9 Fisheries

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For more than a century the Patos Lagoon estuary (von Ihering 1896) and the coastal sea have exemplified the fishing potential in the warm-temperate southwestern Atlantic (Yesaki 1973). Today about 6000 artisanal (Reis 1992) and 3000 industrial fishermen are temporarily or permanently involved in fishing activities. Despite the economic and social importance fisheries have historically assumed in this region, reliable records on fishing methods and landing statistics are lacking before 1945. Until then, artisanal trammel, gill, and channel net fishing with small wooden sail and row boats was largely restricted to the Patos Lagoon and estuary. The event of modern means of storage and transport and the introduction of a large number of synthetic fibre nets and motor-powered boats (< 10 m, 10-24 HP), which permitted artisanal trawl fishing, eventually led to the depletion of estuarine stocks. During the 1980s, artisanal fisheries quickly extended into shallow coastal waters where larger (12-15 m, 90-120 HP) wooden boats with up to 20 tons capacity used gill-nets, and occasionally purse seines and hooks. In the estuary and coastal waters artisanal fisheries follow a clearly defined seasonal pattern (Reis et al. 1994). The black drum (*Pogonias cromis)* and white croacker (*Micropogonias furnieri*), which actively feed in brackish waters, and the catfish (*Netuma barba*), which uses the estuary for reproduction, are fished in the spring, the pink shrimp (*Penaeus paulensis)* is caught in the summer and fall, the mullet (*Mugil platanus)* in the fall, and the bluefish (*Pomatomus saltatrix*), castanha (*Umbrina canosai*), and weakfish (*Cynoscion guatucupa*) in the winter. The mean annual artisanal fishery catch totals 21 500 t (Table 9.1; 58% demersal fishes, 15% pelagic fishes, 14% estuarine shrimp and crab, 12% freshwater fish) but, owing to often incomplete landing statistics, catch figures may be underestimated by as much as 25%. Industrial fisheries began in 1947 for demersal species (Yesaki and Bager 1975), and landings were mostly comprised of sciaenids, the red porgy *Pagrus pagrus* (Haimovici et al. 1989), and to a lesser extent elasmobranchs (Vooren et al. 1990). Pelagic fishery commenced in 1962 (Yesaki and Bager 1975) and intensified after 1977 when foreign vessels were hired and operated out of Rio Grande port (Zavala-Camin and Antero da Silva 1991; Antero da Silva 1994).

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Subtropical Convergence Environments

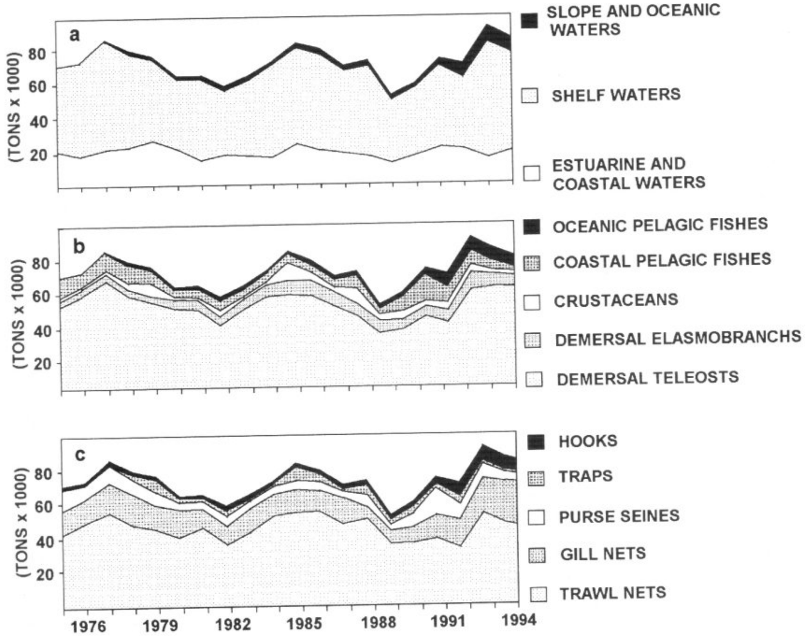

Fig. 9.1. Landed catches of estuarine and marine fisheries in the southwestern Atlantic between 29° and 35° S based on depth range (**a**), type of fishery resource (**b**), and fishing methods (**c**)

