemented to control the extractive activity. In this context, the regular monitoring of the fishery bycatch was included as a tool to assess the composition and distribution of the epibenthic assemblage associated to the resource. Exploratory cruises conducted during 1995 can now be considered as the baseline condition of the scallop fishery, although other trawling fisheries were operating in the region (Bremec & Lasta 2002), whereas the subsequent scallop stock assessment cruises, as well as the data taken by observers on board, provided information that increased the knowledge on composition and structure of the benthic assemblage in the spatial and temporal scales (Bremec et al. 2008a, Escolar et al. 2009, 2011, Sánchez et al. 2011, Mauna et al. 2011, Schejter et al. 2012), production and trophic interactions (Bremec et al. 2000, Schejter et al. 2002; Botto et al. 2006, Souto 2009). Other investigations give useful ecological information of the benthic habitats where the fishery is conducted, particularly with respect to conservation and management purposes. For instance, primary settlement substrate, as well as the spat

of Patagonian scallops were identified (Bremec et al. 2008b, Schejter et al. 2010) and a comparison between fished and nonfished areas reported biomass changes of many invertebrates as the origin of structural differences between areas (Schejter et al. 2008, 2014).

The Patagonian scallop, as many other benthic bivalves of commercial interest, is patchily distributed, which in the end influence the distribution of fishing effort through time (Bogazzi et al. 2005). Despite this well known pattern, a study integrating scallop trawling and the benthic assemblage associated with the fishery is still lacking. It is worldwide recognized that trawling affects the ecosystems in many different, but interrelated, ways (Hall 1999, Hiddink et al. 2006, de Juan et al. 2007, Hinz et al. 2009). In recent decades the wider recognition of the ecosystem effects of fishing activities has led to a shift in fisheries management from a “single-species approach” to an “ecosystem approach”, which is centered on an understanding of the impacts of fishing on species' interactions and environment (Sciberras et al. 2013). Fishing affects habitat complexity, the physical structure, and chemical processes of the sea floor (Schwinghamer et al. 1998, Collie et al. 2000, Jennings et al. 2005, Olgard et al. 2008), populations of bycatch species, community structure, trophic relationships, and production (Kaiser et al. 1996, 2006, Veale et al. 2000, Jennings et al. 2001, Hixon & Tissot 2007, Hinz et al. 2009).

The aim of this contribution is to analyze the species composition and biomass from sampling locations subjected to different levels of Patagonian scallop fishing effort between 39° 00' S and 39° 50' S along the 100-m isobath. To our knowledge, this research represents one of the first published studies developed in the SW Atlantic that quantifies the trawling impact and the structure of the invertebrate bycatch on scallop fishing grounds on the Argentine continental shelf.

MATERIALS AND METHODS

Study Area

This study was conducted in an area within 39° 00' S to 39° 50' S and 55° 45' W to 56° 09' W, along the SW Atlantic

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Argentine shelf-break frontal region (Fig. 1). This thermohaline shelf-break front (Martos & Piccolo, 1988) is produced by the encounter of the subantarctic shelf waters and the cooler and more saline waters of the Malvinas current; creating a permanent feature that characterizes the border of the Argentinean shelf with the inner boundary laying between the 90- and 100-m isobaths. This shelf-break front may be followed from the Burdwood Bank ($\sim 55^\circ$ S) along the shelf break to the east, around Malvinas Islands and northwards up to the Brazil/Malvinas Confluence ($\sim 38^\circ$ S) (Acha et al. 2004). The benthic habitats where the scallop grounds develop are dominated by sandy soft-bottoms, like more than 90% of the Argentinean continental shelf (Parker et al. 1997). The sediment type was characterized by fine sands in this fishing ground (currently named Management Unit B) from samples collected between 38° and $38^\circ 30'$ S (Lasta 2013). The absence of biogenic substrates was shown by means of multibeam sonar (Madirolas et al. 2005).

Fishing Effort

Fishing effort data were taken from Bremec et al. (2011). We selected information of tows from stations sampled during 2007 that corresponded to sites where the trawling exerted could be precisely determined. The number of commercial tows that affected every sampling station was estimated for the period 1996 to 2006 and considered a measure of scallop fishing effort. The location (latitude and longitude) of every sampling station was considered the central point of an area $\sim 2,795$ m², obtained from average towing time and speed of the total number of samples analyzed. Although the fishing vessels operate two nets, we could discriminate that only one of them could trawl within the area of 2,795 m² and provide an accurate estimation of the

effort exerted/number of tows by the scallop fishery in the area of 2,795 m² assigned to every sampling site. This first step of analysis was done considering the stations sampled during 2007 within the study area.

