TECHNICAL FISHERY INTERACTIONS IN SOUTHERN BRAZIL

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ABSTRACT

Technical interactions arise through the incidental catch of non-target species (by-catch) in targeted fisheries and by the co-existence of fleets exploiting the same resource. This study revises the fishery, gears and species captured in southern Brazil and also identifies the technical interactions between the fleets and the species involved (through mixed catch and by-catch), especially of the bluefish, *Pomatomus saltatrix,* and the striped weakfish, *Cynoscion guatucupa*. Data was taken from published material about the southern Brazilian continental shelf fishery, catch records from coastal landing sites, interviews with skippers and managers and data collected by the IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis). The demersal teleosts are the most exploited resources, notably the Sciaenids *Micropogonias furnieri, C. guatucupa, Umbrina canosai* and *Macrodon ancylodon* (55% in weight). The higher proportion of by-catch of the targeted *P. saltatrix* by gill netting is due to *Brevoortia pectinata* and *Parona signata*. The targeted *C. guatucupa* by gill netting is more species-diverse. *M. furnieri* gill netting is very species-selective as only 4% on average of the total catch is regarded as incidental. Trawlers may catch up to 20 species and there is no specific target species. Purse seine is a species-specific gear as, for most of the targeted species, the by-catch is less than 1% by weight. The size range of the exploited *P. saltatrix* and *C. guatucupa* differs amongst gears.

Key words: fishery, southern Brazil, technical interactions.

RESUMO

Interações técnicas na atividade pesqueira do sul do Brasil

Interações técnicas estão relacionadas com a captura incidental de espécies não alvo (fauna acompanhante) em pescarias direcionadas e, pela co-existência de frotas explorando o mesmo recurso. Este estudo revisa a pesca, artes de pesca e espécies capturadas no sul do Brasil e também identifica as interações técnicas entre frotas e espécies (através da captura mista ou

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fauna acompanhante), especialmente para a anchova, *Pomatomus saltatrix,* e pescada olhuda, *Cynoscion guatucupa*. Os dados foram obtidos através de material publicado sobre a pesca da plataforma continetal do sul do Brasil, registros de pesca dos pontos de desembarque da pesca costeira, entrevista com mestres e armadores de barcos e dados coletados pelo IBAMA. Teleósteos demersais são os recursos mais explorados, principalmente os Sciaenídeos *Micropogonias furnieri*, *C. guatucupa, Umbrina canosai* e *Macrodon ancylodon* (55% em peso). A maior proporção da fauna acompanhante da pescaria de rede de emalhe direcionada para o *P. saltatrix* são das espécies *Brevoortia pectinata* e *Parona signata*. A pesca de emalhe direcionada para *C. guatucupa* é mais diversificada. A pesca de emalhe direcionada para *M. furnieri* é muito seletiva em termos de número de espécies uma vez que apenas 4% em media da captura total é incidental. Arrasteiros podem capturar até 20 diferentes espécies e não há uma espécie-alvo específica. Rede de cerco é uma arte específica uma vez que, para a maioria das espécies-alvo, a fauna acompanhante é menor que 1% em peso. A faixa de comprimento do *P. saltatrix* and *C. guatucupa* explorado difere entre as artes de pesca.

Palavras chave: pesca, sul do Brasil, interações técnicas.

INTRODUCTION

In many fisheries, a single fish population is harvested sequentially by a series of fisheries (O'Boyle *et al.*, 1991; Aldebert *et al.,* 1993). Such a case may include (a) the harvesting by different fleets at different stages in the life cycle of the fish stock; (b) the simultaneous or nearly simultaneous harvesting by different fleets, or (c) the sequential harvesting by the same fleet but at separate times (Charles & Reed, 1985). The technical interactions arising from co-existing fleets exploiting the same resource may involve conflicts between users of the fish resource and management must consider that fisheries of the same stock are linked through their exploitation (Charles & Reed, 1985).

Technical interactions may also arise when gear comes into contact with stocks of different species resulting in a mixed catch. From this mixed catch, some species are regarded as target and others as incidental catches of non-target species. By-catch has received a great deal of concern from fisheries managers and conservationist groups as it may be contributing to biological over fishing and to the alteration of ecosystems (Alverson *et al.*, 1994, Alverson & Hughes, 1996). The qualification and quantification of by-catches on non-target population (and mixed catches) must be investigated as different effects may arise depending on life history features of the impacted species (Dulvy *et al.*, 2000).

The bluefish, *Pomatomus saltatrix* (L.), and the striped weakfish, *Cynoscion guatucupa* (Cuvier), are two of the most important commercially exploited species in southern Brazil, with landings over the last decade ranging from 585 to 5,400 tonnes a year for *P. saltatrix* and from 2,800 to 12,400 tonnes a year for *C. guatucupa* (Lucena, 2000). The bluefish is a highly mobile pelagic predator (Lucena *et al.*, 2000a) and is widely distributed along the continental shelf in both temperate and warm waters of the Atlantic, Pacific and Indian Oceans (Wilk, 1977). In the western Southern Atlantic, *P. saltatrix* is recorded from Mar del Plata (Argentina) to Rio de Janeiro (Brazil). The striped weakfish is a demersal predator restricted to the coastal waters of the southwestern Atlantic from Rio de Janeiro (Brazil) to the south of Buenos Aires (Argentina) (Cordo, 1986).