Seasonal changes in the composition and abundance of the necton (Vooren et al. 1990; Haimovici et al. 1994a; Lima and Castello 1995; Haimovici et al. 1996), and consequently also of fisheries, are induced by the alternate influence of cold subantarctic water and warm tropical water over the shelf. Shelf fisheries are more intense in the winter when a variety of commercially important species (castanha, weakfish, red porgy, bluefish, and the school shark *Galeorhinus galeus* immigrate from the south. Offshore fishing occurs all year roung, in the winter with long lines for southward migrating tunas and sailfishes and in the summer with live bait fishery for skipjack tuna (*Katsuwonus pelamis*). Most of the industrial fishery catches occur over the continental shelf (71%) and only 4% in oceanic and slope regions (Fig. 9.1a). About 80% of catches is landed in the fishing port of Rio Grande. Between 1975 and 1994 average annual catches approximated 74 000 metric tons but oscillated between a minima of 52 200 t in 1989 and a maxima of 91 800 t in 1993 (Haimovici et al. 1989; Vooren et al. 1990; IBAMA 1993, 1995). Demersal teleosts (71%) dominate among the catches, followed by pelagic shelf teleosts (10%), demersal elasmobranchs (8%), crustaceans (5.3%), and pelagic oceanic fish (4%; Fig. 9.1b). Trawl-net (61%) and gill-net (19%) methods account for most of the catch, whilst purse seines (10%), traps (4.5%), and hooks (4%) are less important (Fig. 9.1c).

Industrial Fishing Methods

In the early 1980s, when some stocks (*Pogonias cromis, Netuma barba, Pagrus pagrus*) collapsed and others (the royal weakfish *Macrodon ancylodon, Umbrina canosai*) showed signs of overfishing (Haimovici 1988a, b; Haimovici et al. 1989; Reis et al. 1994), demersal fishing diversified into double-rigg trawling, bottom gill-nets, bottom long-lines, and trap methods (Barcellos et al. 1991; Lima and Branco 1991) to exploit new resources.

Pair- and otter-trawling methods were introduced in 1947, but the trawler fleet first grew rapidly during the 1970s as a result of fiscal incentives (SUDEPE 1974; Yesaki and Bager 1975). Both methods use double sheet codends of 50-70 mm mesh size between opposite knots, which drastically reduces the chance of small fish escaping. Fishing vessels, which may employ either method depending on the season, are 22-35 m long and are powered by 250-650 HP engines. Since they lack refrigeration, the catch is stocked for up to 15 days in holds between layers of crushed ice (Haimovici et al. 1989). Although pair- and otter-trawling methods have changed little over the past few decades, fishing has become more efficient, owing to satellite navigation and more efficient use of echo-sounders. Pair-trawling, followed by otter-trawling, are the principal fishing methods for demersal sciaenids, like *Umbrina canosai, Cynoscion guatucupa, Macrodon ancylodon*, and *Micropogonias funieri*, which represent about 80% of total mean annual trawl landings. Otter-trawling over the inner shelf (20-100 m) landed 20 287 t in 1976, but this amount gradually decreased to 2708 t in the early 1990s. However, over the outer shelf (80-200 m) a few larger trawlers (49-52 m) landed an average of 4632 t in 1993 and 1994. Outer shelf otter-trawl catches include sharks and rays (31%) and sciaenids (20%), which are already intensely exploited, and the cutlassfish *Trichiurus lepturus* (24%), which is discarded by the inner shelf trawl fishery (Table 9.1).

Double-rigg trawling was first used in 1985 from 20-24 m long wooden vessels with 250-350 HP engines (Barcellos et al. 1991). Twin nets were employed for both shrimp fishing (*Artemesia longinaris, Pleoticus muelleri*) and demersal teleosts and elasmobranchs, though the length of the ground rope and the mesh size of the codend differed. Shrimps are fished in shallow waters in the spring and summer, whilst *Paralichthys patagonicus* is fished at 20-80 m depth between the fall and spring and *Squatina* spp. over the outer shelf at up to 140 m depth. Double-rigg trawlers landed about 30% of the total elasmobranch catches in 1989-1990, but their contribution decreased to 5% in 1992 (IBAMA 1995). Annual landings of double-rigg trawling totalled 3728 t after 1989 (IBAMA 1995; Haimovici and Mendonça, unpubl.).

