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Review of the monitoring and management of deep-water fisheries off Brazil

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Introduction

The most recent review of Brazilian deep-water fisheries is by Perez et al (2009b). Until the early 1990s deep-water fishing was essentially scientific or restricted to hand-line operations over slope grounds and seamounts targeting various rockfish species (Paiva *et al*., 1996; Peres & Haimovici, 1998). In addition, Soviet trawlers explored the Martin Vaz (20-21°S, 36-39°W) and Rio Grande Rise (28°-35°S, 20°-38°W) seamounts in the 1980s (Clark *et al*., 2007). Despite a few government efforts to map the ocean floor and assess potential resources, commercial fishing beyond the continental shelf break (100-250 m) until the 1990s was generally considered unproductive and uneconomical (Haimovici *et al*., 1994; Haimovici, 2007). The development of deep-water fisheries was mainly in the southeastern and southern sectors of the Brazilian coast (19°-34°S) (see Figure 1) and was motivated by the overfishing of the main coastal resources and a government led vessel-chartering program. Around 2000-2001, foreign-chartered longliners, gillnetters, potters, and trawlers started to operate in Brazilian waters, leading the occupation of the upper slope (250-500 m), mostly targeting monkfish (*Lophyus gastrophysus*), Argentine hake (*Merluccius hubbsi*), Brazilian codling (*Urophycis mystacea*), wreckfish (*Polyprion americanus*), Argentine short-fin squid (*Illex argentinus*), red crab (*Chaceon notialis*), and royal crab (*Chaceon ramosae*). Between 2004 and 2007, chartered trawlers established a valuable fishery on deep-water shrimps (family Aristeidae), heavily exploiting the lower slope (500-1000 m). However, despite intensive data collection, the availability of timely stock assessments, and a formal participatory process for the discussion of management plans, deep-water stocks are already considered to be overexploited due to limitations of governance (Perez et al, 2009b). The purpose of this present review is to describe development of these fisheries and their monitoring and management, in order to inform the DEEPFISHMAN Project regarding the development of a monitoring, assessment and management framework for deep-water fisheries in the NE Atlantic.

Description of the deep-water fishing grounds off Brazil

The continental margin off the Brazilian coast can be subdivided into five sectors: northern, northeastern, central, southeastern, and southern (Figure 1).

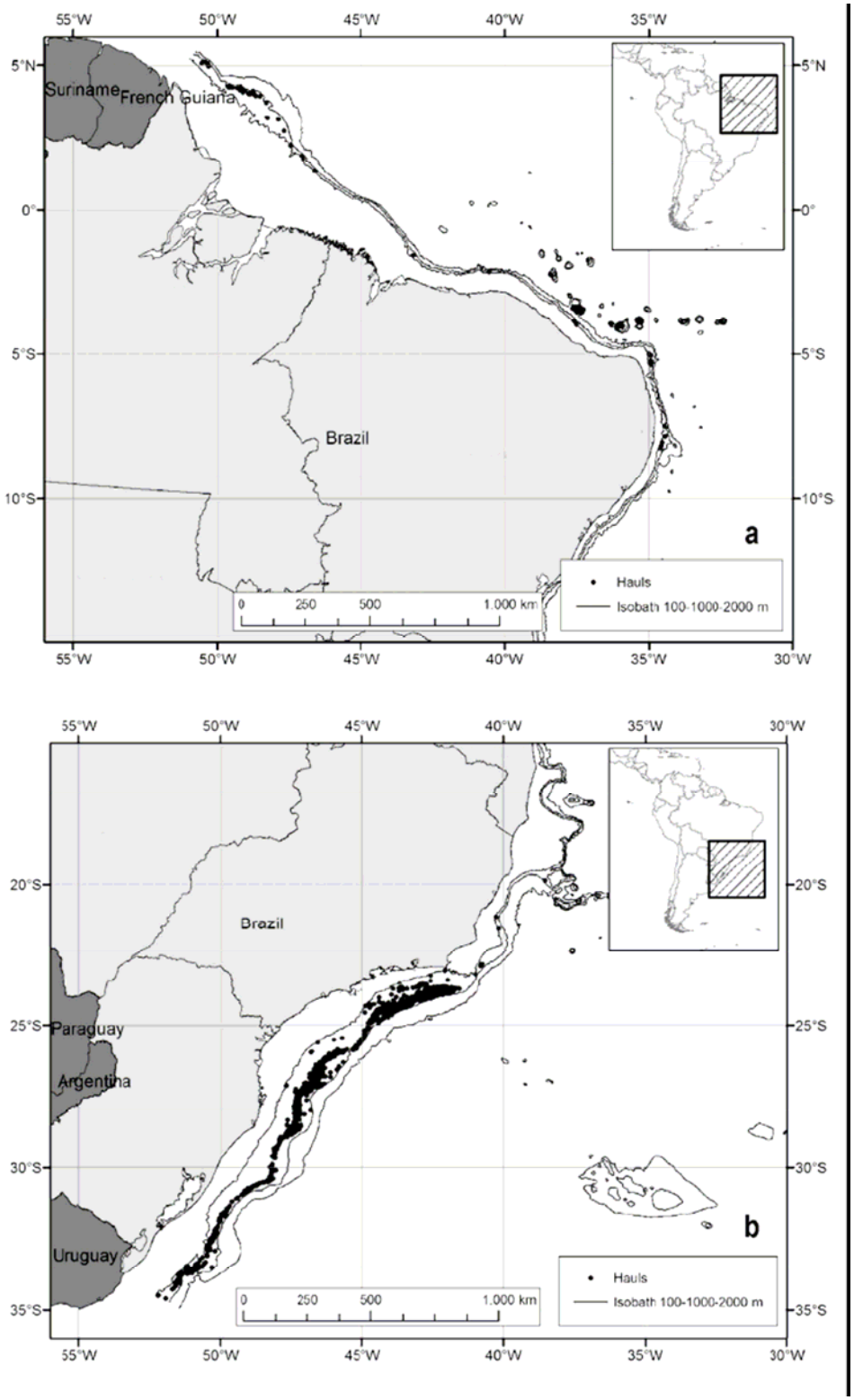

Figure 1. Continental margin off Brazil, SW Atlantic. a) northern and northeastern sectors, b) central, southeastern, and southern sectors (from Rossi-Wongtschowski *et al.*, 2006). Dots represent fishing hauls conducted by the chartered trawlers. (see description of deep-water fisheries below). Chartered gillnetters, potters, and longliners operate in the same slope areas as those occupied by trawlers (see the lower map) but are not represented for clarity.

Deep-water fishing activities have concentrated on the slope grounds of the south-eastern and southern sectors. This area is highly undulated and morphologically characterized by the occurrence of several seaward protrusions and submarine canyons between 100 and 1000 m depth (Figueiredo Jr. & Madureira, 2004). The slope floor is generally covered by mud, but there are areas where nodules of calcareous algae and beach rocks concentrate, predominantly north of 26°S. In addition, deep-water coral reefs have been mapped along the lower slope of southeastern sector (20°-24°S), some of them hundreds of meters long, tens of meters wide, and up to 15 to 20 m high (Pires, 2007).

