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CAPTURE FISHERY IN NORTHERN TODOS OS SANTOS BAY, TROPICAL SOUTHWESTERN ATLANTIC, BRAZIL

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ABSTRACT

Information on marine and estuarine capture fishery activity in northern Todos os Santos Bay, northeastern Brazil, based on daily data collected between September 2003 and June 2005 is presented. Small-scale artisanal fishery in this area includes the use of traditional vessels both non-motorized and motorized for locomotion, being carried out mainly by canoe or on foot, and involves many different kinds of gear, including gillnet, hook and line, seine nets, and traps. A total of 113 taxa were grouped into 77 resources, including 88 fish, 10 crustaceans, and 15 mollusks. Data on nominal catches of fish, crustaceans and mollusks are presented by month and location. A total of 345.2 tonnes of fishery resources were produced (285.4 tonnes of fish, 39.2 tonnes of fresh invertebrates, and 20.6 tonnes of processed invertebrates). Temporal variation in the fish catch was associated with the life cycle of the species or with the hydrographic conditions. The first-sale value of this catch amounted to around US$ 615,000.00, fishes representing 71.3% of it. A table of the average price of each fishery resource is presented. The results produced in this study may be considered a reference for future monitoring programs of fishery resources in the area.

RESUMO

Informações sobre a atividade pesqueira extrativa da região norte da Baía de Todos os Santos, Bahia, nordeste do Brasil são apresentadas, baseadas em coleta diária de dados, realizada entre setembro de 2003 e junho de 2005. Trata-se de uma atividade extrativa artesanal, na qual são utilizadas embarcações tradicionais para o deslocamento ao local da extração. Em cada pescaria foram utilizadas várias artes, tais como rede de espera, linha e anzol, rede de cerco, armadilhas. Foram identificadas 113 categorias taxonômicas de peixes (88), crustáceos (10) e moluscos (15), arranjadas em 77 tipos de pescados comercializados. A produção total no período foi de 345,2 t (285.4 t de peixes, 39,2 t de invertebrados frescos e 20,6 t de invertebrados processados). Variações espaço-temporais da produção total desses pescados podem estar relacionadas à sazonalidade das condições meteorológicas, oceanográficas ou biológicas. A partir do preço da primeira comercialização, foi obtido um valor da primeira venda de R$ 1 279 881,63, sendo 71,3% referentes à produção de peixes. Uma tabela de preço médio de cada recurso pesqueiro é fornecida. Contextualizando os dados pretéritos disponíveis, este trabalho pode ser considerado como uma referência para o futuro monitoramento da pesca na área.

Descriptors: Coastal fishery; Artisanal fishery; Fishing gear; Sale value; Northeast Brazil.
Descritores: Pesca costeira; Pesca artesanal; Arte de pesca; Preço de comercialização; Nordeste do Brasil.

INTRODUCTION

Todos os Santos Bay (12.61-13.13°S / 38.45-38.82°W), one of the most important waterways in Brazil (1,100 km²), is a complex ecosystem with brackish and marine waters, small internal bays, many islands, reefs, rivers, estuaries, mangroves, and rain forest, and has been a protected environmental area since June, 05 1999 in accordance with state law n° 7595 (GOVERNO DA BAHIA, 2007). Thirteen towns, including Salvador (capital of Bahia State), the ports of Salvador and Aratu, the Aratu naval base, chemical and oil terminals, an oil refinery, and small oil fields are also located on Todos os Santos Bay. The northern portion of the bay lies within the area of four municipalities (Madre de Deus, São Francisco do Conde, Salvador and Candeias), which have been under the direct influence of the oil terminal (Madre de Deus) and the PETROBRAS oil refinery – Refinaria Landulpho Alves Mataripe – RLAM (São Francisco do Conde) since 1949. There are thus many sources of anthropogenic pollution such as sewage disposal and industrial waste, the latter consisting mainly of oil refinery effluents.

According to Wake's review (2005) on the ecological impacts of oil refineries on the aquatic environment, there have been many studies concerning the lethal toxicity of refinery effluent, but few studies on the sub-lethal effects. The author pointed out the need for sub-lethal effect studies, especially because the refinery effluents are cleaner now and are more likely to be having sub-lethal rather than lethal effects. The author also pointed out the need for field studies to document the sub-lethal effects of pollutants on the growth and recruitment of aquatic organisms.

While it may be difficult to document individual effects on particular species, it might be possible to examine existing data streams to infer effects due to pollutants. For example, the variability of the fishery production may be a measure of the sub-lethal effects of the oil effluent on the community or population, through the analysis of the variability in species diversity and abundance.

In this context, the aim of this study is to characterize the fishery activities in the area under the influence of the oil refinery and the oil terminal, between September 2003 and June 2005. The catch compositions, their variation from locality to locality and over the months, and the different fishery techniques employed are described. This investigation was conducted within the scope of the "Environmental Monitoring Program of the Estuarine Area near the RLAM Refinery" coordinated by Cenpes/Petrobras in partnership with IOUSP – Instituto Oceanográfico da Universidade de São Paulo (Oceanographic Institute of the University of São Paulo). The purpose of this program was to describe the estuarine region around the oil refinery RLAM in terms of the physical, chemical, and biological aspects of the water and the sediment.

Fishing in the northern portion of Todos os Santos bay, as well as the fisheries on the coast of the state of Bahia, could be described as a typical small-scale artisanal fishery (DIAS-NETO; DORNELLES, 1996), providing food and livelihood for the local community. Although the northern sector of Todos os Santos bay is not considered an important region for the fish trade, this activity is an alternative source of income for the poorer sectors of the community, either temporarily or part-time (ALMEIDA, 1996, unpublished); SILVA, 1996, unpublished); GIANNINI, 2000 (unpublished).

According to the Madre de Deus city hall, depending on the political-economical context, fishery resources can serve as both food supplement and source of income (GIANNINI, 2000 (unpublished). Local fishery resources from estuaries, mangroves, inter-tidal zones, and reefs are exploited. They have been sold locally within the communities or by traders in the larger neighboring towns such as Salvador, the capital of the state and an international tourist center (GIANNINI, 2000, unpublished).

