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COASTAL CEPHALOPOD FAUNA OF SOUTHERN BRAZIL

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ABSTRACT

In the coastal waters between Cabo Frio, Rio de Janeiro State (Lat. 23°S) and Chui, Rio Grande do Sul State (Lat. 34°S), more than 30 species of cephalopods occur in the different marine environments. Temperate benthic octopuses of low fecundity, bearing large eggs, are restricted to the cold bottom waters of the outer shelf and the slope, in contrast to species of tropical origin, which occupy the more diverse shallow water habitats, principally along the Rio de Janeiro coast. Cosmopolitan warm-water octupuses with high fecundity, like *Scaeurgus unicirrhus* and *Octopus vulgaris*, are found along the entire area because the transport of pelagic juveniles is favored by the warm, southward flowing superficial Brazil Current. All three families of epipelagic octopuses are represented. The neritic squid fauna includes only five myopsid squids, four of them of tropical origin. At the upper slope *Illex argentinus* is dominant and several mesopelagic and bathipelagic oegopsids, widely distributed in tropical and temperate Atlantic Ocean waters, also occur. The absence of endemic species indicates the transitional character of the fauna between the Caribbean and the Patagonian regions.

The cephalopod fauna of Brazil was reviewed by Palacio (1977) who listed 31 species, and Haimovici (in Rios, 1985). Since then a considerable amount of additional information was obtained on the coastal cephalopod fauna of the continental shelf and upper slope between Cabo Frio (Lat. 23°S) and Chui (Lat. 34°S) (Table 1). The sources were: (1) The revision of the Cephalopoda collections of the Oceanographic Museum of Rio Grande (MORG), Department of Zoology of the Rio de Janeiro Federal University (UFRJ), Museu Nacional do Rio de Janeiro (MNRJ), Research Foundation of Rio de Janeiro (FIPERJ) (Haimovici et al., 1989), and Zoology Museum of the São Paulo State University (MZUSP) (Perez and Haimovici, 1991); (2) Bottom trawling surveys off Rio Grande do Sul over the inner shelf (Haimovici and Andriguetto, 1986; Haimovici and Perez, 1991), off Cabo Frio (Costa, 1990) and Santa Catarina (J. Kotas, pers. comm.); (3) the report of ommastrephids collected in the southwestern Atlantic in two cruises of the R/V WALTHER HERWIG (Warneke-Cremer, 1986) and (4) unpublished records on cephalopods in tuna stomachs and (5) unpublished records of post-hatchlings in plankton samples off Rio Grande do Sul (Table 2).

The scope of this paper is to summarize and analyze the available information on the distribution of the cephalopod coastal fauna of southern Brazil between Rio de Janeiro and Rio Grande do Sul (Fig. 1), in relation to the coastal morphology, shelf substrates and hydrography of the shelf and slope. A classification according to their habitats and distribution is attempted.

COASTAL MORPHOLOGY AND SHELF SUBSTRATES

The coastline from Cabo Frio to Chui is characterized by sandy beaches and dunes with intermittent areas of beach rocks. Coastal lagoons are common in Cabo Frio and Rio Grande do Sul. Well-developed mangrove swamps only occur in the Bahia of Paranaguá (Lat. 25°S) and are absent south of Santa Catarina State. An important feature is the scarcity of river drainage into the coastal zone due to the "Serra do Mar" mountain chain which borders the coast and diverts most of the river flow to the Rio de la Plata basin.

The southern Brazil coastal shelf varies between 90 km width off Cabo Frio, 180 km off São Paulo, 100 km off Santa Catarina and 150 km off Rio Grande (Fig. 1). The shelf breaks between the 150 and 185 m isobaths and the continental slope deepens gently (Zembruscki, 1979).

