



ANALYSIS

# Evolution of a local Brazilian shrimp market

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## Abstract

This paper examines the evolution of a coastal Lagoon ecosystem in Brazil, focusing on how the dynamics between the ecosystem and human systems have influenced the emergence and dynamics of the shrimp market. We focus on the Ibiraquera Lagoon on the southern Brazilian coast, tracing the history of the development of the Lagoon's seven bordering communities over the last five decades. We then describe the evolution of the area's shrimp market, describing its players and its demand, supply, and price characteristics. The story that emerges is of a transition from a small barter-based market to a patronage-dominated system to a wider, more complex, price-based system in which the traditional middlemen still exist but serve more as distributors than as patrons. The transitions were facilitated largely through the provision of roads and electricity to the Lagoon communities, which opened the area to tourism and greater business opportunities, and made shrimp storage and transport possible. Interaction between the Lagoon ecosystem and the social and economic systems is clearly an important factor in the dynamics of the shrimp market. Natural and manipulated Lagoon channel openings along with fishing activity influence the amount, size and marketability of the shrimp harvest. Additionally, pollution of the Lagoon's waters influences shrimp quality and thus price. New institutional arrangements will be needed to address unwanted developments and to ensure that the shrimp market continues to thrive while the Lagoon on which it depends is sustained.

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## 1. Introduction

This paper examines the evolution of a coastal Lagoon ecosystem in Brazil, focussing on how the dynamics between this common-pool resource and its human systems have influenced the operation

of the shrimp market. We take the ecological economics view of the shrimp market as a product of the interrelationship between fishery ecosystem dynamics and social and economic development (e.g. Faber et al., 1996; Costanza et al., 1997). Of particular interest is how the local community has responded over time to changes in development pressures, technologies, and Lagoon conditions. This study adds to the growing evidence of the significant and continuous interactions between changes in the local economy (in this case, seven

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coastal Lagoon communities in Brazil), the resource base (the Lagoon), and the market for the good harvested from that resource (shrimp). Understanding such interactions is essential to proposing alternative management plans.

For many decades, resource managers and scientists have proposed management plans based exclusively on biological aspects of particular resources. For example, conventional management plans focused on the population dynamics of single species or on the preservation of pristine ecosystems without the interference of human actions. However, failure to achieve sustainable resource use led many scientists to address the inadequacy of such conventional management approaches, particularly in the past three decades (Larkin, 1977; Clark and Munn, 1986; Ludwig et al., 1993; Gunderson et al., 1995). Resource management has now started to move, at least in theory, toward a complex systems approach which asserts that both social and ecological systems change and co-evolve because they are linked (Kauffman, 1993; Levin, 1999; Davidson-Hunt and Berkes, 2003).

A common-pool (or common-property) resource is a class for which exclusion is difficult and joint use involves subtractibility (Berkes, 1989; Feeny et al., 1990). Fisheries are classical examples of common-pool resources. (The exploitation of a fish stock by one fisher directly affects the stock available to other fishers who are difficult to exclude from the system.) The evolution of the common-pool resource theory has contributed immensely to the understanding of social–ecological linkages in natural resources and environmental management systems (McCay and Acheson, 1987; Berkes, 1989; Ostrom, 1990; Bromley, 1992), and linkages between the social and ecological aspects of a common-pool resource management system are often analyzed by studying their institutional characteristics (Hanna et al., 1996a; Berkes and Folke, 1998). In particular, common-pool resource theory has addressed the implications of different institutions and institutional frameworks under which natural resources may be managed.

In management systems, institutions are the working rules or rules-in-use that control resource

use (Ostrom, 1990). As allocative institutions supported by a variety of other institutions, markets are an important component of any socio-ecological system. Hence, understanding their emergence, dynamics, and linkages to the ecosystem can be instrumental to fostering resource sustainability and desirable socio-ecological dynamics. Wang (1999) postulates that changes in the institutional structure of a market are determined mainly by transaction costs, leading to the expectation that sophisticated markets in locales at any scale will only emerge once development attributes (infrastructure/technology, education, property rights regimes, and so on) have advanced enough to sufficiently reduce the costs of gathering information, contracting, and enforcing transactions. This paper provides persuasive evidence supporting Wang's case.

The way institutions are designed and how institutional changes occur strongly influence interactions between humans and nature (Hanna et al., 1996b). Moreover, institutions are dynamic and have an adaptive character. In resource management, institutional changes may occur in response to changes or disturbances in either the socio-economic or ecological system. The evolution of the shrimp market described in this paper illustrates these features and influences.

Our study looks at the evolution of the Ibiraquera Lagoon and its surrounding communities on the southern Brazilian coast. The Ibiraquera Lagoon area is a micro-watershed where most environmental impacts are locally generated and can be locally addressed. In other words, problems are neither exported from the watershed to downstream nor imported to the watershed from upstream. However, the Lagoon is a semi-closed ecosystem seasonally connected by a channel to the Atlantic ocean, with natural and human-engineered channel openings allowing seasonal migration of target and predator species in and out the Lagoon. Thus this case offers an interesting variation on the study of common-pool resources, where closed systems (e.g. closed-lake fisheries) and open systems (e.g. open-sea fisheries) are usually the most studied cases. We begin our discussion with a description of the Lagoon, followed by a summary of its development over

the past five decades. Following that, we describe the evolution of the Lagoon shrimp market. We conclude by discussing the shrimp market as an institution resulting from and influenced on an ongoing basis by ecological-socioeconomic inter-relationships.

Cross-scale institutions (Berkes, 2002) have been found to play an important role in shaping shrimp markets and fisheries management globally. Indeed, the globalization of the shrimp market during the 1960s and 1970s has probably affected fisheries policy and, in turn, small-scale fisheries in several countries. For instance, increased international demand for shrimp in global markets led India's government to subsidize trawlers in Kerala, during the 1960s and 1970s. This subsidy touched off social and ecological crises in the local fisheries system, which had previously been dominated by small, non-motorized boats (Kurien, 1992). In Brazil, fisheries policies during the 1960s and 1970s provided tax incentives to increase fish and shrimp harvests, processing, and commercialization without regard for the effects on stock sustainability (Abdallah, 1998). As a result, Brazilian exports of high quality, high priced fishing products such as shrimp and lobster increased about fivefold between 1970 and 1985 (Abdallah, 1998). Thus, it is clear that cross-scale institutional dynamics influence local fisheries in a variety of ways. However, while the globalization of the shrimp market has probably affected shrimp prices with consequences for several small-scale coastal fisheries in Brazil, the shrimp market and Lagoon fisheries we analyze here seem to be the result of institutional dynamics at much smaller scales (local and regional), and an examination of the extent to which the international shrimp market has affected prices in the local Lagoon shrimp market lies beyond the scope of this study.

The analysis presented here is based on a year of fieldwork that took place during 1999 and 2000. Methods used during this fieldwork included archival research, interviews, participant observation, and collection of data on types and quantities of fish and shrimp harvested and marketed from the Lagoon. Archival research traced changes in fisheries legislation and the local socio-economic system. Formal interviews (30 min–2 h long) were

conducted with 18 respondents to gather information about fisher knowledge, fishing activities (resources, gears and purposes), the local shrimp market, and changes in the local socio-economic and ecological systems over the last five decades. Interview subjects included knowledgeable fishers, the local fishers organization's president, two local middlemen, a former local fishery inspector, and two government fishery agents, including a former one. In addition, several fishers were informally interviewed around the Lagoon area just before starting or just after finishing their daily fishing. Many local people, including middlemen and restaurant owners, were also interviewed during their everyday activities.

