Benthic communities of the Argentine continental shelf

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Southwestern Atlantic
Biogeography
Sediments

Communautés benthiques
Plateau continental argentin
Sud-Ouest Atlantique
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ABSTRACT

The benthic macroinvertebrate assemblages of the Argentine continental shelf were studied from samples of molluscs, echinoderms and bryozoans collected by the R/V *Shinkai Maru*. Two major faunal groups were distinguished: 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. These results confirm the traditional biogeographic division of the Argentine continental shelf into two provinces: Argentine and Magellanic. Furthermore, the results suggest the possibility of subdividing the Atlantic sector of the Magellanic province into two districts: Patagonian and Malvinean, under the influence of the Patagonian and the Malvinas current, respectively.

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RÉSUMÉ

Communautés benthiques du plateau continental argentin

L'étude des assemblages de macroinvertébrés benthiques du plateau continental argentin a été effectuée à partir d'échantillons de mollusques, d'échinodermes et de bryozoaires, récoltés par le N.O. *Shinkai Maru*. Deux principaux ensembles faunistiques ont été identifiés : l'un habitant la partie intérieure chaude du plateau en face de Buenos Aires et du nord de la Patagonie ; l'autre occupant le centre et la partie externe, également en face de Buenos Aires, ainsi que la plus grande partie du plateau patagonien. Ces résultats confirment la division biogéographique traditionnelle du plateau continental argentin en deux provinces : argentine et magellanique. De plus, les résultats suggèrent la possible subdivision en deux districts du secteur atlantique de la province magellanique : patagonien et malouinien, étant respectivement sous l'influence des courants patagonien et des Malouines.

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INTRODUCTION

Ecological studies of the marine benthic communities of Argentina began in the early 1960s with descriptions of intertidal and subtidal communities of Patagonia (*e. g.*, Ringuelet *et al.*, 1962; Olivier *et al.*, 1966) and the coast of Buenos Aires province (*e. g.*, Olivier *et al.*, 1968 *b*). Since then, numerous studies have provided additional information on those assemblages. Few studies of benthic communities of the Argentine continental shelf (ACS) have been made and little is known about their components and structure. Until recently, only the continental shelf off the coast of Buenos Aires had been sampled: Olivier *et al.* (1968 *a*) carried out a short-term survey of a small area of the continental shelf, while Roux *et al.* (1988) sampled several transects perpendicular to the coast.

An intergovernmental agreement between Argentina and Japan has permitted several exploration cruises by the R/V *Shinkai Maru* over the whole ACS from April 1978 until April 1979 (Cousseau *et al.*, 1979; Angelescu, 1981). Although these cruises were not planned for benthic studies, bottom samples collected in some of them (IV, V, X and XI) made it possible to produce a general view of the benthic communities of the continental shelf. Bastida and Urien (1981) analyzed the sediments of the *Shinkai Maru* collections to determine the granulometric patterns of the continental shelf. Castellanos and collaborators (Castellanos 1979 *a*; 1979 *b*; 1981; 1982 *a*; 1982 *b*; 1983; Castellanos and Landoni, 1982; Castellanos *et al.*,1987), López Gappa and Lichtschein (1988; 1990) and Roccatagliata (1985; 1986) have respectively identified molluscs, bryozoans and cumaceans collected during the cruises.

In this paper we describe the main macroinvertebrate assemblages found throughout the ACS and discuss possible factors determining the observed biogeographic patterns. The analysis was based mainly on the groups that were most abundantly represented in the samples, namely, molluscs, echinoderms, and bryozoans. We draw comparisons with distribution patterns described for fishes (*e. g.*, Menni and Gonsztonyi, 1982; Menni and López, 1984); and discuss the possible biogeographic implications of our findings.

GENERAL CHARACTERISTICS OF THE ARGENTINE CONTINENTAL SHELF

Water masses

The ACS is affected by different water masses. The Malvinas current is a northward-running branch of the subantarctic Cabo de Hornos current that affects both coastal and offshore areas. As it moves northward, the Malvinas current separates from the coast and affects only offshore waters. This flowing pattern has seasonal variations. Mean temperature ranges yearly from 4° to 11°C. Salinity ranges yearly from 33.8 to 34.4. The high primary productivity of the Malvinas current supports very important fisheries in this part of the Southwestern Atlantic.

The Brazil current is a branch of the South Equatorial current and moves from north to south along the Brazilian coast. The Brazil and Malvinas currents meet at the subtropical convergence at approximately 35° S. The convergence affects mainly oceanic areas but also has some influence on the ACS where faunistic elements typical of tropical waters are sporadically found. Brazil current waters are less productive than those of Malvinas. Mean temperature ranges yearly from 14° to 25°C, and salinity from 35 to 35.5 (Boltovskoy, 1981).

A third water mass, the Patagonian current, is restricted to the coastal zone of the ACS, and flows between the coast and the Malvinas current. The Patagonian current is a relatively stable water mass (Brandhorst and Castello, 1971) of subantarctic origin, that moves mostly northward reaching up to 38°S. Its mean temperature, variable both with latitude and season, ranges yearly from 5° to 16°C, and its salinity from 33 to 33.5.

Sediments

The topography of the ACS is correlated to the principal morphostructural units of this part of the continent: the Pampian plain, the Patagonian plateau and the Fuegian range. Their main features can be recognized on both coast and shelf. Although the shelf appears very homogeneous due to its great extension and smooth slope, linear shoals, stairs, channels and ridges, probably related to an old sea level, can be found at different latitudes. The shelf's topography is particularly complex at 100 m; this could be related to a level of momentary stabilization of the ancient coastal line (Fray and Ewing, 1963; Richards and Craig, 1963; Urien, 1970; Urien and Ewing, 1974; Parker *et al.*, 1978; Bastida and Urien, 1981).

Submarine ridges and channels extend from the Rio de la Plata estuary across the shelf. Off the coast of Buenos Aires, the shelf shows a series of linear shoals and ridges related to tidal currents. The Patagonian shelf shows bars in sand dominated areas. The large-amplitude tides of Patagonia generate high-energy hydraulic conditions that leave their marks along the shelf. Several important Patagonian gulfs and bays constitute typical sediment traps. The shelf off Tierra del Fuego (south of the Magellan Strait) appears more rugged, with sectors of marked slope and zones with periglacial formations.

The ACS is characterized by a homogeneous layer of unimodal fine and medium size sand (Median Phi. 2.5 = 0.177 mm) which constitutes the main component of the sediment. In some areas this layer is up to 2 m thick (Urien and Ewing, 1974; Bastida and Urien, 1981). This sand has originated on beaches or coastal areas and was deposited on the shelf during the lateral migration of the coastal line from east to west.