Since trawl fishery is a non-selective method, small specimens of commercially valuable species and species without value are generally discarded from the catch. The estimated total annual discard ranges from 17 000 to 25 000 t. Onboard rejection by pair and otter-trawling of small demersal fishes and elasmobranchs (Haimovici and Palacios 1981; Haimovici and Habiaga 1982) may vary between 26 and 46%, though a larger (90 mm between opposite knots) mesh size would remedy this situation (Vooren 1983). Onboard discard of small elasmobranchs and teleosts during double-rigg trawling for fish exceeds 50% of the total catch. Discard during shrimp fishings may reach 20% (Haimovici and Mendonça 1996) which is significantly lower than the rejection rate reported for subtropical and tropical regions (Alverson et al. 1994).

Purse seine fishery for pelagic fishes has occurred in shallow shelf waters of less than 50 m depth since 1962. Seines (600-800 m length, 70-80 m height) are operated by vessels of 20-24 m length and 250-450 HP (Krug and Haimovici 1991). Mullets are caught in the fall and bluefish is the principal catch in the winter, though sometimes the jack mackerel (*Trachurus lathamis*), mackerel (*Scomber japonicus*), menhaden (*Brevoortia pectinata*), and occasionally also demersal fish like white croaker and castanha represent an important portion of the catch which averages (1990-1994) 4261 t annually (Table 9.1).

Trap fishing methods at depths greater than 400 m were employed for the red crab (*Chaceon notialis*) by hired Japanese vessels in 1984/1985, and the catch totalled 1471 t over a 9-month period after which fishing was abandoned (Lima and Branco 1991). Trawl fishing for *Pagrus pagrus* dates back to 1973 (Yesaki and Barcellos 1974), and overfishing made exploitation uneconomical at the beginning of the 1980s (Haimovici et al. 1989). Between 1987 and 1992 *Pagrus pagrus* was caught by trap fishing methods, similar to those used in Argentina (Barcellos et al. 1991), over beachrock outcrops (70-80 m) and gravel bottoms (110-160 m). The average annual catch was 106 t and was composed 83% of *Pagrus pagrus* (Table 9.1).

Hand-line fishery, aimed at the wreckfish (*Polyprion americaus*), was developed over hard bottoms of the upper slope in 1973 and was gradually replaced by vertical long-lines, bottom gill-nets, and bottom long-lines in recent years. Landing statistics of the commercially valuable wreckfish are incomplete but amount to several hundred tons annually (Table 9.1). Individual fishing grounds are abandoned after intense fishing for short periods and recover only after several years.

Bottom gill-nets replaced bottom long-lines, which were used for demersal shark fishing through 1989 (Barcellos et al. 1991). The gill-nets are pulled by 18-30 m long trawlers with 185 to 350 HP engines, and they may exceed several kilometers in length. Gill-netting is used at all depths (>50 m) of the continental shelf and has quickly become the main fishing method (IBAMA 1995). Between 1990 and 1994 mean annual catches equalled 5355 t

(Table 9.1). The increase of the total elasmobranch landings after 1990 clearly reflects the growth of the bottom gill-net fishery.

Japanese fishing vessels initiated surface long-line fishery for tunas, principally *Thunnus alalunga*, *Thunnus obesus*, and *Thunnus albacares*, and the swordfish *Xiphias gladius* over the southern shelf in 1961, followed by Brazilian long-liners in 1969 (Zavala-Camin and Tomas 1990; Zavala-Camin and Antero da Silva 1991), which dominated this fishery after 1977. Even so, a number (2-11) of large foreign vessels continue to fish for tunas and swordfish and land their catch in Rio Grande (Mello et al. 1993). During the 1977-1991 period, the average yield for this fishery was 728 kg/thousand hooks (Antero da Silva 1994). Pole and live bait fishery of the skipjack tuna (*Katsuwonus pelamis)* was introduced in 1979 (Castello and Habiaga 1988) and, owing to high initial yields, rapidly attracted a growing number (up to 97 in 1982) of 24-28 m long vessels (Matsuura 1982b). Four larger foreign vessels were hired in 1991. Almost 93% of the catch is composed of *Katsuwonus pelamis,* and annual landings average 3240 t (Table 9.1).

