

# Fishery and the use of space in a tropical semi-arid estuarine region of Northeast Brazil: subsistence and overexploitation

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## ABSTRACT

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Fishery activities were described in a tropical estuary of the Northeast Coast of Brazil. Semi-structured questionnaires were applied to fishers (N=263) at three villages of the Goiana Estuary. The average individual income was US\$ 329 (SE ± 14.83), and at least 17 (7%) interviewees have an income <US\$109 / month, considered a chronic poverty state. Gillnet with small mesh size (<60 mm) was the most cited gear, although others as trap barriers (seasonally), longline, lobster trap, spear diving, hook and line are also used. Lobster is the most profitable catch, and 68 (53%) fishers are dedicated to its capture, especially during rainy season. Seasonal closure for recovering of lobsters populations is enforced by law during the late dry and early rainy seasons. However, interviewees frequently admitted to fish for lobster off-season, according to market demands and household needs. Dependent dive for lobster capture is also illegal, yet common. Fishers pointed overexploitation of fish stocks as the main problem in the region, especially for lobster. These preliminary results emphasize the urgent need of further efforts to collect information about fishery gears, production, catchability and mortality of target and non-target species while providing food and income for coastal communities. State and community co-governance of the artisanal fishery is a possible way to reduce the pressure on heavily exploited species whilst ensuring the sustainable use of marine resources along the Northeast Brazilian coast.

ADDITIONAL INDEX WORDS: *gillnet, lobster capture, Goiana Estuary*

## INTRODUCTION

Humankind depends on coastal and marine ecosystems in different ways (*e.g.* energy, minerals, aquaculture, transport, tourism and fishing) and these environments are also nursery, foraging, growth, mating and nesting habitats of fish and invertebrate species (Barletta and Costa, 2009; Barletta *et al.*, 2010; Saint-Paul and Barletta, 2010). Estuaries are considered one of the most important aquatic environments for coastal animal life that depends on these habitats and its processes, especially in the earlier developmental stages.

Estuarine fisheries is one of the oldest human activities and has been practiced in the Americas since pre-Colombian times. Fishery gears and strategies developed according to technological advances, societal demands, target species and management techniques. Small-scale fishery (subsistence and artisanal) contributes to the local income, generates an important number of jobs, and plays a fundamental role in the subsistence of a large number of fishing communities in developing countries, including Brazil. This contributes to poverty alleviation and food security where fish is the single most important natural resource. However, most stocks lack information, knowledge about fish species biology and appropriate management have been largely overlooked (Alfaro-Shigueto *et al.*, 2010).

According to Bené (2006) 35 million people worldwide are involved in fishing and fish processing, 80% of those are associated with the small-scale fishery sector. The Brazilian annual fish production in 2007 was 1,072,226 tonnes (t) corresponding to US\$ 2 billion, 2% higher than 2006. Extractive marine fishery represents 50% of total fishery production in Brazil and the export of its products is growing, especially for lobster that corresponds to 30% (in US\$) of total exportation (IBAMA, 2009).

However, recent problems of fishery management such as the increased spatial distribution of fishery effort, degradation of coastal waters and mangrove ecosystems (Saint-Paul and Barletta, 2010), declined catch rates, overexploitation and depletion of some marine resources, and bycatch of non-target species (Guebert-Bartholo *et al.*, 2011) compromise sustainability of species and communities dependent. The creation of Marine Protected Areas (MPAs) has been seen as a contributor to fishery organization and is an increasingly popular strategy for managing fisheries, conserving biodiversity and influencing the quantity and type of benefits to marine ecosystems (*e.g.* abundance and diversity of fishes and the amount caught and associated level of effort required). MPAs impacts on human welfare are still poorly understood, but they affect the social and political power of fishers, including those marginalised and poor which are most dependent on marine resources (Mascia, Claus and Naidoo, 2010).

In Brazil, five categories of MPAs are commonly used to preserve marine diversity and traditional livelihoods. An Extractive Reserve (RESEX), characterized by community-based management decisions at a local level, was created in the studied area.

