Lat. Am. J. Aquat. Res., 44(5): 882-897, 2016
"Pathways for sustainable industrial fisheries in southeastern and southern Brazil"
P.M. Arana, P.R. Pezzuto, A.O. Ávila-da-Silva, D. Queirolo, J.A.A. Perez & C.A. Arfelli (eds.).
DOI: 10.3856/vol44-issue5-fulltext-2

Research Article

Only two fisheries? Characteristics of the industrial bottom gillnet fisheries in southeastern and southern Brazil and their implications for management

Vanessa Mafra Pio[1], Paulo Ricardo Pezzuto[1] & Roberto Wahrlich[1]
[1]Grupo de Estudos Pesqueiros, Universidade do Vale do Itajaí, Brazil
Corresponding author: Vanessa Mafra Pio (vahmafra@hotmail.com)

ABSTRACT. This study aimed at identifying and characterizing the industrial bottom gillnet fisheries existing in southeastern and southern Brazil, and discussing their implication to the current regional management regime. More than 7,000 landings were monitored in Santa Catarina State harbors (Southern Brazil), between 2001 and 2008. Five distinct fisheries have been identified: foreign vessels captured the monkfish (*Lophius gastrophysus*) in slope grounds from 2001 to 2002. National fleets have targeted whitemouth croaker (*Micropogonias furnieri*), and Argentine croaker (*Umbrina canosai*) on the continental shelf, and monkfish and the gulf hake (*Urophysis mystacea*) on the slope. Besides targets and fishing grounds, mesh sizes of the nets were also distinct among the fisheries. Within the four national fisheries only the monkfish have specific legislation, while a general norm orders the others, irrespective of the particularities of the stocks and fleets involved.

Keywords: bottom gillnet fishery, coastal fishing, deepwater fishing, demersal fishing, fleets dynamics, southeastern and southern Brazil.

¿Solo dos pesquerías? Características de la pesca industrial con redes de enmalle de fondo en la región sureste y sur de Brasil y sus implicancias en el manejo pesquero

RESUMEN. El objetivo de esta investigación fue identificar y caracterizar la pesca industrial con redes de enmalle de fondo en la región sureste y sur de Brasil, y discutir sus implicancias en el actual sistema de manejo pesquero. Entre los años 2001 y 2008 más de 7.000 desembarques fueron monitoreados en los puertos del Estado de Santa Catarina (Sur de Brasil). Se identificaron cinco pesquerías distintas: embarcaciones extranjeras direccionadas a la captura del rape (*Lophius gastrophysus*) en el talud en 2001 y 2002, y embarcaciones nacionales, cuyas especies objetivo fueron corvina (*Micropogonias furnieri*) y pargo blanco (*Umbrina canosai*) en la plataforma continental, y rape y brótola (*Urophysis mystacea*) en el talud. Además de las especies objetivos y áreas de pesca, el tamaño de malla de la red también fue diferente entre las pesquerías. Dentro de las cuatro pesquerías nacionales, solamente la pesca del rape presenta una legislación específica, mientras que para las demás, existe una legislación general de manejo pesquero, que no considera las particularidades de las poblaciones y de las flotas implicadas.

Palabras clave: pesquería de enmalle de fondo, pesquería costera, pesquería de profundidad, pesquería demersal, dinámica de flotas, sureste y sur de Brasil.

INTRODUCTION

Initially restricted to coastal areas and continental shelf fishing grounds, bottom gillnet fisheries developed in southeastern and southern (SE/S) Brazil focusing primarily on demersal fishes as angel sharks (*Squatina* spp.), whitemouth croaker (*Micropogonias furnieri*), and Argentine croaker (*Umbrina conosai*) (Klippel *et al*., 2005). Only after 2000 fishing operations expanded also to the slope, where a new resource, the monkfish (*Lophius gastrophysus*) started to be exploited by Spanish vessels chartered by Brazilian companies (Perez *et al*., 2002, 2003) using catch and processing technologies previously unknown by the domestic fleets

Corresponding editor: Patricio M. Arana

(Perez *et al.,* 2002; Wahrlich *et al.,* 2004). Paradoxically, as it was extensively monitored by observers, the monkfish fishery has yielded a bulk of scientific information not comparable to the relatively scarce knowledge previously available on the national coastal gillnet fisheries (see review on the Brazilian deep-sea fisheries in Perez *et al.,* 2009).

Management is also relatively recent in these fisheries. The first legal instrument concerning gillnetting in Brazil was the regulation IBAMA Nr 121/1998 (Brasil, 1998), which established a maximum permitted net length of 2.5 km. This rule, encompassing all types of gillnet fisheries was systematically disregarded along the years as it revealed to be economically unfeasible for the fleets (Pio, 2011). As the new monkfish fishery progressed, a specific management plan was established for this species (NI MMA/ SEAP/PR Nr 23/2005; replaced by NI MPA/MMA Nr 3/2009) (Brasil, 2009), including measures as fleet size, technological restrictions, total allowable catch, exclusion areas, monitoring mechanisms, among others. Conflicts and management problems persisted in the other "traditional" gillnet fisheries however, resulting in the publication of the Normative Instruction (NI) MPA/MMA Nr 12 in August 2012 (Brasil, 2012), which, among other measures, reduced the fishing effort by controlling the extension of the nets, which by the 2000s, had attained dimensions as large as 34 km in the industrial fleets (Pio *et al.,* 2012). This Normative determined also fishing exclusion areas and fixed a small closed season between May 15th and June 15th. In spite of focusing the whitemouth croaker in some aspects, NI MPA/MMA Nr 12/2012 is, in fact, a general norm encompassing all bottom gillnet fisheries operating in the SE/S region, excepting the monkfish one.

Statistical data available from the Group of Fishery Studies (UNIVALI/CTTMar, 2014) since the 2000s and recent works (Pio, 2011; Pio *et al.,* 2012), indicate that industrial bottom gillnet vessels from Santa Catarina State (Southern Brazil) exploit several target species and fishing areas by using different types of nets, both on the continental shelf and slope. Bottom gillnet "fishery" of SE/S region could be, in fact, more diverse than legally supposed. Corrêa (2013) made the same observation for the São Paulo State, identifying several fisheries that are not covered by the current legislation. Multiple gillnet fisheries have been described also in the Rio Grande do Sul State (Vasconcellos *et al*., 2014). By considering neither the regional diversity of bottom gillnet fisheries, nor the necessity of establishing management objectives and reference points NI MPA/MMA Nr 12/2012 has not alleviated the previously existent conflicts, generating new disputes between fishing sector and government. In this sense, the present work aimed at to demonstrate the diversification of bottom gillnet fisheries as conducted by industrial vessels operating from Santa Catarina harbors, increasing our understanding about the complexity involved in the gillnet fisheries management in southeastern and southern Brazil.

MATERIALS AND METHODS

Information used in this paper was provided by the Industrial Fisheries Statistics Program and by the Onboard Observer Program, both developed and maintained by the Fisheries Studies Group of the University of Vale do Itajaí (GEP/UNIVALI). The former monitored national industrial gillnet vessels which landed in Santa Catarina harbors from January 2001 to December 2008, reporting landings by species, effort, fishing areas and characteristics of fishing gears as obtained from logbooks and interviews (see methodology in Perez *et al.,* 1998 and UNIVALI/ CTTMar, 2001). The Observer Program provided essentially the same information (though with a higher degree of detail) from the foreign vessel fleet that targeted monkfish in Brazil between 2001 and 2002.

In both cases, fishing trips were firstly grouped according to the mesh size (measured between opposite knots, stretched) and after the respective landings were aggregated by species and year. Hierarchical cluster analysis and non-metric multi-dimensional scaling (MDS) were used to detect groups of mesh sizes (which could correspond to different "fisheries") according to the similarity in their landings. A matrix containing the total weight landed per species in each mesh size was standardized and transformed (square root), allowing to explore the similarities between the objects - mesh sizes (Q-mode). The Bray-Curtis coefficient of dissimilarity was used to verify the proximity between objects. Clustering was performed based on the unweighted average between groups (UPGMA) (Clarke & Warwick, 1994). An analysis of Similarity Percentage (SIMPER) identified the contribution of each species to the similarity within and to the dissimilarity between the groups identified in the cluster and MDS analysis (Clarke & Warwick, 1994).

Within the several groups, species that contributed to more than 1% of their total landings were classified according to the technique proposed by Biseau (1998). Biseau's technique allows determining the "role" played by each species in the fishery, *i.e.* whether it may be considered a true target or only an accessory species, for example. Classification criteria used in the present paper, as adapted from Biseau (1998) is presented in Table 1.

Table 1. Criteria for classification of the species caught by the industrial bottom gillnet fishing fleets into target categories (Adapted from Biseau, 1998).

