A review of the flatfish fisheries of the south Atlantic Ocean

Una revisión de las pesquerías de lenguados del Océano Atlántico sur

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Resumen.- Se describen las pesquerías de lenguados del Atlántico sur sobre la base de series de valores temporales de desembarcos pesqueros entre los años 1950 y 1998, e información disponible sobre características biológicas, flotas, artes de pesca e importancia económica de las especies comerciales.

Los lenguados de la familia Paralichthyidae, principalmente *Paralichthys patagonicus*, *P. orbignyanus* y *Xystreurys rasile* son intensamente explotados en el Atlántico suroccidental. En el sur de Brasil las capturas de estas especies alcanzaron un máximo de 1.892 t en 1989, mientras que en Argentina excedieron anualmente el valor de 10.000 t entre 1989 y 1998. En el Atlántico suroriental, el lenguado austral oeste, *Austroglossus microlepis* y el lenguado de fango, *A. pectoralis* representan un pequeño porcentaje de las capturas de arrastre en Sudáfrica, sin embargo constituyen los pescados más valiosos por unidad de peso y por lo tanto el principal objetivo de los pequeños barcos arrastreros.

Los desembarques del lenguado austral oeste alcanzaron casi las 2.000 t en 1972, pero luego dicho valor declinó notablemente. La pesca de arrastre es el método más importante utilizado en la pesca de lenguados en el Atlántico suroccidental. La pesca con tangones y redes de enmalle son usadas para la pesca de lenguados. En el Atlántico suroriental, las principales capturas de lenguados se obtienen como fauna acompañante en las pesquerías de arrastre demersal. Los lenguados representan, tanto en el Atlántico suroccidental como suroriental, una fracción relativamente pequeña del total de las capturas comparado con otras especies de peces demersales como la merluza.

Palabras clave: *Paralichthys* spp., *Austroglossus* spp., pesquerías, Atlántico sur

Abstract.- The flatfish fisheries of the South Atlantic Ocean are described from time series of landings between 1950 and 1998 and available information on species life history, fleets and gear characteristics, and economical importance of commercial species.

In the southwest Atlantic, paralichthyid flounders, mostly *Paralichthys patagonicus*, *P. orbignyanus* and *Xystreurys rasile* are intensely exploited. While in southern Brazil, landings of these species reached a maximum of 1 892 t in 1989, in Argentina exceeded 10 000 t annually between 1989 and 1998. In the south-east Atlantic, the west coast sole, *Austroglossus microlepis*, and the Agulhas sole, *A. pectoralis*, although account for a minor percentage of the annual South African trawlfish catch, they are by far the most valuable fish per unit weight landed and are therefore the main target of the small trawlers.

Landings of west coast sole peaked at nearly 2 000 t in 1972 but have declined steeply since then. Trawling is the most important method used in fishing for flatfish in the south-west Atlantic. Double-rig trawling, twin nets and entangling nets are employed for flatfish fishing. In the south-east Atlantic, the main flatfish catches are taken as by-catch in the demersal trawls fisheries. Flatfish represent a relatively small fraction of the total landings in both the south-west and south-east Atlantic, compared with other demersal fish species as hake.

Key words: *Paralichthys* spp., *Austroglossus* spp., fisheries, south Atlantic

Introduction

The flatfishes constitute important commercial and recreational fisheries throughout the Atlantic from the deep Arctic to the southern hemisphere and around the coasts of southern Africa and south America. They are among the most productive demersal fisheries from the commercial view point in the world. Although flatfishes account for a little amount of annual trawlfish catch in comparison to other demersal Atlantic fisheries such cod and hake, they are by far the most valuable fish per unit weight landed. They are regarded as “fine fishing”

due to their value as a food fish, and as a consequence, the price in the market is high (Díaz de Astarloa & Munroe 1998, Fabré & Díaz de Astarloa 2001).

Based on the analysis of the landings and the life history of the most important species, this paper describes the development of the flatfish fisheries in the south Atlantic since 1950 and discusses its present state and future development.

Materials and Methods

Landing statistics, description of fleets and fishing gears were obtained from published reports of the Food, Fishing, Cattle and Agriculture Secretariat of Argentina (SAGPyA 1999), Fisheries Department of the Food and Agriculture Organisation (FAO 2000), and Brazilian National Environment and Fisheries Agency (IBAMA 1998). Geographical distribution and biological information of some flatfish species were obtained from literature and unpublished data, as well.

Results and Discussion

Main species

Southwest Atlantic

Approximately 45 flatfish species belonging to six Families (Pleuronectidae, Achiridae, Bothidae, Paralichthyidae, Cynoglossidae and Achiropsettidae) occur in the southwest Atlantic southward to the Amazon river. Not all of them are of commercial importance due to small sizes or either low abundance. Only the pleuronectids and paralichthyids are the most economically important because they are very tasty flatfishes and the fish products have a high price in the market.

Pleuronectidae is represented by *Oncopterus darwinii* Steindachner, 1874. The species attains up to 35-cm total length and is distributed from Santa Catarina (Brazil) southward to Península Valdés (Argentina) in waters shallower than 50 m (Fabré & Díaz de Astarloa 1996). The quality of the meat has long been appreciated in Brazil where it is fished by artisanal boats (wood fishing boats measuring up to 15 m long) with gill nets in coastal waters at depths of less than 40 m (Reis *et al*. 1994). However, it rarely appears in the fish market due to its very low abundance. In Argentina, artisanal fishermen catch *O. darwinii* using small wooden boats of 8-m long (55-110 HP) and as by-catch of other economically important crustaceans such as the Argentine red shrimp *Pleoticus muelleri* (Bate) or the southern king crab *Lithodes santolla* (Molina) (Elías 1998).

Regarding Paralichthyidae only the most important commercial species are listed as follows: *Paralichthys brasiliensis* (Ranzani), *P. isosceles* Jordan, *P. orbignyanus* (Valenciennes), *P. patagonicus* Jordan, *P. triocellatus* Miranda Ribeiro and *Xystreurys rasile* (Jordan).

P. brasiliensis is a shallow-water species occurring up to 40-m depth. It commonly inhabits bays, beach zones and estuarine areas on muddy and sandy bottoms in northeastern Brazil from São Luiz do Maranhão south to Rio de Janeiro (Figueiredo & Menezes 2000). It can attain up to 1-m length and it is considered one of the finest flatfish in the region (Carvalho-Filho 1999).

P. isosceles and *P. triocellatus* are both endemic species of the Argentine Zoogeographical Province (Figueiredo 1981). *P. triocellatus* is distributed approximately from Rio de Janeiro (25ºS) south to Uruguay, while *P. isosceles* occurs from Paraná (26º30'S) as far south as San Jorge Gulf, Argentina (46ºS) (Figueiredo & Menezes 2000). They are bathymetrically distributed between 50 and 180-m depth (Bittencourt 1982). They generally do not exceed 40-cm total length. *P. isosceles* is typical in the region of its occurrence throughout the year (Haimovici *et al*. 1994).

P. patagonicus is widely distributed from Rio de Janeiro to at least as far south as northern Patagonia (43ºS) (Díaz de Astarloa 1994). Although it occurs in shallow waters up to 200-m depth, is commonly captured between 70 and 100 m (Carneiro 1995, Díaz de Astarloa & Munroe 1998). It is the most economically important paralichthyid flounder in the southwest Atlantic since the high abundance and the big sizes that the flatfish attains, compared to other flatfishes occurring in the area (Díaz de Astarloa 1994). It is also the main species of flounder landed from commercial bottom trawl fisheries on the continental shelf and coastal shallow-waters in southern Brazil (Carneiro 1995). Although flatfish species are not distinguished in commercial landings throughout the region and only one category of flatfishes instead of by species appears in the statistics, it was demonstrated that *P. patagonicus* is the most abundant landed species representing 96.3% of the total flatfish species landed in Rio Grande do Sul (Haimovici 1998) and 70% of the whole flatfishes landed in Argentina (Cousseau & Fabré 1990, Fabré & Díaz de Astarloa 1996).

