

MUSSEL *Perna perna* EXTRACTION AND COMMERCIALIZATION IN GUANABARA BAY, BRAZIL

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RESUMO**A extração e a comercialização do mexilhão *Perna perna* na baía de Guanabara, Brasil**

A baía de Guanabara, no estado do Rio de Janeiro, recebe efluentes industriais e uma alta carga de esgoto doméstico, a partir de uma bacia hidrográfica com mais de 4.000 km². Avaliações para coliformes fecais na água do mar indicam, em várias regiões, uma situação imprópria para cultivo ou extração de mexilhões. Não obstante, a atividade extrativa envolve entre 50 e 100 coletores e uma produção de 20 a 65 t mensais, *in natura*. A Associação dos Maricultores de Jurujuba, em Niterói, com 30 a 40 pescadores, responde por cerca de 50 a 70% desse total. A coleta do mexilhão nas áreas mais internas da baía foi descontinuada, mantendo-se porém inalterada, ao longo dos últimos 20 anos, na região entre Boa Viagem, em Niterói, e o Aeroporto Santos Dumont, no Rio de Janeiro, até a entrada da baía. Mais recentemente, a extração foi estendida às ilhas oceânicas adjacentes à baía. As condições de processamento do mexilhão na Associação de Jurujuba são adequadas às normas sanitárias, porém o produto coletado pelos pescadores independentes é processado e comercializado em condições extremamente precárias.

PALAVRAS-CHAVE: Mexilhão *Perna perna*, extração e comercialização, baía de Guanabara, Brasil.

ABSTRACT

*Guanabara bay in the state of Rio de Janeiro receives industrial effluents and a high load of domestic sewage from a watershed of more than 4,000 km². Water evaluations for *Echerichia coli* showed that various regions of the bay are not suitable for mussel farming or extraction. Notwithstanding, around 50 and 100 fishermen are involved in mussel extraction yielding 20 to 65 t monthly, in live weight. The Mariculture Association of Jurujuba, in Niterói, with 30 to 40 fishermen is alone responsible for 50 to 70% of the total catch. Although the mussel collection in the inner part of the bay was discontinued, the activity has not been interrupted for the last 20 years in the region comprised by Boa Viagem, in Niterói, and Santos Dumont airport, in Rio de Janeiro, until the entrance of the bay. More recently the extraction area was extended to the oceanic islands adjacent to the bay. While the mussel processing at the Jurujuba association is appropriate according to the sanitary standard, the mussel extracted by the independent collectors is processed and commercialized in very poor conditions.*

KEY WORDS: mussel *Perna perna*, extraction and commercialization, Guanabara bay, Brazil.

INTRODUCTION

Total marine and estuarine fisheries production in Brazil has leveled around 500 thousand tons since 2001, with artisanal fisheries comprising almost 50% of total production. Percentages were higher in north and northeastern regions (85% and 63%, respectively) and lower in southeast (33%) and south regions (9%) (IBAMA 2005). Notwithstanding, in some areas of southeast and south regions small scale fisheries are still dominant and extremely important to the wealth of littoral communities.

The available information on fisheries production in Guanabara bay is restricted, in general, to a few reports, congress and symposium papers, and undergraduate courses' monographs. Only more recently, a systematic survey was carried out in the main landing points around the bay (IBAMA 2002). For one year, between April 2001 and March 2002, data collectors located at 32 landing points registered a total catch of 19,000 t, corresponding to the value of US\$ 7,2 million (US\$ 1 = R\$ 2, in September 2007). The monthly average number of fishermen in activity was approximately 1,700 t (Jablonski *et al.* 2006).

Despite the diversity of fish species occurring in the bay, only a few reach the densities compatible with commercial fisheries. More than 70% of the catch is comprised by small pelagics (Atlantic anchoveta, Brazilian menhaden and Brazilian sardinella); among demersal fishes, croaker, mullets, catfish, and largehead hairtail attain almost 20% of total catch, what determines a low average price for the fish caught in the bay. Other important fisheries in the bay are directed to the catch of shrimps and swimming crabs; the collection of crabs in the mangroves and the mussel harvesting along the rocky shores in the bay and on the adjacent islands.

