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EPIBENTHIC ASSEMBLAGE ASSOCIATED WITH SCALLOP (*ZYGOCHLAMYS PATAGONICA*) BEDS IN THE ARGENTINIAN SHELF

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ABSTRACT

By-catch samples were taken in Patagonian scallop (*Zygochlamys patagonica* King and Broderip, 1832) beds during a survey evaluation on the Argentinian continental shelf between 38–46°S in 1995, prior to the development of the present commercial fishery. The invertebrate epibenthic fauna was identified and the community structure was analyzed using univariate and multivariate methods. Patagonian scallop was dominant in weight. In four geographical areas a characteristic assemblage of associated species (sponge *Tedania* sp., anemone *Actinostola crassicornis*, echinoderns *Ophiactis asperula*, *Ophiacanta vivipara*, *Ophiuroglypa lymani*, *Sterechinus agassizii*, *Austrocidaris canaliculata*, *Cosmasterias lurida*, *Ctenodiscus australis*, *Psolus patagonicus* and *Pseudocnus dubiosus leoninus*) could be defined by cluster analysis. Areas differed in biomass of scallops and by-catch and also in the relative presence of scallop epibionts. This study gives baseline information on the undisturbed condition of natural communities and will permit future evaluation of structural changes due to fishery impact, since commercial fishing has taken place on the beds since 1996.

Factors arising from demersal fishing activities (overfishing, by-catch, discard, bottom damage, habitat modification, removal, incidental fishing mortality) produced well documented changes in species composition and abundance in different marine environments. Declines in the target species generally lead to the post-impact understanding that the scarce information about environmental reference points makes difficult to explain the causes implicated in such declines. Recent reviews on by-catches conclude that the scarcity of knowledge is a common feature, not only on the functioning of ecosystems but also on the composition and abundance of the species captured, in order to assess impacts of the fishing (Alverson et al., 1994; Hall, 1996), and a suggested research priority includes the estimation of the quantity and composition of the by-catches and the development of programmes to monitor by-catch (see Hall, 1996). Considerations like these, related to the management of fisheries, have been based mainly on information on fish and shrimp fisheries (Hutchings, 1990; Alverson et al., 1994; Hall, 1996; Parsons, 1996; Alverson and Hughes, 1996). As a general conclusion, studies on bottom environments in fishing areas are based on data from already disturbed ecosystems, while reference data on the pre-impact conditions would be very useful.

In recent years, ecological investigations on scallops fishing grounds have been carried out once fishing activities have been intensively developed, and these studies have revealed the importance of trawl damage to the habitat, benthic communities and species captured (Langton and Robinson, 1990; Strokesbury and Himmelman, 1993, 1995; Brand and Prudden, 1995; Brand et al., 1997). However, there are only a few examples of studies referring to the consequences of dredging that affected scallop populations (Mc. Loughlin et al., 1991) or benthic communities (Jones, 1992), included in the extensive review of 800 papers carried out by Alverson et al. (1994).

During 1996 a new scallop (*Zygochlamys patagonica* King and Broderip, 1832) fishery started on the Argentinian continental shelf. Before commercial fishing was developed by four scallopers, a year-round (1995) study was carried out through a state-industry joint research program. As a result, seven large scallop beds were found along the 100 m isobath (Lasta and Bremec, 1995, 1998; Bremec and Lasta, 1997; Bremec et al., 1998) and benthic samples were collected in each of the high density scallop areas discovered. Considering that the present scallop fishery performs bottom trawling and also factory work on board, the bottom environment is affected through: (1) sediment removal, (2) habitat modification, (3) damage to fauna, 4) extraction of fauna, target and non-target species, and by processing on board, (5) discards of scallops <55 mm (minimum legal size), (6) discards of shells and viscerae and (7) discards of non-target invertebrates. Those invertebrates captured by the gears are discarded at sea after the sorting process, where they become injured or dead. This fauna is composed by both mobile species and epibionts that encrust the scallop shells.

The main objectives of this paper are to describe the undisturbed species composition and structure of the benthic complex during experimental trawling in different scallop beds in 1995 in the Argentine Sea, before the onset of the commercial fishing, and to identify environmental conditions related to the spatial distribution of scallop beds. Consequently, this contribution presents baseline data that will permit future assessment of eventual habitat modifications caused by the fishery.

Materials and Methods

Fifty nine samples (≅5 kg each) were collected from the catches, which were taken with bottom otter trawl (see Lasta and Iribarne, 1997) (average towing time 10 min; average speed 3.8 kt; cod-end mesh size 10 mm) during 12 trips carried out by the FV Erin Bruce from January to October 1995. Samples were taken from the seven undisturbed new beds found during the experimental programme (Lasta and Bremec, 1995). In addition, samples were taken from two previously known beds, Sea Bay and Tres Puntas, this latter in the area of San Jorge Gulf (Lasta, 1992) (Fig. 1, Table 1). The total weight of samples was 277.5 kg (106.77 kg of scallops, 170.69 kg of by-catch) from an estimated total catch of 56,431 kg.

Macrofaunal species were sorted, identified, counted and weighed in the laboratory. Percentages of presence (P) and quantitative dominance (D, excluding colonial and scallop epibionts) (Boudouresque, 1971) of taxa were estimated for the total number of samples and for the different groups of samples resulting from cluster analysis. Cluster analysis was applied to presence-absence data (Sörensen index) and to fourth-root transformed abundance data (Bray-Curtis index) (UPGMA, Q and R modes) (Clarke and Warwick, 1993). The SIMPER test (Clarke, 1993) was used to identify which species contributed most to the similarity between samples. Non-metric multidimensional scaling (Clarke and Warwick, 1993) was carried out with a reduced data matrix (39 species that accounted for 95% cumulative similarity) to show a clear plot. Unique presences were excluded from the data matrix. Colonial species and epibionts, which heavily encrusted the shells were difficult to sort and count due to the small size of individuals (polychaetes, molluscs) or colonial character (sponges, coelenterates), and were thus only included in the presence-absence analysis. Dominance in weight of scallops was expressed as 'scallop index': (biomass of scallops/total biomass of sample) × 100 (Wolff and Alarcón, 1993) from 52 samples.