The assessment, monitoring, and enforcement of the fishery resources and fishery activities are very important for conservation and management. However, according to Giannini (2000, unpublished)), the information on fisheries required for a detailed diagnosis was not available for the Madre de Deus island area or for the state of Bahia as a whole. In addition to the gaps in basic and applied studies, the few research results available are grey literature. This is true of the Brazilian coastal artisanal fisheries as a whole, which need studies on stock assessment as a support for the national policy (VASCONCELLOS et al., 2007).

Material and Methods

Data on daily total catch were obtained by tabulating data forms from local fishermen as well as from 16 monitoring visits by researchers carried out at six fishing landing sites or fishing grounds, between September 2003 and June 2005. One additional site was included in the second year (September 2004 – June 2005) (Fig. 1). Those sites may be considered as capture locations due the limited operational range of the traditional vessels involved.

The local fishermen were trained for collecting scientific data on the forms, supplemented by their fishing knowledge. The fieldwork was supervised by a researcher and coordinated by the fishing association of Madre de Deus municipality working with a team of seven local fishermen, trained to collect data. During the sampling period, these fishermen were first trained, and then meetings were held monthly or every two months to monitor, evaluate, and review the form filling and to correct the identification of the organisms, for the purpose of maintaining confidence in the data.

Data registered on the forms were: name of the fisherman or fisherwoman; location, date and time of the fishing activity; name and type of the vessel; type of fishing gear employed; name, biomass, and first sale value of each resource.

Catches of fish, crustaceans and mollusks are expressed in biomass, which is the nominal weight at the time of capture, or in gutted weight in the case of some crustaceans and mollusks. A mass (kg) conversion table for the various trading units was made in order to calculate the total production, mainly for crustaceans and mollusks (Table 1). This conversion was based on the biomass provided and used by the fishermen. Data on total production of fish, crustaceans, and mollusks were calculated monthly, for each location. Data from Passé were excluded from the temporal comparative analyses because they did not cover the whole monitoring period.

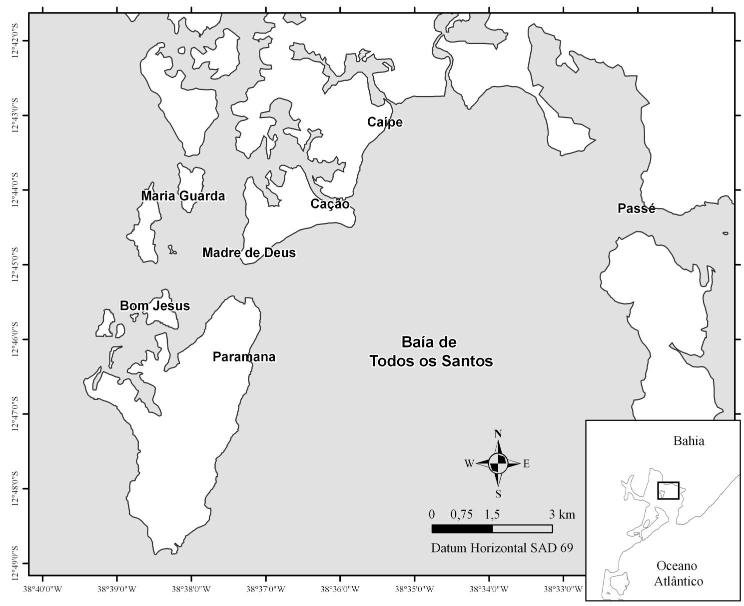

Fig. 1. Map of northern Todos os Santos bay, Brazil showing the six fishing landing sites or fishing grounds.

Table 1. Metric unit conversion of the local sale units of the fishery resources in northern Todos os Santos bay, Brazil

	bucket (8 l)	a hundred	rope (n=10)	a dozen	can (18 l)	liter
CRUSTACEANS						
Ghost crab			1.3 kg			
Land crab			1.1 kg	2.0 kg		
Mangrove crab			1.2 kg	1.2 kg		
Swimcrab	0.2 kg*		0.6 kg	0.6 kg	0.5 kg*	
MOLLUSKS						
American yellow cockle	6.5 kg			0.1 kg*	17 kg	
Ark	0.33 kg*				1 kg*	
Brazilian chank	0.33 kg*				1 kg*	
Conch, melongena					1.1 kg*	
Mussel	0.33 kg*			0.1 kg*	1 kg*	0.07 kg*
Oyster, penshell	0.4 kg*				1.2 kg*	
Stout tagelus				0.1 kg*	1 kg*	0.1 kg*
Thick lucine		0.83 kg*		0.1 kg*		0.1 kg*
West Indian pointed venus	0.33 kg*				1 kg*	
FISH						
Common snook					6 kg	
Herrings, anchovies					12 kg	
Miscellaneous fish					12 kg	
Mojarras					8 kg	
Shrimp eel					3 kg	

* processed product

A list of local names and taxonomic identification of fishes, crustaceans, and mollusks was prepared. Organisms were identified by the authors of the present paper according to specific taxonomy guides (FIGUEIREDO, 1977; FIGUEIREDO; MENEZES, 1978, 1980, 2000; MENEZES; FIGUEIREDO, 1980, 1985; RIOS, 1994; MELO, 1996, 1998; MENEZES et al., 2003). The validity of species was based on Eschmeyer and Fong (2008), ITIS (2008) and Conchas do Brasil (2008). A reference collection (56 fish resources) named as the PROMARLAM series was deposited in the biological collections of the Oceanographic Institute of the University of São Paulo.

Results

Observations during the monitoring visits to the study area indicated a lack of cooling and freezing facilities on the boats, in the fish market of Madre de Deus, and in the three fishery organizations, demonstrating the poor infrastructure of fishing activities. The fishery catch is transported to the landing sites by boat and sold on the spot, on the street, or in the market. Thus, fishing activity is limited by distance due to the availability of boats, and the transit time due to the perishability of the products.