Species	Definition	Criteria
Incidental	Species not subject to directed effort but retained due to its commercial value.	More than 40% of the species total retained biomass originated from sets where the species represented less than 20% (Qualification Level - QL) of the retained biomass.
Target species	Species subject to directed effort.	Between 30 and 60% of the species total retained biomass originated from sets where the species represented more than 40% (QL) of the retained biomass.
Massive target species	Species subject to directed effort whose distribution is extremely gregarious and that are caught massively without abundant bycatch.	More than 60% of the species total retained biomass originated from sets where the species represented more than 40% (QL) of the retained biomass.

Total effort (number of trips) and landings of the species classified as massive targets according to Biseau's technique were mapped by using data collected between 2006 and 2008. Geographical allocation of catch and effort data was carried out in quadrants of half a degree (30'x30') of resolution, by using ArcGis 9.2®. As effort and catch data concerning national vessels were informed only on an aggregated basis by the skippers (*i.e.*, not discriminated by haul) the allocation of the total catch in kilograms for each trip was divided arithmetically along the different quadrants visited by the vessel. Subsequently, production values of each quadrant were summed for all fishing trips. Effort was referred as the sum of all fishing trips in each quadrant, being allocated in the same way as the latter.

RESULTS

Between 2001 and 2008, a total of 7,021 fishing trips were monitored, distributed between a minimum of 502 in 2001 and a maximum of 1,048 in 2006 (Fig. 1a), corresponding to an average of 184 vessels per year (Fig. 1b) and resulting in total of 116,940 ton landed, representing a minimum of 9,735 ton in 2001 and a maximum of 18,625 in 2006 (Fig. 1c). Teleosts were the most abundant group contributing with 93.6% of the total landed weight, followed by elasmobranchs and crustaceans with 4.4% and 0.3%, respectively. Molluscs were only occasionally landed. The white-mouth croaker was the most abundant species in the landings, comprising 57.7% of total weight.

A total of 44 different gears were identified, according to their respective mesh sizes. Each gear was composed by a string of joined nets. They were classified into three categories: i) single nets (*i.e.*, gears showing a single mesh size), ii) mixed nets (*i.e.*, nets containing two or three mesh sizes in the same gear), and iii) double nets (*i.e.*, two different single nets used in the same fishing trip). Eventually, in mixed nets where a determined mesh size comprised 75% or more of the total gear only the predominant mesh size was considered and the net was classified as a single one. This criterion was based on the premise that it would be an opportunistic event and not an intention to capture different species.

Single and double nets presented 14 and five different mesh sizes, respectively (Table 2). Mixed nets included 30 combinations (Table 3). Despite such a high diversity, only two combinations were recorded in more than ten trips during the study period. Eight out of the 14 single nets exceeded this limit while none in double nets. Only these more frequent gears were used in the subsequent analysis in order to characterize the distinct fisheries.

Altogether 103 fish categories (*i.e.*, includes both biological species reported individually on landing statistics or commercial categories including several species aggregated under a more generic name) were reported in the landings. However, only 24 of them were selected for analysis since they contributed individually with more than 1% of the total landed catch (Table 4). The dendrogram (Fig. 2) and the ordination diagram (MDS) (Fig. 3) revealed the existence of five groups (*i.e.*, five distinct fisheries) at 65% of similarity. These groups were composed by the following mesh sizes (in mm): Group 1-280F (foreign charter fleet); Group 2-280D (domestic fleet), 320 and T (with mesh sizes 280D and 320); Group 3-110; Group 4-130, 140 and N (with mesh sizes 130 and 140); Group 5-90, with mesh size 100 and 120.

Group 4 was formed by the highest number of vessels (283), followed by Group 5 with 108 units. Group 1 included only the 10 foreign vessels which operated in Brazil exclusively during 2001 and 2002 (Table 5).

The SIMPER analysis revealed a high similarity within the groups, and also that typical species could be ascribed to each one of them. In Group 2, the angel shark

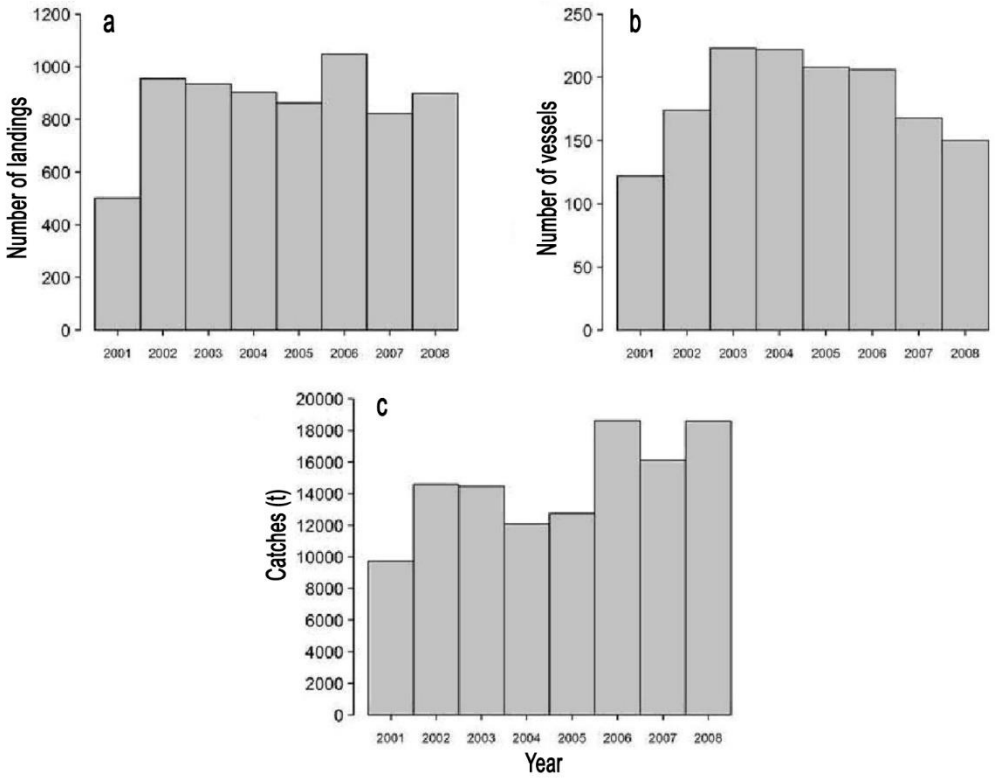

Figure 1. Major characteristics of the industrial bottom gillnet fishing fleet in the Santa Catarina State from 2001 to 2008. a) Number of landings, b) number of vessels, c) total landed catches.

Table 2. Mesh sizes (mm) observed in the single and double nets of the industrial bottom gillnet vessels in Santa Catarina State. *Most frequent mesh sizes.

Gear	Mesh size (mm)															
	70	80	90	100	110	120	130	140	150	180	280	300	320	360	380	400
Single net	X	X	X*	X*	X*	X*	X*	X*			X*	X	X*	X	X	X
Double net				X	X	X	X				X					

Table 3. Mesh size (mm) observed in the mixed nets in the industrial bottom gillnet vessels in Santa Catarina State. *Most frequent mesh sizes.

Code	Mesh size (mm)	Code	Mesh size (mm)	Code	Mesh size (mm)
Gear A	70 and 110	Gear K	110 and 120	Gear U	280 and 360
Gear B	70 and 130	Gear L	110 and 130	Gear V	320 and 360
Gear C	70 and 140	Gear M	120 and 130	Gear W	110, 130 and 140
Gear D	90 and 100	Gear N*	130 and 140	Gear X	120, 130 and 140
Gear E	90 and 130	Gear O	130 and 280	Gear Y	130, 140 and 360
Gear F	100 and 110	Gear P	130 and 320	Gear Z	320, 360 and 400
Gear G	100 and 120	Gear Q	130 and 360	Gear A´	130 and 150
Gear H	100 and 130	Gear R	140 and 320	Gear B´	140 and 150
Gear I	100 and 140	Gear S	140 and 360	Gear C´	130, 140 and 150
Gear J	100 and 280	Gear T*	280 and 320	Gear D´	140, 150 and 180

Table 4. Main biological species or commercial categories landed by industrial bottom gillnet vessels in Santa Catarina State between 2001 and 2008, discriminated by mesh size of the nets. All landing values are in kg.