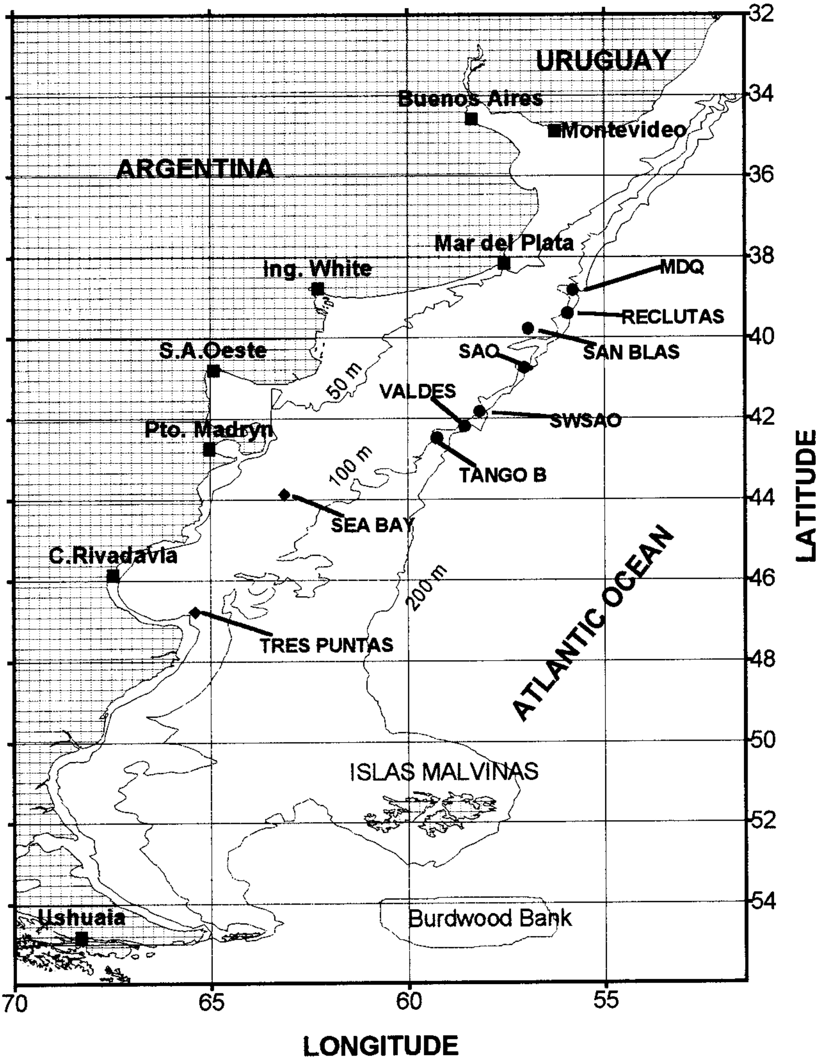

Figure 1. Spatial distribution of the Patagonian scallop (*Zygochlamys patagonica* King and Broderip, 1832) on the Argentine Continental Shelf. Known Beds before 1995 (◊): Sea Bay and Tres Puntas. New Beds discovered during the experimental fishing surveys (•): MDQ, Reclutas, San Blas, SAO, SWSAO, Valdes and Tango B.

Results

Patagonian Scallop Assemblage.—The total number of invertebrate taxa collected in the study area was 82, corresponding to 10 different phyla (Table 2).

Qualitative (67 species) and quantitative (51 species) data matrices were used to perform cluster analysis among species in the study area. Both cluster analyses (R mode) (Fig. 2A,B, cluster 1) indicate that the Patagonian scallop is mainly associated at least with *Tedania* sp. (Porifera), *Actinostola crassicornis* (Coelenterata), *Ophiactis asperula*,

Table 1. Benthic samples collected during 1995. Bed, geographical position (Latitude °S and Longitude °W, minutes and cables), date and depth (meters).

Bed (Sample Nª)	Latitude °S	Longitude °W	Date	Depth
MDQ North (1)	36° 54′ 25	54° 31′ 00	June 28	101.0
MDQ North (2)	36° 50′ 52	54° 33′ 85	June 28	95.0
MDQ (3)	38° 25′ 46	55° 32′ 63	June 27	104.0
AREA 1				
Reclutas (4)	39° 24′ 70	55° 56′ 70	January 18	108.0
Reclutas (5)	39° 31′ 47	56° 02′ 74	March 23	101.0
Reclutas (6)	39° 23′ 72	55° 54′ 69	May 7	111.0
Reclutas (7)	39° 26′ 39	55° 56′ 13	May 7	109.0
Reclutas (8)	39° 26′ 43	55° 57′ 75	May 7	106.0
Reclutas (9)	39° 21′ 92	55° 54′ 82	June 1	109.0
Reclutas (10)	39° 24′ 62	55° 56′ 61	June 1	108.0
Reclutas (11)	39° 26′ 03	55° 57′ 99	June 1	106.0
Reclutas (12)	39° 26′ 17	55° 54′ 72	June 1	113.0
Reclutas (13)	39° 21′ 95	55° 58′ 13	June 1	103.0
Reclutas (14)	39° 26′ 66	55° 56′ 95	October 29	109.0
Reclutas (15)	39° 26′ 66	55° 56′ 95	October 29	109.0
AREA 2				
San Blas (16)	39° 51′ 87	56° 16′ 71	July 5	88.9
San Blas (17)	39° 50′ 47	56° 14′ 84	July 9	96.0
San Blas (18)	39° 48′ 23	56° 15′ 10	July 10	90.0
San Blas (19)	39° 48′ 68	56° 14′ 07	July 24	94.0
San Blas (20)	39° 48′ 68	56° 14′ 07	July 24	94.0
SAO (21)	40° 45′ 35	57° 01′ 54	August 7	104.0
SAO (22)	40° 45′ 35	57° 01′ 54	August 7	104.0
SWSAO (23)	41° 49′ 60	58° 08′ 70	October 12	105.0
SWSAO (24)	41° 51′ 20	58° 14′ 60	October 20	102.0
SWSAO (25)	41° 51′ 20	58° 14′ 60	October 20	102.0