Sand, mud and clays cover most of the shelf of southern Brazil, in contrast to that of northeastern Brazil, where calcareous algal bottoms are dominant. The latter occur, south of Cabo Frio, only in

Table 1. Cephalopods recorded from southern Brazilian waters, including their habitat and range of distribution (sources: Palacio, 1977; Roper et al., 1984; Haimovici, 1985; Haimovici and Andriguetto, 1986; Warneke-Cremer, 1986; Nesis, 1987; Haimovici et al., 1989; Haimovici and Perez, 1991)

	Bathymetric distribution	Habitat	Geographic distribution
Family Sepiolidae Leach, 1817			
Semirossia tenera (Verrille, 1880)	50–200 m	Demersal, muddy and sandy bottoms	Gulf of Maine to Rio Grande do Sul
Heteroteuthis atlantis Voss, 1955	450–950 m	Lower epipelagic, mesopelagic	Tropical and Subtropical Atlantic
Family Loliginidae Steenstrup, 1861			
Loligo sanpaulensis Brackoniecki, 1984	0–60 m	Neritic, semipelagic	Central Brazil to central Argentina
Loligo plei (Blainville, 1823)	16–200 m	Neritic, semipelagic	Lat. 35°N to Northern Argentina
Lolliguncula brevis (Blainville, 1823)	0–20 m	Neritic, shallow bays, estuaries	Bermuda to Patagonia
Sepioteuthis sepioidea (Blainville, 1823)	0–20 m	Coral reefs, grass flats	Cape Canaveral to Rio de Janeiro
Family Pickfordiateuthidae Voss, 1953			
Pickfordiateuthis pulchella Voss, 1953	0–20 m	Shallow waters, grass flats	Florida to São Paulo
Family Ommastrephidae Steenstrup, 1857			
Illex argentinus (Castellanos, 1960)	50–800 m	Epipelagic	Southern Argentina to Rio de Janeiro
Ornithoteuthis antillarum (Adam, 1957)	Oceanic	Epipelagic	Tropical and Subtropical Atlantic
Ommastrephes bartramii (Lesueur, 1821)	Oceanic	Epipelagic	Subtropical and temperate waters
Symplectoteuthis luminosa Sasaki, 1915	Oceanic	Epipelagic	Subtropical worldwide and temperate Pacific
Hyaloteuthis pelagica (Bosc, 1802)	Oceanic	Epipelagic	Warm waters, Atlantic and Pacific
Todarodes filippovae Adam, 1975	Oceanic	Demersal, over slopes	Subantarctic, and temperate waters
Family Thysanoteuthidae Keferstein, 1866			
Thysanoteuthis rhombus Troschel, 1857	Oceanic	Epipelagic	Warm water, worldwide
Family Onychoteuthidae Gray, 1849			
Onycoteuthis banksii (Leach, 1817)	Oceanic	Epipelagic	Warm and temperate waters
Moroteuthis ingens (Smith, 1881)	Oceanic	Epipelagic	Circumglobal, subantartic waters
Family Enoploteuthidae Pfeffer, 1900			
Abralia veranyi (Ruppell, 1844)	200–480 m	Demersal, bathyal, over slopes	Tropical and Subtropical Atlantic
Abralia redfieldi Voss, 1955	208–488 m	Epipelagic-mesopelagic, bathyal	Tropical and Subtropical Atlantic