The main mussel production chain is organized around the Mariculture Association of Jurujuba ("Associação de Maricultores de Jurujuba"), which, despite the name, has only a small income derived from mariculture. Between April 2001 and March 2002, the total production of processed mussel was of 53 t, which is equivalent to 530 t in live weight (IBAMA 2002, Jablonski *et al.* 2006).

Besides the fishermen association, a number of "independent" collectors also operate in the bay extracting the mussel from the rocky shores and

ripraps and processing their catch in a very primitive fashion. It is quite an ancient activity and in some cases the characteristics of subsistence coexist with heavy pollution and intense urbanization.

In this paper we present an estimate of total catch and the number of fishermen involved in mussel collection. We also comment the methods of extraction, processing, and commercialization of the mussel in the bay. The current situation is compared to previous surveys carried out in the Eighties.

The area

Guanabara bay (Figure 1) has a water surface of 381 km²; the number of inhabitants around the bay is over 10.2 million people, occupying a watershed of 4,081 km² (SEMADS 2001).

Almost all the municipalities included in the watershed are densely urbanized (CIDS 2000). Sewage handling is still precarious, with 51% of domestic sewage being collected and only 14% treated. The *in natura* domestic sewage discharged in the bay reaches 17 m³/s (SEMADS 2001). The larger part of non treated effluents is discharged in the west side of the bay, resulting in average levels of dissolved oxygen around 3.1 mg/L near the bottom and anoxic sediment production (Kjerfve *et al.* 1997).

There are more than 14,000 industries around the bay, whose effluents produce a Biochemical Oxygen Demand - BOD - of 4,700 kg/day. Industrial sources are also responsible for discharging 11 kg of heavy metals daily (lead, chrome, zinc and mercury); solid wastes directed to the bay amount 1,000 t/day (CIDE 1998, SEMADS 2001).

The renewal time for 50% of total water volume of the bay was estimated in 11.4 days (Kjerfve *et al.* 1997).

1 – MATERIAL AND METHODS

During November and December 2006, and March and April 2007, interviews based on standardized forms were carried out in several sites of

mussel processing and commercialization in Niterói and Rio de Janeiro. The sites were those identified in França (1988) – Santos Dumont airport, Flamengo embankment (“Aterro do Flamengo”), island and beach of Boa Viagem, and Flechas, Vermelha and Urca beaches; altogether twenty forms were completed.

The registered data referred to extraction sites, schedules and depths; use of boats; single or group working; number of working days a week; part or full-time activity; processing features; auto consumption of part of the catch; packing and commercialization; prices; rotation of extraction sites; and minimum size for extraction and commercialization.

The fishermen association (“Colônia de Pescadores”) Z10, on Governador island, and Z11 in Ramos were contacted, for information about extracting sites in more inner areas of the bay.

Figures concerning mussel production of the “Associação Livre de Maricultores de Jurujuba – ALMARJ” were obtained directly from the Association records.

Along the text, mussel collectors not affiliated to the Jurujuba association are identified as “independent” fishermen. Besides, the terms collectors and fishermen are employed indistinctly.

2 – RESULTS

The “independent” collectors

Figure 1 shows the mussel extraction, processing, and commercialization sites for the independent collectors and Table 1 shows the monthly mussel catch and the number of collectors in Guanabara bay.