Ophiacanta vivipara, *Ophiuroglypa lymani*, *Sterechinus agassizii*, *Austrocidaris canaliculata*, *Cosmasterias lurida*, *Ctenodiscus australis*, *Psolus patagonicus* and *Pseudocnus dubiosus leoninus* (Echinodermata). The multidimensional scaling plot (Fig. 3) also shows those species occurring close together on the figure. Frequent epibionts were: *Iophon* sp. (Porifera), *Alcyonium* sp. (Coelenterata), *Serpula narconensis*, *Idanthyrsus armatus* (Polychaeta), *Magellania venosa*, *Terebratella dorsata* (Brachiopoda), *Hiatella solida*, *Calyptraea pileolus* (Mollusca) and *Ornatoscalpellum* sp. (Crustacea).

Z. patagonica reached 100 P in the surveyed area. The highest D in the study area corresponded to Echinodermata (57.6 %), mainly with the species *O. asperula* (21.5 %), *O. vivipara* (21.1 %) and *O. lymani* (7.6 %). The Mollusca were also abundant (32.1 %), reaching *Z. patagonica* the maximum value (30.5 %).

Cluster Analysis Between Stations.—Qualitative (67 species) and quantitative (46 species excluding scallop epibionts) analysis among stations (Q mode, Fig. 4A,B) clustered samples from different beds in four main groups that correspond to geographical areas: Reclutas (group/Area 1), SAO, SWSAO and San Blas (group/Area 2), Valdes and Tango B (group/Area 3) and Sea Bay and Tres Puntas beds (group/Area 4). Three samples collected in the MDQ bed, at the northern end of the present sampling programme, were

Table 1. Continued.

Bed (Sample Nª)	Latitude °S	Longitude °W	Date	Depth
AREA 3				
Valdes (26)	42° 10′ 50	58° 34′ 20	January 15	98.5
Valdes (27)	42° 11′ 80	58° 27′ 90	January 15	101.0
Valdes (28)	42° 13′ 70	58° 32′ 08	January 27	96.0
Valdes (29)	42° 14′ 05	58° 34′ 50	January 31	98.0
Valdes (30)	42° 13′ 50	58° 31′ 04	February 3	97.0
Valdes (31)	42° 13′ 00	58° 32′ 90	February 4	95.0
Valdes (32)	42° 14′ 80	58° 35′ 20	February 5	97.0
Valdes (33)	42° 13′ 05	58° 32′ 07	February 19	93.0
Valdes (34)	42° 13′ 04	58° 31′ 10	February 21	94.0
Valdes (35)	42° 12′ 79	58° 31′ 21	February 23	94.0
Valdes (36)	42° 14′ 23	58° 34′ 29	March 10	98.5
Valdes (37)	42° 12′ 88	58° 33′ 31	March 12	95.6
Valdes (38)	42° 12′ 88	58° 33′ 31	March 12	95.6
Valdes (39)	42° 13′ 06	58° 33′ 80	March 25	95.0
Valdes (40)	42° 11′ 49	58° 31′ 75	April 6	96.0
Valdes (41)	42° 11′ 99	58° 31′ 92	April 29	97.1
Valdes (42)	42° 15′ 04	58° 35′ 01	June 2	99.5
Valdes (43)	42° 14′ 80	58° 35′ 28	June 2	100.0
Valdes West (44)	42° 16′ 70	59° 12′ 90	January 15	94.7
Valdes West (45)	42° 19′ 00	59° 06′ 80	January 15	95.6
Tango B (46)	42° 32′ 81	59° 15′ 71	April 29	92.8
Tango B (47)	42° 35′ 71	59° 15′ 21	June 3	96.0
AREA 4				
Sea Bay (48)	43° 38′ 30	62° 28′ 20	January 7	82.6
Sea Bay (49)	43° 52′ 90	63° 07′ 90	January 7	76.4
Sea Bay North (50)	43° 28′ 50	62° 51′ 60	January 13	78.5
Sea Bay North (51)	43° 18′ 00	62° 52′ 30	January 13	75.0
Sea Bay North (52)	43° 03′ 90	62° 49′ 80	January 13	73.8
San Jorge North (53)	45° 08′ 90	65° 23′ 90	January 9	85.0
Tres Puntas North (54)	45° 09′ 80	63° 33′ 70	Jan.uary 12	94.0
Tres Puntas Center (55)	45° 33′ 00	63° 02′ 00	January 12	98.8
Tres Puntas South (56)	46° 49′ 70	65° 28′ 40	January 10	53.5
Tres Puntas South (57)	47° 31′ 60	64° 37′ 20	January 11	101.0
Tres Puntas South (58)	46° 49′ 00	64° 12′ 60	January 11	113.0
Tres Puntas South (59)	46° 38′ 70	64° 06′ 10	January 11	98.0

not clustered in any of the groups. These four areas were characterized by their faunal composition (excluding unique presences).

Table 3 shows differences in the number of species, solitary and colonial, and their relative presence and dominance in each area. In general, solitary species with $P > 50$ belong to the Patagonian scallop assemblage described. *Z. patagonica*, the ophiuroids *O. vivipara*, *O. asperula*, *O. lymani*, and the anemone *A. crassicornis* accounted for 90.5 and 95.8 D in Area 1 (Reclutas bed) and Area 2 (San Blas, SAO and SWSAO beds) respectively. Area 3 (Valdes and Tango B beds) reached 93.0 D with *Z. patagonica*, the same three ophiuroid species and the echinoid *S. agassizii*, while the most abundant species in Area 4 (Sea Bay and Tres Puntas beds) were *Z. patagonica, O. lymani* and *A.*

Table 2. List of taxa collected in the *Zygochlamys patagonica* beds during 1995 in the Argentine Sea. Codes in brackets are the 39 most representative taxa.