Table 9.1. Mean annual landed catches (tons) by fishing method in the southwestern Atlantic between 29° and 34° S from 1975 to 1994

Fishing method		1975-1979	1980-1984	1985-1989	1990-1994
Artisanal fishery		24926	20548	20617	20091
Pair-trawl		32056	33951	32051	29137
Otter-trawl (inner shelf)		15237	9160	10055	2708
Otter-trawl (outer shelf)	1993-1994	-	-	-	4362
Double-rigg trawl		-	-	-	3216
Bottom gill-net	Since 1989	-	-	435	5355
Fish trap	1988-1992	-	-	-	106
Hand line and vertical long-line		231	82	321	168
Purse seine		7105	1949	1833	4990
Offshore pelagic long-line	Since 1977	1295	1943	2260	3504
Pole and live bait fishery	Since 1991	-	-	-	3240

Demersal Teleost Fisheries

Demersal teleost catches (1975-1994) amount to 71% of all landings, and 70% are comprised of the sciaenids *Micropogonias furnieri*, *Umbrina canosai*, *Cynoscion guatucupa*, and *Macrodon ancylodon*. Annual landings do oscillate, but catch per unit effort (CPUE) for the first three species has decreased steadily (Fig. 9.2).

Regional *Micropogonias furnieri* stocks, represented by a spawning group near the Patos Lagoon inlet (32° S) and another further south (34° S; Haimovici and Umpierre 1996), have been heavily exploited by artisanal and industrial gill-net fisheries for more than two decades (Reis 1992), which has resulted in a drastic decrease in the density of juveniles in coastal waters between 1980 and 1990 (Ruffino and Castello 1992a). Although annual catches between 8000 and 17 000 t (mean 14 071 t) appear to be stable, the declining CPUE (Fig. 9.2) and changes in the age structure (Schwingel and Castello 1990; Haimovici and Umpierre 1996) indicate that the spawning stocks are overfished.

Umbrina canosai, a small species of low natural mortality (Haimovici and Reis 1984; Haimovici 1988b), is heavily fished along the southern Brazilian coast and to a lesser extent in Uruguay and Argentina (Fig. 9.2). This species represented the largest (19 000 t) part of landings during the 1970s, but gradually decreased to 10 000 t in recent years. Similarly, the biomass diminished from 75 000 t in 1976 to about 37 000 in 1983 (Haimovici 1988b). However, in contrast to *Micropogonias furnieri,* the age structure of *Umbrina canosai* has not changed in recent years. Therefore, in spite of overfishing, actual landings should persist if exploitation levels do not rise.

During the colder months adults of a single *Cynoscion guatucupa* stock migrate from fishing grounds in Uruguay and Argentina to more northern Brazilian shelf regions. Landings in southern Brazil, which represent about 30% of the total catch of the three countries, oscillate between 4000 t (1975 and 1988) and 14 000 t (1986 and 1994). These variations reflect either interannual differences in recruitment or availability to Brazilian trawlers, because the CPUE displays similar oscillations (Fig. 9.2).

A single stock of *Macrodon ancylodon* was found between 29° and 34° S (Yamaguti 1979) and has been exploited since the 1950s, with a maximum catch of 10 617 t in 1977. Landings gradually decreased to 3000 t in 1992 but showed an increase over the last 2 years (Fig. 9.2). Although *Macrodon ancylodon* may reach a maximum age of 12 years (Yamaguti 1967), since 1977 age classes above 6 years have been absent (Martins Juras 1980; Haimovici 1988a), which suggests that sustainable annual yields are below 4000 t. The slow growing and long-living *Pagrus pagrus* was overexploited by trawl fishing during the 1970s (Yesaki and Barcellos 1974; Haimovici et al. 1989), and stocks collapsed after a few years without showing signs of recuperation (Table 9.2). Landings of the flatfishes *Paralichthys* spp., the sea robin (*Prionotus punctatus)*, and *Urophycis brasiliensis* averaged almost 3500 t annually over the last 5 years (Table 9.2). Landings of flatfishes alone reached a maximum of 2157 t in 1990 but decreased more recently. Since *Prionotus punctatus* and *Urophycis brasiliensis* are not abundant over the southern shelf (Haimovici et al. 1996), catches of these species probably cannot be sustained.