After the general quantification of fishing effort exerted, the study sites sampled during 2007 could be divided into two different trawling conditions. Eleven locations had been subjected to continuous fishing effort (CFE, 878 commercial tows between 1996 and 2006) and 12 locations had been subjected to interrupted fishing effort (IFE, 302 commercial tows between 1996 and 2002) (Fig. 1). The areas of 2,795 m² were subjected to trawling every year between 1996 and 2006 and hence the fishing effort was considered continuous up to 2007, when the biological samples were taken. Those areas trawled every year between 1996 and 2002 also contained the sites sampled in 2007, and consequently the fishing effort was considered interrupted.

Sampling

Samples of benthic invertebrates were collected between 87 and 130 m depth, during the cruises directed to stock assessment of the resource *Zygochlamys patagonica* in 2007, on board the R/V “Capitán Cánepa” (Fig. 1). Eleven samples came from the CFE sites and 12 samples from the IFE sites. Bremec et al. (2000) showed species–area curves (bootstrapping resampling) that indicate a minimal number of eight samples to represent the Patagonian scallop assemblage at a regional scale. The commercial fishery started in 1996 and, since 1998, the same sampling method is being used as part of the environmental monitoring program; it permits the comparison of epibenthos, collected as bycatch of the fishery, through time. Both initial (Bremec & Lasta 2002) and recent (Mauna et al. 2011) papers show that dredging provides suitable information in the case of scallop assemblages of patchily distributed fauna. The vessel was operated with a nonselective, 2.5-m-wide dredge fitted with a 10-mm mesh. Dredge efficiency for Patagonian scallops has been estimated to be 43% for soft bottoms (Valero 2002). This value was used to calculate the biomass per meter square, considering that the swept area was the product of the dredge width multiplied by the distance swept; fishing distance was estimated based on standard towing time (10 min) and average speed (3.5 knots). Biological material to assess faunal composition (vol = 10 l per 6–7 kg each) was randomly subsampled from the unsorted catch. Macrofauna was sorted, identified to the lowest possible level, counted, and weighed in the Benthos Laboratory (Instituto Nacional de Investigación y Desarrollo Pesquero). Epibiotic species, which largely encrust scallops and other invertebrates, were not included in the analysis.

The benthic community was characterized from the sites CFE and IFE applying univariate (species richness, Shannon’s diversity index (H') and Pielou’s equitability index (J') and multivariate [similarity percentage analysis (SIMPER), analysis of similarity] analysis by means of licensed PRIMER software (Clarke 1993, Clarke & Warwick 1993). Analysis of variance (ANOVA) and Kruskal–Wallis tests were applied to average biomass values of those species that contributed to the differences between zones.

RESULTS

Multivariate analysis of samples taken in 2007 from areas with continuous (1995 to 2006, CFE) and interrupted (1995 to

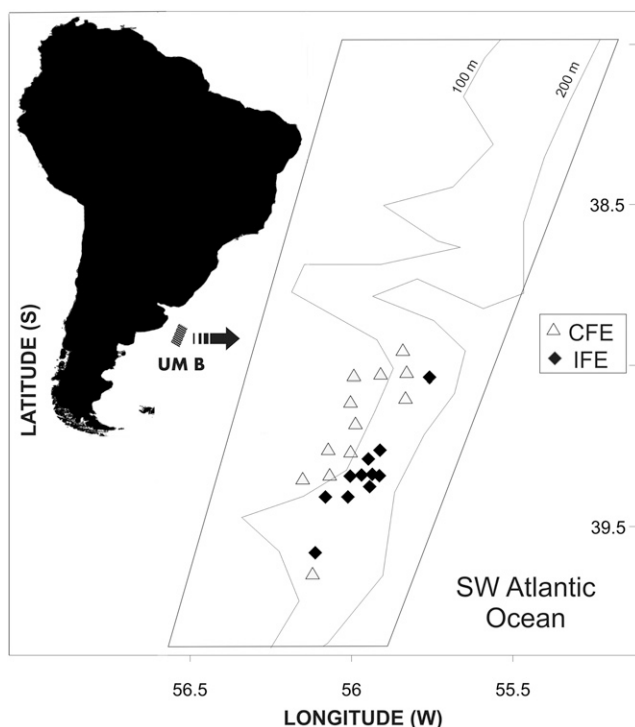


Figure 1. Location of stations sampled during 2007 at the Argentine shelf-break frontal system.