Paralichthys orbignyanus is a shallow-water flatfish occurring from Rio de Janeiro southward to San Matías Gulf, in Argentina. Within its range, it inhabits estuarine areas such as Lagoa dos Patos (Brazil), Rocha lagoon (Uruguay), Río de la Plata estuary (both sides of Argentina and Uruguay), Mar Chiquita coastal lagoon

(Argentina) (Chao *et al*. 1985, Díaz de Astarloa & Munroe 1998). It ranges from depths of less than 1 m to 45 m, but commonly inhabiting depths on the inner continental shelf between the shoreline and about 30 m.

P. orbignyanus represents 2.3% of the total amount of flatfish species landed in Rio Grande do Sul and most of the specimens are captured in the estuarine region of dos Patos lagoon and in the marine area close to the lagoon (Carneiro 1995). At Mar del Plata harbour (Argentina) where almost the 70% of the fishing fleet takes place, *P. orbignyanus* is categorised as big or very big flounder together with *P. patagonicus*. Both species take the eighth place of the total amount of kilograms traded.

Xystreurys rasile is widely distributed from the northeastern Brazil to at least as far south as the continental shelf off San Jorge Gulf (47ºS). Here, it is more abundant on the continental shelf outside the gulf especially at 50-100-m depth. It is scarcely captured in Brazilian waters and represents together with *O. darwinii* 0.3% of the total flatfish captures in southern Brazil. (Haimovici & Mendonça 1996a). In Argentina, throughout its range the species is very abundant in Buenos Aires Province, and in the southern portions of its range between 43 and 45ºS. Southerly it is either absent or occurs only rarely. It is traded as a small-sized or moderate-sized flounder category in Mar del Plata harbour, and with *P. isosceles* the two species represents between 2.4 and 2.6% of the total fish species sold (Fabré 1992, Fabré & Díaz de Astarloa 1996).

Southeast Atlantic

Seven flatfish Families (Psettodidae, Citharidae, Bothidae, Achiropsettidae, Paralichthyidae, Soleidae and Cynoglossidae) are present in the southeast Atlantic (area 47 of FAO) which include approximately 35 species. The bothids, soleids as well as some species of cynoglossids constitute fishery resources of relative commercial importance in the area. Within Bothidae, species of *Arnoglossus* are moderate-sized flatfishes (between 15-25 cm TL) with no commercial value in Angola, although in Namibia are considered commercially important fishes. Other bothids such as the wide-eyed flounder *Bothus podas* (Delaroche), the pelican flounder *Chascanopsetta lugubris* Alcock attain larger sizes (c.a. between 40-45 cm TL). In the region, *Bothus podas* is distributed as far south as Angola where it has commercial importance in fisheries as well as in aquaria. Although *Chascanopsetta lugubris* also reported for Angola, Namibia and South Africa, only in Namibia it is an important commercial species (Hensley 1995).

The cynoglossids are caught mainly with bottom trawls and fixed bottom nets. They are marketed mostly fresh and frozen. Species of *Cynoglossus* are of big size, and relative abundant in the region (M. Desoutter, pers. comm.[1]). Conversely, species of *Symphurus* are of little commercial potential, although some species are caught and marketed locally in Angola (e.g. *Symphurus nigrescens* Rafinesque, *S. normani* Chabanaud) (Desoutter 1990). The lack of commercial importance may be attributed to their small body size and low population abundance.

The redspotted tonguefish *Cynoglossus zanzibarensis* Norman attains 32 cm. It commonly inhabits off the south coast of South Africa. It is regarded as one of the best eating "soles" in the area. It is caught as a negible by-catch in the demersal trawl fishery off the west and south coasts of South Africa, but it is a small component and no separate statistics are available. In the past, catches of redspotted tonguefish have been mixed in the statistics with those of the west coast sole *Austroglossus microlepis* (Bleeker), and therefore it proved impossible to determine with any degree of accuracy how much west coast sole and redspotted tonguefish were actually caught. Because *Cynoglossus zanzibarensis* are more abundant on the south coast of South Africa, such merging of statistics had a greater impact on the declared catches of the east coast sole *Austroglossus pectoralis* (Kaup) than on those of *A. microlepis*. Some of the small fishing companies market *Cynoglossus zanzibarensis* as lemon sole *Solea fulvomarginata* Gilchrist (attains sizes of 75 cm), and where they are reported in log books and drag sheets the catches are recorded together with other fish species (F. le Clus, pers. comm.[2]).

Within soleids, species of *Austroglossus* constitute important commercial species in the southeast Atlantic, especially in South Africa where the sole fishery is based on two species, the west coast sole *Austroglossus microlepis* and the Agulhas sole *A. pectoralis*. Although soles account for little per cent of the South African annual trawlfish catch, they are by far the most valuable fish per unit weight landed and are therefore the principal target of the small trawlers, particularly along the south coast (Payne 1979).

The west coast sole *Austroglossus microlepis* occurs in depths of 100-300 m from northern Namibia to False Bay, South Africa (34ºS, 19ºE) attaining a maximum

[1] Dr. Martine Desoutter. Laboratoire d' Ichtyologie générale et appliquée. Muséum national d'histoire naturelle. Paris.

[2] Dr. Frances le Clus. Directorate Offshore Resources Branch. Marine & Coastal Management Coordination. South Africa.

size of 75 cm TL, and maximum weight of 4 kg (Heemstra & Gon 1995).

The east coast sole or Agulhas sole (mud sole according to FAO) *Austroglossus pectoralis* attains 58 cm and is commonly caught on the south coast of South Africa, between longitudes 20-27ºE. Once very important, the catches of this species declined noticeably in recent years, but it is commercially still the most important of the South African flatfishes (Heemstra & Gon 1995).

History of production

As far as is concerned the expansion of the flatfish fisheries in Brazil, it may be stated that the Brazilian fishing potential is low in relation to the extension of the continental shelf. The fishery intensified in the late 1950s through pair trawlers landing in Santos (24ºS) and further in the late 1960s when the fishing industry started to be subsidised. In the 1970s estimates of total annual landed catches along Brazil averaged 1.4 million t for the entire fishing resources (Neiva & Moura 1977). In 1985 annual catches reached over 760 000 t, and in the 1990s they did not exceed 500 000 t (Dias Neto & Dornelles 1996). At present, the principal demersal fish stocks under exploitation (the king weakfish *Macrodon ancylodon* (Bloch & Schneider), the Argentine croaker *Umbrina canosai* (Berg) are intensely exploited or overexploited in the case of the white mouth croaker *Micropogonias furnieri* (Desmarest), the angelsharks *Squatina* spp., the demersal sharks mostly *Galeorhinus galeus* (Linnaeus) and *Mustelus schmitti* (Springer). Others are depleted such as the black drum *Pogonias cromis* (Linnaeus), the catfishes *Netuma* spp. and the red porgy *Pagrus pagrus* (Linnaeus) (Haimovici 1998). Paralichthyid flounders, mostly *P. patagonicus* and *P. orbignyanus* are intensely exploited. Landings of these species reached 500 t annually in the late 1970s and early 1980s in southern Brazil. They reached a maximum of 1 892 t in 1989 but decreased considerably thereafter (Fig. 1).