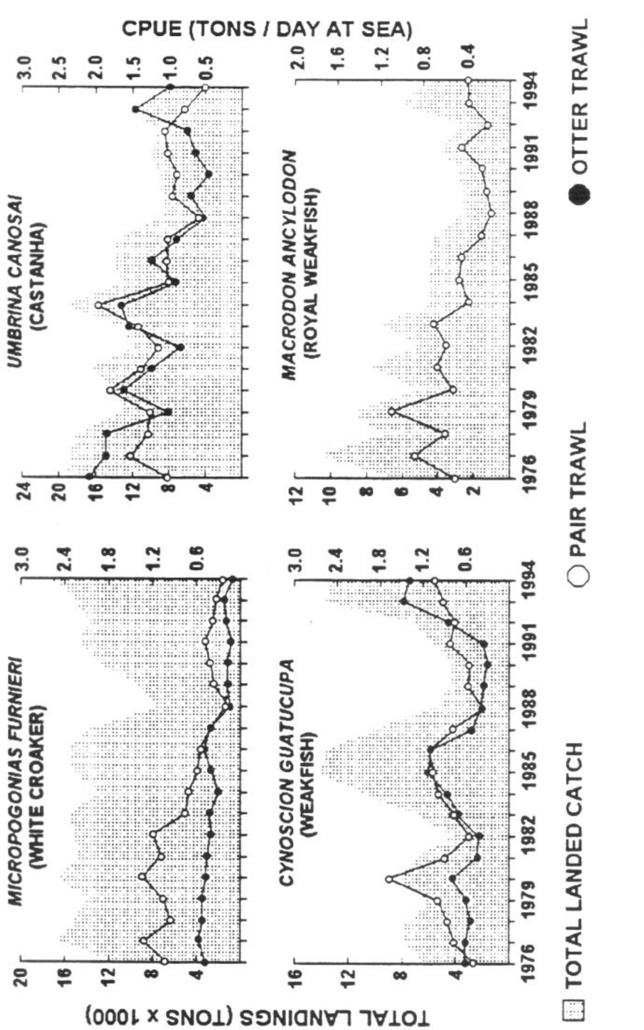

Fig. 9.2. Total landed catches and catch per unit effort (*CPUE*) of otter- and pair-trawls of the most abundant demersal teleosts between 29° and 35° S

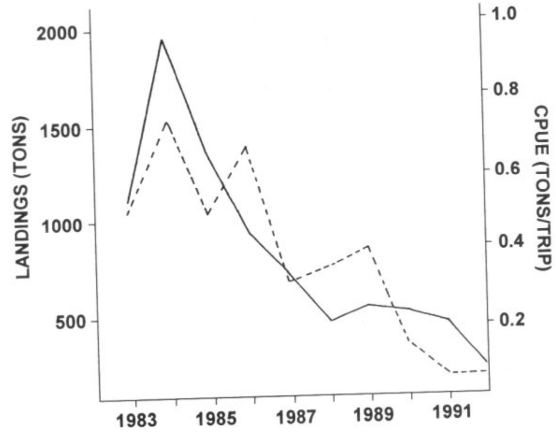

Fig. 9.3. Landings of guitar fish *Rhinobatos horkelii* at the Port of Rio Grande (*solid line*) and mean annual CPUE of the otter-trawl fleet (*dashed line*)

The stocks of demersal teleosts, like *Pogonias cromis*, the catfishes *Netuma barba* and *Netuma planifrons*, and *Micropogonias furnieri*, which use the Patos Lagoon estuary during part of their life-cycle, have been heavily exploited by the artisanal gill-net fishery during the 1970s and collapsed after 1980 (Table 9.2; Haimovici et al. 1989; Reis et al. 1994). The recuperation of *Pogonias cromis* and *Netuma* stocks will be difficult, owing to their high vulnerability to gill-net fishing, slow growth, and late sexual maturation. As a result, only mullet and pink shrimp actually represent economically viable fisheries in the estuary.

Demersal Elasmobranch Fisheries

About 10% of the total sea fish landings (1975-1994) in Rio Grande are comprised of elasmobranchs. Until 1988 almost 80% of all catches were by bottom-trawl fishing (Vooren et al. 1990) but in recent years most catches are being made by bottom gill-nets. Landing statistics are merely subdivided into sharks, angel sharks, guitar fish, and rays (Table 9.2).

Table 9.2. Mean annual landings (1975-1994) of the main fishery resources fished in the southwestern Atlantic between 29° and 34° S