Participant observations were carried out from October 1999 to May 2000 to monitor fish and shrimp catching activities and the fishing methods used, and to understand the role of middlemen, buyers, resource managers, fishers organization officials, government officials, and community councils. Data analysis was based on triangulation of data from field notes, interview transcriptions, and external sources including official documents and academic literature on the subject. In addition, a preliminary analysis (April, 2000) was checked by 12 local people including fishers, residents, school teachers, the president of the fishers' organization, and a government agent working in the area.

Key informant interviews backed by field observations provide the basis for estimates of shrimp abundance and harvest, shrimp migrations, and seasonal cycles of the Lagoon. (As with most inshore fisheries in Brazil, no reliable shrimp population or harvest statistics exist for this locality.) From October 14, 1999 to April 27, 2000, data on the amount of shrimp bought by seven middlemen, five retailers from small grocery stores, and seven restaurant owners around the Lagoon area were recorded weekly for 28 weeks. These were all the middlemen that could be identified in the area, and the retail stores and restaurants were the only ones who bought shrimp directly from local fishers. (Several other restaurants in the area bought shrimp only from local middlemen or from the regional market.) Because they do not account for shrimp that local fishers

sold directly to consumers, shrimp that outside fishers sold elsewhere, or shrimp used for fishers' own consumption, these data provide useful insight to the local shrimp market, but they underestimate the Lagoon's total shrimp production for the period.

## 2. Description of the Lagoon

The Ibiraquera Lagoon, in the municipality of Imbituba (pop. 33 000 in 1991), Santa Catarina State, is located along the southern part of the Brazilian coast. There are seven communities around the Ibiraquera Lagoon (Fig. 1).

The Lagoon is an assembly of four interconnected small basins, with a total area of approximately 900 ha. This is a shallow Lagoon: most of its area is between 0.20 and 2.0 m deep, with a few points reaching about 4 m deep along channels running through the Lagoon area. The Lagoon has a mainly sandy bottom and brackish water. Most freshwater input is provided by rainfall and springs that feed the Lagoon at nine or more points. Through most of the year, there is a sandbar between the Lagoon and the Atlantic Ocean. In the absence of human intervention, when sufficient water pressure builds up, a channel bursts through the sandbar, and the Lagoon's water level drops through natural processes. Most of the time, however, channel openings are triggered by human actions to serve management purposes. The channel eventually closes through sand deposition by ocean currents and tides, which in turn allows the Lagoon's water level to increase once again.

The Lagoon's main fishing species are pink shrimp (*Farfantepenaeus brasiliensis* and *F. paulensis*), mullet (*Mugil platanus*; *Mugil* spp.) and blue crab (*Callinectes* spp.). Of these, shrimp is the most valuable and commercialized. Mullet is seldom sold, and crab is only for the fishers' own domestic consumption. The Lagoon shrimp and fish stocks depend mainly on the season when the channel connecting the Lagoon to the ocean is opened, on the length of time it remains open, and on fishing activities.

The timing of the channel opening affects the diversity of species that may enter the Lagoon. When the channel is open, most shrimp larvae and post-larvae, as well as young and adult fish, enter the Lagoon to grow in its warmer waters. Mature fish and shrimp return to the ocean in a subsequent channel opening whose timing can vary from a few weeks to several months later, depending on rainfall. Hence, channel openings have been managed in order to allow the entry of fish and shrimp stocks moving through the ocean in front of the channel. A major recruitment peak for shrimp at the Ibiraquera Lagoon occurs during spring months, and a minor one occurs during fall.

The length of time the channel remains open determines the opportunities fish and shrimp have to enter or leave the Lagoon. If the channel is open for a long period and no management action occurs, a mullet school in spawning migration may enter and leave the Lagoon in the same opening period. On the other hand, if a channel opening is too short, there may be little stock renewal (as not many fish or shrimp will enter the Lagoon).

The third major determinant of the Lagoon's stocks is fishing activities. The capture of small fish and shrimp reduces the potential harvest of larger (better-priced) fish and shrimp in the future and threatens the sustainability of the fisheries system. This effect is characteristic of all fisheries, but is particularly true of a temporarily closed system such as the Ibiraquera Lagoon. Fishing rules (formal or informal) and their enforcement are critical for sustainable yields from the fishery. These rules would specify permissible gear types, mesh sizes, and fishing spots, and restrict access. In the following section, we draw on work by other researchers to estimate the protocol that would be necessary to capture mature shrimp and leave younger shrimp in the habitat to develop further—a key factor for sustainable management.

### 2.1. Shrimp ecology and implications for gear restrictions

According to Tremel (pers. comm.) and Branco (pers. comm.), *F. paulensis* and *F. brasiliensis* have

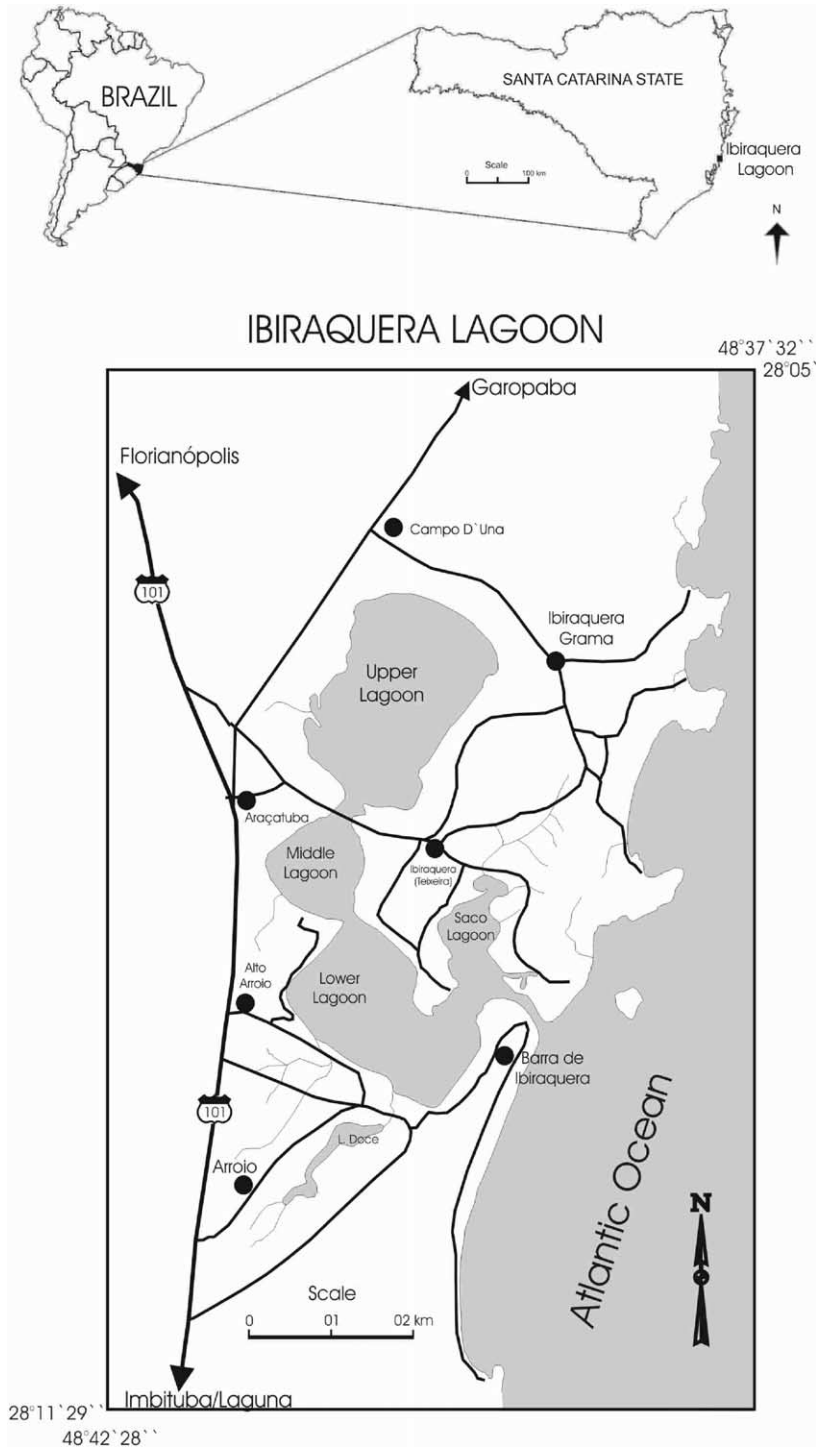


Fig. 1. Map of the Ibraquera Lagoon, Santa Catarina State, Brazil.

