SOCIAL-ECOLOGICAL DYNAMICS IN MANAGEMENT SYSTEMS: INVESTIGATING A COASTAL LAGOON FISHERY IN SOUTHERN BRAZIL

By

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CRISTIANA SIMÃO SEIXAS

A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University of Manitoba in partial fulfillment of the requirements of the degree of

Doctor of Philosophy

To my parents, Licemare and Sergio,
for their love, support and encouragment
– always!

To my child who is coming,
and to my brother who is gone,
in this dynamic cycle of life...

Abstract

This dissertation is about dynamics of social-ecological linkages. In order to contribute to the efforts of sustainable natural resources and environmental management, the research focuses on the history of the Ibiraquera Lagoon fishery management system in Southern Brazil. A diversity of insights and tools are used to address questions of local knowledge, social-ecological resilience, common-pool (common-property) resource management, adaptive management, and stakeholder conflicts. The objective of this study is to investigate: (a) the significance of local knowledge for participatory management; (b) the key factors that build or threaten the social-ecological resilience of the Lagoon management system; (c) the incentives and constraints to development of the local social-ecological system (i.e., the ecological economics of the system); (d) some possible solutions for stakeholder conflicts about the Lagoon use, and (e) the use of the extractive reserves model for marine conservation.

The Lagoon is a brackish water system seasonally connected to the Atlantic Ocean. Pink shrimp (*Farfantepenaeus paulensis* and *F. brasiliensis*) fishing with cast-nets is the major fishing activity. Mullet and blue crabs are also important fishing resources. Legally the Lagoon is a state-property but over the past five decades it has been managed under different property systems. Fieldwork was carried out between June 1999 and May 2000. Research methods included interviews (key informants, structured interviews, and ethnomapping), archival research, participant observation, and collection of data on the diversity and quantity of resources harvested and marketed.

The major findings of the research are presented according to the main issues addressed. (a) *Significance of local knowledge for participatory management.* The study shows that resource users may provide a valuable set of information about resources and ecosystem dynamics. Moreover, local management practices may provide insightful information about the concerns, values, and ethics of resource users. Both user knowledge and local management practices can, and do, usually adapt in response to crises or the perception of crises. Hence, they may serve as an important source of information for participatory adaptive management. That is, they can complement scientific knowledge in designing, implementing and assessing adaptive management plans.

(b) *Key factors that build or threaten the social-ecological resilience of the Lagoon management system.* In analyzing resilience of the management system through cycles of change, the study points out five key factors that strengthen resilience. These are: strong institutions, good cross-scale communication, political space for experimentation, equity in resource access, and the use of memory and ecological knowledge as a source of innovation and novelty. In addition, four key factors that weaken resilience were detected. They include: the breakdown of local institutions, rapid technological change, rapid socio-economic change, and institutional instability across political scales. Other comparative studies would probably come out with other factors.

(c) *Incentives and constraints to development of the local social-ecological system.* Socio-economic incentives and constraints that affected the Lagoon management system included: new values and ideas brought by outsiders, new economic opportunities created by outsiders, increase in market demand for fishing products, community's infrastructure improvements, development projects, and technological innovations. Changes in management institutions had also a direct effect on the resource itself and on fishers' livelihood. To mediate the influences of socio-economic factors in the management system, a new institutional arrangement is proposed.

(d) *Possible solutions for stakeholder conflicts about the Lagoon use.* The study shows that institutional instability at higher political levels, the great diversity of ineffective management agencies, and the lack of coordination among government agencies from different levels and sectors result in stakeholder conflicts, environmental degradation and resource overexploitation at the Ibiraquera Lagoon and the surrounding area. These stakeholder conflicts reflect: a divergence in management goals; degree of dependence on resources; disagreement about fishing rights and resource allocation; a lack of personnel and equipment resources to enforce regulations; a mismatch of the scale of problems and the scale of regulatory and enforcement agencies; the lack of empowerment of fishers and local councils; and different understandings of Lagoon ecosystem dynamics between government managers and local fishers. To overcome management problems and stakeholder conflicts, a new management arrangement is proposed. Such an arrangement could address stakeholder concerns and conflicts, and build a knowledge base upon which management decisions could be made. This knowledge base could bridge concerns and knowledge provided by users, managers and researchers.

(e) *Extractive reserves for marine conservation*: This research indicates that the concept of extractive reserves can be a useful mechanism leading to sustainability. However, property-rights instruments, such as extractive reserves, are a necessary but not a sufficient condition to achieve sustainability. Several policy instruments, including market-based ones, need to be used jointly. In this context, I discuss an alternative policy for the Ibiraquera Lagoon consisting of the establishment of an extractive reserve to restrict the number of fishers, and a combination of regulations and a licensing system to operate such a reserve. In addition, I recommend the creation of a co-management Forum representing the stakeholders to manage the Lagoon.

The findings of this dissertation point out that management designs which build resilience into social-ecological systems and may lead to sustainability should be participatory and adaptive. As well, they should provide a match between the scale of management institutions and the scale of the resource itself. In order to be adaptive, management institutions must create opportunity for learning (i.e., create a political space for experimentation) and for building capacity to adapt to change.

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Muito obrigada a todos!!!

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Chapter I

Introduction

1.1 Context of the study

This dissertation aims to contribute to the efforts for sustainable natural resources and environmental management, that is, a management 'that meets the needs of the present without compromising the ability of future generations to meet their needs" (WCED 1987, p.8). The concept of sustainability encompasses the idea of "constancy of total natural capital" (Costanza and Daly 1992); that is, the capacity of natural environment to provide ecosystem services and resources and to assimilate waste (Goodland 1995). "Sustainability will be achieved only [...] when the scale of human economy is kept within the capacity of the overall ecosystem on which it depends," as Goodland (1995, p.4) explains. Another key aspect of sustainability is the ability of a system to maintain its adaptive capacity (Holling 2001). This issue of adaptive capacity, or resilience, is a major theme in the dissertation, as a way of addressing the dynamics of the system.

Many sustainability analyses of resource use tend to be static; they do not address the phenomenon of change in management systems and how humans respond to such changes. Hence, studies are needed to analyze changes in resource management systems and adaptive responses. Such responses must ensure future options of resource use. For this reason, this research focuses on the *dynamics of changes* in a *common-pool resources* management system and on the *linkages between the social and ecological aspects* of

such a system. This is done by examining a case study scenario in a small-scale fisheries management.

In this introductory chapter, I first present a paradigm shift in natural resources and environmental management science and some commonly used analytical tools. Second, I pose the main research question and five specific questions to help answer it. Third, I propose an analytical framework to address the research question. Fourth, I introduce the case study. Fifth, I present the research methods used. Sixth, I address how the dissertation is structured. Finally, I provide a summary of the plan of the dissertation.

1.1.1 Studying natural resources and environmental management systems

For many decades, resource managers and scientists in western societies have proposed management plans based exclusively on the biological aspect of resource management, and in particular on the assumption that nature is equilibrium-centered and predictable, provided that enough data are available. For instance, conventional management plans focused on the population dynamics of single species (e.g., biological models in fisheries) or on the preservation of 'pristine' ecosystems, without the interference of human actions (e.g., national parks). However, failure in achieving 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. 1995a). Scientists have started to realize the importance of managing 'humans' as part of the ecosystem, the need of managing entire ecosystems, instead of specific target species, and the significance of recognizing the complexity of system dynamics. In other words, a paradigm shift in natural resource and environmental

management science has started to occur. Management has started to move, at least in theory, from a 'biological-centered approach' to a 'social-ecological approach' (Jasanoff et al. 1997, Kates et al. 2001) and from a single population approach to a system dynamics approach, and in particular, a complex systems approach (Kauffman 1993, Levin 1999).

Scientists from different schools of thought have addressed the relationship between humans and nature. Such schools include Human Ecology, Cultural Ecology, Ecological Anthropology, Human Geography, Environmental History, Ethnoecology, Political Ecology and Ecological Economics (Davidson-Hunt and Berkes 2002). In this dissertation, I do borrow insights and analytical tools from many of these fields and sub-disciplines in order to understand linkages between social and ecological systems and the dynamics of integrated social and ecological systems. In particular, I borrow insights and key tools from *resilience*, the *theory of common-pool resources* (CPRs) and *adaptive management.*

It is important to note that social systems, as here defined, encompass the social, economic, and cultural aspect of human societies, including their ethics (values) and worldviews. Hence, the term social system is sometimes interchangeable with socio-economic system in this dissertation.

1.1.1.1 Social-ecological linkages in common-pool resources management

In resource management systems, both social and ecological systems change and co-evolve. Linkages between the social and ecological aspects of a *common-pool resource* management system are often analyzed through management *institutions* (such as

property rights[1]) and systems of *knowledge* (Hanna et al. 1996a, Berkes and Folke 1998a).

A *common-pool (or common-property) resource* is a class of resources for which exclusion is difficult and joint use involves subtractibility (Berkes 1989, Feeny et al. 1990). Fishing resources are classical examples of common-pool resources. The exploitation of a fish stock by one fisher directly affects the stock availability to other fishers who are difficult to exclude from the system. The evolution of the CPR theory has immensely contributed to the understanding of social-ecological linkages in natural resources and environmental management systems (McCay and Acheson 1997, Berkes 1989, Ostrom 1990, Bromley 1992). In particular, the CPR theory has addressed the implications of possible property regimes under which natural resources may be managed. These include four 'pure' property regimes: state property, private property, communal property and open access (Feeny et al. 1990) or a combination of them. An example of the latter is co-management arrangements in which resource management is shared between the state and local users. Property-rights regimes are part of the institutional framework of any resource management system.

Institutions are any formal constraints (rules, laws, and constitutions) or informal constraints (norms of behavior, conventions, and self imposed codes of conduct) that mold interactions in a society (North 1994). In management systems, institutions are the working rules or rules-in-use that control resource use (Ostrom 1990). The way institutions are designed and how institutional changes occur strongly influence the interaction between humans and nature (Hanna et al. 1996b). Ostrom (1990, p.51) argues

[1] "Property right is a claim to a benefit stream that the state will agree to protect through the assignment of duty to others who may covet, or somehow interfere with, the benefit stream" (Bromley 1991, p.2).

that "all rules are nested in another set of rules that define how the first set of rules can be changed". That is, institutions are hierarchically structured. 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 systems.

An institutional change occurs because some individuals (organizations) use bargaining power to create new rules in a society where it is perceived that they, or the entire society, could do better by restructuring the institutional system (North 1994). Institutional changes within management systems can improve productive efficiency, alter the distribution of income, reallocate economic opportunity or redistribute economic advantages. The first three options have a positive contribution to social welfare, while the fourth is just a redistribution of welfare (Bromley 1989). One should keep in mind, however, that some institutional change decreases productivity and social welfare instead of increasing them; that is, ineffective institutions may also be created. Institutional changes are a result of organizational actions based on current knowledge (and mental models) and on the institutional status quo.

Knowledge and learning are the most fundamental long-term sources of institutional change (North 1994). Information (knowledge) is passed by organizations (individuals) and through institutions across time and spatial scales. There is not one single knowledge system. Different societies may have a different understanding of social and ecological processes and phenomena. The most known, and perhaps accepted, system is that of scientific knowledge (also known as western knowledge). Other systems of knowledge can also play an important role in natural resources and environmental

management. Such systems may include traditional and local ecological knowledge systems. Berkes (1999, p.8) defines *traditional ecological knowledge* as "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment". *Local ecological knowledge* may be defined as "the knowledge generated through observations of the local environment and held by a specific group of people" (Berkes et al. 2002). Both traditional and local ecological knowledge should be seen as a complement to rather than a substitute for scientific knowledge in natural resource and environmental management.

1.1.1.2 Dynamics of social-ecological systems

The *dynamics* of integrated social systems and ecological systems (henceforth social-ecological systems) may be analyzed through the lens of *complex systems* thinking. This approach helps us to understand the complex nature of several management problems. Complex systems thinking acknowledges the non-linear nature of system dynamics, the uncertainty intrinsic in any system, the problem of scale, and the systems' capacity of self-organization, among other attributes (Costanza et al. 1993, Kauffman 1993, Levin 1999).

The concepts of adaptive renewal cycles, panarchy and resilience come out of complex system thinking and are useful in understanding the complex dynamics of management systems. Holling (1986, 1995) proposes that ecosystems evolve through *adaptive renewal cycles* which encompass four phases: exploitation, conservation, release and renewal. During the exploitation and conservation phases, there is an increase in the

organization and accumulation of capital. The system then becomes so over-connected that a rapid change is triggered (the release phase), leading the system to a reorganization of functions and structure (the renewal phase). Typically, an ecosystem proceeds from exploitation slowly to conservation; then rapidly to release; and again rapidly to renewal, before returning back to the exploitation phase (Figure 1.1). Conventional, often unsustainable, management plans deal only with the exploitation and conservation phases of the cycle by focusing on reducing variability and increasing economic efficiency in resource systems (Holling and Meffe 1996). Nevertheless, Berkes and Folke (2002) call attention to the importance of the release and renewal phases of the adaptive renewal cycle for resource management. It is these phases that create the opportunity for re-organization, learning and the adaptation of management systems. The adaptive renewal cycle may also provide useful insights on the social dynamics of resource management systems (Gunderson et al. 1995b, 1997, Holling and Sanderson 1996). For instance, Gunderson et al. (1995b) examined six large, regional-scale management systems and concluded that adaptive management systems exhibit periods of innovation, conservation, crisis (release) and re-organization (renewal).

Gunderson et al. (1997) and Gunderson and Holling (2002) propose that ecosystems' adaptive renewal cycles are structured in a number of levels and nested one in another across time and spatial scales in a so-called *panarchy* structure (Figure 1.2). According to Gunderson et al. (1997, p.13), the term panarchy "describes dynamic symmetries across hierarchical scale rather than an asymmetrical static relationship across scales." These authors point out that a growing number of evidence suggests that "events that lead to [release] through revolt, and those events that lead into [renewal] by

remembering or carrying over elements through the period of [release] are the products of cross-scale interactions" (Gunderson et al. 1997, p.13). In other words, minor disturbances that occur within a small-scale ecosystem may lead to major disturbances within a large-scale ecosystem. Likewise, large-scale ecosystems may be a key source of elements (e.g. biodiversity) used in the reorganization phase of a small-scale ecosystem.

These two heuristic models, adaptive renewal cycles and panarchy, relate to the concept of *ecological resilience* proposed by Holling (Holling 1973, 1986, Gunderson 2000). Accordingly, the resilience of a system relies on (a) its capacity to buffer disturbance while maintaining the same control on function and structure; (b) its capacity to self-organize; and (c) its ability to learn and adapt (Resilience Alliance 2001; Holling 2001). There are also other approaches to resilience in the ecological literature (e.g., Pimm 1991); these assume that there is an equilibrium to which a system will bounce back. In this dissertation, the Holling definition is used because it allows for multiple equilibria in a system. The Holling concept of resilience may also be applied to social systems, and tends to be related to the resilience of the ecological system upon which the social system depends (Adger 2000). The importance of addressing linked social-ecological systems in resource management expands this notion of resilience, and changes the area of emphasis to social-ecological resilience (Berkes 2002, Berkes et al. 2002).

To deal with the complex nature of social-ecological systems, some scholars have advocated the *adaptive management* approach (Holling 1978, Walters 1986). In this type of resource management, managers must constantly respond to ongoing changes in ecological systems caused by either 'human-made' or natural disturbances. Disturbances

are inevitable, hence management must always be adaptive (Gunderson et al. 1995b). A resilient management system, "which buffers a great deal of change or disturbance, is synonymous with ecological, economic and social sustainability. One with low resilience has limited sustainability" (Berkes et al. 2002), that is, when subjected to disturbances the system may change its functions and structure, becoming a different one. In order to deal with changes and disturbance, a management system should be flexible, diverse and capable of learning and adapting.

In this dissertation, I use the above concepts and analytical tools to address the dynamics of changes in social-ecological systems and the linkages between the social and ecological aspects of common-pool resource systems.

1.1.2 Research question

Understanding that natural resources and environmental management systems are complex, non-linear in nature, cross-scale in time and in space, and evolve through time (Holling et al. 1998), I propose the following research question:

- *What can one learn from investigating the dynamics of changes in social-ecological systems and the linkages between social and ecological aspects of such systems for building resilience and sustainability in management systems?*

To answer this question, I study a small-scale lagoon fishery management. To focus the study, I propose five specific questions to address the main research question. These are:

a. What is the significance of local knowledge for participatory management? Is it useful in designing, assessing and implementing management plans?

b. What are some of the key factors that help build social-ecological resilience in the lagoon management structure, and what are some key factors that threaten it?
c. Which incentives and constraints have affected the development of the local social-ecological system? That is, what is the ecological economics of the area?
d. What policies across organizational scales may help solve stakeholder conflicts over resource use?
e. Can the extractive reserves model be used for marine conservation?

The primary contribution of this dissertation to knowledge concerns building adaptive capacity and resilience for sustainable resource use. More broadly, this work contributes to the theory and practice of investigating the dynamics of social and ecological linkages. The dissertation also contributes to the methodology of carrying out such studies. It is designed to provide insights for the study of the dynamics of social-ecological systems, social-ecological resilience and sustainable resource management.

1.2 Analytical framework

To address the research question, I propose an analytical framework based on Berkes and Folke (1998b), which includes the following components: (1) *resource system (ecosystem)*, (2) *socio-economic system (people, technologies, and markets)*, (3) *pertinent local and scientific knowledge*, (4) *local and government institutions*, and (5) *management problems, crises, and adaptations*. These components should not be seen as discrete elements, but as interconnected elements of resource management systems. Indeed, the key point of studying the dynamics of social-ecological systems is to analyze the feedback interactions among these components.

1.2.1 Resource systems

In understanding the evolution of a resource system attention should be given to its *general physical attributes* and *biological characteristics* (Berkes and Folke 1998b) including the way such attributes and characteristics are organized in the system. In particular, attention should be given to *changes in patterns of biodiversity* (Warren and Pinkston 1998, Niamir Fuller 1998), the *resource boundaries* and the *history of resource use* (Regier and Baskeville 1986). As well, the types of unexpected events (*surprises*) that the resource system has experienced and the *processes that trigger change and facilitate renewal* (Holling 1986) should be investigated.

1.2.2 Socio-economic system: People, technologies and markets

The analysis of management systems should focus on the *social groups* and the *organizations of resource users* (Brooks 1986; Berkes and Folke 1998b). In different societies, resource users are organized differently according to their culture, the nature of the resource they exploit, and their historical experiences. Hence *socio-economic and cultural heterogeneity* should be addressed. For instance, the degree of economic diversification is directly related to a community approach to management (Hanna 1998).

Attention should also be given to *policies and economies at the local or regional level,* and to *religion and education levels of resource users* as they might directly or indirectly influence local management arrangements (Warren and Pinkston 1998). In addition, the *degree of economic dependence on resources* also influences people's willingness to participate in management (Hanna 1998). As economic dependence on

resources changes over time, a historical study should be undertaken on the way this and other socio-economic factors have influenced the management arrangement; in particular, one should study *market influences* on resource management (Hanna 1998).

The *social mechanisms and safety nets* that some societies have developed in response to environmental uncertainties and variability in market systems (Folke et al. 1998, Niamir-Fuller 1998) should also be investigated. In addition, research should focus on *technology diversity* (Brooks 1986) and *technology efficiency in resource exploitation,* as well as on *technological changes* and *technological development,* which may have either a positive or a negative effect on management systems (Ravetz 1986).

1.2.3 Pertinent local and scientific knowledge

Human adaptations to changes in resource systems are based on a repertory of behavioral responses or "a response pool" in Brooks' (1986) terminology. Brooks (1986) points out that "in order to increase the capacity of organizations or communities to adapt to future changes it is important to deliberately cultivate their response pool variability". In local management systems, the response pool variability is often based on the *local knowledge* about the dynamics of the local resource system, management practices and the efficiency of the technologies used. Hence, it is important to investigate such knowledge, as well as *who holds this local knowledge* and *how it is transmitted.* In 'modern' management systems, the response pool variability is largely based on scientific knowledge, often achieved from different systems. In examining the possible response pool of a management system, both the *scientific* and the *local knowledge* that is available should be considered.

1.2.4 Local and government institutions

In studying the evolution of management institutions it is important to trace *changes in property regimes* and to identify what has triggered such changes. In each type of management arrangement the role of resource users, government, and non-government organizations (NGOs) should be investigated as well as the decision-making, enforcement and monitoring processes (Berkes and Folke 1998b). For instance, local-level decision-making enables rapid institutional feedback to changes in the ecosystem.

A detailed research study on *property-rights institutions* regarding use rights, rights to exclude others, rights to manage, rights to sell and how rights are transferred should be performed. In addition, a *historical analysis of government regulations* regarding the use and appropriation of natural resources, and under what circumstance these regulations were created, should be performed.

In studying management institutions, attention should be given to *how management practices are embedded in institutions, what the key elements are behind adaptive institutional responses* and *why some management institutions fail.*

1.2.5 Management problems, crises, and adaptations

Resource management systems are often impacted by socio-economic development at local or regional levels. Hence, there is a need to evaluate *management problems* and *their relationship to local and regional development.* Environmental surprises may also create management problems and may even lead the management system to a crisis. Gunderson *et al.* (1995b) argue that crises play an important role in resource management

systems because they may trigger learning opportunities and may lead the system to a renewal phase. Thus, when studying the dynamics of social-ecological linkages, it is important to evaluate *crisis events, learning processes, source of knowledge* and *management adaptations*. When examining six resource management cases, Gunderson *et al.* (1995b, p.506-7) noted that during the renewal phases, learning appears to have occurred by: (a) the transference of 'knowledge gained in other systems and applied to the system in crisis', (b) 'the sudden release in local understanding that had accumulated in a separated context' (knowledge held in memory) and (c) 'putting various pieces together during the crisis'.

To study management adaptations, one should research *how human societies have perceived and responded to past environmental surprises and management crises.* Moreover, one should search what the *lessons learned* were and *how they were incorporated into warning, responding, and adapting mechanisms* (Timmerman 1986).

Now that I have delineated the research question and proposed one analytical framework, I introduce in the next section the case study that I chose to address the dynamics of changes in social-ecological systems and the linkages between the social and ecological aspects of such systems.

1.3 Introducing the case study

My research is focused on the Ibiraquera Lagoon management system during the second half of the 20th Century. The Lagoon is located in the municipality of Imbituba (pop. 33,000 in 1991), in Santa Catarina State, along the southern part of the Brazilian coast

(Figure 1.3). This area was chosen because both the management system and the local socio-economic system have experienced several changes in the past five decades. The baseline for the study is the 1950s. This baseline was selected based on the possibility of acquiring reliable information about that period stored in the memory of old people. To my knowledge, substantial documented information about the Ibiraquera region does not exist for earlier periods.

I first visited the Lagoon area in August 1998, when I was traveling on the coast of the States of São Paulo, Paraná and Santa Catarina, in Brazil, while searching for a case study area for my dissertation. At that time, I was looking for a case in which the depletion of fisheries resources had occurred, followed by changes in fishing rules and a restoration of resources. The Ibiraquera Lagoon was the *only* case we (my colleagues Natalia Hanazaki, Andrea Leme and I) found after driving about 3,000 km for one month.

1.3.1 Coastal fisheries in Santa Catarina until the mid 1900s

The coastal zone of Santa Catarina State was originally inhabited by the native Carijos (Tupi-Guarani), who depended on fishing for their livelihoods. The Europeans first arrived on this coast in the early 16th Century (Santos 1977). Until the mid 1700s, however, European settlements were very sparse and populations were small. During the second half of the 18th Century, thousands of immigrants from the Azores and Madeira Islands arrived in the region. New settlements emerged and some eventually became cities, such as Imbituba. By the early 1900s, the native population was almost extinct. Nevertheless, some aspects of their culture and technologies were adopted by the European settlers. For example, it is said that the fishing technologies and strategies

existing during the 1960s in Santa Catarina coast were based on a combination of both the Carijos and Azores practices (Lago 1961).

The basic economic activities in the coastal settlements during the 18th and 19th Centuries included small-scale agriculture, fishing and small industries based on manioc flour production. Whale fishing was an important economic activity in the state of Santa Catarina until British and American whaling ships entered the business in the Falkland Islands, thus intercepting whale migrations to the Brazilian coast, in the end of the 18th Century (Prado Jr. cited *in* Lago 1961). Whale oil was used in public lighting and building construction. In Imbituba a whale fishing industry, which had started in 1796, was the major source of income to local people until the mid 1800s. Whale fishing was mainly performed by slaves, despite the fact that slavery was not common in South Brazil. This possibly explains the origin of some black (African-Brazilians) families in the Ibiraquera region (Avellar 1993).

During the mid 20th Century, several changes occurred in fishing communities along the Santa Catarina coast. A survey of the evolution of fishing activities in Santa Catarina and on the socio-economic status of artisanal fishers was carried out in 1966 in 25 coastal communities (Lago and Gouvea 1968). This survey showed that a shift from agriculture to fishing occurred in several of these communities. An intensification of the commercialization of fishing products, especially through middlemen, also occurred due to an increase in market demand from large cities and an improvement in the road network. The development of tourism also influenced market transactions of fishing products in some of these fishing communities. Tourism gave fishers the opportunity to sell their products directly to local consumers, diminishing, in some cases, their

dependence on middlemen. In other cases, however, middlemen were still in control of most of the fishing market, as they bought products from fishers and sold them to local restaurants and retail stores. The development of tourism also promoted an increase in the value of lands owned by fishers and an improvement in the living standards in fishing communities due to cultural influences (Lago and Gouvea 1968).

Except for the whale fishery in Imbituba, other ocean fisheries have not been of great importance for the municipal economy[2]. As Lago (1961, 185) explains, "The very exposed coast line [of Imbituba], with big surf caused by the wind, raises difficulties in beach seine fishing and other fishing methods used in sea grounds away from the beaches." On the other hand, the lagoons formed between the low terrain and the sand dune formations along the coast of Imbituba and Laguna (located south of Imbituba) created a suitable environment for fishing activities (Lago 1961). Among these is the Ibiraquera Lagoon, situated on the northshore of Imbituba.

1.3.2 The Ibiraquera Lagoon region

Despite the development of the city of Imbituba in the first half of the 20th century, the Ibiraquera region remained quite isolated until the 1960s. Most communities were living on household agriculture and subsistence fishing. Many socio-economic and ecological changes have occurred since then, and as of year 2000, tourism-related activities have come to dominate the economy of most communities. It is important to note, however, that fishing continues to be an important source of cash or in-kind household income.

[2] During the late 19th Century and the 20th Century, the economy of Imbituba was driven by successive business, including a harbor, a railroad, a chemistry industry, and a ceramic industry (Martins 1978, Avellar 1993).

Pink shrimp (*Farfantepenaeus paulensis* and *F. brasiliensis*) and mullet (*Mugil platanus, Mugil spp.*) are the main fishing resources.

There are seven communities around the Ibiraquera Lagoon: Ibiraquera (also known as Teixeira), Barra da Ibiraquera, Arroio, Alto Arroio, Araçatuba, Campo D'Una, and Grama (or Ibiraquera de Garopaba). As of the year 2000, there were about 350 professional (licensed) fishers, few sport (licensed) fishers and several unlicensed fishers living in these communities (Figure 1.3).

The Ibiraquera Lagoon is an assembly of four interconnected small basins, Lagoa de Cima, Lagoa do Meio, Lagoa de Baixo, and Lagoa do Saco ('Upper Lagoon', 'Middle Lagoon', 'Lower Lagoon', and 'Saco Lagoon') with a total area of approximately 900 ha. This is a shallow lagoon; most of its area is between 0.20 m and 2.0 m deep, with a few points reaching about 4 m deep along channels running through the Lagoon area. For the most part, the Lagoon has a sandy bottom and brackish water. Freshwater input is mainly acquired through rainfall surface water and springs which feed the Lagoon at nine or more points. The water level in the Lagoon system rises as the season progresses. Throughout most of the year, there is a sandbar between the Lagoon and the Atlantic Ocean. If there is not any management, when sufficient water pressure builds up, a channel naturally bursts through the sandbar to the sea, and the Lagoon's water level drops. Most of the time, however, channel openings are triggered by human action and serve management purposes. The channel eventually closes naturally through sand deposition by ocean currents and tides, which in turn allows the Lagoon's water level to increase once again.