		Mean annual landings (tons)			
		1975-1979	*1980-1984*	*1985-1989*	*1990-1994*
Estuary and shelf pelagic species					
White croaker	*Micropogonias furnieri*	14308	14904	12364	14709
Weakfesh	*Cynoscion guatucupa*	6439	7377	9572	8785
Royal weakfish	*Macrodon ancylodon*	7941	5865	3659	3966
Castanha	*Umbrina canosai*	16900	14877	11732	9629
Catfish	*Netuma spp.*	3983	1536	452	615
Black drum	*Pogonias cromis*	1044	359	246	63
Hake	*Merluccius hubbsi*	760	101	200	129
Flatfish	*Paralychthis spp.*	424	417	1486	1363
Red porgy	*Pagurs pagrus*	1419	327	294	238
Searobin	*Prionotus punctatus*	12	71	486	988
Abrótea	*Urophycis brasiliensis*	241	337	665	1186
Cutlassfish	*Trichiurus lepturus*	75	79	63	441
Demersal sharks[a]		1637	2486	3754	3748
Angel shark	*Squatina spp.*	947	1485	2607	2183
Guitar fish	*Rinobathos horketi*	1010	1253	901	460
Rays and skates	*various species*	116	461	718	746
Pink shrimp	*Peneus paulensis*	4143	1830	4354	2627
Marine shrimps[b]		-	-	1331	1148
Estuary and shelf demersal species					
Menhaden	*Brevoortia pectinata*	1549	343	646	1324
Bluefish	*Pomatomus saltatrix*	4290	2290	2456	3521
Mullet	*Mugil platanus*	2081	1709	1486	1524
Mackerel	*Scomber japonicus*	-	-	-	969
Jack mackerel	*Trachurus lathami*	-	-	-	1555
Demersal upper slope species					
Wreckfish	*Polyprion americanus*	152	68	145	176
Red crab	*Chaceon notialis*	-	-	-	-
Offshore pelagic species					
Bigeye tuna	*Thunus obesus*	312	419	640	500
Albacore	*Thunus alalunga*	269	446	494	1075
Yellowfin tuna	*Thunus albcarens*	212	336	325	684
Swordfish	*Xiphias gladius*	122	285	350	601
Skipjack tuna	*Katsuwonus pelamis*	-	-	-	2402
Pelagic sharks[c]		182	481	382	547

[a] Mostly *Galeorhinus galeus* and *Mustelus schmitti.*
[b] *Pleoticus muelleri* and *Artemesia longinaris.*
[c] *Isurus oxyrinchus, Prionace glauca, Sphrena* spp. among others.

The division "sharks" consists mostly of the school shark (*Galeorhinus galeus*), with the narrownose smooth-hound (*Mustelus schmitti)* in second place. The latter species was discarded until about 1985 (Haimovici and Palacios 1981), but was subsequently landed in increasing quantities. Both species migrate from the Uruguayan and Argentinian shelf to Brazilian waters in the winter. Annual landings in Rio Grande rose gradually from 1414 t (1975) to 2482 t (1984), then increased sharply to about 3500 t (1985-1987), followed by a drop to 1247 t (1989). The decrease after 1987 reflects the reduced abundance of *Galeorhinus galeus* and possibly also of *Mustelus schmitti*. Owing to increased fishing efforts by bottom gill-netting, total shark landings increased to 2791 t in 1992. The otter-trawl CPUE showed a similar pattern, rising to a peak of about 5 t/trip in 1989, then dropping to 1.5 t/trip in 1992. The rise in CPUE until 1989 reflects increased targeting of shark and a decrease in discarding.

Catches of angel sharks consist mainly of *Squatina guggenheim*, which inhabits the inner shelf at depths down to 80 m, and *Squatina occulta* which is abundant on the outer shelf and the slope down to 350 m. *Squatina guggenheim* is a resident species, but the migratory status of *Squatina occulta* is not clear. Annual landings of angel shark increased from 820 t (1973) to a peak of 2442 t (1988) and then dropped sharply to 1031 t (1990). Similarly, otter-trawl CPUE of angel shark reached a maximum of 6.2 t/trip in 1988, followed by a decline to 0.7 t/trip in 1992, which reflects a major decrease of the abundance of both species of angel shark, the resident *Squatina guggenheim* probably being the most affected. However, while abundance decreased, landings increased to 1761 t in 1992, owing to increased fishing efforts by bottom gill-netting.

Adult females of the guitar fish (*Rhinobatos horkelii)* concentrate between December and February in shallow inshore waters to breed. During this period they are particularly vulnerable to intensive pair-trawl and beach seine fisheries. During the remainder of the year, adults of both sexes disperse over the inner shelf where catching is done by otter-trawling. A continuous decline of otter-trawl CPUE from 0.76 t in 1984 to 0.08 t in 1992 provides a measure of decreasing abundance (Fig. 9.3). Similarly, annual landings of this species decreased from a peak of 1927 t in 1984 to an all-time low of 178 t in 1992.

Pelagic Teleost Fisheries

The fishery for pelagic teleosts, like *Pomatomus saltatrix*, the cutlassfish (*Trichiurus lepturus*), the anchovy (*Engraulis anchoita*), and *Trachurus lathami*, is little developed and represents only about 10% of total landings.