Many different materials are mixed with the sandy basal sediment throughout the shelf. Some places show a high percentage of gravel formed either by small pebbles or bioclasts from different invertebrate groups. Areas asso-

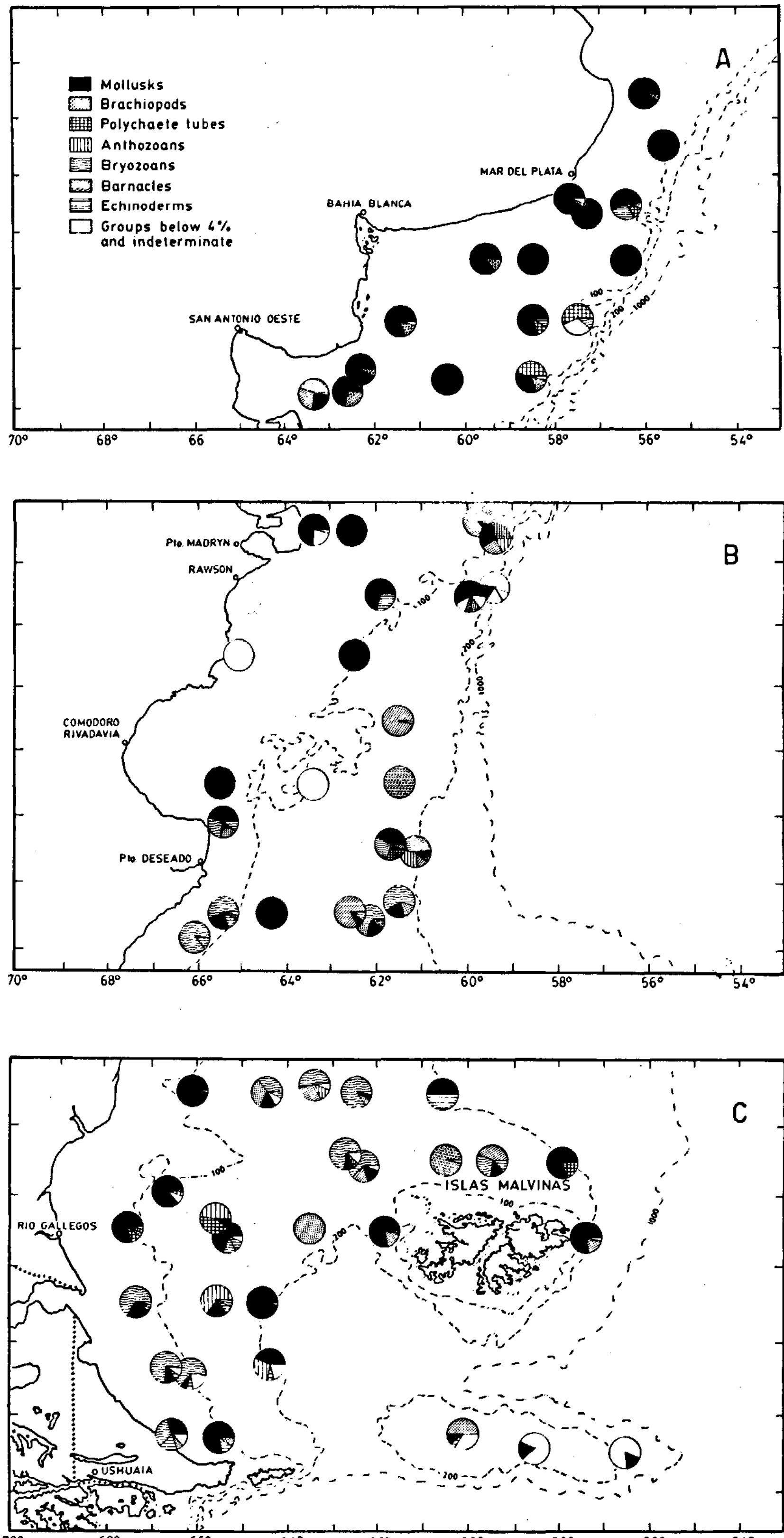

Figure 1

Composition of the bioclasts for each of the stations sampled during the R/V Shinkai Maru *(IV, V, X, and XI) cruises.*

ciated with estuaries, gulfs and bays present fine sediments (mud-sand). Hard-bottom areas seem to be scarce but they are probably under-represented due to the inherent difficulties of sampling this substrate. The concentration of carbonate, most of biological origin, in the sediment is lower than that in tropical zones but some areas show fairly high concentrations. For a thorough discussion on the sediments collected during the *Shinkai Maru* cruises, *see* Bastida and Urien (1981).

Bioclasts

Most bioclasts in the superficial sediments come from recent benthic communities but the sub-bottom bioclasts come from fossil communities of various ages (Bastida and Urien, 1981).

The bioclasts of the ACS show a variable degree of fragmentation and wearing depending on the area considered.

Table 1

List of the stations sampled during the R/V Shinkai Maru *(IV, V, X, XI) cruises.*

Cruise	Station	Date	Latitude S	Longitude W	Depth (m)	Bottom temp. (°C)	Number of species	Area
IV	3	16/7/78	37° 28'	55° 30'	80	6.7	3	B
IV	5	18/7/78	38° 31'	57° 25'	65	10.8	14	A
IV	14	19/7/78	39° 29'	56° 26'	90	6.5	22	C
IV	13	19/7/78	39° 30'	57° 28'	90	6.8	1	C
IV	16	21/7/78	40° 29'	61° 35'	35	10.5	33	A
IV	30	22/7/78	42° 30'	62° 29'	78	10.6	4	B
IV	33	23/7/78	42° 30'	59° 28'	102	6.0	34	C
IV	60	27/7/78	46° 29'	60° 28'	155	5.0	9	C
IV	71	28/7/78	48° 30'	62° 31'	141	6.0	52	C
IV	93	30/7/78	50° 31'	60° 29'	154	5.3	25	C
IV	96	1/8/78	50° 32'	57° 56'	143	4.8	17	C
IV	128	9/8/78	54° 30'	64° 25'	111	5.4	37	C
IV	119	10/8/78	53° 31'	66° 27'	95	4.6	63	C
IV	108	11/8/78	52° 31'	67° 18'	92	5.5	51	C
IV	111	12/8/78	52° 29'	64° 35'	183	4.8	50	C
IV	92	14/8/78	50° 30'	62° 31'	159	5.1	53	C
IV	89	15/8/78	50° 29'	65° 30'	117	5.3	34	C
IV	69	16/8/78	48° 27'	64° 24'	110	6.0	10	C
IV	50	18/8/78	45° 26'	63° 21'	104	6.6	2	B
V	11	26/8/78	39° 30'	59° 30'	60	9.6	9	A
V	19	27/8/78	40° 30'	58° 30'	88	6.8	23	B
V	26	29/8/78	41° 32'	60° 21'	67	9.5	6	A
V	24	29/8/78	41° 42'	62° 30'	50	9.5	15	A
V	36	31/8/78	43° 27'	63° 29'	72	8.7	4	B
V	37	31/8/78	43° 31'	61° 59'	91	8.0	9	B
V	51	2/9/78	45° 31'	61° 29'	113	6.0	3	C
V	65	3/9/78	47° 30'	61° 26'	144	5.0	27	C
V	Ad.3	5/9/78	49° 25'	63° 26'	145	6.0	24	B
V	76	5/9/78	49° 30'	66° 09'	98	5.5	3	B
V	99	6/9/78	51° 32'	67° 35'	100	4.5	10	B
V	101	7/9/78	51° 29'	65° 32'	134	5.0	8	B
V	102	7/9/78	51° 30'	63° 19'	180	5.3	16	C
V	79	9/9/78	69° 27'	62° 28'	152	5.5	42	C
V	81	9/9/78	49° 30'	60° 32'	178	4.8	4	C
X	1	13/1/79	36° 32'	56° 01'	20	19.0	3	A
X	6	14/1/79	38° 31'	56° 22'	85	6.3	10	B
X	5	15/1/79	38° 30'	57° 27'	57	11.8	16	A
X	12	16/1/79	39° 31'	58° 28'	83	7.3	16	B
X	16	17/1/79	40° 25'	61° 34'	30	19.6	33	A
X	28	18/1/79	41° 31'	58° 28'	83	6.3	22	C
X	24	19/1/79	41° 30'	62° 31'	44	18.5	2	A
X	Ad.1	20/1/79	42° 28'	63° 19'	56	15.0	26	A
X	40	21/1/79	43° 27'	59° 32'	145	4.8	18	C
X	44	22/1/79	44° 30'	62° 29'	103	6.0	6	B
X	52	23/1/79	45° 28'	61° 23'	114	5.5	9	C
X	59	24/1/79	46° 28'	61° 30'	121	5.0	9	C
X	65	25/1/79	47° 29'	61° 29'	149	5.2	33	C
X	72	26/1/79	48° 21'	61° 27'	145	4.8	50	C
X	95	29/1/79	50° 29'	59° 29'	152	4.5	24	C
X	106	30/1/79	51° 38'	57° 18'	189	6.4	32	C
X	138	2/2/79	54° 30'	56° 35'	135	4.8	22	C
X	135	3/2/79	54° 30'	58° 30'	133	6.8	23	C
X	133	4/2/79	54° 16'	60° 03'	100	5.7	28	C
X	122	5/2/79	53° 18'	64° 25'	169	6.5	24	C
X	128	6/2/79	54° 20'	65° 28'	93	9.0	9	B
XI	Ad.11	16/2/79	54° 13'	66° 33'	55	11.1	27	B
XI	120	17/2/79	53° 25'	66° 28'	92	9.0	33	B
XI	111	18/2/79	52° 27'	65° 31'	125	7.5	17	C
XI	105	19/2/79	51° 29'	61° 50'	192	5.0	8	C
XI	101	20/2/79	51° 24'	65° 29'	135	7.2	17	C
XI	92	21/2/79	50° 27'	62° 35'	154	6.5	16	C
XI	82	22/2/79	49° 28'	60° 28'	188	4.3	12	C
XI	71	23/2/79	48° 29'	62° 32'	138	5.5	23	C
XI	55	24/2/79	46° 31'	6S° 27'	72	12.5	6	B
XI	57	26/2/79	46° 30'	63° 26'	115	7.0	14	B
XI	Ad.5	28/2/79	47° 04'	65° 27'	70	13.0	10	B
XI	Ad.6	1/3/79	48° 52'	66° 08'	100	10.0	6	B
XI	88	3/3/79	50° 55'	66° 43'	96	9.5	18	B
XI	78	4/3/79	49° 29'	64° 29'	120	6.2	10	B
XI	68	5/3/79	48° 27'	65° 27'	103	10.5	28	B
XI	Ad.3	6/3/79	44° 34'	65° 01'	82	12.5	6	B
XI	Ad.14	8/3/79	43° 33'	59° 50'	116	5.7	16	C
XI	23	9/3/79	41° 46'	63° 13'	65	17.5	36	A
XI	33	10/3/79	42° 29'	59° 29'	95	6.3	20	C
XI	20	11/3/79	40° 31'	57° 30'	98	6.0	17	C