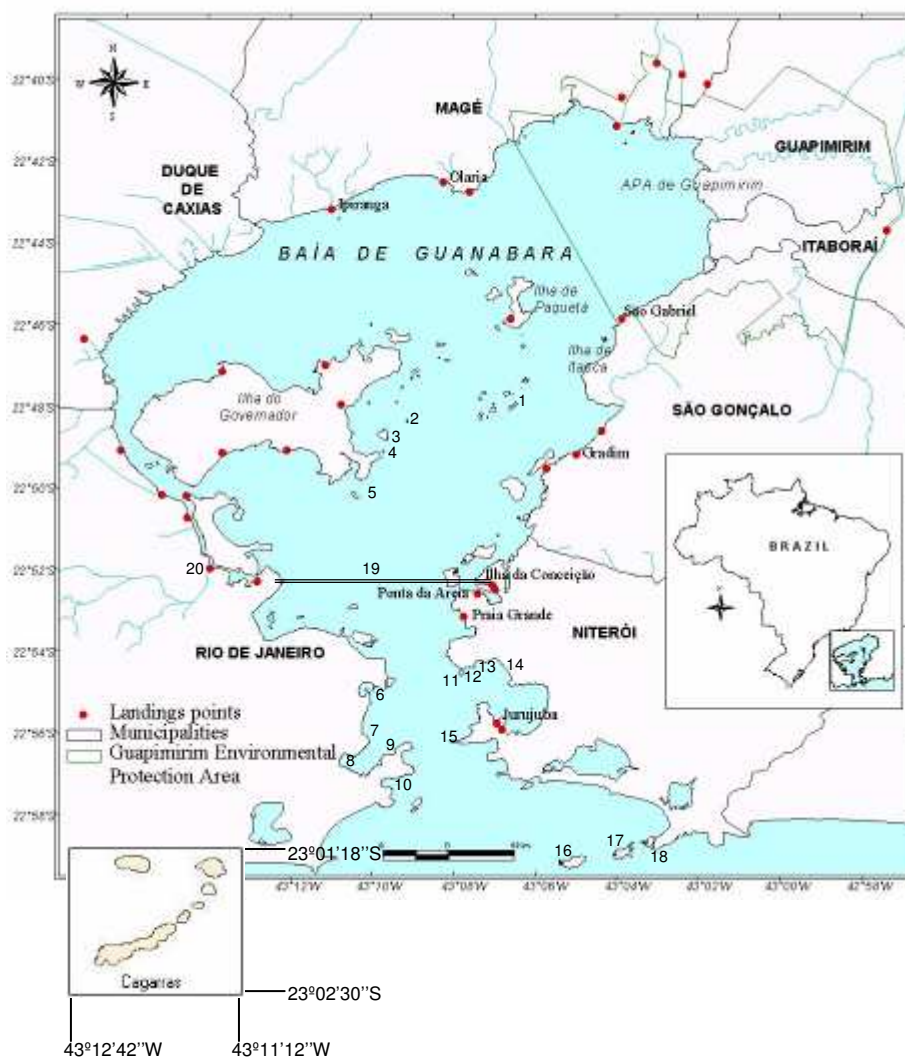


FIGURE 1 – Guanabara bay. Adapted from Jablonski *et al.* (2006). (See text for details).

Dots along the coast indicate the main fish landing points; numbers show the extraction, processing and commercialization sites for the independent mussel collectors, between 1988 and 2007.

1 – Jurubaíba; 2 – Manuéis de Dentro; 3 – d'Água island; 4 – Manuéis de Fora; 5 – Passagem rock; 6 – “Glória” marina and Santos Dumont airport; 7 – Flamengo embankment (“Aterro”); 8 – Botafogo beach; 9 – Urca beach; 10 – Vermelha beach; 11 – Boa Viagem island; 12 – Boa Viagem beach; 13 – Flechas beach; 14 – Icaraí; 15 – Santa Cruz fortress; 16 – Pai island; 17 – Mãe island; 18 – Itaipu; 19 – Rio Niterói bridge; 20 - Ramos Fishermen Association.

TABLE 1 – Estimated monthly production of the independent mussel collectors in Guanabara bay (November and December 2006, and March and April 2007).

Local ¹	Num. of fishermen		Average daily production (kg) ⁴	Average daily production per fisherman (kg)	Working days per week ⁵	Estimated monthly catch (kg)
	Interviewees ²	Declared ³				
S. Dumont airport	1	4	10,0	2,5	7	280
Flamengo	5	16	62.5	3.9	6	1,500
Vermelha beach	1	1	15.0	15.0	3	180
Urca	4	6	125.0	20.8	6	3,000
Boa Viagem ⁶	4	11	107.5	9.8	6	2,580
Flechas beach	5	26	87.5	3.4	6	2,100
Total	20	64				9,640

1 – In Jurujuba no independent collectors was found

2 – Total of fishermen in activity in each area (only those effectively interviewed)

3 – Number of collectors declared as taking part of a group

4 – Average daily production (live weight - kg) in the area

5 – Number of working days in each area

6 – Includes both the island and beach of Boa Viagem

Twenty fishermen were found in the eight sites of processing and commercialization. Considering the remaining fishermen, not interviewed, but pointed out as participants of each of the “groups”, the total number of collectors reaches 64.