Pomatomus saltatrix is a fast growing species which migrates from Argentina to southern Brazilian shelf waters. The species concentrates in surface waters warmed above 15°C temperature (Krug and Haimovici 1989;

Haimovici and Krug 1992). In the winter mainly age classes between 2 and 5 years are fished (Krug and Haimovici 1991). Mean annual landings total 3528 t (1970-1992), with an exceptional peak of 12 126 t in 1971. Since climatic conditions regulate the abundance and migration cycles of *Pomatomus saltatrix*, the fishing potential of this species is highly unpredictable (Haimovici and Krug 1996). *Trichiurus lepturus* is fairly abundant, and the spring biomass may exceed 30 000 t (Haimovici et al. 1996). Since the commercial value of this species drastically declines when kept between ice layers, rather than being deep frozen onboard as is done by some hired Korean trawlers, the stock is underexploited. The small-sized *Engraulis anchoita* is the main pelagic species in southern Brazilian shelf waters. Since the species has no market value, it is unexploited, though the winter biomass may attain over one million tons. *Trachurus lathami* and *Scomber japonicus* may be caught by purse seines between 30 and 80 m depth in the winter and therefore may represent a potential resource for midwater trawling. The irregular occurrence of *Scomber japonicus* is probably related to the intensity of the subantartic water influence.

Large pelagic fishes are caught along the thermal front of the western margin of the Subtropical Convergence and landed in Rio Grande (Mello et al. 1993; Antero da Silva 1994). Landings (1977-1989) contain the yellowfin tuna (*Thunnus albacares;* 23%), the bigeye tuna (*Thunnus obesus;* 21.5%), the albacore tuna (*Thunnus alalunga;* 18%), the swordfish (*Xiphias gladius;* 16%), various pelagic sharks (i.e. *Prionace glauca, Sphyrna zygaena, Sphyrna lewini;* 18.5%), and billfishes (i.e. *Tetrapturus albidus, Makaira nigricans;* 3%; Mello et al. 1993). Although stock assessments are unreliable and catches fluctuate, the tuna fishery shows potential for expansion. The skipjack tuna (*Katsuwonus pelamis)* is caught during the summer and fall with pole and live-bait in waters between 80 and 1000 m depth and surface temperatures between 20 and 26°C (Castello and Habiaga 1988). Since the exploitation rates of skipjack tuna are moderate (Jablonski and Matsuura 1985; Vilela and Castello 1993), the catch could be increased. The availability of live bait appears to be the main limiting factor for the expansion of this fishery (Table 9.2).

Invertebrate Fisheries

Crustacean catches, mostly shrimp, blue crab, and red crab, amount to approximately 6% of the total landings (1975-1994). Subadults of the pink shrimp (*Penaeus paulensis)* migrate from northern coastal waters into the nursery grounds of the Patos Lagoon estuary and coastal lagoons in Uruguay, where the species is caught in the summer and fall (Valentin et al. 1991). Annual artisanal shrimp fishery landings change considerably as a consequence of variable recruitment conditions (Castello and Möller 1977; D'Incao 1991) and growth. Despite predictions that estuarine shrimp fisheries might collapse, owing to excessive catching of juveniles (Valentin et al. 1991), average annual landings between 1988 and 1994 were close to the 20-year annual mean of 3106 t. This leads to the conclusion that environmental variables rather than fishing pressure are the determinants for shrimp fishery catches. Juveniles and adults of the shrimps *Pleoticus muelleri* and *Artemesia longinaris* occur in coastal waters (Harán et al. 1992), and exploitation of *Artemesia longinaris* stocks appeared to have reached saturation in 1989 (Ruffino and Castello 1992b). However, the variability of catches during subsequent years coincided with a reduced catch of largely migratory demersal species, and thus oscillation in the abundance of *Artemesia longinaris* may depend on interannual variations in oceanographic conditions (Table 9.2).

The crab fishery is hardly developed. Small-scale trawl-net fishery for the blue crab *Callinectes sapidus* occurs regularly in the Patos Lagoon estuary. In 1984 the deep water red crab *Chaceon notialis* was experimentally fished over the continental slope (34° S; Lima and Branco 1991), but catches per trap-day decreased sharply in less than 6 months. Since this species has a wide low-density distribution, a biomass estimate (Delury method) of 2183 t of the unexploited stock in the fishing area (3000 km^2) may be conservative. The squids *Loligo sanpaulensis* and *Illex argentinus* frequently occur over the shelf between 30° and 34° S (Haimovici and Perez 1991a). Despite spring biomass estimates of 3500 t for *Loligo sanpaulensis* (Andriguetto and Haimovici 1991), landings of cephalopods are virtually non-existent.