Landing statistics of flatfish species in Uruguay were low up to the beginning of 1990s; a sharp increase was observed thereafter over 400% (Fig. 2). *P. patagonicus* is fished on the continental shelf while *P. orbignyanus* is fished in shallower waters less than 40 m depth, and both *P. isosceles*, and *X. rasile* are fished offshore, but in very low catches compared to the other two paralichthyids.

Annual landings of paralichthyid flounders in Argentina reached up to 3 000 t in the early 1980s and considerably increased in the mid 1980s, exceeding 10 000 t annually between 1995 and 1997 (SAGPyA 1999) (Fig. 3). The main exploited flatfish species are *P. patagonicus, P. isosceles, P. orbignyanus* and *X. rasile*. Historically (1971-1986), the percentage of the target species, the Argentine hake *Merluccius hubbsi* Marini exploited by the trawling fleet was higher than 80% of the total catch (Di Giácomo & Perier 1992). Since 1987, a change in the exploitation pattern of the trawling fleet has been observed, which led the captures of hake to decrease in 25%, and 50% in the case of cockfish *Callorhynchus callorhynchus* (Linnaeus) while flatfishes had increased 1 300% in total catch (M.R. Perier, pers.comm.[3]). Diverse factors may explain this change in the exploitation pattern. Among them, the depletion of traditional fishery resources, drop of the price and the decrease of the Argentine hake's demand in the fish market, and the subsequent exploitation increase of the finest fish, such as the flatfishes (Di Giácomo & Perier 1992). By mid 1980s flatfish landings in Brazil, Uruguay and Argentina increased up to maximum values of 2 800 t annually between 1986-1987 in Brazil, 10 200 t in 1995 in Argentina, and 500 t in 1996 in Uruguay, but have gradually decreased in Brazil, showed a variation in Argentina and slightly increased in Uruguay since subsequent years (Fig. 4).

In the southeast Atlantic, estimated biomass of west coast sole *Austroglossus microlepis* based on stratified random sampling cruises between 1983 and 1990 off Namibia followed different trends in summer and in winter, being biomass estimates based on the summer

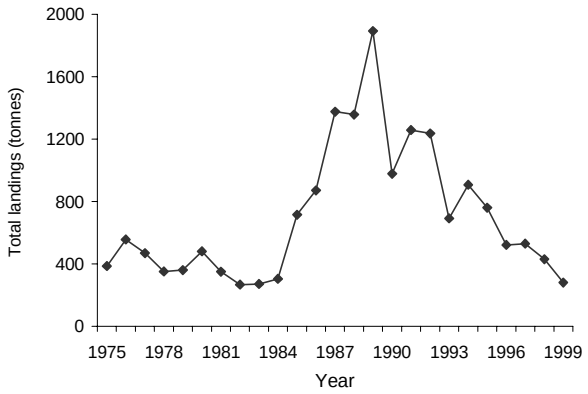

Figure 1

Landings of paralichthyid flounders (*Paralichthys patagonicus* and *P. orbignyanus*) in southern Brazil

Desembarques de lenguados paralíctidos (*Paralichthys patagonicus* and *P. orbignyanus*) en el sur de Brasil

[3] Dr. M. Raquel Perier. Insituto Almirante Storni, San Antonio Oeste, Argentina.

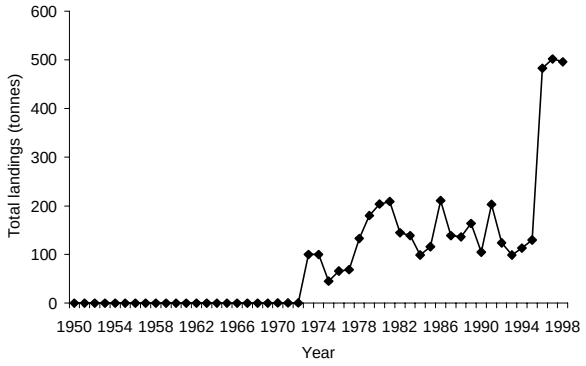

Figure 2

Landings of paralichthyid flounders (*Paralichthys* spp.) in Uruguay

Desembarques de lenguados paralíctidos (*Paralichthys* spp.) en Uruguay

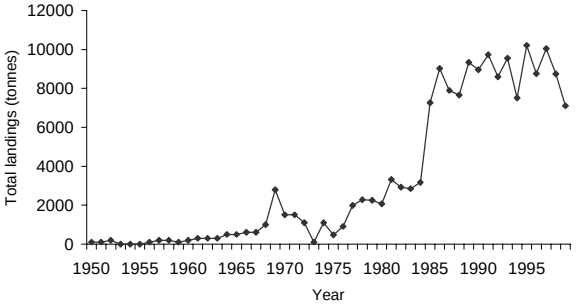

Figure 3

Landings of paralichthyid flounders (*Paralichthys* spp. and *Xystreurys rasile*) in Argentina

Desembarques de lenguados paralíctidos (*Paralichthys* spp. y *Xystreurys rasile*) en Argentina

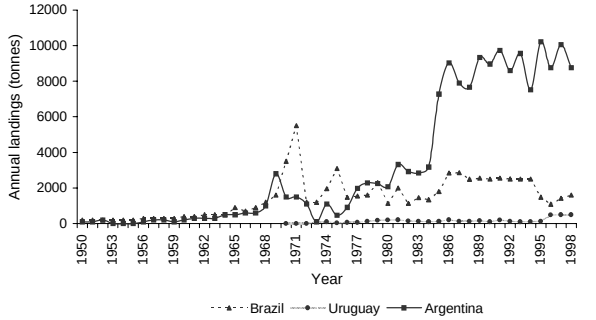

Figure 4

Annual landings (1950-1999) of paralichthyid flounders in the southwestern Atlantic

Desembarques anuales (1950-1999) de lenguados paralíctidos en el Atlántico suroccidental

cruises (1 100 – 11 400 t) higher than those based on winter cruises (400–2 600 t) (Macpherson & Gordoa 1992). This difference between summer and winter values may exert important effects on estimates of biomass, which are more dependent upon the response of populations to oceanographic conditions than to the actual state of those same populations (Macpherson & Gordoa 1992).

Biomass estimates south of the Orange River (geographic boundary between Namibia and South Africa) ranging from 37-792 t during the period 1985-1997. In January 1999 insufficient west coast sole were captured to even attempt a biomass estimate. Between 1990 and 1998, two limited experimental permits per year were granted on socio-economic grounds. However, in 1997 only about 4 t were landed and none in 1998 (F. le Clus, pers. comm.).

Landings of west coast sole constitute a declining percentage per year of the entire annual landings of trawl-fish in south west Africa ranging from 44%-8% between 1969-1971 (Lucks 1972). When west coast sole landings decreased from more than 1 000 t in 1970 to about 50% that value the year after, a selectivity study of fishing gear for investigating the state of the stock was started (Lucks 1972). The conclusion reached was that a mesh size of 75 mm should be applied to the fishery. However, since the mid 1970s all trawlers fishing in the southeast Atlantic have been compelled to use a net with a maximum mesh size of 110 mm when catching more than 30 per cent by weight of hake (Payne 1979). In 1990-1998 two experimental permits were issued each year as a socio-economic measure to catch some southern stock west coast sole with 75 mm mesh-size (F. le Clus, pers. comm.).