Those from Banco Burwood (south of Islas Malvinas) and the south shore of the Islas Malvinas present little fragmentation but a high degree of erosion (wearing), while bioclasts from the Buenos Aires zone range from sand-like beads to whole exoskeletons.

The animal groups most ubiquitously represented by bioclasts in the sediments are, in decreasing order of importance: molluscs, barnacles, bryozoans, brachiopods, echinoderms, polychaetes (serpulids), anthozoans (solitary madreporarians), and sponges. Only clasts bigger than 2 mm were analyzed so that small-sized groups (*e. g.*, several species of forams) may be under-represented.

On the basis of the composition of the bioclasts, the ACS has been latitudinally divided in three sectors (*cf.* Bastida and Urien, 1981). The first includes the shelf off Buenos Aires and northern Patagonia down to Península Valdés [42°S (Fig. 1 *a*)]. In this area, the inner and middle shelf zones are dominated by molluscs, while barnacles are second in abundance. In some locations molluscs represent 100 % of total carbonates. The outer shelf shows higher diversity of bioclasts. Serpulids, bryozoans, brachiopods and echinoderms are common and sometimes more abundant than molluscs. Locations in the outer shelf off Buenos Aires resemble those of the Patagonian coast. Bioclasts from brachiopods begin to appear in coastal samples south of the 41°S but are never found in coastal samples of the Buenos Aires shelf.

The second sector extends from Península Valdés to 49°S (Fig. 1 *b*). In general the area shows higher diversity of bioclasts with some locations being dominated by groups different from those found in the first sector but typical of Patagonia. Such is the case of bryozoans that are very abundant throughout the benthic communities of Patagonia (López Gappa and Lichtschein, 1988; López Gappa and Lichtschein, 1990). In some stations, however, molluscs remain the dominant bioclasts.

The third sector ranges from 49° to 55° S (Fig. 1 *c*). Sediment samples from this sector are quite variable. Samples from the shelf between southern Patagonia and Islas Malvinas show high diversity of bioclasts and, in general, low percentage of carbonates. Stations with higher carbonate content are dominated mainly by molluscs. Bryozoan bioclasts are important in some stations on the coast and in the northern part of the sector. Bioclasts of echinoderms, mostly ophiuroids and echinoids, are present in a high percentage of the samples but their abundance is variable. Bioclasts of the solitary corals of the genus *Flabellum*, found only south of Península Valdés, are more common here than in the second sector. Bioclasts from Banco Burdwood are usually large, but their origin is difficult to determine because of their high degree of wearing. Among the groups whose identification is possible, brachiopods, barnacles and molluscs are dominant.

METHODS

The Argentine continental shelf occupies a large area that reaches a maximum width - 400 miles/640 km - at 52°S. A

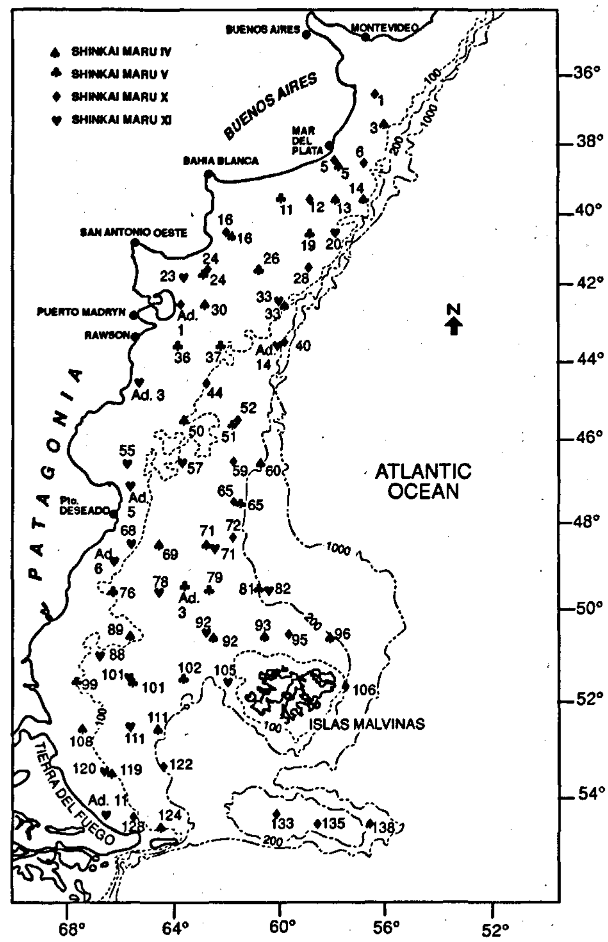

Figure 2

Distribution of the stations sampled during the R/V Shinkai Maru *(IV, V, X, XI) cruises.*

total of 75 stations were sampled during the R/V *Shinkai Maru* cruises IV, V, X and XI (Tab. 1 and Fig. 2). The sampling area extended from 36° 32' S to 54° 30' S and from 55° 30' W to 68° 42' W. Depth ranged from 20 to 192 m. Samples, including organisms and sediment, were collected using a Picard dredge with a 60 by 23 cm mouth (a modified version of the classic Charcot dredge with a canvas bag for quantitative sampling). Sampling tests using Petersen, Ekman bridge and other grabs showed that they were less efficient than Picard dredge due to both the bottom characteristics and the extreme turbulence and strong currents of some areas of the ACS.