Table 1. Continued

	Bathymetric distribution	Habitat	Geographic distribution
Family Lycoteuthidae Pfeffer, 1908			
Lycoteuthis diadema (Chun, 1900)	up to 1,500 m	Bathyal, mesopelagic, over slopes	Subtropical waters worldwide
Family Octopodidae Orbigny, 1845			
Octopus defilippi Verany, 1851	6–60 m	Benthic, sandy and muddy bottoms	Mediterranean, Tropical Atlantic and Indic
Octopus tehuelchus Orbigny, 1834	up to 90 m	Benthic, muddy and rocky bottoms	Peninsula Valdes to Rio de Janeiro
Octopus vulgaris Cuvier, 1797	0–200 m	Benthic, rocks and coral reefs	Worldwide, tropical and subtropical
Octopus joubini Robson, 1929	up to 80 m	Benthic, sand, hard coral, rubble	Tropical western Atlantic
Scaeurgus unicirrhus (Delle Chiaje, 1830)	100–400 m	Benthic, sand and coraline bottoms	Warm waters, scattered worldwide
Pteroctopus tetracirrhus (Delle Chiaje, 1830)	25–720 m	Benthic, muddy bottoms	North Carolina to Uruguay
Eledone massyae Voss, 1964	60–300 m	Benthic, sandy and muddy bottoms	Peninsula Valdes to Rio de Janeiro
Eledone gaucha Haimovici, 1988	60–300 m	Benthic, sandy and muddy bottoms	Rio Grande do Sul to Rio de Janeiro
Pareledone turqueti (Joubin, 1905)	540–4,000 m	Benthic, mud	Circumpolar Antarctica to Rio de Janeiro
Pareledone charcoti (Joubin, 1905)	0–1,500 m	Benthic, sandy bottoms	Circumpolar Antarctica to Rio de Janeiro
Vosseledone charrua Palacio, 1978	10–511 m	Benthic, coraline bottoms	Uruguay to São Paulo
Family Bolitaenidae Chun, 1911			
Japetella diaphana Hoyle, 1885	100–3,000 m	Bathypelagic	Tropical-subtropical cosmopolitan
Family Argonautidae Naef, 1912			
Argonauta nodosa Lightfoot, 1786	Oceanic	Epipelagic	Tropical and subtropical worldwide
Argonauta argo Linnaeus, 1758	Oceanic	Epipelagic	Tropical and temperate waters
Family Tremoctopodidae Brock, 1882			
Tremoctopus violaceus Delle Chiaje, 1830	Oceanic	Epipelagic	Atlantic Ocean between 43°N–35°S
Family Ocythoidae Gray, 1849			
Ocythoe tuberculata Rafinesque, 1814	Oceanic	Epipelagic	Tropical-subtropical cosmopolitan

Table 2. Preliminary identification of post-hatchlings and juveniles in plankton samples collected off Rio Grande do Sul

Order Octopoda
Fam. Argonautidae
Fam. Octopodidae
Octopus defilippi
unidentified sp.
Fam. Bolitaenidae
Japetella diaphana
Fam. Tremoctopodidae
Tremoctopus violaceus
Order Teuthoidea
Fam. Ommastrephidae
Illex argentinus
unidentified sp.
Fam. Loliginidae
Fam. Enoploteuthidae
Fam. Chiroteuthidae
Fam. Cranchidadae
Fam. Cycloteuthidae
Fam. Brachioteuthidae
Fam. Joubiniteuthidae
Fam. Onychoteuthidae
Fam. Thysanoteuthidae
Thysanoteuthis rhombus
Order Sepioidea
unidentified sp.
Fam. Sepiolidae
Heteroteuthis atlantis

protected pockets of warmer waters. The inner shelf is dominated by sandy bottoms, but biodetrital shell banks exist parallel to the coast off the Patos and Mirim lagoons. Sandy mud and muddy sand are dominant in the middle shelf, while mud rich of silts, clay and biodetritic sediments are found in the outer shelf (Martins et al., 1975).

Hydrographic Patterns

Four main water masses determine the oceanographic conditions over the continental shelf and upper slope off southern Brazil (Emilsson, 1961; Miranda et al., 1973; Castello and Moller, 1977; Hubold, 1980a; 1980b; Matsuura, 1986).

Tropical Water of the Brazil Current ($T > 20°C$, $S > 36.0$ ‰), flows over the slope and, due to eddies and meander structures occasionally reaches the continental shelf, especially during winter (Emilsson, 1961).

Subtropical Water, also called South Atlantic Central Water (SACW), with temperatures and salinities between 10°C to 20°C and 34.3 to 35.9 ‰, respectively, runs northwards below the Brazil Current as a result of the mixture between Tropical and Subantarctic waters in the Subtropical Convergence zone, which fluctuates seasonally between latitudes 35°S and 45°S. This water may reach lower depths through seasonal upwelling off Santa Catarina and Cabo Frio or follows the meander-like pattern of the Brazil Current.