Overall catches of soles from the southeast Atlantic by all nations in the period 1973-1987 are shown in Figure 5. This information is discriminated by regions. The International Commission for the southeast Atlantic Fisheries (ICSEAF), which met for the first time in 1971, divided the southeast Atlantic into a number of divisions for the reporting of catch statistics (Crawford *et al*. 1987) (Fig. 6). Between 1973 and 1987, 29% of the catch of west coast sole was made in ICSEAF Division 1.1, 7.8% in Division 1.2, 18.8% in Division 1.3, 39.4% in Division 1.4, 4.9% in Division 1.5 and 0.02% in Division 1.6.

Divisions 1.1 and 1.4 correspond to the Angolan stock and to the northern stock of the west coast sole, respectively, defined by Payne and Badenhorst (1989). Catches in Division 1.3 mainly come from the northern stock south of the Cunene River, while those reported for Division 1.5 south of the Orange River, and Division

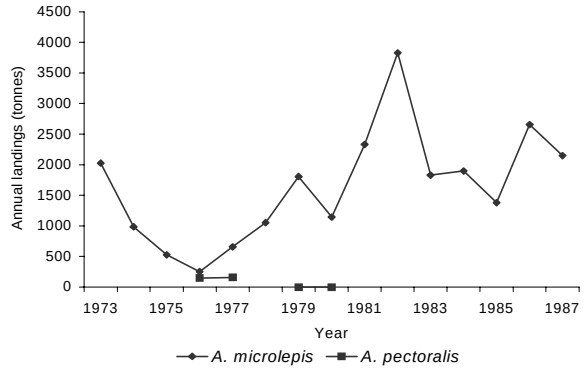

Figure 5

Recorded catches of sole *Austroglossus* spp. in the eastern south Atlantic, ICSEAF Divisions 1.1 - 1.6 (after Crawford *et al.* 1987; F. le Clus, pers. comm.)

Capturas de lenguados *Austroglossus* spp. registradas en el Atlántico suroriental, Divisiones ICSEAF 1.1 - 1.6 (según Crawford *et al.* 1987; F. le Clus, com. pers.)

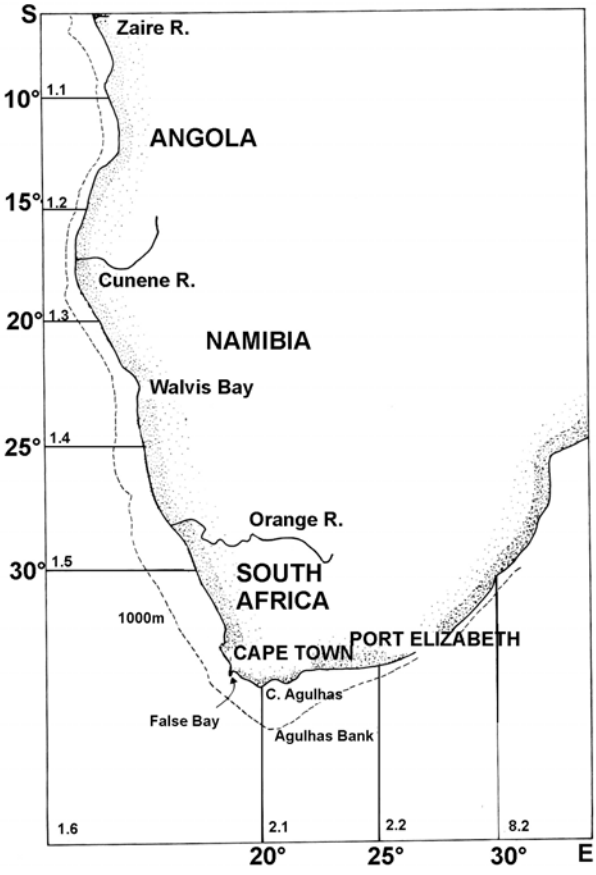

Figure 6

The eastern south Atlantic coast showing the major ICSEAF Divisions (modified after Crawford *et al.* 1987)

Costa oriental del Atlántico sur mostrando las principales divisiones ICSEAF (modificado según Crawford *et al.* 1987)

1.6 correspond to the southern stock, between latitudes 27ºS and 33ºS (Payne 1979, 1985). The catches of west coast sole in area 47 of FAO, under Israel, Spain and Namibia may refer to the northern stock, whereas the catches for Korea and Russia may refer to the Angolan stock off Zaire mouth (F. le Clus, pers. comm.) (Figs. 7 and 8). Flatfish catches in South Africa given by FAO statistics since 1950 are shown in Figure 9 (FAO 2000). Between 1950 and 1962 the catches given for west coast sole (*Austroglossus microlepis*) correspond to west coast sole and Agulhas sole combined (Crawford *et al.* 1987).

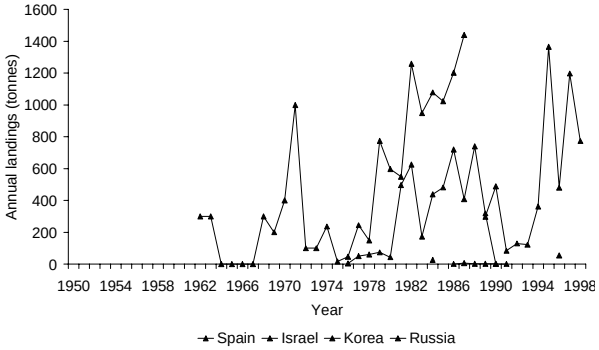

Figure 7

Recorded catches of west coast sole (*Austroglossus microlepis*) in the southeast Atlantic by foreign countries

Capturas del lenguado austral oeste (*Austroglossus microlepis*) por países extranjeros en el Atlántico suroriental

Figure 8

Landings of west coast sole (*Austroglossus microlepis*) in Namibia

Desembarques del lenguado austral oeste (*Austroglossus microlepis*) en Namibia

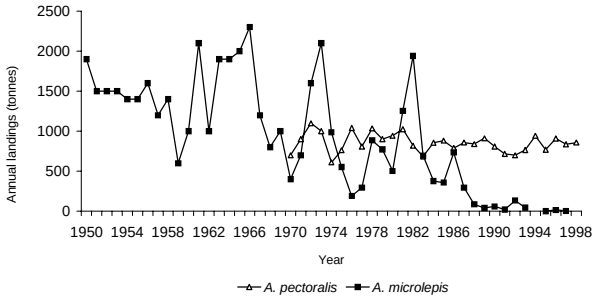

Figura 9

Landings of west coast sole *Austroglossus microlepis* and Agulhas sole *A. pectoralis* in southern and west coasts of South Africa

Desembarques del lenguado austral oeste *Austroglossus microlepis* y del lenguado de fango *A. pectoralis* en las costas sur y oeste de Sudáfrica

On the basis of the presented series of data given by FAO, it may be inferred that west coast sole commercial landings underwent cyclic, long-term fluctuations, with periods of declining species landings (e.g. 1950-1959, 1966-1970) and periods of increasing species landings (e.g. 1959-1961, 1976-1982). However, since 1980s landing statistics of west coast sole declined considerably from more than 1 900 t in 1982 to 3 t in 1997 (Fig. 9). Since 1990 when Namibia became independent, catches of west coast sole by South African boats were made in ICSEAF Division 1.5, south of the Orange River, and could explain the declination of sole catches since the 1990s. FAO has been reporting west coast sole landings in Namibia since 1987 (Fig. 8). No landing statistics of west coast sole were recorded in Namibia before 1987, presumably already included in South African statistics and reported by FAO. Landings of this species reached a maximum of 658 t in 1994 and gradually decreased since subsequent years (Fig. 8).

