Vol. 108: 59–77, 1994 | MARINE ECOLOGY PROGRESS SERIES Mar. Ecol. Prog. Ser. | Published May 12

Demersal bony fish of the outer shelf and upper slope of the southern Brazil Subtropical Convergence Ecosystem

Manuel Haimovici[1], Agnaldo Silva Martins[2], José Lima de Figueiredo[3], Pedro Castelli Vieira[1]

[1] Departamento de Oceanografia, Fundação Universidade do Rio Grande, Caixa Postal 474, 96201-900 Rio Grande, RS, Brazil

[2] Curso de Pós-Graduação em Oceanografia Biológica, Fundação Universidade do Rio Grande, Caixa Postal 474, 96201-900 Rio Grande, RS, Brazil

[3] Museu de Zoologia da Universidade de São Paulo, Caixa Postal 7172, 01064-980 São Paulo, Brazil

ABSTRACT: Ninety-three species of bony fishes were caught in 4 seasonal bottom-trawl surveys carried out between July 1986 and May 1987 on the outer shelf and upper slope (124 to 587 m depth) along the southern Brazilian coast (30° 40' to 34° 30' S). On the outer shelf (< 179 m), the demersal-pelagic species *Trichiurus lepturus*, *Trachurus lathami*, *Cynoscion guatucupa*, *Scomber japonicus*, and *Thyrsitops lepidopoides* predominated and also to a lesser degree the demersal benthonic *Umbrina canosai* and *Mullus argentinae*. *Antigonia capros* and *Priacanthus arenatus* were found associated with the relic coral hard bottoms of the shelf break (180 to 249 m). Further offshore, the demersal-pelagic species *Ariomma bondi* and *Zenopsis conchifera* and the demersal benthonic species *Polyprion americanus* and *Helicolenus lahillei* were abundant, both associated with rocky bottoms. The macrourids *Coelorinchus marinii* and *Malacocephalus occidentalis* characterized deep-water hauls (> 450 m). Frequent and widespread, but less abundant in the catch, were *Polymixia lowei*, *Urophycis mystacea* and *Merluccius hubbsi*. Mean total catch (kg h^{-1}) decreased 6-fold and the number of species by more than half along the depth range, with a sharp step at 350 m. Both catch and number of species were slightly higher in the winter cruises. Most species occurred in both winter and summer-autumn cruises, but, with increasing depth, the relative abundance of species that occur year-round decreased, whereas fishes that occur mostly in winter increased. The catch of demersal-pelagic fish decreased sharply below 350 m and differed little among seasons; catches of demersal-benthonic fish were more evenly distributed across the depth range and were larger in winter and spring. The high number of species on the shelf break may be attributable to the higher variety of soft and consolidated substrates and the overlapping of different water masses along the water column. The north-south shift of the western boundary of the Subtropical Convergence appears to be mainly responsible for the seasonal changes in abundance of the species.

KEY WORDS: Subtropical Convergence · Teleost fauna · Distribution · Southern Brazil · Outer shelf · Upper slope · Fish communities · Demersal survey

INTRODUCTION

During 1986 and 1987, 4 bottom trawl surveys on the external shelf and upper slope off southern Brazil were carried out from the RV 'Atlântico Sul' to assess the fishing potential of the area; this proved to be rather poor (Vooren et al. 1988, Haimovici & Perez 1991a) but included more than 100 species, many of them commercially important in neighboring regions.

The marine fish fauna of the southwestern Atlantic, particularly the demersal fishes from the shelf break and the upper slope of the coast of southern Brazil, has scarcely been studied. Early Brazilian ichthyological surveys were conducted only to 200 m depth (Vazzoler 1975, Benvegnú-Lé 1978). In surveys performed by research vessels of other nations, e.g. RV 'Calypso' in 1961 (Roux 1973) and RV 'Walter Herwig' in 1966 (Yesaki 1973), only a few trawling stations were in our

studied area. Thus, one of the objectives of this paper was to report the teleost fishes in the catches, their sizes and relative abundance over the depth range and the cruises and to provide some information about the life history of better-represented species in the survey. An analysis of trends in the relative abundance and number of species in relation to depth, temperature, latitude, and seasons of the year is also presented. Some comments on the general composition of the fish fauna of the region are included in the 'Discussion'.

As this deeper area is scarcely fished as compared to the continental shelf (Vooren et al. 1988, Haimovici et al. 1989b), its faunal composition is probably in an almost natural undisturbed state, therefore the present study is a good referential base for temporal comparisons or for comparisons with other regions sampled with equivalent gear.

MATERIALS AND METHODS

Samples were obtained in 4 groundfish survey cruises of the RV 'Atlântico Sul' in July 1986 (winter), September 1986 (late winter), March 1987 (late summer), and May 1987 (autumn) over the outer shelf and upper slope between Chui (34° 30' S) and Cape of Santa Marta Grande, Brazil (28° 40' S). Each cruise covered approximately half of the area (Fig. 1).

Sixty-five fish samples were collected using a bottom trawl net with a 23.4 m footrope geared with 40 cm diameter steel bobbins and a 50 mm stretch-mesh cod end. The standard duration of the hauls was 60 min at a speed of 3.0 knots. After each haul bottom temperatures were recorded. All hauls were performed between dawn and dusk. Tow depth ranged from 124 to 587 m: 30% of the hauls were conducted between 124 and 179 m, 21% between 180 and 249 m, 21% between 250 and 349 m, 12% between 350 and 449 m and 14% between 450 and 587 m. Irregular hard bottoms are common in canyons in the shelf break, perpendicular to the coastline from Albardão to Rio Grande, and there are no extensive areas for trawling in the study area (see Vooren et al. 1988).

Temperature and salinity were measured with Nansen bottles at standard depths and along fixed transects at the beginning and end of each cruise and included in the survey final report by Castello (1991). When possible bottom temperature was recorded at the fishing stations. At depths over 200 m measurements were imprecise due to strong currents, and for some fishing stations, bottom temperatures were interpolated from transect and neighboring stations. Temperature profiles are shown in Fig. 2.

After each tow the fishes were classified, measured and weighed. For very large catches, a random subsample of 30 kg of the smaller fishes was classified. The number per hour, weight per hour and size composition of each species were calculated.

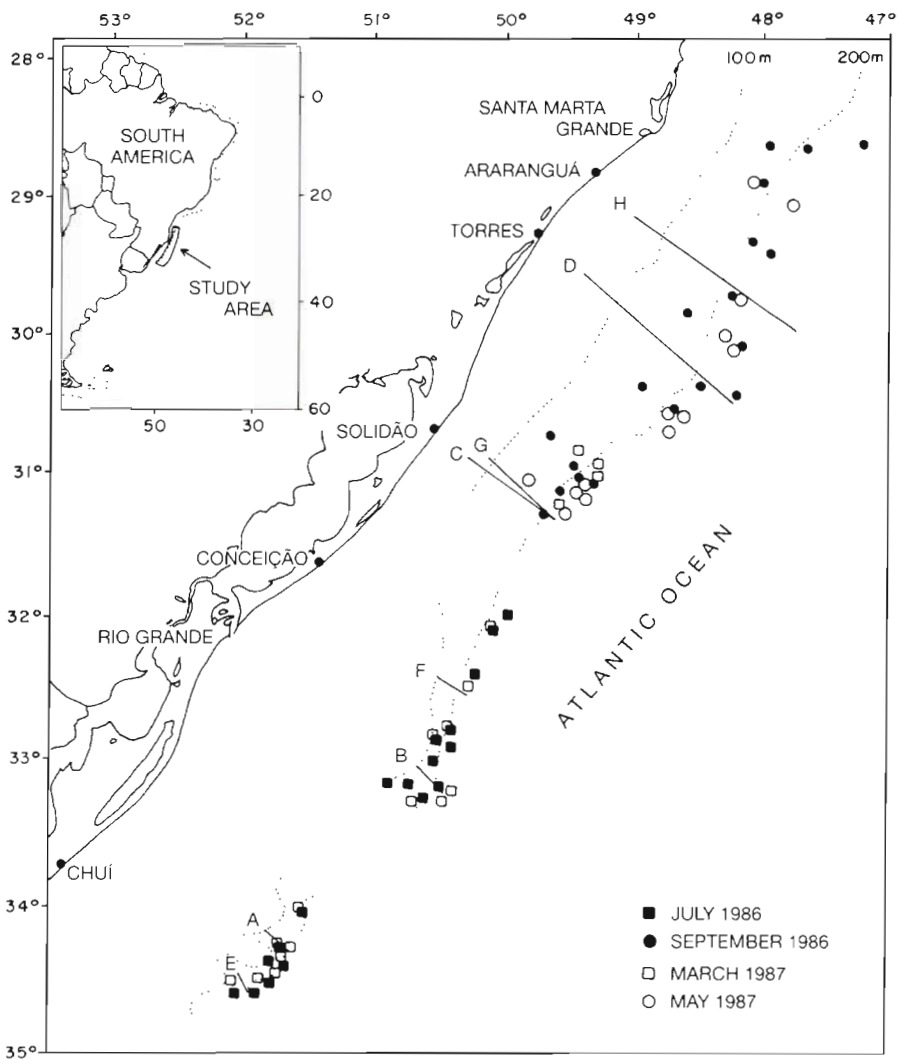

Fig. 1. Study area of the bottom trawl survey by the RV 'Atlântico Sul' off southern Brazil in 1986 and 1987. Empty and full circles and squares indicate fishing stations. Lines and letters indicate temperature profile transects

Bony fishes were identified on board using the fish catalogs (identification guides) of Figueiredo & Menezes (1978, 1980), Fischer (1978), Menezes & Figueiredo (1980, 1985) and Menni et al. (1984).

The fishes were classified as 'demersal-benthonic', species that feed mostly on or near the bottom, or 'demersal-pelagic', that feed mainly in the water column (Angelescu & Prenski 1987). Some mesopelagic species were also caught. The classification criterion was based on observation of the functional morphology, unpublished data on stomach contents and literature information on the species, genera or family.

For each cruise and depth range the total number and mean number of species per tow and the mean total catch (in kg h^{-1}) of demersal-benthonic, demersal-pelagic and mesopelagic species were calculated. Several sources of bias are involved in abundance comparisons, as species and sizes are not equally accessible and vulnerable to bottom trawls. This is a limitation of the exploratory fishing survey method that must be borne in mind. A reciprocate correspondence analysis program [DECORANA described in Gauch (1982)] for the natural logarithm of the numerical abundance plus one [$\ln(x+1)$] was run to investigate the distribution patterns of the bony fishes in winter and summer-autumn. Only species caught more than twice were included in the analysis.

SURVEY AREA

Bottom topography and morphology. The external shelf has a declivity of around 0.1°, becoming about 1° in the upper slope. The shelf break is between 150 and 185 m and is not abrupt. Between Chuí and Rio Grande (34° 20' to 32° 00' S) the shelf is 140 to 180 km wide, becoming narrower to the north, with a minimum of 90 km at the Cape of Santa Marta Grande (28° 40' S). The morphology and sediments of the continental shelf of Rio Grande do Sul were summarized by Martins et al. (1975). The inner shelf is dominated by sandy bottoms, but biodetrital shell banks exist parallel to the coast off Patos and Mirim lagoons. Sandy mud and