PORIFERA	CRUSTACEA
Callyspongia sp.	*Ornatoscalpellum* sp.
Tedania sp. (Tsp)	Amphipoda
Iophon sp.	*Serolis schytei* Lütken, 1858 (Ssc)
Axinella sp.	Isopoda (Iso)
COELENTERATA	*Pagurus comptus* White, 1847 (Pco)
Sertularia sp.	*Pagurus gaudichaudi* H. Milne Edwards, 1836
Hydrozoa	*Eurypodius letreillei* Guérin,1828
Alcyonium sp.	*Libinia spinosa* Milne Edwards, 1934
Sphinteractis sp.	*Libidoclaea granaria* Milne Edwards & Lucas, 1842 (Lgr)
Choryactis sp.	*Peltarion spinosulum* (White, 1843)
Actinostola crassicornis (Hertwig, 1882) (Acr)	ECHINODERMATA
Pennatulacea	*Psolus patagonicus* (Ekman, 1925) (Ppa)
Flabellum sp.(Fsp)	*Pseudocnus dubiosus leoninus* (Semper, 1868) (Pdl)
POLYCHAETA	*Hemiodema spectabilis* (Ludwig, 1882)
Chaetopterus variopedatus (Ranier, 1807) (Cva)	*Austrocidaris canaliculata* (A. Agassiz, 1863) (Aca)
Aphrodita longicornis Kinberg, 1855	*Arbacia dufresnei* (Blainville, 1825)
Eunice argentinensis (Treadwell, 1929)	*Pseudechinus magellanicus* (Philippi, 1857)
Eunice magellanica McIntosh, 1885	*Sterechinus agassizii* Mortensen, 1910 (Sag)
Idanthyrsus armatus Kinberg, 1867	*Ctenodiscus australis* Lütken, 1871 (Cau)
Sabellidae	*Astropecten brasiliensis* Müller & Troschel, 1890
Serpula narconensis Baird, 1865	*Cycethra verrucosa* (Philippi, 1857) (Cve)
Spirorbidae	*Heliaster* sp.
BRYOZOA	*Calyptraster vitreus* Bernasconi, 1971 (Cvi)
Membraniporidae	*Henricia obesa* (Sladen, 1889) (Hob)
Porella sp.	*Diplasterias brandti* (Bell, 1881) (Dbr)
Ascophora	*Cosmasterias lurida* (Philippi, 1858) (Clu)
Bryozoa unid.	*Labidiaster radiosus* Lütken, 1871 (Lra)
BRACHIOPODA	*Gorgonocephalus chilensis* (Philippi, 1858) (Gch)
Magellania venosa (Solander, 1786)	*Amphiodia planispina* (von Martens, 1867)
Terebratella dorsata (Gmelin, 1790) (Tdo)	*Ophiuroglypha lymani* (Ljungman, 1870) (Oly)
MOLLUSCA	*Ophiacanta vivipara* Ljungman, 1870 (Ovi)
Calliostoma consimilis (Smith, 1881) (Cco)	*Ophiactis asperula* (Philippi, 1858) (Oas)
Photinula coerulescens (King, 1831) (Pco)	TUNICATA
Calyptraea pileolus (d'Orbigny, 1841) (Cpi)	*Didemnum* sp.
Argobuccinum magallanicum (Chemnitz, 1788) (Ama)	*Molgula* sp. (Msp)
Murex clenchi Carcelles, 1953 (Mcl)	*Culeolus* sp.
Buccinidae unid.	Ascidiacea 1
Glyptheutria sp. (Gsp)	Ascidiacea 2
Paraeuthria sp. (Psp)	Ascidiacea 3
Odontocymbiola magallanica Gmelin, 1791 (Oma)	Ascidiacea 4
Volvarina patagonica (Martens, 1881) (Vpa)	Ascidiacea 5
Admete magallanica Strebel, 1905 (Ama)	
Chaetopleura isabellei (d'Orbigny, 1841) (Cis)	
Zygochlamys patagonica (King & Broderip, 1832) (Zpa)	
Mytilus edulis platensis d'Orbigny, 1846	
Aulacomya ater ater (Molina, 1782)	
Hiatella solida Sowerby, 1834 (Hso)	
PICNOGONIDA	
Callipallenidae (Pic)	