Catch data, based on 24,218 forms, showed that fishing activity was performed by 1,429 fishermen and fisherwomen, most of them (90%) only working at one landing site. Fishing grounds were reached mainly by canoes (61%), small boats (9%), or on foot (21%); however, these vessels are only used for locomotion, not as fishing platforms. The canoes (3-5 m. long) are wooden vessels, propelled with paddles, some of them with an auxiliary sail, usually operated by one or two fishermen. The boats (4-6 m. long) are fitted with a low-power inboard engine (11 HP or less), and usually operated by two or three fishermen. Fishing activity takes place in the near-shore waters due to the range of the traditional artisanal vessels, and also along the intertidal zones, during the morning (59%).

A total of 47 fishing gear names were registered, classified according to the type of fishing for which they were used, in addition to free diving. A brief description of each gear or set of gear is presented in Table 2. One to five kinds of gear were used in each fishing activity, characteristic of multiple gear fishing. Gathering by hand or with simple hand implements (spoon, axe, hatchet, and shovel) was the most frequent method employed (occurrence of 31%), mainly for gathering bivalve species on foot in the intertidal zones of two sites (Caípe and Cação). Other common fishing techniques were fixed gillnet (passive gear) and handline and longline fishing (active gear). Line fishing was mainly used in Bom Jesus and Maria da Guarda islands, and fixed gillnets in Paramana and Passé. A local kind of encircling net known as *abalo*, a kind of passive-active gear, was mainly used in Passé and Madre de Deus Island; in this method of capture, the paddle is hit on the water (or on the bottom of the boat) to make a noise and to frighten the fish towards the surrounding net and thus get entangled in it. In addition, a range of net types was applied, including beach seine nets, traps, cast nets, luring, and encircling nets. Free diving was usually performed by only one fisherman (averaging two-minute duration) for hand-capture of some mollusks (fighting conch - *peguari* or ark - *sambá*) and lobsters, or for hunting lobsters and some fishes with a spear.

Table 2. Types of fishing gear used by artisanal fishers in northern Todos os Santos bay, Brazil.

English name	**Portuguese name**	**Comments**	Occurrence (%)*
Beach seine	Rede de arrasto	A long net which is dragged parallell to the shoreline by two fisherman. Used to catch shrimps and small fishes.	6.03
Cast nets	Tarrafa	A circular net with varied mesh size operated by a fisherman from the boat or from the shore.	2.23
Diving	Mergulho	Sometimes harpoon is also used.	6.64
Encircling gillnets	Abalo	Noise is used to force fish to gill or entangle themselves in the netting surrounding them.	13.68
Encircling gillnets	Rede de cerco	Nets made of monofilament nylon strand used to encircling schools of fish. Operated by small boats.	0.03
Fixed gill nets	Rede de espera (arraeira, caçoeira, lincheira, paruzeira, rede de caçonete, sororoqueira, tainheira)	Fish are gilled or enmeshed in the net.	14.57
Gathering	Ferramenta manual	Gathering by hand or with simple hand implements	31.02
Handline	Linha de mão	All fishery carried out by monofilament nylon strand operated by hand.	16.01 **
Longline	Espinhel, grozeira	Consists of a mainline 50 to 100 m in lenght, whith 100 to 200 hooks.	
Luring	Atrator luminoso	Light attraction for fishing swimcrab and fish.	4.37
Traps	Armadilha (gaiola, manzuá, jereré, ratoeira)	Cages or baskets made of various materials (wood, metal, bamboo) set with baits. The "jereré" is a saclike net used in shallow waters or from the boat.	10.65
Total of filled forms			23061

* Multiple answers

**Handline and longline coupled

Species

An estimate of 113 taxa (species or genera), grouped into 77 aggregated fishing resources, including 88 fishes, 10 crustaceans, and 15 mollusks, was made for the study area (Table 3). These include pelagic, bentho-pelagic, benthic, intertidal, and coral-reef species. The resources of high catch biomass were small pelagic fishes, such as herrings (Clupeidae) and anchovies (Engraulidae), several species of mullet (Mugilidae), and several species of ray and skate. Other species are included among the representative bentho-pelagic resources: jack (Carangidae), mackerel (Scombridae), and weakfishes (Sciaenidae); and among the benthic or demersal resources: catfish, shrimp, swimming–crab, ghost crab, land crab, oyster, snappers (Lutjanidae), and seabream (Sparidae).

Catches

A total of 345.2 tonnes of fishery resources was produced during the monitoring period (22 months), composed of 285.4 tonnes of fishes, 39.2 tonnes of fresh invertebrates, and 20.6 tonnes of processed invertebrates.

Monthly, the total fish production ranged from 8 tonnes (February 2005) to 19 tonnes (February 2004) (Fig. 2). The highest production occurred in the first quarter (summer) of 2004; the fourth quarter (spring) of 2003 and 2004 showed the same trend, with a decrease in production between October and November, and an increase in December. The most frequently captured fish were rays, mullet, herrings and anchovies. Other representative resources were catfish, horse-eyed, jack (*cabeçudo*), lane snapper (*vermelho*), weakfishes (*pescada*), serra Spanish mackerel (*sororoca*), and western Atlantic sea-bream (*sambuio*). The production of rays was primarily responsible for the monthly variation in total production. There was an alternation between the production of mullet, and that of herrings and anchovies. The production of mullet was higher during the fourth quarter (spring) of 2003 and first quarter (summer) of 2004, the production of herrings and anchovies was higher from the second (fall) to fourth (spring) quarters of 2004 (Fig. 2). During the study period, the highest production occurred in Bom Jesus, and the lowest in Caípe (Fig. 3), with biomass variation of the most important fish.

Table 3. Species composition of fishery resources (scientific and common names) caught between September 2003 and June 2005, in northern Todos os Santos bay, Brazil.