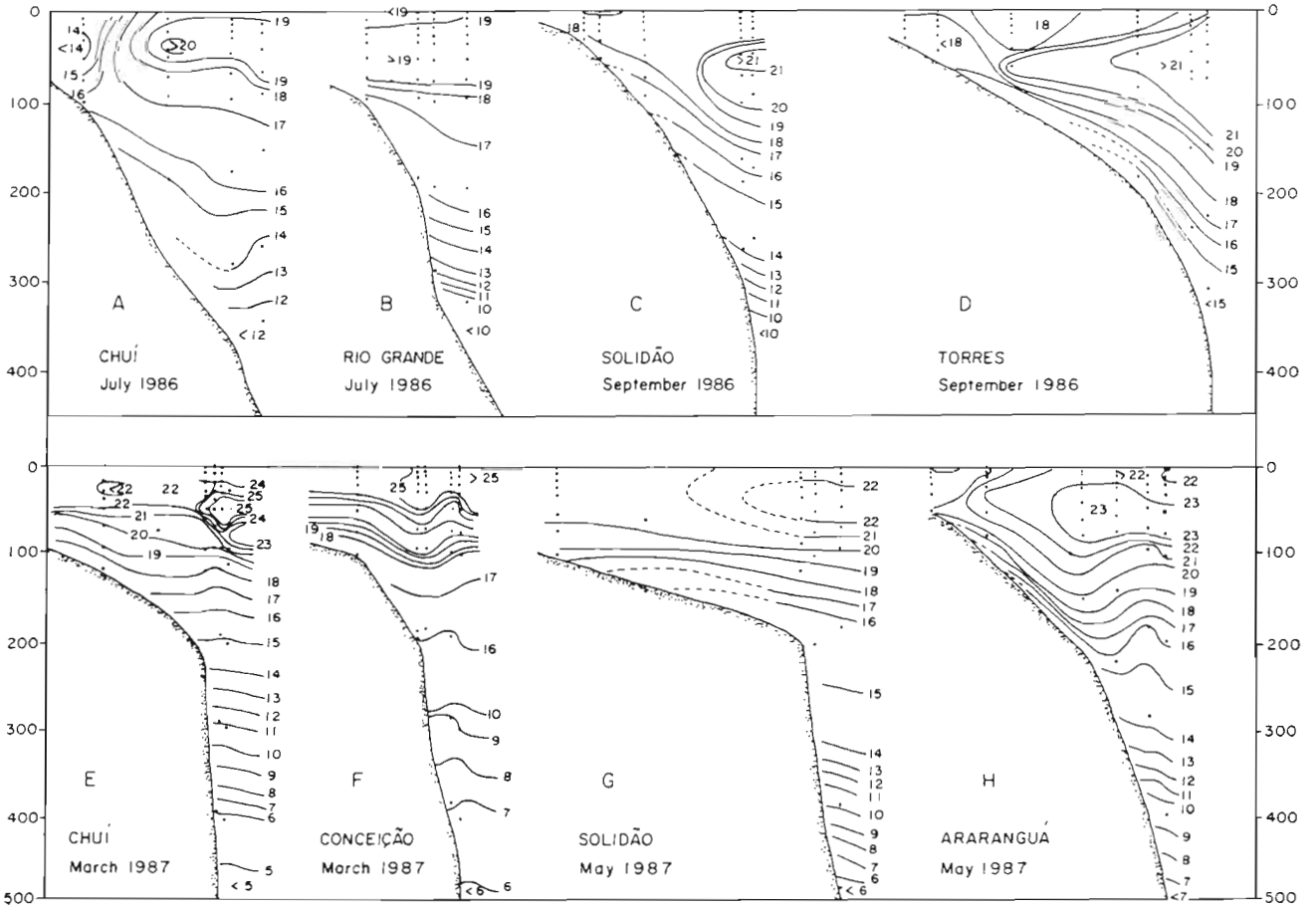

Fig. 2. Temperature profiles in the bottom trawl survey by the RV 'Atlântico Sul' off southern Brazil in 1986 and 1987. Letters indicate the transects in Fig. 1

muddy sand are dominant in the middle shelf, while mud rich in silts, clay and biodetrital sediments are found in the outer shelf. Relic coral hard bottoms are found along the shelf break. Mud is dominant in the slope but irregular hard bottoms are common in canyons perpendicular to the coast off Albardão (33° 20′ S) and north of Rio Grande (32° 10′ S).

Benthic and demersal macrofauna. The macroepibenthonic invertebrate fauna of the area was studied by Capitoli & Bonilha (1991) and D'Incao & Ruffino (1991). In the soft bottoms of the external shelf and upper slope of silty clay sediments the polychaetes *Diopatra tridentata* and *Onuphis tenuis* were common and the small crab *Chasmocarcinus typicus* was dominant. Skeletons and living hermatypic corals *Cladocora debilis* and *Rhizopsammia manuelensis* and gorgonians of the genus *Primnoella* were dominant on biodetrital sediments found extensively in the external shelf to the north of Rio Grande and all along the break of the slope. From 300 to 500 m patches of consolidate sedimentary rocks are common where the polychaete *Eunice frauenfeldi* and hermatypic corals were found. The more frequent and widespread macrocrustaceans were the demersal shrimps *Peneaopsis serrata*, *Parapenaeus americanus* and *Parapandulus* sp., the brachiurid crab *Portunus spinicarpus* and several anomurans of the genus *Munida*, the latter frequently preyed upon by several of the fish species sampled. In the outer shelf and break, the stomatopod *Squilla brasiliensis* and the small crabs *Speocarcinus* sp. and *C. typicus* were also common, and in deeper waters the large crab *Chaceon notialis*, this last species offering some fishing potential (Lima & Lima 1991).

Thirty species of elasmobranch fish were collected in the same survey (Vooren 1991), and 24 of them were also found in shelf surveys. Among the most frequent were the sharks *Galeorhinus galeus* and *Mustelus schmitti* in winter, and 2 species of *Squatina* and *Raja cyclophora* year-round. Six species were found exclusively at depths > 400 m.

Thirteen species of cephalopods were found in the area, most of the catch being represented by *Loligo sanpaulensis* and *L. plei* on the outer shelf, and *Illex argentinus* on the slope (Haimovici & Perez 1991a). Benthic octopuses and sepioids are scarce in the region (Haimovici & Perez 1991b).

Hydrography. Several water masses can be identified over the external continental shelf and upper slope off southern Brazil (Emilsson 1961, Miranda et al. 1973, Castello & Moller 1977, Hubold 1980a, b, Matsuura 1986). Tropical Water (TW) of the Brazil Current (temperature > 20 °C, salinity > 36.0 ppt) flows over the slope and, due to eddies and meander structures, occasionally reaches the continental shelf. Subtropical Water (STW), also called South Atlantic Central Water, with temperatures ranging from 10 to 20 °C and salinities from 34.3 to 35.9 ppt, is found below the Brazil Current. It results from the mixing of TW and Subantarctic Water (SAW) in the Subtropical Convergence zone, which fluctuates seasonally between 35 and 45° S (Legekis & Gordon 1982, Olson et al. 1988). This water may upwell seasonally off northern Rio Grande do Sul, Santa Catarina and Cabo Frio or follow the meander-like pattern of the Brazil Current. SAW, derived from a coastal branch of the Malvinas/Falkland Current, extends up to 32° S but may reach further north in winter. Usually it penetrates beneath the Coastal Water between the 50 and 100 m isobaths. Its temperature off Chui is 10 to 12 °C and can approach 14 to 16 °C off Rio Grande; salinity ranges from 33.7 to 34.15 ppt. Along its eastern boundary a strong thermal gradient, classified by Miranda et al. (1973) as Slope Water, with intermediate temperature and salinity, separates it from the Brazil Current. Upwelling processes occur along the shelf break year-round but with higher intensity in summer (Lima 1992). Intermediate Antarctic Water (IAW) originating at the Antarctic Convergence may be recognized by its lower salinity at depths between 700 and 1100 m (Thomsen 1962). Along the continental slope this water may reach up to 400 m with salinities between 34.26 and 34.41 ppt and temperature under 10 °C in winter at the latitude of Rio Grande.

Bottom morphology contributes to explaining the behavior of the water masses: in winter, SAW of the inner branch of the Malvinas/Falkland Current penetrates onto the wide shelf from the south and reaches at most up to Conceição (31° 40′ S). To the north the shelf is narrower and the influence of the Brazil Current is more evident, particularly in the warm seasons, while in the cold season STW may partially upwell on the shelf near the coast.

Temperature and salinity profiles at the beginning and end of each cruise showed that a mixture of SAW and STW dominated the external shelf and upper slope, and below it IAW was found (Fig. 2). Bottom temperature ranged from 16.6 to 19.0 °C (at 100 m) during winter and 14.0 to 16.0 °C (at 200 m) during summer-autumn surveys. Thermoclines were observed between TW and STW in the upper 200 m layer. Below 200 m depth, the measurement of temperature was imprecise, but temperature decreased gradually to under 10 °C at 400 m and 6.2 °C at 500 m. Bottom temperature in July 1986 in the southern external part of shelf was found to be 2.5 °C warmer than usual for the winter, probably due to a milder Malvinas/Falkland Current influence in that year (Castello 1991).

RESULTS

Species composition

The families, genera and species of teleost caught are listed in Table 1. A total of 93 species of 55 families and 86 genera were identified. The families with the highest numbers of species present were Serranidae (with 6 species) followed by Macrouridae (5), Myctophidae (4), Sciaenidae (4), Trichiuridae (4), Bothidae (3), Triglidae (3), Scorpaenidae (3), and Carangidae (3).

The frequency of occurrence, mean catch, mean weight, total length range, depth of catch and bottom temperature for each species are listed in Table 2. The relative abundance in different seasons (cruises) and depth ranges for individual species were calculated as percentage of the total catch in weight and included in Table 2.

Mean weight ranged from 1 g for *Maurolicus muelleri* to 40 kg for *Mola mola*, both pelagic species. Among those species present in more than 3 tows, only *Polyprion americanus* had a mean weight over 9 kg, and 3 species (*Genypterus brasiliensis, Lophius gastrophysus* and *Priacanthus arenatus*) over 1 kg.

On the outer shelf, the demersal-pelagic species *Trichiurus lepturus, Trachurus lathami, Cynoscion guatucupa, Scomber japonicus* and *Thyrsitops lepidopoides* predominated and also to a lesser degree the demersal-benthonic species *Umbrina canosai* and *Mullus argentinae*; all of them were more abundant in shallower water *Antigonia capros* and *Priacanthus arenatus* were found associated with the relic coral hard bottoms of the shelf break. Further offshore, the abundant species were the demersal-pelagic *Ariomma bondi* and *Zenopsis conchifera,* and the demersal-benthic *Polyprion americanus* and *Helicolenus lahillei*, both associated with rocky bottoms, and *Coelorinchus marinii* and *Malacocephalus occidentalis* in deeper water. Widespread, but less abundant in the catch, were *Polymixia lowei, Urophycis mystacea* and *Merluccius hubbsi*.

Large ichthyophagous demersal bony fishes such as *Epinephelus flavolimbatus, Lopholathilus villarii, Genypterus brasiliensis, Pseudopercis* sp. and *Lophius gastrophysus* were rarely caught and did not occur in water deeper than 350 m.

On the winter cruises, *Polyprion americanus, Scomber japonicus, Trichiurus lepturus, Trachurus lathami, Umbrina canosai* and *Helicolenus lahillei* were the most abundant teleosts. The most frequently occurring species on summer-autumn cruises were *Cynoscion guatucupa, Antigonia capros* and *Priacanthus arenatus* in the south and *T. lathami, Thyrsitops lepidopoides, T. lepturus, U. canosai* and *Zenopsis conchifera* in the north.

This survey yielded a number of species rarely caught or otherwise recorded for the first time in Brazilian waters: *Dysomminia rugosa, Polymetme corythaeola, Stomias affinis, Melanostomias niger, Diaphus effulgens, Gymnoscopelus piabilis, Symbolophorus barnardi, Neocopelus macrolepidotus, Macruronus magellanicus, Benthocometes robustus, Malacocephalus laevis, Malacocephalus occidentalis, Ventrifossa ori, Beryx splendens, Xenolepidichtys dalgleishi, Prometichthys prometheus, Benthodesmus elongatus* and *Lepidopus* sp. (see Nakamura & Parin 1993 for species identity).

Additional information on the distribution, sizes and life history of some species follows.

Merluccius hubbsi. This hake is found from the coast of Rio de Janeiro State to the southern tip of South America (Angelescu & Prenski 1987, Fagundes & Gaelzer 1991). It was the most frequent teleost, occurring in 37 hauls but representing only 1.18% of total bony fishes caught (Table 2). This species was taken in a wide range of depths and bottom temperatures, from 120 to 490 m and from 6.8 to 17 °C. Total length ranged from 8 to 48 cm; most specimens over 40 cm were caught in the south and in winter (Fig. 3A), juveniles under 30 cm being more abundant between the 60 and 180 m isobaths. Mature females were found only in winter. On the shelf, juveniles fed mostly on zooplankton, and adults on fish (*Engraulis anchoita, Trachurus lathami* and *M. hubbsi*) and squid (*Illex argentinus* and *Loligo sanpaulensis*). Commercial catches of *M. hubbsi* are not common in the area and are restricted to the winter season (Haimovici et al. 1989b). Recent studies show that the southern Brazilian coast is mainly a nursery ground for the same population unit that spawns in winter off Uruguay and northern Argentina (Haimovici et al. 1993).

Zenopsis conchifera. The buckler dory is a species widely distributed in the Atlantic Ocean. It occurred in 34 hauls, and its length ranged from 5 to 56 cm. Larger specimens were more frequent in the 250 to 349 m range (Fig. 3B). Yesaki et al. (1976) suggested that there was some fishery potential for the buckler dory, but this did not appear evident with our gear; a mid-water trawl would probably work out better. Females over 35 cm were found maturing in autumn and ripe in winter. *Z. conchifera* preys mainly on *Maurolicus muelleri, Diaphus dumerilii* and *Euphausia similis*. Macpherson (1983) found this species feeding mainly on fishes off South Africa.