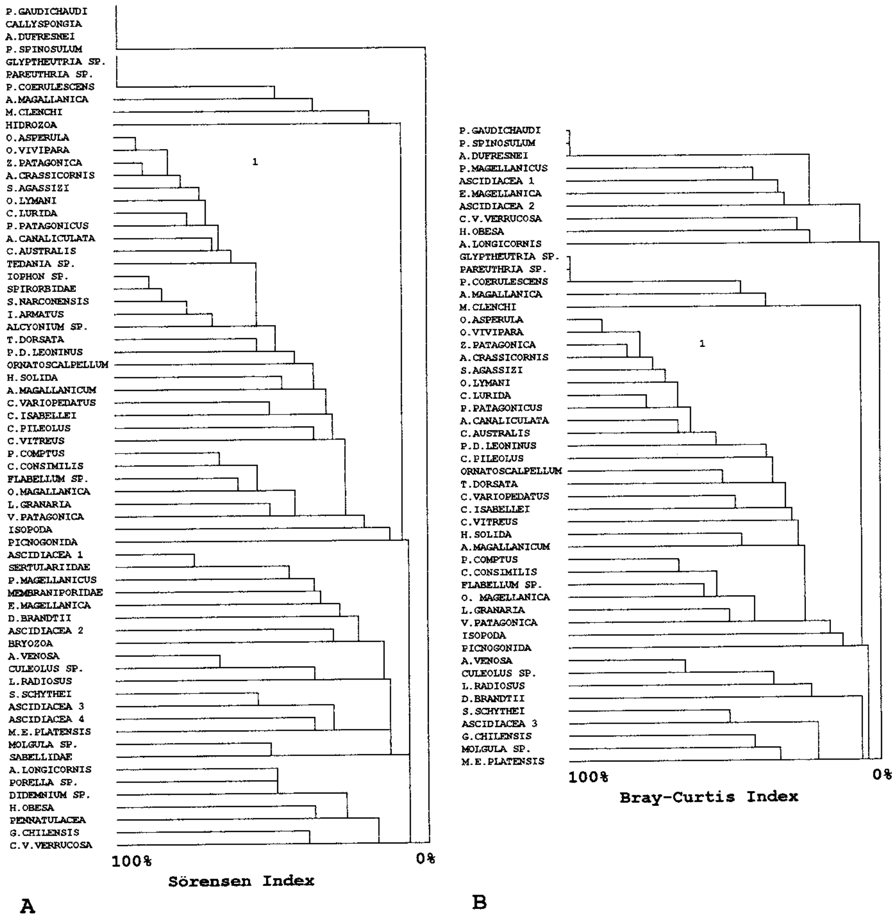

Figure 2. Dendrogram of species collected in the *Z. patagonica* assemblage (cluster 1) in the Argentine Sea during 1995. A) presence-absence data, B) abundance data.

canaliculata, reaching 71.5 D. The SIMPER test indicates that all the above mentioned species contributed most to the inter-site similarity (57.68).

Scallop epibionts were more diversified and showed higher P in Area 4, while the main colonial organisms were the sponge *Tedania* sp., frequently collected (P > 50) in Areas 1, 2 and 3, and the coelenterate *Flabellum* sp. in Area 1 (Table 3).

Scallop Index.—The scallop index averaged 21.13 (SD = 16.14, n = 12) and 38.79 (SD = 19.80, n = 12) in Areas 1 and 4, respectively. Higher average values were estimated for Areas 2 and 3: 52.14 (SD = 14.05, n = 10) and 57.75 (SD = 12.18, n = 18), respectively (Fig. 5).

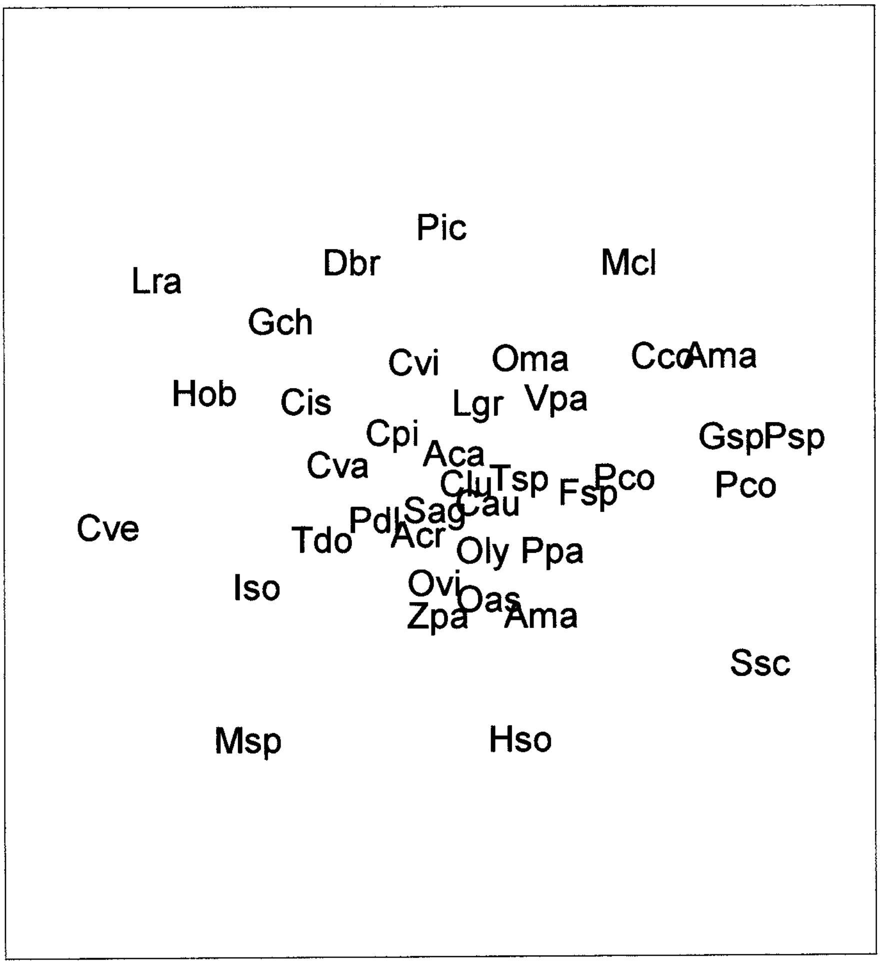

Figure 3. MDS-plot (stress value 0.17) of the 39 species collected in the *Z. patagonica* assemblage in the Argentine Sea during 1995 that accounted for 95% cumulative similarity (SIMPER test) (species codes in Table 2).