Traditional communities of the Northeast Brazilian estuaries depend on the different resources (e.g. fish, crustaceans, shellfishes, mangrove wood) and ecological services (e.g. tourism, transport). The increasing of exploration, especially by non-traditional stakeholders (coconut, sand mining, sugarcane and aquaculture producers), threatens biological diversity, traditional livelihoods, culture and values (Barletta and Costa, 2009). Impacts that have effects on estuarine ecology and productivity are: deforestation of the Atlantic Rain Forest and mangroves, soil erosion, effluents discarding, water eutrophication, chemical contamination; most of them are connected to the sugarcane production (Barletta and Costa, 2009).

This study describes the fishery activities, at small coastal traditional communities of the Brazilian Northeast (tropical semi-arid) comparing protected (1) and non protected (2) areas.

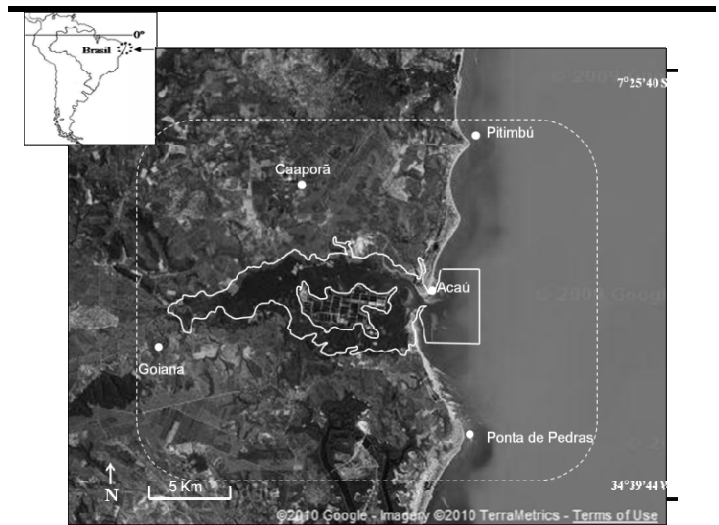


Figure 1. Goiana Estuary and adjacent areas. The Acaú-Goiana RESEX (solid line) and the buffer area (dashed line). Source: Google Earth and IBAMA.

**METHODS**

The study area comprises the lower Goiana Estuary. The system has an area of 4,700 ha, and ends at the Atlantic Ocean, at the Northeast of Brazil (Barletta and Costa, 2009) (Figure 1). The study area comprises three villages (Ponta de Pedras, Acaú and Pitimbú) of two municipalities. The Acaú-Goiana RESEX was created in 2007 around Goiana Estuary (~ 67 km<sup>2</sup>) and has not been structured until now.

The region is a tropical semi-arid estuary and rainfall patterns are responsible for the major seasonal fluctuations. Four seasons characterize the estuarine region: early (March to May) and late rainy (June to August) and early (September to November) and late dry seasons (December to February). The estuarine region is divided by areas according to the salinity patterns: river; upper, middle and lower estuary and coastal waters (Dantas *et al.*, 2010). Fishery at these sites is described as artisanal and some estuarine fish species (catfishes), crustaceans and shellfishes are captured in a sustainable way (Barletta and Costa, 2009).

Data collection by semi-structured interviews as an informal, but guided talk, to fishers took place between September/2009 and February/2010, at three villages boarding the Goiana Estuary: Ponta de Pedras (1), Acaú (2) and Pitimbú (3). Questions were separated into: (1) *social and economic aspects*, with questions about age, income, education and (2) *fishing activities*, with questions about fishing gears, vessels and fishing areas. The best possible estimate of the number of fishers at each village was based on the current registers at the three fishers associations. A minimum of 10% of the fishers from each village were interviewed randomly and separately from the group, generally when they were going to or coming from the sea, repairing fishing nets, and the beach. The same person made all interviews.

The Chi-square independent test was used to determine significant differences in the interviewee's information, with a 5% level of significance (Zar, 1999).