Seamounts have been of secondary importance for deep-water fishing activity off the Brazilian coast. These structures ascend from the slope and ocean basin floor throughout the Brazilian EEZ (Rossi-Wongtschowski *et al.*, 2006). Particularly dense and accessible seamount concentrations are found in the central and northeastern sectors, most notably as part of the Ceará Plateau, Fernando de Noronha Chain, and Vitória-Trindade Chain. Hand-line fishing and trawling have been reported on seamounts of these chains (Fonteles-Filho & Ferreira, 1987; Martins *et al.*, 2005; Clark *et al.*, 2007). In 1982-1984 and 2000-2002, Soviet/Russian vessels also reported trawling on seamounts of the Rio Grande Rise area, outside the Brazilian EEZ (Clark *et al.*, 2007).

Description of the deep-water fisheries off Brazil

At the end of the 1990s, a new government led scientific program was established to assess fishing potential in the Brazilian EEZ (REVIZEE Program; Anon, 2006). Commercial fishing by Brazilian vessels had already expanding to the outer continental shelf and slope, largely as a result of the over-exploitation and subsequent decline in catch-rates in fisheries on the inner shelf (Perez *et al.*, 2001). To enhance this development, the Brazilian fishing authorities in 1998 introduced a foreign vessel-chartering program. This program allowed national companies to operate in Brazilian waters using technologically efficient foreign vessels specialized in oceanic and deep-water fisheries, featuring on board fish handling, processing, packing, and freezing (Wahrlich *et al*, 2004). This program identified the existence of exploitable resources and international marketing opportunities mainly in the EU and Asia (Soares & Scheidt, 2005), and from 2000 onwards an unprecedented commercial exploration began of fishing grounds 200 to 1000 m deep (Perez *et al.*, 2003). Deep-water fisheries off Brazil comprise hook-and-line (operated as handlines, longlines, bottom gillnets, pots, and bottom trawls (Perez *et al.*, 2003). The national fleet participated in the occupation of deep areas with longliners and trawlers. Chartered vessels operated with these gears but also introduced the use of deep-water gillnets and traps in the Brazilian EEZ (Perez *et al.*, 2003; Wahrlich *et al.*, 2004). Chartered fishing operations intensified from 2000 onwards, gradually diminishing between 2004 and 2007 as many foreign vessels moved away from the Brazilian EEZ.

Handline fishing off Brazil was first a coastal activity in the central sector, specifically off the southern coast of Bahia State and the Abrolhos Archipelago (17°25'-18°10'S, 38°33'-39°37'W). In the 1970s, the fleet expanded activity towards the slope grounds of the southeastern and southern coasts (200-600 m depth) and changed its technology to vertical longlines and finally to bottom set horizontal long-line (Peres & Haimovici, 1998). By the end of the 1990s, handline and long-line fleets were operating on slope grounds to the north and south of 29°S, respectively. Handliners targeted the tilefish (*Lopholatilus villarii*), snowy grouper (*Epinephelus niveatus*), sandperch (*Pseudopercis numida*), and catfish

(*Genidens barbus*); whereas the longliners targeted mainly the wreckfish , but also produced important catches of Brazilian codling, red porgy (*Pagrus pagrus*), and pink cusk-eel (*Genypterus brasiliensis*) (Ávila-da-Silva & Arantes, 2007; Haimovici *et al.*, 2007). Four chartered longline vessels operated off the southern sector of the Brazilian EEZ, three in 2000 and one in 2001, all targeting wreckfish concentrations south of 30°S and between 159 and 800 m. These trips also landed important catches of pink cusk-eel, the school shark (*Galeorhinus galeus*), and tilefish (Perez *et al.*, 2003).

The deep-water gillnet fishery started in 2001 with two vessels and increased to a maximum of ten in 2002, most of them originating from Spain (Wahrlich *et al.*, 2004). Fishing took place on the upper slope grounds, between 200 and 500 m depth along the entire southeastern and southern sectors of the Brazilian coast (Perez *et al.*, 2002a). Monkfish was the targeted species, accounting for around 40% of the catch by number. Catches of royal crabs, spider crabs (family Majidae), beardfish (*Polimixia lowei*), silvery John dory (*Zenopsis conchifera*), Brazilian codling, Argentine hake, wreck-fish, angel shark (*Squatina argentina*), and various skates (Rajidae) were also important. In mid-2002, government regulations prohibited foreign gillnetters to operate south of 21°S and this resulted in a cessation of chartered gillnet operations off Brazil. A small national fleet (up to 5 vessels) continued the fishery using the fishing technology and the international markets introduced by the chartered vessels (Wahrlich *et al.*, 2004).

The first recorded pot/trap fishing for deep-water crabs was recorded in 1984-1985, when two chartered Japanese vessels operated off the southernmost extreme of the Brazilian EEZ (Lima & Branco, 1991). This activity began again in 1998 when another Japanese vessel initiated operations in the same area as part of the government led chartering program (Perez *et al.*, 2003). On both occasions, the species targeted was the red crab, a stock whose distribution extends southwards to Uruguayan waters, where a similar pot fishery has existed since the 1990s (Defeo & Masello, 2000). The same single vessel continued to exploit the red crab off Brazil until 2007, operating on the upper and lower slope (200 to 900 m depths) south of 33°S (Pezzuto *et al.*, 2006a). Between 2001 and 2002, four chartered pot vessels from Russia, Spain, and the UK started fishing off southern Brazil for another species of deep-water crab, the royal crab. Fishing was concentrated on the lower slope (500-900 m) within the area bounded by the parallels 27°S and 30°S. In 2003, this area was expanded northward with the establishment of a new fishing ground off southeastern Brazil between 19°S and 25°S, and this coincided with the entry of another two vessels from Spain and one from the USA. By 2007, all of these vessels had gradually abandoned fishing in Brazilian waters. There are only two reported incidences of pot fishing for deep-water crabs by national vessels; briefly in 2004-2005 off southern Brazil and in 2006 off the coast of Ceará in the northeast sector of the Brazilian coast. There, one vessel exploited a third species of the genus *Chaceon*, the golden crab *C. fenneri*, at depths of 600 to 800 m (Carvalho *et al.*, 2009).

Trawling on the slope areas off Brazil intensified from 1999 onwards as a consequence of both the expansion of traditional fishing areas of the national fleet and the operation of foreign trawlers chartered to explore deep grounds within the Brazilian EEZ (Perez *et al.*, 2001, 2003). In southeastern and southern Brazil, a preliminary "exploratory phase" of chartered trawling was carried out in 2000 and 2001 by two large Portuguese and South Korean vessels fishing between 100 and 400 m depth (Perez *et al.*, 2003; Perez *et al.*, 2009a).

This resulted in an "upper slope directed phase" characterized by intense exploitation by seven trawlers mostly from Spain of Argentine hake in two strata, 23°S-25°S and 26°S-29°S, at a depth 250-400 m. Catches of the Argentine squid were also important, along with the monkfish, silvery John dory, and Brazilian codling, the latter usually discarded due to the lack of an international market. After sharing the upper slope and most of its demersal resources with the national fleet for nearly one year, most of chartered trawlers involved in this fishery left Brazilian waters by the end of 2002 (Perez *et al.*, 2009a).