Synagrops spinosus. Widely distributed in the western Atlantic Ocean, this small fish occurred in 33 hauls, mainly in the southern portion of the survey area at depths greater than 350 m. Undersampled because of its small size, but probably abundant in the region, it was caught in a wide range of depths and temperatures. It is commonly preyed upon by *Pagrus pagrus*

Table 1 Teleost species caught in a bottom trawl survey off southern Brazil by the RV 'Atlântico Sul' in 1986 and 1987. Families are arranged in systematic order according to Nelson (1984)

Species
Muraenidae
Gymnothorax ocellatus Agassiz, 1831
Synaphobranchidae
Dysommina rugosa Ginsburg, 1951
Congridae
Conger orbignyanus Valenciennes, 1847
Engraulidae
Engraulis anchoita Hubbs & Marini, 1935
Argentinidae
Argentina striata Goode & Bean, 1896
Sternoptychidae
Maurolicus muelleri (Gmelin, 1788)
Phothichthyidae
Polymetme corythaeola (Alcock, 1898)
Stomiidae
Stomias affinis Günter, 1887
Melanostomiidae
Melanostomias niger Gilchrist & von Bonde, 1924
Synodontidae
Saurida caribbaea Breder, 1927
Chlorophthalmidae
Chlorophthalmus agassizi Bonaparte, 1840
Parasudis truculenta (Goode & Bean, 1896)
Neoscopelidae
Neoscopelus macrolepidotus Johnson, 1863
Myctophidae
Diaphus dumerilii (Bleeker, 1856)
Diaphus effulgens (Goode & Bean, 1896)
Gymnoscopelus piabilis (Whitley, 1931)
Symbolophorus barnardi (Tåning, 1932)
Bregmacerotidae
Bregmaceros atlanticus Goode & Bean, 1886
Gadidae
Urophycis brasiliensis (Kaup, 1858)
Urophycis mystacea Ribeiro, 1903
Merluccidae
Merluccius hubbsi Marini,1933
Macruronus magellanicus Lönnberg, 1907
Macrouridae
Coelorinchus marinii Hubbs, 1934
Malacocephalus laevis (Lowe, 1843)
Malacocephalus occidentalis Goode & Bean, 1885
Ventrifossa ori (Smith, 1968)
Ophidiidae
Benthocometes robustus (Goode & Bean, 1886)
Genypterus brasiliensis (Regan, 1903)
Batrachoididae
Porichthys porosissimus (Valenciennes, 1837)
Lophiidae
Lophius gastrophysus Ribeiro, 1915
Trachichthyidae
Hoplostethus occidentalis Woods, 1973
Berycidae
Beryx splendens Lowe, 1834
Polymixiidae
Polymixia lowei Günter, 1859
Zeidae
Zenopsis conchifera (Lowe, 1850)
Grammicolepididae
Xenolepidichthys dalgleishi Gilchrist, 1922
Caproidae
Antigonia capros Lowe, 1843
Macroramphosidae
Macroramphosus scolopax (Linnaeus, 1758)
Notopogon fernandezianus (Delfin, 1899)
Dactylopteridae
Dactylopterus volitans (Linnaeus, 1758)
Scorpaenidae
Helicolenus lahillei Norman, 1937
Pontinus rathbuni Goode & Bean, 1896
Setarches guentheri Johnson, 1862
Peristediidae
Peristedion altipinne Regan, 1903
Peristedion sp

Species
Triglidae
Bellator brachychir (Regan, 1914)
Prionotus nudigula Ginsburg, 1950
Prionotus punctatus (Bloch, 1797)
Polyprionidae
Polyprion americanus (Schneider, 1801)
Serranidae
Dules auriga Cuvier, 1829
Epinephelus flavolimbatus Poey, 1865
Holanthias martinicensis (Guichenot, 1868)
Pikea rosa (Günther, 1880)
Serranus atrobranchus (Cuvier, 1829)
Priacanthidae
Cookeolus japonicus (Cuvier, 1829)
Priacanthus arenatus Cuvier, 1829
Acropomatidae
Synagrops bellus (Goode & Bean, 1896)
Synagrops spinosus (Schultz, 1940)
Branchiostegidae
Caulolatilus chrysops (Valenciennes, 1833)
Lopholatilus villarii Ribeiro, 1915
Pomatomidae
Pomatomus saltatrix (Linnaeus, 1766)
Carangidae
Decapterus tabl Berry, 1968
Naucrates ductor (Linnaeus, 1758)
Trachurus lathami Nichols, 1920
Bramidae
Brama brama Bonnaterre, 1788
Lutjanidae
Pristipomoides freemani Anderson, 1966
Sparidae
Pagrus pagrus (Linnaeus, 1758)
Sciaenidae
Cynoscion guatucupa (Cuvier, 1830)
Cynoscion jamaicensis (Vaillant & Bocourt, 1883)
Micropogonias furnieri (Desmasrest, 1823)
Umbrina canosai Berg, 1895
Mullidae
Mullus argentinae Hubbs & Marini, 1935
Cheilodactylydae
Sciaenoides bergi Norman, 1937
Percophidae
Bembrops heterurus (Ribeiro, 1903)
Percophis brasiliensis Quoy & Gaimard, 1824
Pinguipedidae
Pseudopercis spp.
Callionymidae
Synchiropus agassizii (Goode & Bean, 1888)
Gempylidae
Prometichthys prometheus (Cuvier, 1832)
Thyrsitops lepidopoides (Cuvier, 1831)
Trichiuridae
Benthodesmus elongatus (Clarke, 1879)
Evoxymetopon taeniatus Poey, 1863
Lepidopus sp. (see Nakamura & Parin 1993)
Trichiurus lepturus Linnaeus, 1758
Scombridae
Auxis thazard (Lacepede, 1800)
Sarda sarda (Bloch, 1793)
Scomber japonicus Houttuyn, 1782
Centrolophidae
Centrolophus sp.
Ariommatidae
Ariomma bondi Fowler, 1930
Stromateidae
Peprilus paru (Linnaeus, 1758)
Bothidae
Citharichthys cornutus (Günther, 1880)
Etropus longimanus Norman, 1933
Paralichthys isosceles Jordan,1890
Paralichthys patagonicus Jordan,1889
Molidae
Mola mola (Linnaeus, 1758)

Table 2. Absolute frequency of occurrence (AFO), sizes, bottom temperature and depth ranges of occurrence and relative abundance per depth of all identified bony fishes caught in 4 bottom cruises by the RV 'Atlântico Sul' in 1986 and 1987. Cruises: WS, winter-south 1986; LN, late winter-north 1986; SS, late summer-south 1987; AN, autumn-north 1987. Habitat: b, demersal-benthonic; d, demersal-pelagic; m, pelagic and mesopelagic

Species	AFO	Mean catch (kg h^{-1})	Mean weight (g)	Length range (cm)		Depth range (m)		Bottom temp. range (°C)		Percentage of catch by weight for depth range:					Percentage of catch by weight for cruises:				Habitat
				Min.	Max.	Min.	Max.	Min.	Max.	120–	180–	250–	350–	450–	WS	LN	SS	AN	
Merluccius hubbsi	37	1.045	78	8	48	120	490	6.8	17.0	12	31	33	17	7	50	13	31	6	d
Zenopsis conchifera	34	1.894	150	5	56	120	334	10.1	17.0	12	13	74			22	27	16	35	d
Synagrops spinosus	33	0.062	15	6	14	129	401	6.8	17.0	31	30	26	12		67	7	21	5	d
Polymixia lowei	29	1.468	50	7	23	152	490	–	16.6	<1	38	52	7	3	7	30	1	61	b
Trichiurus lepturus	27	16.657	375	27	143	120	291	13.0	17.0	80	20	<1			13	12	74	1	d
Thyrsitops lepidopoides	27	2.714	110	16	36	120	350	9.0	17.0	42	57	1	<1		14	27	1	58	d
Urophycis mystacea	26	1.985	124	8	49	120	511	4.9	17.0	19	43	22	7	9	58	6	30	5	b
Ariomma bondi	24	9.211	49	6	19	129	380	–	17.0	2	<1	71	26		<1	99	<1	<1	d
Helicolenus lahillei	24	1.996	82	7	41	150	587	4.0	16.3	<1	4	30	11	55	60	19	17	4	b
Mullus argentinae	22	1.302	65	11	22	120	233	13.0	17.0	86	14				14	65	10	11	b
Coelorinchus marinii	21	0.448	54	12	34	183	587	4.0	16.3		<1	12	46	42	18	72	3	7	b
Saurida caribbaea	20	0.011	7	5	14	128	290	11.5	17.0	37	54	9			3	14	36	47	b
Trachurus lathami	19	15.331	37	9	20	120	301	10.1	17.0	100	<1	<1			6	19	<1	74	d
Antigonia capros	19	3.072	158	3	22	129	479	4.9	17.0	36	64			<1	1	64	34	1	b
Paralichthys isosceles	19	0.126	124	11	33	120	233	13.0	17.0	69	31				20	23	35	22	b
Argentina striata	19	0.056	13	6	23	150	450	8.0	16.6	3	68	27		2	2	45	24	29	d
Benthodesmus elongatus	18	0.079	25	11	70	178	587	–	16.0	<1	1	27	55	17	11	44	42	3	d
Malacocephalus occidentalis	18	0.072	69	12	39	183	587	4.0	16.3		2	10	39	49	19	52	14	15	b
Bembrops heterurus	17	0.018	39	10	24	130	511	8.0	17.0	18	31	45		6	36	24	15	25	b
Genypterus brasiliensis	16	0.755	1 402	37	80	128	334	11.5	17.0	31	25	44			77	1	9	13	b
Prionotus nudigula	16	0.097	54	10	20	129	382	9.0	17.0	67	26	2	4		10	73	7	10	b
Synagrops bellus	16	0.071	82	12	24	144	490	6.8	16.0	2	2	44	29	24	38	58	3	1	d
Diaphus dumerilii	15	0.012	2	4	13	197	587	4.0	15.7		1	7	18	74	35	23	18	24	m
Lophius gastrophysus	13	0.305	1 183	23	64	130	300	11.5	17.0	12	31	56			34	14	31	21	b
Evoxymetopon taeniatus	13	0.265	202	17	121	129	382	9.0	16.5	2	9	9	81		2	74	4	20	d
Lepidopus sp.	11	0.113	77	52	80	183	450	6.0	16.3	<1	19	3	40	38	3	52	28	16	d
Polyprion americanus	10	9.466	11 187	56	113	120	450	6.0	16.2	2	3	37	32	26	51	31	4	14	b
Scomber japonicus	10	4.396	66	12	26	128	290	11.5	17.0	96	3	1			99	<1	<1		d
Xenolepidichthys dalgleishi	10	0.052	39	7	17	186	511	6.0	16.0		6	4	23	67	7	73	10	10	d
Serranus atrobranchus	10	0.013	45	10	17	129	233	13.0	17.0	50	50				54	3	43		b
Peristedion sp.	9	0.104	27	8	23	200	291	13.0	16.0		82	18			10	68	1	21	b
Macrorhamphosus scolopax	9	0.012	11	8	14	144	287	11.5	17.0	4	94	1			1	39	60		b
Urophycis brasiliensis	8	0.041	176	20	37	128	214	14.5	17.0	40	60					36	58	6	b
Maurolicus muelleri	8	0.012	2	4	5	120	380	–	16.3	13	14	39	34		40	18	14	28	m
Porichthys porosissimus	7	0.340	43	9	26	130	212	15.0	17.0	97	3				44	<1	2	54	b
Sciaenoides bergi	7	0.063	206	23	37	120	233	13.0	16.0	41	59				56	6	38		b
Polymetme corythaeola	7	0.005	6	3	17	286	587	4.0	13.0			1	57	42	2	78	7	13	m
Cynoscion guatucupa	6	6.675	73	11	50	120	165	15.8	17.0	100					75	<1	20	5	d
Umbrina canosai	6	3.272	104	10	40	120	165	15.2	16.4	100					12	64		25	b
Pagrus pagrus	6	0.575	705	11	50	134	185	15.0	17.0	90	10				83	14	2	<1	d
Gymnothorax ocellatus	6	0.040	324	46	75	134	229	15.0	17.0	24	76					11	43	46	b
Parasudis truculenta	6	0.005	20	11	19	212	431	8.0	16.0		6	46	48		25	59		16	d
Citharichthys cornutus	6	0.002	9	8	13	144	212	15.0	17.0	9	91				12		7	81	b
Engraulis anchoita	5	0.028	13	8	15	129	152	15.2	17.0	100						100			d

(Table continued on next page)

Table 2 (continued)

