# The harvesting process and fisheries production of the venus clam *Anomalocardia flexuosa* in a Brazilian Extractive Reserve, with implications for gender-sensitive management

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**ABSTRACT**

Resource managers are increasingly concerned regarding the sustainability of the small-scale fishery of the venus clam *Anomalocardia flexuosa*, a key livelihood resource extracted by Brazilian traditional coastal communities in the intertidal or shallow subtidal of mangrove estuaries. To inform the co-management process in an Extractive Reserve in North Eastern Brazil, a twelve month participant observation was conducted, and a semi-structured questionnaire issued (2015, n = 63 shellfisher interviewees from the Acaú community; Extractive Reserve Acaú-Goiana, Paraíba state). The shellfishers provided information on their gender, age, the number of shellfish (i.e. venus clams) collection days per week, the biomass collected, the preferred tide for collection (neap versus spring, ebb versus flood), the clam collection technique used and the different steps involved in the harvesting process. A total of 85.7 % of the interviewees were females and 73.01 % of all interviewees younger than 51 years. The number of days worked per week varied according to wind, rainfall, type of tide and local demand. The shellfish collection process comprised six steps: collection (per hand, handle rake, or with a dipnet), relocation, sorting/grading, loading, shelling and the final step of discarding shell waste, meat packaging and commercialization. Women (and the elderly) preferred the manual or handle rake collection technique, whilst men used the more efficient dipnet, which requires significant physical force but provides higher yields and thus financial return. Hand collection is the only method avoiding bycatch since the catch is scanned with fingers whilst 'fishing', allowing to identify and discard unwanted species and under-sized specimens on-site. In 2015, the community of Acaú alone collected an estimated 5,430 tons of *A. flexuosa*, 80% more than that extracted by all six communities of the Acaú-Goiana Extractive Reserve in 2005. Our research revealed and is informing

the Governing Council of the Extractive Reserve, about the fundamental role of women in the production chain, not only for the collection of the clams, but also for their processing (shelling, meat extraction, packaging of the meat) and commercialization. Consideration of gender-specific roles, techniques, capacities and needs, as well as a stock assessment will be key to ensure ecologically, economically and socially meaningful strategies for sustainable venus clam fisheries co-management, in line with the United Nation's Sustainable Development Goals.

Keywords: Gender, Mangroves, Shellfish, Small-scale fishery.

## 1. INTRODUCTION

Mangrove ecosystems are sustaining marginalized local livelihoods globally. Effective management of mangrove-associated small-scale fisheries supports reaching the United Nations' Sustainable Development Goals such as gender equality (Goal 5), poverty and hunger eradication (Goal 1&2), decent work and economic growth (Goal 8), reduced inequalities (Goal 10), and improved life below water (Goal 14) (UNDP, 2021). Brazil is among the five countries with highest numbers of mangrove-associated fishers (zu Ermgassen et al., 2020) and currently has 95 so called Extractive Reserves (ERs), covering a total area of 156,217 km² (Brasil, 2020). ERs prioritize anthropic presence, considering humans as "actors and conservation managers", rather than as unnatural beings (Rueda, 1995; Ferry, 2009). The aim of ERs is to "protect the livelihoods of the community and to ensure the use and conservation of the renewable natural resources traditionally used by the population in a given area" (Brasil, 2007). They fall under category VI of the IUCN Protected Areas categorization scheme: "Protected area with sustainable use of natural resources".

One of the many species heavily sought after by traditional fishing communities in Brazil for subsistence and as their main income source (Rodrigues et al., 2013; Ferreira-Jr. et al., 2015; Rocha and Pinkerton, 2015; Gomes et al., 2019) is the Venus clam *Anomalocardia flexuosa* Gmelin, (1791), a bivalve mollusk of the family Veneridae. Distributed from the Caribbean to Uruguay it occurs along the entire Brazilian coast (Rios, 1994). The species inhabits intertidal and shallow infralittoral areas protected from the action of waves and currents, dwelling in sandy and/or sandy-muddy substrates at a depth of 0.5 to 1.5 m (Narchi, 1972; Mouëza et al., 1999; Boehs and Magalhães, 2004). The species is collected and its meat extracted throughout the year, in an artisanal manner, by hand or with the aid of instruments, mostly by women (Nishida et al., 2006; 2008; Macnaughton et al., 2010). The clams are collected from intertidal mud and sand banks during low tide periods.

Shell length and abundance of *A. flexuosa* have decreased over time in several locations in Brazil (Rocha et al., 2008; Oliveira et al., 2014; Silva-Cavalcanti and Costa, 2011; Pezzuto and Souza, 2015), often linked to high exploitation levels. In the north-east Brazilian Goiana River estuary, in the late 90s, following land use changes and increased fishing pressure, local stakeholders demanded the creation of an ER to protect their rights and futures, including the shellfishers of the Acaú community who formulated and submitted a petition. Consequently, in 2007 the ER Acaú Goiana was created, located inside the Goiana River estuary (Fadigas, 2009). Several social-ecological studies have been performed in the area since (e.g. Fadigas and Garcia, 2010; 2012, Moura, 2005; Quinamo, 2012; Guedes, 2013; Mourão et al., 2020). Data provided in Mourão et al., 2020 and in the present paper (both of which formed part of an unpublished MSc thesis, Baracho, 2016) contributed to the elaboration of the 2017 Fisheries Agreement for the ER Acaú-Goiana. As is the case for all ERs (Rueda, 1995), the ER Acaú-Goiana is a co-

management area where users have a say in the formal decision-making process. ER agreements such as the one approved for Acaú-Goiana in 2017 are made involving representatives from all stakeholder groups. Therefore, compliance is often better than in protected areas with a top-down management approach. Each ER has local ER managers working closely with the local community who also carry out inspections of compliance for the agreements made.

To reach/maintain sustainable fisheries it is important to understand the different steps involved in the harvesting and commercialization process, since efficient resource management requires knowledge of the behavior of the people performing the extractive activities (Bené and Tewfik, 2001; Begossi, 2008). *A. flexuosa* are collected using a variety of different techniques and equipment, which vary among coastal communities and along the Brazilian coast. Local practices must be understood to inform best on-site management practices. Knowledge of the landed yields is also crucial, but scarce for *A. flexuosa* (Dias et al., 2007; Barletta and Costa, 2009; Rocha, 2013). The lack of stock assessment and landing data is one of the greatest problems for designing management actions for fisheries resources (Berkes et al., 2001).