P. saltatrix and *C. guatucupa* are not exploited independently and these species are, in southern Brazil, a clear example of technical interactions. Each species is a by-catch within the targeted fishery of the other. In addition, their catch period overlaps for gill netting and the same fleet allocates effort towards one or other species depending on a combination of factors such as species availability and market price (Lucena, 2000). For each species, technical interactions arise through the co-existence of different fleets exploiting the same resource.

This study initially revises the fishery, gears and species captured in southern Brazil. It also identifies the technical interactions between the fleets (especially for *P. saltatrix* and *C. guatucupa*) and the species involved (through mixed catch and by-catch).

MATERIAL AND METHODS

The information for this study was taken from published material about the southern Brazilian continental shelf fishery and the following additional sources:

1 - Catch records from coastal landing sites collected directly from fleet managers for the period 1994 – 1997, comprising the specific catch of 1050 trips operated by 25 boats (22 boats of the gill net fleet and 3 boats of the purse seine fleet). All targeted species caught in the coastal gill netting and purse seine activities were analysed. In addition, the by-catch of the targeted gill net and purse seine fisheries is analysed by sampled year and gear.

2 – Interviews with skippers and managers of different fleets (purse seine; otter, pair and beam trawler; gill nets) were conducted during 1992 - 1998 on routine visits to the landing sites of the commercial fishery where information on the fishery (e.g. area, depth) and specific catch were collected.

3 - Data collected by the program ‘Landing System Control’ held by the Brazilian Environmental Agency for official statistics (IBAMA, *Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renováveis*). This includes specific information on landings by fleet and by month. Data collection covers the period 1991-1997. By-catch from the trawlers was obtained from this source.

During routine visits to the landing sites of the commercial fishery, the total length (TL) of 12,976 *P. saltatrix* fish (8,629 from gill net and 4,347 from purse seine catches) and 14,457 *C. guatucupa* (5,889 from gill net and 8,568 for trawlers) were measured to the nearest centimeter. Length compositions were evaluated by:

(a) Co-existing fleets within a single species. For *P. saltatrix*, length compositions derived from the drift surface gill nets and purse seines were obtained and, for *C. guatucupa*, length compositions derived from trawlers and bottom gill nets were obtained and;

(b) the targeted and non-targeted catch composition in the gill net fishery. For *P. saltatrix* the species length distribution in the targeted fishery were compared to the length distribution in the non-targeted fishery (*C. guatucupa* targeted fishery). The same was applied for *C. guatucupa*.

RESULTS

Fisheries in southern Brazil

The annual total landings on the continental shelf of southern Brazil (excluding the inland and estuarine fisheries) increased greatly from 1960 until 1973, when they reached 67,000 tonnes. High catches were recorded in 1986 and 1993. From 1994, the total landings of the southern Brazilian fishery averaged 30,000 tonnes per year (Figure 1).

The demersal teleosts are the most exploited resources, notably the Sciaenids white croaker (*Micropogonias furnieri*), striped weakfish (*C. guatucupa*), Argentinean croaker (*Umbrina canosai*) and king weakfish (*Macrodon ancylodon*) which represented in the last decade an average of 55% of total landings (in weight). The pelagic continental shelf teleosts (including *P. saltatrix*) represented 13% of total landings in weight. Elasmobranchs (mostly the angel sharks, *Squatina* sp) comprised 8.2% of landings and crustaceans and molluscs were 8.4% of the total (Table 1). Other species such as the flatfishes, *Paralichthys patagonicus;* bluewing searobin, *Prionotus punctatus* and the codling, *Urophycis brasilienis* also represented considerable landings in the southern Brazilian continental shelf.

In relation to gears, gill netting has increased sharply and currently this fishery is one of the most important activities in the area (12% of total landings). The coastal gill net fishery is multi-specific, with distinct catch periods for each target species. During the months of October to January, *M. furnieri* is the target species, whilst during late autumn and winter (May to September), *P. saltatrix* and *C. guatucupa* are the targeted species (Lucena & Reis, 1998). This fishery is composed of a multi-purpose fleet in which the same boats are used for the exploitation of different target species. The gill net fishery occurs between Conceição (31° 42' S) and Chuí (33° 43' S) and operates at several depths, depending on the fishing gear and targeted species. Nets targeting *P. saltatrix* are set at depths from 10 to 35 m and for *C. guatucupa* at depths from 23 to 60 m (Lucena & Reis, 1998). *M. furnieri* nets are set between 10 - 44 m depth (Reis, pers. comm). The coastal gill net boats are usually 14 - 16 m in length with engines of 90 - 150 HP and a hold capacity of approximately 20 tonnes (Lucena & Reis 1998). The average crew comprises seven men (Boffo & Reis, 1997).