The average daily production varies a great deal depending on the site – from 10 kg in Santos Dumont airport riprap to 125 kg in Urca – the presence of a motorized boat in Urca favored the extension of the extraction area until Jurujuba, in the east side of the bay, and to the oceanic islands (Comprida and Cagarras). In most areas the collectors worked walking along the coastline; only at

Flechas’ beach a row boat was observed.

Mussels are extracted with diggers (“raspadeiras”) or even by hand reaching a maximum depth of two meters.

The “Glória” marina area, cited by França (1988), was closed during the period of study due to work in progress.

According to 64% of the interviewees part of the collected mussels was consumed by the fishermen themselves.

Figures 2 and 3 summarize, respectively, total daily production declared by the collectors interviewed and the size of the groups.

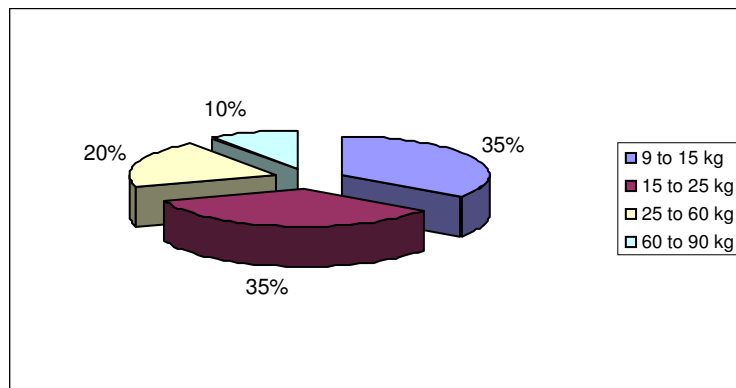


FIGURE 2 – Average daily production percentage distribution per independent mussel collector interviewed in Guanabara bay (November and December 2006, and March and April 2007).

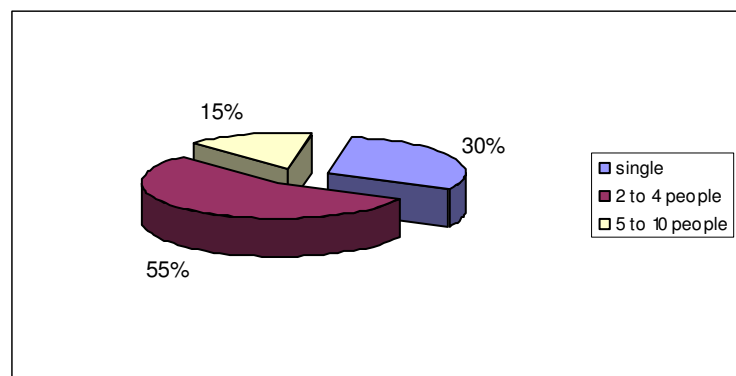


FIGURE 3 – Percentage distribution of the number of collectors in each group of independent mussel collector interviewed in Guanabara bay (November and December 2006, and March and April 2007).

Seventy percent of collectors produced between 9 and 25 kg per day (live weight); the most usual groups were formed by two to four fishermen.

After extracted the mussel is processed (pre-cooking in the local marine water) at open air, inside improvised containers, such as ink or cement cans, heated by small fires lit with any available stuff

(timber, rubber, paper, etc). Pre-cooking facilitates the manual separation of flesh from shells. After separation, the shells are thrown back to the sea or simply left on the site. During the packing process, the meat can be kept inside other improvised containers, in plastic pieces on the ground, or even on rudimentary benches.

The packed mussel can be sold to middlemen on the site or by the collector directly to restaurants or fish markets nearby.

Figure 4 shows the percentage distribution for the unit prices (kg) of processed mussels.