The overall aim of this research was to generate baseline data to inform decision makers involved in the optimization of strategies for sustainable and socially inclusive *A. flexuosa* fisheries management. The objectives were to identify age and gender of the shellfishers working in the northeastern Brazilian ER Acaú-Goiana, to describe the steps involved in *A. flexuosa* collection process in the region and to collect quantitative landing data.

## 2. METHODS

### 2.1 Study area

The study area is an estuarine mangrove ecosystem with tributary rivers (camboas,) muddy sand banks (croas) and saltmarshes (apicuns). The study was performed in 2015 in the coastal community of Acaú. The community forms part of the ER Acaú-Goiana, located in the Goiana Estuary complex in Northeast Brazil (Figure 1;7°32'36.77"S, 34°49'30.96"W), approximately 68 km south of the city of João Pessoa. The reserve encompasses an area of 6,678 hectares.

The Acaú community comprises 300 shellfishers registered in the Association of Shellfish Harvesters of Acaú. They depend on artisanal fisheries as their main income source. It is one of seven communities that are beneficiaries of the ER Acaú-Goiana; that is, its inhabitants are allowed to sustainably use the natural resources of the region (Fadigas and Garcia, 2012; Quinamo, 2012). The research was approved by the Committee on Ethics in Research of the Federal University of Paraíba (protocol 0578/14) and by prior authorization and information on biodiversity (System of Authorization and Information in Biodiversity (SAIBIO, nº 46322-1).

### 2.2 Data collection and analysis

Data was collected from January to October 2015, through participant observation and the issuance of a semi-structured questionnaire. The participant observation technique (Malinowski, 1978) was applied during this period to help establish a relationship of trust with local actors, this relationship is called ‘Rapport’, a term created by Triviños (1987). The questionnaire (supplement S1) was filled in by 63 shellfishers, corresponding to 21% of the total fisher population, selected using the snowball technique (Bailey, 1982). To qualify for interview, shellfishers were expected to meet the following

requisites: to be collecting shellfish and depending on artisanal fisheries for their survival. Questions regarding their gender, fishing experience (number of years), how shellfishing was learned and the primary reason for harvesting shellfish, collections sites, collection method used, and means of commercialization were asked. To collect quantitative data on the collection of *A. flexuosa*, 63 shellfishers (women and men) were asked how many days per week they collected clams, (frequency) (F) and how many kg(visceral mass – the only weight being measured by the shellfishers) taking into account the variation of days collected between the rainy and dry season.

In order to define the total weight (visceral mass + shell) of harvested clams (Pt), the meat-shell ratio of 1:16 proposed by Dias et al. (2007) was used, with Pt = Pc + (Pc . 16), where Pc is the weight of the collected meat (kg/day/person). This ratio is based on the fact that producing 1 kg of meat generally requires 16 kg of clams with shells (Dias, et. al. 2007).

Finally, to estimate the biomass of *A. flexuosa* collected in 2015, the following equation was used: $P_{2015} = \bar{F} \ . \ S \ . \bar{P_t} \ . \ n$, where F is the mean collection frequency of the clams collected per week by the interviewees; S is the number of weeks of the year (52 weeks); Pt is total weight (visceral mass and shell) of the yield; and n is the number of shellfishers registered in the *Associação das Marisqueiras de Acaú* (Association of Shellfish Harvesters of Acaú). The calculated value is an estimate due to the lack of precise information on the number of shellfishers actively working in the community. Hence the total number of members of the Shellfishing Association was used as a reference.

## 3. RESULTS

Of the 63 interviewees, 54 were females and 9 males. The youngest and oldest shellfisher were 18 and 66 years old. Seventeen were 51 years or older ('older year-classes') and the remaining 46 fishers younger than 50 years ('younger year-classes') (see Table 1) and Mourão et al. (2020).

### 3.1 **Steps involved in the collection, processing and commercialization of *A. flexuosa***

All interviewees stated that the *A. flexuosa* collecting process is composed of six steps from relocating to the collection site(s) to the final sale of the processed product (see below, Figure 2). The execution of these steps is performed by individuals or by groups of relatives and/or friends and lasts one or two days, depending on the number of clams collected and the number of people involved. The frequency with which shellfishers performed their activities varied throughout the year, depending on a set of factors, among them wind, rainfall, type of tide and demand of local commerce. All interviewees stated that shellfishing is avoided during periods of intense wind since it increases the probability of the boat capsizing on the way to the collection sites. They also reported a lower frequency of visits of the collection sites during the rainy season when the water is colder and more turbid, complicating the clam collection. The interviewees reported that a total of 50% (n = 31) of their collection sites had a substrate consisting of muddy sand, 28% (n = 18) a predominantly sandy and 22% (n = 14) a predominantly muddy substrate.

*Step 1: Collection*

*Collection per hand* – This technique is performed in places that are totally or at least partially (maximum water depth 1m) exposed at low tide. The shellfishers settle in a chosen place and adopt one of three types of postures: kneeling, sitting, or with back bent leaning forward and knees slightly bent (Figure 3C). They then begin the process of

collecting, using their hands as a "rake" to locate the shellfish in the substrate. Once enough specimens have been collected this way, the yield is shaken to separate the shellfish from the substrate prior to sorting for size (see step 3).

*Handle rake (gadanho) collection* – According to 80% of the respondees, this technique was first implemented in the community two decades ago (beginning in 2000). The same postures are adopted in its execution as when collecting by hand, but the extraction is carried out with the aid of a rake (Figure 4). This tool is built by joining two Polyvinylchloride (PVC) pipes to a "T" –shape, with one of the axes being equipped with nails (Figure 4A-C). It is currently made from custom iron. The part of the rake equipped with nails is pressed against the substrate and pulled towards the shellfisher, into a dipnet held between the legs (Figure 4D-E). The dipnet is composed of an arc surrounded by a seine, with a small cable at one of its ends (Figure 4F-G). Due to its permeability, the dipnet functions to both wash and pre-screen the collected shellfish. When filling the dipnet, the shellfisher deposits the clams into a small bucket. When the net is full, it is emptied directly into the boat or into a larger bucket.