Chartered trawling off Brazil continued, however, through the operation of another group of foreign vessels developing and prosecuting a fishery on the lower slope targeting concentrations of aristeid shrimps: *Aristaeopsis edwardsiana* (scarlet shrimp), *Aristeomorpha foliacea* (giant red shrimp), and *Aristaeus antillensis* (alistado shrimp) (Pezzuto *et al.*, 2006b; Perez *et al.*, 2009a). Two Spanish trawlers started this fishery in late 2002-2003, in a limited area bounded by the 24-26°S parallels and 700-750 m isobaths. In mid-2004, another five trawlers from Spain, Mauritania, and Senegal started operations within the same area, and then moved gradually to new grounds to the north (19°30'-20°S) and, in 2005, to the south of 26°S (Pezzuto *et al.*, 2006b; Dallagnolo *et al.*, 2009). This phase directed at the lower slope was the longest to be sustained by chartered trawlers off Brazil, but it also declined in 2007 when most vessels abandoned Brazilian waters due to poor catch rates.

Chartered deep-sea trawling was also attempted in the northern and northeastern sectors of the Brazilian coast at depths between 428 and 1,158 m deep off the coast of Amapá State (47-50°W) in late 2002, where productive concentrations of *A. edwardsiana* and *A. antillensis* were found (Pezzuto *et al.*, 2006b). Additionally, a few trips by one trawler were directed towards the seamounts making up the Ceará Plateau and Fernando de Noronha Chain. These seamounts rise from nearly 1,000 m at the base to 200 m at the top, where the gentle topography was found suitable for trawling. Catches in these areas were mostly composed of the Warsaw grouper (*Epinephelus nigritus*), but catch rates decreased rapidly to unprofitable levels. These areas have been abandoned ever since (Perez *et al.*, 2009a).

A summary of the deep-water fishing activity carried out by the foreign chartered fleet off Brazil between 2002 and 2007 is given in Table 1, below.

Table 1. Spatial distribution of deep-water fishing hauls conducted by the foreign chartered fleet off Brazil between 2000 and 2007. Hauls are grouped by fishing gears, depth strata (and seamounts), and sectors of the Brazilian coast (data by sector includes a small amount of fishing on the shelf-break (100-250 m). Numbers in parentheses represent the proportion (%) of hauls conducted by gear in each depth strata and sector. In the last line, the number in parentheses represents the proportion of hauls conducted by fishing gear (modified from Perez et al, 2009b)

Fishing gear/depth strata/sector	Longline	Gillnet	Pot/traps	Trawl	Total
Upper slope	9	3186	628	5634	9457
(250-500) m	(19.6)	(92.3)	(9.5)	(24.8)	(28.9)
Lower slope	28	230	5925	15360	21543
(> 500) m	(60.9)	(6.7)	(90.0)	(67.7)	(65.7)
Seamounts	0	0	0	965	965
	(0.0)	(0.0)	(0.0)	(4.3)	(2.9)
Coastal sector					
North	0	0	19	55	74
	(0.0)	(0.0)	(0.3)	(0.2)	(0.2)
Northeast	0	6	57	1221	1284
	(0.0)	(0.2)	(0.9)	(5.4)	(3.9)
Central	0	10	292	3850	4152
	(0.0)	(0.3)	(4.4)	(17.0)	(12.7)
Southeast	4	2294	4498	17438	24134
	(8.7)	(66.4)	(68.3)	(76.9)	(74.0)
South	42	1143	1715	123	3023
	(91.3)	(33.1)	(26.1)	(0.5)	(9.2)
Total	46	3453	6581	22687	32767
	(0.1)	(10.5)	(20.1)	(69.2)	(100.0)

Trawls and pots/traps accounted for almost 70% and 20% of the total fishing activity respectively, most of which was on the lower slope in the southeast sector. Gillnet activity (10% of total) was also focussed in this sector but mostly on the upper slope. Activity by longliners was negligible over the period 2002-2007. Treating the year 2000 as a reference for the start of a deep-sea fishingin Brazil, total landed catches of the main demersal "deep-sea" resources reported for the southeastern and southern sectors of Brazil, where this activity has concentrated, varied annually from around 5,800 t in 2000 to a maximum of 20,000 t ton in 2002, decreasing to nearly 11,000 ton in 2006 (Table 2). These annual figures reported in Perez *et al*, (2009) include landings for some species which may or may not be considered to be deep-water species depending on the definition of deep-water used. These species include the Brazilian codling, Argentine hake, monkfish and the Argentine squid. If these species are excluded, deep-water crab species and, in later years, deep-water shrimp species accounted for the majority of annual landings.

Table 2. Annual landings (t) of deep-water resources in southeastern and southern Brazil between 2000 and 2006 (from Perez *et al*, 2009b).

Species		Year							Total
		2000	2001	2002	2003	2004	2005	2006	
Teleosts									
Brazilian codling	*Urophycis* spp.	1,901.3	5,991.7	7,847.0	5,273.6	3,491.2	4,547.8	4,825.0	33,877.6
Tilefish	*Lopholatilus villarii*	533.2	709.2	597.6	572.5	545.2	560.8	717.0	4,235.5
Argentine hake	*Merluccius hubbsi*	225.8	2,653.4	3,708.8	3,042.4	1,417.8	1,564.5	1,950.5	14,563.2
Silver john dory	*Zenopsis conchifera*	0.0	0.0	82.5	147.1	42.3	85.1	31.0	388.0
Monkfish	*Lophius gastrophysus*	1,934.4	7,063.9	5,073.1	2,556.3	2,410.7	2,544.6	2,516.5	24,099.5
Crustaceans									
Royal crab	*Chaceon ramosae*	2.0	593.6	1,252.3	746.0	849.9	494.5	171.4	4,109.7
Red crab	*Chaceon notialis*	1,157	1,183.6	1,089.0	1,377.7	1,092.5	675.7	302.8	5,899.8
Scarlet shrimp	*Aristaeopsis edwardsiana*	0.0	0.0	13.0	58.9	81.6	182.6	99.3	435.4
Giant red shrimp	*Aristaeomorpha foliacea*	0.0	0.0	0.0	4.6	14.9	42.6	51.7	113.8
Alistado shrimp	*Aristeus antillensis*	0.0	0.0	0.3	0.5	5.5	15.8	5.4	27.5
Molluscs									
Argentine squid	*Illex argentinus*	2.7	13.6	2,600.7	31.2	158.3	453.1	292.5	3,552.1
Total		5,756.4	18,209.0	19,923.0	13,810.8	10,109.9	11,167.1	11,028.1	91,302.1

Sources: IBAMA/DF, IBAMA/RJ, CEPSUL/IBAMA, CEPERG/IBAMA, IP-APTA and CTTMar/UNIVALI.

Fisheries monitoring

The deep-water fishery developed off the coast of Brazil was one of the most intensely monitored fisheries in Brazilian waters. In addition to the use of official data collection logbooks, observers and VMS programs were implemented for the first time in order to enforce the legal obligations of the chartered fleet when the REVIZEE scientific exploration program was commissioned. Observer and VMS coverage applied to all vessels (i.e.100% coverage). These programs were conducted as part of a scientific cooperation agreement between the Brazilian government and the University of "Vale do Itajaí" (Santa Catarina, southern Brazil). In 2005, after a period of development and adjustments, these programs became national policies were incorporated into the agenda of the Special Secretariat of Aquaculture and Fishery, the Ministry of the Environment and Natural Resources, and the Brazilian Navy.