**RESULTS**

A total of 263 interviews were conducted at the three villages. Interviewed fishers were male between 18 and 74 years old. Low level of formal education was detected among fisher (Figure 2).

About 35 (17%) are illiterate. Another 168 (79%) have only 2 to 5 years of formal education. Two hundred and eighteen (88%) interviewees started fishing at an age lower than 15 years, and about 23 (9%) are formally retired by the government (> 65 years old) but still fish as their main activity. Part of interviewees (99, 38%) has a complementary activity working with general services (e.g. construction, seller, boat manager). The average individual income was US\$ 329 (SE ± 14.83), and significant differences among villages were detected (p<0.001). At least 17 (7%) interviewees have an income lower than US\$100 / month.

The fishery fleet showed significant differences among the three villages (p<0.0001). Four categories were described, engine boat with 9 m (114 - 43%) and sail boat (87 - 33%) were the most frequently cited (Table 1) (Figure 3). Despite the fact that 96 (42%) interviewed fishers are the boat owners and the other 130 (57%) are employees, no differences were detected between the income of these two categories (p=0.42).

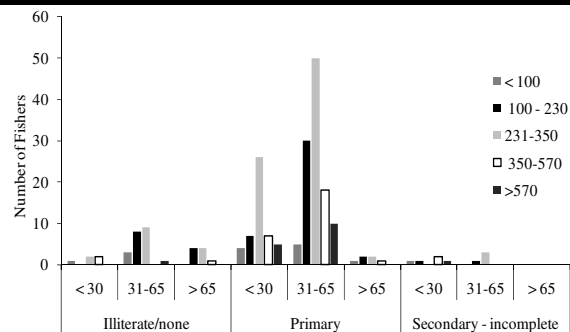


Figure 2. Fishers formal education, age class (<30, 31-65, >65 years) and income of each group (in US\$).



Figure 3. Main types of boats in the fleet at the three studied villages: sail boat (A and B), engine boat with 9 m (C).

Fishery gears differed significantly among areas ( $p < 0.0001$ ), and gillnet with small mesh size ( $< 60$  mm) was the most cited fishing gear (137 – 52.1%) (Figure 4). This can be used with different fishing strategies (sunk, floating, set or drift net), according to the target species. Moreover, other types of fishery gears are also used: lobster trap (49 – 18.6%), longline (26 – 9.9%), diving with spear (19 – 7.2%), gillnet ( $> 60$  mm) (17 – 6.5%) and trap barriers (seasonally) (15 – 5.7%) (Figure 4).

Fisheries are explored according to season and eleven important groups of fish and crustaceans were pointed as the most commonly captured at the Goiana Estuary and adjacent areas: Carangidae, Centropomidae, Hemiramphidae, Lutjanidae, Mugilidae, Sciaenidae, Panuliridae and Penaeidae families (Table 1). In general, fishery activities were significantly related to income ( $p < 0.0001$ ), and subsistence-related species (*e.g.* catfish, cutlassfish) were more frequently captured by fishers with lower income (88, 40%) (Figure 5). Lobster was considered the most profitable catch, and 68 (53%) fishers were dedicated to its capture, especially from May to December (late rainy and early and late dry seasons). Fishers with higher income ( $> 570$  US\$) are mostly dedicated to lobster fishery (19, 63%). Dependent dive, even being forbidden for lobster capture, is frequently used in the studied villages, and about 31 (62%) fishers dedicated to lobster capture by diving use it. This technique is used even during the closed season and targets other species (octopus, reef fish).

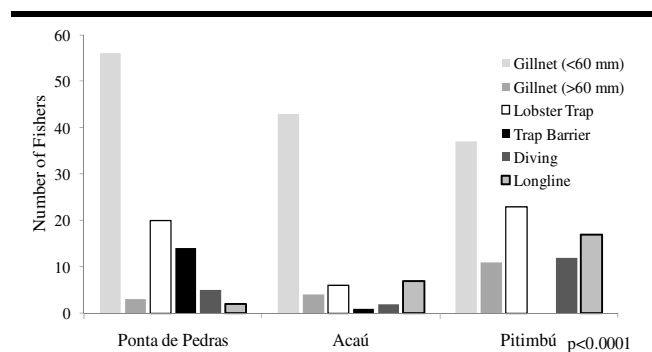


Figure 4. Fishing gears used by fishers at the three studied areas: Ponta de Pedras, Acaú and Pitimbú.