2002, IFE) fishing effort does not show well-defined groupings (Fig. 2). The results of the analysis of similarity between data CFE and IFE do not show differences between assemblages (global $R = 0.109$; $P = 2.2\%$). SIMPER analysis in the two pools of samples (Table 1) indicates the dominance of Patagonian scallop and showed that average dissimilarity between CFE and IFE reaches 35.38%; 13 invertebrate species contribute with 50% of this value (Table 2).

Diversity indexes were not significantly different between areas CFE and IFE (Table 3). These areas did not differ significantly when considering total biomass of associated invertebrates (ANOVA; $F = 1.91$; $P = 0.181$), commercial scallops (greater than or equal to 55 mm total height, ANOVA; $F = 0.003$; $P = 0.959$) or noncommercial scallops (less than 55 mm total height, ANOVA; $F = 0.0003$; $P = 0.987$).

Figure 3 shows mean biomass of species that contributed to 50% dissimilarity between zones IFE 2007 and CFE 2007 (Table 2). From them, those species that significantly differed between zones are indicated in Table 4 ($P > 0.05$). Other three species are also considered due to significant differences in density between zones: the ophiuroids *Ophiura lymani* (Ljungman, 1870), *Austrocidaris canaliculata* (A. Agassiz, 1863), and the tunicate *Paramolgula gregaria* (Lesson, 1830).

Lower biomass of *Ophiacantha vivipara* (Ljungman, 1870) (ophiuroid) and Porifera, as well as the scarcity of the ascidian *Paramolgula gregaria* were detected in zones CFE (Fig. 3), whereas echinoderms, such as *Austrocidaris canaliculata*, *Ophiura lymani* (Ljungman, 1871), *Ophiactis asperula* (Philippi, 1858), *Gorgonocephalus chilensis* (Philippi, 1858), and Anthozoa were significantly more abundant in zones CFE (Fig. 3). Snails—*Adelomelon ancilla* (Solander, 1786), *Odontocymbiola magellanica* (Gmelin, 1791) and *Fusitriton magellanicus* (Roeding, 1798)—and polychaetes (*Chaetopterus variopeatus* (Renier, 1804) and empty tubes) did not show differences in biomass between CFE and IFE zones, together with echinoids [*Sterechinus agassizii* (Mortensen, 1910) and *Pseudechinus magellanicus* (Philippi, 1857)]; however, Ascidiacea, *C. variopeatus* + empty tubes and *Fusitriton magellanicus* were conspicuously well represented in CFE, whereas the snail *A. ancilla* in IFE (Fig. 3).

DISCUSSION

Data obtained during 2007 reflected the synoptic situation at those sites exploited since 1996 and abandoned by the commercial fleet in 2002 and others still exploited in 2007 (Campodónico et al. 2008). The stations where interrupted fishing effort was identified presented a higher biomass of sessile, like sponges or ascidians, and fragile organisms, like little ophiuroids, than the sites continuously disturbed up to 2007. Diversity and total biomass of fauna and scallops did not differ between both trawling conditions established in this study, after 7 (IFE) and 11 (CFE) y of fishing disturbance. Species loss was never recorded after extensive monitoring of heavily exploited scallop grounds and diversity was not correlated with depth or latitude (Bremec et al. 2008c); however, it must be noted that sampling sites did not suffer direct trawling during those years, instead they represent unexploited sites in two regions with different average trawling. We can say that we are really evaluating “indirect trawling effects” on the scallop communities of both regions. Indeed, regardless the overall species