Sampled sediment volumes varied from 25 to 125 dm^3 (mean: 50 dm^3), and were always above the determined minimum volume. For details on sampling and processing of sediment *see* Bastida and Urien (1981). Samples were filtered on shipboard through a series of sieves. All the organisms retained by a 1 mm mesh were fixed in 5 % neutralized formalin. Once in the laboratory, organisms were taxonomically sorted, identified (to the specific level when possible), and preserved in 70 % alcohol. Basic hydrographic parameters (bottom temperature, depth, *etc.*) were measured for each station (data compiled by Cousseau *et al.*, 1979).

Fifteen animal phyla were represented in the sampling, but only molluscs, bryozoans and echinoderms, were included in our analysis because they were found in a high percentage of the samples: molluscs (90 %), echinoderms (92 %) and bryozoans (69 %). Polychaetes, another relatively abundant group, had to be excluded owing to the insufficient taxonomic knowledge of the species inhabiting the ACS.

A total of 450 species of the three chosen phyla were identified. The total abundance (*i. e.*, number of individuals) of each species was plotted in a stations by species data matrix. Species found only once throughout the sampling were deleted from the original matrix. A total of 184 species was retained for further analysis.

Two secondary matrices were computed from the purged data matrix (75 stations x 184 species): a station-by-station similarity matrix using the Czekanovsky Index, and a species by species similarity matrix using the Jaccard Index (Stirn, 1981).From these two matrices, station and species were then grouped by cluster analysis using UPGMA (Sokal and Sneath, 1963). The results of these groupings are shown in the dendrograms of Figures 3 and 6.

RESULTS AND DISCUSSION

The dendrogram of the cluster analysis of stations is shown in Figure 3. Three well-defined groups of stations were established. These groups correspond to areas of the ACS that have been previously recognized in studies of the Argentine-Uruguayan common fishing zone and the Buenos Aires zone (Bastida and Urien, 1981; Roux *et al.*, 1988). Here, we keep the names that were previously given to these areas, namely: A, B and C (Fig. 4). Relevant information about each area is presented in Figure 5 *a*.

Area A occupies the inner shelf from Cabo San Antonio (36°S) to Península Valdés (42°S). This area corresponds to what is traditionally called the Bonaerensian district of the Argentine zoogeographic province (*cf.* Seminario sobre biogeografia de los organismos marinos, 1964). Area A is under the indirect influence of Brazil current waters (*i. e.* temperate and of relative low productivity). Almost 16 % of the total number of species included in our analysis were found exclusively in this area (*e. g.*, *Tegula patagonica*, *Aloidis lyoni*, *A. caribaea*, *Crassinella marplatensis*, *C. lunulata*). Both epifaunal (*e. g.*, *Mytilus platensis*, *Crepidula* spp., *Plicatula spondyloidea* and *T. patagonica*) and infaunal (*Nucula puelcha*, *Transempitar americana* and *Crassinella marplatensis*) species were present.

Area B is the second largest. It extends along the Patagonian coast from Tierra del Fuego to Península Valdés, and then wedges between areas A and C off northern Patagonia and Buenos Aires. This area is mainly under the influence of the subantarctic Patagonian current and can be considered a transitional zone. A total of 112 species were found in this area but only one species was exclusive to B and was present in few samples. Almost all of the species inhabiting B were also present in C, but only a few were shared exclusively by A and B (*see* Fig. 5 *a*). Thus, area B was characterized by the absence of some of the species typical of area C and it might be defined as an impoverished area C. Areas B and C together correspond to what is traditionally called the Patagonian district of the Magellanic zoogeographic province.

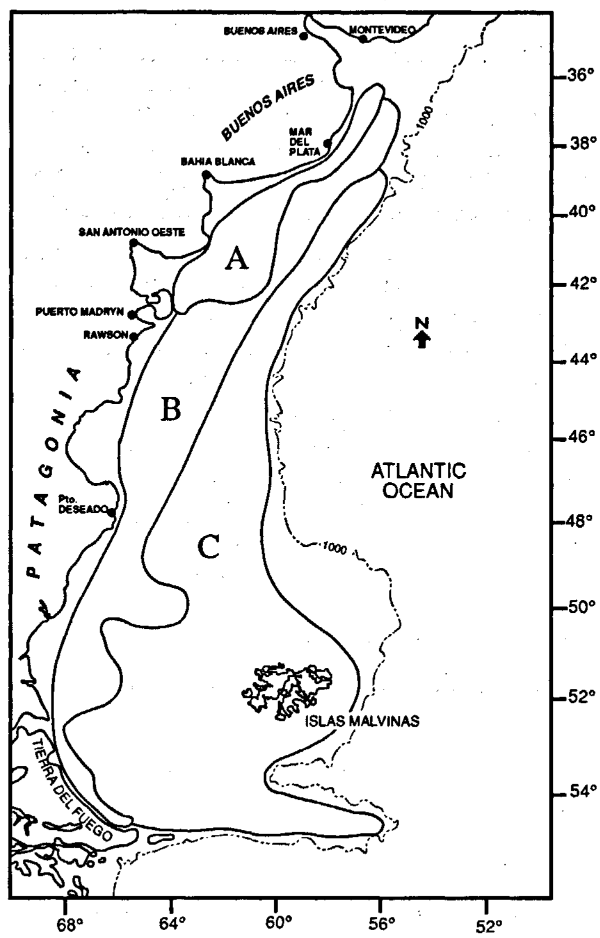

Figure 4

Map of the areas defined by the cluster analysis of stations.

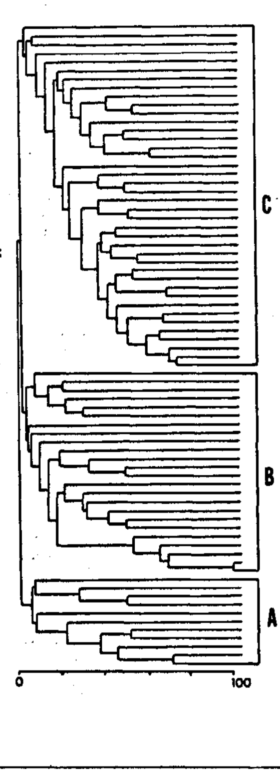

Figure 3

Dendrogram of the cluster analysis of stations. Three groups of stations - A, B, and C - were defined. See *text for the description of the areas.*

Area C is the largest and extends along the ACS beyond (roughly) the 100 m isobath (although it extends into shallower waters in the area off Buenos Aires and northern Patagonia). Area C is under influence of the subantarctic Malvinas current (high productivity and low temperatures). A total of 152 species were found in this area. Area C shows the highest percentage (16.30 %) of exclusive species.