*Collection with a dipnet (jereré)* – The dipnet technique is the most recently implemented technique in the Acaú community, first used in 2010. It is deployed in areas covered with water at depths ranging from a little below the knee to the proximity of the harvester's neck. The dipnet consists of an arc steel rod surrounded by a screen, with a set of nails at one end and a wooden stick (about 2-m in length) at the other. For its execution, the shellfisher, in a standing position, presses the handle of the dipnet against the bottom of the sand (or mud) bank and drags it in any direction (Figure 5) (Figure 5A-F). The collected shellfish, as well as bycatch (i.e. other benthic species such as snails (*Cerithium atratum and Vitta virginea),* the lined sole (*Achirus lineatus)* and red algae (*Cryptonemia crenulate*), which is discarded at the collection site, often in a damaged

235 condition, are shaken inside the dipnet for washing and pre-sorting. They are then
236 transferred to a large bucket or directly into the boat (Figure 5G). This technique is
237 generally practiced by men because of the greater physical strength required. The 2017
238 Agreement for the ER Acaú-Goiana specifies that the nets for dipnets must have a
239 minimum mesh-size of 12 mm.

240 The technique selected for collecting *A. flexuosa* varied according to the
241 preference of each shellfisher, however, participant observation revealed some
242 tendencies. All respondents from the older age classes were women and stated that they
243 were preferring collecting by hand, while 80% of the younger age classes preferred to use
244 a *gadanho* or handle rake. The dipnet method was exclusively used by men of the younger
245 age classes, albeit only by 8%. Each type of collection technique is further described
246 below (Figure 4).

247 *Step 2: Relocation* - Travel of shellfish harvesters from their home to the collection site
248 and later to the place of processing was carried out by foot (10% of the respondees) or,
249 more frequently, by boat powered by paddling (Figure 3A-D, 90% of the respondees),
250 depending on the distance and the depth of the water during the journey. Boats were
251 owned by shellfish harvesters.

252 *Step 3: Sorting (grading)*- The main objective of sorting is the selection of larger clams
253 for further processing, whilst smaller animals are discarded, i.e. released at the collection
254 site. The sorting method varied according to the collection technique used (manual,
255 handle rake or dipnet). When harvesting by hand, sorting was carried out simultaneously
256 on-site. The selected larger specimens were deposited into a hamper or plastic bucket (a
257 container that is gradually replacing the use of a hamper); the smaller clams were returned
258 to the site.The sorting process, when using the handle rake or dipnet, was carried out after
259 the collection at one of three places: at the sand (mud) bank, in the entrance of the river

tributary, or in the yard of the shellfishers' homes. This step is locally referred to as grading (Figure 5H-J) and consists of arranging the collected clams on a plastic crate, swinging the latter repeatedly, thereby removing all smaller individuals falling through the crate. Crates are screen-type monoblocs (normally used for packing and transporting fruits and vegetables) that serve as sieves for the selection of larger clam specimens. The size of the clams discarded in this process varied according to the size of the holes in the crate, for which there is no standardization within the community. The graded material is placed into the boats or else directly into nylon sacks.

*Step 4: Loading* - For processing, the clams were transported to the shellfishers' residences (78% of all respondees) or to a so called *caiçara* (22% of the respondees), a location where fishing/shellfishing gear is kept. Caiçaras are typically built with mangrove wood, and are located near the sea, river or tributary (Figure 6A). The clam yield is transported during several trips (depending on the quantity collected on a particular day) by boat or by foot, with the latter being done with the weight supported on the head/shoulder, or with the aid of a handcar. The distance travelled ranged from a few meters to some kilometers.

*Step 5: Shelling* - The removal of the visceral mass (meat) from the shell requires the animals to be cooked first. A large five litre pot is filled with clams and placed over a wood-burning fire in the backyard of houses for about 10 to 20 minutes. The wood used is deadwood collected on the ground of nearby mangrove forests or it was donated by local industries as woody debris. The shells of dying clams open when they are boiling in water during the cooking process, thus facilitating shelling. Shelling was performed in two ways: by hand or with a sieve (Figure 6B-E). For shelling by hand, small portions of the cooked seafood were placed in a bowl and brought to a table that may or may not be covered by plastic. The shellfishers, then seated around the table, withdrew the visceral

mass of the clams using their fingers depositing the meat in a basin in the middle of the table whilst empty shells were placed into another container arranged between their legs. When using a sieve, fractions of the cooked seafood were poured into a sieve, i.e. a plastic basin whose bottom had been removed and replaced by a screen (Figure 6D-E). The shellfish in the sieve were rocked repeatedly until their visceral mass separated from the shells and fell into another container. The shelled meat was then placed on a table to begin segregating it from other waste (gravel) that may have passed through the sieve.

*Step 6: Discard of the shell waste, meat packaging and sales* - The empty shells were discarded in a disorderly manner in the community, usually on the streets or in a backyard where they form deposits that can reach several meters in height (Figure 6F). Other forms of disposal, although less widely used, involve the use of shells as raw material for the manufacture of handicrafts and sales as animal feed and to construction companies.

The extracted visceral mass was weighed and packed into plastic bags for commercialization. The bags were stored in freezers or in refrigerators. Shellfishers with freezer space accommodated the seafood of those who did not, at no cost. Finally, the product was sold, by the shellfishers themselves, in three different ways: at private homes, at local fairs, or by moving through the community, usually by bicycle, offering the product for sale. Figure 4 summarizes all steps involved in shellfish collecting, processing and commercialization, the different techniques employed and how they interact.

### 3.2 The influence of tides on *A. flexuosa* collection

Shellfishers reported that spring tides are the best tides for collecting shellfish because the sand banks are more exposed, with increased area available for harvesting *A. flexuosa*. In summer (September to February), there was a greater need for collecting clams due to higher demands from visiting tourists, which also influenced the value of

the product. In addition to these factors, other elements influenced decisions regarding the collection process, such as boat availability, competing domestic activities, physical limitations, financial needs and the quantity of the product in stock.

The preferred time for shellfish collection within a given tidal period is defined by the collection technique used. For collection by hand or handle rake extraction, shellfishers began their activity at low tide and left with incoming tide (Figure 3), thus using the sandbank (*croa)* when the area was totally or partially uncovered by water (low tide). In contrast, for the dipnet technique collection began during high tide and ended at low tide.

### 3.3 Landing data

Of all shellfishers interviewed (n = 63), 46.0% collected clams three to five times a week, with a mean and standard deviation (SD) of 3.9 +/- 1.17 days. The mean quantity of shellfish meat (visceral mass) retrieved from the collected clams per day per person was 5.25 ± 3.88 (SD) kg/person/day (data pooled for the study site and observation period), corresponding to 84 kg/person/day of shell waste after meat extraction.