1.4 Research methods

Understanding the complex nature of social-ecological dynamics leads us to recognize the importance of qualitative analysis in natural resource management science. As Berkes et al. (2002) have stated:

> ... this follows from the nature of non-linearity. Since there are many solutions to a nonlinear model and no one 'correct' answer, simple quantitative output solutions are not possible. This does not mean, however, that predictions are not possible. Accurate prediction can still be made – but on the *qualitative* features of a system's behavior, not about the values of the system's variables, such as population numbers or the amount of yield.

To study the evolution of the Ibiraquera Lagoon management system during the second half of the 20th Century, I used, in most cases, a combination of qualitative research methods including interviews, participant observation, and archival research. To study the Lagoon management system and the shrimp market in 1999/2000, I used both qualitative and quantitative research methods. Preliminary fieldwork was done in August 1998, and the main fieldwork was carried out between June 1999 and May 2000. A short description of the methods used is presented below.

1.4.1 Interviews

Interviews were carried out in several formats. These included: structured interviews, semi-structured interviews with key informants and small groups, and ethno-mapping. These interviews were done to elucidate: fisher knowledge, fishery activities (resources, gears, user-groups and purposes), stakeholder conflicts and stakeholder concerns, major management problems and the actors and organizations responsible for, and affected by, such problems, the local fish and shrimp market, and the main changes in the local socio-

economic system and the Lagoon management system in the last five decades. Interviewees' occupations and the number of people interviewed are listed in Appendix I.

Key informant interviews: Eighteen interviews each ranging from 30 minutes to 2 hours were recorded. The interviewees 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 after their daily fishing. Many local people, including middlemen and restaurant owners, were also interviewed during their everyday activities.

In both types of interviews, I was interested in the main fishing resources, how they were caught, who caught them (defining user-groups), the reason for catching them, who sold them, and how they were sold. I also questioned the interviewees about the history of fishing resources, old management practices, fishing gear innovations, changes in fishing practices, changes in fishing regulations, as well as, the main events that have affected the Lagoon management in the past five decades. Interview guides are presented in Appendix II.

Structured interviews: Two types of interviews were carried out: one to understand the shrimp fishery and another to understand changes in the fishery rules (Appendix III). The Shrimp-fishery interviews were conducted with 35 shrimp fishers. The Changes-in-fishery-rules interviews were conducted with 31 shrimp fishers (often the same as in the first interview). In both cases, fishers were approached just before they began fishing.

Questions in the first interview were related to defining user-groups, the shrimp fishing activity, the shrimp market, and the fisher engagement in social movements. In the second interview, questions were related to fisher approval of specific fishing rules (Here I was looking for their understanding of how fishing gears affect fish stocks), and with their concerns about the major problems of the Lagoon management system.

Ethno-mapping: Four interviews were performed with older, knowledgeable fishers. This was done to map fishing spots, to examine species diversity (fish folk names), and to investigate their knowledge on the biology of some target species (mainly shrimp, mullet and crab – the main fishing resources).

1.4.2 Participant observation

Participant observations were carried out from October 1999 to May 2000 to monitor fish and shrimp catching activities, the fishing methods used, and to understand the role of fishers, tourists, tourism entrepreneurs, middlemen, buyers, resource managers, fisher's association officials, government agents, and community councils.

1.4.3 Archival research

Archival research was done to trace changes in fisheries legislation, government organizations and the local socio-economic system. Archives and the materials researched are presented in Appendix I.

1.4.4 Data collection to estimate the Lagoon biodiversity and harvest

Estimations of fish and shrimp abundance and harvest, fish and shrimp migrations, and seasonal cycles of the Lagoon were based on information from key informant interviews backed by field observations. There are no reliable fish and shrimp population or harvest statistics available for this locality or for most inshore fisheries in Brazil. However, there are a number of pertinent reports and scientific publications concerning the Ibiraquera Lagoon and other lagoons on the south coast of Brazil. These served as a source of information about physical-chemical parameters of the Lagoon, species migrations and seasonal cycles. Thy include: Andreatta et al. (1993, 1996), Branco and Verani (1997, 1998a, 1998b), Branco and Masunari (2000), Tremel and Souza (1999), and Vieira (1991).

The major species of fish, shrimp and crabs were collected in the field and identified by the use of species keys or by taxonomic specialists. Of about 39 species identified by fishers, 24 were recorded in the field, and 17 were identified biologically (Chapter II).

1.4.5 Data collection to estimate the Lagoon shrimp marketed

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 (28 weeks). These were all the middlemen who could be identified in the area, and the retail stores and restaurants were the only ones who bought shrimp directly from local fishers. There were several other restaurants in the area that bought shrimp only from local middlemen or from the regional market. These

data provide useful insights to understand part of the local shrimp market. However, they are not an accurate estimate of the Lagoon's total shrimp harvest during the period. For instance, they do not account for (a) shrimp that local fishers sold directly to consumers, (b) shrimp that fishers from outside (henceforth outside fishers) sold elsewhere, or (c) shrimp used for the fishers' domestic consumption.

1.4.6 Data analysis

Data analysis was based on the triangulation of data from field notes, transcribed interviews, and external sources including documents and literature. In addition, the main findings from a preliminary analysis (April, 2000) were checked by 12 people including fishers, local residents, local school teachers, the fisher organization's president and a government agent working in the area. A detailed description of data analysis is presented in Appendix I.

1.5 Plan of the dissertation

This dissertation has five major chapters. In each of them I try to answer one of the five specific questions posed after the main research question. Each chapter stands by itself because the chapters were written as independent publishable articles. Therefore, each chapter has a section describing the case study and the research methods used; these may contain overlapping material.

In Chapter II, *Learning from fishers: Local knowledge for participatory management,* I investigate local fishery management practices and the significance of

fisher knowledge for participatory management. I research fisher knowledge about major fishery species and the Lagoon ecosystem dynamics, as well as fisher view of government management. I also address the problems of changing social values and loss of local knowledge. I conclude by showing the multiple purposes that fisher knowledge may play in participatory management.

In Chapter III, *Dynamics of social-ecological changes in the Lagoon management system*, I analyze the cycles of changes in the dynamics of institutions and the Lagoon system for building social-ecological resilience. I investigate the management system for a period of four decades through the lens of property-rights regimes and social-ecological resilience. The Lagoon management system experienced different property regimes throughout this period. Moreover, the dynamics of the ecological system and the social system appear to have different pace. Key factors for building social-ecological resilience are examined in the context of these changes.

In Chapter IV, *Ecological economics of the Lagoon system: Incentives and constraints to development*, I analyze the co-evolution of the socio-economic and ecological systems through the lens of ecological economics. I particularly examine interactions between changes in the local economy and the evolution of the shrimp market. Then, I study how the local economy affects, and is limited by, the Lagoon ecosystem. Finally, I propose some management alternatives for the Lagoon system based on the development of a co-management Forum.

In Chapter V, *Stakeholder conflicts and solutions across a political scale*, I investigate the major conflicts about the use of the Lagoon area and their roots. As well, I analyze the Lagoon's major environmental and management problems in the late 1990s. I

propose the establishment of a co-management Forum for conflict resolution and resource management, in which the knowledge, values and concerns of all stakeholders may be taken in account. I also propose the creation of a knowledge base, including both local knowledge and scientific knowledge, to help find common ground among stakeholders, which in turn could help resolve or manage conflicts more effectively.

In Chapter VI, *Extractive reserves for marine conservation: a policy alternative for the Lagoon management*, I present the concept of extractive reserves in which use-rights for a certain area are given to a limited number of resource users. The extractive reserve provides the instruments for participatory management between users and government agencies. The discussion leads to the understanding that property-rights mechanisms may help implement policies leading to sustainability. Such instruments are a necessary but not a sufficient condition. To achieve sustainability, several policy instruments, including market-based ones, need to be used jointly.

The major theme unifying these five chapters is the dynamics of natural resource management. The scope of this analysis is not limited to only the ecological or the social relationships because feedbacks cut through both of these sub-systems. Hence, the scope of the analysis of dynamics is the integrated social-ecological system. The Conclusion section recaps the main findings of this research, and points out its major theoretical, methodological and policy contributions.

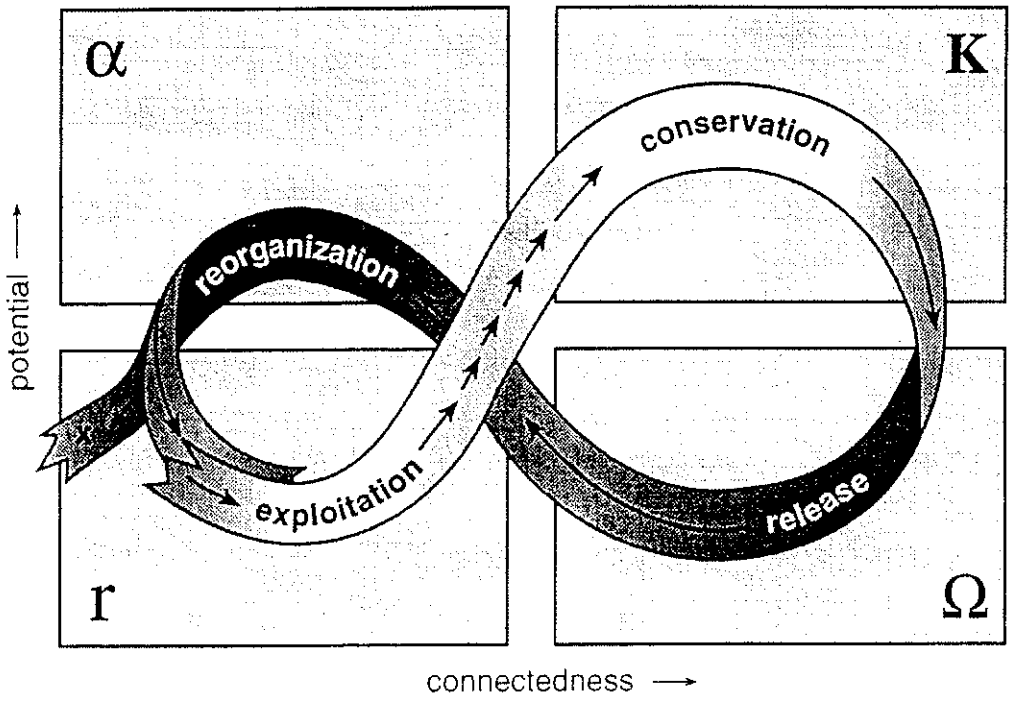

Figure 1.1. Adaptive renewal cycle: A stylized representation of the four phases: exploitation, conservation, release and reorganization (renewal). During the exploitation and conservation phases, there is an increase in the organization and accumulation of capital (i.e. an increase in the potential that is inherent in the accumulated resources and in the degree of connectedness among controlling variables). The system then becomes so over-connected that a rapid change is triggered (the release phase), leading the system to a reorganization of functions and structure (the renewal phase). Typically, an ecosystem proceeds from exploitation slowly to conservation (short closely spaced arrows); then rapidly to release; and again rapidly to renewal (long arrows), before returning back to the exploitation phase. The exit from the cycle indicated at the left of the figure suggests the stage where a system may flip into another domain (i.e., another organizational structure) (Holling 2001).

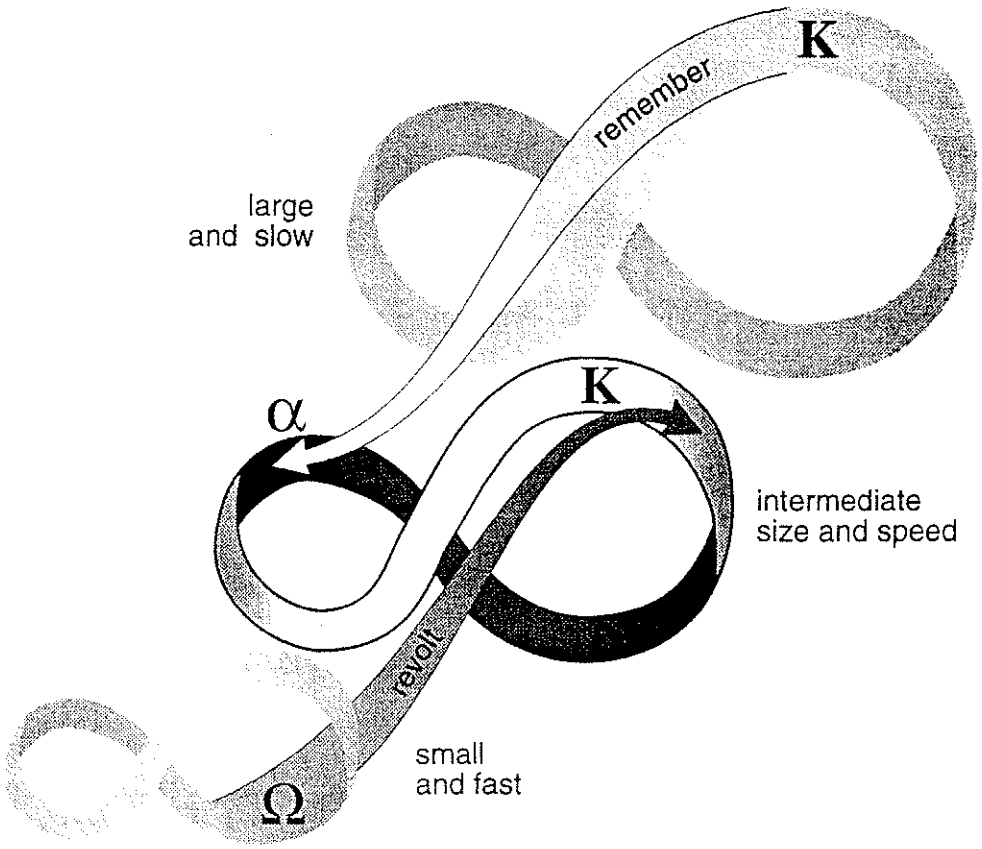

Figure 1.2. Panarchycal connections in nested adaptive renewal cycles. "Three selected levels of a panarchy are illustrated to show the two connections that are critical in creating and sustaining adaptive capability. One is the 'revolt' [or return] connection, which can cause a critical change in one cycle to cascade up to a vulnerable stage in a larger and slower one. The other is the 'remember' [or memory] connection which facilitates renewal by drawing on the potential that has been accumulated and stored in a larger, slower cycle" (Holling 2001).

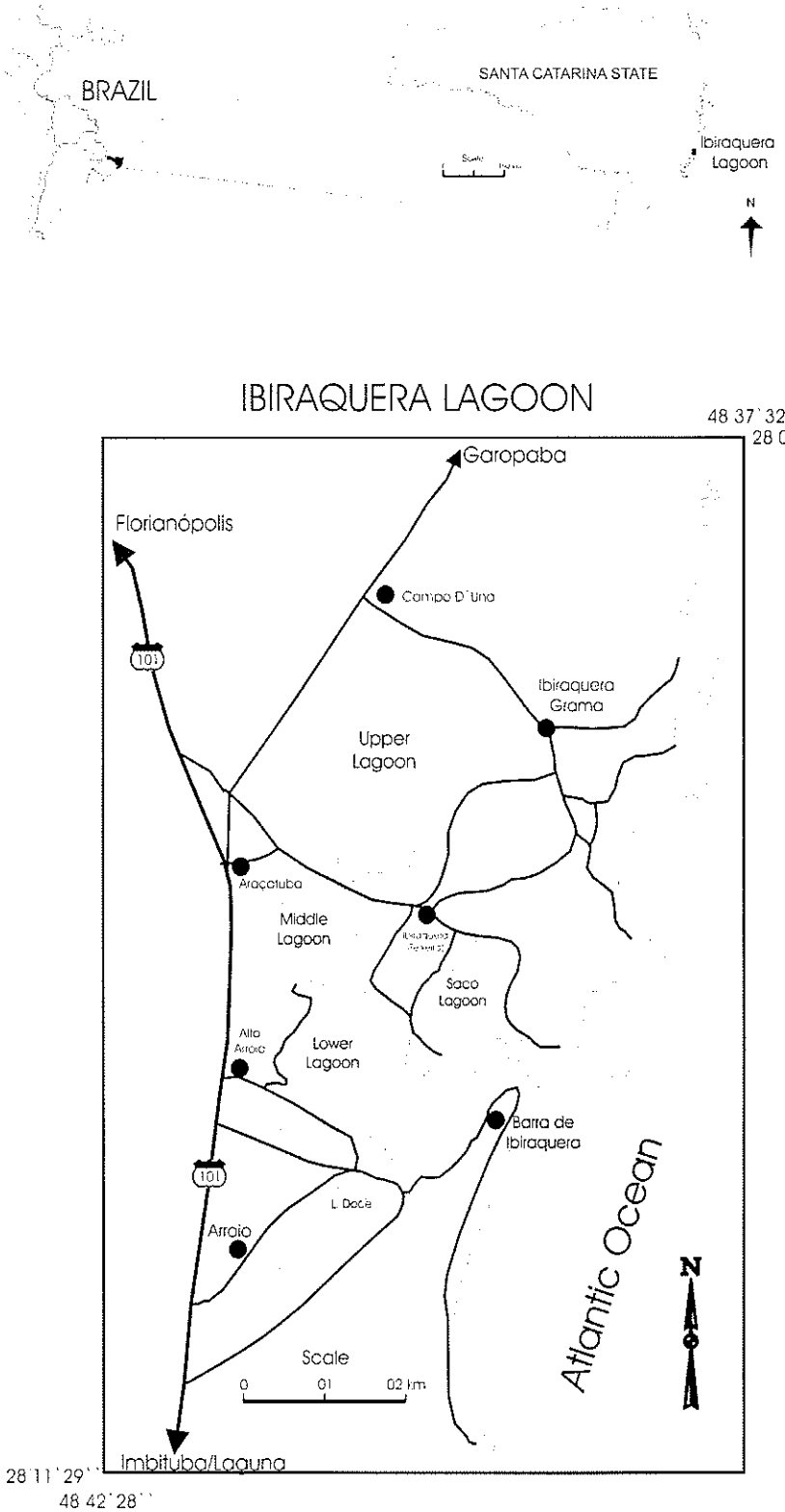

Figure 1 - Map of the Ibiraquera Lagoon, Santa Catarina State, Brazil.

Chapter II

Learning from fishers: Local knowledge for participatory management

Fisher poling his canoe and holding his cast-net while searching for a school of fish (Fall 2000).

Chapter II

Learning from fishers: Local knowledge for participatory management

2.1 Introduction

Conventional fishery resource management relies primarily on stock assessment or the quantitative calculation of populations and yield levels. The problem is that data requirements for such management are huge and expensive. Except for a few large stocks in a few rich countries, conventional fishery management is often not feasible. What are the prospects for the management of the many small stocks in countries that do not have a strong fishery research infrastructure?

Some promising approaches to manage small stocks have emerged lately and can now be used by fishery managers in developing countries (Berkes et al. 2001). These new or revised approaches emphasize the broader objectives of managing the fishery rather than the usual primary focus upon stock assessment (Mahon 1997). They emphasize social and ecological concerns, mainly through participatory decision-making processes. Many of these new approaches include the use of fisher knowledge. For example, Johannes (1998a) describes several cases in which the use of fisher knowledge has led to improved management systems. He argues that such "data-less management" does not mean management without information, and emphasizes that two sources of information should be systematically used: (1) fisher knowledge on marine ecosystems and fish species, and (2) information gained from researches in similar ecosystems.

Over the years, increasingly more important roles have been proposed for traditional and local knowledge. Given the scarcity of scientific knowledge, alternative coastal fishery management models in which local knowledge may substitute for scientific data, have been extensively proposed in Oceania (Johannes 1998a). Such models have yet to be tested, but the questions are of immediate interest. How can resource management be improved by supplementing scientific data with local and traditional knowledge? How can information from resource users themselves broaden the base of knowledge necessary for sustainable resource use?

The term *fisher knowledge* is used here to describe the body of ecological knowledge and management practices on aquatic resources and the environment, evolving by adaptive processes and in some cases accumulated through generations by cultural transmission. In some instances, the terms *local ecological knowledge* and *traditional ecological knowledge* (Berkes 1999), which encompass fisher knowledge, are also used. Fisher knowledge can provide detailed information on fish and other marine resources, including aspects of reproductive strategies (location, timing and behavior), diet, aggregation and migration patterns, life cycle, habitat, etc. As well, it provides information on physical environment, ecosystem dynamics, folk nomenclature (taxonomy) and management practices.

One way to investigate fishers' ecological knowledge is to look at locally devised management practices and social mechanisms based on local knowledge (Turner 1997, Folke et al. 1998). Not all traditional practices are conservation-oriented. It is important to understand that "environmentally destructive practices coexisted, in most societies, with efforts to conserve natural resources. But the existence of the former does not

diminish the significance of the latter" (Johannes 1978a, p.355). Some practices are embedded in conservation ethics[1], others are not. When investigating local management practices, attention should be given to ethics behind them. As Palmer (1994, p.238) argues:

> Conscious values and concerns revealed in indigenous practices are more important than the unintended effects of indigenous practices themselves. Hence, overly simplistic use of folk practices as models for formal regulations should be avoided, and special caution should be used when attempting to model formal regulations on folk practices that appear to have conservative effects but are not consciously intended to be conservative.

In face of these concerns, Palmer (1994, p.247) suggests that:

> Indigenous practices can be a valuable asset to those implementing formal regulations, but not necessarily are models of formal regulations. The social acceptance of formal regulations, which all it entails for reduced enforcement costs and the conservation of the resource, depends upon the conscious concerns and values of fishers. A major value of indigenous practices lies in what they reveal about these concerns and values.

In addition to researching the ethics behind management practices, attention should also be given to the different range of fisher knowledge. Fisher knowledge may be influenced by a range of factors including: gender, age, education, region, technological environment, crew structures, fishing practices, fishing strategies, fishing technology (including gear used), location of fishing effort, local topography, local differences in natural and fishing-induced changes in fisheries, competitive relations among fishers, commitment to the industry, their own fishery history and by the wider context of conflict and debate (Neis et al. 1999).

Investigations about local and/or traditional ecological knowledge used in fishery and/or coastal management from different regions of the world have been widely

[1] Conservation ethics is defined by Johannes and Ruddle (in Ruddle 1994, p.186) "as an awareness of people's ability to deplete or otherwise damage natural resources, coupled with a commitment to reduce or eliminate the consequences."

published in scientific journals, books and reports, particularly in the last two decades. Some examples are summarized in Table 2.1. Fisher knowledge is used to provide information for establishing protected areas and for improving community-based or government management; it is also used to assess government management.

In Brazil, research about fisher knowledge and local fishery management has also been reported in a few studies. Research carried out in the Pantanal wetland, which contrasts local and scientific knowledge, shows that local fishers can have a well-founded understanding of their environment (Calheiros et al. 2000). In coastal islands of Southeastern Brazil, Begossi (1992, 1996) investigated knowledge used by fishers in deciding their fishing strategies through the optimal foraging theory approach. As well, Begossi et al. (2000) point out that the deep knowledge about the local biodiversity held by *caicaras* (Atlantic Forest) and *caboclos* (Amazon), who are often fishers, and their management practices may have a great value for conservation in these hot spot ecosystems. In Bahia State, local fishers have developed complex arrangements of lunar-tide fishing rights based on their knowledge about the "relative mobility of gear and fishing craft, seasonality, microenvironmental zones, life cycles of fish, and [on] a whole host of social variables" (Cordell and McKean 1992, p.190). In the Lower Amazonian floodplain region, local fishers have created lake reserves to restrict access and implement management measures. These reserves are in the process of being legally recognized by federal government (Isaac et al. 1998). In Ceará State, fishers from two reservoirs have been involved in developing fishery management plans in collaboration with a government agency, where their knowledge and concerns have been taken into account (Christensen et al. 1995; Barbosa and Hartman 1997).

Based on the case study of the Ibiraquera Lagoon fisheries management in Brazil, this chapter aims to investigate local fishery management practices and the significance of fisher knowledge for participatory management. I argue here that fishers may have quite good knowledge not only of local species and their interactions but also of the Lagoon ecosystem processes.

2.2 The case-study

2.2.1 The Lagoon setting

The Ibiraquera Lagoon is located in the municipality of Imbituba (pop. 33,000 in 1991) in Santa Catarina State, along the southern part of the Brazilian coast. The Lagoon is seasonally connected to the Atlantic Ocean. The pink shrimp (*Farfantepenaeus paulensis* and *F. brasiliensis*) fishery is active year round while the mullet (*Mugil platanus, Mugil spp.*) fishery is active mainly during the winter months (from May to July). These are the two main fishing activities and they are performed by men. Crab fishing, especially during the hot months, is a family activity, which includes women and children. There are no effective legal access restrictions to the Lagoon. As of the year 2000, there were about 350 professional fishers living in seven communities around the Ibiraquera Lagoon: Ibiraquera (also known as Teixeira), Barra da Ibiraquera, Arroio, Alto Arroio, Araçatuba, Campo D'Una, and Grama (or Ibiraquera de Garopaba). Many of the fishers are descendents of immigrants from the Azores Islands, who arrived in this part of the country about 200 to 250 years ago. Fishers from other communities and municipalities often fish in this lagoon too.

The Ibiraquera Lagoon is an assembly of four interconnected small basins. These include Lagoa de Cima, Lagoa do Meio, Lagoa de Baixo, and Lagoa do Saco ('Upper Lagoon', 'Middle Lagoon', 'Lower Lagoon', and 'Saco Lagoon') and they cover a total area of approximately 900 ha (Figure 1.3). This is a shallow lagoon with most depths ranging from 0.2 m to 2.0 m. Channels where fish and shrimp migration take place run through out the Lagoon, with a few points reaching 4 m in depth. The Lagoon mainly has a sandy bottom and brackish water. The salinity range is from 7 parts permill in the rainy season, to 30 parts permill or more when the Lagoon is connected to the ocean (Unpublished data, Universidade Federal de Santa Catarina). There are not any major river-water sources. Freshwater input occurs mainly through springs, which feed the Lagoon at nine or more points. The water level in the Lagoon system rises as the season progresses due to freshwater inputs and rainfall events. Throughout most of the year, there is a sandbar between the Lagoon and the Atlantic Ocean. When sufficient water pressure builds up, a channel bursts through the sandbar. This channel eventually closes due to sand deposition by ocean currents and tides, which in turn, allows for the increase of the Lagoon water level.

2.2.2 Methods

Fieldwork in Ibiraquera was carried out between June 1999 and May 2000. Data relating to fisher knowledge, fishery activities and main changes in the fishery management system in the last five decades were obtained through semi-structured interviews with key informants, informal interviews with small groups, short-structured interviews with shrimp fishers, ethnomapping, participant observation and archival research. Eighteen

interviews ranging from 30 min to 2 hr were recorded. The interviewees included knowledgeable fishers, the local fishers organization's president, a local middleman, 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 after their daily fishing. Many local people were also interviewed during their everyday activities. In both cases I was interested in the main fishing resources, how they were caught, who caught them (defining user-groups) and the reason for the catch. I also questioned the interviewees about the history of fishing resource, old management practices, fishing gear innovations, changes in fishing practices, changes in fishing regulations, as well as, the main events that have affected the Lagoon's ecosystem in the past five decades. Short-structured interviews were conducted with 31 shrimp fishers. They were approached just before they began fishing. The main questions were: Do you agree with (a specific) fishing rule? Why? (Here I was looking for their understanding of how fishing gears affect fish stocks). And, what in your opinion are the major problems of this Lagoon system? Why?