Scientific names	Common name	Types of netting (mesh size mm)										
		90	100	110	120	130	140	280F	280D	320	N	T
Cynoscion leiarchus	Smooth weakfish	80	152,978	-	-	180	-	-	-	-	-	-
Cynoscion guatucupa	Striped weakfish	17,960	879,216	18,420	10,060	102,129	1,880	-	3,680	49	493	-
Chaceon spp.	Deep sea crab	-	-	-	-	-	-	211,935	20	-	-	-
Cynoscion spp.	Weakfish	-	95,981	11,000	-	12,410	40	3.600	50	-	182	-
Lophius gastrophysus	Monkfish	70	12,672	18,494	1,130	4,822	120	2,280,111	376,375	67,727	848	10,594
Micropogonias furnieri	Whitemouth croaker	34,537	2,762,080	117,701	138,395	42,819,478	610,642	-	11,540	813	963,062	720
Merluccius hubbsi	Argentine hake	850	4,265	75,180	870	18,364	2,090	4,635	2,804	680	530	-
Menticirrhus spp.	Kingcroaker	1,050	43,001	914	-	3,588	-	-	-	-	2,000	-
Oligoplites saurus	Leatherjacket	1,000	24,176	680	310	95,856	1,282	-	-	-	3,240	-
Peprilus paru	American harvestfish	-	6,461	150	690	220,850	2,310	-	-	-	4,920	-
Prionotus punctatus	Bluewing searobin	22,400	1,615,631	51,552	10,590	891,267	13,438	10	10,849	3,040	23,875	1,880
Pomatomus saltatrix	Bluefish	16,130	158,373	6,227	30	22,922	25	-	790	-	20	-
Rajidae	Rays	1,100	7,152	454	320	43,196	1,640	3,074	54,651	39,912	1,350	5,000
Rhinobatos spp.	Guitarfish	-	5,595	-	-	2,806	460	-	41,392	4,455	530	728
Sphyrna spp.	Hammerhead shark	1,269	133,459	4,711	8,536	102,945	13,486	-	19,696	14,072	9,677	3,148
Squalus spp.	Spiny dogfish	3,180	28,436	1,800	20	7,373	3,780	-	790	2,629	340	200
Squatina spp.	Angel sharks	538	77,507	2,602	2,363	138,690	37,097	12,169	203,056	139,250	15,423	81,143
Urophycis brasiliensis	Brazilian codling	13,950	2,422,666	55,983	9,710	98,846	17,650	19,332	1,504	231	7,913	-
Urophycis mystacea	Gulf hake	-	78,446	1,671,129	8,000	290	-	3	69,090	460	-	-
Umbrina canosai	Argentine croaker	104,360	3,484,841	233,801	65,000	350,578	1,600	-	6,380	1,375	7,950	-
-	Sharks	18,000	107,566	14,463	3,050	223,652	20,470	1,978	22,251	991	6,915	1,491
-	Small sharks	9,220	248,682	12,609	26,860	482,189	34,824	-	5,805	60	45,172	-
-	Skate	200	12,475	2,732	450	68,924	790	-	152,071	66,607	543	61,100
-	Mixed species	15,280	144,325	37,053	9,040	631,324	10,803	380	21,937	39,189	13,905	2,020
Total		261,174	12,505,984	2,337,655	295,424	46,342,679	774,427	2,537,227	1,004,731	381,540	1,108,888	168,024

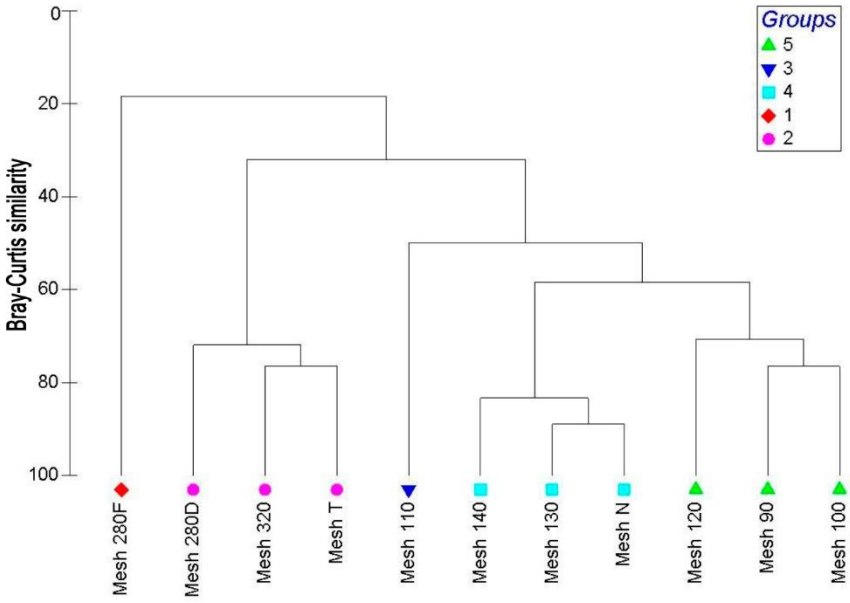

Figure 2. Dendrogram of the mesh sizes of the industrial bottom gillnet fisheries obtained by the unweighted pair-group cluster analysis using arithmetic average (UPGMA) and Bray-Curtis similarities.

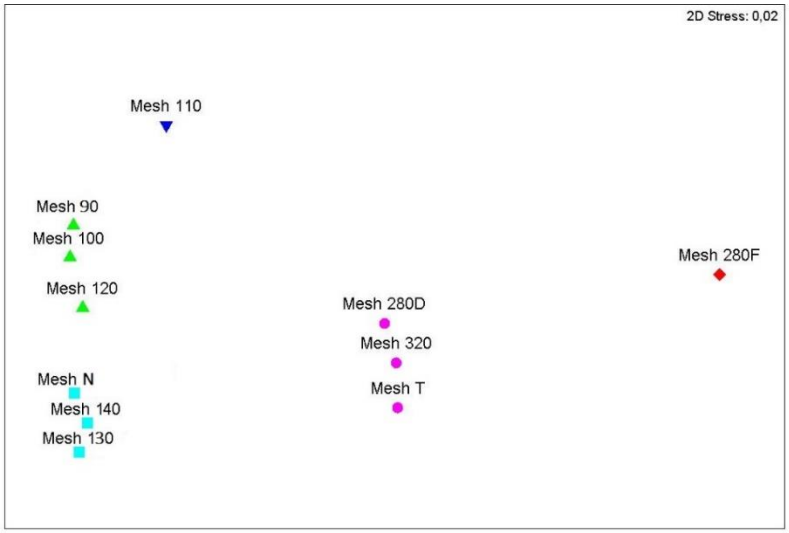

Figure 3. Ordination (MDS) diagram of mesh sizes of the industrial bottom gillnet fisheries (stress = 0.02).

showed the highest contribution (18.2%), followed by skates (*i.e.*, several species of Rajidae) (14.4%) and monkfish (10.9%). Group 4 was characterized by the whitemouth croaker (41.1%) and Group 5 both by the Argentine croaker (15.3%) and whitemouth croaker (12.5%). Groups 1 and 3 showed no average similarity, since they were formed by a sole mesh size each. However, the average dissimilarity showed that these groups distinguished from the others due to the presence of monkfish and gulf hake (*Urophysis mystacea*), respectively (Table 6).

Characterization of the groups

In Group 1, monkfish figured as a massive target during the two years of foreign fleet operation. Deep-sea crab (*Chaceon* spp.) was incidental in 2001 but became target in 2002 (Table 7).

Between 2003 and 2005, the angel shark was classified both as a target and massive target in Group 2. In the following years, however, it became only an incidental species as its landings suddenly decreased. On the other hand, monkfish turned from incidental to

Table 5. Number of vessels that operated in different groups of the industrial bottom gillnet fishing fleets in Santa Catarina State between 2001 and 2008.

Year	Vessels					Total
	Group 1	Group 2	Group 3	Group 4	Group 5	
2001	9	-	1	93	6	109
2002	10	-	-	96	14	120
2003		10	3	102	19	134
2004		14	6	91	40	151
2005		12	6	101	41	160
2006		8	-	130	38	176
2007		7	5	105	20	139
2008		-	14	93	33	141
Average	9.5	10	6	101	26	
Total	10	32	26	283	108	

Table 6. Average similarity within the groups and average dissimilarity between the groups of bottom gillnet fisheries as calculated by the SIMPER analysis. Contribution of each species for the respective similarity/dissimilarity is shown also.