Between 2000 and 2007, 311 fishing trips by the chartered fleet were observed and monitored by satellite VMS. Data on fishing position, depth, and catch/bycatch from over 35,800 fishing sets were recorded. Observers also collected biological samples of these catches and recorded biological data (length, sex, and maturity, depending on the species) for around 713,810 individuals of the main target species. Complementary data was obtained during the same period for landings by the national fleet.

Fisheries-independent surveys

Fisheries and biological data were also obtained from surveys mostly conducted by research vessels in 2001 and 2002 as part of the REVIZEE program (*e.g.*, Cergole *et al.*, 2005; Costa *et al.*, 2005; Rossi-Wongtschowski *et al.*, 2006). The survey area included southern

Brazil's outer shelf and slope between Cabo Frió (23°S) and Chui (34°35'S) and comprised 152,354 km² within a depth range 100 to 600 m. However, much of the data collected and results arising (exploitable biomass estimates using swept area raising methods), were only available for the main largely upper slope demersal species, monkfish and hake species, for example.

Species-specific fisheries, biological information, stock assessments and stock status

Wreckfish (*Polyprion americanus*)

The species is long-lived (up to 76 years), the age of maturity is around 10 years and spawning occurs in localized areas off southern Brazil (Peres & Haimovici, 2003). In these areas, most of the local stock is highly vulnerable to the Brazilian long-line directed fishery as well as unintentional mortality from slope trawling and monkfish gillnetting (Peres & Klippel, 2003; Perez & Wahrlich, 2005). Sparse catch records of this species date back to 1973, but a series of nominal catches has been available from 1986 onwards (Valentini & Pezzuto, 2006). Until 2004, annual reported landings oscillated around 700 to 800 t. These data my be not be accurate as they likely include landings for two other serranids (*Epinephelus niveatus* and *E. flavolim-beatus*) and because there has been a historical trend of unreported catches, particularly during the first half of this period (Haimovici & Peres, 2005). These authors estimated that landings declined nearly 79% since 1989 (dropping from 2,200 t in that year to less than 460 t in 2002), in association with abundance reductions ranging from 57 to 94%, according to CPUE time-series analysis. Part of this reduction has been attributed to a significant increment in fishing mortality as the result of rising demands of international markets and increased fishing power in the longline fleet.

Red crab (*Chaceon notialis*)

Exploitation of the red crab started in Brazil in 1998, when a Japanese factory vessel was chartered by a national company. The vessel has been was closely monitored by observers and VMS and fishing and biological data has been made available. Between 2000 and 2003, annual landings were mostly around 1100 t range, attained a maximum of around 1400 t in 2003, and declined thereafter. Females accounted for around 70% of the biomass exploited and most of the catches are composed of immature individuals. Spawning seems to be localized both in space and time; in Brazil, ovigerous females were found concentrated at depths shallower than 600 m, mostly from July to December (Pezzuto *et al.*, 2006b).

Assessments based on the Effective Fishing Area Method (Defeo *et al.*, 1991; Arena *et al.*, 1994) and Gulland's Formula (Pezzuto *et al.*, 2002) for the "Brazilian" part of the stock (33°00'S and 34°40'S) (there is also a fishery in adjacent Uruguayan waters) estimated virgin biomass and MSY at 17,118 t (16,454-17,779 CI95%) and 1,027 t, respectively (Table 2.).By the end of 2005, the stock biomass, as indicated by commercial catch-rates, was reduced to nearly 60% of its original levels (Pezzuto *et al.*, 2006a).

Royal crab (*Chaceon ramosae*)

The fishery for this species started in 2001 and soon expanded to a fleet of up to eight foreign processor vessels chartered by national companies. The species was also the most abundant and valuable bycatch item of several chartered gillnetters and trawlers that targeted other deep-sea resources such as monkfish and aristeid shrimps (Perez &

Wahrlich, 2005; Pezzuto *et al.* 2006c). Males predominated in catches and ovigerous females were concentrated in areas shallower than 700 m from January to June (Pezzuto *et al.*, 2006b). More than 50% of the males and females caught were sexually immature (Pezzuto & Sant'Ana, 2009).

In the first year of exploitation, catches amounted to around 600 t and this increased to around 1200 t in 2002. Using the same methodology as for red crab, stock biomass and MSY were estimated in 2002 to be 11,636 ton (11,272-12,008 t CI 95%) and 594 t, respectively (Pezzuto *et al.*, 2002, 2006a). Catches declined in 2005 and 2006 as a direct response to lower catch rates and successive reductions in the number of vessels in the fishery (Pezzuto *et al.*, 2006b).

Scarlet shrimp (*Aristaeopsis edwardsiana*)

The scarlet shrimp (*carabinero shrimp*) is an aristeid shrimp distributed in slope areas worldwide. This is a high-valued species that has been commercially exploited by trawl fisheries at low latitudes of both the East and West Atlantic (Dallagnolo *et al.*, 2009). Off Brazil, it has been the main target of the lower slope trawl fishery phase conducted by chartered vessels since 2003 (Pezzuto *et al*, 2006c; Perez *et al.*, 2009a). The main concentrations have been exploited in the southeastern sector, between 22 and 26°S at depths of between 700 to 750 m. After 2004, fishing continued within these depths but expanded latitudinally to areas in the central and southern sectors of the Brazilian coast. Concentrations were also identified in northern Brazil, off the coast of Amapá State, where fishing was mostly exploratory (Pezzuto *et al*, 2006c; Perez *et al.*, 2009a).

The catch size-structure is dominated by females and includes around 20% of immature individuals (Anon, 2007). Males are smaller than females (maximum carapace length 72 mm and 106 mm, respectively). Sexual maturity is reached at 60 mm and 48 mm carapace length in males and females. The reproductive cycle is annual, with most spawning activity in the second half of the year.

Annual catches increased from 13 t in 2002 to a maximum of 183 t in 2005, declining to 20 t in 2007. Using of commercial catch rate data and swept area procedures, a total exploitable biomass of 865 t was estimated within the fishing areas south of 19°S in 2002. This biomass, regarded as virgin, was reduced by around 45% by 2007 due to an intense trawling effort concentrated on spatially discrete fishing grounds (Dallagnolo, 2008). Considerations of the species' life-history (Kirkwood *et al.*, 1994) allowed the definition of an MSY of around 6% of the virginal biomass or approximately 2.5 ton. Taking the total biomass at MSY as a limit reference point, it was concluded that the recent state of the scarlet shrimp stock was biologically 'unsafe'.

Giant red shrimp (*Aristaeomorpha foliacea*)

The giant red shrimp (*moruno shrimp*) was the second most abundant aristeid shrimp caught by chartered trawlers on the lower slope off Brazil (Pezzuto *et al.*, 2006c). Catches were generally associated with the chartered trawling activity directed at the larger, more abundant scarlet shrimp. Nevertheless, the species was found to dominate catches in particular fishing grounds of the southeastern and central sectors, principally in later years as densities of scarlet shrimp decreased (Dallagnolo *et al.*, 2009). Total giant red shrimp catches increased continuously until 2005 and 2006, peaking at 43 and 52 t, respectively,

and then declining to 8 t in 2007. Maximum carapace length of males and females in catches was 62 and 91 mm, respectively, with maturity attained at lengths of 46 and 29 mm. Reproduction was found to be continuous throughout the year. Immature individuals have been rare in the catches (Anon, 2007).