Coastal and deep waters (48% and 50%, respectively) are more frequently explored than the estuarine region ( $p < 0.0001$ ), especially in Pitimbú (65%) (~70 m), where lobster landings are concentrated. Fishing days out at sea vary from 15 to 20 days for lobster, and 1 to 3 days for other resources, depending on the capacity of the boats ice box (Table 1). Non-target species (sea turtles, dolphins, sharks and rays) are incidentally caught, frequently in gillnets ( $p < 0.0001$ ), and their death was related to the characteristics of the gear (Table 2).

Table 1. Fishing gears, vessel type used and target families according to the interviews at the three studied villages. Vessels type: 1- sail boat, 2- engine boat with 9 m, 3- engine boat with 12 m, 4- small boat with 2 m. Fishing areas: E- Estuarine, C- Coastal, D- Deeper waters.

Fishing Gear	Vessel	Target family	Fishing Gear Characteristics					Interview Villages N (%)		
			Mesh size/diameter (mm)	set/drift net	sunk/floating	Fishing area	Days at sea	P. Pedras	Acaú	Pitimbú
Gillnet	1	Hemiramphidae	2- Dec	S	F	E	1	7 (7)		
		Penaeidae	25/2	S	F	E/C	1	2 (2)	17 (27)	
		Mugilidae	35/3	S	F	E/C	1	13 (13)	18 (28.6)	3 (3)
		Carangidae	40/4	D	F	E/C	1 to 3	21 (21)	6 (9.6)	16 (16)
		Carangidae	50/4	D	F	E/C	1 to 3	1 (1)	4 (6.2)	10 (10)
		Carangidae	60/5	D	S	E/C	1 to 3	1 (1)	1 (1.6)	7 (7)
		Carangidae	70/6	D	S	C/D	1 to 3	1 (1)		1 (1)
		Centropomidae, Sciaenidae	80/7	D	S	C/D	1 to 3			1 (1)
		Centropomidae, Sciaenidae	90/8	D	S	C/D	1 to 3			1 (1)
		Centropomidae, Sciaenidae	100/9	D	S	C/D	1 to 3			3 (3)
		Chondrichthyes	200/20	D	S	C/D	1 to 3			
	No boat	Penaeidae	40/3	S	F	C	1	11 (11)		2 (2)
Trawl net	2	Penaeidae	25/18	S	S	C	1	2 (2)	1 (1.6)	4 (4)
Fixed trap	1, 4	Carangidae	30/35	D	S	E/C	1	14 (14)	1 (1.6)	
Lobster trap	2, 3	Panuliridae/ Mullidae	30/35	D	S	C/D	15 to 20	20 (20)	6 (9.6)	23 (23)
Longline	2, 3	Lutjanidae	–	D	S	D	3 to 20		7 (11)	
Hook	2, 3	Lutjanidae, Scombridae	–	D	S	C/D	1 to 10	2 (2)		17 (17)
Dive	2, 3	Panuliridae/ Octopus	–	–	S	C/D	3 to 10	5 (5)	2 (3.2)	12 (12)

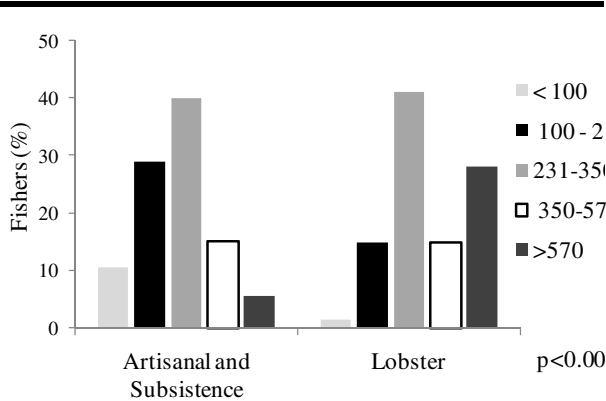


Figure 5. Income (in US\$) of fishers that captures artisanal subsistence species and lobster in the three studied villages.