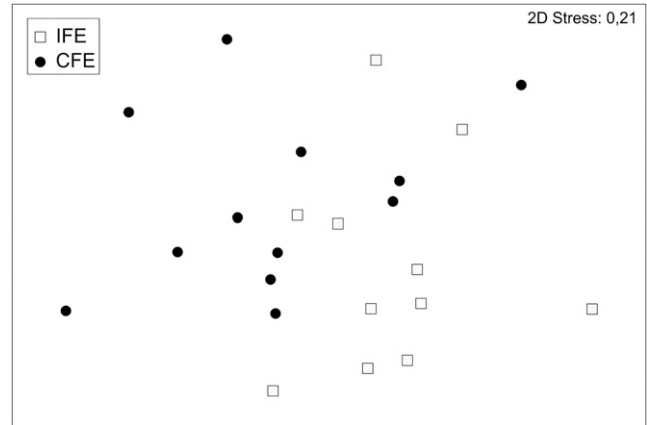


Figure 2. Multidimensional Scaling of samples obtained in the study area (39° 00' S to 39° 50' S) during 2007 (IFE and CFE).

richness detected through time in the different management units distributed all along the shelf-break frontal zone between 36° 43' and 48° 30' S and 70–130 m depth, after more than 10 y of trawling, reduction in the species richness per sample (Bremec et al. 2010) and in the abundance of some species (Schejter et al. 2002, Escolar et al. 2009), as well as lower production of cnidarians and large molluscs in fishing areas (Souto 2009), was detected. Within epifaunal communities, reductions in biomass, secondary production, and species diversity have frequently been associated with increased fishing disturbance (Hiddink et al. 2006, Tillin et al. 2006).

Many of the most frequent and abundant taxa of the bycatch assemblage sampled during exploratory cruises in 1995 before the development of commercial fishery (Bremec & Lasta 2002), like *Ophiacantha vivipara* and Porifera, presented higher

TABLE 1.

Contribution of invertebrate taxa to biomass internal similarity (i.s.) of the assemblages sampled during 2007 in areas CFE (i.s. 66.81) and IFE (i.s. 60.21) between 39° 00' and 39° 50', SW Atlantic.

	Contrib%	Cum.%
CFE 2007		
<i>Zygochlamys patagonica</i>	54.57	54.57
Porifera	6.30	60.87
<i>Ctenodiscus australis</i>	6.11	66.98
<i>Austrocidaris canaliculata</i>	5.94	72.92
<i>Ophiactis asperula</i>	5.78	78.70
<i>Flabellum curvatum</i>	4.50	83.20
Asteriidae	4.36	87.56
<i>Actinostola crassicornis</i>	4.35	91.92
IFE 2007		
<i>Zygochlamys patagonica</i>	44.79	44.79
Porifera	13.17	57.96
<i>Ophiacantha vivipara</i>	6.62	64.58
<i>Actinostola crassicornis</i>	6.30	70.88
Asteriidae	6.22	77.10
<i>Flabellum curvatum</i>	4.18	81.28
<i>Ctenodiscus australis</i>	3.87	85.15
<i>Fusitriton magellanicus</i>	2.86	88.00
<i>Ophiactis asperula</i>	2.07	90.08

TABLE 2.

Contribution of invertebrate taxa to average biomass dissimilarity (35.38) between zones CFE 2007 and IFE 2007 in the study area between 39° 00' and 39° 50', SW Atlantic.

	Contrib%	Cum.%
<i>Ophiacantha vivipara</i>	5.44	5.44
<i>Adelomelon ancilla</i>	4.36	9.80
Ascidacea 1	4.32	14.12
Porifera	3.97	18.10
<i>Odontocymbiola magellanica</i>	3.97	22.07
<i>Fusitriton magellanicus</i>	3.84	25.90
<i>Chaetopterus variopedatus</i> (+ empty tubes)	3.60	29.50
<i>Sterechinus agassizii</i>	3.50	33.00
<i>Pagurus comptus</i>	3.46	36.47
<i>Ophiactis asperula</i>	3.32	39.79
<i>Zygochlamys patagonica</i>	3.24	43.03
<i>Gorgonocephalus chilensis</i>	3.11	46.14
<i>Pseudechinus magellanicus</i>	2.81	48.95
Anthozoa unid.	2.76	54.50
<i>Libidotheca granaria</i>	2.61	57.11
Volutidae (juvenile)	2.60	59.71
Hydrozoa	2.43	62.15
Asteriidae	2.42	64.57
<i>Paraeuthria</i> sp.	2.16	66.73
Pterasteridae	2.15	68.87
<i>Ophiura lymani</i>	2.12	70.99
<i>Austrocidaris canaliculata</i>	1.99	72.98
<i>Psolus patagonicus</i>	1.97	74.95
<i>Flabellum curvatum</i>	1.88	76.83
<i>Actinostola crassicornis</i>	1.83	78.66
<i>Ctenodiscus australis</i>	1.72	80.38
<i>Antholoba achates</i>	1.62	82.00
<i>Pseudocmus dubiosus</i>	1.54	83.54
<i>Trochita pileolus</i>	1.42	84.97
<i>Eurypodius latreillii</i>	1.20	86.17
<i>Paramolgula gregaria</i>	1.12	87.29
<i>Convexella magelhaenica</i>	1.09	88.38
Ascidacea 2	1.05	89.43
Nudibranchia	1.01	90.45