Annual landings of Agulhas sole (*Austroglossus pectoralis*) in South Africa reached up to 1 100 t in 1972 and maintained an average of 850 t thereafter (Fig. 9). Most of the catches comes from the east coast of South Africa. Of the catch of Agulhas sole between 1973 and 1984, 91 % came from Division 2.1 of ICSEAF (Crawford *et al*. 1987).

Although hakes (*Merluccius* spp.) are the main contributor to the southern African demersal fishery, accounting for about 70% of the mass landed, soles although contributing only a small part of the South African annual trawlfish catch, are the most important fish species in terms of value per unit mass (Payne 1985). Similar relationship was found for the southwest Atlantic fisheries in Argentina between hakes and flatfishes (see above).

Flatfish landing statistics in Angola are given for the whole flatfish species with no further species discrimination. Since 1950 there were periods of high flatfish landings (e.g. 700 t in 1970, 784 in 1993) reaching a maximum of 928 t in 1998, although most annual landings were lower than 400 t (Fig. 10).

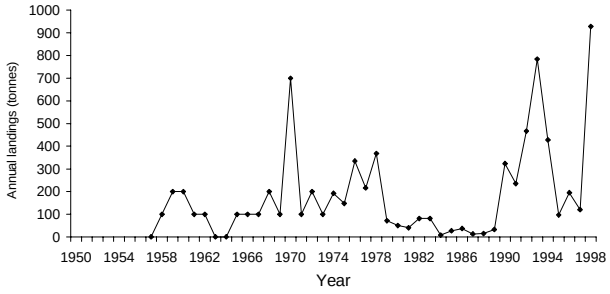

Figure 10

Landings of flatfishes in Angola with no species discrimination

Desembarques de lenguados en Angola sin discriminación de especies

Brief description of catches, fleets and fishing gears

In the southwest Atlantic, the main regions of Brazilian flatfish fisheries occur in the southeastern and southern regions. In 1997, flatfish landings (*Paralichthys* spp.) represented 0.36% of total fishes captured in both central and southeastern Brazil. In southern Brazil the percentage was 0.65% (IBAMA 1998). Here, until 1950, artisanal trammel, gill, and channel net fishing with small wooden sail and row boats was largely used. 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 trawls fishing, eventually led to the depletion of marine stocks (Haimovici *et al*. 1997). 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 t capacity used gill-nets, and occassionally purse seines and hooks. In the early 1980s, when some demersal fisheries (black drum *Pogonias cromis*, red porgy *Pagrus pagrus*, royal weakfish *Macrodon ancylodon*) showed signs of overfishing, fishing diversified into double-rig trawling, bottom gill-nets, bottom longlines, and trap methods (Haimovici *et al*. 1997). Double-rig trawling was first used in 1985 in southern Brazil from 20-24 m long wooden vessels with 250-350 HP engines. Twin nets are employed for flatfish fishing (*Paralichthys patagonicus*) which is fished at 20-80 m depth between fall and

spring. Double-rig trawling in recent years resulted in considerable total landings of the flatfishes *P. patagonicus* and *P. orbignyanus* (Haimovici 1997). Recently, the efficiency of double-rig trawling to capture flounders in Uruguay was demonstrated (Arena *et al*. 1992). While traditionally otter-trawling methods captured 0.1% of flounders, double-rig trawling captured 54.5% of flounders (Arena *et al*. 1992). Similar results were observed in Rio Grande do Sul (Haimovici & Mendonça 1996b). Since 1990s double-rig trawling represented more than 65 % of total flatfish captures, followed by pair trawl 11.2%, artisanal fisheries 9.6%, otter trawl 3.3%, entangling nets 1.6%.

In Argentina, 87% of total flatfish captures are landed in Mar del Plata harbour (Argentina). Mar del Plata, Necochea and Bahía Blanca harbours, all situated in northern Argentina (Buenos Aires Province) (Fig. 11), represent altogether the 94.4% of total flatfish landings in Argentina. The total flatfish catch in 1997 (10 063 t) represented 1.1% of the whole annual fish captured (913 685 t). These data contrast to those obtained for the Argentinean hake *Merluccius hubbsi*, the most important fishing resource to the south-west Atlantic, which represented 64.1% of the total fish captured. The coastal fleet captures most of the total flounder catches (73%). The coastal fleet is composed of small trawlers (vessels up to 18-m length, 20-60 GRT) that operate near shore. The trawlers have minimum detection and navigation equipment, with a total capacity between 4-14 t, with no refrigerated equipment. They are not technologically updated and are very old. These boats catch 12% of the total flounders fished. There are larger vessels in the coastal fleet (between 18 and 27-m length, 60-100 GRT) that also operate in-shore with higher hold capacity (up to 80 t) and have refrigerated equipment. These vessels capture almost 60% of the total flatfish captures. Ice chilling ships landed only 2.3% of total flatfish captures. The main engine power in the fleet is between 200 and 2 600 HP. Fishing boats measure more than 23-m long. They do not process fish onboard and store flatfish in boxes with ice inside refrigerated holds. Less than 1% of flatfish captures are fished by freezer and factory ships. Using trawl nets in both Uruguay and Argentina makes most of the flatfish captures. In this method otter boards are attached at the mouth of the net to keep it open. The fishing gear of coastal fleet comprises trawl nets with an upper rope between 24 and 29 m, a perimeter between 45 and 60 m and a vertical opening of 3 m. The stretch mesh size is 150 mm at the mouth of the net. The otter boards are of the polyvalent egg-shaped type. The gear of the ice chilling vessels consists of trawl nets with an upper rope between 29 and 46 m, a perimeter between 60 and 80 m, and a vertical opening of up to 4 m; stretch mesh size is 150 mm. The coastal vessels and the ice chilling vessels have both stern and side trawl gears.

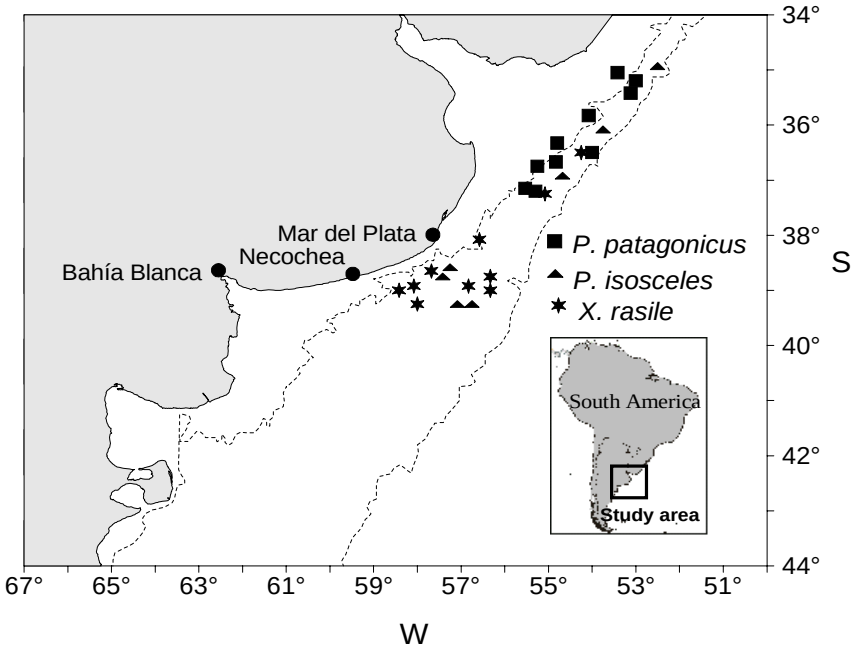

Figure 11

Principal concentrations of paralichthyid flounders in northern Argentina and Uruguay

Principales concentraciones de lenguados paralíctidos en el norte de Argentina y Uruguay

Other gears used for flatfish captures are the entangling nets, which are set or anchored at both ends. The single panel of monofilament webbing is designed to catch flatfish when they attempt to swim through it. The fish are generally wedged in the net, held by a mesh at the widest part of their bodies (Elías 1998). This gear is used in central and northern Patagonia. The flatfish captures using this net are very low. In the southeast Atlantic, the main flatfish catches are taken as by-catch in the demersal trawl fisheries.