Finally, the estimated total weight of *A. flexuosa* collected in the Acaú community in 2015 was 5,430 tons, corresponding to 319,410 kg of extracted meat and 5,110, tons of discarded shells following meat extraction.

## 4. DISCUSSION

Shellfish such as the study species *A. flexuosa* are not very mobile and therefore predictable in space and time. These clams can easily be collected in accessible intertidal areas and harvesting does not require costly equipment. This fishery can therefore be conducted by women, children and the eldery and so provides an important livelihood

335 opportunity for members of society who might otherwise be marginalized (Bailey et al.,
336 2008; Erlandson et al., 2008; Barletta and Costa, 2009; Silva-Cavalcanti, 2011; Fadigas
337 and Garcia, 2012; Mourão et al., 2020). Hence, by creating opportunities for subsistence
338 and income for diverse people in the community rather than men only, the *A. flexuosa*
339 fishery reduces (or alleviates) poverty (Goal 1) and inequalities (Goal 5&10), contributing
340 importantly to the United Nations Sustainable Development Goals.

341 **4.1 The roles of women in the *A. flexuosa* production chain**

342 The role that women play in small-scale fisheries is often overlooked and lacking
343 adequate recognition and valuation (e.g. Torre-Castro et al., 2017; Tilley et al., 2020).
344 The present study revealed the predominance of women in the *A. flexuosa* fishery in the
345 North-east Brazilian marine extractive reserve (ER) Acaú, and their preference and
346 dependency on certain capture techniques. Hence, to assure women's equitable
347 participation in small-scale fisheries and their legal rights, the inclusion of gender-
348 sensitive approaches in fisheries management is important, for the Acaú community as
349 for other ERs in Brazil and beyond (Ciommo and Schiavetti, 2012; Harper et al, 2013;
350 Kleiber et al., 2014; Torre-Castro et al., 2017; Harper et al., 2020).

351 Globally, marine small-scale fisheries production activities comprise an estimated
352 2.1 million women who mainly target invertebrates from intertidal and nearshore habitats
353 (Harper et al., 2020 ) Yet, in most official fisheries statistics their activities are not
354 explicitly noted, or even included, due to a lack of relevant data and economic assessment
355 (Harper et al., 2020). Although women often collect marine invertebrates and produce
356 fishing gear such as fishing nets and lines, they are rarely included in the development of
357 strategies for sustainable fisheries or related decision-making processes. Moreover, they
358 are rarely considered as ‘fishers’ (Chapman, 1987; Fröcklin et al., 2013) and therefore
359 marginalized through the often inadequately used term ‘fishermen’ in fisheries

management. In Ecuador social dynamics and cultural norms were ignored when developing and implementing local aquaculture (shrimp farms), which exacerbated existing gender inequalities, further depriving already marginalized women (Trevino and Murillo-Sandoval, 2021).

Our research in Acaú revealed the fundamental role of women in the production chain, not only in the collection of the clams, but in their processing (shelling, meat extraction, packaging of the meat) and the commercialization of the final product. Consideration of gender-specific roles, techniques, capacities and needs in natural resource management is therefore not only key to assure the sustainability of a mixed-gender fishery and product availability on markets, but also for assuring social equality.

Our gender-relevant research findings have been forwarded to the Governing Council of the Acaú Goiana ER to help assure that any regulatory measures taken in the future will account for the importance of women in this fishery and vice versa, as well as for the elderly, another often overlooked group in intertidal shellfish fishery. For example, we have encouraged ER managers and Acaú Governing Council to adequately consider that women and men are dependent on different collecting techniques, with different capture efficiencies, and capture locations (shallow versus deeper water) when formulating quota. It is important to regularly discuss with local communities and all ER stakeholders involved, to update and adapt fisheries agreements considering and responding to dynamic environmental, technical, social and socio-economic realities affecting the local fishery.

While our research already informed the 2017 Fisheries Agreement resulting in the formal permission of the three locally used shellfish collecting techniques described by us, the agreement does not yet include strategies or quota in respect to collection technique or gender, something we strongly advocate for the future.

385 **4.2 Harvesting process and collection techniques'**

386 Along the 7500 km of Brazilian mangrove-lined coast many different collection
387 techniques are used in the fishery of *A. flexuosa* and other marine invertebrates, likely
388 due to the diverse ethnic and cultural backgrounds of the t coastal communities.
389 Furthermore, environmental conditions such as tidal regimes differ along the coast,
390 requiring local adaptions in collection techniques (see Table 2).

391 The coastal *A. flexuosa* fishing community in Acaú uses local ecological
392 knowledge, for example regarding substrate type and the relationship between moon
393 phase and tidal amplitude, and employs three techniques for shellfish collection, namely
394 harvesting by hand, dipnetting and handle raking. As revealed by the current study, the
395 choice of the collection technique in Acaú is age and gender specific. Harvesting by hand
396 was exclusively conducted by women, as elsewhere along the coast, and is performed
397 with or without the aid of other tools such as a kitchen spoon, knife, rake, spade, machete
398 and other tools (e.g. Botelho et al., 2005; Martins and Souto, 2006; Nishida et al., 2006;
399 Dias et al., 2007; Moura et al., 2008).

400 The propensity of older (51-60 years of age) female shellfishers harvesting by
401 hand is likely related to custom and tradition since they have been practicing this
402 technique since early childhood. There is also no immediate need for using a more
403 efficient technique since these women rarely rely exclusively on shellfish to survive
404 (many are retired), and only collect for their own consumption or for financial
405 supplement. In contrast, men prefer - and have invented - the more efficient dipnet
406 technique, which requires considerable physical force. Gomes et al. (2019) found that the
407 average yield of the latter was about two times greater than that of harvesting by hand.
408 Hence, efficiency, key for men who need to generate income for themselves and their

409 families, has been the driving force behind the optimization and creation of new
410 techniques such as the dipnet, to improving financial returns.

411 The development of 'technological innovations' in small-scale fisheries can
412 increase the number of people involved in a fishery, decrease the species and size-
413 selective character of the practice compared to traditional methods (Nascimento et al.,
414 2011) and drive overexploitation (Silva-Cavalcanti and Costa, 2009). Our study revealed
415 that shellfishers of Acaú have implemented the relatively new collection technique – the
416 dipnet - in the region for about a decade. Individual fishers used different mesh-sizes (12
417 mm) for these nets, depending upon net availabilities. However, simultaneous to the
418 implementation of the dipnet collection technique, they invented the new procedure of
419 grading. This procedure was consciously employed in Acaú for two main reasons: 1)
420 ecological, since capturing smaller clams with the new dipnets compared to manual
421 capture is perceived as likely to decrease the abundance of the resource; and 2) economic,
422 since smaller individuals have less visceral mass and thus yield less meat, with greater
423 time demands for their shelling, thus negatively affecting the cost-benefit ratio.