Species	AFO	Mean catch (kg h^{-1})	Mean weight (g)	Length range (cm) Min.	Max.	Depth range (m) Min.	Max.	Bottom temp. range (°C) Min.	Max.	Percentage of catch by weight for depth range: 120–	180–	250–	350–	450–	Percentage of catch by weight for cruises: WS	LN	SS	AN	Habitat
Notopogon fernandezianus	5	0.008	23	10	17	188	334	11.5	15.0		13	87			14	9		77	b
Pontinus rathbuni	5	0.005	26	6	11	150	233	13.0	16.3	64	36				72		28		b
Priacanthus arenatus	4	1.122	1586	21	53	176	587	4.0	16.3	1	99			<1		2	98	<1	d
Lopholatilus villarii	4	0.122	1325	37	59	140	300	11.5	16.4	33	20	47			94	6			b
Pristipomoides freemani	4	0.025	66	12	22	150	197	15.0	16.3	70	30				75		18	7	d
Decapterus tabl	4	0.008	72	13	27	150	233	13.0	16.5	24	76				66		34		d
Hoplostethus occidentalis	4	0.003	14	6	11	256	511	8.0	14.5			92	8		92	8			d
Synchiropus agassizii	4	0.002	9	12	21	140	229	15.0	16.4	13	87				17	50		34	b
Setarches guentheri	4	0.001	10	6	11	214	431	8.0	15.0		7	14	79			60	11	29	b
Prionotus punctatus	3	0.179	431	14	40	120	140	16.0	16.4	100					34			66	b
Pikea rosa	3	0.004	40	12	16	176	214	15.0	16.0	86	14				55	34	11		d
Mola mola	2	1.231	40000	91		150	300	12.5	16.5	41		59			50		50		m
Pseudopercis spp.	2	0.378	6150	74	88	120	144	15.2	16.0	100					45	55			b
Sarda sarda	2	0.115	1250	39	55	150	157	15.0	15.0	100					100				m
Caulolatilus chrysops	2	0.040	870	33	34	144	197	15.2	15.7	81	19				66	14		19	b
Cookeolus japonicus	2	0.022	467	23	24	129	178	15.8	16.0	100					80	20			d
Symbolophorus barnardi	2	0.005	15	<15		212	488	4.8	16.0		2		98		3		97		m
Naucrates ductor	2	0.005	60	11	20	150	300	12.5	16.5	58		42			33		67		m
Chlorophthalmus agassizi	2	0.001	13	11	13	300	431	8.0	11.5			27	73		42	58			b
Stomias affinis	2	0.000	12	12	14	450	511	8.0	8.0					100		100			d
Diaphus effulgens	2	0.000	3	4	13	452	488	4.8	6.5					100			100		m
Bregmaceros atlanticus	2	0.000	4	5	8	287	511	8.0	11.5			46		54		100			m
Epinephelus flavolimbatus	1	0.302	9800	89		188	188	16.3	16.3		100						100		b
Paralichthys patagonicus	1	0.126	1368	48	59	120	120	16.0	16.0	100		<1			100				b
Gymnoscopelus piabilis	1	0.102	19	11	14	488	488	4.8	4.8					100			100		m
Auxis thazard	1	0.049	3200	60		120	120	16.0	16.0	100					100				m
Centrolophus sp.	1	0.039	3342	54		287	287	11.5	11.5			100				100			d
Micropogonias furnieri	1	0.035	2250	55		120	120	16.0	16.0	100					100				d
Percophis brasiliensis	1	0.026	1700	49		120	120	16.0	16.0	100					100				b
Peprilus paru	1	0.025	76	8	16	140	140	16.0	16.0	100								100	d
Beryx splendens	1	0.023	1500			450	450	8.0	8.0					100		100			d
Holanthias martinicensis	1	0.020	41	11	15	188	188	16.3	16.3		100						100		m
Macruronus magellanicus	1	0.009	580	58		490	490	8.0	8.0					100	100				b
Pomatomus saltatrix	1	0.008	550	39		120	120	16.0	16.0	100					100				d
Conger orbignyanus	1	0.007	223	61		256	256	14.5	14.5			100				100			b
Prometichthys prometheus	1	0.006	210	38	39	511	511	8.0	8.0					100		100			d
Dactylopterus volitans	1	0.004	250	<25		140	140	15.8	15.8	100								100	b
Cynoscion jamaicensis	1	0.003	225	27		120	120	16.0	16.0	100					100				d
Peristedion altipinnis	1	0.002	77	11	22	334	334	12.0	12.0			100						100	b
Dules auriga	1	0.002	37	11	14	134	134	16.0	16.0	100								100	b
Dysommina rugosa	1	0.001	89	36		301	301	10.1	10.1			100					100		b
Benthocometes robustus	1	<0.001	10	11	12	301	301	10.1	10.1			100					100		b
Melanostomias niger	1	<0.001	30	19		350	350	9.0	9.0				100		100				m
Malacocephalus laevis	1	<0.001	13	<10		382	382	9.0	9.0				100			100			b
Bellator brachychir	1	<0.001	5	7		200	200	15.7	15.7		100							100	b
Neoscopelus macrolepidotus	1	<0.001	10	11		587	587	4.0	4.0					100				100	b
Etropus longimanus	1	<0.001	9	11		134	134	16.0	16.0	100								100	b
Ventrifossa ori	1	<0.001	7	12		400	400	8.0	8.0				100		100				b
Brama brama	1	<0.001	3	<5		450	450	8.0	8.0					100		100			d

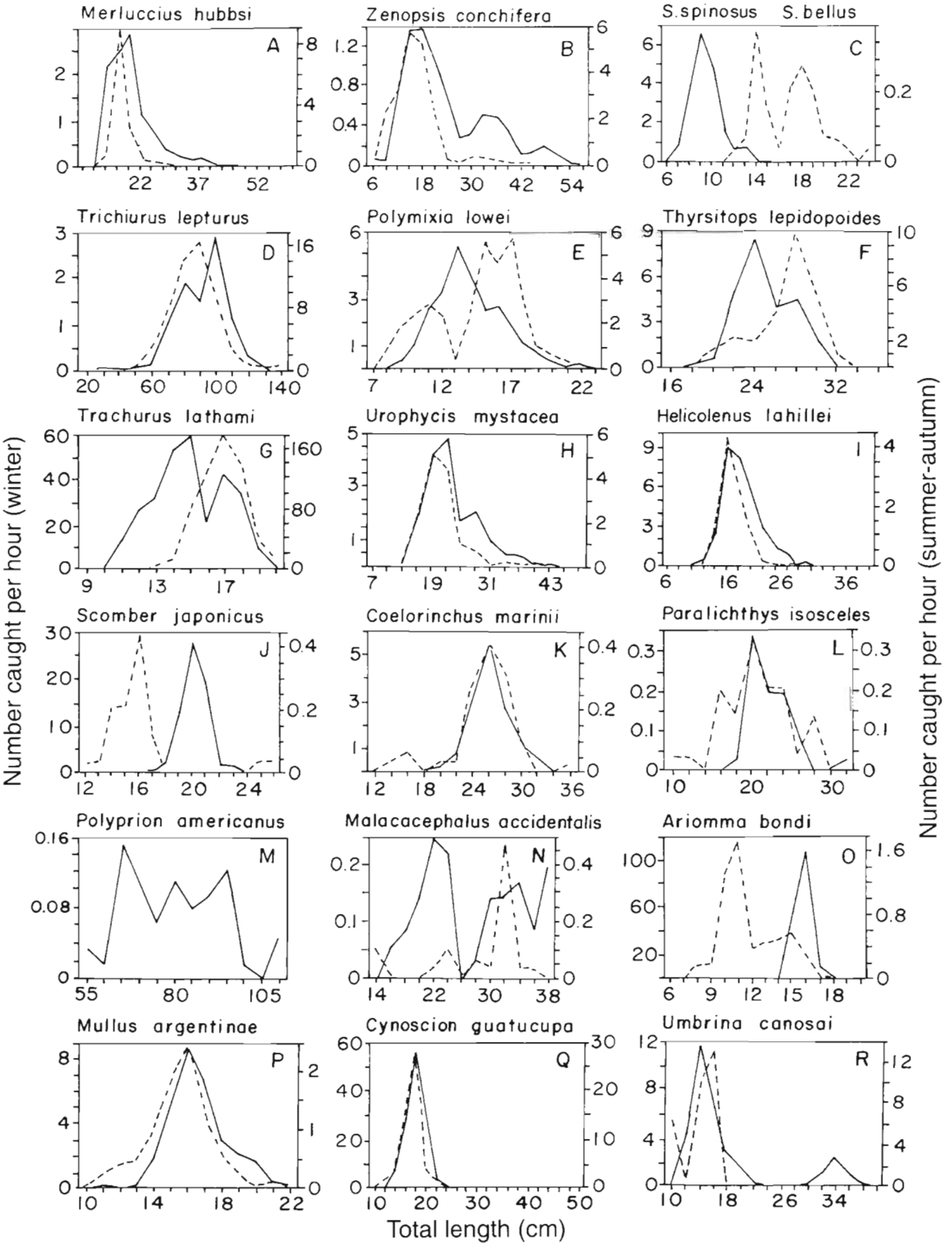

Fig. 3. Total length distributions of selected teleost species caught along the survey for the winter (solid lines) and summer-autumn cruises (dashed lines)

at 50 to 120 m depth (Capitoli & Haimovici 1993). The congeneric species *Synagrops bellus* occurred 16 times, in the same depth and temperature ranges as *S. spinosus*, but was more abundant in deeper waters. Their size distributions did not overlap in the samples (Fig. 3C).

Trichiurus lepturus. Distributed worldwide in tropical and warm-temperate waters, the cutlassfish was found mainly on the outer shelf. Mean weight was 375 g and total length varied between 27 and 143 cm but most fishes were longer than 70 cm (Fig. 3D). Caught in all cruises, the cutlassfish was more abundant in the south, and during the summer. Large adults caught on the outer shelf fed mostly on *Maurolicus muelleri* and euphausiids. Spawning specimens were found during May and September cruises, when specimens from the shelf were still maturing (Martins 1992).

Polymixia lowei. The beardfish is distributed in the western Atlantic from Uruguay to New Jersey, USA. It occurred throughout the surveyed area, but was more common in the northern region. In the warm season cruises 2 modal groups, 11 cm and 17 cm long, were observed (Fig. 3E). No ripe or maturing specimens were found. *P. lowei* feeds mainly on small demersal fishes such as *Bregmaceros atlanticus* and benthic decapod crustaceans.

Thyrsitops lepidopoides. This gempylid fish is limited to the Atlantic and Pacific coasts of southern South America. More frequent in the north, it presented 2 modal groups of 23 and 28 cm long in winter and summer, respectively (Fig. 3F). In winter and spring it was found to feed on young *Engraulis anchoita* and euphausiids on the shelf (Schwingel 1991, based on 11 examples 72 to 248 mm long). Ripe females over 21 cm were observed in November and March.

Trachurus lathami. This jack mackerel ranges from the Gulf of Maine to Argentina. Rather abundant and occasionally landed by sardine or mackerel purse-seiners along the coast of southern and southeastern Brazil, it was caught at 19 stations up to 180 m deep, representing 21.03 % of the catch and being more common towards the north. Length ranged from 9 to 20 cm (Fig. 3G). In winter and spring it preys mainly upon euphausiids and copepods (Schwingel 1991).

Urophycis mystacea. This is a type of hake confined to the waters from Argentina to Rio de Janeiro. It was more frequent in the south in both winter and summer-autumn cruises. Most of the fish caught were immature specimens, a few maturing females over 30 cm long being observed in May and July. Its food consists of benthic crabs and shrimps but also small demersal-pelagic fishes and cephalopods. The congeneric species *Urophycis brasiliensis* has the same geographical distribution, being more abundant in shallower waters, where it is fished by trawlers. It occurred in 8 hauls below 214 m depth. Total length ranged from 20 to 37 cm (Fig. 3H). On the shelf coastal waters it feeds on shrimps, crabs and to a lesser degree on fish.

Helicolenus lahillei. This species is known to occur from the coast of Santa Catarina State to northeastern Argentina. Most of the specimens were juveniles, those over 23 cm long were caught mainly in winter and some of the females were ripe (Fig. 3I). Seldom caught on the shelf, this is one of the most abundant demersal species on the break and upper slope. It is rather abundant in the Rio de la Plata Front over 100 m deep (Otero et al. 1982) where the larger specimens prey upon small benthic invertebrates and fishes (Migliore 1988). In the study area it feeds mostly on myctophid fishes, squids and anomuran crustaceans (*Munida* spp.).