similar life cycles, are very difficult to distinguish from one another, and usually occur together in southern Brazilian coastal lagoons. Indeed, work by Andreatta et al. (1993) found that about 90% of all naturally occurring shrimp in the Ibraquera Lagoon is *F. paulensis* and that less than 10% is *F. brasiliensis*. As a result, the two species are often caught together because fishing gears do not select for either species. Thus, any gear restrictions imposed on pink shrimp fishing in southern Brazil should take into account the growth and ecology variations of both species.

Adult pink shrimp spawn in the deep ocean waters. Larvae and post-larval shrimp enter coastal lagoons and estuaries to develop up to the pre-adult stage, when they leave these habitats to copulate and spawn. Studies by several researchers offer some information about the growth and development of *F. paulensis* and *F. brasiliensis*. Branco and Verani (1998a,b) studied shrimp populations in the Conceição Lagoon in Santa Catarina—a lagoon connected to the ocean year-round and located about 100 km north of the Ibraquera Lagoon—and estimated the total lengths at which each species enters the pre-adult stage<sup>1</sup>. Tremel and Souza (1999) also studied pink shrimp migration from the Conceição Lagoon, gathering information on the size of *F. brasiliensis* and *F. paulensis* during migration.<sup>2</sup> D’Incao (1984) and Branco and Verani (1998b) present a growth function for *F. paulensis* in lagoon ecosystems. In both cases, however, the function ac-

counts only for life stages that shrimp spend in estuaries (rather than the entire life cycle), and they do not present optimum harvest times for the species. We have not found in the literature any other work that shows such information for *F. paulensis* or *F. brasiliensis* in lagoon ecosystems.

To contribute to the sustainability of the fishery, fishing gears used inside coastal lagoons should select for pre-adult shrimp, leaving juvenile shrimp to grow further. In their report on regulating pink shrimp (*F. paulensis* and *F. brasiliensis*) fisheries in Santa Catarina coastal lagoons, Tremel and Souza (1982) recommend a minimum mesh size of 2.5 cm (stretched measure) for any net type. They observed that most of the shrimp (both species) caught by 2.5-cm mesh cast nets were 10.5–11.5 cm in length; that is, the 2.5-cm mesh size selected pre-adult pink shrimp of both species. Additionally, in a different lagoon Tremel and Souza (1982) observed that most shrimp caught by cast-nets with mesh sizes of 1.5 and 2.0 cm measured between 8.0 and 9.5 cm in length (i.e. nets with these mesh sizes catch shrimp younger than pre-adult stage).

Our research found that shrimp fishers in the Ibraquera Lagoon communities consider weight (shrimp per kilogram) rather than body length when discussing what mesh size will capture what sized shrimp or when pricing their catches according to shrimp size. Thus, to assess the sustainability implications of the catch findings in our study, it is necessary to express other researchers’ findings about body length and recommended net mesh size in terms of weight. Using biometric functions for weight/length relations from Branco and Verani (1998a,b), we estimated the shrimp weight when 100% of shrimp (both sexes of both species) reach the pre-adult stage.<sup>3</sup> The results show a range from 9.0 g (111 individuals/kg) for females of *F. brasiliensis* (10.5-cm total length) to 11.3 g (89 individuals/kg) for males of *F. paulensis*

<sup>1</sup> The pre-adult stage is that in which 50% of the males have joined petasma and 50% of the females have functional (completely developed) thelyca. Branco and Verani (1998a) estimated that *F. brasiliensis* reaches the pre-adult stage at total lengths of around 8.8 cm for females and 9.2 cm for males, and that at total lengths greater than 10.5 cm all *F. brasiliensis* were pre-adult. Correspondingly, they estimated that *F. paulensis* reaches the pre-adult stage at total lengths of around 8.8 cm for females and 9.3 cm for males, and that at total lengths greater than 11.5 cm all *F. paulensis* were pre-adult (Branco and Verani, 1998b). They did not catch any pre-adult shrimp with total length less than 7.5 cm.

<sup>2</sup> Tremel and Souza (1999) found that the total length of *F. brasiliensis* leaving the lagoon ranged from 7.5 to 16.5 cm, with a mode length of about 10 cm. For *F. paulensis*, total length ranged from 7.5 to 18.5 cm, with a mode length around 11.5 cm.

<sup>3</sup> Branco and Verani (1998a,b) biometric functions for weight/length relations at the Conceição Lagoon (both species present sexual dimorphism) are: for *F. brasiliensis*,  $wt = 0.0066 lt^{3.0812}$  (males) and  $wt = 0.0100 lt^{2.8916}$  (females); for *F. paulensis*,  $wt = 0.0098 lt^{2.8853}$  (males) and  $wt = 0.0172 lt^{2.6140}$  (females); where  $wt$  = weight (g), and  $lt$  = length (cm).

(11.5-cm total length). Tremel and Souza's (1982) finding that 2.5 cm mesh cast-nets select for shrimp that are 10.5–11.5 cm in length therefore translates to a cast-net with 2.5 cm mesh selecting shrimp weighing 9.0–11.3 g (i.e. 89–111 shrimp/kg). Our estimation corresponds with Beltrame's finding that 3.0 cm mesh cast-nets select pink shrimp weighing 10–12 g (i.e. 83–100 shrimp/kg) (pers. comm.). The shrimp harvest data presented later in this paper can be compared to this recommended selectivity. We now discuss socio-economic and shrimp market developments in the Ibiraquera Lagoon area over time.

### 3. Socio-economic evolution of the Lagoon area

The fieldwork conducted in this study found that, over the last five decades, communities around the Ibiraquera Lagoon experienced major socio-economic changes. The local economy moved from household-level agriculture during the 1950s, to a mix of agriculture and small-scale commercial fishery during the 1970s, and to tourism-related activities during the 1990s. Road access and electrification were the main instruments of change, providing access to markets for fishers and both access to the area and a higher level of comfort for tourists.

In the 1950s and early 1960s, there were relatively few large families (ten or more children was usual) living in the communities around the Lagoon. Four of the seven communities had no road access to other localities, none had electricity, five had no general store, and none had a fish store. Transport of people and goods among some communities was generally by pole canoes along the Lagoon or by ox and cart along trails. Small-scale agriculture was the main source of income for most families, and fishing was mainly for subsistence. Men were usually in charge of both farming and fishing, and women were responsible for housekeeping, although they also helped men with farming, crab fishing and the production of manioc flour and sugar. The lack of local employment opportunities led young people to migrate to cities for work.

Locals occasionally bartered crops and other products (e.g. fish for coffee or manioc flour). However, they sold only manioc flour and sugar, which they produced using ox-powered mills. A patronage system existed in which middlemen provided clothes, shoes and other basic goods to local families in exchange for freshly produced flour. Some families were able to store their flour while waiting for better prices.

During the 1970s, roads were constructed and electricity became available in most communities. These infrastructure improvements facilitated the development of a shrimp market and increased access to the region by tourists and outside fishers. From the mid-1970s on, tourists started to explore the Ibiraquera region, first camping, and later buying property and building summer cottages. Outside fishers came from the city of Imbituba and other nearby municipalities.