Gill nets used in the *P. saltatrix* targeted fishery are drift surface gill nets usually 1,800 m in length and with a stretched mesh size of 90 mm. Gill nets used in the *C. guatucupa* targeted fishery are bottom gill nets of 6,500 m in length and with the same stretched mesh size of 90 mm (Boffo & Reis, 1997; Lucena & Reis, 1998). Gill nets used in the targeted *M. furnieri* are bottom gill nets of 8,200 m in length, 19 m in height with a stretched mesh size of 140 mm (Reis, pers. comm.).

In southern Brazil, trawling activity occurs from Cape Santa Marta Grande (28º 35' S) to Chuí at depths down to 200 m. The fleet is mainly composed of wood or steel boats, between 20 and 35 m in length with 250 to 650 HP engines. Landings are held at factories based in Rio Grande (Haimovici, 1998). Most fishing on the continental shelf is with pair, otter, and double-rig trawlers, accounting for 33%, 9% and 9% of landings (in weight), respectively. Trawling activity is multi-specific but dominated by between 2 and 4 targeted species, depending on the time of year.

Pair trawlers mainly fish for *U. canosai*, *M. ancylodon*, *C. guatucupa* and *M. furnieri*. Fishing activity peaks during the winter months (July to September), when *C. guatucupa* and *U. canosai* are abundant in southern Brazil. Otter trawlers mainly fish for *M. furnieri*, *C. guatucupa*, *U. canosai* and elasmobranchs. Fishing activity is more intense during the winter months. Double-rig trawling with twin nets target shrimp (*Artemesia longinaris* and *Pleoticus muelleri*), *Paralichthys* sp and elasmobranchs. In contrast to the other gears, fishing activity is more intense during the summer months, November to March (Figure 2).

The purse seining activity occurs from ConceiÇão to Chuí at depths down to 100 m. The purse seine fleet targets *P. saltatrix*, *M. furnieri*, and the mullets, *Mugil* spp. Catch periods are determined by fish availability. Purse seine boats are approximately 23 m long with 220-330 HP engines and a hold capacity of up to 100 tonnes (Lucena & Reis, 1998). This fishing activity is responsible for an average of 5% of total landings and is more intense during the winter months, which correspond to the *P. saltatrix* fishery season (Figure 3).

By-catch

Gill net by-catch

The by-catch of the targeted *P. saltatrix* gill netting varied among sampled years. The higher proportion of by-catch is due to the menhaden, *Brevoortia pectinata*, the amberjack, *Parona signata*, and *C. guatucupa*, which constitute an average 17% (by weight) of the total catch (Table 2a).

The annual variability in the by-catch of the targeted *C. guatucupa* gill netting is also reported in Table 2b. This fishery is, compared to the targeted *P. saltatrix* fishery, more species-diverse and *U. canosai*, *U. brasiliensis*, *P. saltatrix*, elasmobranchs and *M. furnieri* comprise 21% of the total catch.

M. furnieri gill netting is very species-selective as only 2% to 7% (4% on average) of the total catch is regarded as incidental. Of these incidental catches, elasmobranchs represent the largest portion (1.9% by weight) of the total catch (Table 2c).

The gill net by-catch species have often a commercial value and gill net fishermen tend to land all fish caught.

Trawler by-catch

Pair trawlers

In pair trawling, *U. canosai*, *C. guatucupa*, *M. ancylodon* and *M. furnieri* are the targeted species (Table 3a). *C. guatucupa* contribute to most of the pair trawler landings. The by-catch (of around 15% of landings) is composed of a large number of species of which the jamaica weakfish *C. jamaicensis*, *P. punctatus*, *U. brasiliensis* and elasmobranchs are the most common.

Otter trawlers

The relative contribution of the three target species (*U. canosai*, *C. guatucupa* and *M. furnieri*) to otter trawler landings varied during the time series, but *U. canosai* most often dominated. Pooled together, these species represent 81.2% of the total landings on average. The by-catch is of around 19% by weight and contains up to 20 species. Incidental catches of *P. punctatus*, hake, *Merluccius hubbsi*, *U. brasiliensis* and elasmobrachs are often recorded (Table 3b).

Double-rig trawler

The relative contribution of the targeted species *Paralichthys* sp., crustaceans and elasmobranchs showed considerable oscillation over the time series (Table 3c). Various species constituted the by-catch of around 32%. *P. punctatus*, *U. canosai*, *U. brasiliensis*, *C. guatucupa*, *M. furnieri* and *M. ancylodon* combined represented most of the by-catch.

Purse seine by-catch

Purse seine is a species-specific gear. For most of the targeted species, the by-catch is less than 1% by weight (Table 4). No by-catch was reported for *M. furnieri* and for *Mugil* spp. and only in 1997, a by-catch of 0.6% by weight of total catch was recorded. The proportion of the *P. saltatrix*'s by-catch is also very low, and *B. pectinata* and *P. signata* represent the non-target species. The purse seine fleet tends to land all fish caught and the terms 'landings' and 'catches' are equivalent.