ENGLISH NAME	LOCAL NAME	OTHER ENGLISH NAMES	OTHER LOCAL NAMES	SCIENTIFIC NAME	FAMILY
CRUSTACEANS	**CRUSTÁCEOS**				
Ghost crab	Caranguejo	-	-	*Ucides cordatus*	Ocypodidae
Land crab	Guaiamu	Giant land crab	-	*Cardisoma guanhumi*	Gercacinidae
Lobster	Lagosta	Spiny loster	Lagosta verde	*Palinurus* spp.	Palinuridae
Mangrove crab	Aratu	Mangrove root crab	-	*Goniopsis cruentata*	Grapsidae
		Mangrove tree crab	-	*Aratus pisonii*	Sesarmidae
Shrimp[1]	Camarão	-	-	-	Penaeidae
Small shrimp	Camarão pequeno	Atlantic seabob	-	*Xiphopenaeus kroyeri*	Penaeidae
Swimcrab[2]	Siri	Blotched swimming crab	Siri bóia, siri branco, siri canxaga, siri regateira, siri mangue	*Portunus spinimanus*	Portunidae
		Dana swimcrab		*Callinectes danae*	Portunidae
		Shelling crab		*Callinectes ornatus*	Portunidae
		Blunttooth swimcrab		*Callinectes bocourti*	Portunidae
MOLLUSKS	**MOLUSCOS**				
American yellow cockle	Rala-côco	-	-	*Trachicardium muricatum*	Cardiidae
Ark	Sambá	Incongruous ark	-	*Anadara brasiliana*	Arcidae
Brazilian chank	Tapu	-	-	*Turbinella laevigata*	Turbinellidae
Conch, melongena	Peguari	Fighting conch	-	*Strombus pugilis*	Strombidae
		Giant hairy melongena	-	*Pugilina morio*	Melonginidae
Mussel	Sururu	-	Sururu-de-coroa	*Mytella* spp., *Mytella charruana*	Mytilidae
Octopus	Polvo	-	-	*Octopus* spp.	Octopodidae
Oyster, penshell	Ostra	Pacific cupped oyster	Ostra de mangue	*Crassostrea* spp., *Crassostrea rhizophorae*	Ostreidae
		Half-naked penshell	Ostra de palma	*Atrina seminuda*	Pinnidae
Squid	Lula	-	-	*Loligo* spp.	Loliginidae
Stout tagelus	Mapele	-	-	*Tagelus plebeius*	Solecurtidae
Thick lucine	Lambreta	-	-	*Lucina pectinata*	Lucinidae
West Indian pointed venus	Papa-fumo	-	-	*Anomalocardia brasiliana*	Veneridae

Table 3. Continuation.

ENGLISH NAME	LOCAL NAME	OTHER ENGLISH NAMES	OTHER LOCAL NAMES	SCIENTIFIC NAME	FAMILY
CRUSTACEANS	**CRUSTÁCEOS**				
Acoupa weakfish	Pescada-amarela	-	-	*Cynoscion acoupa*	Sciaenidae
African pompano	Aracanguira	-	-	*Alectis ciliaris*	Carangidae
Angelfish, Spadefish	Paru	Atlantic spadefish	Paru-branco	*Chaetodipterus faber*	Ephippidae
		French angelfish	Paru-cagão	*Pomacanthus paru*	Pomacanthidae
Atlantic bigeye	Olho-de-vidro	-	-	*Priacanthus arenatus*	Priacanthidae
Atlantic bumper	Garapau	-	Garapau-fava	*Chloroscombrus chrysurus*	Carangidae
Barracuda	Bicuda	-	-	*Sphyraena* spp.	Sphyraenidae
Barred grunt	Corvina-amarela	-	-	*Conodon nobilis*	Haemulidae
Bluewing searobin	Voador	-	Cabrinha	*Prionotus punctatus*	Triglidae
Burrfish	Baiacu-espinho	Web burrfish	-	*Chilomycterus antillarum*	Diodontidae
Chere-chere grunt	Coró	Grunt	Coró branco, coró de pedra	*Pomadasys* spp., *Haemulon steindachneri*	Haemulidae
Cobia	Bijupirá	-	-	*Rachycentron canadum*	Rachycentridae
Common snook	Robalo	-	Robalo branco, robalo-flecha, robalinho	*Centropomus undecimalis*	Centropomidae
Doctorfish	Barbeiro	Ocean surgeon	-	*Acanthurus bahianus*	Acanthuridae
Dog snapper	Dentão	-	-	*Lutjanus* spp., *Lutjanus jocu*	Lutjanidae
Fat snook	Robalo-pena	-	-	*Centropomus parallelus*	Centropomidae
Flounder, sole, tonguefish	Linguado	Sole	Aramaçã	*Achirus* spp.	Achiridae
		Flounder	Aramaçã	*Bothus* spp.	Bothidae
		Tonguefish	Aramaçã	*Symphurus* spp.	Cynoglossidae
		Flounder	Aramaçã	*Citharichthys* spp., *Syacium* spp., *Paralichthys* spp.	Paralichthydae
Giant grouper	Mero	-	-	*Epinephelus itajara*	Serranidae
Grey snapper	Caranha	-	Acaranha	*Lutjanus griseus*	Lutjanidae
Grouper, seabass, hamlet	Garoupa	-	-	*Epinephelus* spp.	Serranidae
		Coney seabass	-	*Cephalopholis fulva*	Serranidae
		Mutton hamlet	-	*Alphestes afer*	Serranidae
	Badejo	-	Badejo-amarelo, badejo guba	*Mycteroperca* spp.	Serranidae
Halfbeak	Agulha-branca	Ballyhoo halfbeak	-	*Hemiramphus brasiliensis*	Hemiramphidae
		Common halfbeak	-	*Hyporamphus unifasciatus*	Hemiramphidae
Herrings, anchovies	Sardinha	Atlantic thread herring	Pititinga, massambê, xangó	*Opisthonema oglinum*	Clupeidae
		Anchovy		*Anchoa* spp.	Engraulidae
		Zabaleta anchovy		*Anchovia clupeoides*	Engraulidae
		Atlantic anchoveta		*Cetengraulis edentulus*	Engraulidae
Jacks	Cabeçudo	Blue runner	Xáreu, xaréu amarelo, chumberga, cabeçudinho, guaricema	*Caranx crysos*	Carangidae
		Horse-eye jack		*Caranx latus*	Carangidae
	Guaraiuba	-	-	*Caranx* spp.	Carangidae
King mackerel	Cavala	-	Cavalinha	*Scomberomorus cavalla*	Scombridae
Ladyfish	Obarana	-	-	*Elops saurus*	Elopidae
Lane snapper	Vermelho	-	Ariacó	*Lutjanus synagris*	Lutjanidae
Largehead hairtail	Espada	-	-	*Trichiurus lepturus*	Trichiuridae
Leatherjacket, pompano	Solteira	Maracaibo leatherjacket	Pampo, pampo amarelo, dourado, riate	*Oligoplites palometa*	Carangidae
		Atlantic leatherjacket		*Oligoplites saurus*	Carangidae
		Pompano		*Trachinotus* spp.	Carangidae
Live sharksucker	Pegador	-	-	*Echeneis naucrates*	Echeneidae
Lookdown	Peixe-galo	-	Galo bandeira	*Selene* spp., *Selene vomer*	Carangidae

Table 3. Continuation.