Four interviews (ethnomapping) were performed with older, knowledgeable fishers. This was done to map fishing spots, to examine species diversity (fish folk names), and to investigate their knowledge on the biology of some target species (mainly shrimp, mullet and crab – the main fishing resources). Participant observation focused on fishery activities during the day and evening, and on community council meetings. Archival research was performed to elucidate changes in fisheries legislation and the local socio-economic system. Data analysis was based on triangulation of data from field notes, transcribed interviews, and from external sources including documents and

literature. In addition, the main findings from a pre-data analysis (in April/00) were checked by 12 people including fishers, local residents, local schoolteachers, the fisher organization's president and a government agent working in the area.

2.2.3 Lagoon fishery management

Until the early 1960s, there were relatively few families in the communities around the Lagoon. Most of the families' livelihoods consisted of household-level agriculture and small-scale fisheries. The main fishing strategies included the use of cast-nets and gillnets (used as setting-nets, encircling-nets or seine-nets) to catch fish, and cast-nets with kerosene lamps to catch shrimp. Fishing rules were mainly decided locally. Respect for the practices of long-term fishers was the main measure through which these rules were enforced. Although the local fishers organization (Colônia de Pescadores) and a federal government fishery agency[2] already existed, they did not play any important role in the local management of the Ibiraquera Lagoon.

The traditional management system was disrupted during the 1960s and 1970s as a result of a shift from a subsistence fishery toward a regional-market oriented fishery. Additionally, the innovation of fishing gears (e.g., monofilament nylon nets; smaller mesh-size nets; and butane gas lamp which attracts much more shrimp than kerosene lamp) and strategies (e.g., gillnet used as beach seine along the lagoon shore), as well as population growth, disrupted the system. Moreover, due to socio-economic and cultural changes, respect for elders' practices had weakened and profit-oriented fishers questioned and disrespected older fisher practices. This situation led to a small crisis in the

[2] Departamento de Caça e Pesca.

management system by the end of the 1960s and a larger one in the late 1970s. In 1971, local fishers made an arrangement to prohibited the use of gillnets in the Upper Lagoon and in the Saco Lagoon (gillnets could only be used in the Middle Lagoon and Lower Lagoon) and prohibited the use of cast-nets and gillnets in the channel whenever it was open. This arrangement did not last long as some gill-netters started poaching again in the Upper and Saco Lagoons. In the early 1980s, the Colônia started to demand regulation changes from the federal government agency (SUDEPE[3]). SUDEPE agents worked together with local fishers to establish new regulations. In 1981, the federal government approved a regulation (N-027/81)[4] specific to the Ibiraquera Lagoon, which banned the use of all nets except for cast-nets, with minimum mesh size of 2.5 cm for shrimp and 5.0 cm for fish. These are the standard mesh sizes of the multi-species coastal fishery in Brazil. The regulation also prohibited any fishing within the channel linking the Lagoon to the ocean, and in a small channel connecting the Upper and Middle Basins. In 1986, the use of gas lamps was banned in the Lagoon (regulation N-09/86), allowing only kerosene lamps. The gas lamps were being used with a new piece of fishing gear, a hand-held shrimp tong, which caught small shrimp in their feeding areas along the Lagoon margins.

From 1992 to 1998, a shrimp-stocking project took place in the Ibiraquera Lagoon. This project, which consisted of releasing post-larval shrimp in the Upper Lagoon, was developed by the Federal University of Santa Catarina (UFSC) and a State research agency (EPAGRI[5]) with the support of the Colônia (Andreatta et al. 1993,

[3] Superintendência para o Desenvolvimento da Pesca
[4] The new regulation (N-027/81) came into force under the Decreto (Decree) 73.632 of 1974, empowering SUDEPE to manage Brazil's fisheries.
[5] Empresa de Pesquisa e Difusão Tecnológica do Estado de Santa Catarina.

1996). Facing a higher abundance of shrimp in the Lagoon, and the fact that small shrimp were being caught with cast-net of 2.5 cm-mesh, the project coordinators in agreement with the Colônia, showed the local fishers that an increase of the cast-net mesh size from 2.5 cm to 3.0 cm would actually improve fishers' yields and profits, since larger and higher-valued shrimp would be caught. Furthermore, such a measure would help to exclude most outside fishers since they usually owned only 2.5 cm mesh shrimp cast-nets. Accordingly, in 1993 another regulation (N-115/93) establishing a minimum 3.0 cm mesh for shrimp cast-nets was approved by the Brazilian Agency for the Environment (IBAMA)[6].

From 1981 to 1994, all of these new regulations proved to work well and the new management system seemed to be sustainable, as long as there was strong rule enforcement. Since then, however, the fishery system is facing another crisis due to very weak rule enforcement. In addition, during the 1980s and 1990s, the main economic activities of most communities surrounding the Lagoon changed from small-scale fishery and agriculture activities to tourism-related activities. As of 2000, the Lagoon system is being pressured both by unregulated fisheries activities and tourism-generated problems.

A more detail description of the history of fishery management in the Ibiraquera Lagoon is presented in Chapter III.

[6] The Federal Fishery Agency (SUDEPE) was extinguished in 1989 and replaced by the Brazilian Agency for the Environment (Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renovaveis – IBAMA) in the same year.

2.2.4 Fisher knowledge and traditional fishery management

The Ibiraquera Lagoon fishers population can be grouped into different user-groups according to the following categories: (a) dependence on fishing: full-time fishers and part-time fishers; (b) legal status: professional fishers (those who hold a fishery license and can commercialize their catches), amateur or sport fishers (those who hold a fishery license but can not sell their catches), and irregular fishers (those without a fishery license); (c) origin: local fishers (*pescadores nativos*) or outside fishers (*pescadores de fora*); and (d) gear type used: cast-netters (*tarrafeiros*) and gill-netters (*redeiros*). These categories can overlap. For example, one person can be at once a local, full-time, professional cast-netter. Fisher knowledge on resource and ecosystem dynamics as well as on management practices is likely to vary among these categories. The interviews concerning these issues, however, focused mainly on elder fishers, who were locally known as the most knowledgeable ones, and who are, or who used to be, both cast-netters and gill-netters. Hence, whenever I mention fisher knowledge I am most likely talking about elders' knowledge. An exception is the section on fisher view of government management, which deals with changes in fishery regulation. Here I interviewed young, adult and old fishers, including locals and outsiders, full-timers and part-timers, professionals and amateurs.

2.2.4.1 Fishers understanding of the Lagoon ecosystem dynamics

Some of the fishers I interviewed had a comprehensive understanding of the Lagoon ecosystem dynamics. According to them, when a channel bursts through the sandbar it usually takes four to five days for the Lagoon to drain and for the water level to reach that

of the ocean. During these few days, most of the fishing resources tend to leave the Lagoon. On the other hand, if there are mullet schools swimming along the beach shore, they tend to enter the lagoon swimming against the water flow. Most fish resources in the Lagoon come from the ocean when the channel is open, but some fish species also spawn inside the Lagoon. Most fish enter the Lagoon in their juvenile stages by actively swimming through the channel. By contrast, shrimp are carried in by the tides in their larval stage (locally called *ovinhos* – little eggs) and post-larval stages (locally called *larva* - larvae). Thus, according to fishers, the Lagoon fish stock (amount and diversity) is determined mainly by: the seasons in which the channel is open in relation to the fish and shrimp stocks moving through the ocean in front of the channel, and the length of time that the channel stays open. Fish and shrimp grow in the Lagoon habitat, returning to the ocean as adults in the next channel opening cycle. Hence, the Lagoon fish and shrimp biomass increases during the months following channel closure. Fishers understand that the fish stock is heavily dependent on channel openings, and they acknowledge that an unregulated fishery can easily deplete the fish stock months before the next season opening. In fact, they have already experienced this situation a couple of times during the end of the 1960s and again, late in the 1970s.

2.2.4.2 Ethnobiology and Ethnoecology

Some local fishers have a detailed knowledge on fish folk taxonomy and species composition in the Lagoon (Table 2.2). According to them, there are three shrimp ethno-species that naturally occur in the Lagoon and another one that was introduced during the shrimp-stocking project. There are at least three ethno-species of salt-water blue crab and

one ethno-species of land crab. At least 24 marine fish species occur in this Lagoon; the most abundant ones located in the fishery landings are mullets and mojarras. It is worth noting that among the fish folk names, I could identify some synonyms, and it is likely that some folk names represent two or more biological species[7]. Freshwater fish are also present in some Lagoon areas, particularly close to freshwater streams. There are at least two freshwater ethno-species naturally occurring in the Lagoon and more recently two other ethno-species (*carpa* – probably *Cyprinus carpio* – and *tilapia* – probably *Tilapia rendalli*) have been caught. These last two ethno-species entered the Lagoon system after fish farming tanks overflowed close to the streams that flow into the Lagoon. Fishers also recognize at least two ethno-species of mollusca. In the following paragraphs fisher knowledge of the main fishery species is addressed: shrimp, mullet and crab.

Shrimp ethno-species are locally differentiated by their morphological and color characteristics, as well as by their behavior. Traditionally, most local fishers used the term *camarão-pata-azul* (literally "blue-feet shrimp") to name both *Farfantepenaeus paulensis* and *Farfantepenaeus brasiliensis*. The UFSC/EPAGRI researchers verified that about 90% of all naturally occurring shrimp in the Ibiraquera Lagoon is *Farfantepenaeus paulensis,* which they call *camarão-rosa* (literally "pink-shrimp") (Andreatta et al. 1993). They also verified that *Farfantepenaeus brasiliensis* occurs in a proportion of less than 10%. In the process of implementing this shrimp-stocking project, many workshops were held in Ibiraquera communities where researchers explained the pink-shrimp (*camarão-rosa*) life cycle to fishers and their children. As a result, many fishers started to call *camarão-rosa* what used to be called *camarão-pata-azul*, probably because it was more 'scientifically' correct. Lately, *camarão-pata-azul* and *camarão-rosa* are used

[7] Biological species is here defined according to western science taxonomy.

interchangeably and correspond to both biological species: *F. paulensis* and *F. brasiliensis*. In the literature, both species are referred as pink-shrimp (Branco and Verani 1998a,b) and have very similar life cycles (Tremel and Souza 1999). Although these two species are very difficult to distinguish from one another (Tremel, Branco, pers.comm.), some fishers argue that these two ethno-species are different. For example, one fisher explained that *camarão-pata-azul* (identified as *F. paulensis*) is bigger than *camarão-rosa* (identified as *F. brasiliensis*) and has blue-feet, while *camarão-rosa* has many body spots. The larger size of *F. paulensis* in relation to *F. brasiliensis* has also been reported by Tremel and Souza (1999) for the pink-shrimp population in the Conceição Lagoon, also located in Santa Catarina coast. Since most fishers do not distinguish between the two ethno-species when describing shrimp movements and life cycles, the term pink-shrimp will be used for both *F. paulensis* and *F. brasiliensis* to avoid misunderstanding in this chapter.

According to the fishers, pink-shrimp larvae and post-larvae are usually carried into the Lagoon by the tides; large shrimp, however, never enter this system. During the day pink-shrimp bury themselves in the Lagoon's deepest location along the mud or sand bottom. At night, the small pink-shrimp feed along the Lagoon shore and then return to the Lagoon bottom. The really small shrimp, however, usually remain and feed in the deepest locations. The large (pre-adult) pink-shrimp, after feeding along the Lagoon shore, begin a movement circulating through the Lagoon's channels in search of the exit channel to the ocean. It is during this night movement of the pink-shrimp groups (*mantas*) that fishing takes place. The color of pink-shrimp varies according to the type of food and bottom where they feed.

Fishers are very knowledgeable of the factors that affect pink-shrimp movements inside the Lagoon. These include: moon phase, wind direction, air and water temperature, rainfall, tides, season, and the presence of luminescent algae (*clarão*). The influence of some of these factors was also verified in a study on the migration of pink-shrimp to the ocean in a nearby lagoon (Tremel and Souza 1999). Accordingly, a fisher's decision on where and when to fish is based on these factors. Moreover, not only can weather and other factors be used to predict shrimp movements, but shrimp movements can also predict weather changes. As an old fisher explained, when pink-shrimp start to move after several rainy days of inactivity, it indicates that blue sky will occur the next day.

According to fishers, pink-shrimp grow faster during the hot months (October to March) and slower during the cold months (May to August). Throughout the summer it takes about 2 to 3 months to grow from post-larvae to young shrimp, while it takes about 4 months during the wintertime. Branco and Verani (1998b) suggest that the abundance of *F. paulensis* in the Conceição Lagoon is mainly regulated by water temperature. Some fishers can differentiate male and female pink-shrimps by their external morphological characteristics, and acknowledge that they molt when growing. When pink-shrimp start to develop their gonads ("to produce eggs" in fishers' language), they migrate to the ocean for spawning. Pink-shrimp spawn in the ocean throughout the entire year, but there are two spawning and recruitment peaks. The major peak occurs during the spring months and another one occurs during the fall when, for about two weeks, the ocean water suddenly increases in temperature (*verãozinho de maio*). According to Mello (1973), *F. brasiliensis* probably spawn during September and October. Branco and Verani (1998b) report that the major recruitment period of *F. paulensis* in Conceição

Lagoon occurs in late spring and early summer with shrimp measuring between 1.0 and 3.0 cm and approximately 2 months old. Tremel and Souza (1999) also report that spawning peaks of pink-shrimp are related to water warm up.

Although the literature mentions that pink-shrimp only spawn in deep waters (Andreatta et al. 1993, Branco and Verani 1998a, b, Tremel and Souza 1999), some fishers say that only a small proportion of pink-shrimp are able to, and do, spawn in the deepest parts of the Lagoon (about 4-5 m deep). Based on their experiences, if shrimp are ready to release their eggs when the channel to the ocean is closed, they will spawn inside the Lagoon; however, only few eggs will reach the larvae and post-larvae stages. One fisher reported that once, after more than eight months without any connection to the ocean, they fished small shrimps in the Lagoon. Contrary to this acknowledgement, other fishers argue that pink shrimp will not spawn inside the Ibiraquera Lagoon because it is not deep enough. It is hard to distinguish in this last sentence if this is knowledge acquired from fishing experience or acquired from researchers lecturing during the workshops. Despite this controversy, most of the Ibiraquera fisher knowledge of the pink-shrimp life cycle is in accordance with the literature.

There is another shrimp ethno-species (*camarão-ferrinho*) that is recognized by some fishers. A reference of its occurrence, however, was not reported by Andreatta et al. (1993). *Camarão-ferrinho* (probably *Pleoticus muller*) is reddish and smaller than the other two ethno-species, and has hard carapace. This shrimp enters the Lagoon around February and is usually caught during the winter; it does not have a commercial value.

The shrimp species (*Penaeus schmitti*) introduced during the shrimp-stocking project is locally called *camarão-branco* (literally 'white-shrimp') or *camarão-legítimo*

(literally 'true shrimp'). *Camarão-branco* is also the name accepted by UFSC/EPAGRI researchers. Although white-shrimp do not naturally occur in the Ibiraquera Lagoon, they are common along the Santa Catarina coast. According to fishers, white-shrimp travel in groups (*mantas*) during the day inside the Lagoon. It is also more difficult to catch white-shrimp with cast-nets than pink-shrimp, because white-shrimp are more aggressive. The white-shrimp diurnal behavior is also described by Andreatta et al. (1993).

At Ibiraquera, fishers distinguish between two major types of mullets: *taínha* (*Mugil platanus*) and *parati* (*Mugil curema, Mugil sp.*). When talking about their catches, however, they usually group them together, calling them "*tainhoto*, *tainhota*, or *tainhotão*". An old fisher estimated that in an overall catch, approximately 40% would be *parati* with 60% of *taínha*. Fishers acknowledge that *parati* and *taínha* are from the same family, but that *parati* are smaller than *taínha*. Indeed, according to Menezes and Figueiredo (1985), *M. curema* and *M. gaimardianus* (also known as *parati*) usually measure 30 cm in length, with a maximum of 45 cm, while *M. platanus* can reach 100 cm. Fishers also indicate that there is one particular type of mullet, *parati-da-quaresma* (literally "Lent-mullet") or *parati-de-abril* (literally "April-mullet"), where juveniles swim in large schools along the ocean shoreline from February to April. Vieira (1991) reported that in Patos Lagoon (the largest and more important estuarine nursery ground in South Brazil and located south of Ibiraquera Lagoon), *M. curema* and *M. gaimardianus* juveniles, which grow during the warm season, disappear during winter. It is predicted that they swim northward in search of warmer water temperatures. Menezes and Figueiredo (1985) also reported that *M. curema* are more abundant during March along the south coast of São Paulo State (north of Ibiraquera Lagoon).

Fishers say that another type of mullet, *tainha-do-corso* ("adult mullet school in spawning migration"), appear along the ocean shore in the winter, from May to August. In fact, the reproductive migration of maturing adults of *M. platanus* from Patos Lagoon estuary northward occurs during April and May (Vieira 1991). Fishers also state that young mullet (known as *tainhotão* or *virote*) appear along the ocean shore during the summer. In his study on Patos Lagoon, Vieira (1991) also verified that juveniles of *M. platanus* were present all year-round, with a peak occurring during winter and early spring. If recruitment occurs all-year round, one might expect to find young mullet during different months of the year.

Fishers differentiate adult *taínha* according to the color of their gonads (*ova*): those with yellowish or reddish gonads are female mullets and those with white gonads are male mullets. Fishers believe that *taínha* can spawn inside the Ibiraquera Lagoon if the channel connecting the Lagoon to the ocean is closed. The spawning period may vary from June to October. This period seems to be in accordance to Vieira's (1991) findings: the peak of recruitment for *M. platanus* occurred during mid-winter and early spring in Patos Lagoon. The chance of *M. curema* spawning in the Lagoon is not null. Albaret and Legendre (1985) reported that *M. curema* achieve gonad maturation in water salinity over 12 parts permill in Ebrie Lagoon (Ivory Coast). There is also evidence that *M. curema* spawn inside Lake Maracaibo (Venezuela), where salinity ranged from 10 to 28 parts permill near the sampling stations (Montano 1994).

According to fishers, when the channel is open, mullet tend to enter the Lagoon swimming against the water flow. One fisher also stated that when juvenile mullet from the Lagoon are carried away by water drainage into the ocean soon after the channel is

open, these juveniles swim back into the Lagoon a short time after they reach the cold ocean water. In fact, Vieira (1991) found warm water temperatures (above 20°C) and salinity to be key factors in the recruitment of juveniles of *M. curema* and *M. gaimardianus*. Juvenile *M. platanus*, however, seem to be more resistant to a wider range of water temperatures and salinity.

Inside the Lagoon, mullet move more on the water surface than in deep water, although they feed on small worms and mud (*lodo*) at the Lagoon bottom. The detritivorous diet of mullet is well known in the literature (e.g., Albaret and Legendre 1985; Blay 1995). In addition to detritus, Vieira (1991) also found parts of crustaceans in the diet of juvenile mullet; that is, they may also feed on some invertebrates. Mullet move during both the day and night; hence it is fished in both periods. Fishers say that adult mullet schools in spawning migration (*tainha-do-corso*) move very fast. If they enter the Lagoon's Lower basin in the morning, by the afternoon they are already at the Upper basin; if not enclosed there, they soon return to the ocean. Fishers also have particular knowledge of environmental factors affecting mullet movement inside the lagoon, and accordingly, they plan their fishing strategies.

Eleven blue crab folk names (*siri;* Portunidae) were cited by fishers who acknowledged the occurrence of sexual dimorphism, and gave different names for males and females. They admitted the existence of several synonyms. Accordingly, there are at least three blue crab species in Ibiraquera. Reports on the occurrence of several blue crab species within the same estuary or lagoon are very common in the literature (e.g., Moreira et al. 1988; Buchanan and Stoner 1988; Pinheiro and Fransozo 1997; Teixeira and Sá 1998). Fishers acknowledge that blue crabs including *Callinectes sapidus* and *C.*

danae spawn inside the Lagoon. This fact is also documented by Branco and Masuari (2000) for *C. danae* in the Conceição Lagoon. These authors reported that although growth, reproduction and spawning occur inside the lagoon, egg eclosion occurs in the open sea after ovigerous female migration. Nonetheless, one knowledgeable fisher reported that egg eclosion may also occur inside the Ibiraquera Lagoon. Fishers mentioned that male blue crabs do not migrate to the ocean. This fact is also documented by Branco and Masunari (2000) for *C. danae*. Fishers also acknowledge that blue crabs molt when they are growing and that they feed on shrimp, *berbigão* (mollusca), small fish, and "*minhoquinhas*" (probably polychaeta). Molting is well known in crabs. It is also known that crustacea, polichaeta, mollusca make up a large portion of *C. danae* diet (Branco and Verani 1997). According to fishers, blue crabs are present in the Ibiraquera Lagoon all year-round. *Siri-nataleira* (*C. sapidus*; literally "Christmas crab") is big, fat and has developed gonads mainly from November to January.

Ibiraquera fishers are also knowledgeable of the food web of some of their fishing resources. There are several fish ethno-species that feed on shrimp, including bluefish (*enchova*, *Pomatomus saltatrix*) and mojarras (*carapicu*; Gerridae). *Pomatomus saltatrix* and the Gerridae are known shrimp-eaters (Kerschner et al. 1985, Albaret and Desfossez 1998, Haimovich and Krug 1992, Lucena et al. 2000). Blue crab and some water birds (*biguá* and *garça*) also feed on shrimp. Water birds (*garça* and *gaivota*) feed on both blue crab and fish. Other fish such as mullet (*taínha* or *parati*; *Mugil* sp.) feed along the Lagoon bottom and do not feed on shrimp, crab or other fish species.

Some fishers are aware of the natural history of several fish ethno-species including elements of the type of habitat, spawning place and time, aggregation behavior,

growth, feeding behavior and diet, movement inside the Lagoon and swimming layer behavior, the season when a species moves along the ocean shoreline, morphological characteristics, and the sound and smell produced by fish. Fishers also recognize several fish ethno-species that spawn inside the Lagoon. Fisher knowledge also includes the gear type and bait that can be used to catch each fish species. As well, their knowledge encompasses the more appropriate (and usually more productive) fishing spots for each gear type and target species (shrimp or fish) according to different environmental conditions (i.e., influences from wind, air and water temperature, rain, moon phase, luminescent algae and tide). During fieldwork, some elder fishers helped me map the fishing spots for each fishing activity according to their traditions.

It is locally acknowledged that shrimp and fish grow faster in the Upper basin because this basin has more food and warmer water than the others. The Upper Lagoon water warms up faster because it is the shallowest basin. Fishers say that there is more food in the Upper Lagoon because there are more *limo* (detritus rich in organic matter) and emergent aquatic vegetation (similar to cattails) there than in the other basins. They associated aquatic vegetation with a lower salinity level in the Upper basin as it receives freshwater inputs from almost 50% of the small streams draining into the Ibiraquera Lagoon. In addition, since the Upper basin is the farthest basin from the Lagoon mouth, it experiences less saltwater renewal than the other basins. It is interesting to note that in justifying why fish and shrimp grow faster in the Upper basin (a fact that most fishers know by their experiences), one fisher said that the UFSC/EPAGRI researchers told them that this basin is the one with more food for fish and shrimp. That is, it is difficult to separate knowledge gained through experience and information achieved from outsiders.

2.2.4.3 Traditional management practices

Based on their knowledge of the Lagoon's ecosystem dynamics as well as the natural history of the main fishing resources, fishers in the past developed a complex fishery management system in the Ibiraquera Lagoon (Table 2.3). Fishers understand that the renewal of the Lagoon fishery stock depends on the season when the channel is open. That is, it depends on the availability of fish and shrimp post-larval stocks moving through the ocean in front of the channel. If nature is left to take its course, the channel will naturally open by the Lagoon when water bursts through the sandbar – but the timing of the opening is highly uncertain. For this reason, local fishers at Ibiraquera traditionally managed the channel opening to coincide with the fish and shrimp seasons. When the Lagoon water level was high, the fishers dug only a small (about 2 m wide, 0.5 m deep) channel across the sandbar (about 30-60 m across). The pressure of the water quickly widened it into a natural channel, about 1.5 to 2.0 m deep and 60 to 100 m wide. The appropriate time to open the channel is during low tides and when the ocean is calm. During a year of normal precipitation, the Lagoon was traditionally opened by fishers at least twice and usually three times. Fishers opened the channel in the spring (sometime around September and October) which is the season of the post-larvae pink-shrimp in the nearby ocean; in summer (sometime between December and February) which is the season of small mullet (*tainhotão* and *parati-da-quaresma*); and in the late fall (sometime between May and June) which is the season of large adult mullet (*taínha-do-corso*) and pink-shrimp post-larvae (from *verãozinho de maio*). When the channel is opened, several other fish species also enter the Lagoon.

Traditionally, fishing activities took place year round in the Ibiraquera Lagoon. Various fishing methods and management practices were used depending on if the channel was open or closed. At the time of the mullet main fishing season (May to July), a bamboo fence (*tapume*) was sometimes built at the Lower basin, just after the mullet enter the Lagoon, in order to prevent fish from returning into the ocean. This was done in case the channel opening lasted for a long period. That is, fishers tried to ensure a food supply for themselves during the next few months.

Prior to any channel opening, a bamboo fence was also built in the Upper Lagoon close to the channel connecting the Upper and Middle Lagoons. During drainage, the fence helped to retain part of the fish stock in the Upper Lagoon, ensuring a food supply even in the case where the channel closes a few days after being opened. Since the Upper Lagoon is the shallowest and farthest one from the opening to the sea, it is the one which is most affected by drainage. If a fence is not present, all shrimp and fish stocks may escape from the Upper Lagoon during drainage. When fish schools initially entered the Ibiraquera Lagoon, part of the fence (a gate) was taken out to allow the fish to come into the Upper basin. The gate was closed soon after the schools came in, so that fish (especially adult mullet schools in spawning migration) would not swim back into the other basins and eventually into the ocean; this was in the event that the channel opening lasted for a longer period. The same procedure of building bamboo fences just before channel openings was sometimes used at the Saco Lagoon. Specialized fishers (*vigias*) monitored mullet movements into the Lagoon, signaling when to build the bamboo fence (or close it in the case of Upper Lagoon), so that the mullet would not swim back out.

Whenever the channel was open, gillnets (fixed nets, about 150 m each), surrounding nets (a mobile gear made by tying together several gillnets), and seines (a surrounding net pulled along the bottom) could not be used in the Lagoon. This was because these methods relied on slapping the water with poles and hitting the sides of the canoe to drive fish into the nets, thus producing a significant amount of noise in the water. Such disturbance repelled fish back to the ocean. Gillnets, surrounding nets and seine nets could be used only when the channel was closed. Cast-nets for both fish and shrimp were used when the channel was either open or closed. Exception was the first two or three days after the channel opened during mullet season when no fishing activity took place in the Lagoon to avoid fish turn back to the ocean. In addition, fish cast-nets were not allowed in the channel and on the nearby beach (100 m from each side of the mouth of the channel) when the channel was open. This was to permit fish to enter the Lagoon undisturbed.

The shrimp cast-net fishery was performed only by fishers standing in certain fishing spots close to the channels used by adult shrimp to move inside the Lagoon. That is, there was not a shrimp fishery along the Lagoon shore where young shrimp come to feed, or from canoes in the middle of the lagoon area, which is the habitat of very small shrimp. There was respect for shrimp fishing locations of the established fishers and first-comer's rights in other areas. As well, in the fish cast-net fishery, there were certain spots where fishers were allowed to stand and fish and others, where they were not. Although fishers could see fish in those latter spots, they were advised by old fishers that if they tried to fish there, instead of getting a good catch they would disturb and spread out a fish

school, which would be easily caught in another location. Fish cast-netting from canoes in the middle of the Lagoon area was a common practice.

Setting gillnets was not allowed in any channel mouth. An exception was the use of small-mesh nets used in a group fishery (*pesca de tapagem*). In this fishery, a specialized fisher (*vigia*) monitored fish movements in one of the deeper channels running through the Lagoon basins. He (usually an elder fisher) stood watch to assess the amount of fish entering the channel. When he decided that enough fish had come through, he gave a sign to close the deep channel using net barriers, allowing a group of fishers to start cast-net fishing. This fishery practice was only used in certain areas of the Lagoon.