Spawning concentrations and migrating stocks

Although paralichthyid flounders are distributed in the southwest Atlantic on the Brazilian, Uruguayan and Argentinean shelves, mainly between the coast and 150 m (Díaz de Astarloa & Munroe 1998), the principal concentrations regarding relative abundance are located in northern Argentina and Uruguay (34º-41ºS) (Díaz de Astarloa & Fabré in press). Three paralichthyid species (*Paralichthys patagonicus, P. isosceles* and *Xystreurys rasile*) co-occur in two principal groups: a northern group between 34º-38ºS, and a southern group between 38º-41ºS (Fig. 11). *P. patagonicus* is the most abundant species in the northern area with relative high densities in spring (Fig. 12). This event agrees with the reproductive activity of the species. The flounder spawns between September and February with a maximum reproductive activity in November (Macchi & Díaz de Astarloa 1996). The low density observed in summer could be due to reproductive migrations towards shallower areas where the species can not be caught by the coastal vessels (Díaz de Astarloa & Fabré in press). The southern group is characterised by high densities of both *P. isosceles* and *X. rasile* (Fig. 13). Both species also spawn in spring and summer (between October and March) (Fabré 1992). Maximum flatfish landings occur within the reproductive season of the flatfish species (between October and March) when the species aggregate to spawn (Fig. 14).

In the southeast Atlantic, there are three geographically distinct stocks of west coast sole. Commercially exploitable quantities of an Angolan stock lie mainly off the mouth of the Zaire River, of a northern stock between 20-25º S, south-west and north-west of Walvis Bay and of a -southern- stock between 28-30º S, off the mouth of the Orange River. The northern stock is found in depths ranging from 75-300 m, whereas the southern stock has only been fished in depths of 50-100 m. The depth range of the Angolan stock is unknown, but it is likely to be reasonably shallow (Payne & Badenhorst 1989).

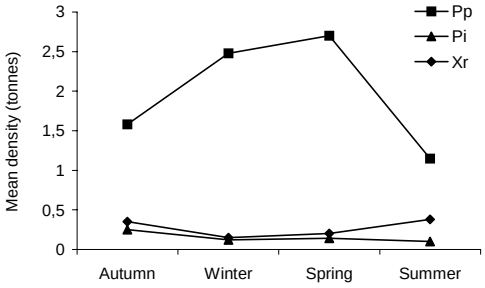

Figure 12

Seasonal mean densities (t ·nm^{-2}) of *Paralichthys patagonicus* (Pp), *P. isosceles* (Pi) and *Xystreurys rasile* (Xr) in Uruguay and northern Argentina between 34º and 38ºS

Densidades medias estacionales (t ·mn^{-2}) de *Paralichthys patagonicus* (Pp), *P. isosceles* (Pi) y *Xystreurys rasile* (Xr) en Uruguay y norte de Argentina, entre 34º y 38ºS

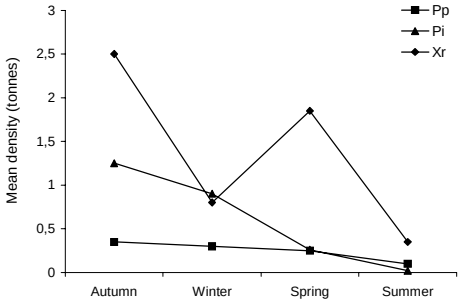

Figure 13

Seasonal mean densities (t ·nm^{-2}) of *Paralichthys patagonicus* (Pp), *P. isosceles* (Pi) and *Xystreurys rasile* (Xr) in northern Argentina between 38º and 41ºS

Densidades medias estacionales (t·mn^{-2}) de *Paralichthys patagonicus* (Pp), *P. isosceles* (Pi) y *Xystreurys rasile* (Xr) en el norte de Argentina, entre 38º y 41ºS

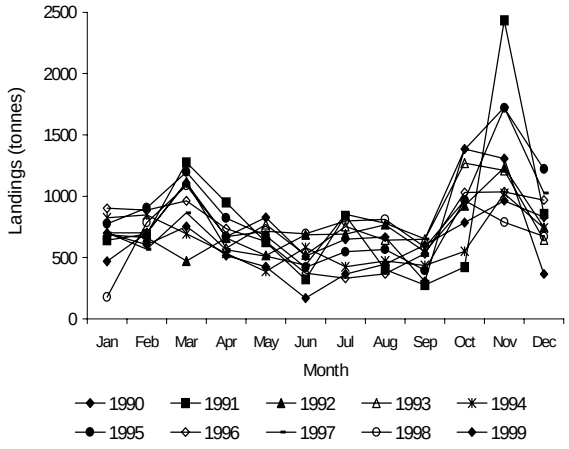

Figure 14

Monthly flatfish landings (*Paralichthys* spp. and *Xystreurys rasile*) recorded in 10 years in Argentina

Desembarques mensuales de lenguados (*Paralichthys* spp. y *Xystreurys rasile*) registrados en 10 años en Argentina

Economic aspects and markets

Flatfish represent a relatively small fraction of total landings in both the southwest and southeast Atlantic countries compared with species such as hake. For example, the participation of Argentine hake (*Merluccius hubbsi*) in total landings reached over 70 % in 1991 (Fig. 15), and in the last 20 years, hake has contributed more than 60% of the total catch of the Argentine fleet (Bezzi *et al*. 1995), while flatfish landings represented between 1 and 2% of the catch in the same period.

Of the total flatfish production, 32% is consumed by the domestic market mainly as fillet. Only 0.3% is consumed frozen fish and H&G. 68% is delivered to foreign markets mainly as fillet and few amounts as whole or H&G. United States are the principal country of destination (97%). Flounders take the 15th place of most fish species consumed in Argentina (1.2%). The Argentinean hake, *Merluccius hubbsi* is the main fish species (76.2 %) consumed in the inner market.

Since 1980s the value of flounders catch has increased greatly from less than 20 million dollars to more than 65 million dollars in export income for 1995 (Fig. 16). This represents 7.15% of total fish export incomes, and 23.5% of Argentine hake's export incomes (SAGPyA 1996). A comparison of the estimated price per kilogram of most commercial fresh fish value is showed in Figure 17. The highest price shown in January is due to the low captures of flounders in that month, and the corresponding high price in the market. On the contrary, the high captures registered in November led a depletion of the price in the market. In the southeast Atlantic, hake accounts for about 70% of the weight landed, but sole remains the most important finfish species in terms of unit value (Payne 1985).