We have characterized areas A, B, and C using the bioclast data from Bastida and Urien (1981). Molluscan bioclasts were the dominant group in all three areas and their abundance decreased from A through B to C (Fig. 5 *b*). The subdominant group in each area was different. In A barnacles, and, to a lesser extent, brachiopods were subdominant. In B, the subdominant groups were bryozoans and echinoderms, but brachiopods were still more common here than in area A. In C bryozoans and brachiopods were subdominant, while echinoderms were less abundant than in area B. The pattern of distribution of the bioclast corresponds well with the actual distribution of the different taxonomic groups in the ACS. Bryozoans, for example, were absent or in low abundance in many samples of area A and the northern part of area B. Echinoderms were usually more abundant in samples form C. Brachiopods were absent from samples of area A off Buenos Aires, but common elsewhere. In summary, bioclast patterns also showed that areas B and C are more similar to each other than they are to A.

Figure 6 shows the dendrogram of the cluster analysis for species. Seven groups, I to VII, can be defined. Table 2 contains a list of all the species included in the analysis, their dendrogram group number, and the range of bottom temperatures and depths at which they were found. Table 2 also includes, for each area, the number of samples in which the species was found (f), and the corresponding percentage over the total number of samples (%). Figure 7 summarizes depth and bottom temperature information corresponding to each species group. Thick bars indicate the mean range for each group calculated as the difference between the average of the maximum depth (or temperature) reached for each species, and the average of the minimum depth (or temperature) reached for each species. The thin lines range from the absolute maximum to the absolute minimum depth (or temperature) at which at least one species of the group was found. Figure 8 represents the original data matrix with both stations and species grouped by cluster analysis. Shading indicates the frequency of species of a group in a given area, *e. g.*, more than 70 % of the species of group I were present in area A, 30-49 % of the species of group I were present in area C, and 10-29 % of species of group I were present in area B. This information permits to determine the degree of correspondence between species groups and areas.

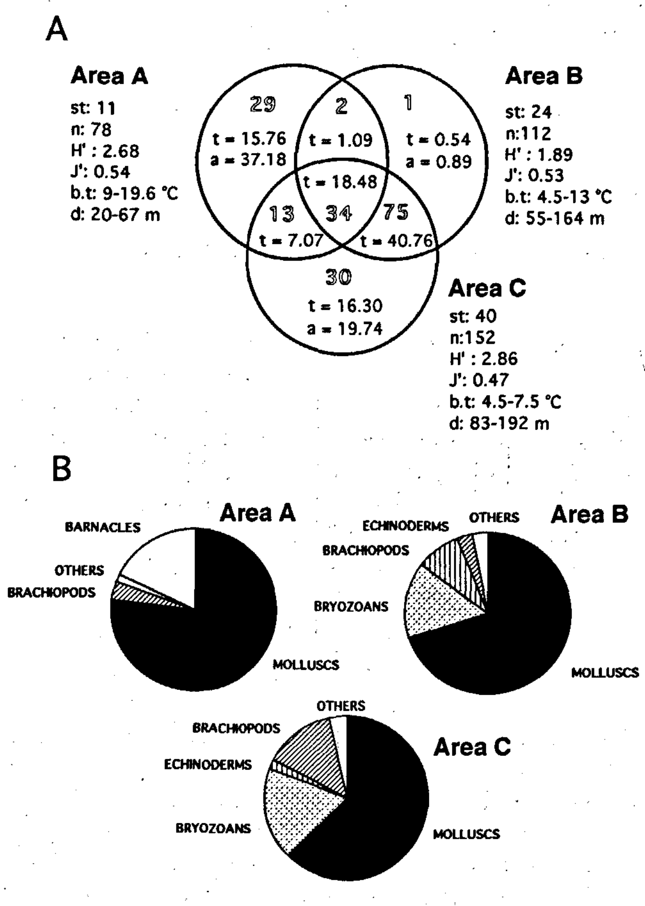

Figure 5

A: general information about areas A, B, and C. Outline: number of species present in that sector; t: species found in a sector as a percentage of the total number species collected in all cruises; a: species exclusive to an area as a percentage of the total number of species found in that area; st: number of stations; n: total number of species found in the area; H': Shannon-Wiener's diversity index; J': Pielou's evenness index; b.t: bottom temperature; d: depth. B: Bioclast composition for each area.

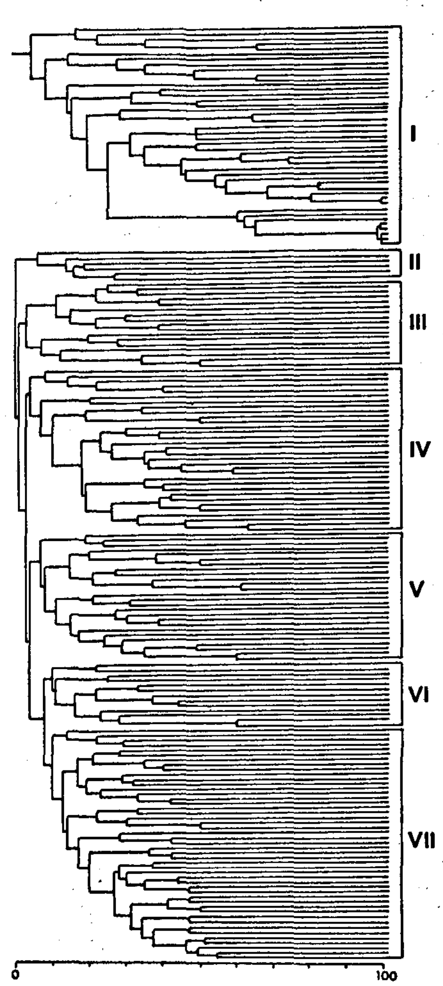

Figure 6

Dendrogram of the cluster analysis of species. Seven groups - I to VIII -were defined. See text for discussion.

Table 2

List of the species of molluscs, echinoderms, and bryozoans collected during the R/V Shinkai Maru *(IV, V, X, XI) cruises. St: number of stations of a given area (A, B, or C) where the species was found; %: St expressed as a percentage of the total number of stations where the species was found.*