ENGLISH NAME	LOCAL NAME	OTHER ENGLISH NAMES	OTHER LOCAL NAMES	SCIENTIFIC NAME	FAMILY
CRUSTACEANS	**CRUSTÁCEOS**				
Mojarra	Carapeba rajada	Caitipa mojarra	Carapeba listrada, carapeba riscada	*Diapterus rhombeus*	Gerreidae
		Irish mojarra		*Diapterus auratus*	Gerreidae
	Carapeba	Brazilian mojarra	Carapeba-branca,	*Eugerres brasilianus*	Gerreidae
			carapeba de lama		
	Carapicu	Jenny mojarra	Carapicu branco, carapicu flecha	*Eucinostomus gula*	Gerreidae
		Silver mojarra		*Eucinostomus argenteus*	Gerreidae
Moray	Caramuru	-	Moréia	*Gymnothorax* spp.	Muraenidae
Mullets	Tainha	Lebranche mullet	Chaverta, curimã, saúna	*Mugil* spp., *Mugil liza*	Mugilidae
Mutton snapper	Cioba	-	-	*Lutjanus analis*	Lutjanidae
Needlefish	Agulha	Atlantic needlefish	-	*Strongylura marina*	Belonidae
		Timucu	-	*Strongylura timucu*	Belonidae
Pacuma toadfish	Pocomom	-	-	*Batrachoides surinamensis*	Batrachoididae
Parrot fish	Budião	-	Budião batata, budião manteiga	*Scarus* spp., *Sparisoma* spp.	Scaridae
Porkfish	Salema	-	-	*Anisotremus virginicus*	Haemulidae
Puffers	Baiacu	Checkered puffer, bandtail puffer	Baiacu mangue, baiacu feiticeiro, baiacu bundinha, baiacu facho, baiacu guimba	*Sphoeroides* spp., *Sphoeroides testudineus, S. splengleri*	Tetraodontidae
Rays	Arraia	Stingray	Arraia-branca, arraia-amarela	*Dasyatis* spp.	Dasyatidae
		Butterfly ray	Arraia-manteiga	*Gymnura* spp.	Gymnuridae
		Guitarfish	Viola	*Rhinobatos* spp.	Rhinobatidae
Sailor's grunt	Cambuba	-	Coró branco, coró de pedra	*Haemulon parra*	Haemulidae
Scad	Xixarro	-	-	*Decapterus* spp.	Carangidae
		Bigeye scad	-	*Selar crumenophthalmus*	Carangidae
Sea catfish	Bagre	Gafftopsail sea catfish	Bagre-branco	*Bagre marinus*	Ariidae
		Madamango sea catfish	Bagre-amarelo	*Cathorops spixii*	Ariidae
		Bressou sea catfish	Bagre-amarelo	*Aspistor luniscutis*	Ariidae
Serra Spanish mackerel	Sororoca	-	-	*Scomberomus brasiliensis*	Scombridae
Sharks	Cação	Caribbean sharpnose shark	Caçonete	*Rhizoprionodon porosus*	Carcharhinidae
		Nurse shark	Cação lixa	*Ginglymostoma cirratum*	Gynglymostomatidae
Sheepshead porgy	Pena	-	-	*Calamus penna*	Sparidae
Shrimp eel	Miroró	-	Miroró mirim, mirim	*Ophicthus* spp., *Ophicthus gomesii*	Ophichthydae
Spotted eagle ray	Pintado	-	Raia-pintada	*Aetobatus narinari*	Myliobatidae
Squirrelfish	Jaguaraça	-	-	*Holocentrus adscensionis*	Holocentridae
Tarpon	Caramuru pinho	-	-	*Megalops atlanticus*	Megalopidae
Weakfish	Pescada	-	Pescada-branca, pirambeba	*Cynoscion* spp.	Sciaenidae
Western Atlantic seabream	Sambuio	-	Bobó	*Archosargus rhomboidalis*	Sparidae
Whitemouth croaker	Corvina	-	Corvina branca	*Micropogonias furnieri*	Sciaenidae
Yellowtail amberjack	Arabaiana	-	-	*Seriola lalandi*	Carangidae
Miscellaneous fish (3)	Peixe misto (3)				

[1] Various species, including *Penaeus* spp.
[2] Soft crab
[3] Small fish of various species

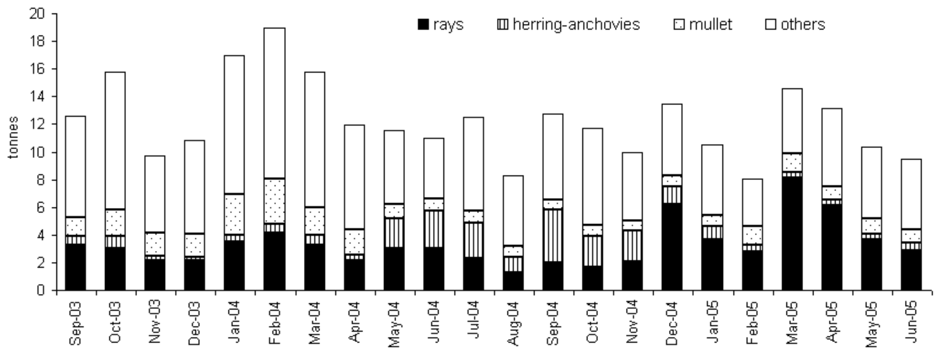

Fig. 2. Monthly fish production during the years 2003 – 2005, in northern Todos os Santos bay, Brazil.