Table 2. Non-target species (sea turtles, rays and dolphins) captured by fishing gears found alive and dead by fishers from the studied villages. ( $p=0.0127$ )

Non-target species	Fishing gear N (%)			
	Gillnet (<60mm)	Gillnet (>60mm)	Lobster trap	Trap barrier
alive	77 (54)	23 (16)	28 (20)	15 (10)
dead	20 (44)	17 (37)	8 (17)	1 (2)

## DISCUSSION

### Artisanal and subsistence fisheries around the Goiana Estuary

Traditional communities around the Goiana Estuary live mostly in a sustainable way, depending on living natural resources for financial income and food. Fishing is the most important activity, considered in a small-scale, and the majority of men are dedicated to it. Even the adolescents and children < 10 years old fish to help keeping the family income. This is the major cause of school drop off.

The description of the artisanal fishery structure shows the importance of Goiana Estuary and adjacent areas for the exploitation of most resources mostly limited to subsistence and small-scale exploitation. The few technologically equipped fleet and the lower investment reflects the resources obtained and consequently the risks for the unsafely forms that fishers work.

The Northeast Coast is the second most productive region in Brazil (IBAMA, 2009). In the studied region (Pernambuco municipality) the Goiana Estuary is responsible for 29% of production (in US\$) with 19% of fishery fleet. Although, the area decreased in production from 2006 to 2007 in about 30%, especially for the artisanal fishery (26%) (IBAMA, 2009). Coastal and deep fishing areas were more frequently used, due to the diversity of species and the higher profitability, exploring resources more intensively (Scianidae, Centropomidae and Panuliridae families). The estuarine area was frequently more explored by Acaú fishers, most of them independent and alone, where the captures are most of subsistence species (Ariidae, Trichiuridae, Carangidae and Penaeidae families) using sail boat with no technology.

### Lobster Fishing

Lobster capture has an important role in the national fishery sector since the 1960s, and the Brazilian Northeast is the main producer (IBAMA, 2009). Lobster production increased 5% in 2007 and Pernambuco is the largest lobster exporter in Brazil reaching 881 tons per year, which represents 43% of the national lobster exportation. The lobster price has been growing in last 6 years, where it was US\$ 24,860/t in 2001 and reached US\$ 44,300/t in 2007. Nevertheless, in the Brazilian scenario, lobster exportation decreased 4% from 2006 to 2007 (IBAMA, 2009).

Overexploitation of fish stocks, especially lobster, was pointed by all fishers as the main problem in the region due to the intense demand for lobster by the international market and tourism. This is the most rentable activity in Goiana fishery sector and generates direct and indirect jobs. From the biological point of view, the two lobster species explored in the area (*Panulirus argus* and *Panulirus laevicauda*) are suffering a steep decline due to fishing pressure in the last 20-30 years. Depletion of most of this natural resource is the consequence of the open-access nature of fisheries and unmanaged programs along the whole Brazilian coast.

Ecological changes have been reported worldwide (Bearzi *et al.*, 2006) of many stocks considered to be outside safe biological limits and/or in a critical state, mostly because the ecosystem do not have the necessary time to recover populations affected by overfishing. Appropriate management and enforcement instruments are capable to be efficient on resources sustainability decreasing the fishing pressure on the subsistence and exportation resources. Therefore, in the study area a seasonal closure for the recovering of lobster populations is enforced by law during the late dry and early rainy seasons. Other measures are establishment of a minimum size (13cm) and distance from the coast (7.5 km) for capture and limits on the gear (e.g. dependent dive is not allowed) Even though, gear apprehensions, arrests, and fees are applied since fishers insist in unsustainable practices when pressured by market demands and poverty.