Subantarctic Water, derived from a coastal branch of the Malvinas/Falkland Current, extends up to Lat. 32°S and may reach further north in winter. Usually it penetrates beneath the Coastal Water between the 50 and 100 m isobath. Its temperature in Chui is 10–12°C and can approach 14 to 16°C off Rio Grande, or further north, with salinities ranging from 33.7 and 34.15‰. Along its eastern boundary a strong thermal gradient, classified by Miranda et al. (1973) as being like "slope water" with intermediary temperatures and salinity, separate it from the tropical waters of the Brazil Current.

Coastal Water, defined by water masses with different temperatures and salinities, occasionally covers part of the shelf. In Rio Grande do Sul salinities may be as low as 26‰ due to the runoff by

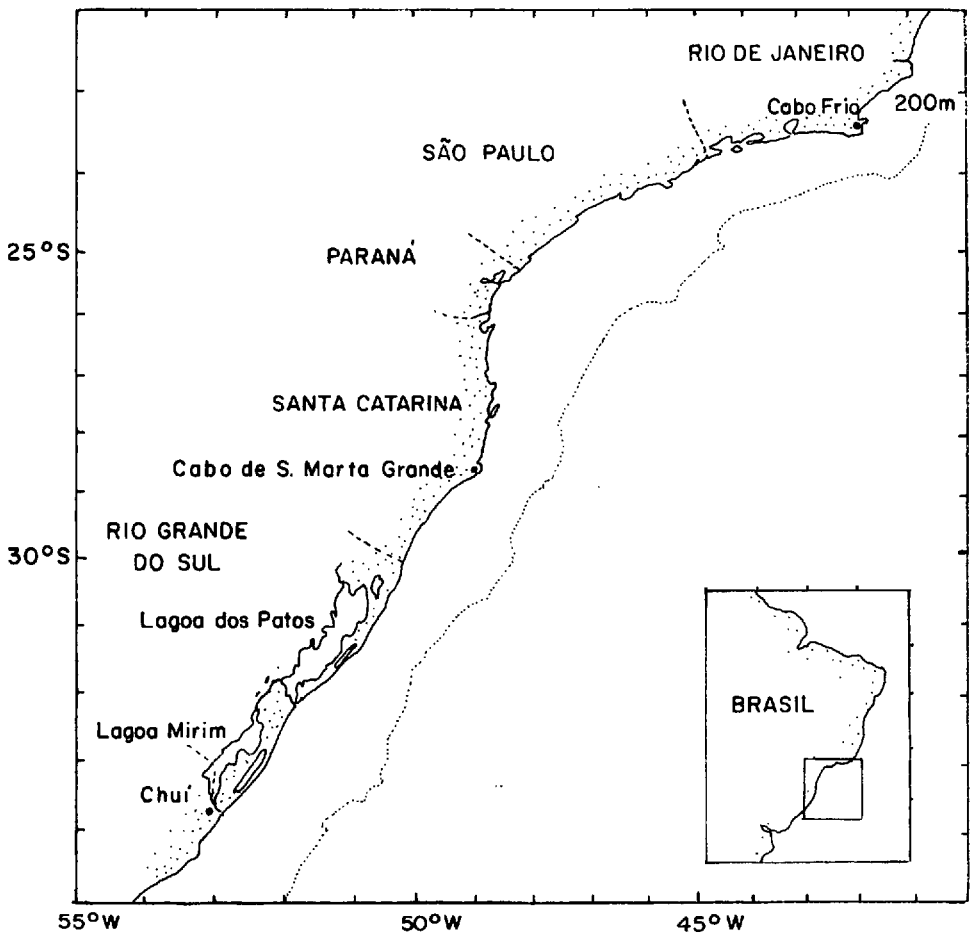

Figure 1. Southern Brazilian coast.

the Rio de La Plata and the Patos Lagoon, and temperatures vary between 12 and 20°C. North of latitude 31°S, salinities of 35.0‰ and temperatures up to 23°C are due to high solar radiation, mixture with the Brazil Current waters and low river runoff. From Santa Marta Grande Cape (Lat. 28°30'S) to Cabo Frio, the Shelf Water is defined as the water mass between Coastal and Tropical waters with salinities between 35 and 36‰ and temperatures from 20 to 26°C (Emilsson, 1961). In late spring, and summer Subtropical Water advances under the Shelf Water forming a strong thermocline (Matsuura, 1986).