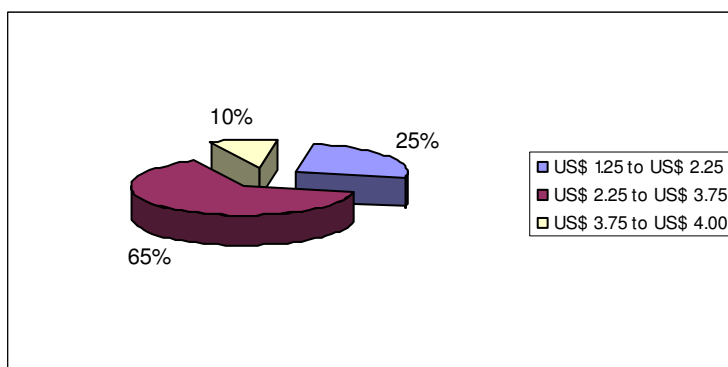


FIGURE 4 – Percentage distribution of prices per kilogram (processed mussels) collected by independent mussel fishermen interviewed in Guanabara bay (November and December 2006, and March and April 2007).

Most of the processed mussel is sold for US\$ 2.25/kg to US\$ 3.75/kg, with the weighted average of US\$ 2.65/kg.

Only part of the interviewees has the mussel collection as a full-time activity. At least six of them see in the mussel collection an opportunity to complement the income from other informal occupation.

Also, according to the interviewees, it seems to exist an intention to preserve the natural banks against overexploitation which is accomplished by avoiding the return to a given area too frequently. Some of the collectors also declared to avoid the extraction of individuals of small size, based on a simple visual inspection.

The Jurujuba Mariculture Association

Despite the denomination, the mariculture itself is only a complementary activity for the fishermen. The main bulk of the production comes from the collection in the natural banks. The association also sells small amounts of octopus caught using hooks.

The distinctive characteristics of the association are concerned to the much more suitable conditions to process and maintain the product according to the Brazilian health regulations, as well as the centralized commercialization. There is not a precise number of fishermen involved in the mussel extraction and even the data on the monthly production do not separate the amounts of mussel derived from the mariculture

from those collected in the wild. The association informs that “sixty families” work in the mussel production chain. The available fleet consists of four boats, two of them owned by the association, each one carrying up to 14 fishermen; the two other boats, with capacity for eleven fishermen each, are owned by individual collectors. In the inner areas of the bay small row boats are used to reach the mussel sites.

The collectors work on average five days a week and seem to adopt a rotation of the banks to avoid overexploitation (IBAMA 2002). The minimum size for the mussel to be directed for processing is seven centimeters. All of those smaller than this are used as “seeds” in the mariculture.

Motorized boats allow the extension of the extraction area, comprising the inner bay as well as the oceanic adjacent region. The inner areas commonly exploited by the association fishermen are: Icaraí, Boa Viagem, Flamengo and Santos Dumont airport. The outer areas are: Vermelha beach, Itaipu, and Cagarras, Meio and Pai islands, among others. However, information from the IBAMA (2002) database indicate a collect effort concentrated in the area of Boa Viagem (59%), followed in importance by the oceanic islands (18%), Botafogo (12%) and Santa Cruz fortress (9%), during the period between April 2001 and March 2002.

The *in natura* mussels are washed and pre-cooked in autoclaves at 100°C, for 20 minutes maximum. After partially cooled the shells are

removed. The flesh is packed and the product is stored in a freezer (-18° to -20°C), for a minimum of 30 minutes before distribution. Any production surplus is stored in coolers at a temperature of -10°C for approximately two months.

The association has an isothermal trunk for the mussel delivery. The production is directed to CEASA (the main wholesale market for fresh fish in Rio de Janeiro), restaurants and local fish markets and also to the state of São Paulo (in Brazilian south region). The processed mussel is sold for US\$ 3.50/kg. The shells are discarded in cases and collected afterwards by the urban cleaning company.

The informed total production in 2005 and 2006 were, respectively, of 18,665 kg and 9,192 kg of processed mussel. Considering a conversion factor of 7:1, the average monthly production (live weight) would have been of 11 t, in 2005, and of 5 t, in 2006.

3 – DISCUSSION AND CONCLUSIONS

The difficulties to get information about a fishery seem to be proportional to their artisanal or subsistence characteristics. In Guanabara bay, mussel collection can be grouped, at least partially, in this last case, on account of the own consumption of

part of the catch by the independent collectors and their households.