	A		B		C			
	ST	%	ST	%	ST	%	Temperature (°C)	Depth (m)
Tegula patagonica (M)	7	100					9.5-19.6	20-65
Epitonium georgettina (M)	7	100					9.5-19.6	20-67
Calliostoma coppingeri (M)	6	100					9.5-19.6	30-65
Olivella tehuelchana (M)	6	100					9.5-19.6	30-67
Crassinella marplatensis (M)	5	100					9.5-19.6	30-65
Aloidis lyoni (M)	5	100					9.5-17.5	35-65
Crepidula aculeata (M)	4	100					10.5-19.6	30-65
Transempitar americana (M)	4	100					10.5-19.6	30-65
Aesopus metcalfei (M)	4	100					9.5-19.6	30-65
Mytilus platensis (M)	4	100					10.5-19.6	30-57
Turbonilla uruguayensis (M)	3	100					9.5-19.6	30-50
Plicatula spondyloidea (M)	3	100					9.5-19.6	30-65
Littoridina australis (M)	3	100					9.6-19.6	30-60
Ancilla tankervillei (M)	3	100					10.5-19.6	20-35
Odostonia canaliculata (M)	3	100					9.6-19.6	35-65
Epitonium tenuistriatum (M)	3	100					9.5-18.0	35-50
Turbonilla elongata (M)	3	100					10.5-11.8	35-65
Actaeon punctostriatum (M)	3	100					10.8-19.6	30-65
Turbonilla paralaminata (M)	2	100					15.0-19.6	30-56
Solariella patriae (M)	2	100					10.5-17.5	35-65
Eulimella bahiense (M)	2	100					10.5-17.5	35-65
Odostomia multituberculata (M)	2	100					10.5-17.5	35-65
Eulimella rudis (M)	2	100					10.5-17.5	35-65
Cadulus quadridentatus (M)	2	100					10.5-17.5	35-65
Turbonilla fasciata (M)	2	100					9.6-17.5	60-65
Terebra gemmulata (M)	2	100					9.5-11.8	50-57
Semele casali (M)	2	100					15.0-17.5	56-65
Clathurella aguayoi (M)	2	100					11.8-19.6	30-57
Retusa caelata (M)	2	100					10.8-19.6	30-65
Crenella divaricata (M)	4	80.0			1	20.0	5.5-19.6	30-92
Crepidula protea (M)	2	66.7			1	33.3	6.3-19.6	30-83
Photinula blackei (M)	2	66.7			1	33.3	5.5-17.5	35-111
Turbonilla dispar (M)	2	66.7			1	33.3	4.8-17.5	35-145
Crassinella lunulata (M)	2	66.7			1	33.3	1.8-17.5	35-145
Anachis rubra (M)	2	66.7			1	33.3	5.4-17.5	56-111
Chaetopleura isabellei (M)	2	50.0			2	50.0	4.6-19.6	30-183
Typhlodaphne filostriata (M)	2	50.0			2	50.0	5.2-19.6	30-149
Chiridota marenzelleri (E)	1	33.3			1	33.3	7.2-15.0	56-166
Trophon laciniatus (M)	3	33.3			6	66.7	4.6-19.6	30-145
Callochiton puniceus (M)	1	20.0			4	80.0	5.4-10.5	35-152
Antistreptus magallanicus (M)	1	14.3			6	85.7	4.6-15.0	56-169
Cylichnina georgiana (M)	1	6.3			15	93.8	4.5-10.8	65-183
Ameghinomya antiqua (M)	2	50.0	1	25.0	1	25.0	5.5-15.0	55-92
Eulima auricincta (M)	2	50.1	1	25.0	1	25.0	6.0-11.8	57-102
Marginella prunum (M)	2	40.0	1	20.0	2	40.0	5.4-17.5	57-189
Scruparia ambigua (B)	1	33.3	1	33.3	1	33.3	6.3-15.0	56-95
Inversiula nutrix (B)	1	33.3	1	33.3	1	33.3	5.4-15.0	56-111
Trophon pallidus (M)	2	33.3	1	16.7	3	50.0	5.1-17.5	56-159
Natica isabelleana (M)	4	33.3	2	16.7	6	50.0	4.6-19.6	30-155
Cellaria ornata (B)	5	29.4	8	47.1	4	23.5	4.5-17.5	56-183
Nucula puelcha (M)	2	28.6	2	28.6	3	42.9	4.3-11.8	57-188
Escharina longispinata (B)	1	25.0	1	25.0	2	50.0	4.6-17.5	55-111
Aetea anguina (B)	1	25.0	1	25.0	2	50.0	4.6-15.0	56-145
Hemioedema spectabilis (E)	1	25.0	1	25.0	2	50.0	5.5-15.0	56-145
Mangelia magallanica (M)	3	25.0	2	16.7	7	58.3	4.8-17.5	60-145
Caberea darwinii (B)	4	21.1	5	26.3	10	52.6	4.6-17.5	56-183
Pseudechinus magellanicus (E)	3	20.0	7	46.7	5	33.3	4.8-12.5	57-183
Anachis paessleri (M)	1	20.0	2	40.0	2	40.0	5.2-19.6	30-169
Paraeuthria ringei (M)	2	20.0	2	20.0	6	60.0	4.8-17.5	56-169
Tronina bella (M)	1	20.0	1	20.0	3	60.0	4.8-19.6	30-183
Epitonium magallanicum (M)	3	20.0	2	13.3	10	66.7	4.6-11.8	35-183
Ataxocerithium pullum (M)	6	18.8	7	21.9	19	59.4	4.6-17.5	35-189
Ophiacantha vivipara (E)	1	16.7	2	33.3	3	50.0	4.3-19.6	30-188
Neolepton cobbi (M)	1	16.7	1	16.7	4	66.7	5.5-11.8	57-189
Astarte longirostris magallanica (M)	2	16.7	2	16.7	8	66.7	4.6-19.6	30-159
Lepidopleurus medinae (M)	2	15.4	3	23.1	8	61.5	4.6-19.6	30-189
Nuculana sulculata (M)	1	12.5	5	62.5	2	25.0	5.3-9.5	67-154