The money generated by the shrimp fishery improved local fisher welfare.<sup>4</sup> As the fishery became an important source of cash income, some local residents became full-time fishers and the importance of household-level agriculture in the economies of some communities began to decline. In addition, the development of tourism activities during the late 1970s and 1980s generated more local job opportunities and precipitated the return of villagers who had migrated to cities. The local population increased and more markets and retail outlets were created (including fish/shrimp stores). Public transportation became available for most communities during the 1980s and some local residents started to commute daily to work in Imbituba or other nearby towns.

During the 1990s, tourism-related activities dominated the economies of most Lagoon communities. Fishing became a part-time activity as many fishers focussed on tourism and construction. These fishers reduced their fishing efforts from a night-long activity to about 2–4 h per night. Several fishers were employed in construc-

<sup>4</sup> Some fishers reported that they were able to buy a foam mattress (replacing the hand-made natural fiber mattress), a refrigerator, a gas stove (replacing the firewood stove), and other amenities.

tion of summer cottages, guesthouses, and restaurants. Some became house-sitters for summer cottages. Others opened their own businesses such as bars and restaurants. Most guesthouses and upper class restaurants in the area, however, were owned and managed by outsiders. Despite the fact that shrimp fishing became a part-time activity, shrimp was still considered an important source of income. Local fishers sold shrimp and bought beef to supply their diet with protein as beef became cheaper than shrimp. In most communities, household-level agriculture declined to a minor activity to supplement the diet and supply a small local market.

By 2000, the local economy was fully integrated into the regional economy and had become significantly influenced by the latter. Pollution of other lagoons in the region pushed many outside fishers into Ibiraquera. The local population grew at an accelerated pace during the past two decades despite the fact that the number of children per family decreased considerably. This population growth was due in part to the growth in a tourism industry that continues to draw new residents to the Lagoon communities. Although population numbers by village are not available from government census data, a population of 15000 (during the peak tourist season) can be estimated from field data on households and the average number of people per household.<sup>5</sup>

The socio-economic changes described above characterize most communities around the Lagoon. While each community has its own economic history (Table 1), the major factors influencing economic change in all communities were infrastructural improvements. Road access and electrification allowed for the development of small businesses and the expansion of tourism-related activities. These combined to drive the emergence of a modern shrimp market, which in

turn led to an increase in fishing efforts and a decrease in stocks.

While the history of the Ibiraquera Lagoon area demonstrates clear advances in local people's well-being from the introduction of the roads and electricity which facilitated the development of a local tourist industry, the emergence of an active shrimp market, and integration into the regional economy, it is now clear that these developments have also contributed to ecosystem stress. Legally, any Brazilian with a professional fishing license can fish in the Lagoon. Those with sport fishing licenses or no licenses cannot. In law, professional fishing licenses are only to be issued to persons who make their main living from fishing. In reality, licenses are issued to almost anyone who requests them, because only the testimony of two professional fishers is needed to obtain one. Thus, there is no effective legal restriction on access to the Lagoon. By 2000, some 350 professional (licensed) fishers, a few sport (licensed) fishers and several unlicensed fishers lived in the seven communities around the Lagoon. This is stressing the Lagoon's shrimp stocks and influencing market prices for shrimp.

Additionally, as the population of the Lagoon area increased and the tourist industry expanded, more wastes were generated. These are sometimes dumped into the Lagoon, and there has been little to no effective restriction on this practice. Deposition of garbage in the Lagoon margins and sewage drainage into the Lagoon (from illegal construction of houses with poorly functioning septic tanks) has now reached a point where the Lagoon's water quality has started to become compromised and is beginning to threaten the traditionally recognized superior quality of its shrimp harvest.

Data on water quality based on the density of fecal coliform bacteria, from 1998 to March 2002, show that Lagoon water remains suitable for swimming (FATMA, unpublished data). Despite this, residents living close to the Lagoon margin near the ocean beach often complain about the odor from sewage drained into the Lagoon when the channel connecting the Lagoon to the ocean is closed. This is markedly worse during the high tourist season. In addition, both locals and tourists

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<sup>5</sup> Data on residential buildings per community are from the files of two local electricity distributors (Cooperativa de Eletrificação Rural de Paulo Lopes—CERPALO—and CELESC). Data on household per community and on average of people per household were obtained from the Health Department (Secretaria da Saúde) of Imbituba City Hall.



Table 1  
Changes in the local economy of four communities from Ibiraquera region

Communities <sup>a</sup>	Basis of local economy <sup>b</sup>			
	1960s	1970s	1980s	1990s
<i>Araçatuba</i> roads: before 1960s beaches: far	Agriculture Fishing Small-business	Agriculture Fishing Small-business Public services <sup>c</sup>	Agriculture Fishing Small-business Public services Waged-labor <sup>d</sup>	Agriculture Fishing Small business Public services Waged-labor
<i>Ibiraquera (Teixeira)</i> roads: in 1970s beaches: near	Agriculture Fishing	Agriculture Fishing Small-business Tourism	Agriculture Fishing Small-business Tourism Waged-labor	Fishing Small-business Tourism
<i>Arroio</i> roads: in 1970s beaches: far	Agriculture Fishing	Agriculture Fishing	Agriculture Fishing Small business Waged-labor	Agriculture Fishing Small business Waged-labor
<i>Barra da Ibiraquera</i> <sup>e</sup> roads: in 1980s beaches: near	–	–	Fishing Tourism	Fishing Tourism

<sup>a</sup> The economic histories of the other three communities are quite similar to these four: Campo D'Una is comparable to Araçatuba, although tourism also became important during the 1990s. Grama has a similar history as Ibiraquera. Alto Arroio resembles in part Araçatuba's and in part Arroio's economic history.

<sup>b</sup> Alphabetical order.

<sup>c</sup> Public services include people who work in local schools, health-care centers, post-offices, etc.

<sup>d</sup> Waged-labor includes people who commute from other communities to Imbituba or Garopaba to work at industries or other businesses.

<sup>e</sup> Until the late 1970s, there were only four families living in this locality; it was not considered a community.

associate shrimp quality with the odor, with consequences for shrimp prices.

Other environmental damages around the Lagoon area include the destruction of several sand dunes and the decimation of forest areas and *restinga* vegetation. Environmental damage, particularly pollution of the Lagoon, may well be the foremost challenge facing Lagoon communities in the near future.

#### 4. Fishing activities and management regimes over time

During the 1950s and 1960s, Lagoon fishers mainly used cast-nets (with kerosene lamps to attract shrimp) and gillnets whose natural fiber construction limited their mesh to a large size (e.g.

shrimp cast-net mesh sizes were equal to or larger than 3.0 cm stretched measure). Fishing was mainly a part-time activity for subsistence purposes, and local rules and traditional practices were sufficient to sustain the Lagoon fisheries through a communal property management regime (Feeny et al., 1990).

During the late 1960s and the 1970s, technological innovations in fishing gears (e.g. use of monofilament nylon nets with smaller mesh size (some as small as 1.5 cm stretched measure) and butane gas lamps which attracted significantly more shrimp than kerosene lamps) increased fishing efficiency. In addition, as a shrimp market emerged, profit-oriented fishers began to disregard traditional rules governing access and gears and fished in prohibited areas using smaller-mesh cast-nets. These fishers used nets with meshes smaller

than 2.5 cm stretched measure. The effects of such actions on the shrimp population were severe. Several periods of resource over-exploitation in the Lagoon system resulted from these changes. Although federal government regulations limited rights to fish, net mesh size, gillnet length, and types of nets allowed in the Lagoon, the rules were not effectively enforced. Hence, the Lagoon system entered an open-access situation (lack of a property regime).

