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Seabob shrimp (*Xiphopenaeus kroyeri* Heller, 1862) fishery in northern Rio de Janeiro State, southeastern Brazil: Costs and revenues

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Abstract
This study analyzed costs and revenues of the seabob shrimp (*Xiphopenaues kroyeri*) fishery practiced in Atafona harbor (21°37'S, 41°00'W), northern Rio de Janeiro State, southeastern Brazil. The highest financial investment is the boat construction, which includes engine, hull, winch and devices such as radio communication and rescue equipment (U$ 24,900.00-U$ 26,900.00). The bottom trawl nets for shrimp capture costs U$ 650.00. During fishing operations, the highest cost refers to fuel (diesel). The shrimp is sold by U$ 1.00 to U$ 2.00 per kg from fishermen to first purchaser (intermediate), and by U$ 4.00 to U$ 12.00 per kg to final consumer, according to shrimps' size and processing. The weekly net revenue is U$ 380 per boat. Thus, this seabob shrimp fishery is an economic activity that requires a high initial investment with low economic performance to the fishermen involved.

Keywords: economy; fishermen; fishing activity; Penaeidae shrimp; *Xiphopenaues kroyeri*.

1. Introduction
The fishery costs vary according to boat size, fishing grounds extension, target species and fishing gears. Consequently, the fishing revenue also varies among different productive systems [1, 2]. Considering the small-scale fisheries or artisanal fisheries, there are intermediate agents (first purchasers) involved in the commercialization, decreasing the net revenue of the fishermen (producers) [1]. Global crustacean fisheries have been considered to be economically unsustainable, with decreasing catch per unit effort and increasing operating costs [3-5].
Crustacean fisheries with bottom trawl nets are widely practiced along the Brazilian coast and worldwide [6, 4]. In tropical waters, Penaeidae shrimps are the main targets of these fisheries [7]. In Brazil, the seabob shrimp, *Xiphopenaeus kroyeri* Heller, 1862 is the main captured species in artisanal shrimp fisheries practiced until 30 m depth, representing 80% of the total shrimp catches along Brazilian coastal waters [8, 9].
In northern Rio de Janeiro State (~21ºS), southeastern Brazil, the commercial fishery of the seabob shrimp is important to the economy of five coastal communities [10, 11]. The local stock of this shrimp species is overexploited by fisheries and the reduction of the fishery effort is necessary to maintain this fishery at sustainable levels of long-term exploitation [9].
This study evaluates costs and revenues of the seabob shrimp fishery in Atafona harbor, an artisanal fishing community located in northern Rio de Janeiro State, southeastern Brazil (~21ºS). The results highlight the financial investments of this activity and its economic performance.

2. Materials and methods
Currently, there are 30 boats involved in shrimp fishery in Atafona harbour, which correspond to 23% of the total fleet. During 2016, the costs and revenues of this fishery were estimated through interviews with 10 fishermen that were also boat's owners. The interviews included questions about boat, fishing gear and fishing operation costs, shrimp commercial value and fishery revenue. The local shrimp fishery is a 6-8 hours daily activity whose details, such as landings, fishing grounds and fishing operating were widely described by Di Beneditto (2001) and Fernandes *et al*. (2014) [10, 11].

3. Results

The boats involved in seabob shrimp fishery in Atafona harbor, called 'traineira', were 10 to 12 m long with 8 to 15 HP engine, carrying a crew of two fishermen ('mestre' and 'camarada') (Figure 1). Eventually, a third fisherman participates in fishing operations. The cost of boat construction was U$ 24,900.00 to U$ 26,900.00, including engine, hull, winch and other devices, such as radio communication and rescue equipment. The winch used to board the two bottom trawl nets after the fishery is made by iron or steel. The price of the winch varied according to type of material. A second-hand boat costed half-price of the new boat (Table 1).

Fig 1: Boat ('traineira') used for shrimp fishery in Atafona harbor, southeastern Brazil.

Table 1: Main costs of the shrimp fishery in Atafona harbor, southeastern Brazil.