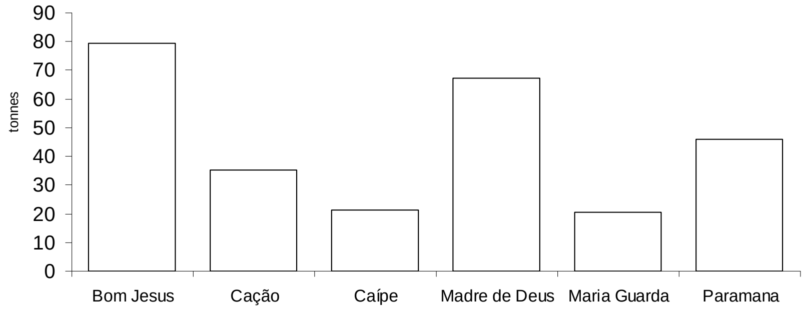

Fig. 3. Total fish production per site, during September 2003 – June 2005, in northern Todos os Santos bay, Brazil.

The total catch of fresh crustaceans ranged from 0.6 tonne in September 2003 and January 2005 to 3 tonnes in February 2004 (Fig. 4). The highest values were registered in the first (summer) and second (fall) quarters of 2004. There were noticeably lower catches toward the second half of the time series. Catches of shrimps and ghost crabs were primarily responsible for that trend. Total production of processed crustaceans, i.e., the swimming-crabs, was lower than that of the fresh ones, and did not show any trend, amounting approximately to 0.4 tonne monthly during the studied period (Fig. 5). In contrast to the crustacean production, the larger part (87%) of the catch of mollusks was processed. The highest values were found during the third (winter) and fourth (spring) quarters of 2003, and the lowest, during the second (fall) and third (winter) quarters of 2004 (Fig. 6). This trend was due to the production of the West Indian oyster, pointed Venus (*papa-fumo*), and fighting conch (*peguari*). The American yellow cockle (*rala-coco*), the main fresh mollusk resource, showed the highest value during the fourth quarter (spring - October) of 2003 and the third quarter (winter - August) of 2004 (Fig. 7).

Fishing catches were sold at the landing spot or in the Madre de Deus market, the only market in the study region. The first value of this catch amounted to US$ 614,995.00, around US$ 28,000.00 per month. Fish resources were responsible for 71.3 % (US$438,491.44) of the total revenue, crustaceans for 20.4 %, and mollusks for 8.4%. The average price of the fish resources varied from US$ 0.78/kg for miscellaneous fish to US$ 3.18/kg for fat snook (*robalo-pena*). Herring and anchovies are among the cheapest fishes; rays are of intermediate values; and snooks and snappers are the most highly valued fishes (Table 4). The table of the first sale value (US$) of crustacean and mollusk resources showed that average value of processed invertebrates was higher than that of the fresh ones (Table 5). Among fresh crustaceans, lobster showed the highest value (US$ 5.53/kg) while the ghost crab (*caranguejo*) and the mangrove-crab (*aratu*) the lowest one; shrimp also had a high price (US$ 3.90/kg). Overall, the average price of processed crustaceans was US$ 4.00/kg, and the processed mollusks reached higher values than the fresh ones, with the exception of squid and octopus.

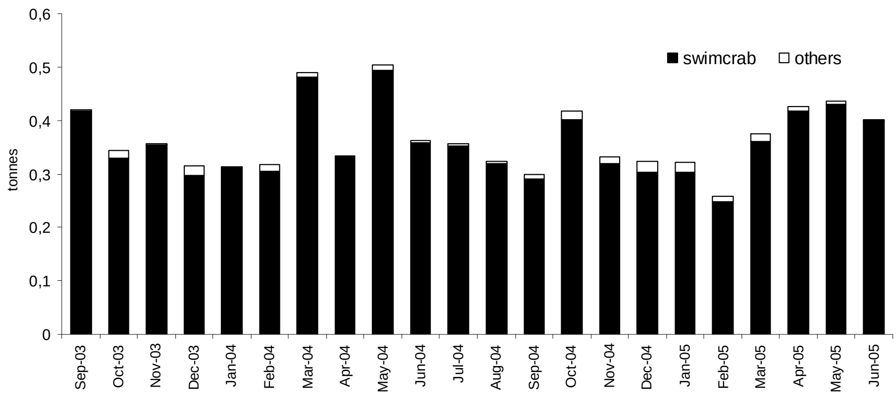

Fig. 5. Monthly processed crustacean production during the years 2003 – 2005, in northern Todos os Santos bay, Brazil.

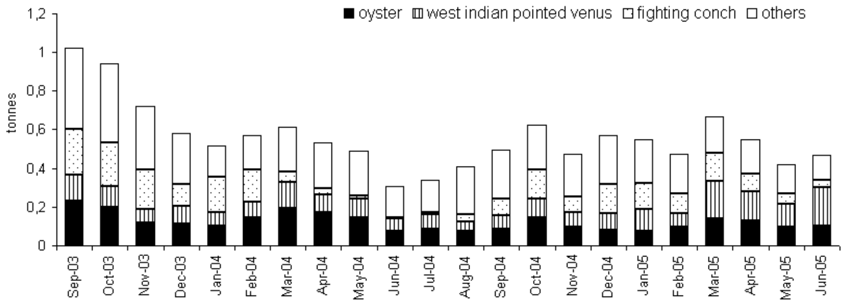

Fig. 6. Monthly processed mollusks production during the years 2003 – 2005, in northern Todos os Santos bay, Brazil.

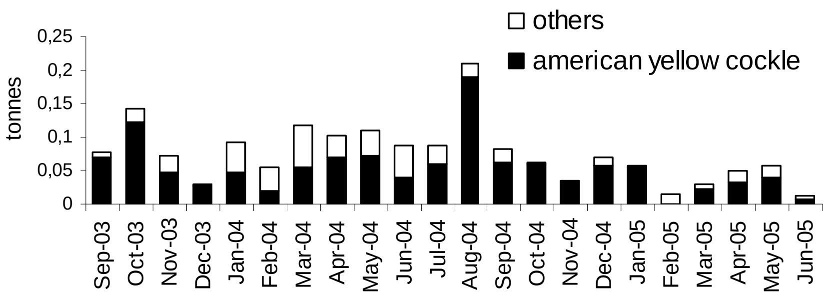

Fig. 7. Monthly fresh mollusks production during the years 2003 – 2005, in northern Todos os Santos bay, Brazil.