Densities increased continuously on the slope off southeastern Brazil from 2002 to 2007, as estimated by commercial catch rate analysis. In this sector, the mean exploitable biomass peaked in 2007 at around 200 t (Dallagnolo, 2008). Off the central sector of the Brazilian coast, a maximum of around 90 t of exploitable biomass was estimated in 2006, declining by around 45% in 2007, possibly in response to harvest rates as high as 22 and 54% in 2005 and 2006. MSY for the giant red shrimp was estimated to be 15-19% and 17-20% of the exploitable biomass of females and males, respectively (Dallagnolo, 2008).

The abundance estimators, methods for stock assessment, reference points, and the status of the major deep-water stocks exploited in southeastern and southern Brazil are summarised in Table 3.

Table 3. Abundance estimators, methods for stock assessment, reference points, and the status of the major deep-water stocks exploited in southeastern and southern Brazil. t: year, B0: virgin or initial biomass, C: catch, Cref: catch in the year of reference, E: exploitation rate (modified from Perez et al, 2009b)

Stocks	**Abundance estimators/ indicators**	**Stock assessment methods**	**Reference points (limits)**	**Stock status**
Teleosts				
Polyprion americanus	-	Ct/Cref; CPUEt/CPUEref (1)	-	Collapsed (1)
Crustaceans				
Aristaeopsis Edwardsiana	Swept area, GLM (2)	Kirkwood *et al*., 2004 (2)	B_t/B_0; B_t/B_{MSY}; $CPUE_t/CPUE_0$; $CPUE_t/CPUE_{MSY}$; GLM_t/GLM_0; GLM_t/GLM_{MSY} (2)	Overexploited (2)
Aristaeomorpha foliacea	Swept area, GLM (2)	Kirkwood *et al*., 2004 (2)	B_t/B_0; B_t/B_{MSY}; $CPUE_t/CPUE_0$; $CPUE_t/CPUE_{MSY}$; GLM_t/GLM_0; GLM_t/GLM_{MSY} (2)	Unknown
Chaceon notialis	EFA, GLM, CPUE (3, 4)	Gulland's equation (3)	B_t/B_0; B_t/B_{MSY}; $CPU\text{-}E_t/CPUE_0$; $CPU\text{-}E_t/CPUE_{MSY}$; GLM_t/GLM_0; GLM_t/GLM_{MSY} (4)	Fully exploited (13)
Chaceon ramosae	EFA, GLM, CPUE (3)	Gulland's equation (3)	B_t/B_0; B_t/B_{RMS}; $CPU\text{-}E_t/CPUE_0$; $CPU\text{-}E_t/CPUE_{RMS}$; GLM_t/GLM_0; GLM_t/GLM_{RMS} (4)	Fully exploited/ Overexploited (13)

1) Haimovici & Peres (2005), (2) Dalagnollo (2008), (3) Pezzuto *et al*. (2006a), (4) Pezzuto *et al*. (2006b).

Bycatch species

The detailed recording of catch compositions by observers on board chartered vessels has provided opportunities to assess the impact of deep-water fishing on the slope ecosystems of Brazil. The most comprehensive study to date has focused on a qualitative and quantitative bycatch analysis of the chartered gillnet fishery for monkfish during 2001 (Perez & Wahrlich, 2005). Absolute catches in numbers of non-targeted species were estimated for the entire chartered gillnet fleet in 2001 through their observed mean catch rates (individuals per sampled net). These bycatches included the royal crab and spider crabs, elasmobranchs, principally the angel shark and various skates; teleosts, the beardfish, silvery John dory, Brazilian codling, Argentine hake, wreckfish; and turtle, cetacean, and bird species. Indirect mortality impacts tended to be higher in mobile bottom dwellers but bycatch abundances decreased and their basic composition changed southwards, where large teleosts, elasmobranchs, cetaceans, and birds were dominant over the small teleosts, crustaceans, and other invertebrates that characterized the bycatch composition in the northern area. Non-intentional mortality inflicted by bottom gillnets on large K-strategists (wreckfish, sharks, rays, turtles, cetaceans, birds) was regarded as critical, although highly correlated with operations in the southernmost areas of the Brazilian EEZ, where these groups tend to concentrate.

Assessments of the gillnet fishery and other fisheries (including cephalopods and other invertebrates) have been mostly qualitative (Perez *et al.*, 2004, Bastos, 2004). A total of 185 macro and mega invertebrates as well as sponges, cnidarians, annelids, crustaceans, molluscs, and echinoderms were recorded. Considering the length of the pot (9 km) and gillnet (20 km) lines used during each fishing set, it has been argued that their impact on benthic fauna may not be as unimportant as previously thought. Previously, closer attention has been paid the impact of the trawling fishery directed at aristeid shrimps on the lower slope because his fishery produces diverse bycatch of truly deep-water benthopelagic fishes and removes deep-sea corals, particularly where they form slope and seamount reef formations (Pires, 2007).

Fisheries management

Until 1998, fishing management and control were responsibilities of the Ministry of the Environment (MMA), which was based on an almost 40-year-old coastal fishing-oriented management model. In 1999, due to political pressure from the fishing industry interested in a more "development than environmentally-oriented philosophy", a second management authority was created under the Ministry of Agriculture and Livestock (DPA/MAPA) with a mandate to develop and manage aquaculture and the economic exploitation of those stocks defined as "sub-exploited, unexploited, and highly migratory".

The REVIZEE program was led by the MMA and the focus was mostly to estimate fishing potential as required by UNCLOS. Brazil had requested a 200 miles EEZ but needed to demonstrate knowledge about the resources of that area. The deep-water fishery in Brazil was developed by means of an independent short-term chartering program launched by DPA. This allowed national and overseas fishing companies to associate and operate foreign deep-water vessels under temporary fishing authorizations. The explicit objectives of the chartering program were:

(i) to enhance the fish supply in the domestic market and to generate foreign currency;
(ii) to improve competence and promote employment in the national fishing industry;
(iii) to occupy rationally and sustainably the Brazilian EEZ;
(iv) to stimulate the formation of a national fleet capable of operating in deep-waters and utilizing equipment that incorporates modern technology;
(v) to expand and consolidate fishing enterprises;
(vi) to generate knowledge on living resources of the continental shelf and EEZ; and
(vii) to sustainably exploit fishing resources on the high-seas.

This strategy led to the rapid development of foreign fleets targeting new, valuable, fragile deep-water resources (Perez *et al.*, 2002a, 2003, 2009a; Pezzuto *et al.* 2006a, 2006c), in some cases, paralleled by an expansion of coastal domestic fleets to the same areas and resources (*e.g.* Perez & Pezzuto, 2006). Not only did fishing effort dramatically increase on virgin stocks for which the fishing potential was virtually unknown, but this process also stimulated conflicts between fleets and resulted in, within most of the national fishing industry, a disregard for fishing authorities and fisheries management plans.