	A		B		C			
	ST	%	ST	%	ST	%	Temperature (°C)	Depth (m)
Balcis sp. (M)	1	12.5	1	12.5	6	75.0	4.6-10.5	15-183
Amphiura eugeniae (E)	1	10.0	4	40.0	5	50.0	4.5-9.5	50-159
Admete magallanica (M)	2	9.5	5	23.8	14	66.7	4.8-19.6	30-169
Falsilunatia soluta (M)	2	7.1	4	14.3	22	78.6	4.3-19.6	30-192
Arachnopusia monoceros (B)	2	6.5	10	32.3	19	61.3	4.5-17.5	55-183
Schizoporella simplex (B)	1	5.6	5	27.8	12	66.7	4.6-15.0	55-183
Calyptraea pileolus (M)	1	5.6	4	22.2	13	72.2	4.5-17.5	55-159
Mangelia michaelseni (M)	1	5.3	1	5.3	17	89.5	4.3-10.5	35-192
Paraeuthria rosea (M)	1	3.8	9	34.6	16	61.5	4.6-13.0	35-183
Anachis isabellei (M)	3	75.0	1	25.0			6.8-19.6	30-88
Amphiura princeps (E)	1	25.0	3	75.0			10.0-19.6	30-100
Amphioplus albidus (E)			3	100.0			7.0-12.5	82-115
Bicrisia edwardsiana (B)			3	75.0	1	25.0	6.3-13.0	55-95
Exochella longirostris (B)			4	66.7	2	33.3	4.6-13.0	55-103
Labidiaster radiosus (E)			2	66.7	1	33.3	6.0-8.0	91-113
Ophiomixa vivipara (B)			3	60.0	2	40.0	4.6-13.0	70-125
Jolietina latimarginata (B)			4	57.1	3	42.9	4.6-11.1	55-189
Calvetia dissimilis (B)			4	57.1	3	42.9	4.6-11.1	55-145
Parasmittina dubitata (B)			8	50.0	8	50.0	4.5-13.0	55-145
Chlamys lischkei (M)			5	50.0	5	50.0	4.8-12.5	72-159
Fenestrulina majuscula (B)			3	50.0	3	50.0	4.6-11.1	55-159
Kennerleya patagonica (M)			1	50.0	1	50.0	6.0-7.3	83-102
Subonoba fuegoensis (M)			1	50.0	1	50.0	5.1-9.0	93-159
Prosipho chordatus (M)			1	50.0	1	50.0	5.5-6.2	120-152
Trophon elongatus (M)			1	50.0	1	50.0	5.5-11.1	55-92
Aspidostoma giganteum (B)			5	45.5	6	54.5	4.3-11.1	55-188
Hippothoa flagellum (B)			3	42.9	4	57.1	4.6-10.5	92-145
Austrocidaris canaliculata (E)			2	40.0	3	60.0	5.1-13.0	70-159
Micropora brevissima (B)			2	40.0	3	60.0	5.1-11.1	55-159
Amastigia benemunita (B)			2	40.0	3	60.0	5.1-10.5	103-159
Amphiura magellanica (E)			3	37.5	5	62.5	4.5-7.0	83-189
Lacerna hosteensis (B)			3	37.5	5	62.5	4.6-11.1	55-159
Nevianipora milneana (B)			6	35.3	11	64.7	4.8-11.1	55-154
Hippopodinella adpressa (B)			1	33.3	2	66.7	4.6-11.1	55-95
Smilasterias scalprifera (E)			1	33.3	2	66.7	5.1-6.5	141-159
Amastigia nuda (B)			1	33.3	2	66.7	4.6-7.0	95-115
Ophiochondrus stelliger (E)			1	33.3	2	66.7	4.5-5.0	100-183
Photinula coerulescens (M)			1	33.3	2	66.7	4.6-6.8	88-95
Lissarca miliaris (M)			1	33.3	2	66.7	4.6-9.0	92-95
Beania costata (B)			2	33.3	4	66.7	4.6-10.5	92-169
Bicrisia biciliata (B)			2	33.3	4	66.7	4.6-9.0	92-145
Leptychaster kerguelensis (E)			2	33.3	4	66.7	5.3-9.5	96-152
Tricellaria aculeata (B)			2	33.3	4	66.7	4.3-9.0	92-188
Ophiactis asperula (E)			7	33.3	14	66.7	4.5-12.5	72-189
Tectonatica impervia (M)			4	30.8	9	69.2	4.8-12.5	72-183
Himantozoum obtusum (B)			3	30.0	7	70.0	4.5-12.5	82-183
Pseudoimonea fissurata (B)			2	28.6	5	71.4	4.8-10.5	96-189
Sterechinus agassizii (E)			2	28.6	5	71.4	4.8-12.5	72-189
Trachithyone parva (E)			4	28.6	10	71.4	4.5-9.0	85-183
Notoplites elongatus calveti (B)			2	28.6	5	71.4	4.8-9.0	92-183
Ophiuroglypha lymani (E)			4	28.6	10	71.4	4.5-9.5	92-189
Beania maxilla (B)			3	27.3	8	72.7	4.6-10.0	92-183
Sertella magellensis aviculifer (B)			6	27.3	16	72.7	4.5-11.1	55-189
Actaeon biplicata (M)			1	25.0	3	75.0	4.5-8.7	72-152
Capulus compresus (M)			1	25.0	3	75.5	4.8-8.0	91-183
Celleporina bicostata (B)			1	25.0	3	75.5	4.6-9.0	92-159
Austrocidaris spinulosa (E)			1	25.0	3	75.5	4.6-11.1	55-189
Mangelia purissima (M)			1	25.0	3	75.5	5.0-10.5	05-169
Smittina lebruni (B)			2	25.0	6	75.0	4.6-11.1	55-141
Philine argentina (M)			3	25.0	9	75.0	4.8-6.8	83-169
Microporella hyadesi (B)			6	23.1	20	76.9	4.5-11.1	55-183
Catadysis immersum (B)			2	22.2	7	77.8	4.5-10.5	113-181
Andreella uncifera (B)			2	20.0	8	80.0	4.6-13.0	70-183
Chapperia gallatea (B)			1	20.0	4	80.0	4.8-9.0	92-183
Foveolaria terrifica (B)			1	20.0	4	80.0	4.6-9.0	92-152
Beania magellanica (B)			1	20.0	4	80.0	4.6-9.0	92-189
Pseudocnus dubiosus leoninus (E)			1	20.0	4	80.0	5.4-7.3	83-111

Table 2 (following)

	A		B		C			
	ST	%	ST	%	ST	%	Temperature (°C)	Depth (m)
Trachithyone peruana (E)			3	20.0	12	80.0	4.6-10.5	90-159
Ctenodiscus australis (E)			6	19.4	25	80.6	4.3-7.3	83-192
Osthimosia bicornis (B)			4	19.0	17	81.0	4.6-11.1	55-183
Limopsis hirtella (M)			4	19.0	17	81.0	4.8-11.1	55-183
Ogivalia elegans (B)			5	18.5	22	81.5	4.5-9.5	92-189
Orthoporidroides deserectus (B)			2	18.2	9	81.8	4.8-10.5	98-183
Spiroporina pentagona (B)			3	17.6	14	82.4	4.5-10.5	92-183
Hiatella solida (M)			5	17.9	23	82.1	4.8-8.0	83-189
Colpospirella algida (M)			4	17.4	19	82.6	4.5-11.1	55-192
Odontaster penicillatus (E)			1	16.7	5	83.3	5.0-6.8	85-152
Cyclocardia velutina (M)			1	16.7	5	83.3	5.1-6.8	103-159
Epicodakia falklandica (M)			3	15.8	16	84.2	4.3-7.3	83-188
Menipea flagellifera (B)			3	15.8	16	84.2	4.3-9.0	83-188
Cyamocardium crassilabrum (M)			1	14.3	6	85.7	4.6-8.7	72-192
Mathilda georgiana (M)			1	12.5	7	87.5	5.0-9.0	83-169
Cuspidaria platensis (M)			1	12.5	7	87.5	4.8-6.8	88-189
Carbasea ovoidea (B)			1	11.1	8	88.9	4.6-9.0	83-183
Cellarinella dubia (B)			2	10.0	18	90.0	4.6-11.1	55-183
Yoldia eightsii (M)			1	9.1	10	90.9	4.3-6.6	88-188
Pseudocnus perrieri (E)			1	7.7	12	92.3	4.6-9.0	90-189
Ophiocten amitinum (E)					15	100	4.3-6.8	102-189
Solariella kempi (M)					14	100	4.8-7.5	125-192
Volvarina patagonica (M)					13	100	4.5-7.5	90-189
Limatula pygmaea (M)					9	100	4.6-6.5	90-159
Savatieria aerolata (M)					8	100	4.6-6.5	95-192
Osthimosia magna (B)					7	100	4.6-7.5	95-152
Carditopsis flavelum malvinae (M)					7	100	4.6-6.8	95-189
Trypilaster philippii (E)					6	100	4.3-6.3	83-188
Neolepton hupei (M)					5	100	4.6-6.8	95-145
Cadulus dalli-antarticus (M)					5	100	4.8-6.0	102-192
Pseudocnus cornutus (E)					5	100	4.8-6.4	145-189
Meteuthria martensi (M)					5	100	4.6-6.0	92-154
Dentalium sp. (M)					5	100	4.5-6.4	145-189
Psolus patagonicus (E)					4	100	6.0-6.5	90-189
Glypteuthria acuminata (M)					4	100	4.5-6.4	95-189
Fasciolaria insularis (M)					4	100	4.5-6.4	110-189
Meteuthtia agnesia (M)					4	100	4.8-6.0	141-183
Thesbia lateplicata (M)					4	100	4.8-6.3	95-183
Toledania limnaeaformis (M)					3	100	4.6-5.4	95-145
Flustapora magellanica (B)					3	100	5.0-6.8	133-189
Ichthyaria oculata (B)					3	100	5.3-6.0	117-141
Paraeuthria paessleri (M)					3	100	4.6-6.0	95-183
Adelomedon sp. (M)					3	100	5.3-6.3	83-141
Trophon malvinarum (M)					3	100	4.8-5.3	117-183
Calliostoma modestulum (M)					3	100	5.3-6.3	95-180
Margarella expansa (M)					2	100	5.2-5.4	111-149
Cingula fuegoensis (M)					2	100	4.8-5.4	111-183
Argobuccinum magallanicum (M)					2	100	6.0-6.5	90-141
Prosipho cancellatus (M)					2	100	4.8-5.5	145-152
Icoplax punicea (M)					2	100	5.5-5.5	92-152

The dendrogram of Figure 6 shows two main groupings which correspond to Argentinean (Group I) and Magellanic (Groups II to VII) species. Group I contains 43 species, most of them abundant in area A. Groups II to VII include 141 species - all of them found in area C. Although most species (*e. g.*, *Solariella kempi*, *Beania costata*, *Ampidostoma giganteum*) are associated to low temperature waters (*see* Fig. 7), the groups include some eurythermic species of wide distribution on the ACS (*e. g.*, *Ataxocerithium pullum*, *Falsilunatia soluta*, *Ogivalia elegans*).