After the channel to the ocean opened, a few fishers used shrimp cast-nets as shrimp trap-nets inside the channel. This was done to catch some of the shrimp that were leaving the Lagoon to reproduce in the ocean. They argued that although they knew it was important to allow shrimp to reproduce in the ocean, this fishery did not really affect shrimp populations because very few fishers were involved and cast-nets were very small compared to the shrimp-trap nets in 2000. Another fishing practice, that in the eyes of many government fishery managers is very destructive, was the capture of big, fat, ovigerous blue crabs and crabs with a soft carapace (just after molting). Crab gonads are a local delicacy. *Siri-nataleira* ("Christmas crab") fishing occurs mainly from November to January, which is the time just before egg eclosion. It is worth noting that the local human population density was quite low until the late 1960s, as compared with the year 2000.

The fishing season remained open within the Lagoon all year round. The only two days of the year that fishing activity did not occur was on Good Friday and the Thursday before it, due to religious reasons (most of the population was Catholic).

2.2.5 Fisher view of government management

2.2.5.1 Fisher view of environmental modifications

The 'Canal do Resgate' causeway

Until the early 1950s there were two channels interconnecting the Upper and Middle basins of Ibiraquera Lagoon summing approximately 160 m in width. One of these channels (*Canal do Resgate*) was filled with land in the late 1950s and the other was narrowed for bridge construction in the early 1980s. These events reduced the water flow between the two basins to only one channel of 30 m in width. According to fishers, these events have severely impacted the Upper basin fishery. Firstly, because they reduced fish passage from the Middle basin; secondly, because part of the land used to fill these channels has been spread out due to water movements during drainage and tides, filling other channels, which are used for fish and shrimp migration. The construction of a bridge linking two of the communities in the area was demanded by the local people (including fishers). The manner in which the bridge was built by the municipal government, however, has affected the fisheries. For that reason, fishers started to demand in 1984 the re-opening of the *Canal do Resgate*. Notwithstanding, an effective action has not yet been taken by the municipal government.

The Lagoon dredging project

According to the fishers organization's (Colônia) president, the construction of tourism resorts along part of the sandbar during the last two decades has wiped out sand dunes. These dunes prevented the channel from closing soon after being opened due to sand deposition from the ocean tides. As a result, a large portion of the main channel was silted in addition to other smaller channels inside the Lagoon. This situation made it difficult for fish to migrate into the lagoon. Moreover, the fact that the channel openings were not lasting long enough has affected the Lagoon salt-water renewal and both the shrimp and fish stock renewal. To cope with these problems, the Colônia in cooperation with the State and Municipal governments began a dredging project in Ibiraquera Lagoon during 1999. The first dredging plan designed by government technicians proposed the enlargement of the main channel and of the small channels inside the Lower and Middle basins. In the Upper Lagoon, they proposed to cut a long channel (800 m long) across a sandbank. Some elder fishers, however, began to complain that this was not the most appropriate trace. The plan was hence re-designed to incorporate some of fisher knowledge about the Lagoon water flows and fish migrations. The dredging project took place throughout most of 1999. It was interrupted, however, due to political matters at the State level in December of 1999, just after work started in the Upper basin (the last one to be dredged). The State promised that the dredging would continue; by May 2000, however, dredging had not resumed.

The results of this dredging project are not totally clear. According to some fishers part of the area dredged in the main channel was again silted because of several surfs that happened in 1999. Despite this fact, the dredging has indeed prolonged the

period that the channel remains open, increasing salt water, and fish and shrimp stock renewal. Some fishers even affirmed that the fish and shrimp stocks have increased. Other fishers, however, are still skeptical in relation to the negative effects this dredging may cause in the Upper basin, which is considered the most productive one. Their concerns have increased particularly after the project was interrupted. Some people are also concerned with the side effects that land deposition from dredging may cause on terrain close to the Lagoon.

2.2.5.2 Fisher view of shrimp stocking

The idea of a shrimp-stocking project came from the Colônia's president, a literate and knowledgeable fisher, who believed that this project would minimize environmental uncertainties (concerning channel openings and stock renewals) and provide more shrimp to an increasing fisher population. His idea was to build a laboratory close to the Ibiraquera Lagoon to produce shrimp post-larvae and transform the Lagoon into an extractive reserve (i.e., restricting access only to local fishers). The Colônia's president talked to the UFSC/EPAGRI researchers. They preferred, instead, to take the pre-adult pink-shrimp from the Ibiraquera Lagoon to reproduce in the UFSC's laboratory. These shrimp post-larvae would then be released back into the Lagoon. During the project implementation several fishers were involved in workshops (mentioned above) and during the process of releasing post-larvae. Some fishers were also taken to the UFSC's laboratory to learn about how shrimp larvae were produced.

During the time that this project took place, from 1992 to 1998, it brought several economic benefits to fishers, their families and middlemen. Because it was a research

project, shrimp post-larvae were financed by research funds[8]. That is, fishers profited from an increase of the Lagoon's shrimp stock. Fishers said that they could get a lot of shrimp all year round, while before the project, shrimp catches during the winter were usually low. Perhaps because of that, fishers did not complain about this project. In fact, their complaints concerned the project ending due to a lack of funds. The real test to investigate fisher concerns about the impacts of shrimp stocking would happen if an extractive reserve was implemented and fishers had to pay for shrimp post-larvae.

Fishers mentioned that the white-shrimp (*P. schimitti*) introduced produced well in the Lagoon. Local fishers quickly developed some knowledge about white-shrimp (e.g., diurnal and more aggressive) as well as about their fishing. Some fishers also argued that they could distinguish between the pink-shrimp released and those naturally occurring in the Lagoon. The project was implemented only in the Upper basin because it was easier to fence the only channel connecting it to the other basins, which prevented shrimp escapement during the Lagoon channel openings. Fishers did not mention any change in the Lagoon's fish diversity as a result of this project.

2.2.5.3 Fisher view of changes in fishery regulations

The idea of prohibiting any net type, with the exception of cast-nets, in the Ibiraquera Lagoon, came from most local fishers who had experienced the destructive effects on the ecosystem caused by an intensive use of many large nets. For the most part, these were hand-drawn beach seines and small-mesh size nets. In addition, banning put an end to the

[8] The shrimp stocking project was funded by three Federal Government Agencies: Fundação Banco do Brasil (1992-1993); Fundo Nacional do Meio Ambiente (1994-1996); Programa de Execução Descentralizada do Ministério do Meio Ambiente (1997-1998).

long-lasting conflict between gill-netters and cast-netters regarding their uneven resource access[9]. As of 2000, 94% of 31 fishers interviewed agree with the large net banning, including some former gill-netters. Most of them also acknowledged that they were catching more shrimp and fish after the large net banning than before it.

The idea of prohibiting the use of gas lamps also came from fishers who realized the threat to shrimp populations when they were used with hand-held shrimp tongs, which caught small shrimp on their feeding areas along the Lagoon margins. The bright light of gas lamps also interfered with other fishing activities at night. Moreover, because the gas lamps attracted much more shrimp than the kerosene lamps and since not all fishers could afford to buy a gas lamp, its use was creating equity problems among the fishers. My survey shows that 97% of the interviewees agreed with the use of gas lamp prohibition, including those individuals who previously fished with gas lamps. Many fishers also stated they caught more shrimp after this banning.

It is interesting to note, however, that fewer fishers (66%) agree with the implementation of the shrimp cast-net minimum mesh size of 3.0 cm. Moreover, some of those who claimed to agree with the regulation were using 2.5 cm mesh cast-nets at the time of the interview. Of those fishers who disagreed with this regulation, 90% suggested the return to a 2.5 cm minimum mesh-size for shrimp cast-nets, especially when the channel to the ocean was open. They reason that when the channels burst through the sandbar, all young shrimp leave to the ocean, as they are not caught by 3.0 cm mesh cast-nets. Some fishers also argue that the 3.0 cm mesh cast-net was useful only while the

[9] The amount of effort to fish with cast-nets is larger than to fish with gillnets. A person has to throw a cast-net many times to make a living. By contrast, a gillnet set in a fishing spot "fishes by itself" for many hours. The only effort required is to set the net and to take it out. When several gillnets attached together

shrimp-stocking project took place (until 1998), and particularly for those fishers fishing at the Upper basin. This was where shrimp larvae were released and a net fence (1.0 cm) prevented shrimp escapement into the other basins and to the ocean. Although the rule of 3.0 cm mesh cast-net was approved by the majority of fishers, the idea of a larger mesh size came from the UFSC/EPAGRI researchers who were looking to improve the results of the shrimp-stocking project, and not from local fisher concerns.

The history of Ibiraquera Lagoon fishery management indicates that when fisher knowledge and concerns are incorporated into official regulations, they are more likely to succeed, than otherwise. For example, when I look at the 1981 regulation issued for the Ibiraquera Lagoon, I see that it was in part based on the former arrangement made by local fishers in 1971, which in turn, was partially based on their traditional management system. On the other hand, the cast-net minimum limitation seemed not to be meeting the needs of many fishers in 2000.

One other regulation that is important to investigate is the prohibition by SUDEPE/IBAMA of *tapume* (net fence) in rivers and lagoons. Regulation N 466/72 prohibits setting gillnets longer than 1/3 of the length of any aquatic environment. *Tapume*, which used to be made of bamboo, is now made by setting a thick nylon net. Local fishers argue that *tapume* should not be considered as gillnet (which is in fact prohibited at Ibiraquera) because its thick monofilament nylon prevents fish netting. According to them, fish are caught only by thin nylon nets. Although this traditional management technique has been informally accepted by the past fishery inspectors in Ibiraquera Lagoon, *tapume* is still an illegal practice. It is worth noting, however, that

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were used to encircle a fish school, a few gill-netter could catch more fish in one short trip than several fishers using cast-nets in an entire day of work.

tapume seems to play an important role in the Lagoon ecosystem management (Chapter III).

2.2.5.4 Fisher view of problems in the Lagoon

Until 1994 there were two fishery inspectors working full-time in Imbituba and in a neighbor municipality (Garopaba). Due to changes in State politics, fishery regulation enforcement was transferred to the State Environment Police and IBAMA, both of which seldom (less than once a month) appear in Ibiraquera. As a result of this lack of enforcement, several irregular fishing techniques have been practiced in the Lagoon. These include the use of setting gillnets, small shrimp trawlers, gas lamps and hand-held shrimp tongs, shrimp pull-nets, shrimp trap-nets set during the channel openings, fish cast-nets used in the open channel, and shrimp and fish cast-nets under minimum allowed mesh-size. In addition, most fishers do not respect the traditional fishing location for shrimp or fish cast-net fishing anymore; they are fishing all over the Lagoon area, including along the Lagoon shore where small shrimp feed.

According to several fishers, these irregular fishing techniques are impacting the Lagoon production of shrimp, fish and crab. For example, one middleman said: "adult mullet are not caught anymore because fishers do not let them grow; only the young ones are caught." Other fishers complained that the intense use of fish cast-nets in the open channel is preventing mullet and other fish to enter the Lagoon. One fisher said that more shrimp larvae used to enter into the Lagoon before some people started to set shrimp trap-nets in the channel during the Lagoon water drainage. He explained later: "shrimp have to leave the Lagoon to procreate in the sea, to then return [as post-larvae] to grow inside

the Lagoon." Two fishers also mentioned that there has been a change in fish species composition in the Lagoon. There are less juvenile and young mullet and more morjarra (*Carapicu*, Gerridae), menhaden (*savelha*, Clupeidae), and sardine (*sardinhas*, Clupeidae). One of the fishers believed that the decrease of juvenile mullet was a result of the intensification of the use of shrimp trap-nets set in the water current during the Lagoon drainage into the ocean. He recently observed that for each 1 kg of shrimp, these trap-nets were also catching 5 to 6 kg of juvenile fish (mullet, mojarra, etc). He believed that these juvenile mullets would have swum back into the Lagoon soon after reaching the ocean cold water.

There are both local and outside fishers using irregular gears or fishing in prohibited areas; this has generated conflict among those who respect the regulations and those who do not. In response to such a crisis, some local fishers organized themselves in 1998 to patrol the Lagoon fishery. Their effort did not last long, however, as they did not get the legal support to do so. In April 2000, a meeting was held between the Environmental Police and local fishers to discuss the fishery regulation and its enforcement. Based on their ecological knowledge of the Lagoon fishery system, fishers made some suggestion to improve the management situation. For instance, to prevent cast-net fishing in fish migration channels, one fisher suggested that the Environmental Police monitor the channel to the ocean, and two other channels interconnecting the Lower and Middle basins, and Middle and Upper basins, during five or six days after the Lagoon opening (i.e., during the water drainage into the ocean which is the time when fish, particularly mullet, enter the Lagoon). Several fishers asked the Police to allow shrimp fishing with 2.5 mesh cast-nets as they are more appropriate for the fishery

situation in the year 2000 (see above). Some fishers volunteered themselves to indicate to the Police where and when irregular fishing was taking place. For example, one fisher told me that gill-netters prefer to set nets on full moon nights because, on darker nights, it is more difficult to catch fish as any movement in the Lagoon water provokes luminescence that repels fish.

In addition to the use of illegal gears and fishing methods, the Ibiraquera Lagoon management system is facing other problems resulting from a lack of regulation enforcement as well as from unplanned growth of tourism activities and construction. Fishers listed some of these problems including: (a) local population growth; (b) increasing number of outside fishers; (c) the closure by tourist landowners of several fisher trails through the hills leading to the Lagoon margins; (d) the use of motor vessels (prohibited by a by-law) and windsurf boards interfering with fisheries; (e) lagoon pollution due to the increase of tourists; (f) the increase of tourists' houses draining sewage into the lagoon from poorly constructed septic tanks; (g) irregular walls or fences built by private landowners in important fishing spots inside the lagoon; and (h) channel openings during wrong periods.

This last item deserves a close investigation. In the last few years, instead of waiting for the Colônia decision to open the channel (the institution responsible for it), some fishers and even non-fishers are opening the channel whenever they think it is appropriate. People living in the community closest to the channel prefer the channel to be opened in December and January – the high season for tourism – so that the lagoon water is flushed constantly to minimize odors caused by sewage. But for other fishers, the issue is that channel openings at the wrong time have been affecting the Lagoon fish and

shrimp stocks. That is, as more local families became dependent on tourism-related activities, the needs of local communities may be changing from a Lagoon managed for fishery purposes to the one managed for tourism purposes.

2.2.6 Changing values and loss of knowledge

When analyzing fisher discourses I verified that their knowledge is a mixture of what they learned from experience ('learning-by-doing'), from elder fishers, from fishers from other regions, and from their contact with researchers and technical personnel from government agencies since the early 1970s. In this context, it is hard to say when an elder invokes scientific knowledge to explain one phenomenon whether he is putting more trust in this scientific knowledge than on his previous knowledge or if he is using the scientific knowledge to validate his own knowledge. What is clear is that fisher knowledge of the Ibiraquera Lagoon is adapting in a similar way as the cray-fisher knowledge in Lake Racken in Sweden (Olsson and Folke 2001). That is, knowledge is being reshaped by a fisher's own experiences and by scientific information and practices brought to them by government agents, researchers, or even local individuals who are more interested in scientific information. In Ibiraquera, the Colônia's president and a government field-extensionist (from EPAGRI) seem to play this latter role.

Concerning fishers knowledge transmission to young generations, the picture of Ibiraquera Lagoon demonstrates that fewer and fewer fishers' children want to become fishers themselves as the tourism-created jobs to which they have access seems to be more profitable and less stressful than fishing. During almost one year in the field, I saw no more than 20 young fishers (under 20 years of age) in the shrimp or fish fishery. Many

older fishers said that they learned to throw cast-nets with their parents or other adult fishers when they were about 7 or 8 years of age. They also said that they respected the lessons from the elders on where and when to fish. During that time, fishing was part of their subsistence. As of year 2000, most of the fishers were part-time and many were only sport fishers. In addition, those practicing irregular fishing were usually young and middle-age adults (age ranging from 20 to 40 years old). That is, the social values (equity in resource access) and elders' ecological knowledge behind traditional management practices – which promoted resource conservation – are not being incorporated by the younger fishing generation which experienced a fish market boom in the 1970s and a tourism boom during the 1980s and 1990s.

2.3 Discussion

What can one learn from the Ibiraquera Lagoon case study, concerning the incorporation of local and fisher knowledge in management design and assessment? This study demonstrates that fisher knowledge can provide a valuable set of information about resources and ecosystem dynamics. As well, traditional management practices can provide valuable information for those designing government management plans. However, not all fishery practices promote resource conservation, especially in the eyes of many western-trained researchers. Therefore, a close investigation of the ecological and socio-economic benefits of each measure is needed. A close investigation of local social values and ethics is also necessary before proposing formal regulations in order to increase compliance. An important lesson from this case study is that, fisher knowledge and local management practices can and do usually adapt in response to crises or the

perception of crises. That is, fisher knowledge can play an important role in designing, implementing and assessing, adaptive management plans. I expand on these points.

When I look at the traditional management practices in Ibiraquera, I find that some of them did have conservation effects. These include the prohibition of shrimp cast-net fishery in locations other than the shrimp migration channels; the prohibition of fish cast-net fishery in certain locations (e.g., in the open channel); and the prohibition of setting gillnets at the mouth of small channels. It is not clear, however, if these practices were embedded in conservation ethics or if their purpose was only to improve fishers' catches. For example, fishers usually caught large (pre-adult) shrimp when fishing in migration channels since only shrimp at this stage within their life cycle migrate. At that time, however, shrimp were caught mostly for subsistence since strong market demand for shrimp did not exist. In these circumstances it is not feasible to confirm if conservation ethics existed behind these practices or not.

From the viewpoint of western science, some traditional management practices did not serve a conservation purpose at all. Examples are *tapume* – fencing shrimp/fish migration channel – the capture of ovigerous blue crab, and shrimp trapping with cast-nets during their migration to the ocean. On the other hand, when I look back to the low human population density in the 1950s and early 1960s, I also conclude that these could not be considered very destructive practices. Indeed, I suggest elsewhere that the *tapume* practice has an important function in promoting ecosystem renewal and building resilience (Chapter III). Moreover, *tapume* may ensure a food supply in case that not enough fishing resources enter the Lagoon. In designing resource management plans, it is

fundamentally important to balance biological considerations with local socio-economic concerns.

The history of Ibiraquera fisheries management shows that many practices, which seemed to be consistent with conservation, were abandoned as soon as the local social values started to change due to the introduction of a cash economy and rapid population growth during the 1960s and 1970s. As McGoodwin (1994, p.51) explains in the case of Mexico,

> Localized management institutions simply cannot persist when localized fisheries undergo a rapid transformation from a subsistence-and-regional-market orientation to a cash-and-export-market orientation. Nor can they persist in the face of rapid socioeconomic change that sees rural-traditional, residentially stable, highly integrated local societies undergo rapid population growth, economic structural change, and an invasion of new residents who bring with them new values and new aims.

It is interesting to note, however, that soon after Ibiraquera fishers faced a crisis in resource management (decrease in catches and increase of user-groups conflicts) many of the fishers advocated the incorporation of some of their traditional practices in the formal regulations. From this perspective, fisher demands indicate that fishers did believe that their traditional practices served conservation purposes. This suggests that there were conservation ethics behind traditional practices. Although older fishers may have conservation ethics, the situation as of 2000 shows that many young and adult fishers do not.

Palmer (1994, p.247) suggests that "to achieve maximum support from fishers for proposed formal regulations, an understanding of the conscious intent behind their folk management practices should be examined". When fishers proposed the banning of larger nets and gas lamps, their main concern in both cases was to conserve resources in order to maintain their livelihood, and to promote equity in terms of resource access. As these

measures met both their purposes, they are still supported by the large majority of Ibiraquera fishers. On the other hand, the regulation limiting cast-net mesh to a minimum of 3.0 cm has not received the support of many fishers recently because it does not seem to be meeting fisher needs. Although this regulation was approved by local fishers, it was not proposed based on fisher knowledge and concerns. As Palmer (1994, p.247) explains, "when folk management practices interfere with the conscious goals of individuals, opposition and conflict are likely outcomes."

It is clear throughout this chapter that Ibiraquera fisher knowledge has been adapting to face new management tasks. It is also clear that this is an important body of locally developed, and adapted ecological knowledge, which has proven to be a source of information both to manage the ecosystem as well as assess management plans. Notwithstanding, this valuable body of local ecological knowledge has been threatened by modernization since fewer fishers depend on their own knowledge about fishing for their survival. Additionally, they have been more and more influenced by outside "scientific" information – which sometimes challenges their own knowledge. To what extent local knowledge will adapt to face new needs of the local society without losing valuable information, I cannot tell. I argue, however, that if local fishers feel that their knowledge is valuable for others and even themselves, through its incorporation into formal management plans, they are more likely to make efforts to keep alive their knowledge, practices and values, than otherwise. For instance, fisher knowledge, and local ecological knowledge in general, may be used in designing and assessing a new management plan for the Lagoon, which incorporates recent needs and concerns, as well as old social values. As tourism-related activities become predominant in the area, the

goals of Lagoon management should perhaps change focus from a strictly fishery-oriented management to one that encompasses recreational needs as well as local fisher needs. In addition, local residents could participate in tourism planning (including eco-tourism) based on their knowledge about the local ecosystems, as another source of income.

Recognition of local knowledge and its incorporation into management plans is important. There is an urgent need to recognize, through formal protection, some traditional management measures that have proved to promote sustainable resource use over the years, as advocated by Cordell and McKean (1992) for the case of Bahia's inshore fisheries. Elsewhere in the world, government recognition of local and traditional management systems have often worked (Table 2.1). For example, recognition of traditional management arrangements has ensured the sustainable use of penaeid shrimp in the Negombo estuary, Sri Lanka (Amarasinghe et al. 1997). At Ibiraquera Lagoon, such traditional practices may include the use of *tapume*, the allowance of shrimp cast-net fishing only in the shrimp migration channels, and the prohibition of any fish fishery during the first five days of the drainage of the Lagoon.

The Ibiraquera Lagoon case study shows that there is a diversity of management practices based on fishers' ecological knowledge of the environment. These practices are not purely for conservation. Rather, they serve to optimize catch size while maintaining the stock for the future and, at the same time, minimizing conflict among the fishers. Thus, fisher knowledge serves multiple purposes and provides a base upon which new measures can be adapted for the changing needs of management.

Table 2.1. Examples of fisher knowledge use in contemporary fishery management systems.

Use of fisher knowledge	How it is incorporated?	Reference
Coral reef fishery in Palau (Oceania)	Fisher knowledge of timing and location of fish spawning aggregations and fisher perception that these aggregations are threatened may be used in establishing marine protected areas	Johannes (1978, 1998a)
Newfoundland cod fishery (Canada)	Fisher knowledge is being combined with scientific knowledge to assess stock structure, spawning times and location of northern cod. Fisher knowledge is also being used to assess fishery policies and their effects on fishing strategies.	Neis et al. (1999)
Nass River fish stocks management (Canada)	The NisGa'a fishery board is using both traditional and modern approaches to count fish and improve knowledge. The use of NisGa'a fish wheel technology and modern statistics proved to be more accurate than electronic tracking systems alone.	Corsiglia and Snively (1997)
Crayfish management at Lake Racken (Sweden)	Management practices are embedded in and influenced by institutions at various levels, from individual to government. Locally generated knowledge about crayfish population and ecosystem dynamics is used by the local fishing association to devise management practices.	Olsson and Folke (2001)
Shrimp trap-net fishery in Negombo Estuary (Sri Lanka)	The traditional arrangement that limited access and ensured equity in resource sharing was recognized by government as an official fishery regulation	Amarasinghe et al. (1997)

Table 2.2: List of folk species occurring in the Ibiraquera Lagoon. Folk species cited by two or more fishers or recorded in the field.

Folk name	English name	Family	Biological species
Crustaceans			
Camarão rosa[a]	Pink-shrimp	Penaeidae	*Farfantepenaeus brasiliensis*[d]
Camarão pata-azul[a]	Pink-shrimp	Penaeidae	*Farfantepenaeus brasiliensis*[d]
			Farfantepenaeus paulensis[d]
Camarão branco	White shrimp	Penaeidae	*Penaeus schmitti*[b]
Camarão ferrinho			Probably *Pleoticus mueller*
Siri	Blue crab	Portunidae	*Callinectes spp.*[b]
Siri-natal or siri-nataleira[a] (female)			*Callinectes sapidus*[d]
Siri-azul[a] or siri-branco (male)			*Callinectes sapidus*[d]
Siri-coca[a] or siri-candeia[a] or siri-rola-coco[a] (female)			*Callinectes danae*[d]
Siri-roxo[a] or siri-carioquinha[a] (male)			*Callinectes danae*[d]
Siri farrapa (female)			Probably *Callinectes boucurti*
Siri cagão (male)			Probably *C. boucurti*
Catanhão (carangueijo)	Land crab		*Cardisoma sp (?).*
Salt-water fishes			
Agulha		Exocoetidae[e]	
Badejo		Serranidae	*Mycteroperca sp.*[c]
Bagre[a]	Catfish	Ariidae	*Genidens genidens*[d]
			Several species
Bicudo[a]		Sphyraenidae[c]	
Canhanha[a]		Sparidae	*Archosargus sp.*[d]
			(possibly *A. abomboidalis*)
Caranha		Lutjanidae	*Lutjanus spp.*[c]
Carapeva[a]		Gerreidae	*Diapterus sp.*[c]
Carapicu, Gordinho or Escrivão[a]	Mojarras	Gerreidae	*Eucinostomus argenteus.*[d]
Corvina (corvinota)[a]	Croaker	Sciaenidae	*Micropogonias funieri*[b]
			Micropogonias sp.[c]

Table 2.2 (Cont'd)

Folk name	English name	Family	Biological species
Enchova (enchoveta) [a]	Bluefish	Pomatomidae	*Pomatomus saltatrix* [d]
Garoupa (garoupeta) [a]	Grouper	Serranidae	*Epinephelus sp.* [d] (possibly *E. marginatus*)
Linguado [a]	Flounder	Families of Pleuronectiforms	
Miraguaia or Boniquete	Black drum	Sciaenidae	*Pogonias cromis* [b]
Pampo (pampinho)	Jacks or Pompano	Carangidae	*Trachinotus spp.* [b]
Parati [a]	Mullet	Mugilidae	*Mugil curema* [d]
			Mugil spp.
Peixe-aipim [a]		Synodontidae [d]	
Peixe-rei	Silverside	Atherinidae [b]	
Robalo		Centropomidae	*Centropomus spp.* [b]
Sardinha (sarda or manjuvão or sardinha legistima)	Sardine	Clupeidae	*Opistonema oglinum* [d]
			Several species and genera
Sarda cascuda or Sarda casca-dura [a]			
Sarda melancia [a]			*Opistonema oglinum* [d]
Savelha [a]	Brazilian menhadens	Clupeidae	*Brevoortia spp.* [b]
Tainha (tainhota, tainhoto, or tainhotão) [a]	Mullet	Mugilidae	*Mugil platanus* [d]
Xerelete [a]	Blue runner	Carangidae	*Caranx* sp. [d]
Fresh-water fishes			
Traira	Tigerfish	Erithrinidae	*Hoplias malabaricus* [b]
Cará [a]		Cichlidae [d]	
Mollusca			
Berbigão		Veneridae	*Anomalocardia brasiliana*
Ostra (?)			

[a]ethnospecies recorded in the field ; [b]source: Fisheries statistics bolletins of Santa Catarina State, SUDEPE and IBAMA/CEPSUL; [c]source: Figueiredo (1977), Figueiredo and Menezes (1978, 1980), Mezenes and Figueiredo (1980, 1985); [d]species collected and identified in this study by J.O. Branco, R. Silvano and M. Hostin-Silva; [e]Seixas and Begossi (2001).