Co-existing fleets exploiting the same resource

The exploitation of *P. saltatrix* differs amongst gears. Fish caught by surface drift gill net range in length from 28 to 60 cm TL, but 91% of the catches are of individuals from 36 to 46 cm TL. The exploitation of *P. saltatrix* by purse seines relies upon a wide range of fish size, varying from 24 to 71 cm TL (Figure 4a).

Similar to *P. saltatrix*, catches of *C. guatucupa* in the coastal bottom gill net fishery are of 27 - 60 cm TL individuals but 94 % of the catches rely upon 38 - 48 cm TL ones. Otter and pair trawlers catch *C. guatucupa* that vary from 14 to 59 cm TL, but 89 % of the catches rely upon individuals between 28 to 48 cm TL (Figure 4b).

Gill netting technical interactions (between species)

P. saltatrix caught by a targeted and non-targeted fisheries have similar length composition. *C. guatucupa* caught by a targeted and non-targeted fisheries have also similar length composition (Table 5).

DISCUSSION

This study attempts to identify the technical interactions in a southern Brazilian fishery relying on (a) co-existing fleets exploiting the same resource, (b) mixed catch resulting from multiple target species and (c) the incidental catch of non-targeted species. Most species in southern Brazil are exploited by more than one gear. The combined exploitation may result in many stages of the life cycle of the species being exploited (Charles & Reed, 1985). Such a situation leads to a serious risk of overexploitation. The exploitation of *M. furnieri* in southern Brazil relies upon different life history stages and both juveniles and adults are exploited. For this species, trawlers land fish of 16 to 74 cm TL and gill nets exploit fish between 34 – 70 cm TL (Reis, 1992). *M. furnieri* in southern Brazil is over-exploited (Haimovici, 1998). Also for *P. saltatrix* and *C. guatucupa*, due to the effect of coexisting fleets catching the same resource, both juveniles and adults are being exploited. According to Lucena *et al.* (2002), *P. saltarix* is overexploited and according to Lucena (2000), the biomass of *C. guatucupa* is decreasing over time.

In some fisheries, the gear comes into contact with stocks of different species, and a mixed catch results due to the exploitation of technologically interdependent species (Anderson, 1986). This is especially the situation for trawlers which at least three species are regarded as targeted. Accordingly to Anderson (1986), each species will have a sustainable yield and the total sustainable yield from this fishery is the sum of those from all species. This combination of yield was designated by Eide & Flaaten (1998) as the maximum sustainable frontier (MSF) and it is the long run limit to what can be harvested from all the species. According to these authors 'the harvesting of less than a combination of yields on the MSF does not necessarily secure a sustainable harvest'.

The effect of incidental catches on non-targeted species is of increasing concern (Hudson & Mace, 1996). As a wide variety of fish species occupies the same habitat, fishers are generally unable to catch individual species without some unintended catch of other species (Pascoe, 2000). Trawlers have a great effect not only on unwanted species, which are discarded, but also on seabed communities. Improvement of gear technology certainly has a role to play in the conservation of both target and non-target species. There are some improvements in mesh configuration and gear design, which have the potential to reduce the by-catch of trawlers (Van Marlen, 1993). In southern Brazil, trawlers have a by-catch of up to 32% of total catch on weight, which can include up to 20 species. By-catches may be represented by species with different life histories, varying from the long-lived elasmobranchs to the short-lived shrimps. Such species may respond to exploitation in different ways.

Compared to trawlers, the gill net's by-catch is proportionally less in weight and in biodiversity but the gear is highly selective for certain size-classes of fish. Typically, the selectivity curve is bell-shaped. For a given mesh size, the similarity between body shape determines which species are potential by-catch in a targeted gill-net fishery (McCombie & Berst, 1969; Reis & Pawson, 1999). *P. saltatrix* and *C. guatucupa* have a similar body shape; both are fusiform and lacking protuberances and spines. Their girths are similar along their body length, except for the terminal portion where *C. guatucupa* are slimmer than the *P. saltatrix* (Lucena *et al.*, 2000b). Both species are caught in the other's targeted fishery.

Discards are estimated to be approximately 27 tonnes of fish annually worldwide, representing 25% of the total marine harvest (Alverson *et al.*, 1994). In southern Brazil it is estimated that discards are up to 52%, 40% and 46% of catches for beam, pair and otter trawlers respectively (Haimovici & Mendonça, 1996). This is mainly related to the wide range of species in the by-catch, many of which are non-valuable and/or undersized by law and for human consumption. For the trawlers case, landings do not necessarily mean catches. In contrast, the unwanted catches of gill nets are in most cases commercialised because species are valuable and, due to gear selectivity, under the law and within market consumption sizes.

Fishery managers may often ignore species interactions because (a) the research can be time consuming and costly, (b) stock dynamics can be predicted by examining stock size and structure, (c) even if we believe that species do interact, we may not be able to quantify the level of interaction and (d) if interaction parameters can be estimated, we may be unable to do anything about other species. These arguments, according to Hilborn & Walters (1992) imply serious weaknesses. It is relatively straightforward to know something about species interactions in ecosystems and, even if they cannot be incorporated into predictive models, a general knowledge of these interactions may improve the design of policies regarding other species.