Items	Price (U$)
Boat (new)	U$ 24,900.00-26,900.00
Engine	U$ 11,000.00-12,500.00
Hull painted	U$ 11,500.00
Winch	U$ 1,000.00-1,500.00
Devices	U$ 1,400.00
Boat (second-hand)	U$ 15,000.00
Two trawl nets (new)	U$ 650.00
Two trawl nets (second-hand)	U$ 100.00-300.00
Fuel (diesel)	U$ 20.00-50.00
Ice (shrimp storage and conservation on board)	U$ 3.00-20.00

Boat hull maintenance was annual or biennial, according to its damage condition. The engine was evaluated daily or weekly as preventive maintenance. Fishing boats with regular maintenance might operate around 20-25 years. The trawl nets were handmade by members of Atafona community and its average durability was around 10 years. Net damages might happen during the fisheries due to collision with submerged obstacles, such as stones and other rigid structures. The net repair was done by fishermen themselves or other members of Atafona community, taking up to two days. The daily fuel consumption varied according to distance from Atafona harbour to fishing grounds. For nearest fishing grounds were necessary 20 to 25 L, while for further areas 40 to 50 L. Ice boxes did the shrimp storage and conservation. The crew feeding was quick snack such as sandwich, biscuit and soft drink, and each fisherman was responsible for his feeding expense.

The commercial value of the seabob shrimp varied according to productive chain and specimens' size and processing: larger and peeled shrimps had higher values (Table 2). By-catch organisms, such as crabs and fishes, might have commercial value locally. The blue crab was sold at U$ 0.50 per kg as bait in triggerfish fishery. The king weakfish had commercial value when specimens were larger than 20 cm in total length (U$ 1.50-2.00 per kg).

Table 2: Commercial value of the seabob shrimp in Atafona harbor, southeastern Brazil.

Commercialization	Price per kg (U$)
From fisherman to first purchaser (intermediate)	
All sizes shrimps	U$ 1.50
Larger shrimps (> 10cm)	U$ 2.00
From first purchaser to final consumer	
Shrimps *in natura*	U$ 4.00
Shrimps without head	U$ 8.00
Shrimps withour whole carapace (peeled)	U$ 10.00

The fuel and ice expenses came from the fishery gross revenue and the remainder amount was divided into four parts, as follow: one part to the 'mestre', another part to the 'camarada' and two parts to the boat's owner. The 'mestre', fisherman who guides the fishery, received more half part from the boat's owner. The fishery net revenue was U$ 380.00 per boat in each week (six fishing days per week). Thus, the weekly and monthly net revenue for each participant was U$ 142.50 and U$ 570.00 ('mestre' and boat's owner) and U$ 95.00 and U$ 380.00 ('camarada'), respectively.

4. Discussion

The boats involved in seabob shrimp fishery in Atafona harbour, southeastern Brazil, measure up to 12 m long, with high construction and maintenance costs due to their size. Most fishermen from Atafona harbor is not a boat owner [11], probably reflecting the high costs demonstrated in this study. The commercial fisheries of this shrimp species in other communities along southeastern and southern Brazil, for instance, are carried out through smaller boats (< 9 m), with lower acquisition and fishing operation costs [4, 12, 13].

Expenses with boat maintenance and fishing gear repair are regular costs in fisheries [14, 15]. Moreover, fuel and ice for fishing storage and conservation are operating costs that directly influence the fishing products value [15, 16]. The fuel can represent up to 60% of the total fishery cost around the world [16], as also verified in Atafona harbor. The distance between landing harbor and fishing grounds and the seasonal distribution of the target species also influence the fishing costs [17].

The commercial value of the seabob shrimp in Atafona harbor varies up to 700% considering the lowest price paid to fishermen (U$ 1.50) and the highest value paid by the final consumer (U$ 10.00) (Table 2). In general, artisanal fishermen depend on first purchaser or intermediates for commercialization of the fishing products [18]. These agents establish a connection between producers (fishermen) and consumers [6]. This type of commercialization facilitates the connection between producers and largest consumer fish markets; however, it imposes a significant decrease in the revenue for the fishermen [7].

The weekly net revenue reported by the local fishermen is U$

380.00 per boat. Considering the net revenue distribution among the participants, the monthly revenue per capita is close to or slightly above the average salary of Brazilian workers (U$ 320.00) [19]. A high financial investment is necessary to begin this fishery activity, but the financial return that fishermen receive is low.

Artisanal fisheries are marginalized activities with a low economic return to the communities [20]. Moreover, these activities are poorly administered by government agencies [21] with low representation of local actors in decision-making processes [22]. The seabob shrimp stock in northern Rio de Janeiro State is over-exploited [5]. Since 2004, this species is in the National List of Aquatic Invertebrates and Overexploited or Threatened Fishes of Overexploitation [23]. Overexploited stocks often collapse fisheries, affecting the resources themselves and the revenue of the professionals involved in the productive chain [16].

5. Conclusion

The seabob shrimp fishery practiced in Atafona harbor is an economic activity that requires high initial investment, but presents low economic returns. Besides, the shrimp commercialization through an intermediate agent reduces the fishermen's net revenue. Local cooperatives for fishing products commercialization as well as a greater economic use of the by-catch organisms may be strategies to increase the profitability of this fishery locally.

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