DISCUSSION

The finding and mapping of new commercial beds of *Z. patagonica* during 1995 (Lasta and Bremec, 1995, 1997) permits the present description of the macrobenthic assemblages in extensive areas of the Argentinian continental shelf (38°S–46°S) and adds information on the spatial distribution and composition of benthic communities in the Argentine Sea. Previous studies of the benthos concluded that three different ecological areas characterize the Argentine continental shelf, corresponding to its coastal, central and external zones (Roux et al. 1988, 1993; Bastida et al., 1992). Two major faunal groups were distinguished in those studies: one inhabiting the warmer inner shelf off Buenos Aires and northern Patagonia, and the other occupying the colder middle and outer shelf off Buenos Aires and most of the Patagonian shelf. The presence of *Z. patagonica* was

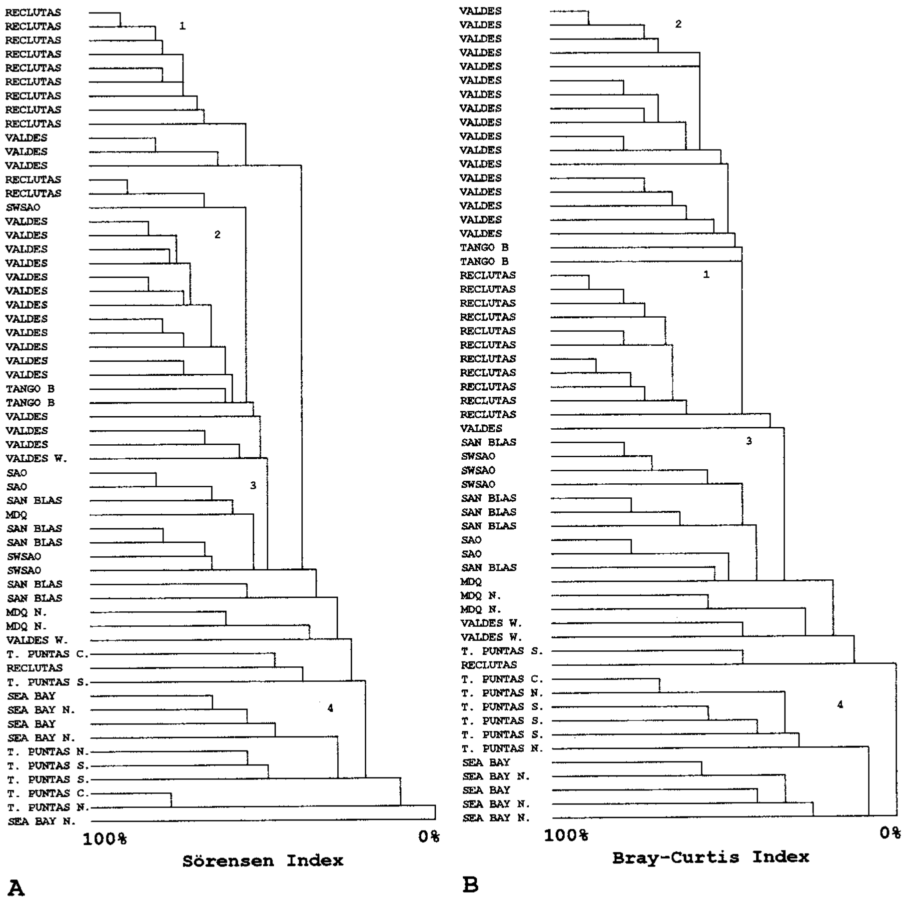

Figure 4. Dendrogram of samples collected in the *Z. patagonica* assemblage in the Argentine Sea during 1995. a) presence-absence data, b) abundance data. Clusters 1–4 represent the different Areas.

reported in sampling stations from the central (55–164 m depth) and external areas (83–192 m depth) of the shelf, in a depth range between 72 and 159 m, distributed together with species of magellanic origin (Roux et al., 1993). Those two ecological areas correspond to what is traditionally called the Patagonian district of the Magellanic Zoogeographic Province, corresponding to the Subantarctic Biogeographical Complex (Boltovskoy, 1981). The invertebrate species that make up the Patagonian scallop assemblage described in this study mainly correspond to fauna of magellanic origin (Balech, 1964; Bernasconi, 1964; Boschi, 1979; Castellanos, 1967; Orensanz, 1974) and the taxonomic results of this extensive sampling fit well with the zoogeographical scheme proposed by these authors.

This study demonstrates the regular distribution and quantitative dominance of *Z. patagonica* in the prospected zone. Main structural differences among the four defined areas correspond to the variable spatial distribution of species (P) and the relative proportions of colonial and solitary organisms. Although noticeable differences were found in

Table 3. List of taxa without single presence collected in the different areas determined through cluster analyses in the study area. P = % Presence, D = % Dominance, C = colonial, S = solitary, E = epibiont, S = number of species, n = number of individuals.

Taxa	Area 1		Area 2		Area 3		Area 4	
	P	D	P	D	P	D	P	D
Callyspongia sp.							16.7	C
Tedania sp.	91.7	C	50.8	C	63.2	C	25	C
Iophon sp.	25	C E	67.8	C E	89.5	C E	66.7	C E
Sertularia sp.							41.7	C E
Hydrozoa					15.8	C E	16.7	C E
Alcyonium sp.	50	C E	54.2	C E	73.7	C E	33.3	C E
A. Crassicornis	100	3.1	81.4	6.6	84.2	0.8	50	0.6
Pennatulacea					10.5	C		
Flabellum sp.	75	C	22	C				
C. variopedatus					68.4	0.6	25	1.2
A. longicornis							16.7	0.2
E. magellanica							33.3	0.5
I. armatus	25	S E	50.8	S E	78.9	S E	50	S E
Sabellidae			20.3	S E			41.7	S E
S. narconensis	16.7	S E	52.5	S E	78.9	S E	33.3	S E
Spirorbidae			55.9	S E	84.2	S E	58.3	S E
Membraniporidae	25	C E			10.5	C E	41.7	C E
Porella sp.							16.7	C E
Bryozoa Unid.							16.7	C E
M. venosa							50	S E
T. dorsata					63.2	S E	33.3	S E
C. isabellei					36.8	0.2		
C. consimilis	41.7	0.2						
P. coerulescens	16.7	0.1						
C. pileolus	25	S E			52.6	S E		
A. magallanicum	66.7	0.8	37.3	1.2	10.5	0.01		
Glyptheutria sp.	16.7	0.1						
Paraeuthria sp.	16.7	0.1						
O. magallanica	66.7	0.2			10.5	0.01		
V. patagonica	50	0.4			21.1	0.2		
A. magallanica	16.7	0.3						
Z. patagonica	100	31.9	100	29.1	100	26.7	100	49
H. solida	25	S E	18.6	S E	15.8	S E		
Callipallenidae					21.1	0.1		
Ornatoscalpellum sp.	25	S E	37.3	S E	31.6	S E	41.7	S E
Isopoda					42.1	0.2		
P. comptus	75	0.4						
P. gaudichaudi							16.7	0.2
L. granaria	58.3	1.7	40.7	0.1	36.8	0.1	41.7	0.5
P. spinosulum							16.7	0.2
P. patagonicus	91.7	0.7	50.8	0.1	78.9	0.8		
P. D. leoninus	33.3	0.2			78.9	1.8		
A. canaliculata	83.3	0.8			57.9		25	4.1
A. dufresnei							16.7	0.5