Scomber japonicus. Chub mackerel is a cosmopolitan species, inhabiting warm and temperate waters. It was mainly caught in the south in winter below 180 m depth. The total length ranged from 17 to 23 cm in winter, with a mode of 20 cm. In summer, its size ranged from 12 to 26 cm, the mode being 16 cm (Fig. 3J). This mackerel feeds on euphausiids and copepods (Schwingel 1991). A single migratory stock living between Rio de Janeiro and Argentina was proposed by Seckendorff & Zavala-Camin (1985) but morphometric differences were found by Perrota et al. (1990) when comparing fishes from southern Brazil and the Mar del Plata region.

Sciaenoides bergi. This species is known to occur from Rio de Janeiro to Argentina, being more frequent in the south. This is a temperate-water benthic invertebrate feeding species common on the Argentinean and Uruguayan shelf (Fernandez & Norbis 1986).

Coelorinchus marinii. This macrourid occurs in the southwestern Atlantic from southern Brazil to Antarctica (Cohen et al. 1990). It was frequent below 350 m depth in winter in the entire area studied. Mean weight was 58 g and total length ranged from 12 to 34 cm (Fig. 3K). Some mature females over 250 mm were taken in all cruises. Its diet includes benthic crustaceans and polychaetes.

Paralichthys isosceles. This flatfish occurs from Rio de Janeiro to northern Patagonia. This species is typical of the outer shelf in the region throughout the year. Specimens smaller than 18 cm were found only in autumn (Fig. 3L). It preys upon small fishes, benthic crustaceans and cephalopods. Spawning seems to occur on the outer shelf in summer.

Polyprion americanus. The wreckfish is found in the Atlantic, Mediterranean and Indian Oceans, and waters around New Zealand. This is the only commercially fished teleost on the upper slope in the study area, where it is fished with a hand line on rocky bottoms (Wahlrich & Peres 1990). This large fish had a mean weight of 9.4 kg, and its total length ranged from

56 to 113 cm (Fig. 3M). It occurred at all fished depths in temperatures varying from 6 to 16.2 °C. Reproduction seems to occur in the cold season. *P. americanus* feeds on fishes such as *Merluccius hubbsi*, *Helicolenus lahillei* and *Urophycis mystacea*, the crab *Cheaceon notialis* and the squid *Illex argentinus*.

Genypterus brasiliensis. Known to occur from Rio de Janeiro to Argentina, this fish was confused with *G. blacodes*, found from Uruguay to the southern tip of South America. This highly appreciated gadiform was caught in small numbers between 128 and 334 m deep, presenting a mean weight of 1.402 kg and a total length from 37 to 80 cm. Specimens smaller than 60 cm were found only in summer. It was more abundant in winter and in the south. Only immature specimens were caught. The few stomachs observed contained benthic macrocrustaceans and unidentified fishes.

Lophius gastrophysus. The blackfin goosefish lives in waters between Rio de Janeiro and Argentina. A few specimens measuring 23 to 64 cm and with a mean weight of 1.183 kg were caught in 13 tows, from 180 to 300 m deep and from 11.5 to 17.0 °C.

Malacocephalus occidentalis. This is a benthic macrourid species found along the slope of both margins of the South Atlantic (Cohen et al. 1990). It was caught mostly at depths >350 m. Total length ranged from 15 to 39 cm (Fig. 3N). *M. occidentalis* was more abundant in the north. Ripe females over 35 cm long were found in July. It feeds on benthic macrocrustaceans, myctophid fishes and cephalopods.

Ariomma bondi. The silver-rag lives in the Atlantic Ocean, ranging from Maine to Uruguay in the western Atlantic. It occurs in large schools on mud or sand bottoms of the outer shelf, and feeds on small benthic-dwelling animals, mainly crustaceans (Fischer 1978). It was present in 24 hauls, from 129 to 380 m, but abundant only in 1 at 250 m depth near the Cape of Santa Marta Grande. Its mean weight was 49 g and total length ranged from 6 to 19 cm (Fig. 3O). Larger specimens were taken in spring and maturing females over 15 cm in winter.

Mullus argentinae. The goatfish is known to occur from Rio de Janeiro to Mar del Plata. It was caught on the outer shelf and was more common in the northern winter cruise. The mean weight was 65 g and total length varied from 11 to 22 cm (Fig. 3P). It feeds on benthic invertebrates.

Cynoscion guatucupa* syn. *Cynoscion striatus. This weakfish (for taxonomic status see Figueiredo 1992) occurs from Rio de Janeiro to Argentina, and is an important commercial species in the coastal trawl fishery of southern Brazil, Uruguay and Argentina (Haimovici et al. 1989b, Vieira 1990). It is a shelf species which was relatively abundant in many of the hauls <165 m depth, and occurs mainly in winter in the south and at bottom temperatures over 15.8 °C. Sizes ranged from 11 to 50 cm (Fig. 3Q). Most specimens taken were juveniles but some adults were caught in the winter.

Umbrina canosai. A migratory species between Argentina and southern Brazil, where it is intensively fished by trawlers, this sciaenid is found in small quantities up to Rio de Janeiro. In the survey it was caught below 165 m depth and at temperatures over 15.2 °C. Sizes ranged between 10 and 40 cm (Fig. 3R). It was more frequent in both northern-area cruises in May and September. Adult spawners were observed in the winter cruise at 130 m depth at 31° S. Specimens over 25 cm were not common at depths over 75 m but some commercial catches of larger specimens have been reported (Haimovici 1982). *U. canosai* is a long-living and slow-growing species that spawns in spring and feeds on benthic invertebrates (Haimovici & Reis 1984, Haimovici & Cousin 1989, Haimovici et al. 1989a).

Pagrus pagrus. The red porgy is an Atlantic and Mediterranean species (Manooch & Hassler 1978). A few specimens measuring from 11 to 50 cm total length and 705 g mean weight occurred in 6 hauls at depths <185 m and bottom temperatures from 15 to 17 °C. It migrates to southern Brazil in winter together with cold waters on the mid-shelf (Yesaki & Barcellos 1974, Haimovici 1991). *P. pagrus* feeds on a wide variety of benthic and demersal fish and invertebrates (Capitoli & Haimovici 1993).

Porichthys porossissimus. Known to occur from Argentina to Rio de Janeiro, the midshipman was taken between 130 and 212 m deep. It was relatively abundant in only 2 hauls, one in winter at 178 m and the other in summer at 134 m.

Diaphus dumerilii. A common and abundant mesopelagic tropical species widely distributed in the Atlantic Ocean, it probably consists of a number of populations. In the southwestern Atlantic adults not yet sexually mature occurred near the continent in relatively cold waters under steep thermoclines and were considered an 'expatriate population' (Hulley 1981). It measured 4 to 13 cm long with a mean weight of 3 g. It was the most frequent myctophid in the survey, occurring in 15 hauls from 197 to 587 m deep and from 4 to 15.7 °C. Undersampled by our gear, it was found in the stomach contents of several fishes and seems to be very abundant and important in the trophic relations on the slope. Catches up to 15 t haul^{-1} were recorded off Uruguay and northern Argentina (Hulley 1981). The congeneric species *D. effulgens* was caught in only 2 hauls below 458 m depth.

Argentina striata. Found along the western Atlantic from Nova Scotia to Uruguay, this studied argentine was taken in small numbers between 150 and 450 m depth, but more frequently up to 250 m deep in the northern region.

Antigonia capros. The boarfish is a cosmopolitan species in temperate and tropical waters, except in the eastern Pacific. In winter only juveniles were taken, ripe females over 15 cm having been caught in March. Boarfish occurred more frequently at temperatures over 12.5 °C and depths up to 250 m. It feeds mostly on hyperiid amphipods, euphausiids and small squid. Most catches occurred in the northern spring and southern summer cruises.

Benthodesmus elongatus. The frostfish is found in subtropical and temperate waters of the southern hemisphere. Frostfish were more abundant in July in the north and in summer in the south, where larger specimens were more frequent. A few examined stomach contents contained euphausiids and myctophids.

Priacanthus arenatus. The bigeye is known to occur from Canada to northern Argentina. It was caught in 4 hauls from 176 to 587 m deep, and from 4 to 16.3 °C. Its mean weight was 1.586 kg and total length ranged from 21 to 53 cm. Most were caught in a summer haul at 188 m depth and 16.3 °C at 31° 09' S.

Maurolicus muelleri. This small mesopelagic fish is common along the continental slope of all oceans up to the 400 m isobath (Weitzman 1986). It was found at only 8 stations and measured from 4 to 5 cm, but was frequent in the stomach contents of several demersal-pelagic fish caught and appears an important species in the food chains in the study area. The species spawns in midwater on the shelf break, mainly from autumn to spring, eggs and larvae being retained in the front between tropical waters of the Brazil Current and colder and less saline coastal waters, and carried over the shelf by the partial upwelling of subtropical waters (Weiss et al. 1988). Frequent and abundant in plankton samples, its stock size was estimated from egg counts as being over 1600 t (Weiss et al. 1988). It feeds on planktonic crustaceans such as copepods and hyperiid amphipods.

Distribution pattern, relative abundance and number of species

Eigenvalues of Axes 1 to 4 in seasonal DECORANA runs and correlation coefficients between depth, bottom temperature and latitude with the scores of the hauls along the 4 axes are shown in Table 3. Depth and temperature were strongly correlated with Axis 1 in both seasons and to a lesser degree with Axis 2 in summer-autumn. Latitude only correlated with Axis 4 in winter-spring. Species and stations simultaneously ordered following DCA Axis 1 in both seasons are shown in Table 4. A more-or-less continuous substitution of species was observed both in winter and summer-autumn with increasing depth and decreasing bottom temperature, probably due to the lack of discontinuities in the bottom topography and morphology in the trawling areas.

Depth ranges. Total teleost mean catch decreased 6-fold along the depth gradient, from 170.9 (120 to 179 m) to 26.3 kg h^{-1} (450 to 587 m). The number of species decreased from 61 to 27 in the same depth range. Demersal-pelagic catches decreased sharply below 180 m depth with a partial recovery due to a large single catch of *Ariomma bondi* between 250 and 349 m. The demersal-benthonic catches decreased little with depth, ranging between 29.4 and 21.4 kg h^{-1}. The total number of species decreased slowly from 61 to 45 down to 350 m depth and to 26 and 27 in the last 2 depth ranges, showing a similar pattern for demersal-pelagic and demersal-benthic species. The mean number of species per haul decreased more gently, from over 14 (to 250 m deep) to 8.1 (below 350 m) (Table 5).

Latitudes and seasons. Mean total catches ranged from 74.4 to 97.5 kg h^{-1}, and total number of species varied from 53 to 67 per cruise, both values being higher in winter cruises (Table 5). Mean number of species ranged from 10.8 to 14.2. The catches of demersal-pelagic bony fishes differed little between seasons, ranging from 54.4 to 66.8 kg h^{-1}, being slightly higher in both northern cruises; the number of species was lower, 19 compared to 23 and 24, in the southern cruises. Demersal benthic fish catches in winter and spring (38.5 to 36.9 kg h^{-1}) were more than 2-fold the catch in summer and early autumn (11.8 to 16.0 kg h^{-1}) but the number of species was similar, ranging from 28 to 32. The difference was due mostly to some deep-water species such as *Polyprion ameri-*

Table 3. Eigenvalues of Axes 1 to 4 in a detrended correspondence analysis (DCA) and correlation coefficients between depth, bottom temperature and latitude with the scores of fishery hauls on Axes 1 to 4 (*significant at 5% probability level)

	Winter and spring cruises				Summer and autumn cruises			
	Axis 1	Axis 2	Axis 3	Axis 4	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	0.66	0.35	0.19	0.13	0.64	0.42	0.31	0.19
Depth	0.89*	0.02	0.09	0.07	0.81*	0.17*	0.04	<0.01
Bottom temperature	0.84*	0.01	<0.01	0.08	0.78*	0.18*	0.06	0.03
Latitude	0.09	<0.01	<0.01	0.49*	0.02	<0.01	<0.01	0.05

Table 4. Species and hauls ordained by Axis 1 on a detrended correspondence analysis (DECORANA), during 2 seasons on the outer shelf and upper slope of southern Brazil between 1986 and 1987. Abundance scale in no. of specimens per hour: <10 (1), 10–99 (2), 100–999 (3), 1000–9999 (4), >10 000 (5)