Groups	Average similarity (%)					Average dissimilarity (%)									
	-	73.4	-	85.2	72.6	44.7	41.6	55.3	87.0	83.4	85.6	69.5	68.4	66.4	71.5
	1	2	3	4	5	5x3	5x4	3x4	5x1	3x1	4x1	5x2	3x2	4x2	1x2
Angel sharks		18.2		3.3	1.7		1.3	1.9			1.8	8.7	10.2	9.3	12.1
Argentine hake						2.3		3.0		3.2			2.7		
Argentine croaker				2.7	15.3	3.8	8.7	5.0	11.4	7.5	1.9	8.3	5.0		
Bluewing searobin		3.4		6.1	7.0	2.2	2.6		5.8	3.4	3.6	3.0			2.2
Brazilian codling				2.6	6.2	2.2	3.5	1.3	4.1	1.6		4.4	2.4	1.4	
Gulf hake						13.1	1.5	17.4	1.7	20.1		1.8	13.9	1.8	2.1
Mixed species		4.3		5.1	4.1	1.0	1.2		3.4	2.7	2.7	1.4	1.4	1.6	4.1
Monkfish		10.9				0.8		1.4	19.2	20.4	24.8	6.4	6.1	8.1	12.3
Rays		6.9										3.3	4.2	4.1	4.7
Deep-sea crab									6.1	6.8	7.7				6.6
Skate		14.4										7.4	8.1	8.9	11.0
Small sharks				6.0	4.9	2.3	1.4	1.6	4.4	1.7	4.5	3.1		2.8	
Striped weakfish					6.6	2.5	3.6	1.0	5.0	2.1		3.6			
Whitemouth croaker				41.1	12.5	4.8	7.8	14.5	10.7	5.3	24.8	7.3	2.8	17.2	1.6

a massive target since 2005. The category "mixed species" exhibited an interesting cycle during the study period. It evolved from incidental in the first year, to target in 2004, and massive target in 2005 returning afterwards to the incidental condition in the following years. Had been a massive target in 2005 probably reflects a transition period when the fleet was choosing a new target, after abandoning angel shark as its main objective (Table 7).

In 2004, 2005 and 2007, both the Argentine and whitemouth croakers were massive targets for Group 3 vessels, the same occurring for Brazilian codling (*Urophycis brasiliensis*), in 2005. While the first two species became targets in 2008, the gulf-hake increased its participation in the landings becoming a massive target since 2007. The prevalence of gulf hake and occurrence of the Argentine hake (*Merluccius hubbsi*) (this last, only incidental, in Fig. 7), in the last years indicates the shifting of Group 3 operations from coastal to deeper waters (Table 7).

Group 4 was characterized mostly by exhibiting the whitemouth croaker as its massive target during all period (Table 7).

The Argentine croaker was the massive target during most of the years for Group 5 vessels. Several other species oscillated from incidental, target and massive target in the same period without any clear pattern, excepting that whitemouth croaker and Argentine croaker were targets and/or massive targets most of the time (Table 7).

Spatial fishing patterns of effort and catches of massive targets

Vessels from Group 2 operated mainly on slope grounds where monkfish and gulf hake were massive

Table 7. Analysis of the targets by groups of the industrial bottom gillnet fisheries between 2001 and 2008, according to criteria defined in Table 1.

Species or comercial categories	Year							
	2001	2002	2003	2004	2005	2006	2007	2008
Group 1								
Deep-sea crab								
Monkfish								
Group 2								
Gulf hake			-	-	-			
Angel sharks								
Hammerhead shark								
Sharks								
Skate								
Mixed species			-					
Monkfish								
Rays								
Guitarfish								
Group 3								
Brazilian codling								
Gulf hake			-	-				
Bluewing searobin								
Argentine croaker								
Whitemouth croaker								
Argentine hake				-				
Mixed species								
Group 4								
Bluewing searobin								
Small sharks								
Whitemouth croaker								
Mixed species								
Group 5								
Brazilian codling								
Bluewing searobin								
Small sharks								
Argentine croaker								
Whitemouth croaker								
Bluefish								
Striped weakfish								
Mixed species								
Hammerhead shark								
Smooth weakfish							-	

Simbols:

No occurrence | Massive target species | Target species | Incidental

targets. The largest catches of the former species were recorded beyond 200 m depth from Santa Catarina (SC) to Rio Grande do Sul (RS). The gulf hake, otherwise, was caught mainly around the border between the two states and beyond 300 m depth (Fig. 4).

Fishing operations of Group 3 concentrated also along the slope. However, some trips encompassed also areas in the continental shelf of Santa Catarina, Paraná (PR) and São Paulo (SP). Gulf hake was intensely caught in the slope areas from northern Rio Grande do Sul to the border between São Paulo and Paraná. The Argentine croaker occurred on the outer shelf and slope off Rio Grande do Sul, while the whitemouth croaker prevailed on shelf waters of Santa Catarina, Paraná and southern São Paulo (Fig. 5).

Group 4 vessels operated along a very large area extending from the inner continental shelf to the 100 m depth between southern Rio de Janeiro (RJ) to southern

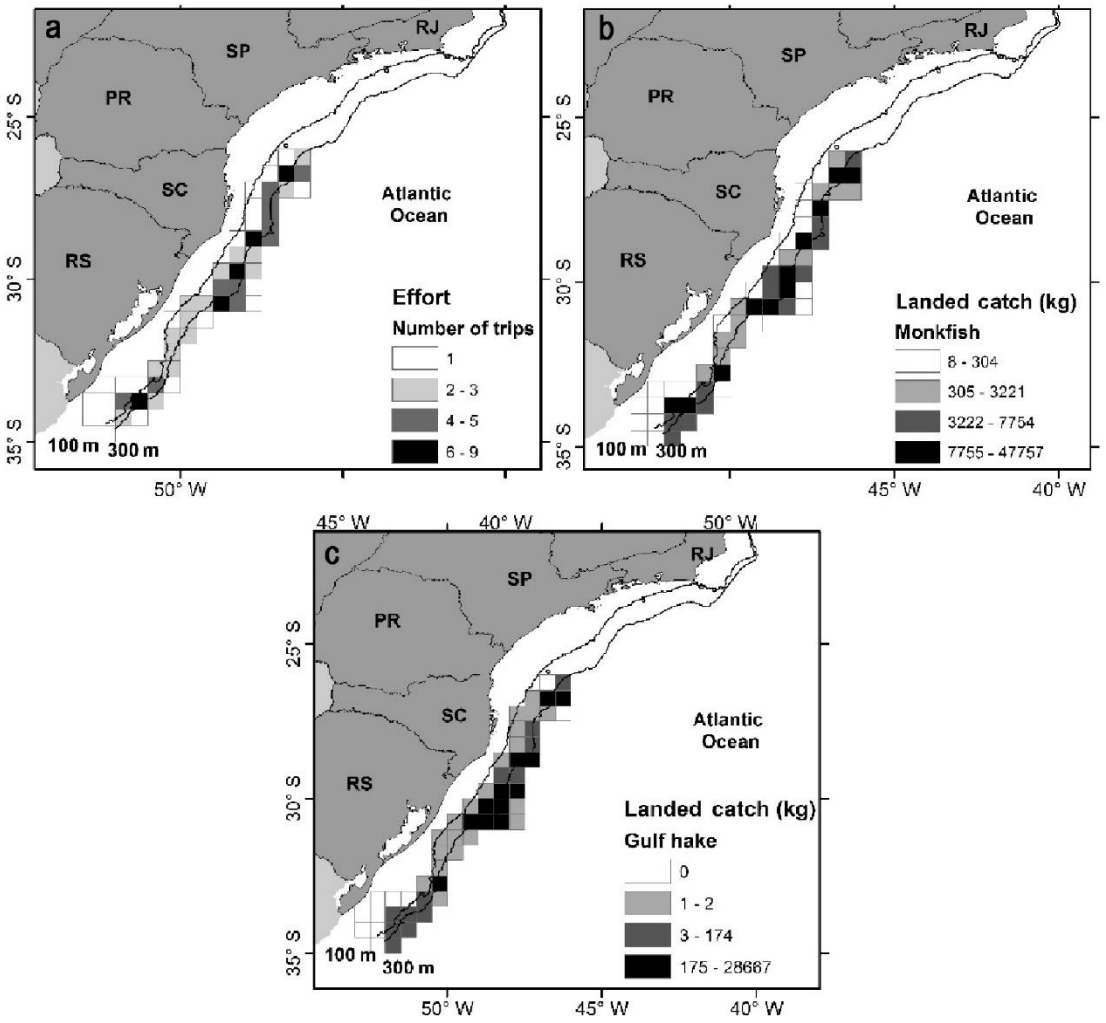

Figure 4. a) Spatial distribution of fishing effort (number of trips) and landed catch b) and c) in Group 2 of the industrial bottom gillnet fleet of Santa Catarina State, Southern Brazil, between 2006 and 2008.

Rio Grande do Sul. Whitemouth croaker was its unique massive target whose catches roughly paralleled the effort distribution of the fleet (Fig. 6). Group 5 operated over the inner and outer shelf from southern Rio de Janeiro to southern Rio Grande do Sul,with the highest number of trips been recorded between Santa Catarina and Rio Grande do Sul. The Argentine croaker and the whitemouth croaker were caught nearly at the same areas, in spite of significant catches of the second species had occurred also on coastal waters of northern Santa Catarina and Paraná (Fig. 7).