percentages of contribution in the IFE than in the CFE assemblage. This diminution of colonial and fragile taxa was early detected in the study area, as a conspicuous decrease in biomass and annual production between 1995 and 1998 was mainly observed in Porifera and Cnidaria (Bremec et al. 2000), as well as on a southern exploited bed by means of experimental studies (Bremec & Lasta 1998, 1999). Large-bodied, fragile, and sessile species are known to be strongly affected by fishing disturbance (e.g., De Groot & Lindeboom 1994, Collie et al. 1997, Kaiser et al. 2000). In general, organisms with emergent growth forms, soft body parts, low motility, and larval dispersal over short distances are more sensitive to mobile fishing gears (Asch & Collie 2008). Colonial taxa like sponges, can take more than 10 y to grow many centimeters and become abundant in areas protected from bottom fishing (Sainsbury et al. 1997, Lindholm et al. 2004). The recovery of populations of most colonial and noncolonial species took 2 y or more to initially respond to the cessation of bottom fishing at Georges Bank, United States, where the scallop *Placopecten magellanicus* is exploited, what indicated that even infrequent trawling could alter benthic

TABLE 3.

Average (\pm SD) species richness, diversity (H'), and evenness (J') from samples collected in areas CFE 2007 and IFE 2007 between 39° 00' and 39° 50', SW Atlantic.

	CFE	IFE	F	P
Range S	19–29	18–32		
S	23.67 \pm 2.67	24.18 \pm 3.63	0.152	0.70
H'	1.41 \pm 0.27	1.59 \pm 0.40	1.575	0.223
J'	0.45 \pm 0.08	0.50 \pm 0.12	1.433	0.245

The F test statistic and P values of the ANOVA are also provided.

communities for years to come (Asch & Collie 2008). These authors conclude that when the ecological community is perturbed across large areas interspersed among small unaffected patches, recovery usually proceeds by the slower process of larval settlement, with most larvae originated from either distant areas or from the small unaffected patches. Regarding the target species, after many years of annual monitoring of the Patagonian scallop grounds, the presence of scallop spat was mainly detected on the sertularid hydroid *Symplectoscyphus subdichotomus*, in 2006, in sites within areas where exploitation was scarce and with high relative biomass of hydroids (Bremec et al. 2008b). The reduction of settlement or juvenile survival in bottoms perturbed by fishing was suggested decades ago by Caddy (1973). Studies involving sampling in areas adjacent to exploited patches could help to evaluate the possibilities of recolonization from immigration and larval dispersal.

An additional anthropogenic impact may help to explain our results, preferably involving solitary mobile taxa. It must be considered that in this fishery, the catch composed of scallops, other benthic invertebrates, and shell hash (Bremec & Lasta 2002) is mechanically processed onboard; nontarget species and noncommercial size scallops (less than 55 mm) are separated by metal drums and discarded. A recent analysis (Escobar et al. 2014) of the damage produced by the fishery on many bycatch species identified the damage by trawling on the deck (caused by the initial encounter with the gear, impaction or crushing by the mesh or by other organism of the catch) and the damage by process in the discards (caused by sorting process on the fishing vessel). Some of the impacted species were the sea urchin *Sterechinus agassizii*, which accounted for the highest mean damage index (*sensu* Jenkins et al. 2001), the snails, *Adelomelon ancilla* and *Odontocymbiola magellanica*, retained during the process on board due to their large size, and Ascidacea. All of them consistently were more abundant, together with the little ophiuroids, in the sites IFE, not disturbed during 4 y. On the other side, other species less represented in the discards than on deck showed higher biomass in the sites CFE than in IFE during 2007, like some sea stars, the echinoids *Gorgonocephalus chilensis* and *Austrocidaris canaliculata* and the snail *Fusitriton magellanicus*. All these taxa constitute the assemblage of invertebrates in that *Zygochlamys patagonica* dominated the total biomass (Bremec et al. 2000), they are relatively large sized and differentially contributed to dissimilarity between sites CFE and IFE. Research on Echinodermata developed in a northern fishing ground also showed significant differences between areas subjected to differential fishing effort; Asterozoa was significantly more abundant than Ophiurozoa and Echinozoa in