The quite primitive mussel extraction and processing and its spread out commercialization make almost impossible any statistical control. The precarious handling and conservation of the product are characteristics of a quite informal activity. Despite the fact that the interviews carried out were not a precise tool, they seemed to be the most adequate one in the context.

Even the Jurujuba association was not collaborative when requested for information. Catch data, only available for 2005 and 2006, do not discriminate the product from mariculture and that obtained from natural banks. Also, it was not possible to have a more definite number concerning the fishermen effectively working with mussel collection.

Different previous works focused on the mussel activity or on general fisheries in the bay tried to quantify the total mussel production and the number of collectors in activity, in general, based on interviews and visits to the processing sites. Table 2 summarizes the available estimates.

TABLE 2 – Collectors and monthly mussel production (live weight – t) in Guanabara bay

Number of collectors	Monthly production (ton)	Source
44 (13) ¹	67 ²	França (1988)
100	25 ³	FEEMA (1990)
-	25	JICA (1994)
250	25 ⁴	Barroso (1997)
32 ⁵	-	Einloft (2000)
-	20	SECT (2000)
29 ⁶	44 ⁶	IBAMA (2002)
64 (40) ⁷	21 ⁸	This paper

1 – Number of independent collectors and those affiliated to the Jurujuba association (in brackets).

2 – Includes the monthly production declared by the Jurujuba association (48 ton).

3 – Production of one ton daily for 25 working days.

4 – Production of one ton daily for 25 working days (only in Jurujuba).

5 – Production obtained multiplying the number of boats of the Jurujuba association, as informed by the author (25 boats), times the average crew registered by IBAMA (2002) (1.26 fisherman per boat).

6 – Number of collectors and average monthly production only for the Jurujuba association.

7 – Estimated number of independent collectors based on *in loco* interviews. The number of fishermen affiliated to the Jurujuba association (in brackets) was estimated based on the “60 families” in activity, which include also people involved in mussel processing.

8 – Includes the monthly production declared by the Jurujuba association, for 2005 (around 11 ton).

It is not possible to assess the precision and reliability of each of the available sources. The information in IBAMA (2002) was the only one obtained

from a direct control of the landings at the Jurujuba association, for one year, and corresponds exclusively to the mussel collected in the natural banks.

Production estimates seem to be less variable than those concerning the number of collectors; even the figure of 250 collectors presented in Barroso (1997) was classified by the author as “uncertain”. Comparisons are difficult because of the lack of concurrent data for the two segments of the fishery in almost all the papers cited. The production declared by the Jurujuba association for the years of 2005 and 2006 was very low when compared to those registered in previous years, what can suggest a misreport.

Taking into account these restrictions we can suggest that mussel production in Guanabara bay and the adjacent islands has been oscillating between 20 and 65 t (live weight) monthly, along the last 20 years; the Jurujuba association contributes with 50 to 70% of this total.

The number of independent collectors in activity is uncertain but can be estimated between a minimum of 20, corresponding to those effectively interviewed, and a maximum of 60, according to the possible group sizes. The number of collectors affiliated to the Jurujuba association is probably around 30 and 40 fishermen.

During the mussel processing there is a weight loss, but the conversion index derived from the available literature is quite variable. França (1988) indicated indexes varying from 2:1 to 6:1, for the independent collectors; The Jurujuba association informed a conversion factor of 7:1, while Jablonski *et al.* (2006), quoting the same source, used a factor of 10:1.

Considering the average prices of US\$ 2.65 and US\$ 3.50/kg of processed mussel, respectively for each segment, and a converting factor of 7:1, the value of the catch of the independent collectors possibly varies from US\$ 3 to US\$ 10 thousand monthly; and from US\$ 6 to US\$ 20 thousand monthly for the fishermen of the Jurujuba association. This implies an average monthly yield of US\$ 75 to US\$ 250 for the independent collector, and of US\$ 170 to US\$ 550 for the Jurujuba fishermen. These quite large estimate ranges are related to the monthly catch variability and the uncertainties concerning the actual number of fishermen.

The auto consumption of part of the catch probably determines a total income even inferior for

the independent collectors. In such a way, the monthly individual yield of US\$ 75.00, according to the lower estimate, seems to indicate that the activity is in fact a way to supplement the income, possibly combining it to another informal occupation.