DISCUSSION

The results of the present paper showed that the industrial bottom gillnet fleets operating from Santa Catarina harbors use a large variety of mesh sizes arranged either as double, mixed or single nets, the latter had been by far the most usual. In fact, single nets predominate along all SE/S region as pointed out by Boffo & Reis (2003); Moreno *et al.* (2009) and Alves *et al.* (2009), the same occurring in the northeast Atlantic (OCEANA, 2006). Otherwise, mixed nets were only occasionally observed, a pattern reported also in Ubatuba (northern São Paulo), where mixed nets were constructed with mesh sizes of 120 and 130 mm (Alves *et al.*, 2009).

Mesh size is one of the main factors influencing catch composition in gillnet fisheries, given the strong effect of the size selectivity in this fishing gear (Karlsen & Bjarnason, 1987; Sparre & Venema, 1997). Thus, each gear has specific technical characteristics (Rosman & Maugeri, 1980; Gamba, 1994), designed for specific targets and fishing areas. In fact, the bottom gillnet fleets operating in SE/S Brazil have directed their effort to several species of teleosts and elasmo branchs

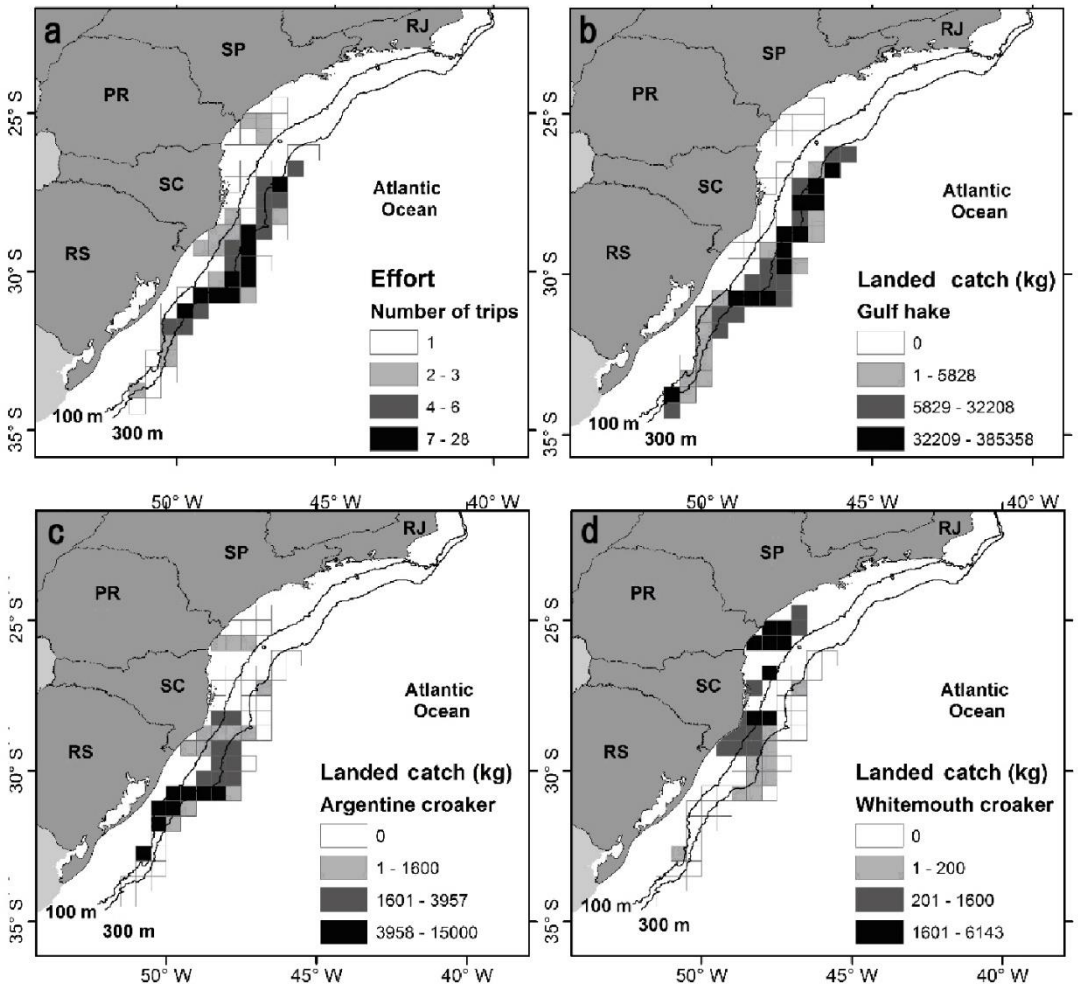

Figure 5. a) Spatial distribution of fishing effort (number of trips) and b), c) and d) landed catch in Group 3 of the industrial bottom gillnet fleet of Santa Catarina State, Southern Brazil, between 2006 and 2008.

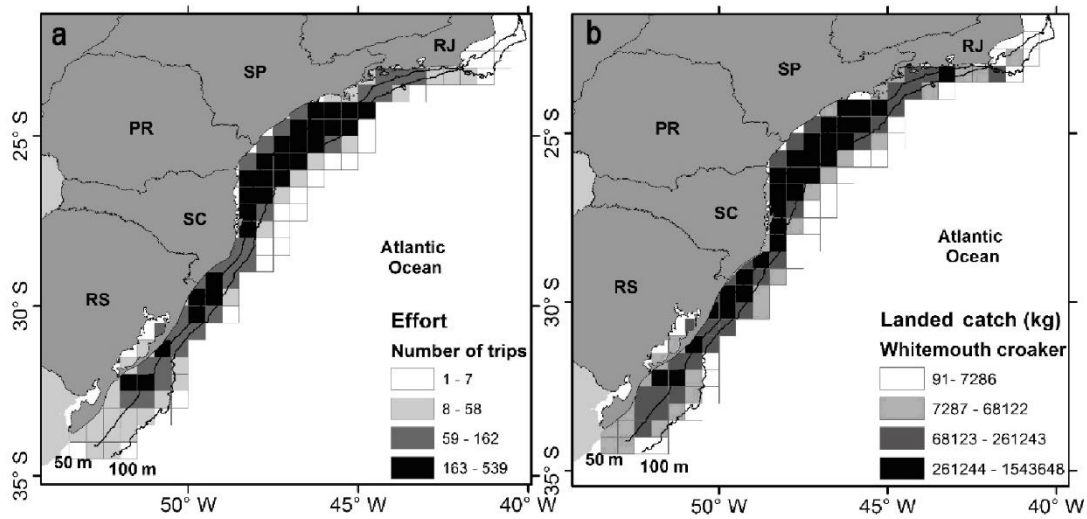

Figure 6. a) Spatial distribution of fishing effort (number of trips) and b), c) and d) landed catch in Group 4 of the industrial bottom gillnet fleet of Santa Catarina State, Southern Brazil, between 2006 and 2008.