Table 2.3. Traditional management practices until the early 1960s in Ibiraquera Lagoon

Practices of traditional management	Effects for conservation
Management of channel openings timed to shrimp post-larvae and fish entering into the lagoon to ensure fish stock replacement	Positive
Tapume (bamboo fence) in some lagoon basins during the channel openings to retain part of fishery stock ensuring a food supply in case that not enough fishing resources enter the Lagoon	Positive*
Tapume gate controlling the fish coming in and out of some the Lagoon basins	Positive*
Elders assessing fish migration through the channel connecting the Lagoon to the ocean to signal when the *tapume* should be built, and through the channel connecting the Upper and Middle basin to signal when the gate should be open and closed.	Positive*
Prohibition of setting gillnets and other methods that make noise and disrupt fish migration from the sea into the Lagoon during open channel seasons	Positive
Prohibition of cast-net use in the channel or on the beach near channel mouth to allow fish enter the Lagoon undisturbed during open channel seasons	Positive
Prohibition of shrimp cast-net fishery in locations other than the shrimp migration channels	Positive
Prohibition of fish cast-net fishery in certain spots	Unclear
Elders assessing fish migration in the deep channels of the basins to signal whether fishing should be taking place (*pesca de tapagem*)	Unclear
Shrimp cast-nets used as shrimp trap-nets during the Lagoon water drainage	Negative
Capture of ovigerous blue crabs and crabs with soft caparace	Negative

*Source: Chapter III

Chapter III

Resilience and the dynamics of social-ecological changes

A fishers' organization (Colônia dos Pescadores Z13) meeting held at the Ibiraquera (Teixeira) community school (Spring 2000).

Chapter III

Resilience and the dynamics of social-ecological changes

3.1 Introduction

Any resource management system has two interrelated dimensions: the social system and the ecological system, often treated separately. In the last decades, considering the failure of many conventional resource management systems (Ludwig *et al.* 1993), some researchers have started investigating the dynamics of integrated social systems and ecological systems (henceforth social-ecological systems) in order to improve resource management (Gunderson *et al.* 1995, Berkes and Folke 1998). To analyze the dynamics of social-ecological systems, I use common-property theory and adaptive management.

The development of common-property theory (McCay and Acheson 1987, Berkes 1989, Ostrom 1990, Bromley 1992) has provided key tools for the understanding of the social dimension of management systems. A common-property (or common-pool) resource (defined as a class of resources for which exclusion is difficult and joint use involves subtractability) can be managed under four "pure" property regimes: communal property (community-based management), state property, private property, or open access (lack of a property regime). In reality, many resources are managed under various mixes of these regimes, as in co-management characterized by a sharing of responsibility between the government and user groups for resource management. The degree of

participation of government agencies and user-groups in the decision-making process may vary greatly from one co-management case to another (McCay and Jentoft 1996, Pomeroy and Berkes 1997). Co-management is a promising regime in developing adaptive management systems because it allows for cross-scale interactions (combining the local-level and higher-levels), and for feedback learning enhanced by the existence of these cross-scale institutions. I define institutions as any formal constraints (rules, laws, and constitutions) or informal constraints (norms of behavior, conventions, and self imposed codes of conduct) that mold interactions in a society (North 1994).

In the field of ecosystem dynamics and adaptive management, the model of an adaptive renewal cycle and the use of the idea of resilience have provided management insights (Holling 1986, 1995). The adaptive renewal cycle encompasses four stages: exploitation, conservation, release and renewal. Typically, an ecosystem proceeds from exploitation slowly to conservation; then rapidly to release; and again rapidly to renewal, before returning back to the exploitation phase. The resilience of an ecosystem is its capacity to absorb disturbances while maintaining its main behavioral processes and structure. It can be defined as the capacity to buffer perturbations, to self-organize, and to learn and adapt (Resilience Alliance 2001).

As ecosystems are hierarchically structured into a number of levels, many adaptive renewal cycles are linked through time and space, termed panarchy by Gunderson and Holling (2002). At least two features of panarchy (or cross-scale interaction) may contribute to understanding resilience: (1) disturbance in the small-scale system can cascade to the broader scale (Carpenter and Kitchell 1993), and (2) a large-scale system can provide resources (by "remembering" or carrying over elements through

its release phase) for the renewal phase of the smaller-scale system.

In this chapter, I combine the common-property approach with the ecosystem resilience approach to navigate the dynamics of social-ecological systems. My purpose is to identify some of the key factors that build social-ecological resilience in resource management, and some key factors that threaten it. To this end, I analyze the case of Ibiraquera Lagoon, which has experienced several drastic changes (flips) of the social-ecological system in the last four decades. In particular, I investigate changes in the socio-economic system, the management practices used, local and government institutions, and Lagoon ecosystem dynamics. I also investigate fishers' local ecological knowledge behind their fishing practices and institutions.

3.2 The case study

The Ibiraquera Lagoon is located in the municipality of Imbituba (pop. 33,000 in 1991), Santa Catarina State, in the southern part of the Brazil coast. The Lagoon is seasonally connected to the Atlantic Ocean. The pink shrimp (*Farfantepenaeus paulensis* and *F. brasiliensis*) fishery year round, and the mullet (*Mugil platanus, Mugil spp.*) fishery in winter (from May to July) are the main fishing activities. Fish and shrimp are men's activities; crab fishing, especially in the hot months, is a family activity including women and children.

Legally, any Brazilian who has a professional fisher license can fish in the Lagoon. Those with sport fishing licenses cannot. Professional fishing licenses, in law, are supposed to be issued only to those who make their main living from fishing. But in reality, they are issued to almost anyone who requests them. The main requirement for a

professional license is the testimony of two professional fishers that the requester makes his living from fishing. Thus, there is no effective legal access restriction to the Lagoon. There are about 350 professional fishers living in seven communities around the Ibiraquera Lagoon, Ibiraquera (also known as Teixeira), Barra da Ibiraquera, Arroio, Alto Arroio, Araçatuba, Campo D'Una, and Grama (or Ibiraquera de Garopaba). Many of the fishers are descendents of immigrants from the Azores Islands, who arrived in this part of the country about 200 to 250 years ago. Until the 1960s, most communities were quite isolated, living on subsistence agriculture and fishing.

To understand the interactions over the time between the social and ecological dimension of the Lagoon management system, I investigate socio-economic and ecological history of this area in the last four decades, divided into four periods according to the occurrence of major changes affecting the management system: (1) the 1960s as a base line; (2) from 1970 to 1981, a period of several socio-economic changes that culminated in a crisis in the management system; (3) from 1981 to 1994, a period of major changes in fishing regulations that resulted in the recovery of the management system; (4) the period from 1994, when the enforcement of fishery management broke down and a new crisis started to emerge.

The Ibiraquera Lagoon was chosen for the study of the dynamics of social-ecological systems because it was known as an area in which resource collapse and recovery cycles had occurred. In the following sections, first I provide a brief overview of the socio-economic history of the local communities, to be expanded later by period. Second, I describe Lagoon ecosystem dynamics. Third, I explore the linkages between the Lagoon dynamics and the "traditional" fishery management. I call it "traditional"

because it represents the pre-commercial, pre-modern system; it is the baseline against which I assessed changes over time. Fourth, I describe the management system in each period. Finally, I analyze the interaction of the Lagoon management institutions and the dynamics of the Lagoon over these periods.

3.2.1 Methods

Fieldwork was carried out between June 1999 and May 2000. Research methods included interviews, archival research and participant observation. Interviews were carried out in several formats -- structured interviews, semi-structured interviews with key informants and small groups, ethnomapping -- to elucidate fisher knowledge, fishery activities, and main changes in the fishery management system in the last four decades. Archival research was done to trace changes in fisheries legislation and the local socio-economic system. Participant observation 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, fishery association officials, and government officials.

Estimations of fish and shrimp abundance and harvest, fish and shrimp migrations, and seasonal cycles of the Lagoon were based on information from key informant interviews, backed up field observations. There are no fish and shrimp population or harvest statistics available for this locality or for most inshore fisheries in Brazil. The major species of fish, shrimp and crabs were collected in the field and identified by the use of species keys or by taxonomic specialists. Of about 39 species identified by fishers, 24 were recorded in the field, and 17 were identified biologically.

3.2.2 Socio-economic background

In the early 1960s, there were relatively few families living in the communities around the Lagoon. Four of the seven communities had no road access, none had electricity, five of the seven had no general store, and none had a fish store. The general stores did sometimes sell fish. Fish and shrimp were not marketed outside the area, except for what might be sold by the road in the three villages with road connection, and what could be carried on one's back along the beach to Imbituba. The local economy was based mainly on household-level agriculture (manioc flour and sugar as the main products), and fishing was done mainly for subsistence. There were no job opportunities for young people who often migrated to big cities for work.

From 1970 to 1981, roads were constructed and electricity became available in most communities. With the roads came the tourists. Tourism-related activities created local job opportunities, and precipitated the return of villagers who had migrated to the big cities. They saw new job opportunities in the area and some brought capital. More markets and retail outlets were created, including fish stores. Fish and shrimp started to be exported to regional markets. The importance of household-level agriculture in the economy of most communities declined.

From 1981 to 1994, the resident as well as the tourist population increased. All communities, by now, had road access and electricity. Telephone services became available in most communities, and several summer cottage developments, guesthouses and restaurants were built around the Lagoon. In addition, even more retail stores were created, including fish stores. By this period, tourism-related activities had come to

dominate the economy of most communities. In most communities, household-level agriculture was reduced to a minor activity to supplement the diet.

Since 1994, community growth has continued at an accelerated pace, as well as the tourism-based economy. Although population numbers by village are not available from the census data, a population estimate can be made from the data on households and the number of people per household. For the seven villages in the Lagoon area, this estimate comes to about 5,000 people. Judging by the number of summer cottages, which is twice the number of resident households, the population of the area is estimated to reach about 15,000 people in the peak tourism season. The area surrounding the Lagoon and the nearby beaches on the ocean are a hot summer spot for tourists mainly from Porto Alegre which is the largest city to southwest.

3.2.3 The lagoon ecosystem

The Ibiraquera Lagoon is an assembly of four interconnected small basins, Lagoa de Cima, Lagoa do Meio, Lagoa de Baixo, and Lagoa do Saco ('Upper Lagoon', 'Middle Lagoon', 'Lower Lagoon', and 'Saco Lagoon') with a total area of approximately 900 ha (Figure 1.3). This is a shallow lagoon; most of its area is between 0.20 m to 2.0 m deep. Channels in which fish and shrimp migration takes place, run through the Lagoon, with few points reaching about 4 m deep. The Lagoon has mainly sandy bottom and brackish water. The salinity range is from 7 parts per thousand in the rainy season, to 30 parts per thousand or more when the channel is open to the sea (unpublished data, Universidade Federal de Santa Catarina). There are no major river water sources. Freshwater input is mainly through springs which feed the Lagoon at nine or more points. A freshwater fish

fauna (as opposed to marine or brackish water fauna) is found in several places around the Lagoon system, but especially in the Upper Lagoon.

The water level in the Lagoon system rises as the season progresses. Through most of the year, there is a sandbar between the Lagoon and the Atlantic Ocean. When sufficient water pressure builds up, a channel bursts through the sandbar. Lagoon water pressure increases with rainfall which helps the Lagoon 'explode' into the ocean. The channel eventually closes through sand deposition by ocean currents and tides, which in turn, allows once again the increase of the Lagoon water level.

Almost all fish resources in the Lagoon come from the ocean when the channel is open. According to fishers, most fish enter the Lagoon in their juvenile stages by actively swimming in. By contrast, shrimp are carried in by the tides. Post-larval stage shrimp may be observed in large numbers as they enter the Lagoon; larval stage shrimp, which are planktonic and difficult to observe, is also carried in by the tide. Thus, the Lagoon fish stock is determined mainly by the seasons in which the channel is open, in relation to the fish and shrimp stocks moving through the ocean in front of the channel, and by the length of time that the channel stays open. Fish and shrimp grow in the Lagoon habitat, returning to the ocean as adults in the next channel opening cycle. This represents a 'capital accumulation' in the Holling (1986) sense, or a fish and shrimp biomass increase over the months after the channel is closed.

The Ibiraquera Lagoon is a good example of a small ecosystem going through the adaptive renewal cycle (Figure 3.1). Following Holling's (1986) adaptive renewal cycle, the release stage is the few hours that takes from the time the channel bursts through the sandbar to the time the Lagoon water level matches the water level of the ocean; that is,

the period it takes to drain the excess water of the Lagoon. The renewal stage is the period that the channel remains open, which can vary from a few days to a few months. In this stage, the Lagoon's saltwater and fish and shrimp stocks are renewed. The period encompassing the exploitation and conservation phases, usually the longest one in the Holling model, corresponds to the period when the channel is closed. This period may last from one to several months depending on rainfall. During this time the Lagoon water level rises and the fish and shrimp grow, representing a gradual accumulation of 'capital'. As the system becomes 'overconnected,' the Lagoon releases its water and production to the ocean, restarting its renewal cycle.

The Ibiraquera Lagoon system also illustrates how adaptive renewal cycles may be nested in one another over time and space scales, the panarchy (Gunderson and Holling 2002) (Figure 3.2). During the release phase, the Lagoon (the smaller ecosystem) liberates adult fish and shrimp into the Atlantic Ocean (the larger ecosystem) where these species reproduce; the Lagoon is a source of renewal for the ocean fish and shrimp stocks. In turn, the ocean is the source of saltwater and juvenile and adult fish, and larval and post-larval shrimp during the Lagoon renewal stage. Also worth noting, but outside of our scope of study, is that changes in the ocean ecosystem, such as an oil spill or decisions such as overexploiting coastal stocks of shrimp and mullet, would affect the Lagoon ecosystem.

3.2.4 Lagoon ecological dynamics and "traditional" management

The renewal of the Lagoon fishery system depends on the season when the channel is open. That is, it depends on the availability of fish and shrimp post-larval stocks moving

through the ocean in front of the channel. If nature is left to take its course, the channel does naturally open by the Lagoon bursting through the sandbar – but the timing of the opening is highly uncertain. For this reason, local fishers at Ibiraquera traditionally managed the channel opening to coincide with fish and shrimp season. The fishers dug only a small (2 m wide, 0.5 m deep) channel across the sandbar (about 30-60 m across). The pressure of the water quickly widened it into a natural channel, 1.5 to 2 m deep and 60 to 100 m wide.

In a year of normal rain precipitation, the Lagoon was traditionally opened by fishers at least twice and usually three times. If it were left to nature, the channel opening in most years would probably take place only once, at the end of the rainy season. Thus, the additional openings by the human hand acted as 'putting the brakes on release' and served to avoid large disturbances later. As well, it helped avoid the ecological surprise of the Lagoon bursting at an unexpected time, and the loss of Lagoon's fish/shrimp stocks into the ocean at a time when no fish or post-larval shrimp stocks were available to renew the Lagoon's stocks.

Fishers opened the channel in the spring (sometime around September and October) which is the season of the post-larvae shrimp in the nearby ocean; in late summer (sometime between December and February) which is the season of small mullets; and in the late fall (sometime between May and June) which is the season when large adult mullets will come into the Lagoon. When the channel is opened, several other fish species also enter the Lagoon.

Traditionally, fishing activities took place year round in the Ibiraquera Lagoon. Various fishing methods and management practices were used at different stages of the

Lagoon adaptive renewal cycle: release and renewal (open channel), exploitation and conservation (closed channel). At the time of the mullet fishing season (May to July), just after the release phase (the period when mullets enter the Lagoon, swimming against the brackish water drainage into the ocean), a fence was sometimes built at the Lower basin, in order to prevent fish return into the ocean, in case the channel opening lasted for a long period. The use of the fence, made of bamboo and fixed at the two ends by use of two segments of railroad rail, can be viewed as an insurance mechanism.

If there were still many fish or shrimp in the Upper Lagoon just before the release phase, a bamboo fence was also built in the Upper Lagoon close to the channel connecting the Upper and Middle Lagoons. During the draining, the fence helped to retain part of the fish stock in the Upper Lagoon, 'putting the brakes' on the release phase and functioning as an insurance mechanism for maintaining biodiversity. In this case, however, the fence was built not only in the mullet season, but used in any channel opening. Since the Upper Lagoon is the shallowest and farthest one from the opening to the sea, it is the one most affected by drainage. If no fence is present, all shrimp and fish stocks may escape the Upper Lagoon during draining. During the renewal phase, part of the fence (a gate) was taken out to allow fish to come into the Upper basin. The gate was opened when a school of fish was trying to come in and closed soon after that, so that fish would not swim back into the other basins and eventually into the ocean in case the channel opening lasted for a long period. The same procedure of building bamboo fences just before the release phase was sometimes used at the Saco Lagoon. If there were not many fish and shrimp left in the Upper Lagoon before the channel opening, a bamboo fence was built only after some fish stocks entered that basin during the renewal phase.

Specialized fishers acted as monitors to check fish movements. In the deeper channels running through the basins, there were sometimes elder fishers who stood watch to assess the amount of fish entering the channels. When a fish monitor decided that enough fish had come through, he gave a sign to close the deep channel using net barriers, allowing the fishers to start fishing. These expert fishers also monitored mullet movements into the Lagoon, signaling when to build the bamboo fence (or close it in the case of Upper Lagoon), so that the mullet would not swim back out.

Whenever the channel was open (release and renewal stages), gillnets (fixed nets, about 150 m each), surrounding nets (a mobile gear made by tying together several gillnets), and seines (a surrounding net pulled along the bottom) could not be used in the Lagoon. This was because these methods relied on slapping the water with poles and hitting the sides of the canoe to drive fish into the nets, thus producing much noise in the water. Such disturbance repelled fish back to the ocean. Gillnets, surrounding nets and seine nets could be used only during the exploitation and conservation phases (closed channel). Cast-nets for both fish and shrimp could be used in all four phases of the cycle, except in the first two or three days after the channel opening in the mullet season to avoid the problem of fish turning back to the ocean. Cast-nets for fish were not allowed in the channel and on the nearby beach (100 meters from each side of the mouth of the channel) when the channel was open. This was to permit fish to enter undisturbed into the Lagoon.

The shrimp cast-net fishery was performed only by fishers standing in certain spots close to the channels used by pre-adult shrimp. There was no shrimp fishery along the Lagoon shore where the young shrimp come to feed, or from canoes in the middle of

the Lagoon area, which is the habitat of very small shrimp. There was respect for shrimp fishing locations of the established fishers and for first-comer's rights in other areas. In the fish cast-net fishery, there were certain spots where fishers were allowed to stand and fish. In other spots, even though fish were visible, old fishers advised no fishing because that would cause scattering of the fish school which could be caught easily in another location. Fish cast-netting from canoes in the middle of the Lagoon area was a common practice. Setting gillnets was not allowed in any channel mouth.

3.2.5 Fishing management by period

3.2.5.1 Fishing system in the 1960s

In the early 1960s, the fisher organization, Colônia de Pescadores, already existed but was not responsible for regulating or enforcing fishing rules[1]. One of its responsibility was to transmitting documents so that government could issue fishing licenses. Although some government fishing regulations existed, these were either unknown or not recognized by most local people. Most fishing rules were decided locally, and respect for the practices of old fishers was the main measure which these rules were enforced. State fishery inspectors or police did not normally come to the Lagoon area, except when occasionally called by the Colônia to enforce rules or solve conflicts among fisher groups.

The main fishing gears included the cast-net (25-28 m circumference; mesh size

[1] The Colônia de Pescadores was founded in 1952; its president and board of directors are elected by its members every two or three years. This organization encompasses fishers from the entire municipality of Imbituba and not only those living around the Lagoon. As of 1999, there were about 1,500 members fishers, including about 350 fishers living around the Lagoon.

from 4.0 cm to 5.0 cm stretched measure) used for small fish and large shrimp, cast-net (28-31 m circumference; mesh size of 6.0 cm or larger) used for large fish; gillnet (180-220 m length; mesh size of 3.5 or 4.0 cm) used for small fish and shrimp, and gillnet (180-220 m length; mesh size of 5.0 cm or bigger) and seine-net (about 300 m length with mesh size of 5.0 to 9.0 cm, with a cod-end of 15-30 m length with mesh size of 4 or 5 cm) used for large fish. Local fishers used a torch made of dry vegetation to attract shrimp in night fishing. Fishing gears were handmade and so were the boats (dugout canoes). Until the mid-1960s when synthetic fibers were introduced, nets were made of cotton or *tucum* (a fiber made of palm tree). Making nets was costly in both the time and money. Cast-net, a small gear, was more affordable to most people than gillnet or seine-net. In fact, it was gear types that separated the user-groups. Local fishers were divided into two groups: *tarrafeiros,* those who used cast-nets (most fishers), and *redeiros,* those who used gillnets or seine-nets (a smaller group). There were no outside fishers in the system.

The main fishing methods included (a) individual fisher using a shrimp cast-net or a fish cast-net while standing in a known fishing spot close to fish and shrimp migration channels; (b) one or two fishers using fish cast-nets from a canoe; (c) individual fisher setting a gillnet; (d) a group of fishers with two or more canoes encircling a fish school with gangs of gillnets, inside which they and others in more canoes threw cast-nets; (e) four or five fishers in a canoe, encircling a fish school with a seine net; and (f) two fishers holding an open cast-net used to catch shrimp in the water current when channel was open. The local management rules, described in the earlier section, were based on respect to the practices and instructions of the elders.

In the early 1960s, due to low population density, lack of roads, and little market development, supply exceeded demand, and fishers caught a lot of large fish and shrimp. Although there was an abundance of fishing resources all year around, there was a conflict between *tarrafeiros* and *redeiros* for resource access, as *redeiros* caught more fish than did *tarrafeiros*. The amount of effort to fish with cast-nets is larger than to fish with gillnets. A person has to throw a cast-net many times to make a living. By contrast, a gillnet set in a fishing spot "fishes by itself" for many hours. The only effort required is to set the net and to take it out. When several gillnets attached together are used to encircle a fish school, a few *redeiros* might catch more fish in one short trip than several *tarrafeiros* using cast-nets in an entire day of work. From the point of view of *tarrafeiros*, other factors contributed to this inequity. For example, when *tarrafeiros* fished inside the encircling gillnets, they had to give one-third of their catches to the gillnet owners (*redeiros*).

This conflict between *tarrafeiros* and *redeiros* had existed for decades; however, it intensified in the late 1960s as a result of two technological innovations. First, the use of synthetic fibers made it easier to produce nets and with a smaller mesh size than before. Second, *redeiros* started to use a new fishing method, several gillnets attached together as beach seines, for fish and shrimp along the Lagoon coast.

3.2.5.2 Fishing system from 1970 to 1981

The road access to the communities favored the development of outlets to sell fish from about 1970. At first, local middlemen bought fish and shrimp from the Lagoon and sold them in the big cities. A patronage system developed in which a middleman used to give

money or fishing gears to a fisher, who in turn had to sell his catch exclusively to the former. After mid-1970s when tourism started in the region, opportunities increased for the sale of fish, and particularly shrimp, within the Lagoon communities. However, the roads also brought some fishers from nearby communities and municipalities, adding another user-group to the mix (outside fishers). These outsiders could be either *tarrafeiros* or *redeiros*.

By the 1970s, the Colônia became the decision-making agency for the opening of the channel. Although net fences were legally prohibited, they were informally allowed by the Colônia. The main fishing gears included all those used in the previous period, plus trap-nets, hoop-nets, and mini-trawl style pull-nets for shrimp. As the intensity of exploitation increased as a result of market pressures, mesh-size started to diminish. Shrimp cast-nets had mesh size of 2.0 or 2.5 cm and fish gillnets had mesh size of 3.0 cm. As fishers started making money in fisheries in the early 1970s, they were able to afford kerosene lamps to attract shrimp, easier to use and more efficient than torch. In the late 1970s, some fishers started to use butane gas lamps to attract shrimp, which was, in turn, more efficient than the kerosene lamp.

The main fishing methods included all those used in the previous period, with the increase of the hand-drawn beach seine fishery, some reportedly as large as 600 m in length. Fishers, using canoes, started to use shrimp cast-nets all over the Lagoon, instead of a few fishing spots. Shrimp trap-nets and hoop-nets (two kinds of anchored nets, one larger and the other smaller) were used in place of cast-nets in the channel. Shrimp pull-nets were drawn along the Lagoon shore.

In 1971, an attempt was made to resolve the conflict between *tarrafeiros* and

redeiros. The arrangement between the two parties made in the presence of the Colônia president and the director of the State Department for Fishing and Hunting[2], (a) prohibited the use of gillnets in the Upper Lagoon and in the Saco Lagoon (gillnets could only be used in the Middle Lagoon and Lower Lagoon); (b) prohibited the use of cast-nets and gillnets in the channel whenever it was open; and (c) prohibited sport fishers from selling their catches. These rules were enforced by a voluntary local fishery inspector who had the support of many *tarrafeiros* in monitoring the Lagoon. The first voluntary inspector affirms that the agreement also included the prohibition of cast-nets with mesh size smaller than 3.0 cm (Lênio Teixeira, pers. comm.). However, reference to this rule was not made in the Colônia's meeting report. Despite many regulations issued by the Federal Fishery Agency (SUDEPE) in the first half of the 1970s[3], fishers observed only the local agreement and previous local rules because there was almost no rule enforcement by municipal, state or federal fishery inspectors[4]. Most of the fishing gears and methods used during this period were in fact legally prohibited.

Initially, the first local voluntary inspector apprehended illegal gears and deposited them in the State Department for Fishing and Hunting office. Fishers were then able to retrieve their gears after paying their fines. As fines were very low, many fishers took the risk of using illegal gears again and again. As a response, the first voluntary inspector started to cut or burn the illegal gears. During this period, there was some

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[2] Departamento Estadual de Caça e Pesca

[3] The Federal Fish Agency, Superintendência para o Desevolvimento da Pesca (SUDEPE), issued several regulations for national or state territory which apply to the Ibiraquera Lagoon, and included the following rules: Establishment of minimum mesh size of 2,5 cm for shrimp cast-net (1970), of 5,0 cm for fish cast-net (1972), and of 7,0 cm for fish gillnet (1972); prohibition of setting gillnet longer than 1/3 of lagoon width (i.e., it also prohibit the use of nets as fences in the lagoon channels) (1972); prohibition of trap net use in the channel linking the lagoon to the ocean (1972); prohibition of hand-drawn beach seine and seine (1972) and trawling (1975).

recovery in fish and shrimp catches.

In 1974, however, the first voluntary inspector resigned because he got a paid job. The new voluntary inspector was the Colônia president, a *redeiro* himself. According to some informants, he allowed the use of nets in all basins, and enforced regulations that only favored *redeiros*. Hence, the 1971 agreement failed after the mid 1970s, and the conflict flared up again.

In conclusion, the enforcement of both local rules and government rules broke down. Respect for elders' practices weakened. Profit-oriented fishers now questioned and disrespected old practices. The conflict became worse as difference in fishing incomes magnified the economic differences between *redeiros* and *tarrafeiros*. Using big gears, *redeiros* caught more and more fish and made more money than *tarrafeiros*; moreover, they bought more material to make even more nets.

By the late 1970s, all fish and shrimp stocks in the Lagoon were caught within about two months of channel closure. This was a result of the smaller mesh-sizes used, and particularly the intensive use of the hand-drawn beach seine. This meant that there was almost no production in the Lagoon for several months before the next opening. The pressure on fishing resources and the conflict between the two user-groups triggered the crisis and a 'revolt' of *tarrafeiros*.

3.2.5.3 Fishing system from 1981 to 1994

Facing resource over-exploitation and the ongoing conflict between *tarrafeiros* and *redeiros*, the *tarrafeiros* (the larger group) organized themselves, and elected in 1981 a

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[4] Those who enforced fishing regulations included members from the local Police Force and SUDEPE.

new Colônia president (an outsider *tarrafeiro* and ocean fisher), but one who promised to work towards the restriction of nets other than cast-nets, in the Ibiraquera Lagoon. The Colônia, then in the hands of a strong and knowledgeable leader who had support of the majority of fishers, and good political relations with the State Government, conducted several regulation changes that helped rebuild Lagoon management and ecosystem resilience. As a result of the positive results of these changes, the president was reelected five times.