Concerns about the sustainability of the target species as well as environmental, social, economic, and political impacts of such an uncontrolled scenario led to the creation in 2002 of the Consultant Committee for the Management of Deep-water Resources (CPG). This Committee comprises delegates of the fishing sector (ship-owners, fisherman, and fishing industry workers), representatives of governmental agencies, an Executive Secretariat and members of Scientific and Compliance Subcommittees (SCC and SC, respectively). The SCC produces the bulk of data and recommendations to be discussed and approved at the regular CPG meetings. Management plans and other recommendations from the CPG have consultant power only, as the final decision to implement is under the jurisdiction of the Secretariat. Perez et al (2009b) report that despite representing significant progress towards a more rational management process, the CPG experience has not yet been totally successful. Fishing development and its negative impacts have occurred more rapidly than the Government Secretariat (challenged by political and institutional pressures) has been able to deal with. They cite the upper slope monkfish fishery as an example of the monitoring and management problems encountered.

Following the rapid start of the monkfish fishery in the late 1990s, biological, technical and operational data were collected intensively during 2001. A complete stock assessment and management recommendations were first made available to government and industry in April 2002 (Perez *et al.*, 2002b). Scientific results and recommendations were subsequently analyzed and improved during SCC meetings in 2002. Meetings of a special working group formed by the SCC, government, and industry members produced the first version of the monkfish management plan.

A new government body (the Special Secretariat for Aquaculture and Fishing) decided to reopen the debate on the monkfish fishery in 2003, considering not only the new institutional and political circumstances (a change in elected government), but also the strong opposition by the part of the industry interested in a more free-access regime to the fishery. A new version of the management plan was discussed and approved but was not implemented. After more than four years of uncontrolled exploitation, in May 2004, the stock was declared to be overexploited. In 2005, SCC decided to adopt a strong political

stance demanding legal intervention in the process in order to ensure the sustainability of the stock. As a consequence, the monkfish management plan was introduced (Table 4). Since then enforcement of management rules has been poor and subsequent biomass assessments have not shown any signs of recovery.

Table 4. Management elements of the deep-water fisheries in southeastern and southern Brazil. Logbooks and VMS: 100% coverage. Observers: 100% cover-age. Exceptions are indicated in specific cases (from Perez et al, 2009b)

	Bottom longline	Double-rig trawl (shelf break)	Bottom trawl (upper slope)	Bottom trawl (lower slope)	Gillnet	Trap	Trap	Trap
Management plan	No	2008	2008	Now implementing	2008	2008	2005	Now implementing
Target and accessory species	*Polyprion americanus* (*); *Lopholatilus villarii*; *Pseudopercis numida*; *Epinephelus niveatus*; *Urophycis mystacea*; *Galeorhinus galeus*; *Genypterus brasiliensis*; *Helicolenus lahillei*	Multispecies (**)	*Urophycis mystacea*; *Merluccius hubbsi*; *Zenopsis conchifera*; *Illex argentinus*	*Aristaeopsis edwardsiana*; *Aristaeomorpha foliacea*; *Aristeus antillensis*	*Lophius gastrophysus*	*Chaceon notialis*	*Chaceon ramosae*	*Chaceon fenneri*
Fleet size	Unlimited	Unlimited among coastal pink-shrimp trawlers	17 (< 600 HP)	2	9	2	2	1
Area	Brazilian EEZ	18°20´ S to the Southern limit of the Brazilian EEZ; 100-250 m depth	18°20´ S to the Southern limit of the Brazilian EEZ; 250-500 m depth	18°20´ S to 28°30´; 500-1000 m depth	21°´ S to the Southern limit of the Brazilian EEZ; > 250 m depth	32° S to the South-ern limit of the Brazilian EEZ; > 200 m depth	19° S to 30° S; > 500 m depth	NE coast > 200 m depth
Fishing season	Jan-Dec	March - May	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec
TAC	No	No	No	60 ton.year^{-1}. Individ-ual (not-transferable) quotas of 7.5 ton.trimester^{-1}	1.500 ton.year^{-1}	735 ton. year^{-1}	420 ton.year^{-1}	No
Effort limits	No	No	No	No	Up to 1000 nets.vessel^{-1} (maximum net length: 50 m)	No	Up to 900 traps.vessel^{-1}	
Minimum legal sizes	Yes, species-specific	No	No	No	No	No	No	No
Gear restrictions	No	Double-rig trawl	Stern trawl; minimum cod-end mesh size 90 mm stretched	Stern trawl; minimum cod-end mesh size 60 mm stretched	Minimum mesh size 280 mm stretched; nets tagged with vessel register	Mesh size 120 mm stretched; escape panels; traps tagged with vessel register	Mesh size 120 mm stretched; escape panels; traps tagged with vessel register	Mesh size 120 mm stretched; escape panels; traps tagged with vessel register
By-catch limits	No	*Lophius gastrophysus* (5%); other coastal spe-cies*** (15% of the total catch)	*Chaceon* spp. (5%); *Lophius gastrophysus* (5%); Aristeidae shrimps (1% of the total catch)	*Chaceon* spp. (15%); *Lophius gastrophysus* (5% of the total catch).	*Lopholatilus villari* (5%); *Chaceon* spp. (5% of the total catch)	No	No	No

The management of other deep-water resources such as geryonid crabs, aristeid shrimps, and demersal fishes has faced the same difficulties, with negative consequences for the sustainability of the respective stocks.

Discussion and conclusions

The development of the Brazilian deep-water fishery is a useful case study from which much can be learned by the DEEPFISHMAN Project regarding the development of monitoring and management Frameworks for deep-water fisheries/stocks in the NE Atlantic. When the chartering program commenced the goal of a new sustainable, well-monitored and managed deep-water fishery appeared to be achievable. The fishery was relatively small-scale in terms of the number of vessels participating, all vessels were monitored by VMS and there was 100% observer coverage. Moreover, there was a comprehensive scientific monitoring regime in place comprising comprehensive biological sampling and regular stock assessments. However, Perez et al (2009b) noted:-

"Despite intensive data collection, the availability of timely stock assessments, and a formal participatory process for the discussion of management plans, deep-water stocks are already considered to be overexploited due to limitations of governance"

Undoubtedly, the time lag between the provision of scientific advice and the implication of management plans has been a major driver of over-exploitation. Fisheries for some species e.g. shrimp species, lacked a management plan even in 2009, although these are under development. This scenario echoes that in the NE Atlantic where despite repeated strong advice from ICES for almost a decade, deep-water fisheries were unregulated until 2003.

Although there is much to commend in the content of the Management Plans introduced, there are number of important features which could be construed as possible weaknesses (and therefore practices we may wish to avoid in the frameworks for the NE Atlantic):-

- Management plans have not been imposed on all fisheries e.g. bottom longline fisheries.
- There are no minimum landing size restrictions for most of the species fished (except for species taken by bottom longline), even though mesh size restrictions are place.
- Encounter protocols are not in place for vulnerable marine ecosystems (VMEs) and protected, endangered and threatened (PET) species. However, all fisheries need to comply with an endangered species law.
- Crucially, harvest control rules (HCRs) are not in place and this can adversely impact on management when there is conflict of interest between conservation, socio-economic, stakeholder interests.