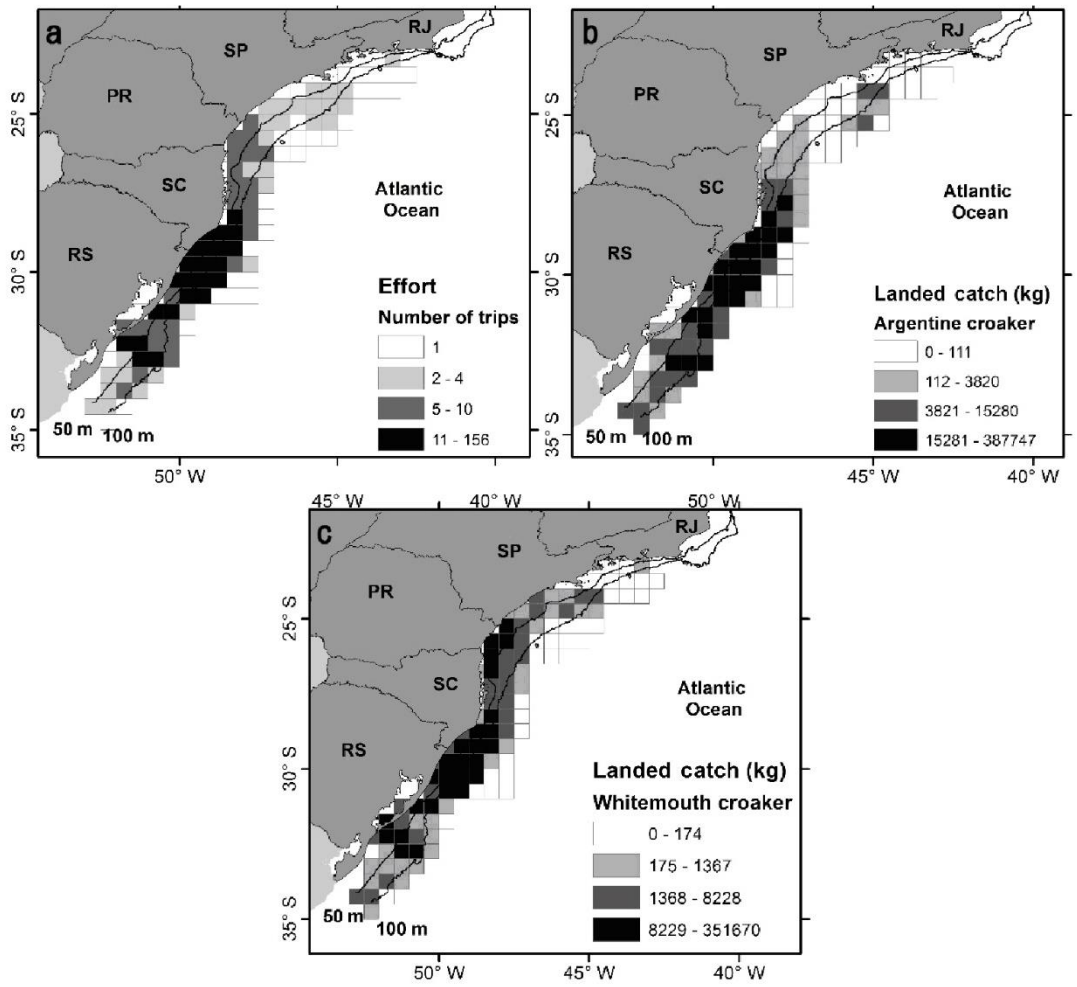

Figure 7. a) Spatial distribution of fishing effort (number of trips) and landed catch b) and c) in Group 5 of the industrial bottom gillnet fleet of Santa Catarina State, Southern Brazil, between 2006 and 2008.

(Haimovici, 1997; Tomás, 2007; Kotas *et al.*, 2008) both on the continental shelf and slope waters. As showed in the present study, not only the targets have varied, but also, the meshes used for each one of them.

Bottom gillnetting in Brazilian slope waters was started by the foreign chartered fleet interested in the nearly virginal monkfish stock present on slope grounds (Perez *et al.*, 2002). As revealed by the present study, the species represented more than 80% of the landings, or nearly 40% of the total catch, if discards are also considered (Perez & Wahrlich, 2005). Challenged by growing conflicts with the domestic trawling fleet in disputing partially the same fishing areas and resources, in 2002 government prohibited the foreign bottom gillnet operations southern than 21ºS (Perez *et al.*, 2009), leading shortly to the abandonment of the fishery by the Spanish vessels. One of the main goals of the chartering program stimulated by the Brazilian fishing authority between the late 1990s and middle 2000 was developing national fleets capable to operate on deeper waters and over alternative resources by assimilating "modern" technologies available elsewhere in the world (Perez *et al.*, 2009). In fact, already in 2001, a single national gillnet vessel started to fish monkfish with 280 mm mesh size nets, following essentially the same techniques used by the foreign fleet (Brasil, 2002). This isolated initiative was conducted on an experimental basis, mostly because using meshes of 320 mm and 280 mm by national vessels were, in the early 2000's, a common practice for fishing angel sharks, a pattern which remained unchanged until 2004/2005. At that date, however, the angel sharks *Squatina guggenheim* and *S. occulta* were officially recognized as been at risk of extinction (NI MMA Nr 5/2004) (Brasil, 2004) and their catches were prohibited. As expected, landings of angel sharks began to decline immediately and by 2006 monkfish became an effective new target for some national vessels using

280 mm nets, the single mesh size allowed by the monkfish management plan. Shifting targets implied also transferring operation areas from shelf to slope, mainly in southern Santa Catarina and Rio Grande do Sul areas.

Similarly to Group 2, characterized by using 280 mm mesh size, Group 3 (110 mm mesh size) showed distinct targets along the study period. Exploiting initially mostly the whitemouth croaker and the Argentine croaker on the inner shelf, from 2007 on the fleet moved to the outer shelf and slope where gulf-hake started to be exploited on a directed form. Landings of this species increased significantly during the 2000s, as it became also one of the main targets of double rig and stern trawlers operating in slope grounds (Andrade *et al.*, 2005; Valentini & Pezzuto, 2006; Perez *et al.*, 2009).

Gulf-hake (Group 3) and the national and foreign monkfish fisheries (Groups 2 and 1, respectively) were, therefore, the three bottom gillnet fisheries which occupied the outer shelf and slope areas of SE/S Brazil since early 2000s. Expanding fisheries to deep waters has been argued as one of the alternatives found by government and fishing sector to reducing fishing effort in coastal areas and/or compensating diminishing receipts (Perez *et al.*, 2003). However, as other deep-water resources, sustainable exploitation of gulf hake and monkfish depends on strong management regimes, as their limited biological productivity are incompatible with high levels of fishing mortality (Perez *et al.*, 2005; Haimovici *et al.*, 2006) at least as compared to coastal resources.

Operating on the continental shelf, two industrial gillnet fisheries were characterized in the present study, both directed to sciaenid fishes as Argentine croaker (Group 5) and whitemouth croaker (Group 4). Importantly, these species are not exclusively caught by gillnet vessels, but are also important targets or bycatch items of double rig, stern and pair trawlers, especially when operating in the southern shelf (Perez *et al.*, 2001). Such a high overlapping among fleets has contributed, in part, to make whitemouth croaker the main demersal resource in the SE/S region of Brazil (Vasconcellos & Haimovici, 2006).

While the whitemouth croaker fishery (Group 4) occurred in shallower waters and presented a mono-specific character, the Argentine croaker fishery (Group 5) was multi-specific and was conducted slightly deeper on the outer shelf. According to the targeting analysis, the Argentine croaker and the whitemouth croaker were the two main species of the latter fishery. However, the striped weakfish (*Cynoscion guatucupa*), Brazilian codling and smooth weakfish (*Cynoscion leiarchus*) were also landed in high volumes by the fleet. The multi-specific character of this fishery exacerbates the problem of overlapping of their catches with other fleets (Perez *et al.*, 2001; Silva, 2007; Pezzuto & Benincá, 2015) and adds complexity to any specific management plan to be proposed to this fishery.

Excepting the monkfish fishery, the other gillnet fisheries described above are not covered by any specific legislation in Brazil, being all indistinctly encompassed by NI MPA/MMA Nr 12/2012 (Table 8) (Brasil, 2012). Besides been not species-specific, this norm presents several shortcomings like the lack of management objectives, reference points and a clear fleet size limit policy (Table 8). The lack of specific measures regulating each bottom gillnet fishery may be one of the factors contributing to the unsustainability of the activity. The current management regime limit the entrance of new vessels in the fishery, but allows the use of a large range of mesh sizes by the vessels, does not limiting as well the catches of the several possible targets exploited in the extensive fishing zone of the SE/S Brazil. Consequently, opportunistic changes both in targets and fishing strategies may be performed by the fleet, potentially generating strong effort concentrations in the space and time, increasing therefore, the risk to the sustainability of the several stocks involved in the fishery. In fact, following the global trend, most stocks of SE/S Brazil (22º-34º40'S) are over-exploited, including whitemouth croaker (Haimovici & Ignácio, 2005; Vasconcellos & Haimovici, 2006), Argentine croaker (Haimovici *et al.*, 2006a) and gulf hake stocks (Haimovici *et al.*, 2006b). Monkfish stock assessments conducted simultaneously to the operation of the chartered fleet already indicated overexploitation of this resource (Perez *et al.*, 2005). Despite the monkfish national fishery had begun experimentally in 2001 with a single vessel, soon before the withdrawal of the foreign vessels, the first management plan for the species was published only in 2005 (NI MMA/SEAP-PR Nr 23/2005) (Brasil, 2005), after the adoption of a political position by local scientists requiring legal intervention in the management process in order to ensure stock sustainability and respect to the Federal Constitution (Perez *et al.*, 2009). Mora *et al.* (2009) have emphasized that the scientific advice is of paramount importance to the effectiveness of fisheries management, since uncertainty is minimized. Following some other African and South American countries (Pitcher *et al.*, 2009), Brazil is characterized as an example of flawed management and rated in an intermediate level of transparency in the formulation of fisheries policies. In the global context, only 0.85% of all fisheries have combined scientific advice and transparency on fisheries management (Mora *et al.*, 2009), a fact exemplified by the gillnet monkfish fishery (see review in Perez *et al.*, 2009).

Table 8. Main characteristics of the industrial bottom gillnet fisheries of Santa Catarina State.

Group	Target species	Mesh size (mm)	Main area
2	Monkfish	280	Santa Catarina and Rio Grande do Sul; >200 m depth
3	Gulf-hake	110	Northern Rio Grande do Sul, Santa Catarina and Paraná; slope areas
4	Whitemouth croaker	130	Southern Rio de Janeiro to Southern Rio Grande do Sul; <100 m depth
5	Argentine croaker	100	Santa Catarina and Rio Grande do Sul; <200 m depth

Table 9. Management elements of the industrial bottom gillnet fisheries in SE/S Brazil.