The first, and perhaps the most important, rule change was the banning of any nets excepting the cast-net, in all Lagoon basins. Local fishers, through the Colônia president, demanded this ban from the Federal Fishery Agency (SUDEPE) and two other State Agencies working with the fishery (IPEP, ACARPESC)[5]. After a study to evaluate the Lagoon management situation, SUDEPE agents elaborated on a project upon which local fishers voted and decided to ban all net types, except the cast-net. The Federal Government approved the regulation (N-027/81) in October 1981[6]. The new regulation, specific to the Ibiraquera Lagoon, banned the use of all nets but cast-nets, with minimum mesh size of 2.5 cm for shrimp and 5.0 cm for fish. These are standard mesh sizes for multi-species coastal fishery in Brazil. The regulation also prohibited any fishing in the channel and in a small channel connecting Upper and Middle basins.

In 1986, use of the gas lamp was banned in the Lagoon, allowing only kerosene lamp. The gas lamp was being used with a new fishing gear, the shrimp sucker, which caught small shrimp on their feeding areas in the Lagoon margins. Also, its bright light

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[5] IPEP: Instituto de Pesquisa e Extensão da Pesca. ACARPESC: Associação de Crédito e Assistência Pesqueira de Santa Catarina.

[6] The new regulation (N-027/81) came into force under the Decreto (Decree) 73.632 of 1974, empowering SUDEPE to manage Brazil's fisheries.

interfered with other fishing activities at night. Because the gas lamp attracted much more shrimp than did the kerosene lamp and since not all fishers could afford buying a gas lamp, its use was creating equity problems among the fishers. The change was demanded by a majority of fishers, through the Colônia, and officially approved (N-09/86) by the Federal Fishery Agency (SUDEPE).

Until 1988, the Colônia president decided about the channel opening, after consulting with local fishers. Yet, to implement the decision, he had to have approval from the District Navy Commander who acts as the Port Authority ("Capitão dos Portos"). After 1988, the decision and the approval process were transferred to the Municipal Government. From 1989 to 1992, the person in charge of the opening had no knowledge of Lagoon ecosystem dynamics. He listened to fishers as well as others living in the Lagoon area. Houses in the area have septic tanks and the water levels in the Lagoon affect the discharge of sewage because the watertable is too superficial, causing foul smell inside the houses. From the point of view of sewage disposal, it was desirable to open the channel more frequently to improve flushing and to get rid of foul-smelling water. The decision was sometimes made in favor of the sewage problem and not to optimize the fishery. This, in turn, created a conflict between fishers and non-fishers, especially tourism interests. In 1993, the Municipal Government returned the decision-making on channel openings to the Colônia.

According to the Colônia president, due to channel openings in wrong periods and some weather surprises in 1990 and 1991, the quantity of shrimp larvae entering the Lagoon diminished, severe affecting shrimp production. The Upper Lagoon was particularly affected due to landfill in the channel connecting to the other basins.

Moreover, the natural shrimp production had became insufficient to supply the growing number of fishers. In face of these circumstances, the Colônia president contacted the Federal University of Santa Catarina (UFSC) and a State research agency (EPAGRI)[7] to develop a shrimp-stocking project in the Ibiraquera Lagoon (Andreatta 1999). The project, which consisted of releasing post-larval shrimp in the Upper Lagoon, started in 1992 and lasted until 1998 (Andreatta et al. 1993, 1996)[8]. A net fence (1.0 cm mesh) built in the Upper Lagoon just before channel openings prevented shrimp escapement into the ocean.

Now that there was a higher abundance of shrimp, the project coordinators, in agreement with the Colônia, showed the local fishers that an increase of the cast-net mesh size from 2.5 cm to 3.0 cm would actually improve fishers' yields and profits, since larger and higher-value shrimp would be caught. Furthermore, such a measure would help exclude most outside fishers who usually own only 2.5 cm mesh shrimp cast-nets. Accordingly in 1993, local fishers, through the Colônia, demanded another regulation change, establishing a minimum of 3.0 cm mesh for shrimp cast-nets. This was officially approved (N-115/93) by the Brazilian Department for the Environment (IBAMA)[9].

These three new regulations (N-027/81; N-09/86; N-115/93), specific for the Ibiraquera Lagoon, replaced most of the regulations of the previous period. They worked only because of a strong enforcement structure. Between 1981 and 1994, through an agreement with the Federal Fishery Agency (SUDEPE was replaced by IBAMA), the

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[7] Empresa de Pesquisa e Difusão Tecnológica do Estado de Santa Catarina (EPAGRI)

[8] The shrimp stocking project was funded by three Federal Government Agencies: Fundação Banco do Brasil (1992-1993); Fundo Nacional do Meio Ambiente (1994-1996); Programa de Execução Descentralizada do Ministério do Meio Ambiente (1997-1998).

[9] The Federal Fishery Agency (SUDEPE,) was extinguished in 1989 and replaced by the Brazilian Department for the Environment (Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renovaveis –

State Government staffed fishery inspector positions in certain localities, including the municipality of Imbituba. Local Lagoon fishers also helped these inspectors, but this help had to be withdrawn later because it was generating conflicts between *tarrafeiros* and those *redeiros* who insisted on fishing with prohibited gears. As a result of all these rule changes and strong enforcement, the Lagoon's fish and shrimp stocks recovered in about two years after the net banning, according to fishers.

Meanwhile, most local and informal fishing rules either disappeared or became formal. Exceptions included the use of net fences in some Lagoon basins during channel openings, respect for fishing spots in areas in which only locals fished, and first comer's rights in the remaining areas. With the above exception, respect for elders' practices almost completely disappeared. Fences were now made of netting, with a few poles to keep nets in place, as opposed to all-bamboo fences which were harder to make.

Tarrafeiros were catching more than they did in the previous period, but many of them, in effect, had become part-timers. Previous *redeiros* who were now fishing with cast-nets, were catching less. As a result of the dominance of tourism-related activities in the economy, most local fishers of both groups were looking for other employment, especially in the construction business.

From 1992 to 1998, overall shrimp production increased considerably as a result of the shrimp-stocking project (Andreatta et al. 1993, 1996). At the same time, however, there were emerging challenges to the Lagoon fishery from the increase of tourists, whose sailing and sport fishing interfered with professional fishing. As well, there was an increase of outside fishers, and the unregulated growth of summer cottages, guesthouses

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IBAMA) in the same year.

and restaurants. Excessive development was destroying vegetation on the Lagoon edge which, in turn, increased erosion, siltation, and mudslides, filling up the fish migration channels and destroying fish and shrimp feeding habitat.

3.2.5.4 Fishing system from 1994 to 2000

In 1994, the arrangement between IBAMA and the State Government broke down and the fishery inspector positions were extinguished, probably due to budget constraints. A new arrangement was then made between IBAMA and the State Environmental Police[10], which already had the personnel to do the job. In this new arrangement, a small group of officers had to cover a large area encompassing several municipalities, dealing with all resource and environmental issues, including the fishery. A place such as the Ibiraquera Lagoon was only visited sporadically, and usually only when infractions were reported. The weakening of enforcement had given the opportunity to many fishers to violate regulations. As a result, by 1996, the depredation of the Lagoon system was again evident, and some fishers demanded better service from the Environmental Police to avoid a new crisis. Due to the ineffective action of the Environmental Police and the IBAMA, fishers living close to the Upper Lagoon decided in 1998 to organize themselves into groups to patrol it. Nonetheless, this activity did not last long because fishers did not have the legal right to patrol the area. On several occasions, they called the IBAMA and the Environmental Police to stop illegal fishing but to no avail. Moreover, monitoring groups were sometimes threatened with shotguns by those fishers using illegal gears.

In addition to changes in the enforcement structure, the only other rule change

[10] Companhia de Polícia de Proteção Ambiental (State Police)

regarding Lagoon management since 1994 was the prohibition of motorized vessels at the Lagoon. In 1994, fishers organized themselves to demand the restriction of jet-skis and any other mechanized boats because their use was affecting fishing and threatening the security of fishers and tourists in the Lagoon. In 1995, the Mayor of Imbituba issued a regulation (N-1501) prohibiting any type of engines in the Lagoon. In 2000, dugout canoes with pole or paddle were the most used vessels; however, jet-skis and motor canoes were still used by some tourists.

As a result of lack of enforcement, all prohibited gears and fishing methods used before 1981 have returned to the Lagoon. In addition, another destructive gear, which stirs the Lagoon bottom, disturbing nutrient sedimentation, was introduced: the shrimp trawl (*gerival*) which is a small net dragged by a canoe. Banned gears were being used by local fishers and outsiders. Evidently, *redeiros* fishers became a user-group again; yet, *tarrafeiros* remained the majority. In fact, probably more fishers had (or can afford buying) big nets in 2000 than in the 1970s; fishers did not have to make their own nets anymore. Because of tourism and local economic growth, most fishers were part-time. Indeed, there were about 10 fishers in 2000 in the whole area who relied only on fishing for their livelihood; many others supplemented their incomes from tourism-related activities and agriculture.

The lack of a strong enforcement had also affected the issue of channel openings. In the last few years, instead of waiting for the Colônia decision to open the channel, some fishers were opening it whenever they think it was appropriate. People living in the community closest to the channel preferred the channel to be opened in December and January – the high season for tourism – so that the Lagoon water was flushed constantly

to minimize smells caused by sewage. But for other fishers, the issue was that channel openings in the wrong time were affecting Lagoon fish and shrimp production.

As well, the use of banned gears was affecting Lagoon production. On the one hand, the use of small mesh sizes decreased potential production during the months that the channel was closed. On the other hand, the use of illegal shrimp trap net when the channel opened, increased shrimp catches. Since 1998, when the shrimp-stocking project ended, there has been a reduction of shrimp production. Lagoon production in the 1990s was mainly sold in the area; there was no excess to sell to big cities. Fishers either sold their product to middlemen or directly to local restaurants and tourists. The patronage system in which middlemen lent money to the fishers, who in turn had to sell their catches exclusively to the middlemen, had almost disappeared. A large proportion of fishers, however, did not sell their catch; they fished for their own family consumption.

The problems affecting the Lagoon had multiplied again since the end of rule enforcement. Some of these new problems were aggravations of old problems and included: (a) the use of illegal gears and fishing methods; (b) the use of motor vessels and windsurf boards interfering with fisheries; (c) Lagoon pollution due to the increase of tourists; (d) the increase of tourists houses draining sewage into the Lagoon from poorly constructed septic tanks; (e) illegal constructions inside the Lagoon and on its margins; (f) channel openings in wrong periods; (g) renewed conflict between *tarrafeiros* and *redeiros*; (h) increased conflict between local and outside fishers; and (i) conflict between professional fishers and sport fishers. This scenario shows that a new crisis was emerging in Lagoon management.

'Why was the Colônia not responding to the emerging crisis?' one may ask. 'Because the Colônia had become a 'brittle' organization', is probably the best answer. Indeed, this is a very common characteristic of most fishers' colônias in Brazil which have no tradition of responding to fisheries crises or to any local demand (Breton et al. 1996). In the Ibiraquera case, the Colônia president had been there for a long time, re-elected several times since 1981. However, the organization appeared to have lost its ability to respond flexibly to problems, had become complacent, and too centralized. The Colônia had not responded in a resilient manner to a range of feedbacks such as those summarized in the previous section. The president had, in fact, become 'the organization' itself. Although, the Colônia's board of directors included other members, they played no real role; all decisions were made by the president who also acted as secretary and controls the Colônia's budget. Meanwhile, to deal with the impacts of unregulated tourism, three of the seven communities surrounding the Lagoon re-activated their community councils[11] in 1999/2000. As of year 2000, the Ibiraquera Lagoon management system seemed to be poised for a new round of institutional renewal.

3.3 The dynamics of a social-ecological system

The history of the Ibiraquera Lagoon fishery is particularly interesting as it shows the resilient "traditional" management system of the 1960s, transforming into a less resilient and non-viable system in the 1970-1981 period; rebuilding resilience after experiencing a

[11] In 1999, Conselho Comunitário de Ibiraquera and Associação dos Amigos da Praia da Barra da Ibiraquera, and in 2000 Conselho Comunitário de Araçatuba were activated. The Associação de Ibiraquera-Gramense has remained active since 1986.

crisis (1981-1994), but once again transforming into a less resilient system since 1994. I evaluate the resilience of the social-ecological system on the basis of: its ability to respond to feedbacks and absorb perturbations; its ability for self-organization; and its capacity to learn and adapt (Resilience Alliance 2001). Figure 3.3 summarizes these institutional and ecological flips in Ibiraquera Lagoon system. The adaptive renewal cycles are used here as a heuristic model to understand cycles of changes in socio-ecological system. This is by no means a predictive model.

What conferred social-ecological resilience until the 1960s were the "traditional" management practices, in addition to a strong informal enforcement based on respect for elders' practices. These management practices mainly applied to the release and renewal phases of Lagoon ecosystem dynamics (Table 3.1). They triggered critical ecosystem processes; for example, opening the channel produced a small-scale disturbance to avoid larger-scale disturbance later. These practices helped to avoid ecological surprises, performing as insurance mechanisms for maintaining biodiversity.

From 1970 to 1981, the management system began to lose its social-ecological resilience as fishing effort increased due to changes in the local economy and as social enforcement declined. Although fishing gears and methods used in this period were very similar to those used in the previous period, changes in the socio-economic system affected ecosystem resilience (Table 3.2). Changes in the local economy also reduced the social resilience of the management system. This happened as profit-oriented fishers spurned elders' authority, and as over-fishing by *redeiros* magnified the differences in socio-economic status between *redeiros* and *tarrafeiros*. The loss of social-ecological resilience triggered a crisis in the management system.

The rebuilding of social-ecological resilience between 1981 and 1994 depended on a series of changes. The two main responses to that crisis were the election of a Colônia president willing to promote management changes and the implementation of a new enforcement system – a formal one. After 1994, however, the social-ecological resilience of the system was threatened again by the lack of a strong enforcement structure. As well, resilience was threatened by the "brittle" organization that the Colônia had become. These changes are summarized in Figure 3.3.

Another way to interpret Figure 3.3 is in terms of property-rights arrangements. The "traditional" system in the 1960s is clearly a communal management system[12]. With economic modernization and opening of road access in about 1970, the area entered an open-access competition over Lagoon resources. Overfishing and conflicts culminated in the revolt of the small fishers, ending the cycle of *laissez-faire* exploitation. The management regime in the third period in Figure 3.3 may be characterized as co-management. The fishers and their organization successfully lobbied the government to pass a series of regulations, and shared the power and responsibility for the management of Ibiraquera Lagoon. However, the fishers did not have the formal power to enforce rules. The restoration success of the 1981-1994 period relied on government enforcement of the new regulations. Given the fact that the fishers of the Lagoon could not legally exclude outsiders, and given the immense pressure of tourism development, it is not surprising that the system fell apart when the State fishery inspectors were withdrawn in 1994. Table 3.3 summarizes these changes over time with respect to decision-making, formal and informal organization, and rule enforcement.

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[12] I make no attempt to go back further in history, but suffice to say that there must have been many

3.3.1 Key factors that affect social-ecological resilience

Having analyzed the case study with respect to historical changes and social-ecological system dynamics, I now turn to the identification of key factors that build or threaten resilience. The case study allows for the identification of both kinds of key factors. The four key factors that weaken resilience included the breakdown of local institutions; rapid technological change; rapid socio-economic change; and institutional instability across political scales (Table 3.4).

I identified five key factors that strengthen resilience: strong institutions; cross-scale communication; political space for experimentation; equity; and use of ecological knowledge as source of novelty (Table 3.5). These factors are in fact clusters. For example, the first factor (institutions) includes the elements of robustness, enforcement, and leadership, as detailed in Table 3.5.

Communication appears to be a major factor. The three regulations brought in during the 1981-94 period (banning of all nets but cast-nets; banning of gas lamps, increasing shrimp cast-net mesh size) involved cross-scale cooperation and communication. Four levels of organization were identified: local resource users, the fisher organization (Colônia), State Agencies, and the Federal Fishery Agency. Cross-scale communication was important both during the evaluation of the Lagoon fishery, and during the decision-making process. The banning of motor vessels in the Lagoon also involved the local fishers, the Colônia, and the Municipal Government. Important aspects of cross-scale communication concerns the sharing of facts about resource status and threats to management, and the ability of resource users to detect environment

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changes as different groups succeeded one another in colonial history of Brazil for this region.

modifications and management crises. Another important aspect concerns the co-management of the Lagoon using both scientific and local ecological knowledge. Local knowledge on the effect of large nets and gas lamps was taken into account by the Federal Fishery Agency. Scientific knowledge about the implications of mesh size on shrimp production was used by local fishers to demand a rule change for larger mesh sizes (Table 3.5).

In the Ibiraquera case, the Federal Fishery Agency allowed local fishers' input for the formulation of regulations, thus creating political space for experimentation. The case shows a multitude of changes, problems, and management responses, including a rich set of fishers' own management measures and fishers' rules incorporated into government management. Given the reality of top-down government management that historically characterized resource management in Brazil, the creation of such political space for experimentation was unusual by the standards of the early 1980s. This has been less so in the 1990s (e.g., Barbosa and Hartman 1997). The positive results of the three major regulations brought in during the 1981-1994 period show that the opportunity for local fishers' inputs was used effectively, even though all fishing rules had to be approved by the Federal Fishery Agency. Moreover, the positive result from the first rule modification in 1981 led fishers to demand other modifications in 1986 and in 1993 (i.e., there was positive feedback learning). These many changes, in fact, add up to adaptive management arising from the creation of political space for experimentation (Table 3.5).

Equity in resource access was the driving force in many of the changes and conflicts observed in the Lagoon. The creation of equitable access improved system resilience; loss of equity led to conflict and system breakdown, reducing resilience. The

banning of overly efficient nets and lamps, as detailed in Table 3.5, contributed to more equitable resource access and allocation. Such equity could not have been achieved by the use of larger nets by all; the experience in the late 1960s and late 1970s proved that the use of larger nets resulted in resource depletion.

Adaptive renewal cycles depend on the existence of memory for the cycle to resume. Further, innovation and novelty allow the reorganization phase of the cycle to respond to changes. In the Ibiraquera case, the use of fishers' memory and ecological knowledge, as source of innovation and novelty, appear in two circumstances: (a) in the innovation of regulations based on past arrangements; and (b) in using memory /knowledge for resource monitoring and management (Table 3.5). An example is the banning of large nets in 1981 which was inspired by the first attempts in 1971 to prohibit their use in two Lagoon basins. Another example is the regulation prohibiting any fishing activities in the channel and in the small channel between the Upper and Middle Lagoons. These measures were probably based on pre-1970s management practices.

In conclusion, using a combination of common property theory and Holling's (1986) adaptive renewal cycle, the Ibiraquera Lagoon case clearly demonstrates the feasibility of studying the linked dynamics of social-ecological systems. Although the social dynamics and ecological dynamics in this case have different time scales (decadal in the former and a few months in the latter), the resilience of the management system is analyzed through cycles of change. Over the last four decades, the Ibiraquera Lagoon management system has gone through several cycles of change in property rights regimes. These changes have consequences also for resource sustainability.

The trend at the end of the 1990s was one of unsustainable resource use.

However, the pattern of changes in the last four decades provides the promise that the crisis in the late 1990s may trigger a new round of institutional renewal. The impediments for such renewal include enforcement problems, the brittleness of the local fisher organization (Colônia), and the fact that the Lagoon is increasingly used for a different set of economic benefits (i.e., tourism). In one sense, these are adaptive responses, but at a different time-scale (i.e., shorter-term economic gain) than the management of the Lagoon's resilience. To the extent that they result in a loss of options, they entail a loss of resilience in the social-ecological system as a whole. However, the experience of the last four decades indicates that the resilience of the Ibiraquera Lagoon management system is not in its maintenance of stable and sustainable resource use. Rather, it is in its ability to turn successive resource crises into opportunities for a new round of institutional renewal.

Table 3.1. Traditional management practices until the early 1960s, according to phases of the adaptive management cycle (Holling 1986, Gunderson et al. 1995).

Cycle phase	Practices of "traditional" management
Release	Increasing the frequency of Lagoon water discharge into the ocean ('putting the brakes on release') Management of channel openings timed to shrimp post-larvae and fish entering into the Lagoon to avoid ecological surprises Bamboo fence in some Lagoon basins to retain part of fishery stock as an insurance mechanism and to "put the brakes on release"
Renewal	Elders assessing fish migration through the channels connecting the Lagoon to the ocean to signal when the bamboo fence should be built Fence gate controlling the fish coming in and out of some Lagoon basins Prohibition of gillnets and other methods that make noise and disrupt fish migration from the sea into the Lagoon Prohibition of cast-net use in the channel or on the beach near channel mouth to allow fish enter undisturbed into Lagoon Prohibition of fishing during the first two or three days after channel openings in the mullet season to avoid the problem of fish turning back to the ocean
Exploitation	Shrimp cast-net fishing allowed only in shrimp migration channels Fish cast-net fishing allowed only in particular spots Prohibition of setting shrimp/fish gillnets in channel mouth Use of large mesh size only Elders assessing fish migration in the deep channels of the basins to signal whether fishing should be taking place
Conservation	Shrimp cast-net fishing allowed only in shrimp migration channels Fish cast-net fishing allowed only in particular spots Prohibition of setting shrimp/fish gillnets in channel mouth Use of large mesh size only Elders assessing fish migration in the deep channels of the basins to signal whether fishing should be taking place

Table 3.2. Ibiraquera Lagoon ecosystem resilience: Management practices that allowed the use of cast-nets and banned other nets contributed to ecosystem resilience and avoidance of over-fishing in face of a large market demand for Lagoon shrimps and a strong rule enforcement.

	The 1960s	**1970 – 1981**	**1981 – 1994**	**1994 – 2000**
Phases of the adaptive renewal cycle:				
Release				
Lagoon	Cast-net/other nets	Cast-net/other nets	Cast-net	Cast-net/other nets
Channel	Other nets	Other nets	Not allowed	Other nets
Renewal				
Lagoon	Cast-net	Cast-net/other nets	Cast-net	Cast-net/other nets
Channel	Not allowed	Not allowed	Not allowed	Cast-net
Exploitation				
Lagoon	Cast-net/other nets	Cast-net/other nets	Cast-net	Cast-net/other nets
Conservation				
Lagoon	Cast-net/other nets	(no resource left)	Cast-net	Cast-net/other nets
Market demand[a]	None	Small to medium	Medium to large	Large
Rule enforcement[c]	Strong	Weak	Strong	Weak
Ecosystem resilience[c]	Strong	Weak	Medium-Strong	Medium

[a] Scale: *none* (almost no Lagoon shrimp were sold); *large* (almost all Lagoon shrimp were sold).
[b] Scale: *weak* (cheating often occurred); *strong* (cheating hardly occurred).
[c] Scale: *weak* (management practices led the Lagoon stocks to be over-fished before the next release phase (channel opening) – i.e., the Lagoon system was not able to absorb disturbances while maintaining its behavioral processes and structure); *strong* (management practices allowed for part of the stocks to leave the Lagoon during the release phase for reproduction in the Ocean, while retaining another part to ensure the Lagoon stock renewal – i.e. the Lagoon system was able to absorb disturbances while maintaining its behavioral processes and structure)

Table 3.3: The Ibiraquera Lagoon fishing management: changes in property-rights over time.

Periods	**The 1960s**	**1970 – 1981**	**1981 – 1994**	**1994 – 2000**
Decision-making for fishing rules	Local	Local & national	Local & national	Local & national
Degree of rule enforcement	Strong	Weak	Strong	Weak
Informal organization of fishers	Strong	Weak	Strong	Weak
Formal organization of fishers	Weak	Developing	Strong	Medium
Social-ecological system resilience[a]	Strong	Weak	Medium-Strong	Weak
Property-rights regimes	Communal management	Open-access	Co-management (Mix of communal and state)	Mix of state, communal, and open-access

[a] Scale: *strong* (management practices buffered ecosystem disturbances and allowed for ecosystem renewal, while the social system responded to changes in both social and ecological systems); *weak* (management practices did not buffer ecosystem disturbances neither promote ecosystem renewal; and the social system was not able to quickly respond to changes in both the social and ecological systems)

Table 3.4. Key factors that weaken social-ecological resilience.

Key factors	Examples from the Ibiraquera case
1. Breakdown of "traditional" institutions and authority system	Loss of respect for old fishers' practices and knowledge in the late 1960s and late 1970s, and loss of confidence in the Colônia leadership in the late 1990s.
2. Rapid technological changes leading to more efficient resource exploitation	Innovation in fishing gears during the late 1960s led to resource depletion and triggered conflicts among user-groups, as the more efficient gears were not affordable by all fishers.
3. Rapid changes in the local socio-economic system	Rapid changes in local economy during the 1970s impacted the social system that gives support to management institutions. Respect of elders' practices and authority (the enforcement structure) diminished as fishing profits became more and more important. Tourism development introduced additional user conflicts and resource stresses.
4. Institutional instability in higher political level negatively affecting local management	Changes in the arrangement between State and Federal government extinguished fishery inspector positions, leading to an enforcement crisis and management problems.

Table 3.5. Key factors that strengthen social-ecological resilience.

Key factors	Examples from the Ibiraquera case
1. Strong institutions	
(a) Robust local institutions	Respect of elders' practices in the early 1960s, and a responsive fishers organization the 1981-1994 periods.
(b) Strong enforcement of rules (local, regional or national)	Respect of elders authority (informal enforcement) in the early 1960s, strong informal enforcement (voluntary fishery inspectors) from 1971 to 1974, and strong formal enforcement (fishery inspectors) in the 1981-1994 period, were central to successful management.
(c) Strong leaders with credibility and willingness to promote changes	The Colônia president elected in 1981 was determined to change the fishing rules, whereas the previous Colônia presidents had no such interest, as the old rules suited them well.
2. Good cross-scale communication	
(a) Sharing of facts about resource status and threats; ability of resource users to detect environmental modifications and management crises	Fishers detected resource overexploitation in the end of 1970s, and recognized threat posed by the use of gas lamps (too efficient). The knowledge generated at local level by qualitatively monitoring the resource was successfully communicated to the Federal level.
(b) Co-management of the Lagoon using both scientific and local ecological knowledge	Two of the three major changes in the 1981-1994 period were based primarily on local ecological knowledge, and one primarily on scientific knowledge.
3. Political space for experimentation	Three major regulations brought in during the 1981-1994 period showed that the Federal Fishery Agency was open to suggestion by fishers.
4. Equity in resource access	The banning of the use of large nets in two basins from 1971 to 1974 and in all basins since 1981, as well as the banning of gas lamps in all basins since 1986, led to a more equitable resource allocation among user-groups.
5. Use of memory and knowledge as source of innovation and novelty	
(a) Innovation in regulations based on past arrangements	The banning of all nets but cast-nets in all four basins in 1981 were inspired by the 1971 agreement.
(b) Memory/knowledge of resource monitoring and management practices	Although legally prohibited, the use of net fences in some Lagoon basins (traditionally functioning as an insurance mechanism) was informally accepted by the Colônia president and fishery inspectors.

