

THE SOCIAL AND ECONOMIC FRAMEWORK OF ARTISANAL FISHING IN THE STATE OF CEARÁ, BRAZIL

O QUADRO SOCIAL E ECONÔMICO DA PESCA ARTESANAL NO ESTADO DO CEARÁ, BRASIL
EL MARCO SOCIAL Y ECONÓMICO DE LA PESCA ARTESANAL EN EL ESTADO DE CEARÁ, BRASIL

<https://doi.org/10.26895/geosaberes.v11i0.871>

LUCIANA DE SOUZA QUEIROZ^{1*}
SERGIO ROSSI²
AIDA TAPIA MERCADER³
CAMILA SERRA-POMPEI⁴
DAVID VIDE PIFARRÉ⁵
JOAN CARRASCO DOMÍNGUEZ⁶
JÚLIA AMORÓS MONRABÀ⁷
JÚLIA MUNTANÉ CAROL⁸
MARIA BRIANSÓ MARTÍNEZ⁹
ANTONIO JEOVAH DE ANDRADE MEIRELES¹⁰

¹ Postgraduate Program in Geography, Post-doctoral scholarship, Federal University of Ceará (UFC), Campus Universitário do Pici, Bl. 911, CP: 60.450-900, Fortaleza (CE), Brazil, +55 (85) 3366-9489, luvitales@gmail.com, <http://orcid.org/0000-0002-1186-5005>

* Corresponding author

² Università del Salento, Lecce, Italy, sergio.rossi@unisalento.it, <http://orcid.org/0000-0003-4402-3418>

³ Ciencias Ambientales, Universitat Autònoma de Barcelona (UAB), Barcelona, Spain, aida.tapia@gmail.com, <http://orcid.org/0000-0003-0840-5486>

⁴ Ciencias Ambientales, Universitat Autònoma de Barcelona (UAB), Barcelona, Spain, camila.serra.pompei@gmail.com, <http://orcid.org/0000-0003-2627-466X>

⁵ Ciencias Ambientales, Universitat Autònoma de Barcelona (UAB), Barcelona, Spain, davidvide13@gmail.com, <http://orcid.org/0000-0002-4576-5555>

⁶ Ciencias Ambientales, Universitat Autònoma de Barcelona (UAB), Barcelona, Spain, joan.carrasco.dominguez@gmail.com, <http://orcid.org/0000-0001-6500-596X>

⁷ Ciencias Ambientales, Universitat Autònoma de Barcelona (UAB), Barcelona, Spain, julia.amoros.monraba@gmail.com, <http://orcid.org/0000-0002-8911-0585>

⁸ Ciencias Ambientales, Universitat Autònoma de Barcelona (UAB), Barcelona, Spain, ju.muntane@gmail.com, <http://orcid.org/0000-0001-5835-9946>

⁹ Ciencias Ambientales, Universitat Autònoma de Barcelona (UAB), Barcelona, Spain, maria.brianso.m@gmail.com, <http://orcid.org/0000-0002-6773-1161>

¹⁰ Postgraduate Program in Geography of the Federal University of Ceara (UFC), CNPq Researcher 1B, meireles@ufc.br, <http://orcid.org/0000-0003-0464-2863>

RESUMO

As comunidades tradicionais assentadas no manguezal próximo à costa desenvolveram um modo de vida baseado em serviços ecossistêmicos com várias utilidades e atividades (lenha, pesca artesanal, coleta de bivalves e caranguejos etc.). A importância da segurança e soberania alimentar é frequentemente mencionada em relação à pesca artesanal, mas raramente tem sido articulada como objeto de pesquisa específica. Este trabalho identifica um vácuo informativo relacionado aos benefícios gerados pela exploração artesanal de pescas que não são refletidos nas estatísticas oficiais. Nós compilamos os dados econômicos em duas áreas do litoral do Ceará (Brasil), Curral Velho e Cumbe, combinando uma série de técnicas de coleta de dados (tabelas de monitoramento, entrevistas, zoneamento e questionários). Os pescadores geralmente trabalham em média 5 horas por dia durante 4,6 dias por semana (23 horas por semana), ganhando cerca de 127,20 € por semana (ou 5,53 € / hora). Conclui-se que esse tipo de pesca não é apenas economicamente viável, mas que compete diretamente com a monocultura do camarão em termos monetários e tempo gasto para a atividade.

Palavras-chave: Pesca artesanal. Soberania alimentar. Manguezal. Populações costeiras e vulnerabilizadas.

ABSTRACT

Traditional communities situated in mangrove forests near the coast have developed a way of life based on ecosystem services associated with various uses and activities (firewood extraction, artisanal fishing, crab and clam harvesting, etc.). The importance of food security and sovereignty is frequently mentioned in the context of small-scale fishing but has seldom been articulated as an explicit objective. The present work identifies a knowledge gap concerning the profits generated by artisanal exploitation, which are not recorded in official statistics. We compiled economic data from Cumbe and Curral Velho, in the state of Ceará (Brazil), using a combination of techniques (tracking tables, interviews, zoning and questionnaires). Fishermen typically work up to 5 hours a day for 4.6 days a week, working 23 hours/week, and earning € 127.20/week or € 5.53€/hour of work. It is concluded that the artisanal fishing carried out by coastal communities is not only economically viable but competes directly with industrial monocultures in terms of monetary income and workers' leisure time.

Keywords: Artisanal fisheries. Food sovereign. Shrimp aquaculture. Mangrove. Vulnerable coastal populations.

RESUMEN

Las comunidades tradicionales asentadas en el manglar cerca de la costa han desarrollado un modo de vida basado en los servicios ecossistémicos con varias utilidades y actividades (recolección de leña, pesca artesanal, recolección de bivalvos y cangrejos, etc.). La importancia de la seguridad y soberanía alimentaria se menciona con frecuencia en relación con la pesca artesanal, pero raramente se ha articulado como objeto de investigación específico. Este trabajo identifica un vacío informativo relacionado con los beneficios generados por la explotación pesquera artesanal que no salen reflejados en las estadísticas oficiales. Compilamos los datos económicos en dos localidades de la costa de Ceará (Brasil), Curral Velho y Cumbe, combinando una serie de técnicas de recolecta de datos (tablas de seguimiento, entrevistas, zonación y cuestionarios). Los pescadores suelen trabajar una media de 5 horas al día durante 4.6 días a la semana (23 horas por semana) ganando unos 127.20€ por semana (o 5.53€/hora). Se concluye que este tipo de pesca es no solo económicamente viable, sino que compete directamente con la monocultura del camarón en términos monetarios y de tiempo empleado para la actividad.

Palabras clave: Pesca artesanal. Soberanía alimentaria. Manglares. Poblaciones costeras vulnerables.

INTRODUCTION

Mangroves are recognized as being among the richest and most productive ecosystems on Earth. They form at the interface between land and sea and are found in estuaries and coastal areas in 123 countries in tropical and subtropical regions (BARBIER, et al. 1997; SPALDING et al., 2010). These frontier systems are essential for the conservation of biological diversity, providing refuge from predators and habitats for spawning, hatching and feeding, as well as nutrients for a range of organisms (FAO, 2007). It has been estimated that up to 80% of the fish catch in tropical coastal areas is directly or indirectly dependent on mangroves (FIELD et al., 1998; ALONGI, 2002), reaching around 90% in developing countries (DUKE et al. 2007).