	NI MPA/MMA Nr 12/2012	NI MPA/MMA Nr 3/2009
Management plan	No	2009
Target and accessory	No	Monkfish
Fleet size (maximum)	Unlimited (*)	9
Area	Southeastern to the Southern limit of the Brazilian EEZ	21°S to the Southern limit of the Brazilian EEZ; >250 m depth
Fishing season	Jun 15th - May 15th	Jan-Dec
TAC	No	1.500 ton year^{-1}
Effort limits	Gradual reduction of fishing gear (**)	Up to 1,000 nets vessel^{-1} (maximum net length: 50 m)
Minimum legal sizes	No	No
Gear restrictions	Mesh size between 70-140 mm stretched	Minimum mesh size 280 mm stretched; nets tagged with vessel register
By-catch limits	No	*Lopholatilus villari* (5%); *Chaceon* spp. (5% of the total catch)
Exclusion areas	Yes	Yes
Control	Logbooks; VMS	Logbooks; VMS; Observers

*The status of the fishery cannot be considered open access because the entry of new vessels was forbidden.

**Gradual reduction during the period 2012-2016 was defined according to the gross tonnage (GT): a) Aug/2012 - Dec/2013: ≤50 GT up to 16 km length vessel^{-1} and >50 GT up to 18 km length vessel^{-1}; b) Jan/2014 - Dec/2015 ≤50 GT up to 13 km length vessel^{-1} and >50 GT up to 16 km length vessel^{-1}; c) after Jan/2016 ≤50 GT up to 10 km lenght.vessel^{-1} and >50 GT up to 13 km lenght.vessel^{-1}.

Management of these fisheries should be improved by considering the different gillnet fisheries exactly as they are: different fisheries, characterized by their respective target species, gears and fishing grounds and deserving specific management measures (Table 8). However, solutions are not to be simple as each fishery presents specific pitfalls and conflicts to be resolved, and most resources are shared by different fishing fleets. The gillnet monkfish fishery, the only covered by a specific management plan, does not deserves reducing effort measures at this moment as the number of vessels in the fleet has never attained the maximum of nine units as established by NI MPA/MMA Nr 3/2009 (Brasil, 2009) (Table 9). On the other hand, unauthorized catches conducted by trawlers have met or exceeded the Maximum Sustainable Yield estimated for the species, compromising the TAC of 1,500 ton per year authorized for the bottom gillnet vessels. Recognizing and managing a "new" gillnet gulf-hake fishery implies changing the NI SEAP-PR Nr 22/2008 (Brasil, 2008), a norm which defines the species as one of the main targets for stern trawlers operating in slope grounds of SE/S, between 250 and 500 m depth, imposing strong restrictions to their capture by other fleets. In the case of sciaenid fisheries, the scenario is even more complex, as social conflicts would emerge as one of the main bottlenecks in their management, given the historical free access to these resources, and the strong overlap with other fleets (Castro *et al.*, 2007; Pezzuto & Benincá, 2015). Overexploitation of the two main target species suggest the need of reducing fishing capacity by removing vessels and/or reducing the extent of the fishing gears, if their biological sustainability are to be achieved (Pio *et al.*, 2012). Effort reduction has been adopted in many fisheries worldwide (Boude *et al.*, 2001; OECD, 2009; Srinivasan *et al.*, 2012), as well as the use of TAC´s (Flaaten *et al.*, 1998; Perez *et al.*, 2009; Srinivasan *et al.*, 2012; Sumaila & Huang, 2012). Whatever measures are to be adopted, they should take in account the characteristics of the each gillnet fishery, as the potential incomes resulting from the species involved,

sustainable catches and/or effort, fishing gear characteristics and other variables are not uniform among them, as shown here and in other states of the SE/S region. In fact, multiple gillnet fisheries have also been identified in São Paulo State (*e.g*., whitemouth croaker, king weakfish (*Macrodon ancylodon*)), with their own particularities (Corrêa, 2013). There is multiple gillnet fisheries in Rio Grande do Sul State, and gillnet fisheries from Rio Grande has a substantial part of total catches by gillnets in Southern Brazil (Klippel *et al*., 2005; Vasconcellos *et al*., 2014). Therefore, while the present results does not reflect a pattern observed along all SE/S region, they demons-trate the need for broadening the view about the management of the regional industrial gillnetting as, definitely, it cannot be considered as been characterized by only two fisheries (*i.e.*, monkfish and "the else").

ACKNOWLEDGEMENTS

We are indebted to the Fishing Studies Group team (GEP/UNIVALI) by collecting, processing and providing us with the corresponding landing statistics. All members of the Onboard Observer Program for their hard work and the collected data. CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Ministry of Education - Brazil) funded this study (Edital Capes Ciências do Mar 09/2009, AUXPE 1141/2010 - IGEPESCA Project) and supported V.M.P. by a Ph.D. scholarship. P.R.P. coordinates IGEPESCA/ CAPES Project and is supported by a research grant from CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico - Ministry of Science, Technology and Innovation - Brazil, Process 306904/2012-8).

REFERENCES

Alves, P.M.F., C.A. Arfelli & A.R.G. Tomás. 2009. Caracterização da pesca de emalhe do litoral do Estado de São Paulo, Brasil. Bol. Inst. Pesca, 35(1): 17-27.

Andrade, H.A., S.H.B. Lucato & G.S. Soares. 2005. *Urophycis brasiliensis* (Kaup, 1858). In: M.C. Cergole, A.O. Ávila-da-Silva & C.L.D.B. Rossi-Wongschoski (eds.). Análise das principais pescarias comerciais da região sudeste-sul do Brasil: dinâmica populacional das espécies em explotação. Série Documentos REVIZEE-Score Sul, Instituto Oceanográfico-USP, São Paulo, pp. 167-172.

Biseau, A. 1998. Definition of a directed fishing effort in a mixed-species trawl fishery, and its impact on stock assessments. Aquat. Living Resour., 11(3): 119-136.

Boffo, M.S. & E.G. Reis. 2003. Atividade pesqueira da frota de média escala no estremo sul do Brasil. Atlântica, 25(2): 171-178.

Boude, J.P., J. Boncoeur & D. Bailly. 2001. Regulating the access to "sheries": learning from European experiences. Mar. Policy, 25: 313-322.

Brasil. 1998. Portaria Instituto Brasileiro do Meio Ambiente e dos Recursos Renováveis (IBAMA) Nr 121.

Brasil. 2002. Comitê de gestão permanente sobre recursos demersais de profundidade. CPG, Itajaí, 38 pp.

Brasil. 2004. Instrução Normativa Ministério do Meio Ambiente (MMA). Law Nr 5.

Brasil. 2005. Instrução Normativa Ministério do Meio Ambiente (MMA)/Secretaria Especial de Agricultura e Pesca (SEAP-PR). Law Nr 23.

Brasil. 2008. Instrução Normativa Secretaria Especial de Agricultura e Pesca (SEAP-PR). Law Nr 22.

Brasil. 2009. Instrução Normativa Ministério do Meio Ambiente (MMA)/Secretaria Especial de Agricultura e Pesca (SEAP-PR). Law Nr 3.

Brasil. 2012. Instrução Normativa Interministerial Ministério da Pesca e Aquicultura (MPA)/Ministério do Meio Ambiente (MMA). Law Nr 12.

Castro, P.M.G., M.H. Carneiro, G.J.M. Servo, C.M.D. Mucinhato & M.R. Souza. 2007. Dinâmica da frota de arrasto de parelhas do Estado de São Paulo. C.L.B Rossi-Wongtschiwski, R.A. Bernardes & M.C. Cergole (eds.). Série Documentos REVIZEE-Score Sul, Instituto Oceanográfico-USP, São Paulo, pp. 60-103.

Clarke, K.R. & R.M. Warwick. 1994. Change in marine communities: an approach to statistical analysis and interpretation. Plymouth Marine Laboratory, Plymouth, 144 pp.

Corrêa, K.M. 2013. Avaliação das pescarias com redes de emalhar descarregadas no Estado de São Paulo entre 2008 e 2011. Master Thesis, Instituto de Pesca, São Paulo, 78 pp.

Flaaten, O., A.G.V. Salvanes, T. Schweder & O. Ulltang. 1998. Fisheries management under uncertainty - an overview. Fish. Res., 37: 1-6.

Gamba, M.R. 1994. Guia prático de tecnologia de pesca. IBAMA/CEPSUL, Itajaí, 50 pp.

Haimovici, M. 1997. Recursos pesqueiros demersais da região Sul. FEMAR, Rio de Janeiro, 80 pp.