Declining fish and shrimp stocks triggered changes in Lagoon fishery management during the 1980s and early 1990s. A collaborative management process emerged through which both local fishers (through their organization) and government agencies played a role in making decisions about how, when and where to fish. One 1993 regulation that resulted from this process increased the minimum permissible size of shrimp cast-net mesh from 2.5 to 3.0 cm. Researchers from a shrimp stocking project<sup>6</sup> which took place at the Ibraquera Lagoon from 1992 to 1998 showed local fishers that the increased mesh size would improve their yields and profits by catching only larger, higher-value shrimp (Andreatta et al., 1993). Additionally, the regulation helped to restrict fishery access to local fishers because most outside fishers own only 2.5-cm mesh shrimp cast-nets. Furthermore, during the 1980s and early 1990s, government agencies provided effective enforcement of fishing rules. The new co-management regime improved shrimp and fish stocks and harvests.

In 1994, the enforcement structure changed, probably due to budget constraints. This new enforcement structure proved ineffective from 1994 to 2000, returning the system to open-access conditions. As a result, unregulated fishing activities resumed, negatively affecting shrimp and fish stocks. By 1999, fishers were catching up to 400 shrimp/kg (or 2.5-g shrimp) using cast nets with 2.0 cm mesh or smaller.

## 5. Evolution of markets for the Lagoon's shrimp

Although fishing was mainly for subsistence during the 1950s and 1960s, fishers sometimes sold shrimp by transporting it on their backs along the beach (~11 km) to Imbituba. Shrimp was sold fresh either by dozens or by local units (*saco*, a manioc flour bag of  $\approx 50$ –60 kg). Later, fishers adopted the standard unit, kilograms (kg), used in regional and national markets.

In the early 1970s, two local residents bought cars and started to buy shrimp from the Lagoon and sell it in the region. This shrimp trade became possible due to the construction of roads to remote communities and electrical refrigeration. Tourism development from the mid-1970s on encouraged a local market for shrimp, increasing demand and prices. In the late 1970s, at least five middlemen were involved in the Lagoon's shrimp market. The shrimp market evolved through a patronage system similar to that for agricultural products. During the 1970s and early 1980s, middlemen provided fishers with materials to make gears (e.g. cast-nets and gillnets), money to buy canoes and medicines, and transport for family members to doctors and hospitals. In return for this help, fishers were obliged to sell all of their catch to their supporting middleman.

Until the mid-1980s, middlemen exported the Lagoon's shrimp to the regional market (mainly Florianópolis, the state capital). From the mid-1980s on, due to tourism development and population growth, many fishers sold their catches directly to consumers (both locals and tourists), local restaurant owners and grocery retailers, who paid better prices than middlemen. As well, most, if not all, middlemen focused on supplying the local market, where demand exceeded the Lagoon's fish and shrimp supply, especially during the peak tourist season. Indeed, during the peak seasons of the late 1990s, middlemen imported shrimp and fish from the regional market to supply local demand.

As some fishers started to sell their catches directly to consumers, especially during peak tourist seasons, the patronage system weakened. As a punishment for breach of informal contracts, middlemen curtailed their lending to fishers. In

<sup>6</sup> The shrimp stock project was a joint effort of national, state, and local agencies: Federal University of Santa Catarina (UFSC); a state-level research agency (EPAGRI) and the local fishers organization (Colônia de Pescadores Z13).

1999, some middlemen said that they no longer gave fishers money to buy canoes or gears, but only helped them in the case of illness. Two middlemen affirmed that they gave money to only a few fishers because most of the other fishers were not as loyal as they used to be; they were selling their catch to the highest-paying buyers, regardless of whether the buyers were consumers, restaurants, retailers or other middlemen. It therefore appears that the patronage aspect of the middlemen's relationship with fishers declined as the local market grew in importance relative to other markets.

By 1999, only a few full-time Lagoon area fishers remained in patron-client relationships with middlemen. Part-time fishers who relied less on fishing for income and income stability could afford to assume the risk of bypassing the middlemen and seeking the highest-paying buyer. However, it is noteworthy that after a particularly good harvest, even full-time fishers would risk selling to the higher-paying buyers rather than to middlemen. Only a few full-time fishers continued to rely heavily on middlemen. Although these full-time fishers could be better off selling shrimp directly to consumers during high seasons, they need a guaranteed buyer during low tourist seasons and non-productive months (e.g. they borrowed money from middlemen in an informal credit system).

### 5.1. *Shrimplfish market in the late 1990s*

Fig. 2 presents the channels through which local shrimp were marketed at Ibiraquera during the 1999–2000 fieldwork season. Fishers could sell their catch to consumers (both residents and tourists), local grocery stores (retailers), local and non-local restaurants, and middlemen. Shrimp sellers could be local fishers, outside fishers, middlemen, or retailers. Sellers who sold to non-local restaurants were outside fishers. Middlemen sold to both consumers and local restaurants; when middlemen accumulated surpluses, they sometimes sold to other local middlemen or to the regional market. Retailers sold directly to consumers. Local fishers sometimes directed a small portion of their catches to their families'

consumption. During fieldwork, seven middlemen, five local grocery stores and seven local restaurants in Ibiraquera were observed buying shrimp directly from fishers. Retailers are distinct from middlemen in that the former do not put any effort into searching for shrimp because of the high opportunity cost of the search in terms of the value of other goods that can be sold using the same effort. That is, retailers buy shrimp only when fishers come to them to offer it, while middlemen actively search for both sellers and buyers.

Of the seven middlemen identified around the Lagoon area, five also had a fish/shrimp store; that is, they were middlemen-retailers and had to divide their time between these activities. Of these middlemen-retailers, only one had other major sources of income, which allowed him to open his shop only during high tourist season—the most profitable time. This middleman is one of the first two individuals who marketed shrimp from Ibiraquera to the regional market in the early 1970s. By the late 1990s, he owned several other businesses and seemed to be the wealthiest middleman in the region. Despite the fact that his fish/shrimp shop had the largest storage capacity (freezers), this middleman was the least active in buying directly from fishers. This may suggest that, for the size and diversity of his business, the opportunity cost of buying directly from fishers was too high, and he probably imported shrimp from the regional market or bought from other local middlemen. Of the two middlemen who did not own a store, one was not very active and had only one buyer (a restaurant); that is, although he spent time searching for shrimp sellers, he spent no time searching for buyers. The other middleman without a store was one of the most active middlemen in the area, and spent most of his time searching for shrimp and selling it to local restaurants. The tradeoff between having a shrimp shop and spending time searching for sellers is, thus, not clear-cut. On the one hand, there are certain operating costs involved in running a shop; on the other, there are costs in terms of time, gasoline, and car repairs associated with searching for buyers.