These ecosystems provide at least US \$1.6 billion each year in ecosystem services, which include supporting the livelihoods of coastal communities with raw materials and food, coastal protection, soil erosion control, water purification, maintenance of fisheries and carbon sequestration, as well as providing opportunities for recreation, education and research (COSTANZA *et al.* 1997; BARBIER *et al.* 2011).

The lifestyle of communities living near mangrove areas is frequently based on traditional activities that are closely tied to seasonal cycles, biodiversity and fluctuating stocks. People have adapted to living with the mangrove system, exploiting it in a number of ways and benefiting from ecosystem products and services such as wood fuel and artisanal fishing, including collection of shellfish and crabs (ABURTO-OROPEZA *et al.* 2008; FARLEY *et al.* 2010; WARREN-RHODES *et al.* 2011; QUEIROZ *et al.* 2017). This is a long story of interaction, marked by profound transformation over the last few centuries due to the shift from pre-Columbian to colonial management (LÓPEZ-ANGARITA *et al.* 2016). Most of the local people continue to use traditional tools, but their dependence on the market is not subject to the same logic as capital-intensive trade. They have developed special ways of managing natural resources that do not directly seek profit, but rather cultural and social production, reflecting an alternative perception of the natural world marked by the association with nature and its cycles (DIEGUES, 1983; O'GARRA, 2009; QUEIROZ *et al.*, 2017).

Small Scale Fishing (SSF), significant in mangrove areas, is a highly productive sector accounting for more than 50% of the world annual fish catch (FAO, 2015). With respect to local communities, Small Scale Fisheries play a dynamic and diversified economic role, are typically respectful of local natural resources and pursue sustainable habitat exploitation. They incorporate the values and traditions of the areas where they are sited, favouring cohesive social processes that contribute to global cultural enrichment (FAO, 2015). Although their importance has been demonstrated however, artisanal fisheries are disappearing in many places (TESFAMICHAEL *et al.*, 2014). This is especially evident in coastal areas near large urban areas, where 50% of the human population now lives (SMALL; NICHOLLS, 2003). Strategies for managing and recognising the importance of artisanal fisheries are still very weak, because information is scarce or even non-existent (SALAS *et al.*, 2007).

The local economies of traditional communities obey their own logic but are nevertheless very important to the capitalist societies in which they operate. When respectful of the ecosystem, the relationship between traditional communities and the mangrove serves to protect these wetlands, since traditional communities play an important role in the protection of natural areas (SAENGER, 1999; RÖNNBÄCK *et al.*, 2007). This reflects another important aspect of these traditional cultures, i.e. an approach to natural resource management that is marked by respect for the system's natural cycles and exploitation that takes account of the capacity of animal and plant species for recuperation (HUSSAIN; BADOLA, 2010). Monocultures such as shrimp aquaculture have relegated the traditional economy to a second and third level compared to the theoretical progress associated with intensive shrimp farming (LÓPEZ-ANGARITA *et al.*, 2016). Thousands of families survive on artisanal fishing, but little is known about how and how much they contribute to the economic sustainability of local populations (DIELE; SAINT-PAUL, 2005; ABURTO-OROPEZA *et al.*, 2008; WALTERS *et al.*, 2008, HUSSAIN; BADOLA, 2010). Data on artisanal fisheries are sparse, incomplete and biased, their position within a country's economic and social framework being very difficult to ascertain (HUSSAIN; BADOLA, 2010; HELLEBRANDT *et al.*, 2014), which is the main reason for the invisibility of this economic sector. It is thus essential to estimate their monetary contribution and how they distribute their working time throughout the week.

Brazil has more than 8400 km of coastline and is the fifth largest country and 8th largest economy in the world (FMI, 2017). The country is now facing a complicated fisheries situation, with biodiversity and renewable resources threatened by the lack of appropriate

management policies (AMARAL; JABLONSKI, 2015; PINHEIRO *et al.*, 2015). Some efforts to recognize the economic and social role of artisanal fishing have been made, including the creation in 2003 of the Fisheries and Aquaculture secretariat (SEAP), whose main objective is establishing sustainable measures for marine and fluvial renewable resources. Despite the measures adopted since 2000, efforts have not been regular and the work has not yielded an ordered and effective body of data, especially for artisanal fisheries (DIAS-NETO; DIAS, 2015). Data on Brazil's artisanal fisheries show that the sector is responsible for around 65% of the country's seafood production, employing 957,000 persons (99.2% of the officially registered fishermen in the country) (IBAMA, 2007; MPA, 2012). Precise and reliable (comparable) data are, however, almost nonexistent, and understanding the current importance of this sector requires semi-quantitative tools.

The purpose of this paper is to make an economic assessment of activities related to the extraction of renewable resources (fish, crabs and shellfish) directly or indirectly related to mangroves or adjacent systems. The main questions are: 1) What are the economic benefits of mangrove-based artisanal fisheries? 2) What is the community's contribution to this type of artisanal activity and how does it relate to the welfare of the people who depend on these activities? To develop and achieve our objectives, field research was conducted in the traditional communities of Cumbe and Curral Velho, in the state of Ceará (NE Brazil), which are representative of traditional fishing in this South American country. Economic monitoring of artisanal fisheries was performed in accordance with protocols that can easily be extrapolated to other coastal or fluvial communities.

METHODS

The study was conducted in the communities of Cumbe and Curral Velho (Figure 1). Cumbe is located on the estuary of the river Jaguaribe, in Aracati municipality in the state of Ceará, Brazil. The village is situated in the Environmental Preservation Area (APA) of Canoa Quebrada, Aracati region. The Jaguaribe is the largest river in the state with a catchment area of around 72,645 square kilometres, which, together with the surrounding area, occupies 50% of the territory of Ceará (ARAÚJO, 2006). Due to its geographical location at some distance from the sea, the Cumbe community maintains a closer relationship with the mangrove and the estuary area. It is composed of fishermen, farmers and craftsmen (QUEIROZ, 2007). The Cumbe community has 621 inhabitants distributed in 155 families (SMS, 2012).

Curral Velho is located in the municipality of Acaraú, on the coastal plain in the state of Ceará, Brazil. Given its geographical location, Curral Velho is known for fishing in the mangroves and the sea, as well as for farming and handicrafts. The total population of Curral Velho is 2,663, belonging to 707 families (SMS, 2013).

MONITORING OF THE CUMBE FISHING COMMUNITY

In Cumbe, two types of research were carried out. The first sought to comprehensively quantify the scale of artisanal fishing based on information about the fish, crabs and shellfish caught or collected, and the location of the fishing grounds. It focused on a group composed of 45 fishing workers and 27 crab and shellfish harvesters. Fishing grounds with a total area of 2166ha (544ha of river, plus 1622ha of mangrove) were selected for monitoring. The workers were monitored using tracking tables, which recorded information collected every day on fish species, number of fish specimens, weight, etc. (QUEIROZ, 2014). The information was supplemented by means of semi-open questionnaires (Table 1).

Figure 1 - Map of the study area



Source: authors of the research.