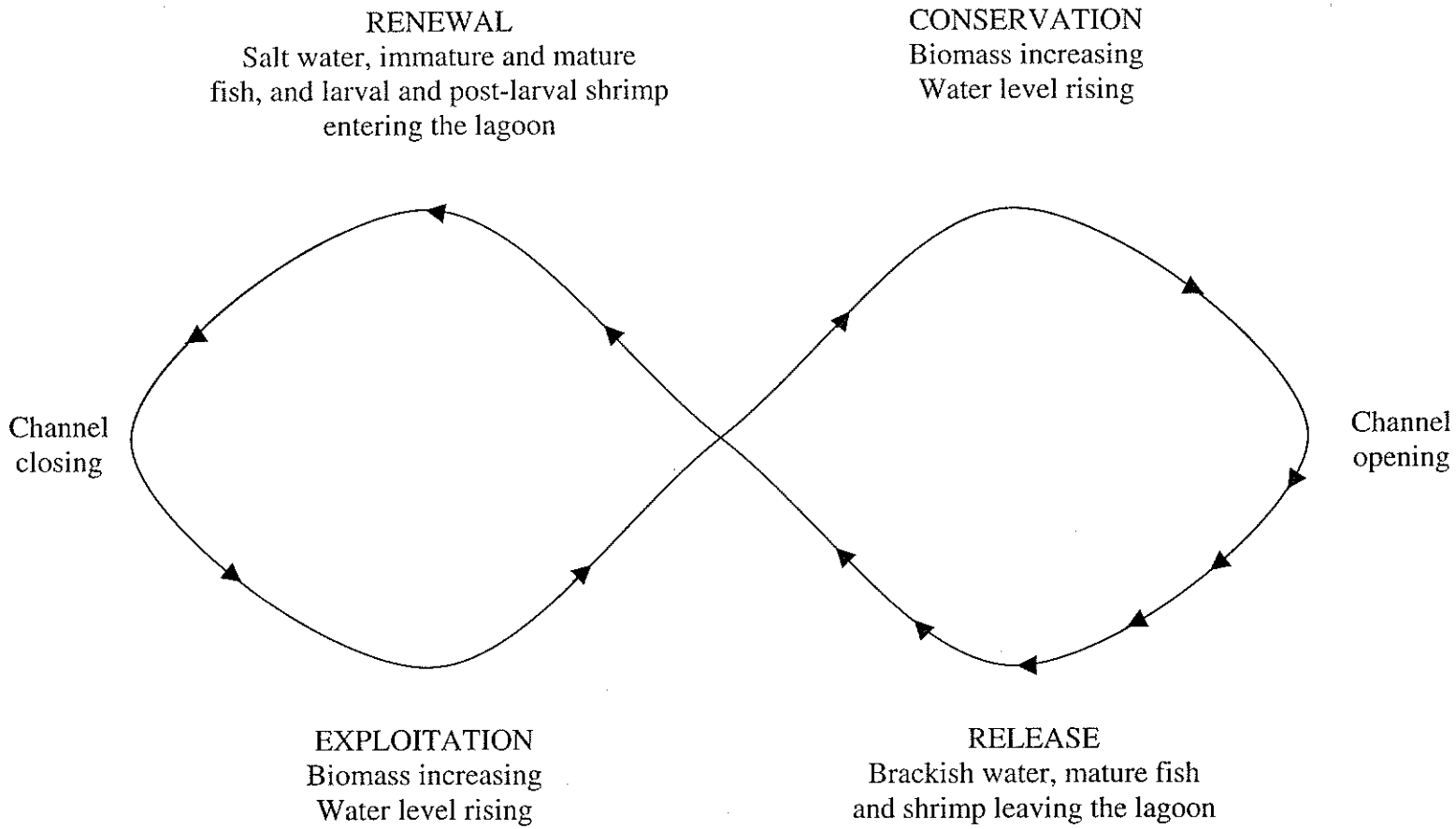
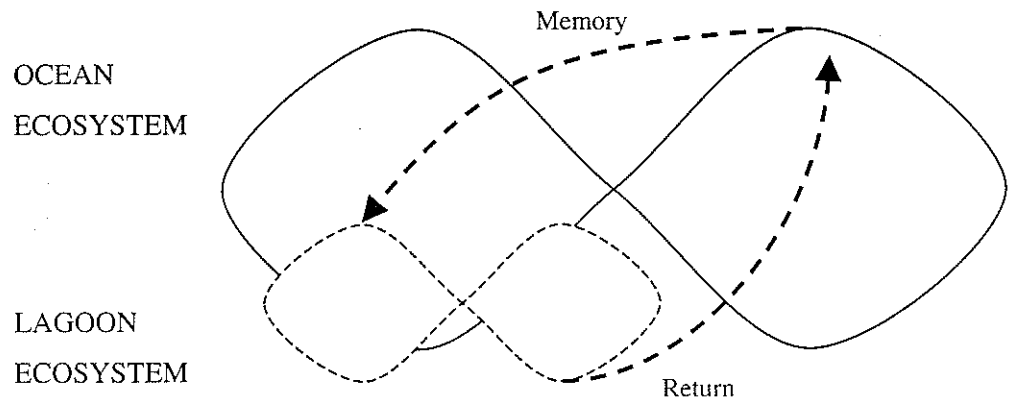


Figure 3.1. Ibiraquera Lagoon ecosystem renewal according to Holling's (1986) adaptive renewal cycle.



Memory (remember): renewal of shrimp larvae and fish from ocean to lagoon

Return (revolt): return of adult shrimp and fish from lagoon to ocean

Figure 3.2. Panarchy: the nested relationship between the small ecosystem (lagoon) and the larger ecosystem (ocean). Panarchy idea after Holling (2001) and Gunderson and Holling (2002).

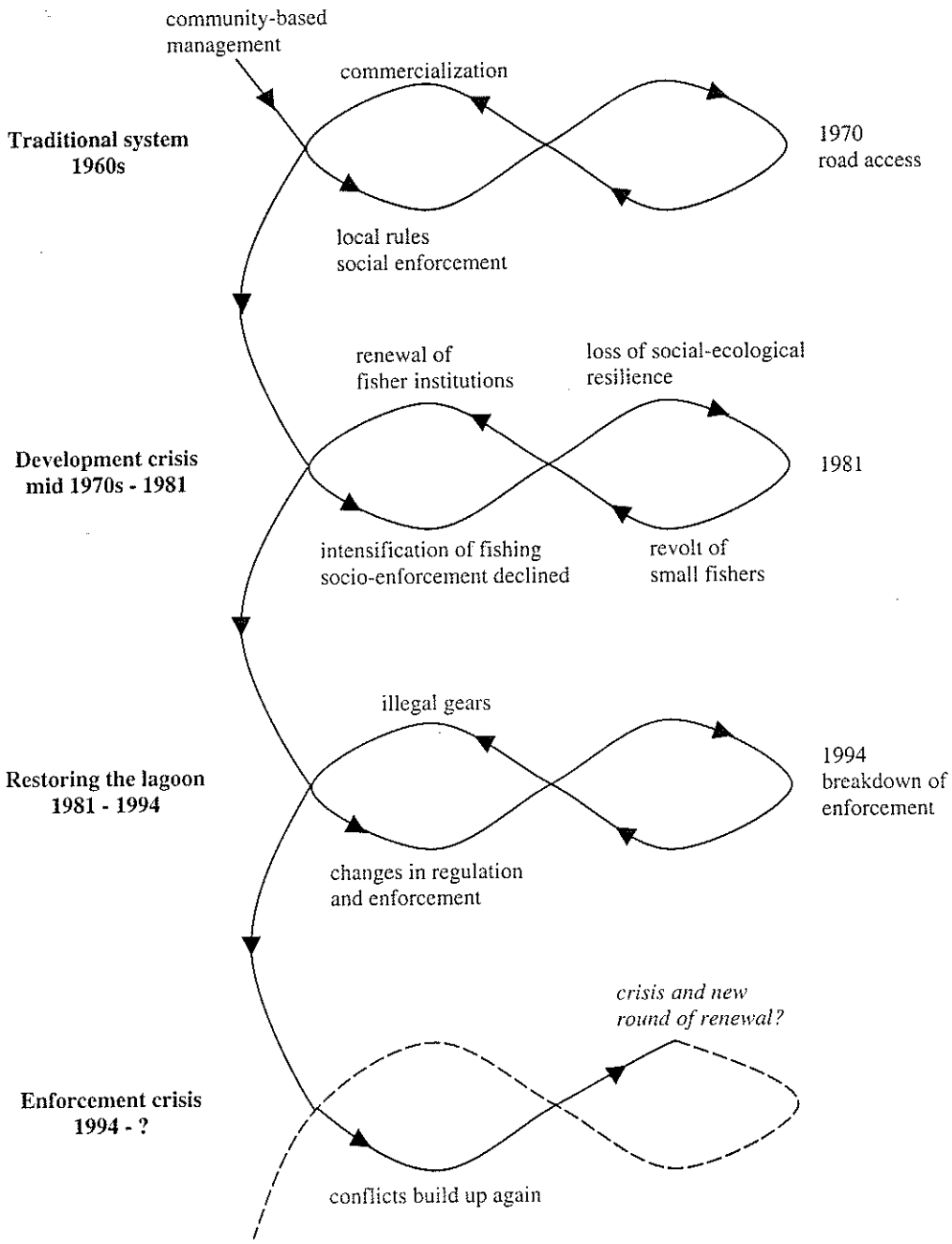


Figure 3.3: Different periods of Lagoon and fishery management in Ibiraquera, as represented by successive iterations of the adaptive renewal cycle (Holling 1986, Gunderson et al. 1995).

Chapter IV

Ecological economics of the Lagoon system: Incentives and constraints to development

Ibiraquera community council members cleaning the edge of the Lagoon (Summer 2000).

Chapter IV

Ecological economics of the Lagoon system: Incentives and constraints to development

This chapter presents an ecological economics approach for coastal resource management, focusing on the case study of the Ibiraquera Lagoon fisheries management, in Brazil. First, the ecological economic approach is introduced; second, the socio-economic and ecological history of the area is presented; third, the socio-ecological incentives and constraints to development are discussed; fourth, the major socio-economic events and their effects on the management system is addressed, and finally an alternative management design for the Lagoon fisheries system is proposed.

4.1 Introduction

It is often argued that the ultimate goals of natural resources management shall be ecological sustainability, economic efficiency and social justice (intra- and inter-generations). In order to propose or reformulate management rules and policies to achieve these ultimate goals, natural resources managers shall understand how ecological and socio-economic systems interconnect and change over time as they constantly co-evolve. For this purpose, the ecological economics view of systems interaction can provide a useful analytical framework. Ecological economics acknowledges that "human preferences, understanding, technology and cultural organization all co-evolve to reflect broad ecological opportunities and constraints" (Costanza et al. 1997, p.337). The Earth

is seen as materially finite and a closed system; hence, technical advances do not create new resources (i.e., human-made capital is a complement to rather than a substitute for natural capital) (Daly 1977). Surprises and uncertainty are considered part of any ecosystem although they may have exogenous origins (Holling 1986).

Ecological economics differs from conventional neo-classical economics in that the latter typically "assumes that society is simply the sum of its individuals, the social good is the sum of individual wants, and markets automatically guide individual behavior to the common good." Ecological economics, on the other hand, acknowledges that "community relations define who people are, affect what they want, [and] facilitate collective action" (Costanza et al. 1997, p.24).

Using theories, concepts and instruments from different disciplines[1] and rethinking their applicability, ecological economists investigate co-evolutionary processes between environment, technology, knowledge, institutions and values, to develop tools (e.g. policy instruments) that are able to promote sustainable governance of resources (Constanza et al. 1997). Policy instruments can be used to incorporate environmental uncertainty and the real value (including the long run ecological costs) of natural capital (including both materials and services) into the economic system. As well, they can be used to minimize the differences in income distribution and resource access, both inter- and intra-generationally.

Concerning coastal and ocean management, some ecological economists suggest six principles – the Lisbon principles – to be applied when formulating policies to

[1] Ecological economics draws on several approaches including systems analysis, evolution and co-evolution of systems, adaptive management, property-rights and other institutions, energetics, steady-state economics, and neo-classical economics.

promote sustainable governance of the oceans (Costanza et al. 1998, 1999). These principles concern:

1. the responsibility of individuals or corporations to use environmental resources in an ecologically sustainable, economically efficient and socially just manner (*Responsibility principle*);
2. the importance of assigning decision-making to the scale of governance which has the most relevant ecological information, which considers ownership and actors, and which internalizes costs and benefits (*Scale-matching principle*);
3. the need to take uncertainty about potentially irreversible environment impacts into account (*Precautionary principle*);
4. the requirement to continuously monitor social, economic and ecological information because resource management systems are dynamic and have some level of uncertainty associated with them (*Adaptive management principle*);
5. the need to identify and allocate all internal and external costs and benefits (social and ecological) of alternative uses of environment resources (*Full cost allocation principle*);
6. the importance of full stakeholder participation in the formulation and implementation of decisions about environmental resources (*Participation principle*).

Because two-thirds of the world's population lives in coastal areas and human welfare is highly dependent on the oceans (Costanza 1999), disruption of coastal ecosystems is one of the major threats, both to the oceans (Antunes and Santos 1999) and to humans

themselves. Hence, appropriate governance of coastal areas and management of coastal resources must be a high priority policy for any state with coastal area. Ideally, effort shall be made to promote sustainable governance of coastal areas at the global scale. However, such global effort can be very costly in time and money. Actions taken locally are more likely to be effective in the short run as "local level institutions are generally better able to identify the recipients of both costs and benefits and assign responsibilities that internalize both" (Costanza et al. 1999).

In this context, the aim of this chapter is to use an ecological economic approach to investigating management strengths and shortcomings of a coastal ecosystem in order to propose more appropriate policy instruments and management rules. The study focuses on the co-evolution of local communities and the Ibiraquera Lagoon in the Southern Brazilian coast. This area was chosen because it is a micro-watershed where most environmental impacts are locally generated and can be locally addressed. That is, there is no 'exportation' of problems downstream or 'importation' from upstream in the watershed, although Lagoon problems may be exported to the ocean and vice-versa. The specific objectives of the study are (a) to examine interactions between changes in the local economy and the evolution of the shrimp market; (b) to understand how the local economy affects and is limited by the Lagoon ecosystem; and (c) to propose some management alternatives based on the Lisbon principles (Costanza et al. 1999).

4.2 The case study

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

communities around the Ibiraquera Lagoon: Ibiraquera (also known as Teixeira), Barra da Ibiraquera, Arroio, Alto Arroio, Araçatuba, Campo D'Una, and Grama (or Ibiraquera de Garopaba) (Figure 1.3). Most of the local people are descendents of immigrants from the Azores Islands, who arrived in this part of Brazil about 200 to 250 years ago. Until the 1960s, most communities were quite isolated, living on household agriculture and subsistence fishing. Many socio-economic and ecological changes have occurred since then, and as of year 2000, tourism-related activities had come to dominate the economy of most communities; yet fishing continues to be an important source of cash or in-kind household income.

As of the year 2000, there were about 350 professional (licensed) fishers, few sport (licensed) fishers and several unlicensed fishers living in the seven communities around the Lagoon. Legally, any Brazilian who has a professional fishing license can fish in the Lagoon. Those with sport fishing licenses or no licenses cannot. Professional fishing licenses, in law, are supposed to be issued only to those who make their main living from fishing. But in reality, they are issued to almost anyone who requests them. The main requirement for a professional license is the testimony of two professional fishers that the requester makes his living from fishing. Thus, there is no effective legal access restriction to the Lagoon.

The Ibiraquera Lagoon is an assembly of four interconnected small basins, Lagoa de Cima, Lagoa do Meio, Lagoa de Baixo, and Lagoa do Saco ('Upper Lagoon', 'Middle Lagoon', 'Lower Lagoon', and 'Saco Lagoon') with a total area of approximately 900 ha (Figure 1.3). This is a shallow lagoon; most of its area is between 0.20 m 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. Freshwater input is mainly through rainfall and springs which feed the Lagoon at nine or more points. The water level in the Lagoon system rises as the season progresses. Through most of the year, there is a sandbar between the Lagoon and the Atlantic Ocean. If there is no management, 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. That is, the lagoon is seasonally connected to the Atlantic Ocean.

To understand the interactions over time between the local socio-economic system and the Lagoon ecosystem, I first investigate the Lagoon's major fishing resources. Second, I examine the socio-economic evolution of local communities. Third, I describe changes in the Lagoon management in response to changes in the local and regional socio-economy. Fourth, I study the evolution of Lagoon's shrimp and fish market. Finally, I analyze some of the major socio-economic factors affecting resource stocks, allocation, and sustainability.

4.2.1 Methods

Fieldwork was carried out between June 1999 and May 2000. Research methods included interviews, archival research, participant observation, and collection of data on types and quantities of fish and shrimp harvested and marketed. Interviews were carried out in several formats -- structured interviews, semi-structured interviews with key informants

and small groups, ethnomapping -- to elucidate fisher knowledge, fishery activities (resources, gears and purposes), the local fish and shrimp market, and main changes in the local socio-economic and ecological systems over the last five decades. Eighteen interviews ranging from 30 minutes to 2 hours in length were recorded. The interviewees included knowledgeable fishers, the local fishers organization's president, a local middleman, 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. Archival research was done to trace changes in fisheries legislation and the local socio-economic system. 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, fishery association officials, government officials, and community councils.

Data analysis was based on triangulation of data from field notes, transcribed interviews, and external sources including documents and literature. In addition, the main findings from a preliminary analysis (April, 2000) were checked by 12 people including fishers, local residents, local school teachers, the fishers organization's president and a government agent working in the area.

Estimations of fish and shrimp abundance and harvest, fish and shrimp migrations, and seasonal cycles of the lagoon were based on information from key informant interviews backed by field observations. (There are no reliable fish and shrimp population or harvest statistics available for this locality or for most inshore fisheries in

Brazil.) The major species of fish, shrimp and crabs were collected in the field and identified by the use of species keys or by taxonomic specialists. Of about 39 species identified by fishers, 24 were recorded in the field, and 17 were identified biologically (Chapter II).

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 (28 weeks). These were all the middlemen that I could identify in the area, and the retail stores and restaurants were the only ones who bought shrimp directly from local fishers. There were several other restaurants in the area that bought shrimp only from local middlemen or from the regional market. These data provide useful insights to understand part of the local shrimp market. However, they are not an accurate estimate of the Lagoon's total shrimp production during the period. For instance, they do not account for (a) shrimp that local fishers sold directly to consumers, (b) shrimp that outside fishers sold elsewhere, or (c) shrimp used for fisher own consumption.

4.2.2 Lagoon's major fishing resources

The Ibiraquera Lagoon's main fishing species are 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 one's own domestic consumption. The Lagoon shrimp and fish stocks are mainly determined by the season when the channel connecting the Lagoon to the ocean is opened, by the length of time it remains open, and by fishing activities.

The season when the channel opens has an effect on species diversity that may enter the Lagoon. When the channel is open, most shrimp larvae and post-larvae, as well as young and adult mullet, enter the Lagoon to grow in its warmer waters. Mature fish and shrimp return to the ocean in a subsequent channel opening which can vary from a few weeks to several months, depending on rainfall. Hence, channel openings have been managed to match fish and shrimp stocks moving through the ocean in front of the channel. Adult mullet in spawning migration (those with higher economic value) usually appear along the ocean shore in the winter, from May to August. A major recruitment peak for shrimp at Ibiraquera Lagoon occurs during spring months and a minor one occurs during fall. Seasons may also influence growth rate of some species. For instance, shrimp grow from post-larvae to young individuals more quickly (usually two or three months) during hot months (October to March) and more slowly (about four months) during cold months (May to August).

The length of time the channel remains open influences the chances of fish and shrimp to enter or leave the Lagoon. If the channel is open for a long period and no management actions is taken place, 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 it might happen that no much stock renewal occurs (i.e., not much fish or shrimp enter the Lagoon).

Another major determinant affecting the Lagoon's stocks is fishing activities. The capture of small individuals from fish and shrimp stocks reduces the potential harvest of larger (and better-priced) individuals in the future. This effect is characteristic of all fisheries, but is particularly true of a temporarily closed system such as the Ibiraquera

Lagoon. In other words, fishing rules (formal or informal) and their enforcement are critical for sustainable yields from the fishery. Fishing rules (or lack of them) specify permissible gear types, mesh-sizes, and fishing spots, and restrict access. The evolution of fishing activities and their influence on the Lagoon's stocks and harvests is investigated in a later section of this chapter.

4.2.3 Socio-economic evolution of local communities

Over the last five decades of the 20th Century, communities around the Ibiraquera Lagoon experienced major socio-economic changes. Although each community had its own particularities, the overall picture for the area shows that the local economy moved from a household-level agriculture during the 1950s to a mix of agriculture and small-scale commercial fishery during 1970s and to tourism-related activities during the 1990s. The main driving forces influencing such changes seems to be road access in the case of fisheries and proximity to the ocean in the case of tourism. I expand on these issues.

In the 1950s and the early 1960s, there were relatively few, but quite large[2] families living in the communities around the Lagoon. Four of the seven communities had no road access to other localities, none had electricity, five of the seven had no general store, and none had a fish store. Transport of people and goods among some communities was usually through pole canoes along the Lagoon or through ox and cart along trails. Household-level agriculture was the main source of income for most families, and fishing was mainly for subsistence[3]. There were no local employment opportunities for young people who often migrated to big cities for work. Men were

[2] At that time, families with 10 or more children were not an exception.

usually in charge of both farming and fishing, and women were responsible for housekeeping, although they also helped men with farming, crab fishing and production of manioc flour and sugar.

Cultivated crops included manioc, corn, beans, watermelon, potato, rice, coffee, banana and sugarcane, among others. Crops and/or their products were sometimes traded among locals (for example, sugar for coffee, fish for coffee, and fish for manioc flour). The only products sold by locals, however, were manioc flour and sugar, which were produced using ox-powered mills. In this system, middlemen provided clothes, shoes and other basic goods to local families in exchange for freshly produced flour. That is, there existed a patronage system. Some families, however, were able to stock 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 access to the region by tourists and outside fishers. From the mid-1970s on, tourists started to explore the Ibiraquera region, first by camping and later buying property from locals 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. 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 firewood stove), etc. 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 economy of some

[3] Indeed, fish and shrimp were the main source of animal protein for locals.

communities started 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 big cities. The local population increased, more markets and retail outlets were created (including fish/shrimp stores), and tourism resorts and summer cottages were built. Public transportation became available for most communities during the 1980s and some local residents started to commute daily to work at industries and other businesses in Imbituba or Garopaba (a nearby town).

During the 1990s, tourism-related activities had dominated the economy of most communities. Fishing became a part-time activity for most fishers who started to work for tourism. These fishers reduced their fishing efforts from a night-long activity to about two to four hours per night. Several fishers were employed in construction 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 fancy 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 and most local fishers sold shrimp and bought beef to supply their diet with protein as beef became cheaper than shrimp. This happened because the price of shrimp came to exceed that of beef as a result of the dynamics of the shrimp market.

In most communities, household-level agriculture declined to a minor activity to supplement the diet and supply a small local market. For instance, according to one informant, by the end of the 1980s, there were about 40 manioc-flour mills in the local communities; as of 2000, there were fewer than 10 mills. In addition to cultivating crops,

some families raised a few (usually two or three) cows or oxen and some small animals (e.g., chickens and pigs) which they sold locally. It seems that cows and oxen were used as saving investments for locals – a common tradition in rural Brazil where most people do not have a banking account; but no detailed study was performed in this sense.

As of 2000, the local economy was totally integrated into the regional economy and had become significantly influenced by the latter. For example, pollution of other lagoons in the region has pushed many outside fishers into Ibiraquera. The area surrounding the Lagoon and the nearby beaches on the ocean became a popular summer spot for tourists from other Brazilian states and even from other countries, especially Argentina. The local population has grown at an accelerated pace during the past two decades despite the fact that the number of children per family has decreased considerably (estimates vary from one to five children in 2000). This population growth is due in part to the growth in the tourism industry which is drawing new residents to the Lagoon communities to open tourist businesses. Although population numbers by village are not available from the government census data, a population estimate can be made from the data on households and the average number of people per household[4]. For the seven villages in the Lagoon area, this estimate comes to about 5,000 people in 2000. Judging by the number of summer cottages, which is twice the number of resident households, the population of the area is estimated to reach about 15,000 people in the peak tourism season.

[4] Data on residential buildings per community were obtained 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.

The picture of socio-economic changes just described encompasses aspects of most communities around the Lagoon. Each community, however, has its own particularities and economic history (Table 4.1). It seems that the two major factors influencing economic changes in each community were (1) road access and (2) proximity to ocean beaches. Road access allowed for the development of small business (starting in Araçatuba) while tourism-related activities expanded mainly in communities close to the ocean beaches (Ibiraquera, Barra de Ibiraquera and Grama).

Indeed, several interviewees associated the development of local communities with road construction. They also associated road access with an increase of outside fishers and decline of fish and shrimp stocks in the Lagoon. As expanded in the next section, road construction allowed for the development of a shrimp market, which in turn, furthered an increase in fishing efforts and a decrease in the stocks. The history of Ibiraquera communities shows, therefore, both the positive and negative impacts of 'development'. For instance, several interviewees emphasized the contrasting scenario of the local economy in the late 1990s compared to the 1950s and 1960s when they were young. They usually talked about how difficult life was before roads were built, electricity became available, local markets emerged and tourism began; and what hard work it was to cultivate manioc and produce its flour. On the other hand, some locals also recognized the negative impacts of the local 'progress'. One old fisher mentioned that after electricity became available, major destruction of the area occurred (*A luz acabou com tudo*) and the community he lives in (Barra da Ibiraquera) grew tenfold in number of household between 1990 and 2000. Examples of environmental destruction include several sand dunes that were removed, forest areas and *restinga* vegetation that were

wiped out, and pollution problems that arose. Some of these issues are addressed in a later section of this chapter.

4.2.4 Interaction of socio-economy and Lagoon management

During the 1950's and 1960's, the main fishing strategies in the Lagoon included the use of cast-nets and gillnets (used as setting-nets, encircling-nets or seine-nets) to catch fish, and cast-nets with kerosene lamps to catch shrimp. Although the local fishers' organization (Colônia de Pescadores) and a federal government fishery agency[5] already existed, they did not play any important role in the local management of the Ibiraquera Lagoon[6]. Local rules and traditional practices were sufficient to manage the Lagoon fisheries. According to fishers, during these decades, they captured mainly large fish and shrimp, and harvests were quite good for four main reasons. First, the two main fishing gears, gillnet and cast-net, were made of natural fibers which limited their mesh to large size. Second, there were relatively few families living around and fishing from the Lagoon, i.e., low use. Third, fishing was mainly a part-time activity for subsistence purposes only. Fourth, fishers respected the practices and rules of long-term fishers regarding where, when and how to fish or not to fish (i.e., the traditional management system). The fishers interviewed viewed these four factors as being responsible for the

[5] Divisão de Caça e Pesca (DCP) was replaced by Superintêndia do Desenvolvimento da Pesca (SUDEPE) in 1962.

[6] Colônia dos Pescadores was responsible for helping fishers to get their fishing licenses and to take fishers' complaints to the state fishery agency (Departamento Estadual de Caça e Pesca – DECP); but Colônia had no power in decision-making or enforcing of fisheries regulations. Federal government (DCP and SUDEPE) regulations concerning access rules and technological limitations were very general and hardly enforced in small-scale fisheries. Federal fisheries policy at that time focused on promoting fisheries development and organization at medium and large scale through economic incentives (Abdallah 1998).

large sustainable individual harvest of fish and shrimp enjoyed by fishers during the 1950's and 1960's.

Socio-economic changes during the late 1960s and the 1970s led, however, to several periods of resource over-exploitation during this time. Two main factors were responsible for these periods of over-harvest: technological improvements, and road construction which led to the emergence of markets for Lagoon fish and shrimp.

First, technological innovations in fishing gears and strategies resulted in more efficient fishing. The improved gear included monofilament nylon nets, smaller mesh-size nets, and butano gas lamps which attracted significantly more shrimp than kerosene lamps. A new strategy was the use of a gillnet as beach seine along the Lagoon shore. As a result of the introduction of these gears and strategies, fishers harvested larger quantities of, albeit smaller, fish and shrimp, in a shorter time. Fishers also spent less time fixing or making nets as nylon nets were more resistant than natural fiber nets. These technological innovations also intensified the frequency and gravity of conflicts between the two major user-groups, gill-netters and cast-netters, over resource access[7]. Such conflicts had existed for decades but were often expressed in forms of complaints with few episodes of physical confrontations. Since technological innovations resulted in an increase of size and amount of gill-nets set in the Lagoon, which in turn led to over-harvest, some physical confrontations occurred, the police were involved in many cases, and some fishers were arrested.