Cephalopod Faunal Composition and Distribution

All orders, except Vampyromorpha and deep-sea octopods of the suborder Cirrata, are represented. Both suborders of Teuthoidea were present. The Myopsida occupy the shelf while Oegopsida occur over the border of the shelf and the slope. Only two species of the family Sepiolidae represent the Order Sepioidea in southern Brazil (Fig. 2).

Suborder Incirrata.—Eleven benthic species of the family Octopodidae were found, six of the subfamily Octopodinae and five Eledoninae. Of the former, *Enteroctopus* sp. is a doubtful record (Palacio, 1977). Five pelagic octopods of the families Bolitaenidae, Argonautidae, Ocythoidae and Tremoctopodidae were found. Lar-

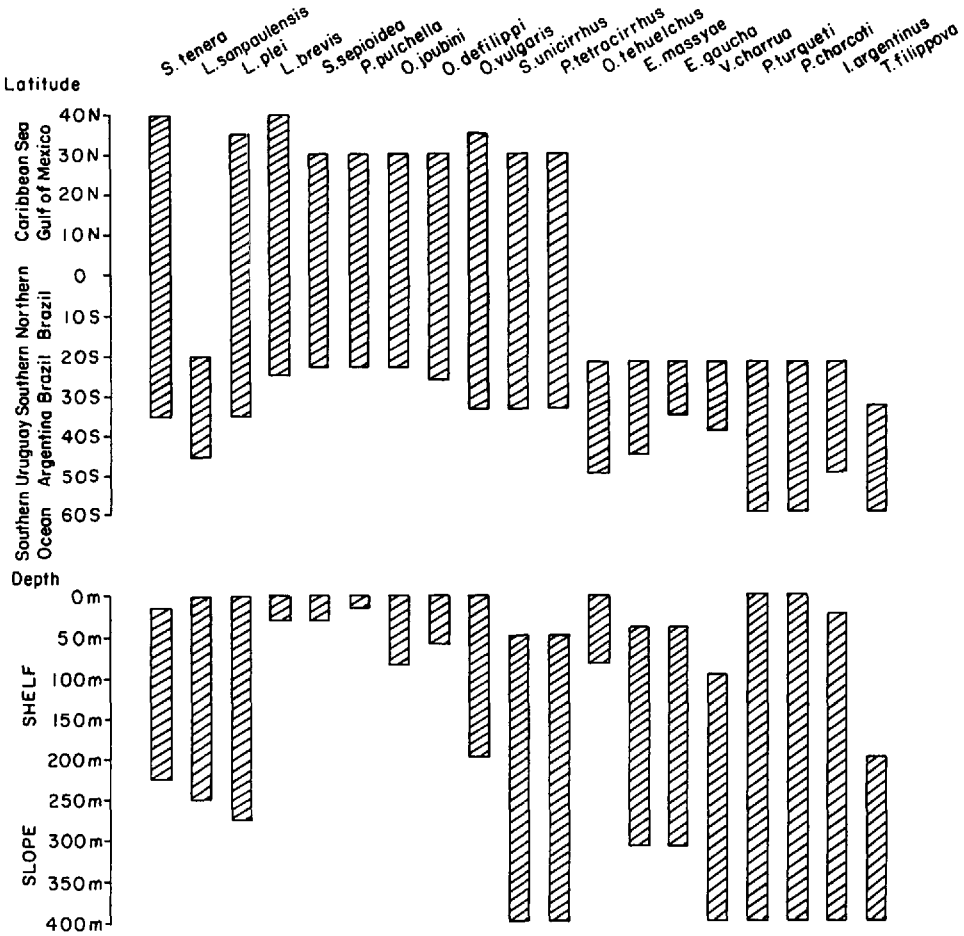

Figure 2. Geographic and bathimetric distribution in the Western Atlantic of coastal cephalopod species occurring in southern Brazil, excluding the epi, meso and bathypelagic species.