The second type of monitoring carried out in Cumbe aimed to generate information on the total average production of crabs in the study area as well as the number of people and families supported directly by the harvesting of crabs (*Ucides cordatus* and *Cardisoma guanhumi*) and shellfish (*Mytella charruana*). The present study found that 72 people from the Cumbe community (belonging to 43 families, 27% of the total population) depend directly on artisanal fishing in the mangrove as their main economic activity. The income per month from the sale of crabs and shellfish and the average salary of harvesters (per month) was also reported. 42 crab collectors and 17 shellfish harvesters (those who go gathering more than three days per week at least 6 months per year) participated in the monitoring. The Cumbe community in which the crabs are collected occupies an area of approximately 400 hectares located in the central part of the mangrove zone on the lower river Jaguaribe, which is 2.6 km wide and 1.5 km long and runs perpendicular to the river. This monitoring was also carried out in accordance with the methods explained in Table 1.

To obtain data on the total production of crabs, the productivity of three separate areas characterised by varying degrees of harvesting pressure (due to population density) and degradation (due to shrimp aquaculture) (QUEIROZ *et al.*, 2013a) was measured. Figure 2 shows the study area divided into three zones with differing degrees of anthropogenic pressure and degradation: low pressure (green zone), intermediate pressure (yellow zone) and high pressure (red zone). The data show the number of crabs with carapaces wider than four centimetres per square metre (BURRIEL, 2012). Considering that the saleable crab catch includes those bigger than 4 cm, such individuals were regarded as potentially productive. The selection of the study zones was based on observation of the territory and information provided by the fishing workers themselves. To achieve the objectives, we chose an area encompassing various habitats and various degrees of degradation of the mangrove resulting from shrimp farms (BETORZ *et al.*, 2012; CAROL *et al.*, 2012; BURRIEL, 2012). An area of 400 hectares,

which included three different levels of degradation caused by human action (urbanization and aquaculture farms) (BURRIEL, 2012), was thus selected.

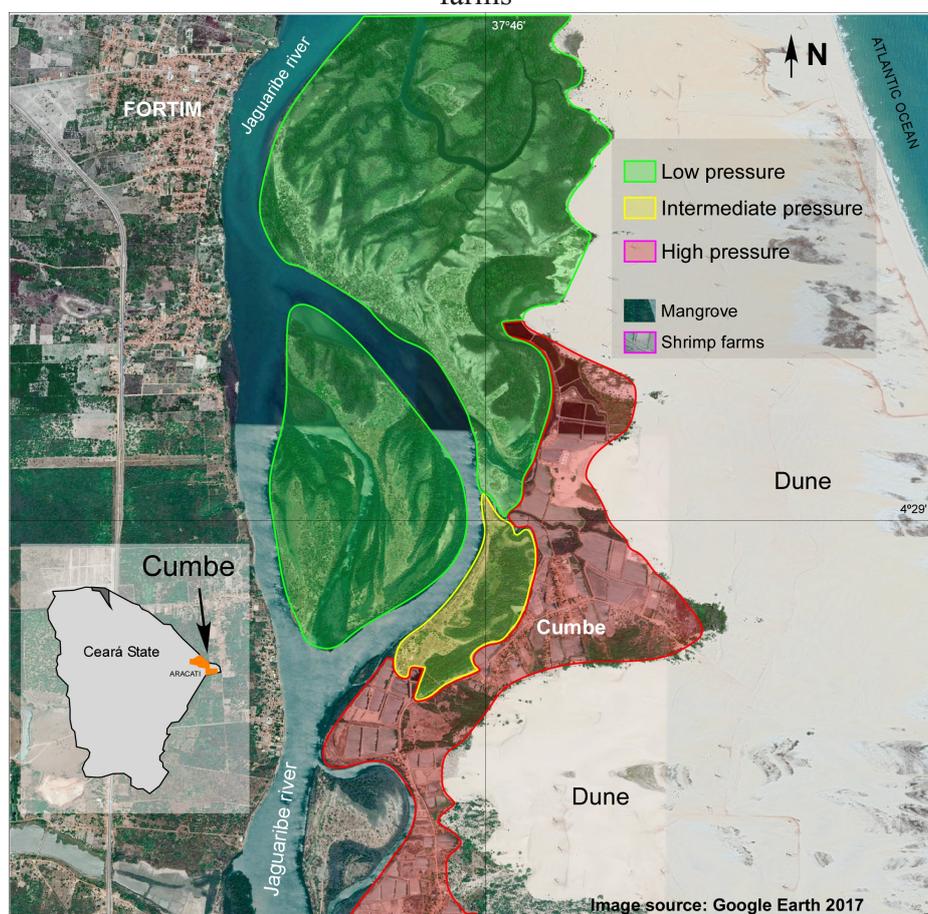
Table 1 - Tracking table with the requested information, techniques used and sample sizes.

Monitoring	Community	Type of Artisanal Fishing	Ecosystem	Tools for information collection	Information monitored	Sample
First Monitoring (October to December 2011)	Cumbe	Fishing (finfish); Crab and shellfish harvesting	Mangrove (Gamboas)	Tracking table (Annex III)	Economic gain generated by artisanal fisheries (€/month) Number of fish / crabs, species and location. (kilos or units / month) Average salary of artisanal fishers / crab harvesting workers (€/month)	35 fishers (finfish)
				Semi-open questionnaires (Annex IV)		35 fishers (finfish) 20 shellfish harvesters
Second Monitoring (October to December 2012)		Crab harvesting; Shellfish harvesting	Mangrove	Zoning Interviews (Annex VI and VII)	Total production of crabs (€/ha) Families supported directly by artisanal fishing in the mangrove Economic profit generated by artisanal fisheries (crabs / seafood) (€/month) Average salary of artisanal fishers / crab fishermen (€/month) Hourly value of artisanal fishing / crab harvesting labour (€/hour)	42 crab harvesters 17 shellfish harvesters
Third Monitoring (October to December 2013)	Curral Velho	Fishing (finfish); Shellfish harvesting	Continental Shelf; Mangrove (Gamboas)	Tracking table (Annex III)	Total fish production (Kg/day) Characteristics of fishing group or individual Destination of catch (sale / consumption) Catch (amount)	17 fishers (finfish) (23% of total population)

Source: authors of the research.

The total number of families who are dependent on the mangroves is associated with the number working in the artisanal harvesting of crabs and shellfish. Other economic activities, directly and indirectly related and unrelated to the mangrove system (wood collection for building houses and providing heat, beekeeping, crafts etc.), were not counted in the results. The information was collected by means of interviews with crab and shellfish harvesters.

Figure 2 - Different harvesting areas in the Cumbe area. Pressure is qualitatively defined in three ways: distance from the village, accessibility (road vicinity) and impacts of shrimp farms



Source: authors of the research. Image: Google Earth 2017

Monitoring of artisanal fisheries in Curral Velho

The third monitoring of artisanal fisheries was conducted in Curral Velho considering 17 local fishers (finfish, coast and continental shelf) and shellfish harvesters in the *gamboa* areas. The aim was to obtain an approximation of the economic profit generated by these two types of craft fishing near the mangrove (Table 1). A *gamboa* is a device composed of sticks and a long net arranged to create a trap. These artisanal tools are placed perpendicular to the coast, and in such a way that fish enter the net and cannot escape (QUEIROZ, 2007; 2014). Information was collected on fishing effort and fisheries, using the same methods as in the above-mentioned area of Cumbe (Table 1).