Table 4. First sale value of fish resources (US$/ kg) and total catch (kg) in northern Todos os Santos bay, Brazil.

Fish	US$/kg	Total Catch (kg)
Acoupa weakfish	2.54	425.5
African pompano	2.35	190.5
Angelfish and Spadefish	1.47	2424.5
Atlantic bigeye	2.04	358.5
Atlantic bumper	1.01	3949.5
Barracuda	2.04	1176.0
Barred grunt	2.03	143.0
Bluewing searobin	0.94	389.3
Brazilian mojarra	1.41	5410.8
Burrfish	1.34	63.5
Caitiba mojarra, Irish mojarra	1.85	1039.8
Chere-chere grunt	1.06	5791.1
Cobia	2.71	1251.0
Common snook	3.05	6317.2
Doctorfish	1.12	93.8
Dog snapper	3.07	2258.4
Fat snook	3.18	2033.0
Flounder, sole, tonguefish	1.50	939.2
Gafftopsail sea catfish	0.84	9838.7
Giant grouper	2.65	454.5
Grey snapper	2.83	709.0
Grouper, seabass, hamlet	1.82	243.0
Halfbeak	1.54	424.5
Herring, anchovies	0.82	25620.9
Jacks	2.16	13102.0
Jenny mojarra, Silver mojarra	1.03	1536.2
King mackerel	2.11	2132.3
Ladyfish	1.38	460.0
Lane snapper	2.70	9698.7
Largehead hairtail	1.14	1567.0
Leatherjacket and pompano	2.29	3817.4
Lebranche mullet	1.76	29642.6
Live sharksucker	0.85	13.5
Lookdown	2.69	527.5
Miscellaneous fish	0.78	929.3
Miscellaneous sea catfish	1.26	3643.8
Moray	1.58	2652.2
Mutton snapper	2.59	782.0
Needlefish	1.44	647.8
Pacuma toadfish	1.36	926.1
Parrot fish	1.47	2220.0
Porkfish	2.88	15.0
Puffers	1.51	1471.2
Rays	1.21	72538.0
Sailor's grunt	1.26	4470.5
Scad	1.17	600.0
Serra Spanish mackerel	1.93	9441.5
Sharks	2.20	2400.0
Sheepshead porgy	2.24	487.3
Shrimp eel	1.11	2891.5
Spotted eagle ray	1.89	9926.0
Squirrelfish	0.80	9.0
Tarpon	1.63	147.0
Unidentified grouper	2.63	102.6
Unidentified jack	1.69	338.0
Weakfish	2.12	8027.2
Western Atlantic seabream	1.42	8232.9
Whitemouth croaker	1.97	2911.0
Yellowtail amberjack	1.73	45.0
Average = 1.56		269 897.3

Table 5. First sale value of crustaceans and mollusks (US$/ kg) and total catch (kg) in northern Todos os Santos bay, Brazil.

	Fresh		Processed	
	First value (US$/kg)	Total catch (kg)	First value (US$/kg)	Total catch (kg)
Crustacean				
Ghost crab	1.46	9506.9	3.96	49.2
Land crab	1.83	2673.4	4.00	6.0
Lobster	5.53	1782.4		
Mangrove crab	1.43	619.2	3.74	145.1
Shrimp	3.90	8528.1		
Small shrimp	2.16	804,0		
Soft crab	3.68	553.1	4.80	0.6
Swimcrab	2,00	6804.4	4.40	6363.9
Average	**2.56**		**4.38**	
Mollusks				
American yellow cockle	0.27	1201.1	3.01	211.6
Ark	1.50	24,0	4.84	2267.4
Brazilian chank			3.75	54.9
Conch, melongena			4.82	2041.1
Mussel	0.72	98.5	3.51	
Octopus	4.43	13,0		1569.1
Oyster, penshell	1.98	12,0	3.22	2400.3
Squid	4.01	237.8		
Stout tagelus	3.46	3.1	6.41	14.4
Thick lucine	0.65	38.5	6.59	528.8
West Indian pointed venus	1.71	7.0	3.35	1794.9
Average	**1.16**		**4.07**	

DISCUSSION

Worldwide the marine fisheries primarily exploit the continental shelves and coastal waters (LONGHURST; PAULY, 2007), which have long been heavily impacted by human activity. Todos os Santos bay is a populous area which has suffered the corresponding anthropogenic impact of fishing activities, and since 1949 has been under the impact of oil effluents, after the establishment of an oil refinery and oil terminal. Overall in the coastal areas of the world the decline of fishery stocks has been caused primarily by overfishing and environmental degradation, though, according to the concept of Pauly (1988), it is closely linked to poverty. For example, in eight Asian countries (Bangladesh, India, Indonesia, Malaysia, the Philippines, Sri Lanka, Thailand, and Vietnam) and developing countries such as Brazil, the major contributor to this decline is overfishing, followed by environmental degradation (STOBUTZKI et al., 2006).

Assessment, monitoring and enforcement are crucial for the conservation and sustainable management of fishery resources. It is, further, crucial to identify the natural fluctuations of populations, which depend on the capacity of the environmental and the life cycles of the species concerned as well as on the evaluation of the effects of the anthropogenic impacts (CASPERS, 1987). Nevertheless, so that the assessment and monitoring may be carried out, the information on the status and trends of fisheries should be provided opportunely, in accordance with the strategy recommended by FAO (2003). There are many gaps in catch databases and our knowledge of the population dynamics of the stocks in the study area as a result of the priority accorded to the economic vision of the national fisheries policy prior to the end of the 80's. The environmental view of fishing, which regards fishery resources as components of ecosystems, was implemented between 1991 and 1995 (DIAS-NETO, 2002, (unpublished); DIAS-NETO; MARRUL-FILHO, 2003), conjointly with the economic view. Beyond that, the available fishery information from the area has been presented as grey literature or in Government statistical bulletins (IBAMA, 2003, 2005). The main difficulty is the lack of systematic time series data on catch production.