val forms of all the pelagic families and the benthic octopodid, *Octopus defilippi,* were identified in plankton samples. The benthic octopuses can be divided in cold and warm-water species. Among the first, all Eledoninae and one Octopodinae, *Octopus tehuelchus* are of cold and temperate-waters. *Octopus tehuelchus,* a shallow water species, was frequently observed associated with empty gastropod shells on detrital bottoms along the 30-m isobath in Rio Grande do Sul (Haimovici and Andriguetto, 1986), but in Argentina it is found in rocky littoral areas (Re, 1989). *Eledone massyae* and *E. gaucha* occur in moderate depths on sandy and muddy bottoms. In Rio Grande do Sul, both species are likely to move to rocky bottoms of the upper slope to spawn and breed (Perez, 1990). Off Cabo Frio (23°S) they move to shallow waters only in spring and summer, with the upwelling of the South Atlantic Central Water. (Costa, 1990; Costa and Haimovici, in press). *Vosseledone charrua* was found in Rio Grande do Sul on the upper slope on calcareous detritus between 200 to 500 m depth, although off São Paulo, there is doubtful a record from 10 m depth (Palacio, 1978). *Pareledone turqueti* and *P. charcoti* are typical of Antarctic waters (Voss, 1988) and were recorded only once

from deep waters on muddy bottoms off the Rio de Janeiro coast (Palacio, 1978). All species in southern Brazil are associated with either the seasonal influence of the Malvinas/Falkland Current over the central shelf or subtropical waters of the SACW. Of the cold water species, only *Octopus tehuelchus* and both *Eledone* were found at more than 15°C, though usually under 22°C.

The warm water benthic octopods occurred principally associated with rocky bottoms of the northern portion of the region. *Octopus joubini* is a truly Caribbean species while *Octopus vulgaris, Octopus defilippi, Scaeurgus unicirrhus* and *Pteroctopus tetracirrhus* are considered warm-water multi-ocean or amphi-atlantic species. In Rio Grande do Sul, *O. vulgaris* appears in small numbers on patches of biodetrital bottoms (Haimovici and Andriguetto, 1986) and *S. unicirrhus* was recorded only once (Perez and Haimovici, 1991). Macrotritopus larvae of *O. defilippi* were also found (Table 2).

Suborder Myopsida.—Five myopsids, four included in the family Loliginidae and one in Pickfordiateuthidae, were present in the area. *Pickfordiateuthis pulchella, Lolliguncula brevis* and *Sepioteuthis sepioidea* are round-bodied species restricted to shallow, warm littoral habitats including rocky and coraline coast, marine grass flats, bays and estuaries. None of them are found in Rio Grande do Sul where these habitats are absent and the southern cold waters have strong influence, primarily in winter. The southern records of the Caribbean species *P. pulchella, L. brevis* and *S. sepioidea* are São Paulo and Rio de Janeiro respectively and that of the widely distributed Western Atlantic *L. brevis* is Santa Catarina.

The neritic loliginids, *Loligo plei* and *L. sanpaulensis* are relatively abundant along the entire region (Juanicó, 1979; Andriguetto, 1989; Costa, 1990). In Rio Grande do Sul *L. sanpaulensis* is dominant throughout the year over the shelf in depth up to 250 m in winter (Andriguetto, 1989). During summer and autumn, *L. plei* penetrates from the north on the border of the shelf, following the superficial Brazil Current (Haimovici and Perez, 1991). *L. plei* is widely distributed in the Western Atlantic and *L. sanpaulensis* is the only cephalopod whose distribution may be centered in southern Brazil.

Suborder Oegopsida.—Subadults and adults of 10 oegopsids were recorded, 6 of the family Ommastrephidae and 4 of the families Lycoteuthidae, Enoploteuthidae and Thysanoteuthidae. The families Cranchiidae, Cycloteuthidae, Joubiniteuthidae, Brachioteuthidae, Onychoteuthidae and Chiroteuthidae were identified from plankton samples and are represented only as larval forms (Table 2).