None of the groups of species rendered by the cluster analysis seems to positively define area B. Species of group I, which characterize area A, are poorly represented in B. Some species of groups I, III, V and VI, that are found in C are not present in B. Again, B seems to be best defined as an impoverished C. Water temperature appears to correlate most closely to the impoverishment of B relative to C. Species of the groups III, V and VI, which mark the difference between B and C (Fig. 8), showed the narrowest temperature ranges and preferred low temperatures (Fig. 7). An additional factor that might limit the spread of some C-species into area B is bottom morphology. The topography of the ACS is particularly irregular along the 100 m isobath; perhaps microenvironmental conditions (*e. g.*, particular currents, unstable sediments) make the area unsuitable for the some of the species found in the deeper and presumably more stable area C.

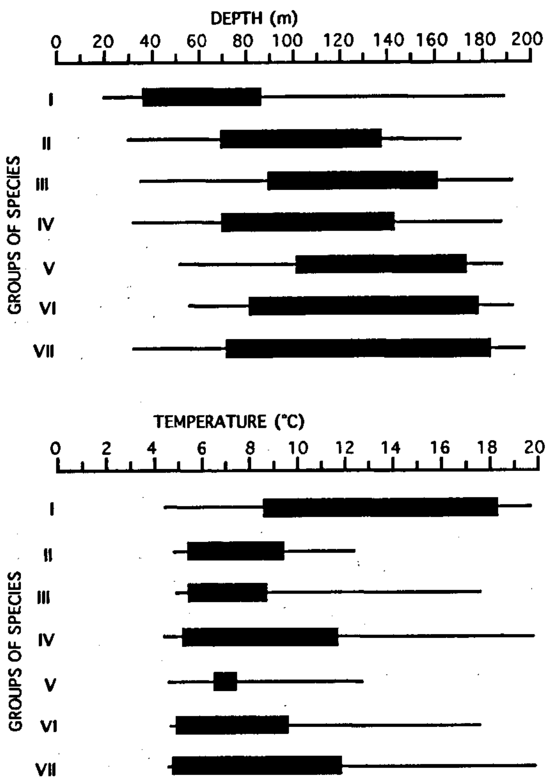

Figure 7

Depths and bottom temperatures for the groups of species defined in the dendrogram of Figure 5. Thick bars indicate the mean range (from the average maximum to the average minimum for of all the species of a given group). Thin lines are the absolute maximum or minimum reached by at least one of the species of the group.

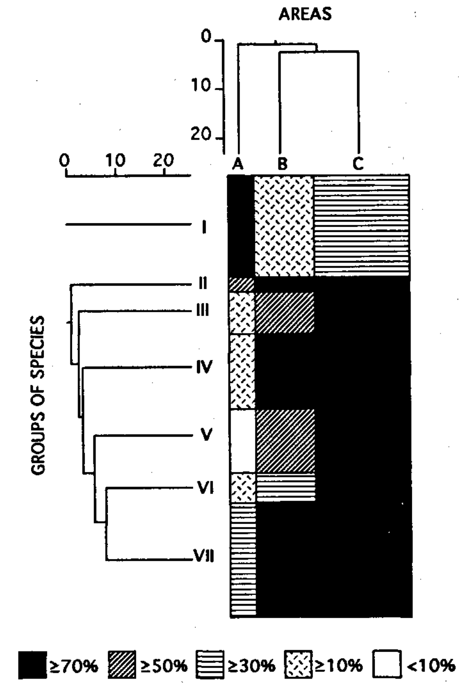

Figure 8

Original stations by species data matrix reorganized according to the cluster analysis groupings. Shading indicates the percentage of species of a group (I-VII) in a given area (A, B, C). For example, more than 70 % of the species of group I were present in area A.

Two zoogeographic provinces have been traditionally recognized for the southwestern Atlantic coastal areas off Argentina, namely, the Argentine and the Magellanic provinces. Although this classification was based on sound hydrographic and biological information, no previous study provided a snapshot of the whole area for several taxonomic groups. Our results corroborated the classical zoogeographic division and suggested the possibility of subdividing the Atlantic sector of the Magellanic province into two districts: one internal, influenced by the Patagonian current (B), and one external affected by the Malvinas current (C). These districts might be respectively called Patagonian and Malvinean. Menni and Gosztonyi (1982) and Menni and Lopez (1984), who studied the distribution of marine fishes of the ACS, have suggested that magellanic fishes may be divided into at least two assemblages, one occupying the warmer inner shelf, and the other occupying the deeper and colder outer shelf. We hesitate to describe area B as a particular subunit within the Magellanic province given its transitional features. However, only further studies will allow us to decide on the convenience of distinguishing between a Patagonian and a Malvinean district.

CONCLUSIONS

1) On the basis of the assemblages of molluscs, bryozoans and echinoderms, the Argentinean continental shelf can be divided into three main areas: area A corresponds to the Bonaerensian district of the Argentine zoogeographic province; and areas B and C correspond to the Atlantic sector of the Magellanic zoogeographic province.

2) Area A occupies the inner shelf off Buenos Aires and northern Patagonia, and is under the influence of the subtropical waters of the Brazil current. Almost 16 % of the total number of species included in our analysis were exclusive to this area. Species of the faunistic group I were particularly frequent in this area. Bioclasts were dominated by molluscs and, to lesser extent, barnacles.

3) Area C is the largest and extends in the outer shelf (usually beyond the 100 m isobath). The area is directly affected by the cold and highly productive waters of the subantartic Malvinas current. Of the total number of species analyzed, 16.30 % were exclusive to this area. Bioclasts were dominated, in decreasing order, by molluscs, bryozoans, and echinoderms.

4) Area B extends between the coast and area C off south and middle Patagonia, and between areas A and C off northern Patagonia and Buenos Aires. Although the area does not seem to have a characteristic group of exclusive species, several of the species that inhabit area C seemed unable to occupy the warmer waters of area B. Bioclasts were dominated, in decreasing abundance, by molluscs, bryozoans, and brachiopods.

5) Molluscs were the dominant group in the bioclasts of the all three areas but their percentage of the total decreased from A through B to C.

6) Our results suggest the possibility of a further subdivision of the Atlantic sector of the Magellanic zoogeographic province into two districts. The Patagonian would occupy the warmer inner shelf while the Malvinean would extend over the deeper and colder outer shelf. Further research is necessary to decide on the merits of such subdivision.

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