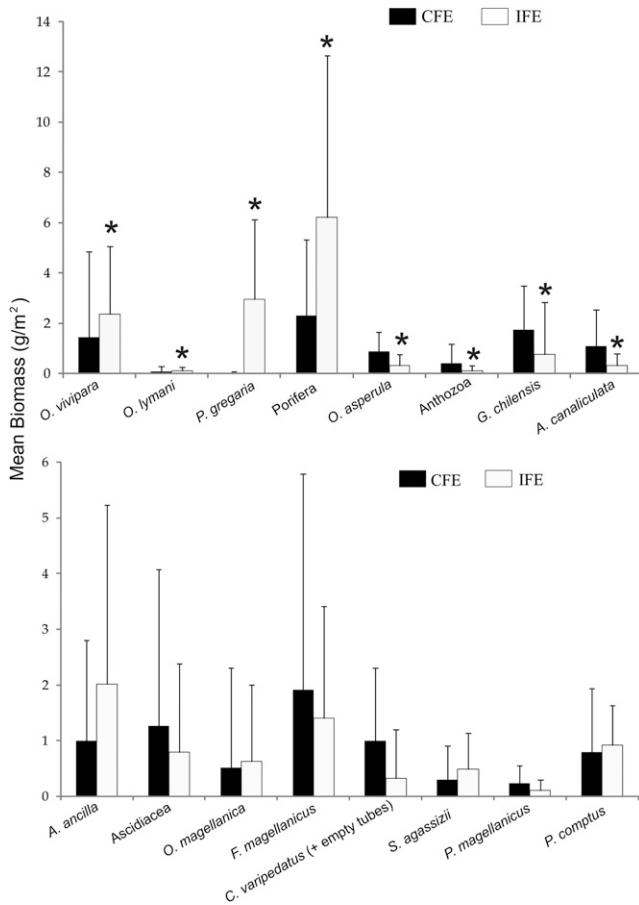


Figure 3. Average biomass of the most frequent invertebrates collected in the study area, with and without significant differences between samplings 2007 CFE and 2007 IFE (also see Table 4).

more disturbed areas (Escolar & Bremec, in press). A higher food availability probably favors predators, like sea stars (McClintock 1994, Botto et al. 2006, Mangano et al. 2013), in intensively perturbed areas (like sites CFE), whereas echinoids are largely known as one of the groups more affected by trawling due to their fragile structure (Bergman & van Santbrink 2000, Kaiser et al. 2000, Hinz et al. 2009, Morsan 2009). Regarding ophiuroids in this benthic assemblage, Escolar et al. (2011) indicate their omnivorous feeding habit; *Ophiacantha vivipara* and *Ophiactis asperula* possibly taking advantage on discards of the fishery, being the latter more abundant in areas subjected to high fishing effort. Although the response to disturbance at specific level is undoubtedly related with the variable population parameters of the many species throughout the shelf-break system, we stress out that the ophiuroids *O. vivipara* and *Ophiura lymani* as well as the most affected echinoid *S. agassizii* resulted more abundant in sites IFE.

A case to point out refers to the high biomass of empty polychaete tubes in areas subjected to continuous disturbance. The worm *Chaetopterus variopedatus* lives within large pergamentaceous U-shaped tubes buried into the soft bottoms (Rouse 2001). Consequently, the chronic removal of sediments could contribute to produce huge amounts of tubes that remain empty and cover the bottom. Polychaete tube biomass showed an increase from 1998 to 2002 in the fishing grounds whereas in

TABLE 4.
Results of Kruskal–Wallis test (*H* test statistic and *P* values) applied to taxa that mostly contributed to biomass dissimilarity (SIMPER analysis) between samples in areas IFE 2007 to CFE 2007.