ANALYSIS AND PROCESSING OF DATA

The tracking information on the fishing workers was systematized in Microsoft Excel tables and analysed to extract the absolute values, averages and percentages. Economic data obtained from the first and second monitorings in Cumbe and the third monitoring in Curral Velho are presented in Euros¹.

¹ All the values obtained during Monitoring 1 and 2 were converted to euros: 1 euro = 2.56034 BRL. Consulted on 24/05/2012 <http://www.xe.com/ucc/convert/?Amount=1&From=EUR&To=BRL>

RESULTS

For part of the community of Cumbe, artisanal fishing is the main economic activity. This group is composed of 45 fishermen (fish and crabs) and 27 shellfish harvesters.

There are large variations in the earnings of fishing workers in the area considered (Table 2). Of the three monitored months, the 1st and 2nd had higher revenues than the 3rd. This is because the 3rd month was December, a month with many celebrations and holidays in which people go fishing less frequently. The average economic gain from the artisanal collection of crabs and finfish in the mangrove of Cumbe during the 3 months of research was € 12,557/month.

Table 2 - Economic gain generated by artisanal fisheries (crabs and fish).

FISHERMEN	TOTAL (€/MONTH)
month 1	14,217
month 2	14,224
month 3	9,231

Source: authors of the research.

Table 3 shows the average salary of fishing workers per month. The calculations give an average value of 369 €/month from both fishing and collecting crabs.

Table 3 - Average economic gain per fisherman (€/month).

	Month 1	Month 2	Month 3	Total (€/3 months)
Average per fisherman ± st.dev.	418 ± 237	418 ± 192	271 ± 188	1108

Source: authors of the research.

Table 4 shows the quantities of fish and crabs caught in the 3 months by the same group of fishing workers (35 in total). A total of 130,337 crabs (43,445 pcs./month) and 1,931 kg of fish (643 kg/month) were caught within the 3 months of the investigation.

Table 4. Production of crabs (pcs./month)

Months	Month 1	Month 2	Month 3	TOTAL (Units)
Number of crabs (Pcs.)	46,191	50,858	33,288	130,337

Source: authors of the research.

To get an approximation of the real income from artisanal fishing, three scenarios are assumed: 1) if fishing workers sell 100% of their catch, total direct earnings are € 37,672.94; 2) if they sell 50% of their catch, total direct earnings are € 18,836.47; and 3) if they sell 25% of their catch, total direct earnings are € 9,418.24.

The semi-open questionnaires were filled in by 35 fish and crab catchers (81% of the total) and 20 shellfish collectors (74% of the total). The total sum earned by fishing workers in Cumbe, considering artisanal fishing of crabs, fish and shellfish, was found to be € 103,438 / year, i.e. € 8,619 / month. The results of the second monitoring in Cumbe showed that the value of a well-preserved hectare of mangrove from the production of crabs is € 0.71 / m² / year, i.e. € 7,120 / ha / year. This value was obtained from measurements of mangrove productivity in three separate areas of study in the community.

Of the 155 families in Cumbe, 44 (27%) are dependent on artisanal fishing in the mangrove, obtaining products that they can consume themselves, send to market (generating income for their families) or exchange for other commodities. These data concern only those who collect crabs and shellfish, but several other mangrove resources are extracted (finfish,

firewood, etc.). Therefore, this result is possibly an underestimate and the percentage of families who depend directly or indirectly on mangroves could be even higher.

The second monitoring campaign conducted in Cumbe indicates another value for financial gain: € 20,985/month, from artisanal fishing in the Cumbe mangrove considering only the collection of crabs and shellfish (42 crab collectors and 17 shellfish collectors) and not caught fish (Table 5). The values obtained for each of the species were added to obtain the total economic value as the profit generated by the harvesting of crab and seafood (€/month).

Table 5 - Economic gain generated by artisanal fisheries in Cumbe mangrove (€/month).

	Quantities	Price (€)	€/month
<i>Ucides cordatus</i> (individuals)	80,560	0.24	19,334
<i>Cardisoma guanhumi</i> (individuals)	2,760	0.4	1,104
<i>Mytella charruana</i> (kg/month)	2,280	2.4	547
TOTAL			20,985

Source: authors of the research.

The data in Table 6 show that on average, each crab collector can earn a salary of € 508 / month (*Ucides cordatus*) and 360 €/month (*Cardisoma guanhumi*). On average, *Ucides cordatus* harvesters worked 5 hours a day for 4.6 days a week, working 23 hours / week (€ 127.20 / week or € 5.53 / hour of work).

Table 6 - Average monthly salary obtained from the sale of crabs (€/m²).

	Individuals/Week/Fisher	Individuals/Month	€/Individual	€/Month
<i>Ucides cordatus</i>	4530	2120	0.24	508
<i>Cardisoma guanhumi</i>	225	900	0.40	360

Source: authors of the research.

Two results can thus be deduced: 1) catching fish and crabs yields an economic gain of € 12,557/month, based on daily monitoring of 35 fishers; 2) catching fish, crabs and shellfish yields an economic gain of € 103,438/year or € 8,619/month, based on semi-open questionnaires conducted with 35 male and 20 female fishing workers. Crab and shellfish collection yields an economic gain of € 20,985/month, based on daily monitoring of 42 crab collectors and 17 shellfish harvesters. It can be seen that the data vary depending on the method applied and the fishing activity observed.

RESULTS OF MONITORING CONDUCTED IN CURRAL VELHO

The results of monitoring conducted in Curral Velho showed that the artisanal fishing sector in this community employs 99 people divided into fishers (finfish, caught on the continental shelf and in the gamboa areas) and shellfish collectors. Artisanal fishing on the continental shelf yields an economic profit of € 11,428/month, but it is noteworthy that 19% (€ 2204) of this value is consumed or exchanged within the community. The monitoring also showed that there are differences in the economic profits generated by artisanal fishing in Curral Velho performed individually and in groups (Tables 6 and 7).

Table 8 shows more accurately the benefit to each individual or group of fishing workers per working day. On average, over a period of three months, individual fishers worked 42 days to earn € 1,871, which means receiving € 624 / month (€ 45 / hour). Fishers working in groups worked 16 days to earn € 558, which is € 186 / month (€ 34 /hour).

Table 7 - Economic gain generated by artisanal fishing for individuals and groups in Curral Velho (€/month)

	Total fishing (€)	Total number of fishing workers	Days	Total €/fishing worker	Total €/fishing worker/business day	Total €/fishing worker/calendar day	Total (fishing worker/month)
Individual	13,099	7	42	1871	45	21	624
Group	21,186	38	16	558	34	6	186
TOTAL	34,285	45	58	2150	51	13	405

Source: authors of the research.

Table 8. Total economic profit generated by artisanal fishing in Curral Velho (€/month)

Destination	Total (€/month) fishing worker	Total (€/month) Group of fishing workers	Total General	%
Sold	3,179	6,043	9,223	80
Self-consumption	1,186	1,018	2,204	20
TOTAL	4,366	7,061	11,428	100

Source: authors of the research.