Due to the need to guarantee fishers' anonymity (and to avoid conflicts), it was not possible to identify specifically which fishers sell to which

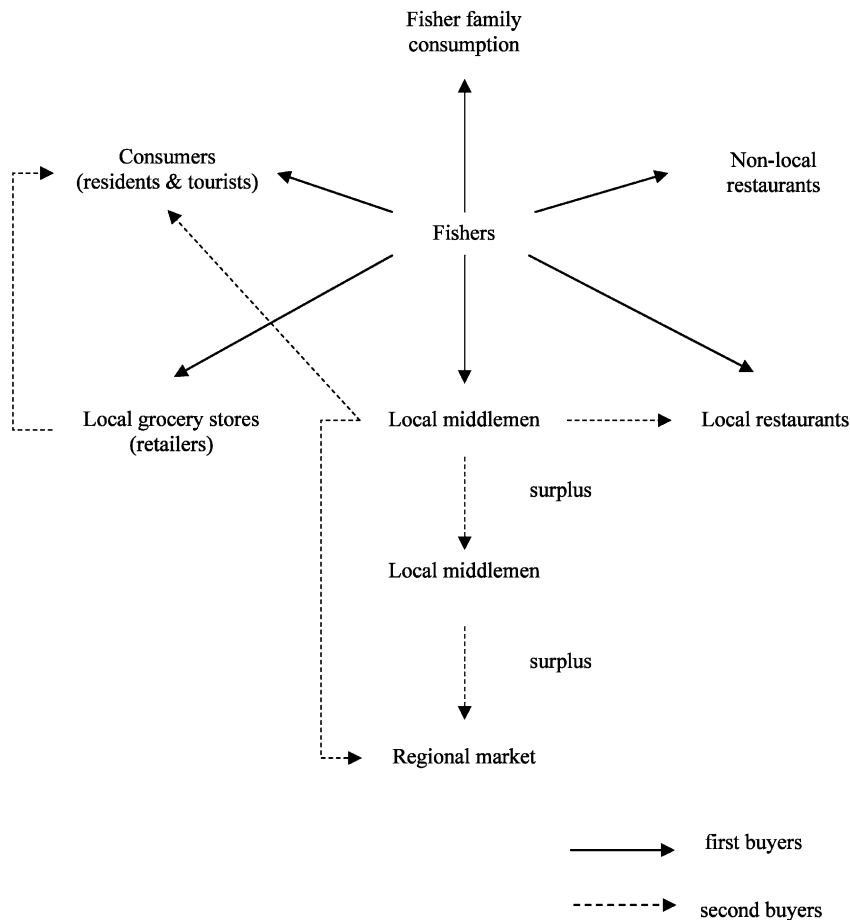


Fig. 2. Channels of Ibiraquera shrimp marketing.

middlemen or retailers and under what circumstances. However, some middlemen mentioned that the areas around the Lagoon where fishers live are informally divided among middlemen. As these middlemen described it, a middleman drives to fishers' houses in 'his' area to buy shrimp. During peak shrimp season, the middleman might make six trips per week. During low shrimp season, the opportunity cost of each trip increases, thus the middleman makes only one trip per week, which is possible because all fishers now own refrigerators in which to store shrimp.

Although most fishers are free to sell their catch to any middleman, sometimes a temporary loyalty between a fisher and a particular middleman emerges. Other middlemen respect this relation-

ship most of the time. Sometimes this loyalty is broken when another middleman offers better prices for shrimp or for some reason a middleman temporarily cannot work. For instance, one middleman complained that he could not match the high shrimp prices offered by a second middleman soon after the Lagoon channel was opened (during a highly productive part of the season). This occurred because the first middleman's business was much smaller than that of the second. Hence, the first middleman lost all 'his' fisher loyalty. However, despite some isolated examples like this, there seemed to be no open conflict among middlemen. Indeed, sometimes one helped another, for example, when one bought another's surplus (i.e. when all his freezers were full) during

a peak shrimp season that fell outside a high tourist season.

Middlemen's importance as buyers varies with the season. Most fishers sell their catches to middlemen mainly during winter because in summer (the high tourist season) they prefer to sell directly to higher-paying tourists. Consequently, the dynamic relations between middlemen and fishers in today's Ibiraquera shrimp market can be explained by price-driven factors in which weakened patronage forces occasionally surface, as opposed to the strongly patronage-based market of the past.

### 5.2. Shrimp supply

Panel (a) of Fig. 3 shows the total amount of Lagoon shrimp marketed via middlemen, retailers and restaurants in the Lagoon area during 28 weeks of study. (Recall that this underestimates total production for the period.) Fig. 3a suggests that the amount of shrimp marketed reflects in part the shrimp life cycle and total shrimp catches. When the channel connecting the Lagoon to the ocean was opened (week 10), catches and sales increased considerably. During Lagoon water drainage, pre-adult shrimp try to reach ocean waters to spawn; many, however, are caught with trap-nets inside the interconnecting channel. Lagoon water drainage only takes place during a few days; hence there is a drastic decrease in the quantity of shrimp caught and sold soon after that (week 12). As the Lagoon's water level comes to match that of the ocean, ocean water starts to enter the Lagoon, bringing in larvae and post-larval shrimp that will grow to a marketable size in 2 or 3 months.<sup>7</sup> This explains the lack of sales (and presumably catches) from week 12 to week 21, followed by a rebound in sales (and catches) in weeks 22–28. Also worthy of note in Fig. 3a is that the quantities of shrimp of various sizes marketed each week indicate the presence of several shrimp

populations inside the Lagoon, and reflect the shrimp life cycle's effect on catch and on fishers' incomes.

The price fishers receive for each kilogram of shrimp may vary according to shrimp size, supply and demand factors (e.g. peak tourist season versus off-season), and whether fishers transport their product to middlemen (higher prices) or middlemen travel to fishers' houses (lower prices due to the operating cost that middlemen incur). Shrimp size is usually classified into four categories: (a) large: about 25–40 shrimp/kg; (b) medium: from 45–70 shrimp/kg; (c) small: less than 75 shrimp/kg (sometimes up to 400 shrimp/kg); (d) assorted: large, medium and small shrimp are mixed and sold together. Small shrimp are rarely sold separately; they are usually sold in an assortment.

Our study attempted to collect information on shrimp prices received by fishers, as well as the profits earned by middlemen and retailers from trading shrimp. However, because these are sensitive issues to businessmen, the number of observations was small and data should be taken as potentially illustrative rather than wholly representative. Table 2 presents the range of prices for Lagoon shrimp during the study. Prices are delineated according to shrimp size, supply, demand, and buyer type. Not surprisingly, large-shrimp prices were higher than medium-shrimp prices, with prices for assorted-shrimp tending to fall between large-shrimp and medium-shrimp prices. Prices paid varied fairly consistently according to who the buyers were. Middlemen usually paid less than retailers, and much less than restaurants. As can be seen in Table 2, shrimp prices also varied over time, due to fluctuations in demand (tourist season) and Lagoon ecosystem cycles. Shrimp prices tended to increase as a result of: (a) the approach of the high tourist season (beginning at Christmas) when buyers wanted to stockpile shrimp; and (b) the drastic drop in supply soon after the Lagoon channel was opened (see Fig. 3a). However, because shrimp size varies within a single size category, an increased price may also be captured for larger shrimp within a given category. Lower shrimp prices corresponded to the ending of the high tourist season (soon after

<sup>7</sup> Branco and Verani (1998b) provide the growth (length) curve for *F. paulensis* from the Conceição Lagoon:  $L_t = 14.2 (1 - e^{-0.1995t})$  for females;  $L_t = 12.8 (1 - e^{-0.2309t})$  for males; where  $L_t$  is total length (cm) and  $t$  is time (months).