Of all the interactions present in a fishery system, those of a biological nature (e.g. predation, cannibalism, competition, resource partitioning) are often the most discussed (Dann, 1987; Tjelmeland & Bogstad, 1998). The quantification of biological interactions can, however, be difficult, expensive and may take many years of study (Pikitch, 1988). However, interactions arising from technical concerns are more realistically identified and can actually be applied in stock assessment and management of fishery resources.

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REFERENCES

ALDEBERT, Y., RECASENS, L. & LLEONART, J. 1993. Analysis of gear interactions in a hake fishery: the case of the Gulf of Lions (NW Mediterranean). *Sci. Mar.*, 57(2-3): 207-217.

ALVERSON, D.L., FREEBERG, L.G., MURAWSKI, S.A. & POPE, J.G. 1994. A global assessment of fisheries by-catch. *FAO Fish. Tech. Paper*, 339: 233p.

ALVERSON, D.L. & HUGHES, S.E. 1996. Bycatch: from emotion to effective natural resource management. *Rev. Fish and Biol. Fish.*, 6: 443-462.

ANDERSON, L.G. 1986. The economics of fisheries management. London: The Johns Hopkins University Press.

BOFFO, M. & REIS, E.G. 1997. Estrutura da pesca artesanal costeira no extremo sul do Brasil.VII Congresso Latino-Americano de Ciencias del Mar, Mar del Plata, 88-90.

CHARLES, A.T. & REED, W. 1985. A bioeconomic analysis of sequential fisheries: competition, coexistence, and optimum harvest allocation between inshore and offshore fleets. *Can. J. Fish. Aquat. Sci.*, 42: 952-962.

CORDO, H.D. 1986. Estudios biologicos sobre peces costeros con datos de dos campanas de investigacion realizadas en 1981. III la pescadilla de red (*Cynoscion striatus*). *Publ. Com Téc. Mix. Fr. Mar.*, 1(1): 15-27.

DANN, N. 1987. Multispecies versus single-species assessment of North Sea fish stocks. *Can. J. Fish. Aquat. Sci.*, 44: 360-370.

DULVY, N. K., METCALFE, J.D., GLANVILLE, J., PAWSON, M.G. & REYNOLDS, J.D. 2000. Fishery stability, local extinctions, and shifts in community structure in rays. *Cons. Biol.*, 14 (1): 283 - 293.

EIDE, A. & FLAATEN, O. 1998. Bioeconomic multispecies models of the Barents Sea fisheries. In: Rodseth, T., ed, Models for multispecies management, Springer-Velag, Heidelberg. 141-172.

HAIMOVICI, M. & MENDONÇA, J.T. 1996. Descartes da fauma acompanhante na pesca de arrasto de tangones dirigida a linguados e camarões na plataforma continental do sul do Brasil. *Atlântica*, 18: 161-178.

HAIMOVICI, M. 1998. Present state and perspectives for the southern Brazil shelf demersal fisheries. *Fish. Man. Ecol.*, 5: 277-289.

HILBORN, R. & WATERS, C.J. 1992. Quantitative fisheries stock assessment. Choice, dynamics and uncertainty. New York: Chapman and Hall. 570 p.

HUDSON, E. & MACE, G. 1996. Marine fish and the IUCN red list of threatened animals. London: Zoological Society of London.

LUCENA, F.M. & REIS, E.G. 1998. Estrutura e estratégia de pesca da anchova *Pomatomus saltatrix* (Pisces: Pomatomidae) na costa do Rio Grande do Sul. *Atlântica*, 20: 87-103.

LUCENA, F.M. 2000. Species interaction in fish stock assessment and management in southern Brazil: a bio-economic approach. PhD thesis, University of East Anglia, 235p.

LUCENA, F.M., VASKE JR, T. ELLIS, J.R. & O'BRIEN, C.M. 2000a. Seasonal variation in the diets of bluefish *Pomatomus saltatrix* (Pomatomidae) and striped weakfish *Cynoscion guatucupa* (Sciaenidae) in southern Brazil: implications of food partitioning. *Env. Biol. Fish.*, 57(4): 423-434.

LUCENA, F.M., O'BRIEN, C.M., & REIS, E.G. 2000b. The effect of fish morphology and behaviour on the efficiency of gill nets, their selectity and by-catch: two examples from southern Brazil. *ICES, CM* J 11, 2000.

LUCENA, F.M., C.M. O'BRIEN & E.G. REIS. 2002. Effects of exploitation by two co-existing fleets on the bluefish *Pomatomus saltatrix* in southern Brazil: application of a seasonal catch-at-age model. *Mar. Fresh. Res.*, 56: 1-13.

MCCOMBIE, A.M. & BERST, A.H. 1969. Some effects of shape and structure of fish on selectivity of gillnets. *J. Fish. Res. B. Can.*, 26: 2681-2689.

O' BOYLE, R.N., SINCLAIR, A.F. & HURLEY, P.C.F. 1991. A bioeconomic model of an age-structured groundfish resource exploited by a multi-gear fishing fleet. *ICES Mar. Sci. Symp.*, 193: 264-274.