424 According to Arruda-Soares et al. (1982) and Araújo (2001) individuals of *A.*
425 *flexuosa* that have a shell length of less than 20 mm should not be captured, because they
426 have not yet sexually matured. Thus, a biologically correct opening mesh size of the
427 dipnet (and/or grid of the grading basket used, see figs 5 H and 5 I) is important.
428 Interestingly, since 2017, despite the implementation of a minimum mesh size for dipnets,
429 fishers using the dipnet technique, including those adhering to the legislation, have
430 nevertheless continued to use the grading baskets as well, adhering to this former
431 tradition. Given this and the fact that not everyone is using the legal mesh size for their
432 dipnets, we suggest that future management strategies should also contain locally a
433 meaningful minimum 'grade' size of the gradings baskets (for example by adding a 12mm

mesh into them to comply with current (2017) ER legislation), in addition to maintaining the minimum mesh size for dipnets.

As well as adhering to a biological meaningful minimum capture size, it is also necessary to consider appropriate places in the environment to return the smaller individuals and bycatch sorted out in the collection process. *A. flexuosa* inhabits areas protected from the action of waves and currents (Boehs and Magalhães, 2004) and therefore the discarded animals should be returned to these zones to increase their survival. Hand collection is the only method which avoids bycatch in the first place, since the catch is scanned with the fingers whilst 'fishing', allowing to identify and discard unwanted species and under-sized specimens on-site.

**4.3 Landing data**

The daily per-person collection of *A. flexuosa* by shellfishers estimated here for Acaú in 2015 *(*5.25 kg /person/day) was higher than the average yield in other regions of the country (e.g. 3.2 kg/person/day in the northeast of Brazil (Dias et al., 2007) and the global average (2.4 kg/person/day, Bose et al., 2013). During our study, the average clam biomass collected (including the shell) per household (441 kg per day; Baracho 2016) was also exceeding the maximum quota later established for the fishery of this species part of the 2017 ER agreement (300 kg clam meat per household per day; Portaria nº 851, ICMBio 2017).

The 300kg quota clam meat per household per day was established without consideration of variations in catch in response to lunar/tidal phases, and without consideration of capture technique and gender. Quota for individual units, such as e.g. households, are a management measure already implemented for many species in different regions of the world (Sigler and Lunsford , 2001; Tveteras et al., 2011) and their

459 main objective is to enhance the economic benefits and promote sustainable fishing
460 (Soliman, 2014). Based on the questionnaire responses and our on-site observations we
461 estimate that shellfishers of Acaú collected about 5,430 tons of shellfish (meat and shells)
462 in 2015. Data on the landing of *A. flexuosa* are rare (Rocha and Pinkerton, 2015);
463 however, Barletta and Costa (2009) reported that in 2005, in the same study area,
464 approximately 3,000 tons (clams and meat) / year were captured, thus, between 2005 and
465 2015 landings have almost doubled.

466 **5. Final considerations**

467 Shellfishers in the Northeast Brazilian coastal community of Acaú used a six-step
468 harvesting process, which is dynamic given that new techniques are being developed and
469 implemented. The personal choice for a specific collection techniques is influenced by
470 gendered preferences and harvesting efficiency. The practicalities, and ecological as well
471 as economic benefits and risks of the three currently applied techniques differ. Hand- or
472 handle rake collection require least force and equipment, but are less efficient compared
473 to the dip net. The latter provides a higher financial return, however the fact that the
474 number of clams collected is greater compared to the other two techniques, using the dip
475 net increases the risk of overfishing. We advocate the need of future studies determine
476 age/size of sexual maturity of the local *A. flexuosa* stock and the abundance of mature
477 specimens to assess whether the current dipnet mesh (and grading size) is sustainable.
478 Furthermore, rules should be included regarding the ecologically appropriate locations
479 for return of undersized clams (i.e. intertidal or shallow infralittoral zones.)

480 Given the 80% higher annual *A. flexuosa* weight of clams collected of the Acaú
481 fishers in 2015 compared to 2005, we further suggest a comprehensive assessment of the
482 dynamics of the in all fishing areas and, depending on the availability of such sites, in
483 unfished control areas. To establish ecologically and socially adequate quota it will also

be necessary to determine collecting-technique specific yields locally. In summary, an update of the 2017 Fisheries Agreement will need to account for a range of ecological and economic trade-offs and of the shellfish collection technique employed in the area. Ecologically, economically and socially meaningful management strategies will help to achieve key Sustainable Development Goals, including an 'Improvement of Life Under Water' (Goal 14) through sustainable resource management.

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## 7. REFERENCES

Araújo, C. M., 2001. Biologia reprodutiva do berbigão Anomalocardia brasiliana (Mollusca: Bivalvia, Veneridae) na Reserva Extrativista Marinha do Pirajubaé (REMAPI), Estado de Santa Catarina. Florianópolis. Tese de Doutoramento. Universidade de São Paulo.

Arruda-Soares, H., Schaeffer-Novelli, Y., Mandelli-Jr. J., 1982. "Berbigão" Anomalocardia brasiliana (Gmelin, 1791), Bivalve comestível da região da Ilha do Cardoso, estado de São Paulo, Brasil: aspectos biológicos de interesse para a pesca comercial. *Boletim do Instituto de Pesca*, 9: 21-38.

Bailey, K. D., 1982. *Methods of social research*. New York, USA: McmILLIAN Publishers, The Free Press: p. 553.

Bailey, G., Carrión, J. S., Fa, Darren A., Finlayson, G., Finlayson, C., Rodríguez-Vidal, J., 2008. The coastal shelf of the Mediterranean and beyond: Corridor and refugium

509 for human populations in the Pleistocene. Quaternary Science Reviews, 27: (23-24); 2095
510 - 2099.

511 Baracho, R. L., 2016. Conhecimento Ecológico local e a Cogestão: O caso da
512 Reserva Extrativista Acaú-Goiana. Dissertação de Mestrado. João Pessoa, Paraíba:
513 UFPB.

514 Barletta, M., Costa, M. F., 2009. Living and Non-living Resources Exploitation
515 in a Tropical Semi-arid Estuary. *Journal Coastal Research*, 56: 371-375.