Illex argentinus and *Todarodes filippovae* are cold water species of southern origin; the other ommastrephids are considered oceanic or slope species. *Abralia veranyi, A. redfieldi* and *Lycoteuthis diadema* are warm-water meso- and bathypelagic species with amphi-Atlantic or cosmopolitan distributions.

Family Sepiolidae.—This group appears to be poorly represented in the study area as compared to the Caribbean, where at least eight species are recorded (Nesis, 1987). *Semirossia tenera* is a small, muddy-bottom dweller with a wide Western Atlantic distribution ranging from the Gulf of Maine to Argentina (Roper et al., 1984). In Rio Grande do Sul, it occurs between 50 and 200 m depths. *H. atlantis* is a warm-water bathypelagic species with a wide amphi-Atlantic and cosmopolitan distribution.

Discussion

Landings of cephalopods in the fisheries of southern Brazil from Cabo Frio to Chui approached 2,627 metric tons in 1986, more than 80% being the neritic

squids *Loligo sanpaulensis* and *L. plei* and the rest of the benthic octopods *Octopus vulgaris* and *Eledone massyae* (Costa and Haimovici, 1990). These values represent less than 1% of the total marine fishing landings, thus the southern Brazil continental shelf cannot be considered rich in cephalopods when compared with other shelf areas of the world (Rathjen and Voss, 1987). Large stocks of squids and octopods are common in high productivity regions. The southern Brazilian shelf has relatively low productivity (Gulland, 1972), and most commercial catches occur in a small seasonal upwelling region off Rio de Janeiro (Valentin, 1984) and on the southern coast of Rio Grande do Sul where the coastal waters and the inner branch of the Malvinas/Falkland Current raises winter and spring primary and secondary production (Hubold, 1980b).

The southern Brazilian coast corresponds with the boundary between two zoogeographic provinces in the western Atlantic (Palacio, 1982). The region is transitional between the tropical or Caribbean province (Milne-Edwards, 1838) and the warm temperate or Patagonian province (d'Orbigny, 1835–43). The cephalopod fauna, composed of species from both southern and northern provinces is adapted to fluctuations of water temperature. Palacio (1982), in a review of the distribution of the cephalopods and other groups, proposed that the area between Espírito Santo (Lat. 20°S) and Rio Grande do Sul (Lat. 34°S) represented a distinct transitional province.

The neritic cephalopod fauna of the northern part of the studied area, is more diversified than that of the southern end and includes both warm-water and cold-water species.

Tropical benthic octopus and round bodied myopsids are restricted to the more diversified warm-water habitats in shallow regions, including rocky and sandy bottoms, marine grass flats, bays and estuaries. Cold-water octopus are found on deeper soft bottoms where the influence of cooler subtropical waters is stronger (Haimovici et al., 1989; Costa, 1990).

At the southern end of the study area, in Rio Grande do Sul, cold-water species predominate and the warm-water species present, *Loligo plei, Semirossia tenera, Octopus vulgaris, Scaeurgus unicirrhus* and *O. defilippi,* are multi-ocean or broad Western Atlantic in their distributions.

All cold-water octopus have big eggs and benthic juveniles and are not excluded from the more northern warm-water area. This is due not only to their wider range of temperature tolerance (Palacio, 1977), but also to the marked influence of subantarctic and subtropical waters along the southern Brazilian Coast, over the shelf and slope.

Tropical stenothermic species, on the other hand, are limited in their distribution southward by low temperatures and a reduction in the diversity of benthic habitats. Multi-ocean octopus with small eggs and pelagic post-hatchlings, such as *Octopus vulgaris, Scaeurgus unicirrhus* and *O. defilippi,* can reach the southern limit of Brazil, transported superficially by the south flowing Brazil Current; and at least one of them, *Octopus vulgaris,* is common, though not abundant, in Rio Grande do Sul.

Most of the epipelagic octopuses and oegopsid squids that are found occasionally in southern Brazilian neritic waters have cosmopolitan warm-water distributions. Their occurrence along the entire studied region is related to the superficial warm waters of the Brazil Current.

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