PASCOE, S. 2000**.** Economic incentives to discard in unregulated and individual transferable quotas fisheries In: Kaiser, M.J. & de Groot, S.J., eds, The effects of fishing on non-target species and habitat. Biological, conservation and socio-economic issue, Blackwell Science, Oxford, 315-331.

PIKITCH, E.K. 1988**.** Objectives for biologically and technically interrelated fisheries In: Woodter, W.S., ed. Fisheries Science and management: Objectives and limitations, Springer-Verlag, New York, 107-136.

REIS, E.G. 1992. An assessment of the exploitation of the white croaker *Micropogonias furnieri* (Pisces, Scianidae) by the artisanal and industrial fisheries in coastal waters of southern Brazil. PhD, University of East Anglia.

REIS, E.G. & PAWSON, M.G. 1999. Fish morphology and estimating selectivity by gill nets. *Fish. Res.*, 39: 263-273.

TJELMELAND, S. & BOGSTAD, B. 1998**.** Biological modelling. In: Rodseth, T., ed., Models for multispecies management. Heidelberg, Springer-Verlag: 69-92.

VAN MARLEN, B. 1993**.** Research on improving the species selectivity of bottom trawls in the Netherlands. In: Wardle, C.S. & Holligworth, C.E., eds., Fish behaviour in relation to fishing operation, Bergen, 196: 165-169.

WILK, S.J. 1977. Biological & fisheries data on bluefish, *Pomatomus saltatrix* (Linnaeus). *NOAA Tech. Ser. Rep.*, 11: 1-56.

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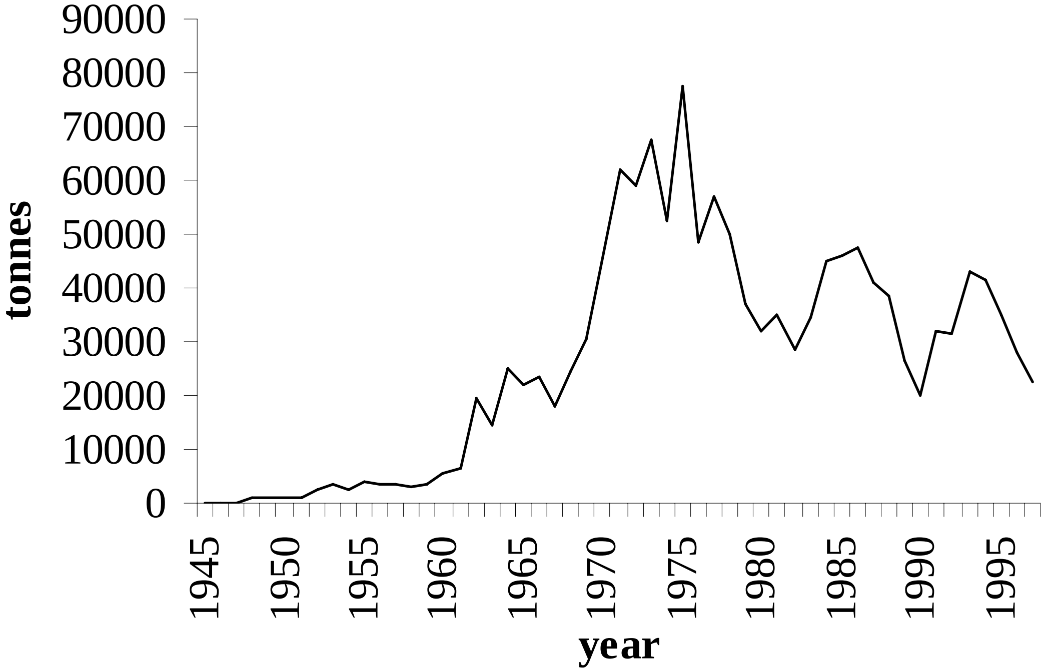

Figure 1. Total landings in southern Brazil (excluding inland and estuarine fisheries).