Table 3. Continued.

Taxa	Area 1		Area 2		Area 3		Area 4	
	P	D	P	D	P	D	P	D
P. magellanicus							75	13
S. agassizi	75	0.8	62.7	0.9	94.7	3.9		
C. australis	100	1.3	57.6	0.3	52.6	0.3	50	0.7
C. verrucosa					15.8	0.01	25	0.2
C. vitreus	16.7	0.1			36.8	0.1		
H. obesa					15.8	0.01	16.7	0.4
D. brandti					21.1	0.1	41.7	1
C. lurida	100	1	50.8	0.3	63.2	0.3		
L. radiosus							25	0.3
G. chilensis					10.5	0.01	16.7	0.2
O. lymani	83.3	9.1	54.2	1.6	68.4	8.1	25	18.4
O. vivipara	100	34	72.9	7.8	100	28.9		
O. asperula	91.7	12.4	67.8	50.7	94.7	25.4		
Didemnum sp.							16.7	C E
Molgula sp.					10.5	0.1	16.7	0.5
Culeolus sp.							25	0.5
Ascidiacea 1			13.6	0.1	10.5	0.6	25	1.6
Ascidiacea 2							50	1.8
Sample n°	12		10		19		12	
S (without single presence)	32		22		39		39	
n	5,541		3,031		7,162		2,126	
S (scallop epibionts)	6		7		8		13	

the 'scallop indices' estimated for different areas, the composition of associated invertebrates in the by-catch represents a conspicuous epibenthic assemblage along the latitudinal range.

Other studies (Lasta and Bremec, 1995, 1997, 1998) show that Reclutas bed (Area 1) was characterized by large concentrations of *Z. patagonica* recruits and juveniles during the study period, while larger individuals predominate in the other beds. In relation to this, the low frequency of occurrence of epibionts in specimens from Area 1 is to be expected. Adult scallops from Areas 2, 3 and 4 were heavily encrusted by suspension feeding animals. The sponge *Iophon* sp. and polychaetes, in general the same species found on Patagonian scallops in the Magellan Strait (Sanfilippo, 1994) were the main epibionts.

Some species present in the *Z. patagonica* assemblage herein studied are predators: starfishes (*C. lurida*, *C. australis*), gastropods (*Argobuccinum magellanicum*, *Odontocymbiola magellanica, Volvarina patagonica*) and crabs (*Libidoclaea granaria*, *Pagurus comptus*). Studies on *Argopecten purpuratus* in northern Chile (Wolff and Alarcón, 1993) concluded that a crab, two starfish and two snail species closely associated with the scallops are predators, suggesting interdependence of the total epibenthic macroinvertebrate biomass with scallop abundance (about 30% of total biomass). On the other hand, the role of epizoic sponges to reduce predation of scallops by starfish has been considered in the literature, principally reducing adhesion of their tube-feet to the shell (Bloom, 1975;