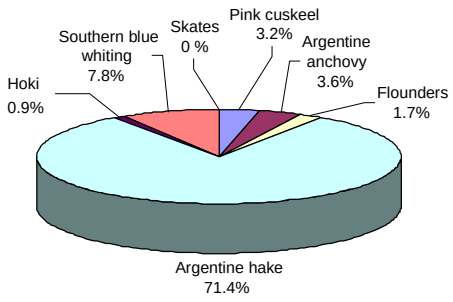

Figure 15

Argentine hake *Merluccius hubbsi* contribution in total landings in Argentina in 1991, compared to other important fish resources

Contribución de la merluza común *Merluccius hubbsi* en el total de desembarques pesqueros en Argentina en 1991, comparada con otros importantes recursos ictícolas

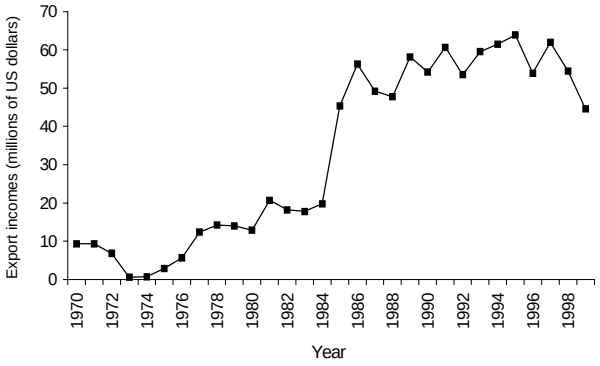

Figure 16

Export incomes of flounders in Argentina

Ingresos por exportación de lenguados en Argentina

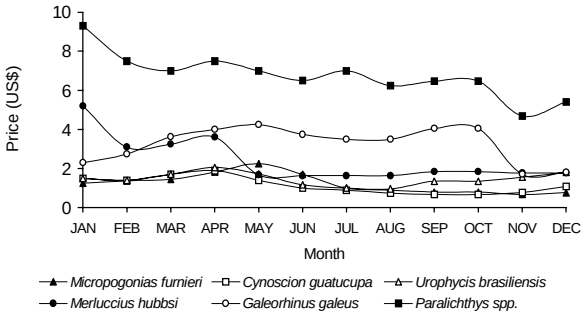

Figure 17

Estimated price (in US dollars) per kg of big-sized fresh fish in Argentina during 1998

Precio estimado (en dólares estadounidenses) por kg de pescado fresco de gran tamaño en Argentina durante 1998

Management

No specific assessment methods are performed in Argentina for flounder resources. The available information comes from research cruises carried out for assessing Argentinean hake, so methods of assessing are those employed for *Merluccius hubbsi*. *Paralichthys* spp. and *Xystreurys rasile* are assessed by applying two-step stratified random sampling (Doubleday 1981) using the swept-area technique with a research vessel. The strata are determined based on historical records of seasonal distribution patterns of hake. The area is divided latitudinally and bathymetrically. The isobaths that delimit the strata are at 50, 80, 100 and 200 m. Fabré (1992) estimated the Maximum Sustainable Yield (MSY) from biological parameters data using Cadima method (Sparre *et al*. 1989) considering the natural mortality estimated by Beverton and Holt method, and total mean biomass. The results obtained were as follows: *Xystreurys rasile* 3 782 t/year; *Paralichthys isosceles* 1 931 t/year.

Little information is given regarding the status of flatfish fisheries in southern Brazil. The fishing pressure of both *P. patagonicus* and *P. orbignyanus* is high, the stock abundance is unknown, and the present status of exploitation is intensely exploited (Haimovici 1998). The stock of *P. patagonicus* still yielded high landings (1 363 t the mean annual landing) between 1990 and 1994, but falling CPUE are signals of rapid decrease of the abundance and a possible near future sharp decrease in the landings (Haimovici 1998).

There is an encouraging movement towards co-operative management of shared flatfish stocks between Argentina and Uruguay by means of a joint management zone (Zona Común de Pesca) and under advice from a joint technical commission. Detailed landing and effort statistics and a better knowledge of stock boundaries are necessary. International cooperation in research and management among the three countries in the region is essential since many of the stocks fished in southern Brazil are shared with Uruguay and Argentina (Haimovici 1998).

In the southeast Atlantic there are few direct estimates of the status of flatfish stocks. Biomass estimates are available for west coast sole off Namibia as a result of bottom trawl surveys undertaken to sample for hake. These indicate a wide range of estimates from 400 to 1 100 t (Macpherson & Gordoa 1992) over the period 1983-1990. Estimates for west coast sole off the south African coast range from 37 to 792 t over a twelve year period from 1985-1997.

Conclusions

Although at least 80 flatfish species have been recorded to occur in the south Atlantic Ocean, only few species are regarded as important fish resources from the commercial view point. The paralichthyids are the most economically important and have a high price in the market in the southwest Atlantic. In the southeast Atlantic, only the soleids, bothids, and some species of cynoglossids constitute fishery resources of commercial importance in the area and they are by far the most valuable fish per unit weight landed.

Twin nets and double-rig trawling are employed for flatfish fishing in southern Brazil. In Uruguay, double-rig trawling has been shown to be highly effective compared by conventional otter trawl. In Argentina, trawling is the most important method used in fishing for flatfish, although small landings are also made in central and northern Patagonia using entangling nets. In the southeast Atlantic, the main flatfish catches are taken as by-catch in the demersal trawls fisheries.

Flatfish represent a relatively small fraction of total landings in both the southwest and southeast Atlantic countries compared with species such as hake. For example, flatfish landings have contributed between 1% and 2.1% of the total catch of the Argentine fleet in the last 20 years. Nevertheless, since the 1980s the value of the flounders catch has increased considerably, representing 7.2% of total fish export income. In the southeast Atlantic, hake accounts for about 70% of the weight landed, but sole remains the most important finfish species in terms of unit value.

In the southwest Atlantic, no specific assessment methods are performed in Argentina for flounder resources and the information available comes from research cruises carried out for assessing Argentinean hake. Little information is given regarding the status of flatfish fisheries in southern Brazil, but falling CPUE are signals of rapid decrease of the abundance and a possible near future sharp decrease in the landings. In the southeast Atlantic, there are few direct estimates of the status of flatfish stocks. Biomass estimates are available for west coast sole off Namibia as a result of surveys undertaken to sample for hake.

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Literature Cited

Arena G, L Barea, D Barreiro, G Beathyate & Y Marín. 1992. Utilización de redes de baja apertura en la pesca del lenguado (*Paralichthys* spp.). Instituto Nacional de Pesca, Montevideo, Informe Técnico 37: 1-22.

Bezzi SI, GA Verazay & CV Dato. 1995. Biology and fisheries of Argentine hakes (*M. hubbsi* and *M. australis*). In: Alheit J & TJ Pitcher (eds), Hake: Biology, fisheries and markets, pp. 239-267. Chapman & Hall, London.

Bittencourt MM. 1982. Estudo comparativo de aspectos da distribução, morfologia e biologia de *Paralichthys isosceles* (Jordan, 1890) e *Paralichthys triocellatus* (Ribeiro, 1904) (Pleuronectiformes: Bothidae) da região da plataforma continental comprendida entre Cabo Frio e Torres (23°S-29°21'S). Tesis de maestrado. Universidade de São Paulo, Brazil. 172 pp.

Carneiro MH. 1995. Reprodução e alimentação dos linguados *Paralichthys patagonicus* e *Paralichthys orbignyanus* (Pleuronectoformes: Bothidae), no Rio Grande do Sul, Brasil. Tesis de maestrado. University of Rio Grande, Brazil. 181 pp.

Carvalho-Filho A. 1999. Peixes: costa brasileira, 3rd ed., 320 pp. Melro Ltd, São Paulo, Brazil.

Cousseau MB & NN Fabré. 1990. Lenguados. In: Cousseau MB (ed), Muestreo bioestadístico de desembarque del Puerto de Mar del Plata período 1980-1985, pp. 179-184. Contribución INIDEP 585, Argentina.

Crawford RJM, LV Shannon & DE Pollock. 1987. The Benguela Ecosystem. Part IV. The major fish and invertebrate resources. Annual Review of Oceanography and Marine Biology 25: 353-505.