Temperature and depth in each haul:	490 m, <8.0 °C	460 m, <8.0 °C	511 m, <8.0 °C	431 m, <8.0 °C	450 m, <8.0 °C	400 m, <8.0 °C	385 m, <8.0 °C	316 m, 12.0 °C	300 m, 11.5 °C	350 m, 9.0 °C	382 m, 9.0 °C	290 m, 11.5 °C	286 m, 13.0 °C	300 m, 12.5 °C	287 m, 11.5 °C	256 m, 14.5 °C	380 m, –	212 m, 16.0 °C	208 m, 14.5 °C	250 m, 14.5 °C	150 m, 15.0 °C	208 m, 14.5 °C	178 m, 16.0 °C	188 m, 15.0 °C	157 m, 15.0 °C	176 m, 15.0 °C	152 m, 16.6 °C	165 m, 16.2 °C	185 m, 15.0 °C	120 m, 16.0 °C	129 m, 17.0 °C	140 m, 16.4 °C	144 m, 15.2 °C	170 m, 15.0 °C	145 m, 15.2 °C	129 m, 15.8 °C
Winter and spring cruises																																				
Setarches guentheri				1																																
Stomias affinis			1		1																															
Diaphus dumerilii	3	1	2	2	2		1			1	1		2																							
Xenolepidichthys dalgleishi			1	2	2		1		2				1																							
Polymetme corythaeola				2	1					1			1																							
Chlorophthalmus agassizi				1					1																											
Coelorinchus marinii	1	1	2	3	3	1		1	2			2	1																							
Malacocephalus occidentalis		1	1	1	1	1			2		1	1						1					1												
Helicolenus lahillei	3	2	2	2	2		1	3	1		1	2	1	1																						
Lepidopus sp.				1	1								1					1			1				1										
Hoplostethus occidentalis			1	1					2							1																				
Bregmaceros atlanticus			1												1																					
Polyprion americanus				2	1			2	1			1	2																							
Benthodesmus elongatus		1	1	1	2		1		1	1		1	1				3	1										1		1						
Synagrops bella	1			1	1	1	1		2		1	1	1		1			1					1													
Parasudis truculenta				1								1				2		1			1											1				
Polymixia lowei	1			1	2			2	2		2	1	3	1	2	2	1	1	2																	
Merluccius hubbsi	1			2	1	1	1	1	2	1	1	2	2	1		2		2	1			2		3			1									
Evoxymetopon taeniatus									1		2	1							1		1	1	3			1	1	2		2	1	1				
Notopogon fernandezianus									1			1							1						1								1			1
Urophycis mystacea		1	2	1		1	1		2			2	1			1		3						1												
Symbolophorus barnardi													1					1					3			1		1		1		2			
Decapterus tabl																		1																		
Bembrops heterurus			1						1				1			1		1	1																	
Lopholatilus villarii									1									1			1	1	1	1		1									
Lophius gastrophysus									1				1		1																1	1				
Peristedion sp.													2			1		1	3	1					1							1		1		
Maurolicus muelleri								1						3			3					2														
Synagrops spinosus							1	1				1	2	1	1	1		2												3						
Zenopsis conchifera								1				1	3	1		2		1	1		1	1	2	1	1	1	1	1	1							1
Argentina striata					1								1		1	1		1		2			1		1	1		1		1	1	2	1			1
Citharichthys cornutus																		1		2	1	2		1		1	1								
Genypterus brasiliensis									1				1					1			1														
Ariomma bondi									1						1	2	4	1			1		1		1	1		1			1	1				
Saurida caribbaea												1				1			1	4	1	1	1		1	1	1		1		3					
Scomber japonicus												2						2				1	1	1			1					1				
Macrorhamphosus scolopax															1				1		3		3		4			1			1				
Sciaenoides bergi																		1	1				1	2										1	
Pontinus rathbuni																									1					1		1			
Porichthys porosissimus																		1			1		1		1										
Serranus atrobranchus																		1					3	1							2				
Pristipomoides freemani																					1				1		1			1					
Pikea rosea																					2				1										
Gymnothorax ocellatus																							1			1									
Thyrsitops lepidopoides										1			1					1	1					1		1									
Prionotus nudigula											1								1	1		1	2	1		1	3		3	2		2		1	1
Priacanthus arenatus																					1			2	1	1		1			1		1	2	
Pagrus pagrus																									1	1									
Paralichthys isosceles																			1		2				2				1			1			
Synchiropus agassizii																						1	1	1		1		1		1	1	1		1	1
Trichiurus lepturus													1					1	1		1			1								1			
Mullus argentinae																			2		1		2	3	1	2				1		3	2	2	2
Urophycis brasiliensis																					2	2	2	2	2	1	2	2		2	3	2	3	2	2
Antigonia capros																		1				1		1										1	1
Cynoscion guatucupa																					1	2	2		1		1		3		1		2	3	1	
Cookeolus japonicus																												3		4		4				2
Prionotus punctatus																							1													1
Trachurus lathami																														1		2				
Pseudopercis spp.																						2	3			2		2		4	4	3	3		3	4
Umbrina canosai																														1			1			
Engraulis anchoita																												1		3		2			3	3
Caulolatilus chrysops																										1					1		3		2	1

(Table continued on next page)

Table 4 (continued)

Temperature and depth in each haul:	488 m, 4.8 °C	452 m, 6.5 °C	587 m, 4.0 °C	422 m, 8.5 °C	348 m, 8.0 °C	479 m, 4.9 °C	450 m, 6.0 °C	304 m, 10.0 °C	401 m, 6.8 °C	188 m, 16.3 °C	334 m, 12.0 °C	196 m, 15.7 °C	301 m, 10.1 °C	214 m, 15.0 °C	186 m, 16.3 °C	291 m, 14.0 °C	233 m, 13.0 °C	197 m, 15.7 °C	183 m, 16.3 °C	285 m, 14.5 °C	229 m, 15.5 °C	200 m, 15.7 °C	130 m, 17.0 °C	164 m, 15.7 °C	128 m, 17.0 °C	150 m, 16.5 °C	144 m, 17.0 °C	134 m, 16.0 °C	140 m, 15.8 °C
Summer and autumn cruises																													
Symbolophorus barnardi	2																												
Polymetme corythaeola		1	1	1																									
Diaphus dumerilii	2		2	2		1								1				1											
Benthodesmus elongatus		1	1		2	1			1					1															
Diaphus effulgens	1	1																											
Helicolenus lahillei	2		1	1		2	2	3			1		2				2		1										
Coelorinchus marinii		1	1	1		1	1	1			1			1	1				1										
Synagrops bellus				1				1	1																				
Xenolepidichthys dalgleishi		1			1		1								1														
Malacocephalus occidentalis	1		1	1		1			1			1		1	1				1										
Parasudis truculenta				1												1													
Polyprion americanus							1							1															
Priacanthus arenatus			1							2																			
Notopogon fernandezianus											2																		
Lepidopus sp.				1			1						1	2	1	1			1										
Pontinus rathbuni										1							1												
Antigonia capros					1					3		1			3		1		2			1					1		
Maurolicus muelleri				1										2		3			2										
Pikea rosea														1															
Sciaenoides bergi														1			1												
Polymixia lowei								2	1		2		1	1	2	2	1	2		3	1	3							
Pristipomoides freemani															1			1											
Serranus atrobranchus										1					1		1							1		1			
Synagrops spinosus								1	1		1		1	1	2	1	1	2	1		1	1	2				1	1	
Argentina striata											1	1			2	1		3		1	1	1							
Urophycis mystacea						1	1		1				1	3	1				1		1		2		1			2	
Merluccius hubbsi					1			1	1		1		1	3		1	1					1	2		1	2		1	
Caulolatilus chrysops																		1											
Setarches guentheri														1		1				1									
Macrorhamphosus scolopax															1		2							1			1		
Zenopsis conchifera										1	1		1	3	1	3	2	1	2	1	1		2	2	1	2	1		1
Lophius gastrophysus														1		1		1		1			1				1		
Genypterus brasiliensis											1			1						1	1				1	1			
Peristedion gracile														1		2					2	1							
Ariomma bondi														1	1		1	1		2		2	1	2		1	2		
Saurida caribbaea												1			1			2	1		1	2	1	1	1	1		1	1
Evoxymetopon taeniatus															1				1	1	1			1		1			
Paralichthys isosceles														1			1	1	1			1	1					2	1
Bembrops heterurus																			1	1	1	1	1					1	
Citharichthys cornutus																		1				1				1	1		
Urophycis brasiliensis														1											1		1	1	
Trichiurus lepturus														3	1	1	1		2		1	1	4	1	3	1	2	2	2
Gymnothorax ocellatus															1					1							1	1	
Decapterus tabl																	1							1		1			
Thyrsitops lepidopoides														1			1		1	1	3	2	1	1	1	1	1		1
Synchiropus agassizii																					1								
Prionotus nudigula																1				1		1	1			1		1	
Porichthys porosissimus																			1				1					3	
Trachurus lathami													1		1				1				2		2	1	3	2	5
Scomber japonicus																								1	1	2			
Cynoscion guatucupa																							4					3	
Mullus argentinae																	1		1			2	1				3	2	2
Pagrus pagrus																											1	1	
Umbrina canosai																												2	
Prionotus punctatus																												3	

Table 5. Catch (kg h^{-1}) and number of teleost species per cruise and depth range in a bottom trawl survey off southern Brazil during 1986 and 1987

	Cruise				Depth range (m)				
	Jul 1986 Winter South	Sep 1986 Spring North	Mar 1987 Summer South	May 1987 Autumn North	120–179	180–249	250–349	350–449	450–587
No. of hauls	17	19	17	12	20	14	14	8	9
Total bony fish catches	95.9	97.5	74.4	82.9	170.9	48.4	79.1	37.9	26.3
Mesopelagic species	3.0	0.0	2.9	0.0	2.6	0.1	2.9	0.0	0.8
Demersal-pelagic species	54.4	60.6	59.7	66.8	138.9	26.9	43.1	15.6	1.0
Demersal-benthonic species	38.5	36.9	11.8	16.0	29.4	21.4	33.1	22.2	24.4
Total no. of species	67	62	56	53	61	54	45	26	27
Mesopelagic species	8	4	8	2	5	3	5	3	6
Demersal-pelagic species	23	24	19	18	24	19	17	11	9
Demersal-benthonic species	35	33	28	32	32	31	22	11	11
Mean no. of species per haul	14.2	11.4	11.5	10.8	14.4	14.5	11.0	8.1	8.0

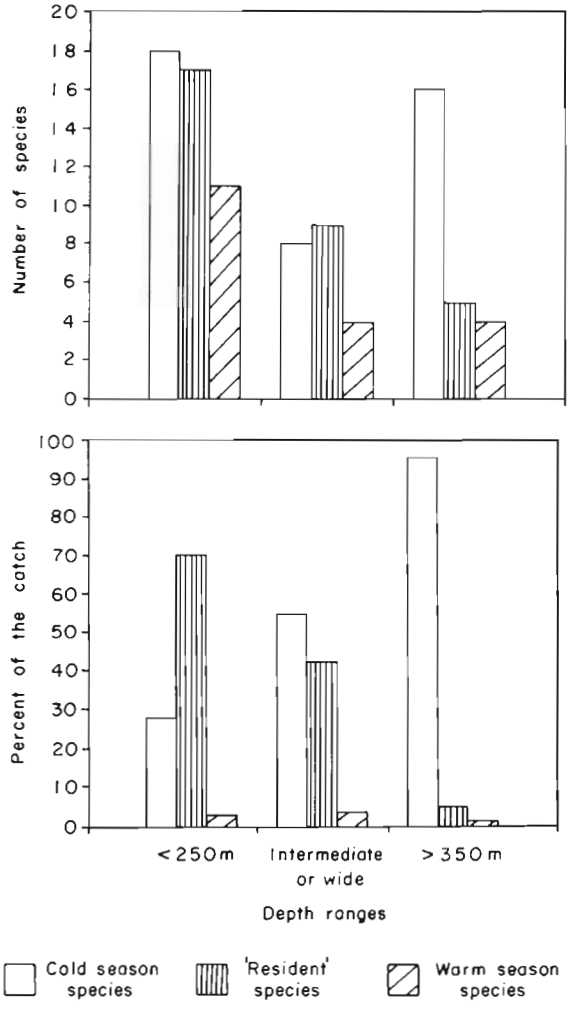

Fig. 4. Catches and number of teleost species per depth range classified according to their relative abundance in the winter-spring (cold) and summer-autumn (warm) cruises (for further details on the classification see text)

canus, *Helicolenus lahillei* and *Coelorinchus marinii*. Few mesopelagic species were caught, mainly myctophids, and were more abundant in both southern cruises.