516 Begossi, A., 2008. Local knowledge and training towards management.
517 Environment, *Development and Sustainability*, 5: 591-603.
518 https://doi.org/10.1007/s10668-008-9150-7

519 Bené, C., Tewfik, A., 2001. Fishing effort allocation and fishermen's decision
520 making process in a multi-species small-scale fishery: Analysis of the conch and lobster
521 fishery in Turks and Caicos Island. *Human Ecology*, 29: (2); 157-186.
522 https://doi.org/10.5039/agraria.v9i1a2947

523 Berkes, F., Mahon, R., McConney, P., Pollnac, R., Pomeroy, R., 2001. *Managing*
524 *small-scale fisheries: alternative directions and methods*. International Development
525 Research Center, Ottawa.

526 Boehs, G., Magalhães, A. R. M., 2004. Simbiontes associados com
527 *Anomalocardia brasiliana* (Gmelin) (Mollusca, Bivalvia, Veneridae) na Ilha de Santa
528 Catarina e região continental adjacente, Santa Catarina, Brasil. Revista Brasileira de
529 Zoologia, 21: (4); 865-869.

530 Bose, S., Al-Kind, F., Al-Balushi, A., Rajab, M., 2013. Accounting the
531 Unaccounted: A Case of Women's Participation in Shellfish Harvesting in the Sultanate
532 of Oman. Gender Technology and Development, 17 (1): 31-53.
533 https://doi.org/10.1177/0971852412472123

534 Botelho, E. R., Furia, R. R., Santos, M. C. F., 2005. Biologia do siri Callinectes
535 maracaiboensis (Taissoun, 1969) (Crustacea, Decapoda, Portunidae) no estuário do Rio
536 Uma, município de São José da Coroa Grande (Pernambuco, Brasil). *Boletim Tecnico*
537 *Cientifico CEPENE* 13 (2): 11-25, 2005.
538 http://www.icmbio.gov.br/cepene/images/stories/publicacoes/btc/vol13b/btcvol13b.pdf
539 (acessado em 7 de abril de 2020).

540 Brasil., 2007. Decreto Federal nº 6.040, de 07 de fevereiro de 2007. Institui a
541 Política Nacional de Desenvolvimento Sustentável Dos Povos e Comunidades
542 Tradicionais. Brasília -DF: Presidência da República. Casa Civil.
543 http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2007/decreto/d6040.htm (acessado
544 em 10 de maio de 2020).

545 Brasil, 2020. Site oficial do Ministério do Meio Ambiente.
546 https://www.mma.gov.br/areas-protegidas/sistema-nacional-de-ucs-snuc (acesso em 20
547 de maio de 2020).

548 Chapman, M. D., Women's Fishing in Oceania. Human Ecology, 15: (3); 267-
549 288. Ciommo, R. C., Shiavetti, A., 2012. Women participation in the management of a
550 Marine Protected Area in Brazil. *Ocean & Coastal Management*, 62: 15-23.
551 https://doi.org/10.1016/j.ocecoaman.2012.02.010

552 Ciommo, R. C., Shiavetti, A., 2012. Women participation in the management of a
553 Marine Protected Area in Brazil. Ocean & Coastal Management, 62: 15-
554 23https://doi.org/10.1016/j.ocecoaman.2012.02.010

555 Dias, T. L. P., Rosa, R. S., Damasceno, L. C. P., 2007. Aspectos socioeconômicos,
556 percepção ambiental e perspectivas das mulheres marisqueiras da Reserva de
557 Desenvolvimento Sustentável Ponta do Tubarão (Rio Grande do Norte, Brasil). *Gaia*
558 *Scientia*, 1: 25-35.

559 Erlandson, J. M., Rick, T. C., Braje, T. J., Steinberg, A., Vellanoweth, R. L., 2008.
560 Human impacts on ancient shellfish: a 10,000 year record from San Miguel Island,
561 California. Journal of Archaeological Science 35: (8) 2144-2152.

562 Fadigas, A.B.M. 2009. As marisqueiras e a Reserva Extrativista Acaú-Goiana:
563 uma análise de práticas participativas para a conservação do ambiente. Dissertação de
564 Mestrado. João Pessoa: UFPB.

565 Fadigas, A. B. M., Garcia, L.G., 2010. Uma análise do processo participativo para
566 a conservação do ambiente na criação da Reserva Extrativista Acaú-Goiana. *Sociedade*
567 *& Natureza* 22: 261-276. http://dx.doi.org/10.1590/S1982-45132010000300012

568 Fadigas, A. B. M., Garcia, L. G., 2012. Conservation of the estuarine zone of the
569 Goiana and Megaó rivers in northeastern Brazil: an analysis of the strategies adopted by
570 fisherwomen communities. *Journal of Integrated Coastal Zone Management*, 12: (4);
571 577-582. https://doi.org/10.5894/rgci386

572 Ferreira Júnior, A. L., Neto, R. L. B., Kolm, H. R., Absher, T. M., 2015.
573 Relationship between reproductive cycle of Anomalocardia brasiliana (Mollusca:
574 Veneridae) and the suspended particulate matter in the Paranaguá Estuarine Complex,

575 Brazil. *PANAMJAS* 10: 44-54.
576 http://www.panamjas.org/pdf_artigos/PANAMJAS_10(1)_44-54.pdf (acessado em 14
577 de maio de 2020).

578 Ferry, L., 2009. *A nova ordem ecológica: a árvore, o animal, o homem*. Tradução
579 de Rejane Janowitzer. Rio de Janeiro: DIFEL: p. 253.

580 Fröcklin, S., de la Torre-Castro, M., Lindström, L., Jiddawi, N. S., 2013. Fish
581 Traders as Key Actors in Fisheries: Gender and Adaptive
582 Management. *AMBIO,* 42**:** 951–962. https://doi.org/10.1007/s13280-013-0451-1

583 Gomes, J. O. L., Melo, A. S., Lopes, S. F., Mourão, J. S., 2019. "Techniques for
584 Catching the Shellfish Anomalocardia flexuosa in a Tropical Estuary in Northeast Brazil.
585 *Human* Ecology, 476: 931-939.

586 Guedes, M. C. A., 2013. Resex Acaú-Goiana: da criação à atuação análise da
587 percepção das marisqueiras sobre a atual conjuntura da Reserva Extrativista e a atuação
588 de seu órgão gestor. Trabalho de Conclusão de Curso (Especialização em Gestão
589 Ambiental) – Faculdade de Ciências e Tecnologia Prof. Dirson Marciel de Barros,
590 Instituto de Ensino Superior de Goiana, Goiana, 52 p.