DISCUSSION

This is one of very few studies presenting an assessment of the economy based on the artisanal extraction (direct and indirect) of natural resources from mangroves and their surrounding areas (fish, crabs and shellfish) (HUSSAIN; BADOLA, 2010). There are very few studies based on direct monitoring using economic and social tools, but there is a consensus that they are urgently needed in order to understand the potential loss of tangible and non-tangible ecosystem services (SAENGER, 1999; QUEIROZ *et al.*, 2017). Mangroves are often undervalued and perceived as dispensable, efforts of fishers than by the support of official bodies (ACOSTA, 1996). This is an economic sector that generates (with low investment) many sources of employment while producing food for localities and for the market, which is important for society. One of the few studies that includes an in-depth economic evaluation of fisheries (and another services) is the one by Hussain and Badola (2010). The authors calculated that in areas with mangroves, income may be as high as US\$ 44 per hour of work. In areas where mangroves are not present, those fisheries drop to US\$ 3 per hour (HUSSAIN; BADOLA, 2010). That is to say, from a five-hour work day in this area (a conservative estimate based on our study), a fishing team may earn up to US\$ 220. Of course, care needs to be taken when considering these numbers, as each community is different and the renewable resources may differ widely. However, when we compare the income of artisanal fishermen in the State of Ceará with the average income of workers in the shrimp industry, we find that the former earn € 33 / day, working fewer hours than shrimp farm workers, who work an average of 8 hours a day (22 days per month) to earn an average of € 269 / month, i.e. € 12 / day (QUEIROZ, 2014). These data show that the fishing workers not only earn a higher salary than those employed in the shrimp industry, but also enjoy a superior quality of life in the coastal mangrove forest. It has been suggested that any economic analysis trying to estimate the value of mangroves without recognizing their contribution to subsistence economies will be incomplete (HUSSAIN; BADOLA, 2010). On the one hand, our results show that a fisher in an artisanal fishery can earn double or triple the minimum wage. On the other hand, taking into consideration other types of fishing operation, the part of the catch kept for their own consumption and the other complementary activities (such as handicrafts and agriculture) that they pursue, the people living in the mangroves appear to have ample opportunity to satisfy

their economic and societal needs (GIRY *et al.*, 2017). These activities may have a high specific economic value but are difficult to estimate (SHATIRATAI; BARBIER, 2001).

It is important to stress that most people working in artisanal fisheries are very proud and happy in their work (HUSSAIN; BADOLA, 2010; BETORZ *et al.*, 2012; CAROL *et al.*, 2012; QUEIROZ *et al.*, 2013b; DOMINGUEZ *et al.*, 2014; QUEIROZ *et al.*, 2017). These people value not only the economic benefits but also the fact that working in the mangroves means more freedom. *"I am proud to be a collector of crabs (...) we are free, free to decide how and how much we want to work, and that makes us responsible. Mangroves are our bank and we decide when we get the money, we owe nobody but Him."* (Testimony of a fishing worker from Cumbe). In contrast, those engaged in activities related to shrimp aquaculture do not describe their employment in sentimental terms, as may be the case with workers in the artisanal extractive economy, but rather with reference to concepts such as *"it's progress," "it's secure money"* or *"artisanal fishing is out of date."* Another lifestyle found in mangrove forests is that of the *concheros* (clam harvesters) (KUHL; SHERIDAN, 2009). The people making a living from this activity in the Ecuadorian mangrove forests are very proud of who they are, being a small and closed clan that lives mainly by collecting these bivalves and selling them at low prices to neighbouring villages (KUHL; SHERIDAN, 2009). What is important to them is not the direct economic profit, but the identity conferred by this particular activity and the habitat that feeds their families. The lifestyle of such groups should not be idealized, but the history of resource exploitation is very long and has ancient roots that need to be considered when making management plans (LÓPEZ-ANGARITA *et al.*, 2016).

The results obtained in the present study confirmed the economic potential of the mangrove and showed how the distribution of income in the village is very important when assessing their economy. Other perceptions and values also need to be quantified, but with new approaches (SATHIRATHAI, 2003; HUSSAIN; BADOLA, 2010; QUEIROZ *et al.*, 2013a; QUEIROZ *et al.*, 2017). The economic benefits generated by artisanal fisheries in terms of the sale of the products are very significant, representing a valuable contribution to the economic sustainability of traditional communities living in coastal areas (DIELE; SAINT-PAUL, 2005; ABURTO-OROPEZA *et al.*, 2008; HUSSAIN; BADOLA, 2010). Beyond the economic benefits however, other invisible benefits have been identified that do not fit into the current market logic. The benefits for the fishermen's families of the direct consumption and exchange of fishing products for other goods between families, together with the economic benefits in terms of the market, underpin the economy in traditional communities and are the basis for their survival. For example, in the communities studied along the coastal zone there are children who spend time after school in the mangroves catching crabs and/or oysters for food. When people go fishing together as a family, everything collected or fished stays at home or is given away. In the general accountancy of the Brazilian State, such benefits are not considered, but in rural society they make coexistence possible (KRONEN, 2004; WALTER, *et al.*, 2008; WARREN-RHODES, 2011).

It is clear that the two types of exploitation (artisanal fisheries and aquaculture) are incompatible. For the Cumbe community we demonstrated that the deletion of 1ha of mangroves for the construction of shrimp farms would mean the loss of € 7,120 / ha / year calculating artisanal crabbing alone, without considering all the other fishing activities occurring there and other services. This is a very high value and shows the high capacity of this ecosystem. In north-eastern Brazil, every hectare of mangrove destroyed in Suape (Pernambuco, Brazil) would mean the loss of € 3 million per year, calculating the economic benefits of ecosystem services such as fisheries, tourism, the retention of carbon from the atmosphere, containment of erosion, biological purification and landing sites for migratory birds (WALTERS *et al.*, 2008). Crab harvesting in this area is compatible with the conservation of the resource, because the practice takes only animals of appropriate size (DIELE; SAINT-

PAUL, 2005). In general, artisanal fisheries, when well-managed, respect ecosystem functioning, which is often explicitly recognized by the stakeholders themselves (HUSSAIN; BADOLA, 2010; BELHALIB *et al.*, 2013).

The profits generated per hectare of shrimp farm are difficult to match with the economic values that a hectare of mangrove can provide (fishing, harvesting, etc.), though they may appear superior. It is widely recognized that shrimp aquaculture generates serious medium-term environmental damage, because it has to physically displace part of the natural resources of an area (LÓPEZ-ANGARITA *et al.*, 2016). The process of occupation and installation produces a variety of chemical and biological changes in the ground, causing waterproofing of soils and making them unusable (ALONGI, 2002; SHANAHAN *et al.*, 2003; IBAMA, 2005; RIVERA-FERRE, 2009; POLIDORO *et al.*, 2010, QUEIROZ *et al.*, 2013a). The closer the farms, the greater the disruption to the structure of mangrove soil organic matter and the higher the mortality of filter feeders such as oysters. Crabs may also be affected by this (as well as by greater accessibility due to the proximity to the town), which is why their extraction levels differ by region (DIELE; SAINT-PAUL, 2005), the less degraded areas providing up to € 0.66 / m², and the areas most affected by shrimp farms only € 0.32 / m² (BURRIEL, 2012). These data are consistent with observations in the literature that the mangroves in disturbed areas are younger, more poorly structured and less bio-diverse (ALONGI, 2002).