Most species occurred in both winter and summer-autumn cruises (Table 2) but, because the study area is in the western boundary of the Subtropical Convergence, some seasonal pattern in the bony fish fauna is expected to occur. To investigate this possibility, the species were classified according to their relative abundance in the winter and summer-autumn cruises (Fig. 4). Species were grouped into: 'cold season species', those in more than 75% of the catches in the winter-spring cruises; and 'warm season species', those in more than 75% of the catches in summer-autumn cruises; the rest were included in a 'resident species' group. Overall, 42.5% of the catches were composed of 42 cold season species, and 19 warm season species amounted to 1.8% of the catch. A total of 32 resident species represented 55.7%. To account for bottom depth, species were arranged in 3 groups: (1) those found above 250 m depth, (2) those found below 350 m depth, and (3) those caught at intermediate depths or over a wider depth range. Warm season species were of little importance in all 3 ranges (2.4, 3.3 and 3.3% of the catch) and were more numerous on the outer shelf. Resident species were more abundant and numerous at <250 m (69.9%), second in intermediate depth (42.1%) and scarce at >350 m (4.2%). The opposite was observed for the cold season species (27.7%, 54.6% and 95.0% respectively in each depth range) which were almost as numerous on the outer shelf as at greater depth. With increasing depth, the relative abundance of species that occur year-round decreases, meanwhile it was higher for fishes that occur mostly in winter, the warm season species having little quantitative importance in the catches.

DISCUSSION

The southern Brazilian coast is on the boundary between subtropical and warm temperate regions. Figueiredo (1981), studying the continental shelf fish fauna, set the limits of the transitional zoogeographic Argentinean Province at Cabo Frio (21° S) and Valdés Peninsula (42° S), between the Caribbean and Patagonian provinces (Palacio 1982). The Argentinean Province has a low proportion of endemic fish species, ca 10%, characterized by high tolerance to temperature and salinity variations (Figueiredo 1981) as a consequence of the influence of the seasonal shift of the Subtropical Front and the (seasonal) upwelling of cold waters off southeastern Brazil (Matsuura 1986).

In this survey, species endemic to the Argentine Province, e.g. *Umbrina canosai, Urophycis brasiliensis, Mullus argentinae, Paralichthys isosceles*, and *Cynoscion guatucupa*, were found mostly on the outer shelf, and were more abundant in shallower waters. Many species with a wide Western Atlantic distribution, stretching from northern Argentina to the northern hemisphere, in some cases up to Canada, are found along the upper slope, e.g. *Trachurus lathami, Scomber japonicus, Ariomma bondi, Polymixia lowei*, and *Polyprion americanus*. In deeper waters species with a wider geographic distribution, even cosmopolitans, are found, e.g. the benthic and demersal macrourids, trichiurids, mesopelagic myctophids, *Maurolicus muelleri* and *Zenopsis conchifera*. Species from cold temperate waters abundant in southern Argentina were scarce in this survey; only *Merluccius hubbsi* was numerically abundant. Except for some demersal-benthonic species on the outer shelf, most abundant species were demersal-pelagic or hard bottom species.

Our results show a weak latitudinal gradient in the composition of fish fauna. This is expected as there are no geographic or hydrographic barriers and the amplitude in the bottom temperatures between north and south extremes of the study area in each season was small. Instead, the north-south shift of the western boundary of the Subtropical Convergence appears as the main factor responsible for seasonal changes in species abundance. Variation in demersal-pelagic species abundance was small, as at these latitudes the Brazil Current is present along the slope year-round and water temperature varies little. Colder water demersal-benthonic slope species were more affected, probably moving southward or to deeper waters in the warm season when the Convergence is further south. With increasing depth, the demersal-benthonic bony fishes that move northward are more abundant in winter, while no seasonal fluctuation was observed for the demersal-pelagic fauna, which was more abundant on the outer shelf compared to offshore. This situation is probably caused by the stronger convergence shift phenomena near the bottom than the surface, as the Brazil Current runs southward all year in the upper layers (Fig. 2).

Depth as the main ordination factor of marine fish assemblages is well documented (Lleonart & Roel 1984, Longhurst & Pauly 1987, Bianchi 1991, 1992). Physical characteristics of the water masses (temperature, oxygen, salinity) as well as other factors such as bottom type, light intensity, and pressure are mostly related to depth (Bianchi 1991, 1992), but the way in which these factors affect the fish distribution pattern, and the intensity of their effects, are difficult to assess and our data do not support further analysis.

Catches and species numbers in the 2 southern cruises were compared with catches in 2 surveys on the inner shelf between 10 and 120 m in the same seasons in April 1983 and August 1983 (unpubl. data). Catches from the shelf were divided by 2 as the net used on the shelf had a footrope of 52.9 m, approximately twice the length of the one in the present study (Fig. 5). In winter greater catches were observed on the shelf between 40 and 60 m, in the core of the inner branch of the Malvinas/Falkland Current. Demersal-pelagic species were more abundant and therefore associated with the higher winter pelagic productivity. A second, much smaller, peak was found on the upper slope between 250 and 350 m, mostly composed of *Polyprion americanus* and *Ariomma bondi*. The highest mean number of species per trawl was found in the shelf break and included both resident and northward winter immigrant species of the shelf and slope. In summer, the shelf peak was lower, in the 20 to 60 m depth range, and a there was a shelf break peak composed mainly of *Trichiurus lepturus* and *Trachurus lathami*. This shelf break peak is probably associated with the vortices and the partial upwelling of subtropical waters (Podesta 1990, Lima 1992). Many of the demersal-pelagic species of wide geographic distribution represented by adults in the survey were sexually mature. Egg and larval survival of these species may be favored by the upwelling and transport from the slope to more productive waters of the shelf, as suggested for *Maurolicus muelleri* by Weiss et al. (1988).

Despite the lower catches compared to the inner shelf, the number of species was high on the shelf break (Fig. 5). This may be due to a higher variety of soft and consolidated substrates and the overlapping of different water masses along the water column. A sharp decrease in the number of species was observed at depths greater than 350 m and may be associated with the generally poor benthic invertebrate fauna of the slope found by Capitoli & Bonilha (1991).

Catches of demersal-pelagic species under the core of the Brazil Current in the upper slope were very low

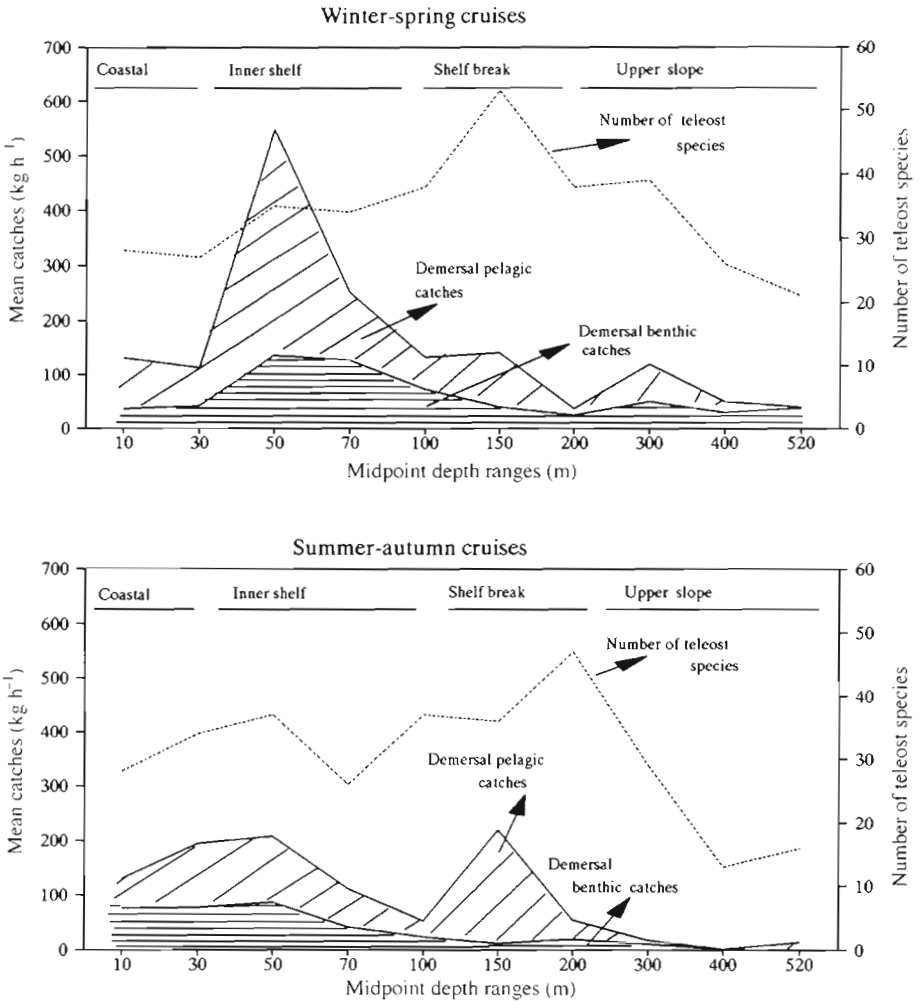

Fig. 5. Relative abundance (kg h^{-1}) and number of teleost species per depth range in the cold and warm season cruises off southern Brazil (see text for details)

and, at least in winter and spring, the short fin squid *Illex argentinus* was rather abundant (Haimovici & Perez 1991a). Ommastrephid squids may be an important part of the demersal-pelagic necton of the upper slope. Amaratunga (1983) and Santos (1992) showed the importance of *I. argentinus* in the food chains of that region.

The only bottom fish resources of the shelf break and upper slope are the migratory school shark *Galeorhinus galeus* in winter and *Polyprion americanus* (Vooren et al. 1988), both more efficiently fished with bottom longline, the king crab *Chaceon notialis* (syn. *Geryon quinquedens)* (Lima & Lima 1991) and the short fin squid *Illex argentinus* (Haimovici & Perez 1991a). Bony fish from the shelf break and upper slope do not appear to sustain a large commercial bottom trawl fishery but the catches of demersal-pelagic small bony fish, e.g. *Ariomma bondi, Trachurus lathami, Scomber japonicus,* and *Trichiurus lepturus,* all feeding mainly on zooplankton, were considerable in some hauls. Their midwater trawl-fishing potential is still unknown.

Acknowledgements. The authors thank C. Borzone for his help with the multivariate analysis and J. P. Castello for his comments on the hydrographic description. B. A. G. Lourerio drew the figures. The research was funded by the Banco do Brasil Research Fund (FIPEC) and grants to M.H. from the Brazilian Research Council (CNPq).

LITERATURE CITED

Amaratunga, T (1983). The role of Cephalopoda in the marine ecosystem. In: Caddy, J. F. (ed.) Advances in assessment of world cephalopod resources. FAO Fish. tech. Pap. 231: 379–415

Angelescu, V., Prenski, L. B. (1987). Ecología trófica de la merluza común del Mar Argentino (Merlucciidae, *Merluccius merluccius hubbsi*), Parte 2. Série Contribuciones No. 561. INIDEP, Mar del Plata

Benvegnú-Lé, G. Q. (1978). Distribuição dos peixes teleósteos marinhos demersais na plataforma continental do Rio Grande do Sul. Ph.D. thesis, Universidade de São Paulo

Bianchi, G. (1991). Demersal assemblages of the continental shelf and slope edge between the Gulf of Tehuantepec (Mexico) and Gulf of Papagayo (Costa Rica). Mar. Ecol. Prog. Ser. 73: 121–140

Bianchi, G. (1992). Study of the demersal assemblages of the continental shelf and upper slope off Congo and Gabon, based on the trawl surveys of the RV 'Dr Fridtjof Nansen' Mar. Ecol. Prog. Ser. 85: 9–23

Capitoli, R., Bonilha, L. E. (1991). Comunidades bentônicas. In: Vooren, C. M. (ed.) Projeto Talude. FIPEC Final Report, FURG, Rio Grande, p. 79–92

Capitoli, R., Haimovici, M. (1993). Dieta alimenticia del besugo *Pagrus pagrus* en el extremo sur de Brasil. Frente Maritimo, Montevideo 14: 81–86

Castello, J. P. (1991). Hidrografia. In: Vooren, C. M. (ed.) Projeto Talude. FIPEC Final Report, FURG, Rio Grande, p. 19–22

Castello, J. P., Moller, O. Jr (1977). Sobre as condições oceanográficas do Rio Grande do Sul. Atlântica, Rio Grande 2(2): 1–19

Cohen, D. M., Inada, T., Iwamoto, T., Scialabba, N. (1990). FAO Species Catalogue Vol. 10, Gadiform fishes of the world (Order Gadiformes). FAO Fish. Synopsis 125, Rome

D'Incao, F., Ruffino, M. L. (1991). Crustáceos Decapoda e Stomatopoda. In: Vooren, C. M. (ed.) Projeto Talude. FIPEC Final Report, FURG, Rio Grande, p. 67–78

Emilsson, I. (1961). The shelf and coastal waters off southern Brasil. Bolm Inst. Oceanogr. S. Paulo 11(2): 101–112