591 ICMBIO. 2017. Instituto Chico Mendes de Conservação da Biodiversidade.
592 Portaria nº 851, de 22 de dezembro de 2017. Diário Oficial da União, Seção 1,
593 01/02/2018: 92. http://www.in.gov.br/materia/-
594 /asset_publisher/Kujrw0TZC2Mb/content/id/1538836/do1-2018-01-02-portaria-n-851-
595 de-22-de-dezembro-de-2017-1538832 (acessado em 12 de maio de 2020).

596 Harper, S., Zeller, D., Hauzer, M., Pauly, D., Sumaila, U. R., 2013. Women and
597 fisheries: Contribution to food security and local economies. *Marine Policy*, 39: 56-63.
598 https://doi.org/10.1016/j.marpol.2012.10.018

599 Harper, S., Adshade, M., Lam, V. W. Y., Pauly, D., Sumaila, U. R., 2020. Valuing
600 invisible catches: Estimating the global contribution by women to small-scale marine
601 capture fisheries production. *PLoS ONE*, 15: (3); e0228912.
602 https://doi.org/10.1371/journal.pone.0228912

603 Kleiber, D., Harris, L. M., Vincent, A. C. J., 2014. Gender and small-scale
604 fisheries: a case for counting women and beyond. *Fish and Fisheries*, 16: 574-562.
605 https://doi.org/10.1111/faf.12075

606 Macnaughton, A., Rocha, L., Wojciechowski, L. M., Carolsfeld, J., 2010. Tools
607 for understanding the complexities of small-scale coastal fisheries economies in
608 northeastern Brazil: participatory value chain mapping and economic feasibility studies.
609 *In: Proceedings of the Fifteenth Biennial Conference of the International Institute of*
610 *Fisheries Economics & Trade.* França: Montpellier.

611 Malinowski, B.K. 1978. *Argonautas do Pacífico Ocidental*: Um relato do
612 empreendimento e da aventura dos nativos nos Arquipélagos da Nova Guiné Melanésia.
613 São Paulo: Abril Cultural

614 Martins, V. S., Souto, F. J. B., 2006. Uma análise biométrica de bivalves coletados
615 por marisqueiras no manguezal de Acupe, Santo Amaro, Bahia: uma abordagem
616 etnoconservacionista. *Sitientibus Série Ciências Biológicas*, 6: 98-105.

617 Mouëza, M., Gros, O., Frenkiel, L., 1999. Embryonic, larval and postlarval
618 development of the tropical clam, *Anomalocardia brasiliana* (Bivalvia, Veneridae).
619 *Journal of Molluscan Studies*, 65: (1); 73-88. https://doi.org/10.1093/mollus/65.1.73

620 Moura, G.F., 2005. A pesca do camarão marinho (Decapoda, Penaeidae) e seus
621 aspectos sócioecológicos no litoral de Pitimbu, Paraíba, Brasil. Tese de Doutorado.
622 Recife, Pernambuco: URPE.

623 Moura, D. F. G., Neto, A. O. S., Almeida, R. O. A., 2008. A etnoecologia das
624 marisqueiras da comunidade de Praia Grande, Ilha de Maré, Salvador – BA. *Candombá*,
625 4: (2); 91-110.

626 Mourão, J. S., Baracho, R. L., Martel. G., Barbosa, R. R. D., Lopes, S. F., 2020.
627 Local ecological knowledge of shellfish collectors in an extractivist reserve, Northeast
628 Brazil: implications for co-management. *Hydrobiologia*, 847: 1977–1997.
629 https://doi.org/10.1007/s10750-020-04226-w

630 Narchi, W., 1972. Comparative study of the functional morphology of
631 *Anomalocardia brasiliana* (Gmelin, 1791) and *Tivela mactroides* (Born, 1778) (Bivalvia,
632 Veneridae). *Bulletin of Marine Science*, 22: 643-670.

633 Nascimento, D. M., Mourão, J. S., Alves. R. R. N., 2011. A substituição das
634 técnicas tradicionais de captura do caranguejo-uçá (*Ucides cordatus*) pela técnica
635 "redinha" no estuário do Rio Mamanguape, Paraíba. *Sitientibus série Ciências*
636 *Biológicas*, 11: 113-119. https://doi.org/10.13102/scb68

637 Nishida, A. K., Nordi, N., Alves, R. R. N., 2006. Mollusc gathering in Northeast
638 Brazil: An ethnoecological approach. *Human Ecology*, 34: 133-145.
639 https://doi.org/10.1007/s10745-005-9005-x

Nishida, A. K., Nordi, N., Alves, R. R. N., 2008. Aspectos socioeconômicos dos catadores de moluscos do litoral paraibano, Nordeste do Brasil. *Rev. de Biologia e Ciências da Terra*, 8: 207-215.

Oliveira, I. B., Neto, S. R. S., Filho, J. V. M. L., Peixoto, S. R. M., Gálvez, A. O., 2014. Efeito do período chuvoso na extração do molusco bivalve *Anomalocardia brasiliana* (Gmelin, 1791). Revista Brasileira de Ciências Agrárias, 9: (1); 139-145. https://doi.org/10.5039/agraria.v9i1a2947

Pezzuto, P. R., Souza, D. S., 2015. A pesca e o manejo do berbigão (*Anomalocardia brasiliana*) (Bivalvia: Veneridae) na Reserva Extrativista Marinha do Pirajubaé, SC, Brasil. *Desenvolvimento e Meio Ambiente*, 34: 169-189. https://doi.org/10.5380/dma.v34i0.39758

Quinamo, T., 2012. A importância da atividade pesqueira artesanal para a população dos municípios que abrigam a RESEX Acaú-Goiana nos estados de Pernambuco e Paraíba. Fundaj, Recife.

Rios, E. C., 1994. *Seashells of Brazil*. Rio Grande: Fundação Universidade de Rio Grande. 131 p.