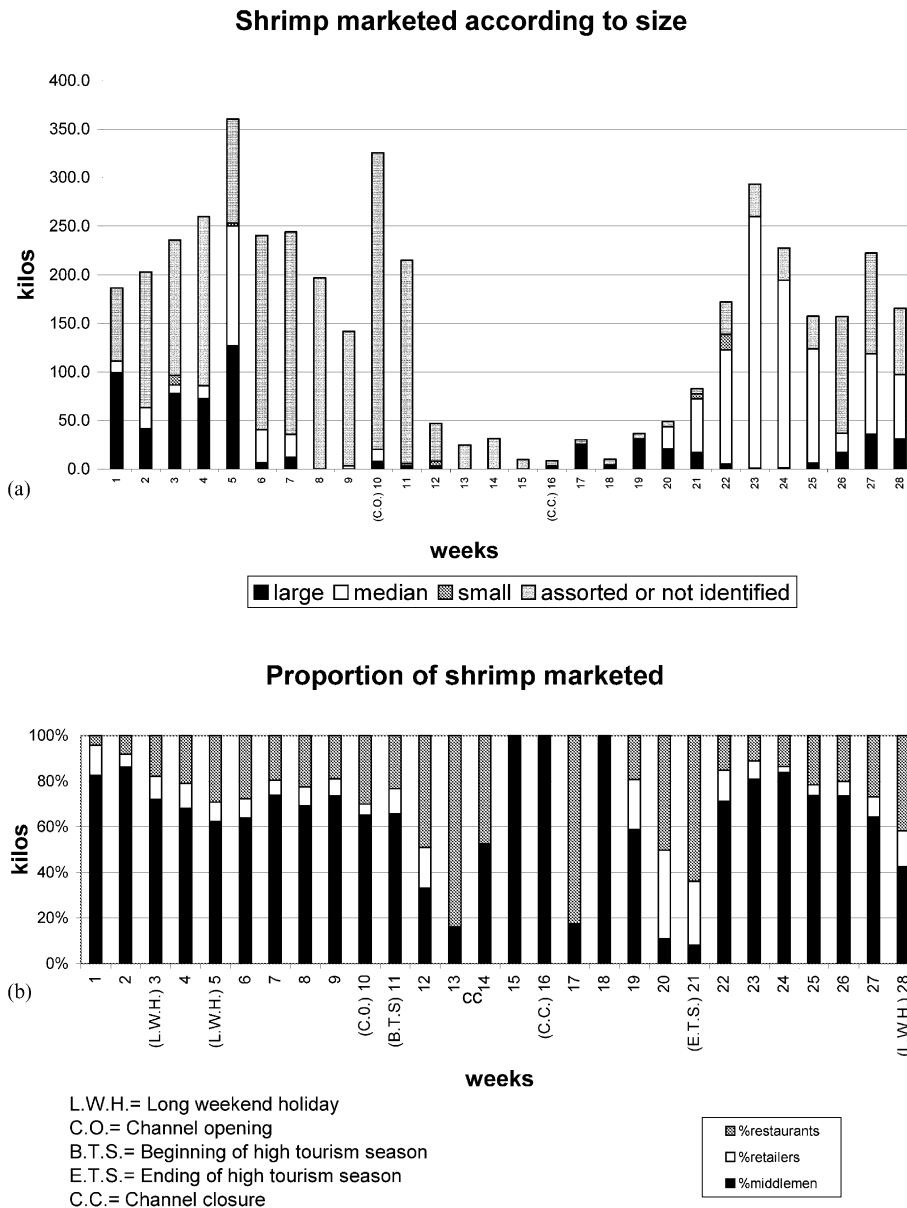


Fig. 3. Ibraquera Lagoon shrimp marketed locally from October 1999 to April 2000. (a) Amount of each size marketed per week; (b) Proportion among middlemen, retailers and restaurants in each week.

carnival—Ash Wednesday) as well as to times of increased supply (Fig. 3). The profits earned by middlemen and retailers in shrimp trading seemed to range from 10 to 50% of the price at which shrimp were sold.

Table 3 presents the quantities of Lagoon shrimp purchased by Lagoon area middlemen, retailers, and restaurants during the 28 weeks of study. Of the total 4339 kg of Lagoon shrimp sold in the Lagoon area during these 28 weeks, 68%

Table 2  
Price range of Lagoon shrimp according to its size, supply, demand and buyers

Weeks	Supply <sup>a</sup> (kg/week)	Demand	Range of prices per kilogram according to shrimp size (R\$) <sup>b</sup>			
			Buyers	Large	Medium	Assorted
1–4	223	Tourist low season	Middlemen	\$10–\$12	na <sup>c</sup>	na
			Retail stores	\$11	\$7	na
			Restaurants	\$13	na	na
5–9	237	Pre-tourist high season	Middlemen	\$11–\$13	\$7–\$11	\$9–\$12
			Retail stores	\$10–\$14	\$8–\$10	\$10–\$11
			Restaurants	\$13–\$14	\$9–\$12	\$9–\$14
10–11 <sup>d</sup>	270	Tourist high season	Middlemen	na	na	\$12–\$13
			Retail stores	\$14	\$10	\$12
			Restaurants	na	na	\$12–\$15
12–21 <sup>e</sup>	33	Tourist high season	Middlemen	\$15–\$16	na	na
			Retail stores	\$14–\$18	\$6–\$7	na
			Restaurants	\$15–\$20	\$6–\$7	\$13–\$14
22–28	199	Tourist low season	Middlemen	\$9–\$10	\$6–\$8	\$7 to \$8
			Retail stores	\$9–\$14	\$6–\$8	\$8
			Restaurants	\$9–\$15	\$7–\$8	\$7–\$8

<sup>a</sup> Average of Lagoon shrimp marketed locally per week.

<sup>b</sup> Brazilian currency (Real): R\$1.00 = CNDS 0.72 in April 9, 2001; no 'small' size category because small shrimp are almost always sold in an assortment.

<sup>c</sup> Data not available.

<sup>d</sup> Week 10, channel opening; week 11, beginning of tourism high season (Christmas).

<sup>e</sup> Week 21, ending of tourism high season (soon after Carnival—Ash Wednesday).

Table 3  
Ibiraquera Lagoon shrimp sold for local middlemen, retailers and restaurants from October 1999 to April 2000

Group	Shrimp marketed during 28 weeks		
	kg	% total amount	% of group
Middleman A	984	23	34
Middleman B	702	16	24
Middleman C	472	11	16
Other middlemen ( $n = 4$ )	771	18	26
Sub-total	2930	68	100
Retailers ( $n = 5$ )	396	9	100
Restaurant A	256	6	25
Restaurant B	245	5	24
Restaurant C	214	5	21
Other restaurants ( $n = 4$ )	298	7	30
Sub-total	1013	23	100
Total	4339	100	

was bought by middlemen, 9% by retailers and 23% by restaurants. It is interesting to note that 50% of the total amount was bought by only three middlemen; moreover, these three middlemen accounted for 74% of the shrimp bought by middlemen. In other words, three middlemen dominate the local shrimp market. As well, three restaurants accounted for 70% of the Lagoon shrimp bought by all seven of the restaurants buying directly from fishers. Interestingly, these three restaurants were the only ones located adjacent to ocean beaches. It is important to note that, with one exception, the owners of all of the restaurants studied were local residents. The exception, however, is an owner who is a part-time fisher himself and interacts with many local fishers. Therefore, it appears that fishers sell their shrimp solely to restaurants whose owners are familiar to them.

The above results were based on the total quantity of shrimp marketed during 28 weeks.

The percentages of catch purchased by different types of buyers changed over time, as shown in panel (b) of Fig. 3. Three different periods can be observed in Fig. 3b. During the first productive period, from week 1 to week 11, the percentage of catch bought by restaurants increased before and during long-weekend holidays (week 3: November 2 (Memorial Day); week 5: November 15 (Republic Proclamation Day); week 11: December 25 (Christmas Day)). From week 12 to week 21, almost no shrimp were marketed and any kilogram sold could make huge differences in percentages. Hence, this period is not considered of importance to understand variability in the local market. During the second productive period, from week 22 to week 28, the percentage of Lagoon shrimp bought by restaurants again increased as another long-weekend holiday approached (week 28: April 21 (Tirandentes Day)).