Fagundes Neto, E. B., Gaelzer, E. L. R. (1991). Associações de peixes bentônicos e demersais na região do Cabo Frio, RJ, Brasil. Nerítica 6(1–2): 139–156

Fernandez, A., Norbis, W. (1986). Distribucion y abundancia de la castañeta (*Cheilodactylus bergi*) en la Zona Comun de Pesca Argentino Uruguaya durante el periodo 1980–1984. Publnes Comn téc. mixt. Frente marit., Montevideo 1(1): 180–190

Figueiredo, J. L. (1981). Estudo das distribuições endêmicas de peixes da Província Zoogeográfica Marinha Argentina. Ph.D. thesis, Universidade de São Paulo

Figueiredo, J. L. (1992). Sobre a aplicação dos nomes *Cynoscion striatus* (Cuvier, 1829) e *Cynoscion guatucupa* (Cuvier, 1830) (Teleostei: Sciaenidae). Comun. Mus. Ciên. PUC RS, sér. zool., Porto Alegre 5(8): 117–121

Figueiredo, J. L., Menezes, N. A. (1978). Manual de peixes marinhos do sudeste do Brasil. II. Teleostei (1). Museu de Zoologia da Universidade de São Paulo, São Paulo

Figueiredo, J. L., Menezes, N. A. (1980). Manual de peixes marinhos do sudeste do Brasil. III. Teleostei (2). Museu de Zoologia da Universidade de São Paulo, São Paulo

Fischer, W. (ed.) (1978). FAO species identification sheets for fishery purposes. Western Central Atlantic (fishing area 31), Vols. 1–7. FAO, Rome

Gauch, H. G. (1982). Multivariate analysis in community ecology. Cambridge University Press, Cambridge

Haimovici, M. (1982). Estructura y dinamica poblacional del pargo blanco *Umbrina canosai* (Pisces, Sciaenidae) del litoral de Rio Grande do Sul, Brasil. Ph.D. thesis, Universidade de Buenos Aires

Haimovici, M. (1991). Edad, crecimiento y tipos de escamas del besugo (*Pagrus pagrus*) en el sur de Brasil. Octavo Simposio Cientifico de la Com. Tec. Mix. del Frente Maritimo. 2 a 4 de Diciembre de 1991, Abstracts. Montevideo, p. 41

Haimovici, M., Arruda, M. C., Teixeira, R. L. (1989a). Alimentação da castanha *Umbrina canosai* no litoral sul de Brasil. Rev. Bras. Biol. 49(2): 511–522

Haimovici, M., Cousin, J. C. B. (1989). Reproductive biology of the castanha *Umbrina canosai* (Pisces, Sciaenidae) in southern Brazil. Rev. Bras. Biol. 49(2): 523–537

Haimovici, M., Martins, A. S., Teixeira, R. L. (1993). Distribuición, alimentación y observaciones sobre la reproduccion de la merluza *Merluccius hubbsi* en el sur de Brasil. Frente Maritimo, Montevideo 14: 33–40

Haimovici, M., Pereira, S. D., Vieira, P. C. (1989b). La pesca demersal en el sur de Brasil en el período 1975–1985. Frente Maritimo, Montevideo 5: 151–163

Haimovici, M., Perez, J. A. A. (1991a). A pesca de cefalópodes em quatro cruzeiros de prospeção pesqueira demersal na plataforma externa e talude continental do sul do Brasil entre Chuí (34° 30' S) e o Cabo de Santa Marta Grande (28° 40' S). Atlântica, Rio Grande 13(1): 189–200

Haimovici, M., Perez, J. A. A. (1991b). A coastal cephalopod fauna of southern Brazil. Bull. mar. Sci. 49(1–2): 221–230

Haimovici, M., Reis, E. G. (1984). Determinação de idade e crescimento da castanha *Umbrina canosai* (Pisces, Sciaenidae) do sul do Brasil. Atlântica, Rio Grande 7: 25–46

Hubold, G. (1980a). Hydrography and plankton off southern Brazil and Rio de La Plata, August–November, 1977. Atlântica, Rio Grande 4(1): 1–22

Hubold, G. (1980b). Second report on hydrography and plankton off southern Brazil and Rio de la Plata; autumn cruise: April–June 1978. Atlântica, Rio Grande 4: 23–42

Hulley, P. A. (1981). Results of the research cruises of FRV 'Walther Herwig' to South America. LVIII. Family Myctophidae (Osteichthyes, Myctophiformes). Arch. FischWiss. 31(1): 1–300

Legekis, R., Gordon, A. (1982). Satellite observations of the Brazil and Falkland currents, 1975 to 1976. Deep Sea Res. 29(3A): 375–401

Lima, I. D. Jr (1992). Distribuição e abundância de anchoita *Engraulis anchoita* em relação aos processos oceanográficos na plataforma continental do sul do Brasil. M.Sc. thesis, Universidade do Rio Grande

Lima, J. H. M., Lima, B. R. (1991). Análise das operações de pesca do caranguejo de profundidade *Geryon quinquedens* Smith 1879, por barcos japoneses arrendados na região sul do Brasil — 1984/85. Atlântica, Rio Grande 13(1): 179–188

Lleonart, J., Roel, B. (1984). Análisis de las comunidades de peces y crustáceos demersales de la costa de Namibia (Atlántico Sudoriental). Invest. pesq. 48(2): 187–206

Longhurst, A. R., Pauly, D. (1987). Ecology of tropical oceans. Academic Press, San Diego

Macpherson, E. (1983). Ecologia trófica de peces en las costas de Namibia. I. Hábitos alimentarios. Invest. pesq. 11: 81–137

Manooch, C. S., Hassler, W. W. (1978). Synopsis of the biological data on the red porgy *Pagrus pagrus* (Linnaeus). NOAA Tech. Rep. NMFS Circular 412. FAO Fish. Synopsis 116

Martins, A. S. (1992). Bioecologia do peixe-espada *Trichiurus lepturus* Linnaeus, 1758, no sul do Brasil. M.Sc. thesis, Universidade do Rio Grande

Martins, L. R., Urien, C. M., Butler, L. W., Martins, I. R. (1975). Morfologia e sedimentos da plataforma continental atlântica sulamericana entre o cabo Orange e o Chuí (Brasil). Anais Hidrográficos 3–32, p. 81–106

Matsuura, Y (1986). Contribuição ao estudo da estrutura oceanográfica da região entre Cabo Frio (RJ) e o Cabo de Santa Marta Grande (SC). Ciênc. Cult. (Sao Paulo) 38(8): 1439–1450

Menezes, N. A., Figueiredo, J. L. (1980). Manual de peixes marinhos do sudeste do Brasil. IV. Teleostei (3). Museu de Zoologia da Universidade de São Paulo, São Paulo

Menezes, N. A., Figueiredo, J. L. (1985). Manual de peixes marinhos do sudeste do Brasil. V. Teleostei (4). Museu de Zoologia da Universidade de São Paulo, São Paulo

Menni, R. C., Ringuelet, R. A., Aramburu, R. H. (1984). Peces marinos de la Argentina y Uruguay. Editorial Hemisferio Sur, Buenos Aires

Migliore, M. M. (1988). Biologia y parametros poblacionales del rubio (*Helicolenus dactylopterus lahillei* Norman, 1937). Seminario de Investigacion, Univ. Nac. de Mar del Plata

Miranda, L. B, Leudemann, E. F., Miyao, S. Y (1973). Relatório sobre a segunda pesquisa oceanográfica e pesqueira do Atlântico Sul entre Torres e Maldonado (Lat. 29–35). Distribuição de temperatura, salinidade e circulação geral em superfície. Publ. esp. Inst. oceanogr. S. Paulo 3(2): 1–82

Nakamura, I., Parin, N. V (1993). FAO Species Catalogue, Vol. 15, Snake mackerels and cutlassfishes of the world (Families Empylidae and Trichiuridae). FAO Fish. Synopsis 125

Nelson, J. S. (1984). Fishes of the world. John Wiley & Sons, New York

Olson, D. B., Podesta, G. P., Evans, R. H., Brown, O. B. (1988). Temporal variation in the separation of the Brazil and Malvinas currents. Deep Sea Res. 35: 1971–1990

Otero, H., Bezzi, S., Renzi, M., Verazay, G. (1982). Atlas de los recursos pesqueros demersales del mar argentino. Contrib. 423 INIDEP, Mar del Plata

Palacio, J. F. (1982). Revisión zoogeográfica marina del sur del Brasil. Bolm Inst. Oceanogr. S. Paulo 31(1): 69–92

Perrota, R. G., Aubone, A., Sanchez, A. (1990). Estudio comparado de los caractéres morfométricos y merísticos de la caballa (*Scomber japonicus* Houttuyn, 1782) (Teleostei, Scombridae) del sur de Brasil y del área marplatense (Mar Argentino). Scientia mar. Barcelona 54(1): 47–53

Podesta, G. P. (1990). Migratory pattern of Argentine hake *Merluccius hubbsi* and oceanic processes in the Southwestern Atlantic Ocean. Fish. Bull. U.S. 88: 167–177

Roux, C. (1973). Résultats scientifiques des campagnes de la 'Calypso' large des côtes atlantiques de l'Amérique du Sud (1961–1962). Fascicule X. Campagne de la Calypso. Première partie (suite). 26. Poissons téléostéens du plateau continental brésilien. Masson et Cie, Paris

Santos, R. A. (1992). Relações tróficas do calamar argentino *Illex argentinus* (Castellanos, 1960) (Teuthoidea: Ommastrephidae), no sul do Brasil. M.Sc. thesis, Universidade do Rio Grande

Schwingel, P. R. (1991). Alimentação de *Engraulis anchoita* (Clupeiformes, en Engraulidade) na plataforma continental do Rio Grande do Sul, Brasil. M.Sc. thesis, Universidade do Rio Grande

Seckendorff, R. N., Zavala-Camin, L. A. (1985). Reprodução, crescimento e distribuição de *Scomber japonicus*. Bolm Inst. Pesca, S. Paulo 12(2): 1–13

Thomsen, H. (1962). Massas de agua caracteristicas del Oceano Atlântico (parte sudoeste). Secretaria de Marina/SHN, Buenos Aires, Publ. H623: 1–27

Vazzoler, G. (1975). Distribuição da fauna de peixes demersais e ecologia dos Sciaenidae da plataforma continental brasileira entre as latitudes 29° 21' S (Torres) e 34° 44' S (Chuí). Bolm Inst. Oceanogr. S. Paulo 24: 85–169

Vieira, P. J. C. (1990). Biologia populacional de *Cynoscion striatus* (Pisces: Scianidae) no litoral sul do Brasil. M.Sc. thesis, Universidade do Rio Grande

Vooren, C. M. (1991). Elasmobrânquios. In: Vooren, C. M. (ed.) 'Projeto Talude', Relatório Final. Convênio FIPEC-FURG, Rio Grande, p. 33–36

Vooren, C. M., Haimovici, M., Vieira, P. C., Duarte, V. S., Ferreira, B. P. (1988). Pesca experimental na margem externa da plataforma e no talude continental do Rio Grande no inverno de 1986. Anais do V Congresso Brasileiro de Engenharia de Pesca 435–447, Fortaleza

Wahlrich, R., Peres, M. B. (1990). Relatório final do projeto otimização bioeconômica dos recursos pesqueiros marinhos do Rio Grande do Sul FAPERGS. Universidade do Rio Grande, Rio Grande

Weiss, G., Hubold, G., Bonecker, A. C. T (1988). Eggs and larvae of *Maurolicus muelleri* (Gmelin, 1789) (Teleostei, Sternoptychidae) in the southwest Atlantic. Meeresforsch. 32(1): 53–60

Weitzman, S. H. (1986). Family no. 75: Sternoptychidae. In: Smith, M. Heemstra, P. C. (eds.) Smith's sea fishes. Springer-Verlag, Berlin, p. 253–259

Yesaki, M. (1973). Sumário dos levantamentos de pesca exploratória ao largo da costa sul do Brasil e estimativa da biomassa de peixe demersal e potencial pesqueiro. Doc. Tec. SUDEPE-PDP/T, Rio de Janeiro 1: 1–27

Yesaki, M., Barcellos, B. N. (1974). Desenvolvimento da pesca do pargo róseo ao longo da costa sul do Brasil. Série Documentos Ocasionais SUDEPE-PDP, Rio de Janeiro 6: 1–8

Yesaki, M., Rahn, E., Silva, G. (1976). Sumário das explorações de peixes de arrasto de fundo ao largo da costa sul do Brasil. Doc. Tec. SUDEPE-PDP, Rio de Janeiro 19: 1–37

This article was submitted to the editor

Manuscript first received: October 15, 1993
Revised version accepted: February 2, 1994