Haimovici, M. & J.M. Ignácio. 2005. *Micropogonias furnieri* (Desmarest, 1823). In: M.C. Cergole, A.O. Ávila-da-Silva & C.L.D.B. Rossi-Wongschoski (eds.) Análise das principais pescarias comerciais da região sudeste-sul do Brasil: dinâmica populacional das espécies em explotação.. Série Documentos REVIZEE-Score Sul, Instituto Oceanográfico-USP, São Paulo, pp. 101-107.

Haimovici, M., L. Absalonsen, G. Velasco & L.V. Miranda. 2006a. Diagnóstico do estoque e orientações para o ordenamento da pesca de *Umbrina canosai*

(Berg, 1985). In: C.L.D.B. Rossi-Wongtschowski, A.O. Ávila-da-Silva & M.C. Cergole (eds.). Análise das principais pescarias comerciais da Região Sudeste-Sul do Brasil: dinâmica populacional das espécies em explotação - II. USP, São Paulo, pp. 77-85.

Haimovici, M., A.O. Ávila-da-Silva, L.G. Fischer. 2006b. Diagnóstico do estoque e orientações para o ordenamento da pesca de *Urophycis mystacea* (Ribeiro, 1903). In: C.L.D.B. Rossi-Wongtschowski, A.O. Ávila-da-Silva & M.C. Cergole (eds.) Análise das principais pescarias comerciais da Região Sudeste-Sul do Brasil: dinâmica populacional das espécies em explotação - II. USP, São Paulo, pp. 86-94.

Karlsen, L. & B.A. Bjarnasson. 1987. Small-scale fishing with driftnets. FAO Fish. Tech. Pap., 284: 61 pp.

Klippel, S., C.M. Vooren, A.F. Lamónaca & M.B. Peres. 2005. A pesca industrial no sul do Brasil. In: C.M. Vooren & S. Klippel (eds.). Ações para a conservação de tubarões e raias no sul do Brasil. Igaré, Porto Alegre, pp. 135-177.

Kotas, J.E., M. Petrere Jr., F. Fiedler, V. Mastrochirico & G. Sales. 2008. A pesca de emalhe-de-superfície de Santa Catarina direcionada à captura dos tubarões-martelo, *Sphyrna lewini* (Griffith & Smith, 1834) e *Sphyrna zygaena* (Linnaeus, 1758). Atlântica, 30(2): 113-128.

Mora, C., R.A. Myers, M. Coll, S. Libralato, T.J. Pitcher, R.U. Sumaila, D. Zeller, R. Watsom, K.J. Gaston & B. Worm. 2009. Management effectiveness of the world´s marine fisheries. Plos. Biol., 7(6): 1-11.

Moreno, I.B., M. Tavares, D. Danilewicz, H. Ott & R. Machado. 2009. Descrição da pesca costeira de média escala no litoral norte do Rio Grande do Sul: comunidades pesqueiras de Imbé/Tramandaí e Passo de Torres/Torres. Bol. Inst. Pesca, 35(1): 129-140.

OCEANA. 2006. Northeast Atlantic deep-sea gillnet fishery management. Oceana, 15 pp.

OECD. 2009. Reducing fishing capacity: best practices for decommissioning schemes. OECD, 118 pp.

Perez, J.A.A. 1998. Programa de amostragem da pesca industrial desenvolvida para o Porto de Itajaí, SC. Notas Téc. Facimar, 2: 93-108.

Perez, J.A.A. & R. Wahrlich. 2005. A bycatch assessment of the gillnet monkfish *Lophius gastrophysus* fishery off southern Brazil. Fish. Res., 72: 81-95.

Perez, J.A.A., R. Wahrlich, P.R. Pezzuto & F.R.A. Lopes. 2002. Estrutura e dinâmica da pescaria do peixe-sapo *Lophius gastrophysus* no sudeste e sul do Brasil. Bol. Inst. Pesca, 28(2): 205-231.

Perez, J.A.A., P.R. Pezzuto, R. Wahrlich & A.L.S. Soares. 2009. Deep-water fisheries in Brazil: history, status and perspectives. Lat. Am. J. Aquat. Res., 37(3): 513-542.

Perez, J.A.A., P.R. Pezzuto, L.F. Rodrigues, H. Valentini & C.M. Vooren. 2001. Relatório da reunião técnica de ordenamento da pesca de arrasto nas regiões sudeste e sul do Brasil. Notas Téc. Facimar, 5: 1-34.

Perez, J.A.A., R. Wahrlich, P.R. Pezzuto, P.R. Schwingel, F.R.A. Lopes & M. Rodrigues-Ribeiro. 2003. Deep-sea fishery off southern Brazil: recent trends of the Brazilian fishing industry. J. Northwest Atl. Fish. Sci., 31: 1-18.

Perez, J. A. A., P. R. Pezzuto & H.A. Andrade 2005. Biomass assessment of the monkfish *Lophius gastrophysus* in southern Brazil. Fish. Res., 72: 149-162.

Pezzuto, P.R. & E.M. Benincá. 2015. Challenges in licensing the industrial double-rig trawl fisheries in Brazil. Lat. Am. J. Aquat. Res., 43(3): 495-513.

Pio, V.M. 2011. A pesca industrial de emalhe de fundo em Santa Catarina - Brasil: dinâmica, tecnologia, economia e gestão. Master Thesis, Universidade do Vale do Itajaí - UNIVALI, Itajaí, 117 pp.

Pio, V.M., P. R. Pezzuto & R. Wahrlich. 2012. Aspectos tecnológicos das pescarias industriais com rede de emalhar de fundo no Estado de Santa Catarina - Brasil. Bol. Inst. Pesca, 38(1): 1-14.

Pitcher, T., D. Kalikoski, G. Pramod & K. Short. 2009. Not honouring the code. Nature, 457: 658-659.

Rosman, I. & S. Maugeri. 1980. Fishing with bottom gillnets. FAO Training Series, Rome, 57 pp.

Silva, S.O. 2007. Análise da estrutura da comunidade de peixes demersais da plataforma continental e talude superior do sudeste brasileiro vulneráveis à pesca de arrasto-de-fundo. Master Thesis, Instituto de Pesca, São Paulo, 86 pp.

Sparre, P. & S.C. Venema. 1997. Introdução à avaliação de mananciais de peixes tropicais. FAO Doc. Téc. Pesca, 306/1. Ver 1: 404 pp.

Srinivasan, U.T., R. Watson & U.R. Sumaila. 2012. Global fisheries losses at the exclusive economic zone level, 1950 to present. Mar. Policy, 36: 544-549.

Sumaila, U.R. & L. Huang. 2012. Managing bluefin tuna in the Mediterranean Sea. Mar. Policy, 36: 502-511.

Tomás, A.R.G. 2007. Dinâmica da frota de emalhe do Estado de São Paulo. In: C.L.D.B. Rossi-Wongtschiwski, R.A. Bernardes & M.C. Cergole (eds.). Dinâmica das frotas pesqueiras comerciais da região Sudeste-Sul do Brasil. Série Documentos REVIZEE, Score Sul. Instituto Oceanográfico-USP, São Paulo, pp. 263-275.

UNIVALI/CTTMar. 2001. Boletim estatístico da pesca industrial de Santa Catarina - ano 2010: programa de

apoio técnico e científico ao desenvolvimento da pesca no sudeste e sul do Brasil/ Universidade do Vale do Itajaí, Centro de Ciências Tecnológicas da Terra e do Mar - (CTTMar). Universidade do Vale do Itajaí, Itajaí, 73 pp.

UNIVALI/CTTMar. 2014. Produção pesqueira on-line. [http://www.univali.br/gep]. Reviewed: 20 April 2014.

Valentini, H. & P.R. Pezzuto. 2006. Análise das principais pescarias comerciais da região Sudeste-Sul do Brasil com base na produção controlada do período 1986-2004. Série Documentos REVIZEE-Score Sul do Instituto Oceanográfico-USP, São Paulo, 56 pp.

Vasconcellos, M. & M. Haimovici. 2006. Status of white croaker *Micropogonias furnieri* exploited in southern Brazil according to alternative hypotheses of stock discreetness. Fish. Res., 80: 196-202.

Received: 6 July 2015; Accepted: 9 March 2016

Vasconcellos, M., M. Haimovici & K. Ramos. 2014. Pesca de emalhe demersal no sul do Brasil: evolução, conflitos e (des) ordenamento. In: M. Haimovici, J.M. Andriguetto-Filho & P.S. Sunye (eds.). A pesca marinha e estuarina no Brasil: estudos de caso multidisciplinares. FURG, Rio Grande, pp. 41-52.

Wahrlich, R., J.A.A. Perez & F.R.A. Lopes. 2004. Aspectos tecnológicos da pesca do peixe-sapo (*Lophius gastrophysus*) com rede de emalhar no sudeste e sul do Brasil. Bol. Inst. Pesca, 30(1): 87-98.