The most noticeable aspect when comparing the work of independent collectors to the work of those affiliated to the association is that the latter holds suitable mussel processing, conservation and commercialization conditions. It is also probable that the association fishermen are more prone to comply with the closed season (annually from September, 1st to December, 31th).

Different studies have attempted to evaluate the pollution effect on the bay living organisms, and especially on mussel population. Mussels as filter feeders are subjected to different forms of contaminants, being able to concentrate them from very diluted solutions, without showing any visible adverse effects (Maia *et al.* 2006).

The current conditions of the bay seem to prevent mussel contamination with higher concentrations of heavy metals. The low bioavailability of copper, cadmium, lead and mercury apparently is favored by the particulate matter content and presence of anoxic sediments (Francioni *et al.* 2004, Kehrig *et al.* 2002). Even for PAHs, the mussels seem to rapidly respond to oil presence and absence (Francioni *et al.* 2005).

However, when sanitary standards are concerned the situation of the bay environment is rather unsafe.

Mussels collected by the association fishermen, even when *in natura*, were negative for the presence of *Salmonella* spp. (Pereira 2003), so we can suppose that the same occurs with the product of the independent collectors. Similarly, emerging pathogens (Vibrionaceae), detected also in the association's processed mussels, certainly will be present in the product of the independent collectors. The epidemiological relevance of the identified pathogenic agents is related to their potential to cause diverse diseases in exposed human populations after consumption of *in natura* and pre-cooked mussels (Pereira 2003).

The Brazilian legislation for *Echerichia coli* in water prohibits mussel extraction or raising in areas

where the concentrations are higher than 700 *E. coli*/100mL in marine water. Areas with levels between 70-700 *E. coli*/100mL are classified as “limited”, being necessary the depuration of the mussels before processing. Analyses carried out in the Guanabara bay for *E. coli* indicated that the areas close to the mariculture facilities (Icaraí, Boa Viagem and Santa Cruz fortress) “would be not suitable for raising or extracting mussels for human consumption” (Pinheiro Jr. *et al.* 2002). It should be stressed that the Jurujuba association does not have facilities for mussel depuration.

When comparing the areas of occurrence and extraction of mussels described in previous works, it is clear the displacement of extraction areas towards the adjacent oceanic areas. Torres (1983) registered “reasonable” mussel concentrations on the islets near to Governador island (Passagem islet and Manuéis de Dentro rocks; see Figure 1). The innermost occurrence with isolated individuals was observed in Jurubaíba. França (1988) identified commercial extraction on d’Água island, Manuéis de Dentro and Manuéis de Fora rocks; on the pillars of Rio-Niterói bridge, by fishermen affiliated to “Colônia Z11” (Ramos), and at the more southern points at both sides of the bay. Jablonski *et al.* (2006), based on data from 2001 to 2002, registered a more extended area for the Jurujuba association besides the regular points inside the bay including the oceanic islands.

Currently, the fishermen of “Colônia Z11” do not operate at the bridge area. The inner areas for the mussel extraction are limited at west by the riprap of Santos Dumont airport and at east by the Boa Viagem island. There is no immediate explanation for the displacement of the extraction areas to the south, but we can possibly suggest a combined effect of the density reduction due to pollution and overfishing. Also important is that mussel biology and ecology also restrict their occurrence in waters of low salinity and reduced waves intensity, and also that the northern natural banks never were as dense as those in the more external areas.

The work of the independent collectors along the last decades, practically without any marked change in the patterns of mussel collection and processing, is surprising. This suggests that the traditional extractions sites have being exploited with

a sustainable effort, maybe exactly due to its primitive characteristic. The expansion of the extraction area involving the oceanic islands seems to have compensated the abandonment of the inner areas, but did not replace, at least until 2002, the extraction in the traditional sites, specially the island and beach of Boa Viagem.

Mussel extraction favors the income enhancement and even the subsistence of part of the collectors interviewed. However the absence of sanitary control in the case of the independent collectors turns the activity into a risk for the potential consumers.

The maintenance of mussel processing and commercialization practices in poor sanitary conditions points out the weakness of the public inspection concerning destination and human consumption of shellfish in important urban regions in the state of Rio de Janeiro.

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