Fisheries Interactions

Fishing activities interact with both sea birds and marine mammals. Between November and May flocks of several types of sea birds (*Puffinus gravis, Sterna hirundo, Procellaria aequinoctialis conspicillata, Diomedea chlororhynchos*) are reliable indicators of schools of the skipjack tuna *(Katsuwonus pelamis)* over the mid and outer shelf (Chiaradia 1991). A variety of sea birds (*Procellaria a. aequinoctialis, Fulmarus glacialoides, Diomedea melanophoris*) die on the hooks of long-line tuna fisheries along the western margin of the Subtropical Convergence, and the annual death toll may exceed 2650 birds (Vaske 1991). Fishery interactions may be the main cause for the decline of *Diomedea exulans* populations in the South Atlantic Ocean (Croxall and Prince 1990). Discard from trawl fisheries is composed of a large number of either small, floating teleosts or fast-sinking, small sharks and skates, and represents an important additional food source for sea birds like subantartic albatrosses and petrels (Vooren and Fernandes 1989) and the sea lion *Otaria flavescens*. Dead stranded specimens of *Otaria flavescens* are commonly found on southern Brazilian beaches. A large number have broken skulls or bullet holes inflicted by fishermen, while others may have died from entrapment in nets (Rosas et al. 1994). Gill-nets are the principal cause of small cetacean mortality in the southwestern Atlantic (Pinedo 1994a). The species most affected is the small dolphin *Pontoporias blainvillei*, but the bottle-nose dolphin (*Tursiops truncatus*) is also occasionally entangled and killed by gill-nets near the Patos Lagoon inlet (Pinedo 1994b).

Fishery Perspectives

Total annual catches in the southwestern Atlantic (38°-34°S), including a conservative estimate of 25% discard, range from 70 000 to 120 000 t, inter-annual differences being partly due to environmental factors. Changes of landing statistics with time are principally a result of the establishment of new fisheries (i.e. bottom gill-net fisheries for elasmobranchs and double-rigg trawling for flatfishes and shrimp) as the older stocks became overexploited. Today, most commercially important estuarine, coastal, and shelf stocks are either fully or overexploited, and landings are expected to decrease in coming years. Overfished stocks of demersal finfishes include *Netuma* spp., *Pogonias cromis*, and *Pagrus pagrus*. The abundance of *Rhinobathos horkelii*, *Galeorhinus galeus*, and other shark species have declined up to 90% in recent years, probably due to recruitment overfishing since these species are low-fecundity viviparous fishes. The assessment of the status of stocks of less abundant shark species and of many other species, which are simply grouped as rays and skates in the landing statistics, is at present impossible. Furthermore, about two-thirds of recent demersal catches have concentrated on migratory stocks (i.e. *Micropogonias furnieri*, *Umbrina canosai*, *Cynoscion guatucupa*, *Mustelus schmitti*) which are shared by Uruguayan and Argentinian fisheries. Estuarine and marine shrimp, menhaden, bluefish, and mullet catches are highly variable. These stocks do not clearly confirm overfishing but appear to lack potential for expansion. In addition, the growth potential of under- or unexploited stocks seems to be limited. Only *Engraulis anchoita* and *Trachurus lathami* stocks might have some fishery potential, and catches of offshore tunids may eventually increase.

Demersal teleost and elasmobranch stocks are affected as a whole, and thus their abundance and diversity are at risk under intensive and uncontrolled fishing. For example, if present trends continue, the populations of *Rhinobatos horkelii* and *Squatina guggenheim* will become extinct. The same may well be true for an unknown number of other species, whose decline remains unnoticed because they are not listed in the landing statistics. Although proposals to reduce estuarine and all demersal fishing efforts and to decrease onboard discard (Haimovici and Palacios 1981; Vooren 1983; Haimovici et al. 1989; IBAMA 1993, 1995) have provided an adequate legal basis, neither fishing efforts nor discard of undersized fish has diminished. Unquestionably, future fishery management strategies must not only involve both the fishermen and the fishing industry in creating effective legislation, but also encourage international management of shared stocks.

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Subtropical Convergence Environments

The Coast and Sea in the Southwestern Atlantic

With 66 Figures

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