The economic contribution of ecosystem services provided by mangroves in tropical coastal regions is conservatively estimated at about \$ 1.6 billion a year. On the basis of several studies, it is also estimated that nearly 80% of the fish catch in tropical coastal areas directly or indirectly connected to mangroves depends on the health of the habitat (COSTANZA *et al.* 1997; FIELD *et al.*, 1998; SATHIRATHAI, 2003; ELLISON, 2008; POLIDORO *et al.*, 2010). The lack of clear ownership and planning laws, as well as an underestimation of other services that are not recorded by conventional tools, has made mangroves vulnerable to short-term economic considerations. This is seen not only in this case, but in many others where the opinion of the fishermen is not properly considered (YATES; SCHOEMAN, 2014). The importance of food security is frequently mentioned in the debate over small-scale fisheries, but seldom articulated as an explicit objective (HELLEBRANDT *et al.*, 2014).

The original ancient mangroves disappeared long ago and their role nowadays is far from what it was in pre-Columbian times (LÓPEZ-ANGARITA *et al.*, 2016). Although the benefits of these forests have been widely recognized since 1990, their services have undergone rapid transformation through industrial agriculture and aquaculture (VALIELA *et al.*, 2001). Alongi (2002) predicted that in the 25 years following his study, shrimp aquaculture, overfishing and other intensive practices would be the greatest threats to mangrove conservation. Duke *et al.* (2007) concurred, setting out a very bleak prospect for one of the world's greatest providers of biodiversity and ecosystem services at a local and global level. The final question is which model should be pursued in the future: one with immediate benefits, disregarding the potential environmental and social damage, or one with long-term benefits, preserving traditional cultures and ecosystems (and respectful exploitation)? We need to consider tools such as those used in this study as an example to be extrapolated. It is essential to identify activities which are compatible with maintaining the proper functioning of productive ecosystems, their biodiversity and the sustainable provision of a wide range of ecosystem services, as in the case of artisanal fisheries. It is also important to highlight data that remain obscure, incomplete and poorly calculated, and most importantly, this information should reach all levels of society, especially managers responsible for setting public policies. It should also be considered that lowlands (especially mangroves and other wetlands) will be deeply affected over the next few decades by sea-level rise (PEDROZO-ACUÑA *et al.*, 2015), with potential impacts on these forests and related services. The way of life of thousands of people who earn a living directly from their renewable resources will be transformed, and the

defence of their way of life could be another tool with which to preserve the integrity of these biodiverse systems as much as possible.

REFERENCES

- AMARAL A.C.Z., and JABLONSKI S. Conservation of marine and coastal biodiversity in Brazil. **Conservation Biology**, 2005, 19 (3) 625–631p.
- ABURTO-OROPEZA O., EZCURRA E., DANEMANN G., VALDEZ, V., MURRAY J., and SALA E. Mangroves in the Gulf of California increase fishery yields. **Proceedings of the National Academy of Sciences**, 2008, 105:10456-10459p.
- ACOSTA V. G. Historia y desastres en América Latina (Vol. 1). La Red/Ciesas, 1996.
- ACSELRAD H.; CAMPELLO C.; MELLO G.N.B. **O que é justiça ambiental**. Rio de Janeiro: Editora Garamond, 156p., 2009.
- ALONGI D.M. Present state and future of the world's mangrove forests. **Environmental conservation**, 2002, 29(3): 331-349p.
- ASSOCIAÇÃO BRASILEIRO DOS CRIADORES DE CAMARÃO ABCC. **Projeto executivo para apoio político ao desenvolvimento do camarão marinho cultivado**, Recife, Brasil. Available via MCR AQUACULTURA, 2004. Disponible: www.mcraquacultura.com.br/arquivos/projeto/Marco_04.pdf. Access: 20 Dez 2005.
- BAILEY C. The social consequences of tropical shrimp mariculture development. **Ocean and Shoreline Management**, 1988, 11(1): 31-44.
- BALVANERA P., and H. COTLER. Acercamientos al estudio de los servicios ecosistémicos. 2007, **Gaceta Ecológica** 84-85:8-15.
- BARBIER E.B., M. ACREMAN, and D. KNOWLER. **Economic valuation of wetlands: a guide for policy makers and planners**. Gland, Switzerland: Ramsar Convention Bureau, 1997.
- BARBIER E.B., and I. STRAND . Valuing Mangrove Fishery Linkages: A Case Study of Campeche, Mexico. **Environmental and Resource Economics**, 1998, 12:151–166.
- BELHABIB D., V. KOUTOB, A. SALL, et al. Fisheries catch misreporting and its implications: The case of Senegal. **Fisheries Research**, 2014, 151, 1-11.
- BETORZ S.G., A.T. MERCADER, J.M. CAROL. **Evaluación Ambiental de la Acuicultura de Camarón sobre el ecosistema Manglar en el tramo bajo del río Jaguaribe**. Universitat Autònoma de Barcelona (UAB). Trabajo de fin de carrera, Barcelona, España, p 123, 2012.
- BEVERIDGE, M.C.M.; KELLY, L. A. Aquaculture and biodiversity. **Ambio**, 23:497-498, 1994.
- BURRIEL M.C. **L'altra cara del progr'es: estudi multidimensional sobre les conseqüències de les activitats d'explotació intensiva sobre les activitats derivades de les economies tradicionals a la comunitat de Cumbe, Brasil**. Universitat Autònoma de Barcelona (UAB). Trabajo de fin de carrera, Barcelona, España, 2012, 147p.

BUTLER, C.D., W. Oluoch-Kosura. 2006. Linking future ecosystem services and future human well-being. **Ecology and Society** 11(1): 30.

CORPORACIÓN COORDINADORA NACIONAL PARA LA DEFENSA DEL ECOSISTEMA MANGLAR - C-CONDEM. **Certificando la Destrucción: Análisis integral de la certificación orgánica a la acuicultura industrial de camarón en Ecuador.** In: L.F. GÓNGORA, M. T. BENAVIDES (Ed). Ecuador, 2007, 66p.

CAROL J.M., J.P. SALVÀ, S.G. BETORZ. **Análisis de la Dimensión Social y Económica de la Relación de la Comunidad de Cumbe con el Manglar y los impactos de la Industria Camaronera.** Universitat Autònoma de Barcelona (UAB). Trabajo de fin de carrera, Barcelona, España, 100pp, 2012.

COSTANZA R., R. DARGE, R. De GROOT. The value of the world's ecosystem services and natural capital. **Nature**, 1997, 387:253–260.

COSTA-PIERCE B.A. The 'Blue Revolution' - Aquaculture must go green. **World Aquaculture**, 2002 33(4):4-5p.

DAILY G.C. **Nature's Services: Societal Dependence on Natural Ecosystems.** Island Press, Washington, DC, 1997, 392pp.

DEWALT B.R., P. VERGNE, and M. HARDIN. Shrimp aquaculture development and the environment: people, mangroves and fisheries on the Gulf of Fonseca, Honduras. **World Development**, 1996, 24(7):1193-1208p.

DIAS-NETO J., and J.F.O. DIAS. **O uso da biodiversidade aquática no Brasil: uma avaliação com foco na pesca.** Ministério do meio Ambiente, Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (2015) 290pp.

DIEGUES A.C. **Pescadores, Camponeses e Trabalhadores do Mar.** São Paulo, Ática, 1983, 287pp.

DIEGUES A.C., and R.S.V. ARRUDA. **Saberes tradicionais e biodiversidade no Brasil.** Ministério do Meio Ambiente, Brasília, 2001, 176P.