Rocha, L., Pinkerton, E., 2015. Co-management of clams in Brazil: a framework to advance comparison. *Ecology and* Society, 20: (1); 7. http://dx.doi.org/10.5751/ES-07095-200107

Rocha, L. M., 2013. Ecologia humana e manejo participativo da pesca do búzio Anomalocardia brasiliana (Gmelin, 1791) (Bivalvia: Veneridae) na Reserva de Desenvolvimento Sustentável Estadual Ponta do Tubarão (RN). Tese Doutorado. Natal – RN: UFRN

663 Rocha, M. S. P., Mourão, J. S., Souto, W. M. S., Barboza, R. R. D., Alves, R. R.
664 N., 2008. O uso dos recursos pesqueiros no estuário do Rio Mamanguape, Estado da
665 Paraíba, Brasil. *Interciência*, 33: (12); 903-909.

666 Rodrigues, A. M. L., Borges-Azevedo, C. M., Costa, R. S., Henry-Silva, G. G.,
667 2013. Population structure of the bivalve Anomalocardia brasiliana (Gmelin, 1791) in the
668 semi-arid estuarine region of northeastern Brazil. *Brazilian. Journal. Biology*, 73 (4):
669 819-833. https://doi.org/10.1590/S151969842013000400019

670 Rueda, R. P., 1995. Evolução histórica do extrativismo. In: *Murrieta, J.R, and R.P*
671 *Rueda, (Ed.)*. Reservas Extrativistas. Cambridge: UICN/CCE/CNPT/IBAMA. p.13-17.

672 Sigler, M. F., Lunsford, C. R., 2001. Effects of individual quotas on catching
673 efficiency and spawning potential in the Alaska sablefish fishery. *Canadian Journal of*
674 *Fisheries and Aquatic Sciences*, 58: 1300-1312.

675 Silva-Cavalcanti, J. S., Costa, M. F., 2009. Fisheries in Protected and Non-
676 Protected Areas: Is it Different? The Case of *Anomalocardia brasiliana* at Tropical
677 Estuaries of Northeast Brazil. *Journal of Coastal Research*, 56: 1454-1458.

678 Silva-Cavalcanti, J. S., Costa, M. F., 2011. Fisheries of *Anomalocardia brasiliana*
679 in Tropical Estuaries. *Pan-american Journal of Aquatic Sciences*, 6: 86-99.

680 Soliman, A., 2014. Individual transferable quotas in world fisheries: Addressing
681 legal and rights-based issues. *Ocean & Coastal Management*, 87: 102-113.
682 https://doi.org/10.1016/j.ocecoaman.2013.09.012

683 Souza, A.C.F.F., 2011. *Dinâmica socioambiental da pesca de marisco em um*
684 *estuário urbano nordestino*: um estudo etnoecológico dos pescadores da Bacia do Pina,
685 Recife/PE. João Pessoa, Dissertação (Mestrado em Ciências Biológicas) – UFPB.

686 Tilley, A., Burgos, A., Duarte, A. Lopes, J. R., Eriksson, H., Mills, D., 2020.
687 Contribution of women's fisheries substantial, but overlooked, in Timor-Leste. *Ambio*,
688 50: 113 -124. https://doi.org/10.1007/s13280-020-01335-7

689 Treviño, M., Murillo-Sandoval, P. J., 2021. Uneven consequences: Gendered
690 impacts of shrimp aquaculture development on mangrove dependente communities.
691 *Ocean and Coastal Management*, 210: 3-13.
692 https://doi.org/10.1016/j.ocecoaman.2021.105688

693
694 Triviños, A. N. B., 1987. *Introdução à pesquisa em ciências sociais: a pesquisa*
695 *qualitativa em educação.* São Paulo: Atlas.

696 Torre-Castro, M., Fröcklinb, S., Börjessonb, S., Okupnik, J., Jiddawic, N. S.,
697 2017. Gender analysis for better coastal management – Increasing our understanding of
698 social-ecological seascapes. *Marine Policy*, 83: 62 - 74.
699 https://doi.org/10.1016/j.marpol.2017.05.015

700 Tveteras, S., Paredes, C. E., Peña-Torres, J., 2011. Individual Vessel Quotas in
701 Peru: stopping the race of anchovies. *Marine Resource* Economics, 26: 225-232.

702 UNDP, 2021. United Nations Development Programme. Sustainable
703 Development Goals. (https://www.undp.org/content/undp/en/home/sustainable-
704 development-goals.html). Accessed: April 20, 2021.

705 zu Ermgassen, P. S.E., Mukherjee, N., Worthington, T. A., et al., 2020. Fishers
706 who rely on mangroves: Modelling and mapping the global intensity of mangrove-
707 associated fisheries. Estuarine Coastal Shelf Science.
708 https://doi.org/10.1016/j.ecss.2020.106975

709 Table 1. Shellfisher interviewees (n = 63) per gender/age group and preferred collection
710 technique

| Are groups (years) | women % | men % |
|---|---|---|
| 18 – 20 | 1.59 (1) | 1.59 (1) |
| 21 – 30 | 9.52 (6) | 0 (0) |
| 31 – 40 | 22.22 (14) | 1.59 (1) |
| 41 – 50 | 26.98 (17) | 9.52 (6) |
| 51 – 60 | 19.05 (12) | 1.59 (1) |
| 61 – 70 | 6.35 (4) | 0 (0) |
| Average | 14.29 | 2.38 |
| Collection technique | | |
| hand | 6.35 (4) | 0 (0) |
| handle hake | 79.37 (50) | 0 (0) |
| dipnet | 0 (0) | 14.29 (9) |

711
712
713 Table 2 – Description of the techniques used for collecting *A.flexuosa.*
714

| **Collecting technique** | **Description** |
|---|---|
| Manual | This study (see description in results section) |
| Handle rake | This study (see description in results section) |
| Hook or Hand Dredge | "It is a handwork trawl dredge made up of a grated iron basket (currently stainless steel) and wooden handle. During trawling, the fisherman walks backwards and remains positioned facing the mouth of the equipment, monitoring the volume of material accumulated during the operation." [a] |
| Trolley (cart) | An instrument consisting of a wooden frame with a sloping grid on one side to collect shellfish and another grid at the bottom to select the size of the collected individuals. This technique is operated in places covered by water and involves two people to drag the cart with the objective of collecting the sediment and disposing of it in the lower part for later sorting of the extracted material. [b] |
| Arrasto de Galeia (Crates) | "It is handwork trawl usually practiced in submerged areas and consists of scraping the substrate with the ends of the 'basket" ' for a certain distance on the bank of the sediment aiming to capture the available shellfish". [c] |

| | Dipnet | This study (see description in results section) |
|---|---|---|

[a] Pezzuto & Souza (2015, p. 173); [b] Nishida et al. (2006); [c] Souza (2011, p. 46)