Taxa	IFE–CFE	
	<i>H</i>	<i>P</i>
Anthozoa unid.	4.385	0.036
<i>Austrocidaris canaliculata</i>	4.918	0.026
<i>Gorgonocephalus chilensis</i>	4.084	0.043
<i>Ophiacantha vivipara</i>	4.166	0.041
<i>Ophiactis asperula</i>	3.878	0.048
<i>Ophiura lymani</i>	5.955	0.014
<i>Paramolgula gregaria</i>	7.055	0.007
Porifera	4.640	0.031

the reserve area located within our study area (Res. 5 CFP 2009) they were not registered at all within that study period (Schejter et al. 2008). Conspicuous amounts of polychaete tubes not inhabited by living worms were registered on the bottoms (Bremec et al. 2012) and erroneously considered as a notable biomass of suspension feeders in marginal areas of the frontal system (Mauna et al. 2011). Conspicuous settlement of *C. variopedatus* was observed on scallops, a phenomenon scarcely registered during the initial years of the fishery, instead of infaunal habit (authors' personal observation; Bremec et al. 2012). Moreover, decline of bioturbating species due to fishing disturbance may have further cascading effects on the diversity and functioning of the entire benthic community, e.g., enhancement of infaunal diversity (Widdicombe et al. 2004).

The alteration of benthic communities was widely documented in fisheries that dredge the seafloor. Worldwide concern regarding bottom trawling as the most important source of anthropogenic disturbance to soft-sediment benthic communities and habitats has increased in recent years (Dayton et al. 1995, Collie et al. 1997, Jennings & Kaiser 1998, Kaiser et al. 2000, 2006, Pauly et al. 2002, Kenchington et al. 2007, Olsgard et al. 2008, Morsan 2009, Reiss et al. 2009, Atkinson et al. 2011, Seiberras et al. 2013). Other investigations lead to different results after studying bottoms subjected to limited short-term sea scallop fishery on Georges Bank, and emphasize that the natural dynamic environmental conditions appeared to alter the epibenthic community more than the harvesting (Stokesbury & Harris 2006).

It is well known that the different types of habitats where any fishery is conducted are differentially affected by bottom fishing, what impedes the extrapolation of results on trawling disturbance from a small scale to the scale of the fishery (Hiddink et al. 2005). In the case of heterogeneous habitats, the importance of the type of substrate, together with wave stress, tidal velocity, and fishing, in determining the biomass and size composition of emergent epifauna around the Isle of Man, Irish Sea, was shown (Lambert et al. 2011). The Patagonian scallop fishing grounds cover homogeneous habitats of sandy bottoms (Parker et al. 1997) distributed along the productive shelf-break frontal system at nearly 100-m depth (Acha et al. 2004), where, still presently, the fishery develops intense commercial activity. In the North Sea, for instance, both

theoretical and field data demonstrated that the impacts of trawling were greatest in areas with low levels of natural disturbance, whereas the impact of trawling was small in areas with high rates of natural disturbance (Hiddink et al. 2006). Of course we do not intend to extrapolate results or predict the overall impact of the fishing disturbance; however, structural changes are expectable in such homogeneous habitats inhabited by the same assemblage of benthic invertebrates conspicuously associated to the dominant target species, and subjected to aperture and closure of fishing areas (Pottinger et al. 2006). It was demonstrated that bottom trawling also affected the infaunal components of the benthic ecosystem, even in areas with high chronic fishing disturbance, fact that has ramifications for fisheries management especially in the context of an ecosystem approach (Reiss et al. 2009).

In the present case, the Patagonian scallop fishing effort exerted on selected sampling sites was quantified and the structure of the fishery bycatch was shown. Some sessile and

small fragile taxa showed significant higher biomass in the sites not exploited during 4 y than in others continuously trawled. The higher presence of other taxa very sensitive to trawling and process on board the scallopers (Escolar et al. 2014) is also stressed out. Our results were more than expectable and showed a trend already demonstrated worldwide; however, the remarkable validity of this investigation at a local scale should be in accordance with the dimension of the Patagonian scallop fishery in Argentinean waters.

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