DIELE K., V. KOCH, U. SAINT-PAUL. Population structure, catch composition and CPUE of the artisanally harvested mangrove crab *Ucides cordatus* (Ocypodidae) in the Caeté estuary, North Brazil: Indications for overfishing? **Aquatic Living Resources**, 2005, 18(2):169-178.

DOMINGUEZ J.C., J.A. MONRABA, M.M. BRIANSÒ. **Estudio económico sobre la pesca artesanal y análisis de sus diferencias con la acuicultura del camarón.** Universitat Autònoma de Barcelona (UAB). Trabajo de fin de carrera, Barcelona, España, 2014, 106p.

DUKE N.C., J.O. MEYNECKE, S. DITTMANN, A.M. ELLISON. A world without mangroves? **Science**, 2007, 317 (5834), 41–42.

ELLISON A.M. Managing mangroves with benthic biodiversity in mind: moving beyond roving banditry. **Journal of Sea Research**, 2008, 59:2-15p.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA (EMBRAPA). 2004. **Questões ambientais da carcinicultura de águas interiores: o caso da bacia do baixo Jaguaribe/Ceará**. Fortaleza, Ceará. 51 p.

FAO. Organización de las Naciones Unidas para la Alimentación y la Agricultura. **Mangroves of South America 1980–2005: country reports**. Forest Resources Assessment Working Paper No. 139, 2007. Rome. [online] Disponible: www.fao.org/forestry/site/mangrove/statistics. Access: 04 dec. 2019.

FAO. Organización de las Naciones Unidas para la Alimentación y la Agricultura. **Directrices voluntarias para lograr la sostenibilidad de la pesca en pequeña escala en el contexto de la seguridad alimentaria y la erradicación de la pobreza**. Roma, 2015, 25 pp.

FARLEY J., D. BATKER D., I. de la TORRE, and T. HUDSPETH . Conserving mangrove ecosystems in the Philippines: transcending disciplinary and institutional borders. **Environmental Management**, 2010, 45:39-51p.

FIRMO A.M., M.M. TOGNELLA, S.R. SILVA, R.R. BARBOZA, and ALVES R.R. Capture and commercialization of blue land crabs ("guaiamum") *Cardisoma guanhumi* (Latreille, 1825) along the coast of Bahia State, Brazil: an ethnoecological approach. **Journal of ethnobiology and ethnomedicine**, 2012, 8(1):1-12p.

FLAHERTY M., and G. KARNJANAKESORN. Marine shrimp aquaculture and natural resource degradation in Thailand. **Environmental Management**, 1995, 19 (1):27-37pp.

FIELD C.B., J.G. OSBORN, L.L. HOFFMAN et al. Mangrove biodiversity and Ecosystem Function. **Global Ecology and Biogeography Letters**, 1998, 7(1):3-14p.

GIRY F., T. BINET, and N. KEURMEUR. Les bénéfices de la protection des mangroves de l'outre-mer français par le Conservatoire du littoral: une évaluation économique à l'horizon 2040. **Etudes caribéennes**, 2017, Volume 35.

GODELIER M. **L'idéal et le matériel**. Paris: Fayard., 1984.

HELLEBRANDT D., E.H. ALLISON, and A. Delaporte. Segurança alimentar e pesca artesanal: análise crítica de iniciativas na América Latina. **Desenvolvimento e Meio Ambiente** 32, 2014.

HUSSAIN S.A., and R. BADOLA. Valuing mangrove benefits: contribution of mangrove forests to local livelihoods in Bhitarkanita Conservation Area, East Coast of India. **Wetlands Ecology and Management**, 2010, 18: 321-331.

IBAMA. Instituto Brasileiro do Meio Ambiente e Recursos Renováveis, Brasil. **Diagnóstico da Carcinicultura no Estado do Ceará**, relatório final. Vol. 1, 2005, 177 pp.

IBAMA. Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis. **Estatística da pesca Brasil. Grandes regiões e unidades de federações.** Ministério do Meio Ambiente, Brasília-DF, 2007.

KAUTSKY N., P. RÖNNBÄCK, M. TADENGREN, M. TROELL. Ecosystem perspectives on management of disease in shrimp pond farming. **Aquaculture**, 2000, 191:145-161p.

KRONEN M. Fishing for fortunes? A socio-economic assessment of Tonga' s artisanal fisheries. **Fisheries Research**, 2004, 70:121-134.

KUHL L., and M.J. SHERIDAN. Stigmatized property, clams, and community in coastal Ecuador. **Ecological and Environmental Anthropology**, 2009, 5: 1-22.

LÓPEZ-ANGARITA J., C.M. ROBERTS, A. TILLAY, J.P. HAWKINS, and R.G. COOKE. Mangroves and people: Lessons from a history of use and abuse in four Latin American countries. **Forest Ecology and Management**, 2016, 368: 151-162p.

MILLENNIUM ECOSYSTEM ASSESSMENT (MA). **Ecosystems and Human Well-being: Biodiversity Synthesis**, 2005, 64p. <http://www.bioquest.org/wp-content/blogs.dir/files/2009/06/ecosystems-and-health.pdf>

MARTÍNEZ-ALIER J. La defensa de los manglares contra la industria camaronera. **Ecología Política**, 2007, 41-48p

MEIRELES A.J.A., R.S. CASSOLA, S.V. TUPINAMBÁ, and L. QUEIROZ. Impactos ambientais decorrentes das atividades da carcinicultura ao longo do litoral cearense, nordeste do Brasil. **Revista Mercator**, 2007, 12:83-106p.

MEIRELES A.J.A., and L. QUEIROZ L. **A monocultura do camarão: danos socioambientais à base da vida comunitária tradicional no litoral do Nordeste brasileiro.** In: A. ZLNOURI, K. LASCHEFSKI (Editores). Universidade Federal de Minas Gerais (UFMG), Belo Horizonte, 2010, pp. 224-249.

MONTSERRAT M.M.; M. ORTEGA-CERDÀ ; E.M. VILLEGAS; RAMOS-MARTÍN. Conflictos socio-ambientales de la acuicultura del camarón en Centroamérica. Un análisis desde la justicia ambiental. Fundación Barcelona, **Colección DOCS Núm.1.** Vilanova i la Geltrú: Fundació Ent., 2011.

MONTSERRAT M.M. Conflictos socioambientales de la acuicultura del camarón en Centroamérica: un análisis desde la justicia ambiental. **Ecología política**, 2001, 41:90-96.

MPA. Ministério da Pesca e Aquicultura, 2012. **Boletim Estatístico da Pesca e Aquicultura 2012.** Brasil.

O'GARRA T. Bequest values for marine resources: how important for indigenous communities in less-developed economies?. **Environmental and Resource Economics**, 2009, 44(2): 179-202.

PEDROZO-ACUÑA A., R. DAMANIA, M.A. LAVERDE-BARAJAS, and D. MIRA-SALAMA. Assessing the consequences of sea-level 15 rise in the coastal zone of Quintana Roo, México: the costs of inaction. **Journal of Coastal Conservation**, 201519: 227-240.

PINHEIRO H.T., F. Di DARIO, L.C. GERHARDINGER, M.R.S. MELO. Brazilian aquatic biodiversity in peril. **Science**, 2015, 350 (6264) 1043–1044.