There may also have been a number of monitoring/biological issues which may have impacted adversely on the sustainability of these fisheries. These are:-

- Overestimation of MSY levels
- Although the REVIZEE provided fisheries-independent extimates of initial biomass, subsequent assessments relied largely on abundance indices from commercial vessels (with all the inherent problems of adjusting for spatial, temporal, fishing power and technological creep effects (the latter can be particularly important in new and developing fisheries)).
- Relatively short time-series abundance and length frequency data
- Little information on stock identity, stock distribution and immigration/emigration.

Given the above management, monitoring and biological concerns and related uncertainty there would appear to have been a strong case on commencement of the fisheries for invoking the Precautionary Approach and the application of precautionary TACs/effort limits set at very low levels. These levels would have remained low until it was reliably demonstrated that higher levels of exploitation were sustainable. However, this approach would have been in conflict with the socio-economic (and possibly political) objectives of the chartering program which was to accelerate the development of deep-water fisheries. Such objectives are very laudable either to develop new fisheries or to preserve existing small-scale artisanal fisheries, however there may be an argument for deep-water fisheries (where there is high uncertainty regarding estimates of virgin biomass, MSY, current biomass, current level of exploitation, a paucity of information on stock identity and

migration and limited fisheries-independent monitoring) for socio-economic considerations to have a lower weighting in the management and governance process.

References

Anon. 2006. Programa REVIZEE. Avaliação do poten-cial sustentável de recursos vivos na Zona Econômica Deep- water fisheries in Brazil 537 Exclusiva. Relatório Executivo. Ministério do Meio Ambiente. Secretaria de Qualidade Ambiental nos Assentamentos Humanos, Brasília, 303 pp.

Anon. 2007. Presidência da República. Secretaria Espe-cial de Aqüicultura e Pesca. Comitê Consultivo Per-manente de Gestão dos Recursos Demersais de Pro-fundidade. Sub-Comitê Científico. Relatório da 5a Reunião Ordinária. Itajaí, SC, 11-13 de junho de 2007. SEAP/PR, Brasília, 75 pp.

Ávila-da-Silva, A.O. & L.H. Arantes. 2007. Análise da pesca de peixes demersais com linha-de-fundo pelas frotas doRio de Janeiro e São Paulo de 1996 a 1999. In: C.L.D.B.Rossi-Wongtshchowski, 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. Série Documentos REVIZEE, Score Sul. Instituto Oceanográfico, USP, São Paulo, pp. 277-294.

Bastos, M.S. 2004. Invertebrados bentônicos capturados pela frota pesqueira arrendada no sudeste e sul do Brasil. Bachelor Thesis, Curso de Oceanografia, Uni-versidade do Vale do Itajaí, Santa Catarina, Brasil, 93 pp.

Carvalho, T.B., R.R. Oliveira Filho & T.M.C. Lotufo. 2009. Note on the fisheries and biology of the golden crab (*Chaceon fenneri*) off the northern coast of Bra-zil. Lat. Am. J. Aquat. Res., 37(3): 571-576.

Cergole, M.C., A.O. Ávila-da-Silva & C.L.D.B. Rossi-Wongtshchowski (eds.). 2005. Análise das principais pescarias comerciais da região sudeste-sul do Brasil: dinâmica populacional das espécies em explotação. Série Documentos REVIZEE, Score Sul. Instituto Oceanográfio, USP, São Paulo, 176 pp.

Clark, M.R., V.I. Vinnichenko, J.D.M. Gordon, G.Z. Beck-Bulat, N.N. Kukharev & A.F. Nakora. 2007. Large scale distant water trawl fisheries on sea-mounts. In: T.J. Pitcher, T.J. Morato, P.J.B. Hart, M.R. Clark, N. Haggan & R.S. Santos (eds.). Sea-mounts: ecology, fisheries and conservation. Black-well Fisheries and Aquatic Resources Series 12. Blackwell Publishing. Oxford, pp. 361-369.

Costa, P.A.S., A.S. Martins & G. Olavo. 2005. Pesca e potenciais de exploração de recursos vivos na região central da Zona Econômica Exclusiva Brasileira. Sé-rie Livros 13, Documentos REVIZEE/SCORE Cen-tral. Museu Nacional, Rio de Janeiro, 247 pp.

Dallagnolo, R. 2008. A pesca de camarões-de-profundidade (Aristeidae) na região sudeste-sul do Brasil: avaliação da dinâmica de biomassa como fer-ramenta para gestão. MSc. Dissertation. Mestrado em Ciência e Tecnologia Ambiental, Centro de Ciências Tecnológicas da Terra e do Mar, Universidade do Va-le do Itajaí, Itajaí, 215 pp.

Dallagnolo, R., J.A.A. Perez, P.R. Pezzuto & R. Wahrli-ch. 2009. The deep-sea shrimp fishery off Brazil (De-capoda: Aristeidae): development and present status. Lat. Am. J. Aquat. Res., 37(3): 327-345.

Defeo, O. & A. Masello. 2000. La pesquería de cangrejo rojo *Chaceon notialis* en el Uruguay: un enfoque de manejo precautorio (1995 y 1996). In: M. Rey (ed.). Recursos pesqueros no tradicionales: moluscos, crus-táceos y peces bentónicos marinos. Proyecto URU/92/003. INAPE, Montevideo, pp. 7-22.

Figueiredo Jr., A.G. & L.S.P. Madureira. 2004. Topogra-fia, composição e refletividade do substrato marinho e identificação de províncias sedimentares na região sudeste-sul do Brasil. Série Documentos REVIZEE, Score Sul. Instituto Oceanográfio, USP, São Paulo, 64 pp.

Fontelles-Filho, A.A. & F.T.P. Ferreira. 1987. Distribui-ção geográfica da captura do pargo, *Lutjanus purpu-reus* Poey, e sua relação com os fatores oceanográfi-cos nas regiões norte e nordeste do Brasil. Bolm. Ciên. Mar., Fortaleza, 45: 1-23.

Haimovici, M.. 2007. A prospecção pesqueira e abun-dância de estoques marinhos no Brasil nas décadas de 1960 a 1990: levantamento de dados e avaliação críti-ca. Programa REVIZEE. Avaliação do Potencial Sus-tentável de Recursos Vivos na Zona Econômica Ex-clusiva. MMA/ SMCQ, Brasília, 325 pp.

Haimovici, M. & M.B. Peres. 2005. *Polyprion america-nus* Bloch & Schneider, 1801. In: M.C. Cergole, A.O. Ávila-da-Silva & C.L.D.B. Rossi-Wongtshchowski (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. 124-131.

Haimovici, M., A.S. Martins, J.L. Figueiredo, & P.C. Vieira. 1994. Demersal bony fish of outer shelf andslope off southern Brazil subtropical convergence ecosystem. Mar. Ecol. Prog. Ser., 108: 59-77.

Haimovici, M., A.O.Á vila-da-Silva, S.H.B. Lucato, G. Velasco &L.H. Arantes. 2007. A pesca de linha-de-fundo na plataforma externa e talude superior da re-gião sudeste-sul do Brasil em 1997 e 1998. In: C.L.D.B. Rossi-Wongtshchowski, 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. Série Documentos REVIZEE, Score Sul. Instituto Oceanográfico, USP, São Paulo, pp. 309-325.