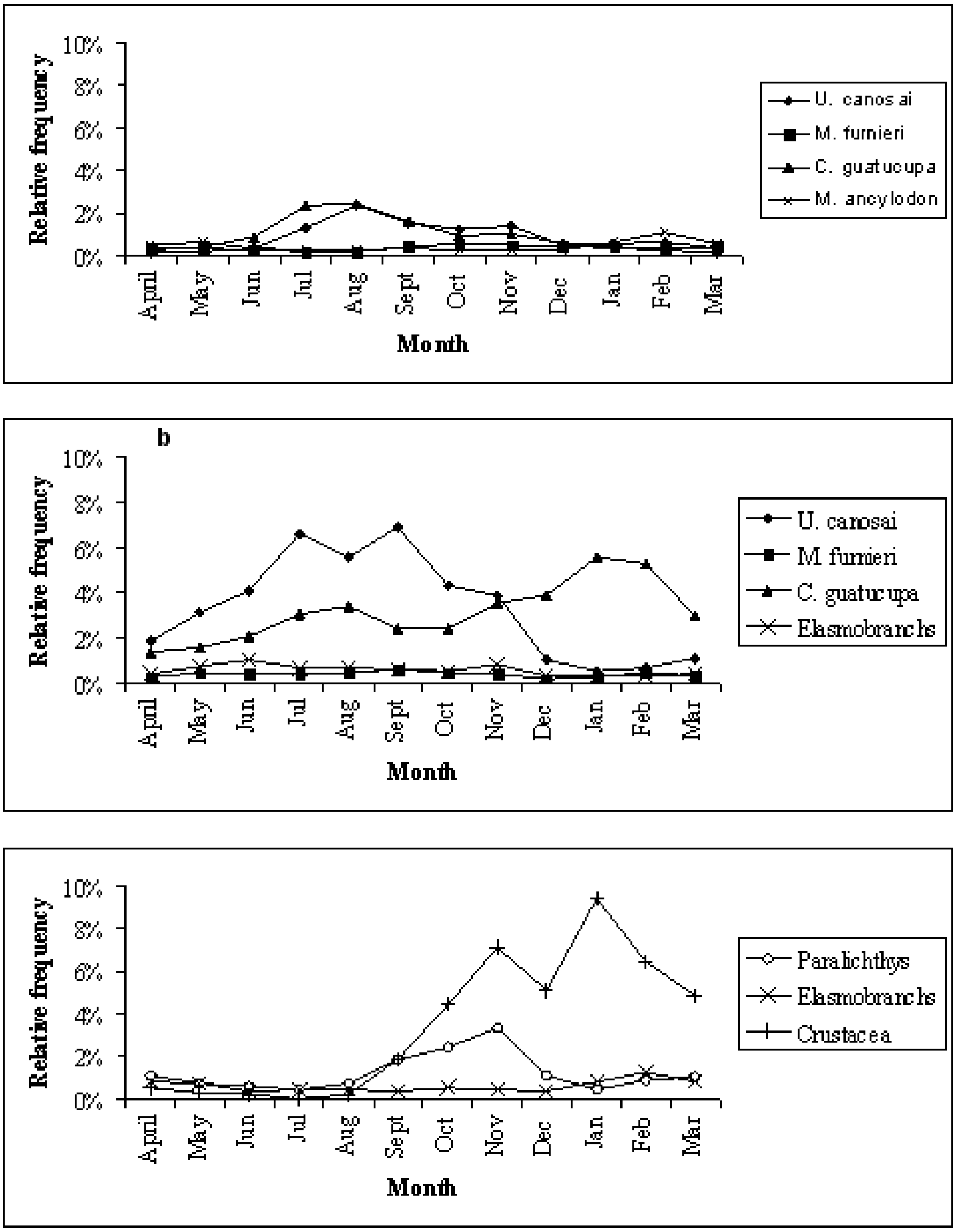

Figure 2. Monthly proportion in weight of the target species in the (a) pair, (b) otter and (c) double-rig trawl fisheries, in relation to the total trawling landings.

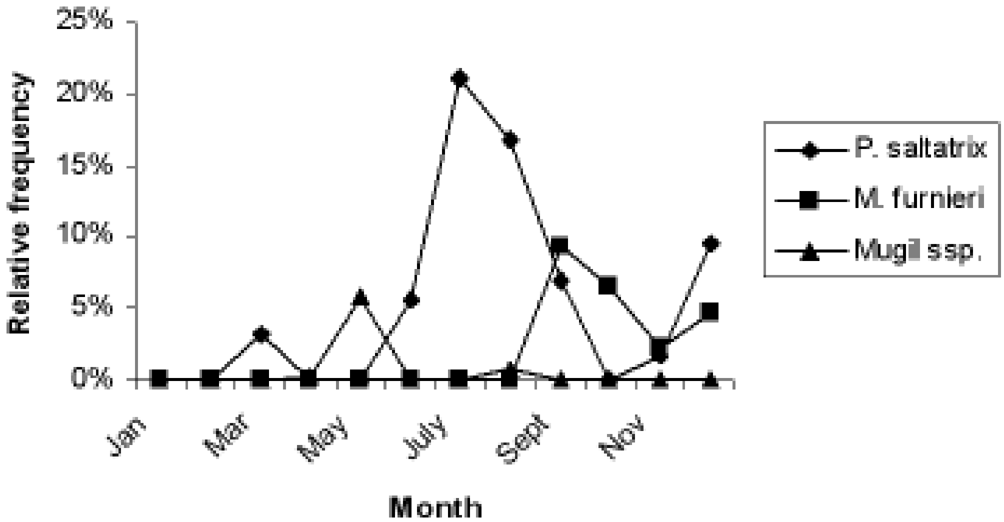

Figure 3. Monthly percentage in weight of the target species in the purse seine fishery