Chao LN, LE Pereira & JP Vieira. 1985. Estuarine fish community of the dos Patos Lagoon, Brazil: a baseline study. In: Yáñez-Arancibia A (ed), Fish community ecology in estuaries and coastal lagoons: towards an ecosystem integration, pp. 429-450. Universidad Nacional Autónoma de México Press, México.

Desoutter M. 1990. Cynoglossidae. In: Quero JC, JC Hureau, C Karrer, A Post & L Saldanha (eds), Check-list of the fishes of the eastern tropical Atlantic, pp. 2:1050-1054. (CLOFETA). JNICT, Lisbon; SEI, Paris; and UNESCO, Paris.

Di Giácomo EE & MR Perier. 1992. Retracción de la pesquería demersal del golfo San Matías: escasez de recursos o disminución de la eficiencia? Frente Marítimo 11: 7-13.

Dias Neto J & LDC Dornelles. 1996. Diagnóstico da pesca marítima do Brasil. IBAMA, Brasília, Série Estudos Pesca 20: 1-163.

Díaz de Astarloa JM. 1994. Las especies del género *Paralichthys* del Mar Argentino (Pisces, Paralichthyidae). Morfología y sistemática. Tesis doctoral. Universidad Nacional de Mar del Plata, Argentina. 194 pp.

Díaz de Astarloa JM & NN Fabré. **In press**. On the abundance of three flatfishes off northern Argentina and Uruguay in relation to environmental factors. Archive of Fishery and Marine Research 50.

Díaz de Astarloa JM & TA Munroe. 1998. Systematics, distribution and ecology of commercially important paralichthyd flounders occurring in Argentinean-Uruguayan waters (*Paralichthys*, Paralichthyidae): an overview. Journal of Sea Research 39: 1-9.

Doubleday W. 1981. Manual on ground fish surveys in the NAFO area. NAFO SCS Documents (81/6/7), 77 pp.

Elías I. 1998. Alternativas de explotación pesquera en áreas costeras norpatagónicas ecológicamente sensibles. Tesis doctoral, Universidad Nacional de La Plata, Argentina. 132 pp.

Fabré NN. 1992. Análisis de la distribución y dinámica poblacional de lenguados de la Provincia de Buenos Aires (Pisces, Bothidae). Tesis doctoral, Universidad Nacional de Mar del Plata, Argentina. 266 pp.

Fabré NN & JM Díaz de Astarloa. 1996. Pleuronectiformes de importancia comercial del Atlántico sudoccidental, entre los 34º 30' y 55º S. Distribución y consideraciones sobre su pesca. Revista de Investigación y Desarrollo Pesquero 10: 45-55.

Fabré NN & JM Díaz de Astarloa. 2001. Distributional patterns and abundance of paralichthyid flounders in the south-west Atlantic (Pleuronectiformes: Paralichthyidae). Thalassas 17: 45-55.

FAO 2000. FISHSTAT Plus: Universal software for fishery statistical time series, Version 2.3. FAO Fisheries Department, Fishery Information, Data and Statistics Unit, Rome.

Figueiredo JL. 1981. Estudo das distribuições endêmicas de peixes da Província Zoogeográfica Argentina. Tesis doctoral, Universidade de São Paulo, Brazil. 121 pp.

Figueiredo JL & NA Menezes. 2000. Manual de peixes marinhos do sudeste do Brasil. VI. Teleostei (5), 116 pp. Museu de Zoologia, Universidade de São Paulo.

Haimovici M. 1997. Demersal and benthic teleosts. In: Seeliger U, C Odebrecht & JP Castello (eds). Subtropical Convergence Ecosystem: the Coastal and Sea in the Southwestern Atlantic, pp. 129-136. Springer-Verlag, Berlin.

Haimovici M. 1998. Present state and perspectives for the southern Brazil shelf demersal fisheries. Fisheries Management and Ecology 5: 277-289.

Haimovici M & JT Mendonça. 1996a. Análise de pesca de arrastro de tangones de peixes e camarões no sul do Brasil. Atlântica 18: 143-160.

Haimovici M & JT Mendonça. 1996b. Descartes da fauna acompanhante na pesca de arrasto de tangones dirigida a linguados e camarões na plataforma continental do sul do Brasil. Atlântica 18: 161-177.

Haimovici M, JP Castello & CM Vooren. 1997. Fisheries. In: Seeliger U, C Odebrecht & JP Castello (eds). Subtropical Convergence Ecosystem: the Coastal and Sea in the Southwestern Atlantic, pp. 183-196. Springer-Verlag, Berlin.

Haimovici M, AS Martins, JL Figueiredo & PC Vieira. 1994. Demersal bony fish of the outer shelf and upper slope off southern Brazil subtropical convergence ecosystem. Marine Ecology Progress Series 108: 59-77.

Heemstra PC & O Gon. 1995. Family No. 262: Soleidae. In: Smith MM & PC Heemstra (eds), Smiths' sea fishes, pp. 868-874. Southern Book Publishers, Johannesburg.

Hensley DA. 1995. Family No. 259: Bothidae. In: Smith MM & PC Heemstra (eds), Smiths' sea fishes, pp. 854-863. Southern Book Publishers, Johannesburg.

IBAMA. 1998. Estatística da Pesca 1997, Brasil, grandes regiões e unidades da federação. CEPENET/Tamandaré, 84 pp.

Lucks DK. 1972. Mesh selectivity studies on sole off South West Africa. The South African Shipping News and Fishing Industry Review 27: 54-57.

Macchi GJ & JM Díaz de Astarloa. 1996. Ciclo reproductivo y fecundidad del lenguado *Paralichthys patagonicus* Jordan, en Jordan y Goss 1889. Revista de Investigación y Desarrollo Pesquero 10: 73-83.

Macpherson E & A Gordoa. 1992. Trends in the demersal fish community off Namibia from 1983 to 1990. In: Payne AIL, KH Brinck, KH Mann & R Hilborn (eds), Benguela Trophic Functioning. South African Journal of Marine Science 12: 635-649.

Neiva G & SC de Moura. 1977. Sumário sobre a exploração de recursos marinhos do litoral brasileiro, situação atual e perspectivas. Documentos ocasionais SUDEPE 27: 1-27.

Payne AIL. 1979. A survey of the stock of the southern African west coast sole *Austroglossus microlepis* between 28º 30' S and 32º S. Fishery Bulletin of the Division of Sea Fishery of South Africa 12: 26-34.

Payne AIL. 1985. The sole fishery off the Orange River, Southern Africa. International Symposium on the most important upwelling areas off Western Africa, Instituto de Investigaciones Pesqueras, Barcelona 2: 1063-1079.

Payne AIL & A Badenhorst. 1989. Other groundfish resources. In: Payne AIL & RJM Crawford (eds), Oceans of life off southern Africa, pp. 148-156. Cape Town, Vlaeberg.

Reis EG, PC Vieira & VS Duarte. 1994. Pesca artesanal de teleósteos no estuário da Lagoa dos Patos e costa do Rio Grande do Sul. Atlântica 16: 55-68.

SAGPyA 1996. Consumo de pescado en el mercado argentino. Secretaría de Agricultura, Ganadería, Pesca y Alimentación, Subsecretaría de Pesca, Argentina. 173 pp.

SAGPyA 1999. Estadísticas de capturas martimas pesqueras. Secretaría de Agricultura, Ganadería, Pesca y Alimentación, Subsecretaría de Pesca.

Sparre P, E Ursin & SC Verema. 1989. Introduction to tropical fish stock assessment. Part 1. FAO Fishery Technical Papers 306: 1-337.

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