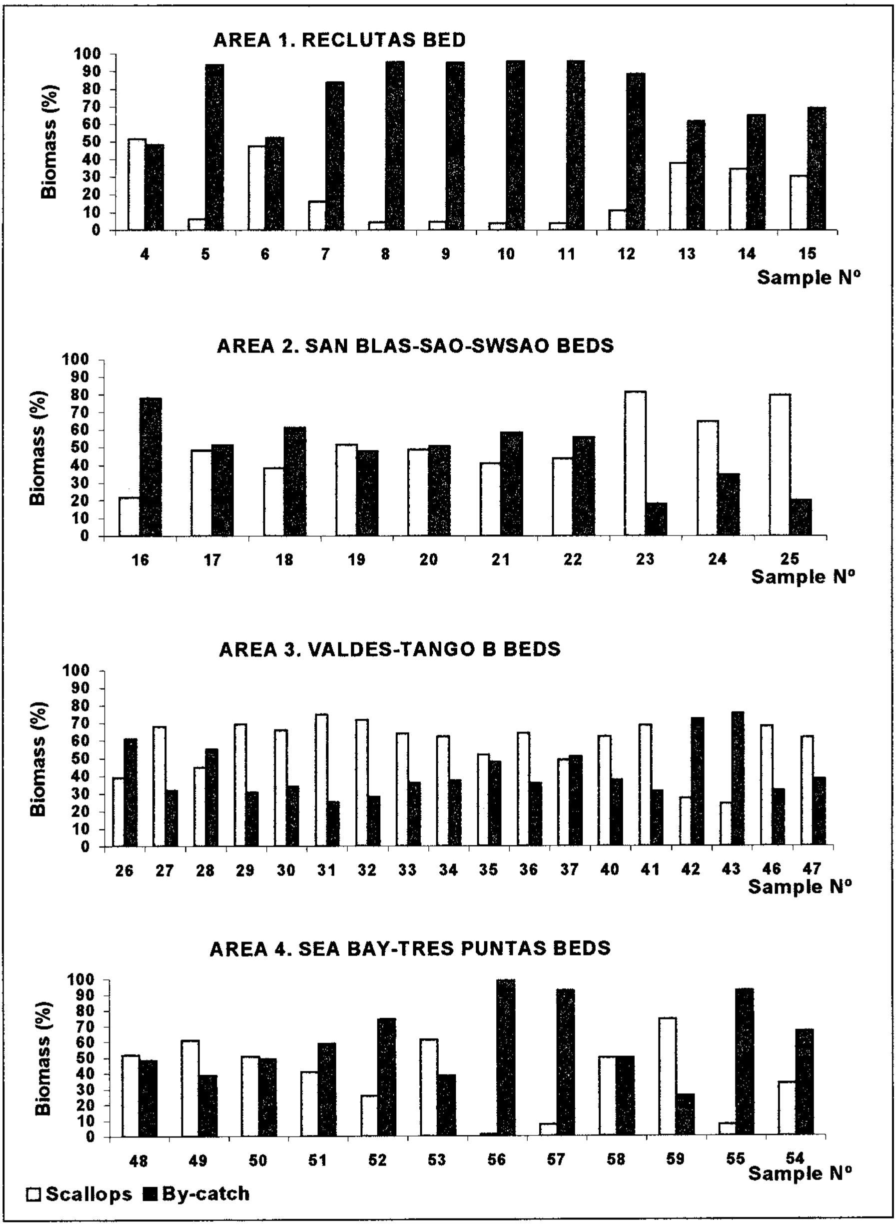

Figure 5. Relative percentages of biomass (kg) of scallops (scallop index) and by-catch in the four Areas determined through cluster analysis (Q mode) of samples collected during 1995 in Patagonian scallop beds (Sample number in Table 1).

Vance, 1978; Brand, 1991). Therefore, further work is needed to assess the main trophic interactions and the potential activity of predators and epibionts in structuring this community, including consideration of the disturbances due to fishing activity since 1996. It was observed that trawling severely impacts the natural faunal associations on fishing grounds (Ciocco, 1988; Langton and Robinson, 1990; Rumohr and Krost, 1991;

Strokesbury and Himmelman, 1993, 1995; Brand et al., 1997) and greatly increases the activity of predators (Caddy, 1973), implying a potential risk to recruitment (Strokesbury and Himmelman, 1993). Estimates of annual production in Reclutas bed (Area 1) (Bremec et al., 2000), experimental studies of effects of trawling on Valdes bed (Area 3) (Bremec and Lasta, 1998, 1999) and similar studies on Georges Bank (Collie et al., 1997), British Isles (Hall-Spencer and Moore, 2000) and Australia (Moran and Stephenson, 2000) showed sessile taxa are extremely sensitive to fishing.

Other possible consequences of disturbance could be negative effects on suspension-feeding scallops produced by sediment removal, alteration of the primary settlement substrates due to bottom modifications and incidental fishing mortality of discarded or damaged specimens, that could interfere in species interactions (Orensanz et al., 1991; Alverson et al., 1994). The role of scallop beds in increasing spatial complexity of the soft bottoms and thus in providing ecological niches has been stressed out in several studies on different taxa associated to *Z. patagonica* in the Magellan Strait (Di Gerónimo et al., 1992; Lorenti and Mariani, 1997; Gambi and Mariani, 1999).

The numerical dominance of a few species was found in the study area, reflecting the pristine condition of the Patagonian scallop assemblage. Areas 1, 2 and 3 conform an extensive zone, from 38°S to 43°S and between 90–110 m depth (Fig. 1), influenced by a shelfbreak front, observed as a maximum horizontal temperature gradient (Martos and Piccolo, 1988; Baldoni, 1993). The high productivity of the shelfbreak front is well documented on the basis of remote sensing and in situ measurements (Brandhorst and Castello, 1971; Carreto et al., 1981, 1995; Podestá and Esaías, 1988). Lower and higher average 'scallop indices' reflect, in this case, abundance of juvenile scallops in Area 1 and abundance of adult scallops in Areas 2 and 3, respectively (Lasta and Bremec, 1998). The beds clustered in these three areas along the 100 m isobath are influenced by the productive shelfbreak front, where food availability, factor related with growth (Griffiths and Griffiths, 1987; Barber and Blake, 1991) and limiting of population size in scallops (Olivier and Capitoli, 1980; Orensanz et al., 1991), is considered to be high. Studies on feeding of *Z. patagonica* in Reclutas bed (Area 1) during an annual period clearly demonstrate that maximum food ingested in November is related to the oceanographic condition (thermocline still in formation), fact probably linked with the maximum somatic growth registered for the species (Schejter et al., 2000). Due to higher production, commercial fishing is conducted in beds associated to the shelfbreak front (Areas 1, 2 and 3), covering swept areas that increased from 199 km^2 in 1995 to 1547 km^2 in 2000 (Lasta et al., 2001).

Area 4 includes beds influenced by different water masses. Sea Bay bed (44°S) is associated to the intermediate shelf regime, with lower productivity (Carreto and Benavides, 1990) due to the strong seasonal variations in the vertical structure of the water column (Bianchi et al., 1982; Krepper, 1977). Tres Puntas bed (47°S) is associated to a coastal regime (Brandhorst and Castello, 1971), characterized by tidally mixed water, with high concentrations of nutrients and chlorophyll reported (Bertolotti et al., 1996).

This study provides baseline information that will make it possible to detect structural changes in the scallop assemblage during the development of the fishery and to formulate conservation recommendations. The establishment of marine reserve areas has been recommended as management criteria (Lasta and Bremec, 1997), as the different time scales of humans and benthic communities imply that refuges are needed to protect species from collapse (Pauly, 1997) and environmental parameters must be considered for appropiate management of the stocks (Parsons, 1996). In this sense, by-catch controls are permanently carried out by observers onboard the fishery vessels, in order to collect information about the relative biomass of shells, scallops, damaged and not damaged by-catch in Patagonian scallop fishing grounds. This will permit short and long term studies of the main effects of trawl impact and fluctuations of non-target species, which are in general poorly studied in comparison with the commercial resource.

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