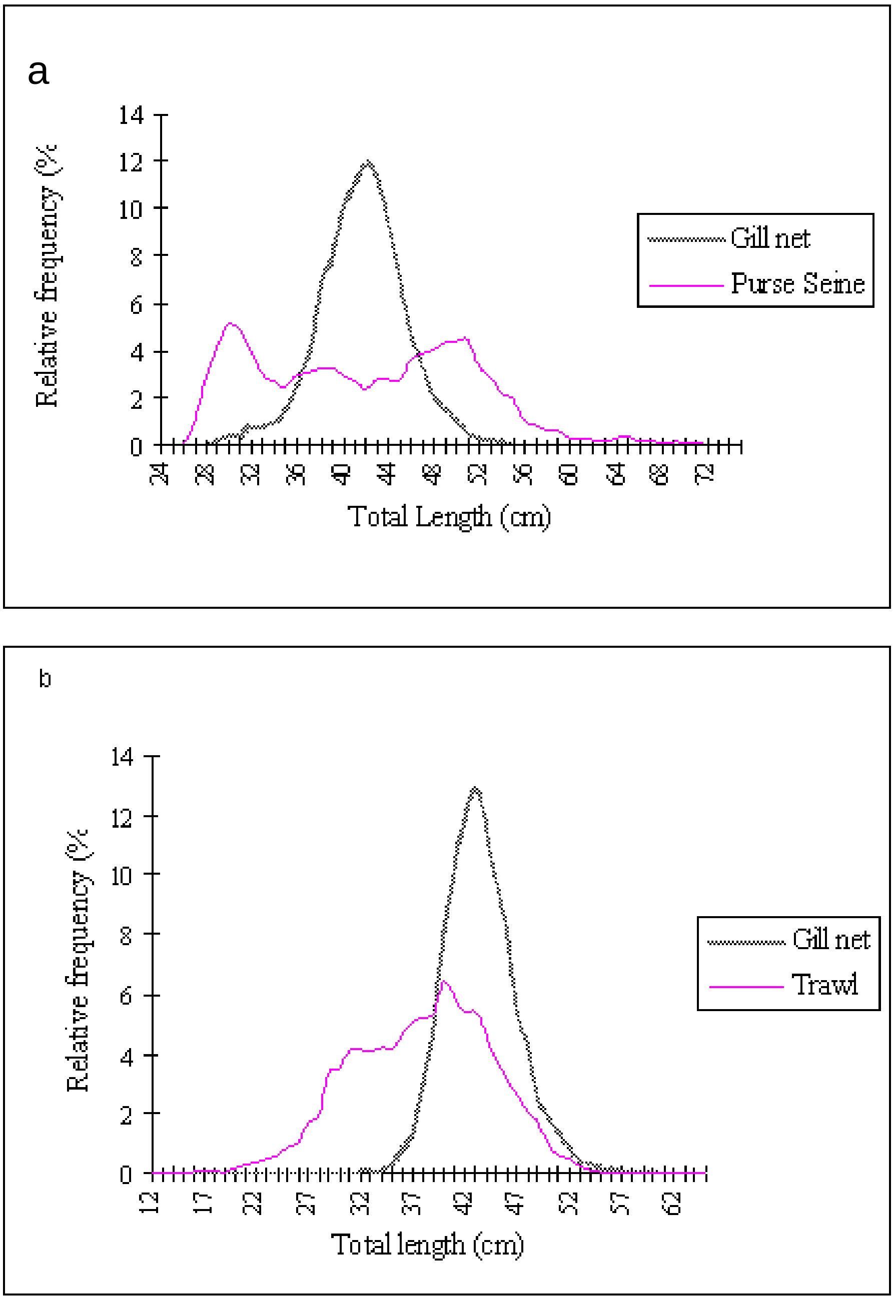

Figure 4. Length distribution of sampled (a) *P. saltatrix* and (b) *C. guatucupa* caught by different gears.

Table 1. Percentage of landings (in weight) of the main species caught by the southern Brazilian continental shelf fishery.

	1991	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*Mean*
Elasmobranchs	**7.4**	**9.7**	**12.4**	**9.6**	**5.6**	**6.6**	**5.9**	**8.4**
Molluscs and crustacea	**4.9**	**7.0**	**5.6**	**4.7**	**10.6**	**12.1**	**14.2**	**8.0**
Teleosts	**87.7**	**83.3**	**82.0**	**85.7**	**83.8**	**81.3**	**79.9**	**83.6**
M. furnieri	20.3	19.5	14.0	21.7	13.9	19.3	17.2	17.9
C. guatucupa	8.3	9.9	15.0	18.9	18.8	15.1	15.2	14.6
U. canosai	10.9	10.9	11.0	8.2	12.6	7.6	6.9	9.9
M. ancylodon	3.6	1.9	3.8	4.3	3.5	4.4	6.7	3.9
Paralichthys	2.3	2.2	1.0	1.4	1.3	1.1	1.3	1.5
P. saltatrix	9.9	4.5	3.4	4.3	8.7	8.0	2.1	5.8
Sarda sarda	2.6	5.8	4.2	6.8	8.0	8.6	15.7	7.4
Mugil sp.	4.8	3.1	1.2	0.8	3.0	2.6	2.6	2.6
xc	24.9	25.4	28.2	19.2	14.0	14.8	12.2	19.9