Haimovici. M., M.C. Cergole, R.P. Lessa, L.S. Madureira, S. Jablonski & C.L.D.B. Rossi-Wongstchowski. 2006. Capítulo 2. Panorama Na-cional. In. MMA/ SQA. Programa REVIZEE: Avali-ação do Potencial Sustentável de Recursos Vivos na Zona Econômica Exclusiva. Relatório Executivo, pp. 79-126.

Kirkwood, G.P., J.R. Beddington & J.R. Russouw. 1994. Harvesting species of different lifespans. In: P.J. Ed-wards, R. May & N.R. Webb (eds.). Large-scale ecology and conservation biology. Oxford Blackwell Scientific, pp. 199-227.

Lima, J.H.M. & R.L. Branco. 1991. Análise das opera-ções de pesca do caranguejo de profundidade (*Ger-yon quinquedens* Smith 1879) por barcos japoneses arrendados na região sul do Brasil – 1984/85. Atlân-tica, Rio Grande, 1(13): 179-187.

Martins, A.S., G. Olavo & P.A.S. Costa. 2005. A pesca de linha de alto mar realizada pelas frotas sediadas no Espírito Santo, Brasil. In: P.A.S. Costa, A.S. Martins & G. Olavo (eds.). Pesca e potenciais de exploração de recursos vivos na região central da Zona Econômi-ca Exclusiva Brasileira. Série Livros, no. 13. Museu Nacional, Rio de Janeiro, pp. 35–55.

Paiva, M.P., C.A.S. Rocha, A.M.G. Gomes & M.F. An-drade. 1996. Fishing grounds of bottom liners on the continental shelf of south-east Brazil. Fish. Man. E-col., 3: 25-33.

Peres, M.B. & M. Haimovici. 1998. A pesca dirigida ao cherne-poveiro, *Polyprion americanus* (Polyprionida-e, Teleostei) no sul do Brasil. Atlântica, Rio Grande, 20: 141-161.

Peres, M.B. & M. Haimovici. 2003. Alimentação do cherne-poveiro *Polyprion americanus* (Polyprionidae, Teleostei) no sul do Brasil. Atlântica, Rio Grande, 25(2): 201-208.

Peres, M.B. & S. Klippel. 2003. Reproductive biology of southwestern Atlantic wreckfish, *Polyprion america-nus* (Teleostei: Polyprionidae). Environ. Biol. Fishes, 68(2): 163-173.

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

Perez, J.A.A. & P.R. Pezzuto. 2006. A pesca de arrasto de talude do Sudeste e Sul do Brasil: tendências da frota nacional entre 2001 e 2003. Bolm. Inst. Pesca, São Paulo, 32: 127-150.

Perez, J.A.A., R. Wahrlich & P.R. Pezzuto. 2009a. Chartered trawling on the slope off Brazilian coast. Mar. Fish. Rev., 71(2): 24-36.

Perez, J.A.A., P.R. Pezzuto, R. Wahrlich & A.L. Souza Soares. 2009b. Deep-awter fisheries in Brazil: history, status and perspectives. Lat. Am. J. Aquat. Res., 37(3):513:541,

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

Perez, J.A.A., P.R. Pezzuto, L.F. Rodríguez, H. Valentini & C.M. Vooren. 2001. Relatório da reunião técnica de ordenamento da pesca demersal nas regiões Sudes-te e Sul do Brasil. In: P.R. Pezzuto, J.A.A. Perez, L.F. Rodriguez & H. Valentíni (eds.). Reuniões de Orde-nanento da Pesca Demersal no Sudeste e Sul do Bra-sil: 2000-2001. Notas Téc. FACIMAR, 5: 1-34.

Perez, J.A.A., P.R. Pezzuto, H.A. Andrade, P.R. Schwin-gel, M. Rodrigues-Ribeiro & R. Wahrlich. 2002b. O ordenamento de uma nova pescaria direcionada ao peixe-sapo (*Lophius gastrophysus*) no sudeste e sul do Brasil. Notas Téc. FACIMAR, 6: 65-83.

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

Pezzuto, P.R. & R. Sant'Ana. 2009. Sexual maturity of the deep-sea royal crab *Chaceon ramosae* Manning, Tavares & Albuquerque, 1989 (Brachyura: Geryoni-dae) in southern Brazil. Lat. Am. J. Aquat. Res., 37(3): 297-311.

Pezzuto, P.R., J.A.A. Perez & R. Wahrlich. 2006a. O ordenamento das pescarias de caranguejos-de-profundidade (*Chaceon* spp.) (Decapoda: Geryonida-e) no sul do Brasil. Bolm. Inst. Pesca, 32(2): 229-247.

Pezzuto, P.R., J.A.A. Perez & R. Wahrlich. 2006c. Deep-sea shrimps (Decapoda: Aristeidae): new targets of the deep water trawling fishery in Brazil. Braz. J. Oceanogr., 54(2-3): 123-134.

Pezzuto, P.R., J.A.A. Perez, R. Wahrlich, W.G. Vale & F.R.A. Lopes. 2002. Avaliação da pescaria do caran-guejo-de-profundidade no sul do Brasil. Convênio Ministério da Agricultura, Pecuária e Abastecimento, Universidade do Vale do Itajaí (MAPA/SARC/DPA 03-2001; MAPA/SARC/DENA COOP/176/2002). Relatório Final, Itajaí-SC, 121 pp.

Pezzuto, P.R., J.A.A. Perez, R. Wahrlich, R. Sant'Ana, W.G. Vale & R.C. Santos. 2006b. Avaliação de esto-que e biologia populacional dos caranguejos-de-profundidade (*Chaceon notialis* e *Chaceon ramosae*) nas regiões sudeste e sul do Brasil. Relatório Técnico apresentado à 4a Sessão Ordinária do Subcomitê Ci-entífico do Comitê Consultivo Permanente de Gestão dos Recursos Demersais de Profundidade (CPG/Demersais)/ SEAP/PR, Itajaí, SC, 03-05/05/2006. DOC 11 SCC CPG 042006. SEAP/PR, Brasília, 42 pp.

Pires, D.O. 2007. The azoxanthellate coral fauna of Bra-zil. In: R.Y. George, & S.D. Cairns (eds.). Conserva-tion and adaptive management of seamount and deep-sea coral ecosystems. Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Mi-ami, pp. 265-272.

Rossi-Wongtshchowski, C.L.D.B., J.L. Valentin, S. Jablonski, A.C. Amaral, F.H. Hazin & M. El-Robrini. 2006. Capítulo 1. Ambiente marinho. In: Programa REVIZEE. Avaliação do Potencial Sustentável de Recursos Vivos na Zona Econômica Exclusiva. Rela-tório Executivo. Ministério do Meio Ambiente, Brasí-lia, pp. 21-78.

Soares, A.L.S. & G.S.S. Scheidt. 2005. Exportações brasileiras de caranguejos de profundidade (*Chaceonramosae* e *Chaceon notialis*) 1999- março 2004. Braz. J. Aquat. Sci. Technol., 9(1): 13-17.

Valentini, H. & P.R. Pezzuto. 2006. Análise das princi-pais pescarias comerciais da Região Sudeste-Sul do Brasil com base na produção controlada do período 1986-2004. In: C.L.D.B. Rossi-Wongstchowski (ed.) Série Documentos REVIZEE, Score-Sul. Instituto Oceanográfico da USP, São Paulo, 56 pp.

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