POLIDORO B.A., K.E. CARPENTER, L. COLLINS. **The loss of species: mangrove extinction risk and geographic areas of global concern**. PLoS One 5:e10095. doi:10.1371/journal.pone.0010095, 2010.

QUEIROZ L. **Na vida do Cumbe há tanto mangue: As influências dos impactos socioambientais da carcinicultura no modo de vida de uma comunidade costeira**. Dissertação de Mestrado, Universidade Federal do Ceará (UFC), Fortaleza, Brasil, 2007, 121 pp.

196

QUEIROZ L., S. ROSSI, A.J.A. MEIRELES, and C. COELHO JR. C. Shrimp aquaculture in the state of Ceará, 1970-2012: Trends in mangrove forest privatization in Brazil. **Ocean & Coastal Management**, 2013^a, 73:54-62.

QUEIROZ L., A.J.A. MEIRELES, and S. ROSSI. Serviços Ecosistêmicos Costeiros e Comunidades Tradicionais (Coastal Ecosystem Services and Traditional Communities). **Revista da ANPEGE**, 2013b, 8(10):145-159.

QUEIROZ L. **Industrial shrimp aquaculture and mangrove ecosystems: A Multidimensional analysis of a socioenvironmental conflict in Brazil**. PhD Thesis: Universitat Autònoma de Barcelona (UAB). Barcelona, Spain., 2014, 174 pp.

Raheem N., S. Colt, E. Fleishman, et al. 2012. Application of non-market valuation to California's coastal policy decisions. **Marine Policy**, 36:1166–1161.

RIVERA-FERRE, M.G. 2009. Can export-oriented aquaculture in developing countries be sustainable and promote sustainable development? The shrimp case. **Journal of Agriculture and Environmental Ethics** 22(4):301-321.

ROCHA I.P., J. RODRIGUES, and L.A.A. AMORIM. 2004. Carcinocultura brasileira em 2003. **Revista da ABCC**, [online] URL: <http://www.abccam.com.br>.

ROBERTSON A.J., and D.C. DUKE. Mangrove fish-communities in tropical Queensland, Australia: Spatial and Temporal Patterns in densities, biomass, and community structure. **Marine Ecology**, 1990, 104:369-379.

RÖNNBÄCK P. The ecological basis for economic value of seafood production supported by mangrove ecosystems. **Ecological Economics**, 1999, 29:235-252.

RÖNNBÄCK P., I. CRONA, and L. INGWALL. The return of ecosystem goods and services in replanted mangrove forests: perspectives from local communities. **Environmental Conservation**, 2007, 4:313–324.

SAENGER P. Sustainable management of mangroves, in J. Rais, I.M. Dutton, L. Pantimena, R. Dahuri & J. Plouffe (eds), **Integrated coastal and marine resource management:**

Proceedings of International Symposium, Batu, Malang, Indonesia, 25-27 November, National Institute of Technology (ITN) Malang in association with Bakosurtanal and Proyek Pesisir, Malang, Indonesia, 1999, pp. 163-168.

SALAS S., R; CHUENPAGDEE, J.C; SEIJO, and A. CHARLES. Challenges in the assessment and management of small-scale fisheries in Latin America and the Caribbean. **Fisheries Research**, 2007, 87: 5–16p.

SATHIRATHAI S. Environmental Governance: The case of industrial waste and pollution management in Thailand under the existing context of globalization. **Politics of the Commons: Articulating Development and Strengthening Local Practices**, 2003, 41pp. http://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/1152/Suthawan__Sathirathai.pdf?sequence=1&isAllowed=y

SCHMITHÜSEN F. Challenges to Forest Education in a Changing Social and Academic Environment. **Journal of Forest Science**, 1999, 45(5):232-234p.

SECRETARIA MUNICIPAL DE SAÚDE. 2012. **Ficha de identificação por comunidade, Aracati**, Ceará.

SECRETARIA MUNICIPAL DE SAÚDE. 2013. **Ficha de identificação por comunidade, Acaraú**, Ceará.

SHANAHAN M., C. THORNTON, S. TRENT et al. **Smash and Grab, Conflict, Corruption, and Human Rights Abuse In the Shrimp Farming Industry**. EJF, London, 2003, 37p.

SHATHIRATHAI S, and E.B. BARBIER. Valuing mangrove conservation in Southern Thailand. **Contemporary Economic Policy**, 2001 19 (2):109-122p.

SMALL C., and R.J. NICHOLLS. A global analysis of human settlement in coastal zones. **Journal of Coastal Research**, 2003 19: 584–599p.

SPALDING M.D., M. KAINUMA, and L. COLLINS. **World Atlas of Mangroves**. Earthscan, London, UK, 2010. 319 p.

SPANINKS F., VAN BEUKERING, O. 1997. **Economic Valuation of Mangrove Ecosystems: Potential and Limitations**. CREED Working Paper 14, International Institute for Environmental Development, Amsterdam.

STANLEY D.L. Explaining persistent conflict among resource users: The case of Honduran mariculture. **Society and Natural Resources**, 1998, 11:267-278p.

STONICH S., J. BORT, L. OVARES. Globalization of shrimp mariculture: the impact on social justice and environmental quality in Central America. **Society & Natural Resources** 10:161–179, 1997.

THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY. Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB. In: Sukhdev P (eds). **Brussels**, 2010. 39 p.

TESFAMICHAEL D., T.J. PITCHER, D. PAULY. Assessing changes in fisheries using fishers' knowledge to generate long time series of catch rates: a case study from the Red Sea. **Ecol. Soc.**, 2014, 19 (1), 18. <http://dx.doi.org/10.5751/ES-06151-190118>.

UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP). The Importance of Mangroves to People: A Call to Action. In: VAN BOCHOVE, J (eds). **United Nations Environment Programme World Conservation Monitoring Centre**, Cambridge, p 128, 2014.

WALTERS B.B., P. RÖNNBÄCK, J.M. KOVACS. Ethnobiology, socio-economics and management of mangrove forests: a review. **Aquatic Botany**, 2008, 89(2):220-236.

WARREN-RHODES K., A. SCHWARZ, and L.N. BOYLE. Mangrove ecosystem services and the potential for carbon revenue programmes in Solomon Islands. **Environmental Conservation**, 2011, 38(04):485-496.

YATES K.L.; D.S. SCHOEMAN. Incorporating the spatial access priorities of fishers into strategic conservation planning and marine protected area design: reducing cost and increasing transparency. **ICES Journal of Marine Science: Journal du Conseil**, 2014, <https://doi.org/10.1093/icesjms/fsu122>.

ACKNOWLEDGEMENTS

L. S. Queiroz received financial support from the Brazilian National Council of Technological and Scientific Development (CNPq). S. Rossi was funded with a Marie Curie International Outgoing Fellowship (ANIMAL FOREST HEALTH, Grant Agreement Number 327845) and assistance from P-SPHERE (COFUND Marie Curie, Grant Agreement Number 665919). This research was conducted as part of the activities of the ICTA Maria de Maetzu “Unit of Excellence” (MinECo, MDM2015-0552). Internationalization Project (PRINT) financed by the Coordination for the Improvement of Higher Level Personnel Ministry of Education (CAPES/MEC). Internationalization program PRINT/Geography UFC/CAPES.