The fisheries in the study area are typically artisanal and small-scale, being carried out with a large variety of techniques, as is generally true of the fishing on the coast of Bahia state (total of 1,188 km, including bays and estuaries; 13% of the Brazilian coast) (IBAMA, 2003; IBAMA, 2007). A consequence of this complexity is that, due to the variety of gear used as well as to the great variety of species that compose the stocks, the assessment of catch production and of fishing effort are challenging tasks. This is typical of the worldwide scenario of artisanal fisheries and few countries have been successful in implementing adequate data collection and monitoring multispecies stocks under these conditions (VASCONCELLOS et al., 2007).

Some difficulties, such as the common names of the resources and generally low literacy among the fishermen, were encountered during the study. This is typical of artisanal fisheries in developing countries (OBURRA et al., 2002) and of fishermen living in poorer conditions. In some cases several common names are used for one particular species or many species may be grouped under one common name. The richness of the common names of Brazilian fish species has been the subject of an extensive article, and the authors concluded that it poses a problem for catch statistics because any attempt to assess the relative impact of different resources will be rendered unsatisfactory by the incomplete understanding of the nomenclature involved (FREIRE; PAULY, 2005). We attempted to cope with this problem by revising all the data on the forms carefully during the monitoring visits, but much still remains to be done. A satisfactory solution to the problem of the common names of the resources would be a collection of references to each resource, listing both the common and the scientific names.

The total proportion of the catches of fish, crustaceans and mollusks showed a similar tendency to that of those registered between 2002 and 2006 for the Bahia state coast. Also, the lists of the species caught and of the top fishery resources (sardine and anchovy, mullet, and shrimp) are similar to those available in the literature (CEPENE, 2003, 2005, 2007; IBAMA, 2008). The production was dominated by demersal species, following the tendency of the Brazilian capture marine fisheries (FAO, 2005), and also the tendency of small-scale fisheries worldwide, e.g. in Asia (STOBUTZKI et al., 2006) and in Tanzania (JIDDAWI; OEHMAN, 2002). A resource peculiar to the Brazilian fishery market is the ghost crab (*Ucides cordatus)*, one of the main mangrove swamp resources in northeastern Brazil, the stocks of which have been managed by the government since 1989 (MOTA, 2005).

The intra-annual variability of the fish total catch (mainly ray and skate) showed similar trends in the study area to those on the whole of the coast of Bahia state during 2002, the highest production occurring during summer and spring (BAHIA PESCA, 2003). Different trends were observed depending on the resource category or local conditions, which may be associated with many factors such as oceanographic, meteorological, biological, and socio-economic conditions, or even oil pollution. The study area is evidently subject to a meteorological seasonal cycle. In the estuary, there is a hydrographic summer-winter cycle, with prevailing marine conditions during the summer and estuarine conditions during the winter (PETROBRAS/FUSP/IOUSP, 2005, unpublished). Possibly this variability could be linked to fluctuations in the abundance of some resources, as in the case of sardine catches during fall and winter months or the catches of mullet, shrimps, crabs, and fighting conch (*peguari*) during the spring and summer months. Studies on population dynamics are needed for us better to understand the interactions between the populations and the environment, which may explain the great variations in abundance. However, no basic information on the population dynamics of the main species of the study area is yet available in the literature.

In summary, as expounded above, there are some similarities between our results and those found in the literature in terms of the proportion of the total catch of fish, crustaceans, and mollusks, of the resources most frequently caught, and of intra-annual variability of total catch. But in terms of production, there is a discrepancy both in total catch and in number of fishermen. At first sight, hypothetically, one may attribute this scenario to the impact of oil effluents in the study area. The decrease in fish production, even the collapse or extinction of some fish resource species has also been associated with the oil discharge (PETROBRAS/PANGEA, 2004, unpubliahed). This is a plausible argument because the oil refinery wastes can produce a severe, negative impact on the aquatic environment. Nevertheless, as things stand, a comparative and critical analysis of the data does not allow one to relate the decrease in the fishery resource production to the oil pollution, because different sampling designs and methodologies have been used to obtain the catch data in the available studies. In view of the lack of a robust database for purposes of comparison, we propose that our results should be used as a reference point for future monitoring of the marine fisheries of the Madre de Deus and nearby regions, with a view to improving responsible harvesting of the wild fish stocks. It serves as an initial baseline contribution to separating the effects of fishing from those of pollution and natural climatic variability.

Our first recommendation is that fisheries statistics should be improved in order to characterize the population dynamics of the fish species and to assess the environmental impact on those dynamics. We also recommend the maintenance of the monitoring of the fish species on a daily basis by the oil companies such as to cover other areas free of oil pollution to serve as control areas. The oil companies should be invited to contribute to a funding source for the purpose of establishing baseline monitoring of fisheries along the Brazilian coast so that we might thus better assess the impact of refineries, terminals, pipelines, off-shore platforms and land wells on the marine environment.

Although complex and challenging, the ideal design for assessing oil pollution impacts would be a BACI (Before/After Control/Impact) design (UNDERWOOD, 1991, 1992; SMITH, 2002). Starting from our baseline, the monitoring of the gathering of shellfish should be distinguished from that of other fishing activities. For the shellfish gathering, Cação and Caípe could be considered as replicated impacted sites, and Maria da Guarda Island and Bom Jesus as control sites. For the other fishing activities, mainly for fish capture, we propose Madre de Deus Island, Paramana and Passé as replicated impacted sites, and the same control sites as those for shellfish gathering.

Abundance of resources in terms of catch per unit effort (CPUE) should be calculated in terms of fisherman/day for each kind of gear and fishing locality in order to assess the status of individual stocks and communities. Population parameters (e.g. growth, mortality) and biological cyclic events (e.g. spawning season, larval time span) should be addressed for detecting short-term (pulse) or long-term (press) impacts (UNDERWOOD, 1991) on the resources. Initially, we propose that population studies should focus on the most abundant and economically important species: the bivalves *Crassostrea rhizophorae* and *Anomalocardia brasiliana* for shellfish gathering; the fishes *Opisthonema oglinum and Mugil curema* for other fishing activities.

The inventory of the common and scientific names of the resources needs to be improved to assess the relative impact on the different resources. Also of paramount importance is the monitoring of the socio-economic dynamics of the fishing communities.

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