Two ecological supply-related concerns have emerged concerning the Lagoon's shrimp supplies, which will eventually influence market prices. First, according to middlemen, Lagoon shrimp production is no longer sufficient to supply local shrimp demand, especially during summer. This is not only due to increased local demand but also to reductions in shrimp stocks caused by the widespread practice of fishing with small-mesh cast-nets (2.5 cm or smaller). Fig. 3b illustrates that small and medium-sized shrimp are harvested in much greater numbers than are large shrimp. Smaller, younger shrimp (< 111 shrimp/kg) have not developed sufficiently (i.e. have not reached pre-adult stage) to have had the chance to exit the Lagoon for reproduction before being caught, thus diminishing the potential of new recruitments and consequently the sustainability of the Lagoon's shrimp stocks. Second, polluting behaviors (e.g. draining sewage directly into the Lagoon) in the area's communities have started to compromise Lagoon water quality, which has the potential to lower the quality of Ibiraquera shrimp and thus erode the product's competitive edge. Ibiraquera shrimp traditionally enjoyed recognition as the best shrimp in the region (and, according to some, in Brazil) because they came from a non-polluted Lagoon. Fishers and middlemen remain very proud of the high quality of Ibiraquera shrimp.

However, sewage drainage into the Lagoon and poorly constructed septic tanks are likely to affect shrimp quality in the near future if no preventive action is taken.

## 6. Discussion and conclusions

The story of the Ibiraquera Lagoon management system is a dynamic story of change when an area experiences lower transaction costs due to infrastructure development. The lower transaction costs open the area to outside influences. Markets and other institutions adjust in response to new opportunities presented by the outside influences, and the natural resource base experiences stresses that point to the need for further institutional change to deal sustainably with the changes brought by the outside influences.

While the Lagoon has always been a *de jure* state property with no access restriction (i.e. any Brazilian with a professional fishing license can fish in it), it has been managed under different property regimes over time. In its early history (1950s and 1960s), the Ibiraquera Lagoon shrimp market existed as a small, barter-based allocative mechanism in a traditional, primarily agricultural setting characterized by low population and a lack of physical infrastructure. The local communal property management system at that time proved sustainable due to the physical limitations exerted by the area's remoteness (due to lack of roads), the communities' low population, the technologies of the time (less efficient fishing gears and practices, lack of electrical refrigeration, and inability to transport due to the absence of roads), and respect for traditional locally-devised fishing rules. Infrastructural developments (road construction and electricity) during the early 1970s opened the area for regional trade. By the late 1970s, the shrimp market institution had transitioned to a local patronage system tied to a wider regional network in which middlemen provided money or fishing gear to local fishers, who in turn became obliged to sell all of their shrimp to their patrons.

During the mid-1970s through the late 1980s (and continuing to the present), the construction of roads to and within the Lagoon area along with



the area's electrification produced a continually increasing population and greater range of business opportunities as tourism in the area continued to expand. The area's higher population increased demand for Lagoon shrimp, and supply to satisfy that demand was facilitated by improved fishing, storage, and transport technologies. From the mid-1980s on, middlemen operated primarily in the local market, reducing their activity in the regional market. The traditional shrimp market did not break down—middlemen and remnants of the patronage system remain—but, starting in the mid-1980s, it was largely replaced by a complex network of transactions that are mostly arms-length and in which middlemen carry far less power. Patronage institutions particularly weakened when the local socio-economic system expanded during the tourism boom of the 1990s to offer alternative jobs to fishers and new buyers for their shrimp. Most fishers who formerly needed informal credits as a form of insurance against risk of natural hazards and economic uncertainty became less dependent on fishing as they got other jobs; moreover, they tried to maximize their expected income by selling shrimp directly to consumers or restaurants for better prices. The middlemen who remain and who have prospered still wield significant market share (occupying half the market in shrimp sold to retail customers (recall this excludes shrimp sold directly to end consumers)), but they now serve more as distributors than patrons. The presence of more competitive forces regionally (i.e. the more sophisticated market serving the larger population brought by the roads and electrification) compels today's middlemen to compete on the basis of price more than they did in the past, because fishers have many more potential buyers to whom to sell their catch.

It is clear that the Ibiraquera shrimp market's sophistication increased only when the costs of shrimp storage and transportation to regional markets diminished due to technological improvements. In other words, the modern market really emerged once transaction costs decreased sufficiently to ensure that sellers could profit from commercial shrimp production, as Wang (1999) predicts.

On the ecological front, at least two observations emerge, both of which point to the need for corrective institutional transactions. First, since prices increase as shrimp size increases and the Lagoon is a closed system for most of the year, one may ask why fishers do not wait to capture large shrimp later in the season (i.e. avoid using small-mesh cast-nets). Doing so would generate more financial benefit and the added ecological benefit of increasing the chances that part of the pre-adult shrimp stock would return to the ocean for reproduction. The problem is that lack of enforcement of existing regulations (concerning how, where and when to fish, and who is allowed to fish) places the Lagoon (a common-pool resource) under a *de facto* open-access situation (i.e. lack of property regime). Individuals have privilege but no rights in using and controlling use of the resource (Bromley, 1989). Locals harvest shrimp primarily for commercial purposes, while fishing serves as entertainment for most outsiders. Since most outsiders and sport-fishers have no economic dependence on the Lagoon resource, they have no economic incentive to use large-mesh nets and prevent overfishing. In the face of an open-access system where anyone holding a professional fishing license can fish, local fishers also lack any economic incentive to use large meshes and prevent overfishing.

In addition, there also existed some profit-maximizing local fishers whose private interests dismiss all possible social goals, and whose implied rate of time preference must be sufficiently high to shrink future earning streams from a sustained shrimp stock. This high discounting of future stocks could be attributed to the presence of alternative potential sources of income when fish stocks are depleted. Hence, in order to increase the size (and price) of shrimp marketed and avoid overfishing, new incentives and constraints are needed. In other words, a new institutional arrangement should provide fishers with signals that incorporate the costs of their fishing activities. Charging a user fee of some sort could work toward this.

A second way in which the opportunities presented by the shrimp market negatively influence the Lagoon ecosystem is through the Lagoon's

current role as a sink beyond its assimilative capacity. The idea that Lagoon use is costly to others not only applies as described above but also extends to ‘using’ the Lagoon as a receptacle for waste. The open-access situation resulting from a lack of control of the sewage drained into the Lagoon by illegal construction (with poorly functioning septic tanks) and garbage dumped in the Lagoon margins by tourists and local residents has begun to compromise the quality of the Lagoon’s water. Since the good quality of the Lagoon water is responsible for the higher prices of Ibiraquera shrimp compared to shrimp from nearby lagoons, sustaining the Lagoon ecosystem and fisheries requires the prevention of further pollution of its water and surroundings. If no effective action is taken to monitor sewage and garbage disposal and to construct proper sewer systems, the quality and price of Ibiraquera shrimp is likely to decrease in the near future. Creating a mechanism to enforce the already existing (and often appropriate) environmental regulations (e.g. the Nature Law (number 9605) imposes high fines and even jail terms for transgressors) is one possible solution. Another solution would be to attempt to limit polluting behaviours through environmental education.

Both of these ecological trends point to the idea that ecological systems and socio-economic systems evolve at different paces (Seixas and Berkes, 2003). In the case of the Ibiraquera Lagoon system, the opening up of the area in response to the arrival of modern infrastructure rendered the manageable communal property regime of the early 1960s incapable of sustaining the Lagoon fisheries by the late 1970s. Moreover, due to the breakdown of rules enforcement, what functioned sustainably during the 1980s and early 1990s, as a co-management regime (state and communal property) has become effectively open-access with the externality problems (e.g. stock depletion and water pollution) associated with such systems.

In conclusion, interaction between the Lagoon ecosystem and the social and economic systems is clearly an important factor in the dynamics of the shrimp market. Natural and manipulated Lagoon channel openings along with fishing activity influence the amount, size and marketability of the shrimp harvest. Additionally, polluting the La-

goon’s waters influences shrimp quality and thus price. Formal and informal institutional reforms will likely be necessary to acknowledge the current nature of the interrelationship between ecosystem conditions and local human systems in order to sustain the Lagoon and therefore foster the continuation of the Ibiraquera area’s lively and important shrimp market.

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