Difficulties were found to precisely report rates of lobster catch using dependent dive since some deliberated misreported their activities to avoid confrontation. Nevertheless, the information obtained is relevant enough to argue that innumerable problems are related to this practice. Fishers practice dependent dive with different, sometimes unbalanced, air mixtures, stay more than 3 hours down, go until 80m deep, and most of the times do not respect decompression stops. Different problems were reported, most of them related to the decompression sickness (DS): alteration in nervous, motor and circulatory systems and death. Another cause of DS is the tentative to hide it when under police inspection with a diver still down.

Social problems detected in the studied villages are related to the fact that part of fishers receiving the financial support during the lobster closed season do not work. It reduces family income, facilitates alcoholism and the use of illicit drugs. As a result, part of them are lead to poverty and marginalisation.

### Bycatch

Bycatch of non-target species events were very common in interviews, especially for gillnets. Sea turtles, dolphins and rays were the most cited captured animals that in most of times are sold, or eaten by the local community. Gillnets catchability have been studied around the world and its non-selective method has received more attention where deterrents to reduce megafauna bycatch have been being used (e.g. baits, hooks, on boarder observers), especially for industrial fleet (Lewison *et al.*, 2004). Although, the effect of artisanal fishery bycatch on endangered species, especially sea turtles which utilize the region as nursery,

feeding and nesting habitat, is poorly known and has to be urgently investigated. Fishery gears as hook and line were considered by fishers the most selective gear, not capturing non-target species and individual fish lower than the expected size (juveniles).

## CONCLUSIONS

Results presented here are a baseline to begin the necessary discussions among stakeholders towards the development of a management plan for the Acaú- Goiana RESEX. This is especially important when the social, economic and health problems concerning lobster fishing. The economically vulnerable situation of every fisher within the estuarine portion of the system is also worrying. Moreover, problems such as deforestation, expanding area of sugarcane plantations, unsustainable aquaculture practices and the massive presence of non-traditional stakeholders in the RESEX should also be discussed and dealt with in the management plan, aiming at a better conservation and sensible use of resources by the traditional communities.

Investments in instruction are absolutely necessary for fishers, both in the form of basic education as well as technical capacity building (*e.g.* GPS use, communications systems, safety equipments and onboard and on land environment friendly practices). The existing measures (closed season and minimum catch size) will not be enough to improve lobster species conservation and its maximum sustainable yield, unless people are also valued as a highly precious resource. Such mentality must prevail among government, private institutions, RESEX management, third sector and all stakeholders. Inspection on lobster regulations obedience should be made not only at the fishers end of the production chain, but also to important costumers as restaurants and traders. Bycatch of non-target species should be investigated, and appropriate techniques experimented and used, when successful.

The existence of fishers associations did not guarantee the groups organization as a mechanism to serve the best interest of a professional. A strong, well-organized and equipped, local fish market could guarantee better prices and relationships that are more reasonable with intermediaries, if necessary. Work diversification including tourism (*e.g.* boating, dive, sports fishing, lodging) could also be an appropriate way to earn money, as well as engagement on environmental and educational projects managed by the third sector and small businesspersons.

A special and vigorous incentive to children and young people to go to school and complete their education could have a positive effect on communities at a relatively short term (25 years, one generation). A consortium between schools and all the other alternatives cited above must be taken into account in order to include these youngsters in their communities' economic life from an early age, but under tight supervision and better conditions.

Further efforts to collect information about fishery gears, landings, destination and handling of the production, catchability and mortality of target and non-target species are another possible action for researchers and manager alike. A long-term study involving the hot-spots of marine megafauna bycatch and the main fishing gears responsible for it is essential. A management plan must soon be drawn for the protection and conservation of the estuarine ecocline and the adjacent coastal region as a whole, while providing food and income for coastal communities. Therefore, the participation of all stakeholders in this plan and its execution will be necessary to enhance the understanding of particular needs and local economy. This will almost necessarily lead to co-government options for the RESEX and its buffer territories.

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