Second, road construction allowed for the emergence of a shrimp market, which shifted fishing activities from subsistence to commercial fishing in response to outsiders'

[7] Gill-netters (few fishers) were able to catch more fish than did cast-netters (most fishers), as the amount of effort required to fish with cast-nets is greater than that required to fish with gillnets

demand for Lagoon products. As well, roads brought outside fishers to the Lagoon, increasing the number of users harvesting resources. Roads also brought tourists, increasing demand for fish and shrimp. As a shrimp market emerged, profit-oriented fishers started to disregard traditional rules governing access and gears (i.e., how, when, and where to fish) and began to fish in areas not allowed before and to use smaller-mesh cast-nets. By the late 1970s, all fish and shrimp stocks in the Lagoon were caught within about two or three months of channel closure. This meant that there was almost no harvest in the Lagoon for several months before the next opening. In contrast, during the 1950s and 1960s, fish and shrimp stocks in the Lagoon lasted from one closure until the next opening. During the late 1960s and 1970s, federal government regulations existed limiting net mesh-size, gillnet length, and types of nets allowed in the Lagoon[8]. However, the rules were not effectively enforced.

Declining fish and shrimp stocks, fishers' economic dependence on fishing, and conflicts between user-groups triggered several changes in Lagoon fishery management during the 1980s and early 1990s. First, a new leader with credibility and willingness to promote changes was elected for the local fisher organization in 1981. Second, the federal government approved three regulations demanded by local fishers which reduced fishing effort and led to more equitable resource allocation among fishers. These regulations included (a) banning of gillnets in 1981; (b) banning of the butano gas lamps which were being used with a new fishing gear (a hand-held shrimp tong) to catch small

[8] The Federal Fish Agency, Superintendência para o Desevolvimento da Pesca (SUDEPE), issued several regulations for national or state territory which apply to the Ibiraquera Lagoon, and included the following rules: Establishment of minimum mesh size of 2,5 cm for shrimp cast-net (1970), of 5,0 cm for fish cast-net (1972), and of 7,0 cm for fish gillnet (1972); prohibition of setting gillnet longer than 1/3 of lagoon width (i.e., it also prohibit the use of nets as fences in the lagoon channels) (1972); prohibition of trap net use in the channel linking the lagoon to the ocean (1972); prohibition of hand-drawn beach seine and seine (1972) and trawling (1975).

shrimp in their feeding areas, in 1986; and, (c) banning of shrimp cast-nets with mesh smaller than 3.0 cm stretched measure, in 1993. Third, the municipal government issued a regulation prohibiting any type of engine, which disturbed fishing in the Lagoon in 1995; only dugout canoes with poles or paddles were allowed. Fourth, rule enforcement became effective as two state fishery inspectors were designated to the area. Most of these changes served to improve shrimp and fish stocks and harvest.

Despite the recovery of Lagoon's shrimp and fish stocks, the natural shrimp production became insufficient to supply the local market during the 1990s due to increased shrimp demand as tourists, the local population and the number of outside fishers increased. From 1992 to 1998, a shrimp-stocking project (Andreatta et al. 1993, 1996) took place in the Lagoon increasing the overall shrimp production considerably. For instance, a report estimates the shrimp harvests in the first two years of the project to have been as follows: 72,699 kg of pink-shrimp (*F. paulensis*) and 10,198 kg of white-shrimp (*P. schimitti*) (Andreatta et al. 1993). This project improved fishers welfare (better houses, appliances, etc.) by bringing more money to them as well as to middlemen. Because it was a research project, shrimp post-larvae were financed by research funds[9]. That is, fishers profited from an increase in the Lagoon's shrimp stock. Fishers said that, once the project was underway, they could get a lot of shrimp year round, while before the project, shrimp catches during the winter were usually low. The project ended due to a lack of funds.

In 1994, the fishery inspector positions were extinguished, probably due to budget

[9] The shrimp stocking project was funded by three federal government agencies: Fundação Banco do Brasil (1992-1993); Fundo Nacional do Meio Ambiente (1994-1996); Programa de Execução Descentralizada do Ministério do Meio Ambiente (1997-1998).

constraints. In the absence of local fishery inspectors, the newly implemented rule enforcement structure proved to be ineffective from 1994 to 2000. As a result, several unregulated fishing activities took place during this period, including the use of banned gears and new destructive gears. These activities negatively affected shrimp and fish stocks. At the same time, there were emerging challenges to the Lagoon fishery from the increase of tourists, whose sailing and sport fishing interfered with professional fishing (i.e., fishing carried on by part-time and full-time local fishers). As well, there was an increase of outside fishers, and the unregulated growth of summer cottages, guesthouses and restaurants. Excessive development was destroying vegetation on the Lagoon edge which, in turn, increased erosion, siltation, and mudslides, filling the fish migration channels and destroying fish and shrimp feeding habitat. In addition, drainage of sewage into the Lagoon by the large number of tourists and illegal constructions (with poorly constructed septic tanks) was polluting the Lagoon.

Various Lagoon communities responded to the lack of rule enforcement in various ways. A subset of local fishers decided in 1998 to organize themselves into groups to patrol the Upper Lagoon. Nonetheless, this activity did not last long because fishers lacked legitimacy. Indeed, they were sometimes threatened with shotguns by those fishers using illegal gears. As well, to deal with the impacts of unregulated tourism, three of the seven communities surrounding the lagoon have re-activated their community councils[10] in 1999/2000. The results of their actions are still yet to be verified. To tackle the siltation problem, the fisher organization, in cooperation with state and

[10] Conselho Comunitário de Ibiraquera and Associação dos Amigos da Praia da Barra da Ibiraquera were activated in 1999, while Conselho Comunitário de Araçatuba was activated in 2000. The Associação de Ibiraquera-Gramense has been active since 1986.

municipal governments, implemented a Lagoon dredging project whose effects remain uncertain.

The scenario at the end of the 1990s indicated that a new resource crisis was emerging. It is noteworthy, however, that at that time, very few fishers (less than 10 of 350 holding professional licenses) were strictly dependent economically on fishing (i.e., full-time fishers). Most local fishers were part-time fishers, working in tourism-related activities, and fishing shrimp at night to supply the local market and supplement their incomes. In contrast, most outside fishers were mainly sport fishers. Consequently, as a fisher stated, if another big production crisis occurred in the Lagoon, this crisis would not be as disruptive to fisher well-being as those of the end of the 1960s and 1970s, because fishers are less dependent on fishing in the late 1990s than then. On the other hand, because the Lagoon is one of the major attractions of the region, a large disruption in its ecosystem, for instance caused by pollution, would negatively impact tourism activities, and consequently, fisher well-being.

4.2.4.1 Fishing activities in the late 1990s: species, gears, and fisher-groups

During fieldwork, several fishing methods were observed. Table 4.2 presents these and other methods that are used but were not observed during the fieldwork for this research. For each fishing method, Table 4.2 identifies the target species, gears used, legitimacy, main season, fishing time, user-groups and fishing purposes. Shrimp is the major target species and it is used largely for sale but also for fisher's home consumption. Blue crab is captured mostly for home consumption. Mullet (large fish) and mojarras (small fish, *Eucinostomus* spp.) are the main target fish species. The former is used either for home

consumption or for sale; the latter is mainly for home consumption. Other fish target species include small blue-fish (*Pomatomus saltatrix*), small grouper (*Epinephelus* sp.), and sardine (Clupeidae, e.g., *Opistonema oglinum*) which were caught exclusively for fishers' home consumption.

Significant use of illegal fishing gears and methods is apparent in the Lagoon (Table 4.2). Illegal methods were used by sport, part-time and full-time fishers, and by both local and outside fishers. In spite of the large diversity of fishing methods, shrimp is mainly caught with cast-net and kerosene lamp when the channel connecting the Lagoon to the ocean is closed, and with trap-nets and hoop-nets set in the channel soon after it is opened (for about one week or so)[11].

Trap-nets and hoop-nets are illegal because they prevent shrimp from leaving the Lagoon and reaching the ocean to reproduce. One trap-net can capture up to 200 kg of shrimp per night while a fisher throwing a cast-net usually catches only about 2 kg per night in a reasonable night (up to 10 kg per night in a rare very good night). The amount of shrimp captured by each cast-netter in one night may vary considerably according to (a) a fisher's ability and knowledge about shrimp behavior; (b) shrimp movements inside the Lagoon; (c) time spent fishing. Shrimp movements inside the Lagoon depend on several factors such as moon phase, wind direction, rapid temperature change, tides, and presence of luminescent algae. Time spent fishing usually alters according to the purpose of and dependence on fishing. The peak number of shrimp cast-netters is in the first hours of the night when sport-fishers and most part-time fishers are still fishing (Figure 4.1). Late in the night only few fishers, probably full-timers, still keep fishing.

[11] It is important to observe that the time of channel openings may vary considerably from year to year, as it depends on the Lagoon's high water level.

4.2.5 Evolution of markets for the Lagoon's shrimp and fish

Although fishing was mainly for subsistence during the 1950s and 1960s, fishers sometimes sold shrimp by transporting it on their backs along the beach (about 11 km) to Imbituba. Fish was seldom sold and only inside local communities. To store fish, many families sun-dried it with salt or hard-pressed it with salt; however, it was usually sold fresh. Shrimp was sold either fresh or salted and dried, and either by dozens or by other units locally called *saco* (a manioc flour bag of approximately 50 to 60 kg), *arquê* (half-*saco*), and *meio-arquê* (half-*arquê*). Later, fishers had to adopt the standard unit, kilograms (kg), used in regional and national markets.

In the early 1970s, two local residents (one from Grama and other from Teixeira) bought cars and started to buy shrimp from the Lagoon and sell it in the regional market (fish continued to be sold by fishers within local communities only). This shrimp trade became possible due to road construction (i.e., giving access to remote communities) and available electricity (i.e., shrimp could be preserved in refrigerators). As a result of tourism development from the mid-1970s on, a local market for fish and shrimp emerged, increasing demand and prices, especially for shrimp. In the late 1970s, at least five middlemen were already 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. Fishers, in turn, were obliged to sell all of their catch to the particular middleman who had helped them before.

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 or grocery retailers, which paid better prices than middlemen did. 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 the local market 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 diminished or stopped loaning money to fishers. In 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 buyers who paid the best prices, regardless of whether the buyers were consumers, restaurants, retailers or other middlemen. From this study, it appears that the role and prominence of the middlemen declined as fishing declined in importance as a source of income for fishers. In the Lagoon communities in 1999, the fishers who were still most engaged with middlemen were those who still fished full-time. Part-time fishers who relied less on fishing for income and income stability could afford to assume the risk of abandoning the patronage system 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 their patrons. The few full-time fishers seemed to still rely heavily on middlemen support, especially during low tourist seasons and non-productive months (e.g., they borrowed money from middlemen in an informal credit system). Although full-time fishers could be better off selling shrimp directly to consumers during high seasons, they had to ensure having a buyer during low tourist seasons.

Whether middlemen take advantage of (wrest surplus from) fishers in the patronage system is unclear. One full-time fisher said that middlemen do not charge interest rates for loans, and do not pay less for shrimp when fishers are repaying their debts. On the other hand, another full-time fisher mentioned that middlemen underpaid when fishers are repaying debts. Perhaps this might occur in some but not all cases. What is clear is that some middlemen pay less for shrimp than others. One full-time fisher described patronage relations as a positive thing, although he made it clear that he sometimes sold shrimp directly to consumers. It was interesting to note that some fishers, especially full-time fishers, tried to create a *compadrio* (godparenthood) relationship with middlemen, by inviting middlemen to baptize their children. This can be seen as a way to ensure economic safety. Godparenthood networks have also been observed in Bahia (Brazil) to ensure success in fishing (Cordell and McKean 1992).

4.2.5.1 Shrimp/fish market in the late 1990s

The channels through which local shrimp were marketed at Ibiraquera during the 1999-2000 fieldwork season are presented in Figure 4.2. Fishers may sell their catch to consumers (both residents and tourists), local grocery stores (retailers), local and non-

local restaurants, and middlemen. Sellers of shrimp may 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. A smaller portion of local fishers' catch was sometimes used for their families' own 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 in 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 sources of income, which allowed him to open his shop only during high tourist season – the most profitable time. Indeed, this middleman is an entrepreneur – one of the first two who started marketing shrimp from Ibiraquera to the regional market in the early 1970s. In the late 1990s, he had some 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 to buy 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 did spend 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 tradeoffs between having a shrimp shop and spending time searching for sellers is, thus, not clear-cut. On 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. In the latter case, however, the middleman also uses his time and instruments to trade, to a lesser extent, some other farm products and animals, such as manioc flour, poultry, and cow.

During quantitative data collection on shrimp commercialization, due to the need to guarantee fishers' anonymity (and to avoid conflicts), it was not possible to identify specifically which fishers sell to which middlemen or retailers and under what circumstances. However, some middlemen mentioned that there was an informal division of areas around the Lagoon where fishers lived, from which middlemen bought shrimp. As these middlemen described it, a middleman drives to fishers' houses to buy shrimp, usually two or three times in a week. During peak shrimp season, the middleman might expand to six trips per week. During low-productive season, the opportunity cost of each trip increases, thus the middleman makes only one trip a week, which is possible because all fishers own refrigerators in which to store shrimp.

Although most fishers were free to sell their catch to any middleman, sometimes there seemed to be a temporary loyalty between a fisher and a particular middleman, and this relation seemed to be respected by other middlemen. From time to time, this loyalty was broken when another middleman offered better prices for shrimp or for some reason a middleman temporarily could not work. For instance, one middleman complained that another offered much better prices for shrimp soon after the Lagoon channel was opened (during a highly productive part of the season), which the first middleman was unable to match. This occurred because the business of the first middlemen was much smaller than that of the second one. Hence, the first middleman lost all 'his' fisher loyalty. 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 in the tourist season. It is important to note that 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 tourists because of the higher prices tourists pay. In conclusion, the dynamic relations between middlemen and fishers might be explained either by a weak patronage system (see above section) or by price-driven factors. Before investigating shrimp prices, however, it is important to understand the relationship between of the quantity of shrimp marketed (supply) and Lagoon ecosystem dynamics, including shrimp life cycles.

Panel (a) of Figure 4.3 shows the total amount of Lagoon shrimp marketed via middlemen, retailers and restaurants, around the Lagoon area during 28 weeks of study. As mentioned in the Methods section, this by no means represents the total amount of

Lagoon shrimp caught during this period. Nevertheless, Figure 4.3.a suggests that the amount of shrimp marketed reflects in part the shrimp life cycle and probably shrimp total catches. When the channel connecting the Lagoon to the ocean was opened (week 10), catches and sales increased considerably. This happened because 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 of shrimp catches and sale soon after that (week 12). As the Lagoon's water level comes to match the ocean's level, ocean water starts to enter the Lagoon, bringing larvae and post-larval shrimp which in two or three months will be grown enough to be fished. This explains why from week 12 to week 21 there was almost no sale (and presumably almost no catch) and that after 10 weeks shrimp sales (and catches) increased again (weeks 22 to 28). Also worthy of note in Figure 4.3.a is that the quantities of shrimp of various sizes marketed each week indicate the presence of several shrimp populations inside the Lagoon, and are highly reflective of 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., tourist season: peak versus off-season), and whether fishers transport their product to middlemen (higher prices) or middlemen have to travel to fishers' houses (lower prices due to the operation cost that middlemen incur) (Table 4.3). Shrimp size is usually classified as follows: (a) large: from 25 (or fewer) to 40 individuals per kg; (b) medium: from 45 to 70 individuals per kg; (c) small: from 75 to 150 (or even more) individuals per kg; (d) assorted: large, medium and small shrimp are mixed and sold together. Small shrimp are rarely sold separately; they are usually mixed

with medium and/or large shrimp and sold as assorted. This explains the absence of a "small" category in Table 4.3.

An attempt was made 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. The range of prices for Lagoon shrimp during the 28 weeks of data collection is presented in Table 4.3. Prices are delineated according to shrimp size, supply, demand, and buyer type. Not surprisingly, large-shrimp prices were higher than medium-shrimp prices, and prices for assorted-shrimp tended 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 4.3, 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 Figure 4.3.a). However, because shrimp size varies within a single size category (e.g., large shrimp usually range from 25 to 40 individuals/kg), an increased price may also be captured for larger shrimp within a given category (i.e., a decreased number of individuals per kg). Lower shrimp prices corresponded to the ending of the high tourist season (soon after carnival – Ash Wednesday) as well as to times of increased supply (Figure 4.3). The profits earned by

middlemen and retailers in shrimp trading seemed to range from 10% up to 50% of the price at which shrimp were sold.

Table 4.4 presents the quantities of Lagoon shrimp purchased by Lagoon area middlemen, retailers, and restaurants during the 28 weeks of study. Of the total 4,339 kg of Lagoon shrimp sold in the Lagoon area, during these 28 weeks, 68% 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, only three restaurants accounted for 70% of the Lagoon shrimp bought by all seven of the restaurants which buy 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 someone who is a part-time fisher himself and interacts with many local fishers. Therefore, it appears that fishers sell their shrimp solely to whose restaurants 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 Figure 4.3. Analyzing Figure 4.3.b in three different periods elucidates some points. During the first productive period, from week 1 to week 11, the percentage of catch bought by restaurants increased during long-weekend holidays[12] or just before. From week 12 to week 21, almost no shrimp was marketed and any kilogram sold could make huge differences in percentages. Hence, this period is not

[12] Week 3: November 2nd (memorial day); Week 5: November 15th (Republic Proclamation day); Week 11: December 25th (Christmas).

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[13] approached. No conclusion can be made about the percentage of Lagoon shrimp bought by retailers, as they put almost no effort into searching for shrimp. To get a better understanding of the Lagoon shrimp market during different seasons, a follow-up study covering all months of the year is needed.

According to some middlemen, the Lagoon shrimp production is not sufficient anymore to supply local shrimp demand, especially during summer. When supply exceeds demand during a few weeks in winter, middlemen export shrimp to the regional market (especially to Imbituba and Florianópolis). To supply the local market during summer, middlemen usually import shrimp from other nearby lagoons (e.g., Mirim Lagoon, Garopaba Lagoon, Santo Antônio Lagoon). In these cases, they might buy shelled shrimp, something that never happens in the case of Ibiraquera Lagoon shrimp. According to one middlemen, Ibiraquera shelled shrimp is not competitive with imported shelled shrimp because Ibiraquera shrimp are more expensive than shrimp from nearby lagoons. This results from the fact that Ibiraquera shrimp is locally recognized as the best shrimp in the region (and according to some, in Brazil) because it comes from a non-polluted lagoon. Interesting to note is fishers' and middlemen's pride about the high quality of Ibiraquera shrimp. Nevertheless, problems generated by excessive development, such as sewage drainage into the Lagoon and poorly constructed septic

[13] Week 28: April 21st (Tiradentes day – a national martyr day)

tanks, are likely to affect shrimp quality in the non-too-distant future if no preventive action is taken.

The prices which middlemen, retailers and restaurants paid for Lagoon shrimp varied from R$6 to R$20 per kg. Lagoon mullet was much less valuable, however; mullet prices only varied from R$2.00 to R$2.50 per kg. The costs of fishing for mullet and shrimp were quite similar: both species were caught with cast-nets, and fishers could or not use a polling canoe. The difference in fishing costs was the price of kerosene used to attract shrimp (R$2 for an entire fishing night). This cost was relatively small as it would probably represent less than 10% of shrimp prices[14]. That is, shrimp was more valuable from a profit standpoint than mullet. As shrimp generates much greater returns for fishers than mullet, most fishers prefer to invest their time in shrimp fishing rather than fishing for mullet. Exceptions are sport fishing, subsistence fishing and full-time fishers; the latter must keep fishing even during the shrimp off-season. These fishers usually sell their catches directly to consumers, local restaurants or small retail outlets. As a result, middlemen seldom buy mullet from the Ibiraquera Lagoon. They do however buy fish (mullet and blue fish) captured in large fisheries in front of beaches near the Lagoon. As well, middlemen import fish and crab meat from the regional market (Laguna and Florianópolis) to supply the local market. The main imported fish species are mullet, blue fish, croaker (*Micropogonias* spp.), and weakfish (*Cynoscion* spp.).

[14] Assuming that a fisher would get in average about 3 or 4 kg of shrimp in an entire night.

4.3 Discussion

The Ibiraquera case provides useful information for ecosystem management planning based on an ecological economics approach. The case shows several interactions among the local socio-economic system, the Lagoon management, and the Lagoon shrimp market through a historical perspective. In the following sections I first investigate how the Lagoon shrimp market was/is influenced by social-ecological incentives and constraints; then, how the Lagoon ecosystem and the local social system were influenced by socio-economic events; and finally, I discuss a potential alternative for the Lagoon management based on the six core principles proposed by Costanza et al. (1999).

4.3.1 Shrimp market: social-ecological incentives and constraints

It is clear that the Ibiraquera shrimp market only started when the costs of shrimp storage and transportation to regional markets diminished due to technological improvements. In other words, the market really emerged once transaction costs decreased sufficiently to ensure that sellers could profit from commercial shrimp production. Additionally, this market development depended on the efforts of two entrepreneurs. As Wang (1999, p.801) puts it, "the provision of the market is costly and requires entrepreneurial efforts".

The initial shrimp market institution was based on a similar local institution for agricultural products - a patronage system. In both cases, middlemen provided money or basic goods for local families, who in turn, became compromised to sell all their products (manioc flour or fish/shrimp) to their patrons. Nevertheless, patronage institutions became weakened when the local socio-economic system expanded, became influenced by outsiders' values and ideas, and offered 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 (Platteau and Abraham 1987) 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. From the middlemen's point of view, giving credits to fishers as a way to ensure access to their catches – credit as an output-securing device (Platteau and Abraham 1987) – also became a risky transaction: as local communities have lost most of their 'traditional' identity, social sanctions of credit arrangements were not likely to occur and 'moral hazard' (i.e., cheating) became uncontrollable.

Wang (1999) asserts that changes in the institutional structure of a market are determined mainly by transaction costs. The Ibiraquera shrimp market illustrates this. The modification of the local Ibiraquera shrimp market from export-oriented to import-oriented reflected changes in transaction costs. For instance, the increased local demand for shrimp reduced the operating costs of marketing shrimp within local communities relative to the regional market. Indeed, as a result of such modification, the regional market now seems to have almost no influence on the local shrimp market (although further research is needed to confirm this). Ibiraquera shrimp prices came to reflect mainly local demand, supply, ecological uncertainties, shrimp size and shrimp quality (i.e., source being an unpolluted lagoon).

The relationship between supply and demand forces in the Ibiraquera shrimp market does not match the predictions of neoclassical economic theory. Ibiraquera shrimp demand is mainly determined by the stage of the tourist season (peak versus off-season). Shrimp supply is highly dependent on the Lagoon channel-opening management, which

in turn depends on rainfall and the movements of shrimp larvae and post-larvae in the ocean. Hence, shrimp supply is subject to ecological uncertainties and shocks. Generally under these conditions one would expect potential negative supply shocks to drive up the market price for a commodity. In this case, however, ecological uncertainties do not add economic value to the product; instead, they decrease shrimp prices and fishers' profits. I suggest here that this happens because the Lagoon shrimp market is dominated by only three middlemen, who usually pay less for shrimp than retailers, restaurants and probably tourists, but who purchase shrimp year-round instead of buying it only during the tourist season. Because shrimp harvests may peak during the tourist off-season, some fishers prefer to sell shrimp to middlemen for reduced prices during the tourist season to ensure that they will have a buyer during the off-season – the period when tourism-related jobs decrease. If this is the case, then the dynamics between demand and supply in the Ibiraquera shrimp market can be viewed as operating to provide an "income-insurance mechanism".

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 regulation enforcement (concerning how, where and when to fish, and who is allowed to fish) makes the Lagoon a *de jure* common property resource but a *de facto* open-access situation. Individuals have privilege but no rights in using the resource (Bromley, 1989). In the late 1990s, locals harvested shrimp primarily for commercial

purposes, while, for most outsiders, fishing served mainly as entertainment[15]. Since most outsiders and sport-fishers had no economic dependence on the Lagoon resource, they had no economic incentives to use large mesh nets and prevent overfishing. In the face of an open-access system where anyone holding a professional fishing license could fish, local fishers, both full-timers and part-timers, also had no social or 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. 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 accomplish this.

The idea that the Lagoon use is costly to others extends to "use" the Lagoon as a receptacle for waste. The open-access situation resulting from a lack of control (by governments) of the sewage drained into the Lagoon by illegal constructions (with poorly constructed septic tanks) and garbage dumped in the Lagoon margins by tourists and local residents started to compromise the quality of the Lagoon water. The good quality of the Lagoon water accounts for the higher prices of Ibiraquera shrimp compared to shrimp from nearby lagoons. The sustainability of the Lagoon ecosystem and fisheries relies on preventing 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,

[15] It was interesting to hear from sport-fishers that fishing was like playing cards: if you win one night you return to play (fish) in the next night, expecting to win as well; if you lose one night, you return to play in

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 determines high priced fines and even jail terms for transgressors) is one possible solution. Another solution is to propose some voluntary mechanisms to stop polluting through environmental education.

4.3.2 The effects of socio-economic evolution on Lagoon ecosystem and stakeholder well-being

Table 4.5 summarizes the impacts of major evolutionary events on the Lagoon's goods and services and on stakeholder well-being over the past five decades. Although I did not attempt to calculate the monetary costs or benefits of each impact, I have delineated their positive and negative effects on the ecosystem and stakeholder well-being .

The major evolutionary events in the Ibiraquera region in the last five decades of 20th Century were described throughout previous sections of this chapter. They include: innovations in fishing technologies from the late 1960s on; some infrastructure improvements such as road construction and electric power availability especially during the 1970s; development of a shrimp market during the 1970s; an overfishing crisis in the late 1970s; the creation of new fisheries regulations and the establishment of a strong rule enforcement between 1981 and 1994; the breakdown of the enforcement structure in 1994 leading to illegal sewage disposal into the Lagoon and the use of illegal fishing gears and vessels in the following years; the implementation of a shrimp-stock project from 1992 to 1998; the occurrence of a dredging project to re-open the Lagoon's silted up

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the next night, expecting to win in order to compensate what you lost the night before (time fishing).

channels in 1999; and the excessive and unplanned 'development' of region due mainly to a tourists boom during the 1980s and 1990s.

Technological innovations may result in more efficient fishing, but, if not properly used, they may cause overfishing and ecosystem disruption. In addition, technological innovations might promote unfair resource distribution, as some technologies are not affordable to all users. Increasing market demands may lead to species by-catching (which may cause ecosystem disruption) and to put fishers' private interests (i.e., profit-maximization) upon social goals (i.e. sustainable resource use). Overfishing causes ecosystem disruption and may reduce fishers' and middlemen's welfare in the long-run. As a result, some technological restrictions may prevent overfishing and promote better resources distribution (see next section).

Official regulations based on fishers' ecological knowledge and concerns (see Chapter II) and an appropriate enforcement system proved to restore the Lagoon's structure and dynamics, to reduce user-group conflicts, to promote more just resource allocation, to increase people's safety, and to avoid pollution. On the other hand, lack of rule enforcement may disrupt ecosystem natural dynamics and lead to overfishing, increase the risk of pollution and human health problems, and decrease people's safety on the water. Often, most people bear the cost of the actions of just a few cheaters.

Infrastructure improvements (e.g., roads, electricity) may increase the local population's well-being, but it may also expose the local society to immigrants' social and cultural values. The introduction of different values may cause a breakdown in the local authority system and disruption of social life, resulting in a 'community failure' of resource management (McCay and Jentoft 1998). Depending on the type of infrastructure

'improvement', it may either relieve pressure on the ecosystem or exacerbate ecosystem destruction. Excessive (and usually unplanned) development often results in ecosystem degradation, increased pressure on resources, and conflict of interests between outsiders and the local population holding some sense of place[16]. 'Development' projects, such as the shrimp stocking project and the Lagoon-dredging project, focus mainly on human benefits, disregarding the side-effects on ecosystem structure and resilience. Some projects may result in positive impacts on the ecosystem; others result on negative impacts. As well, some stakeholders may benefit from development projects, while others may not. Hence, all the socio-economic-ecological benefits and costs of a project must be investigated a priori.

4.3.3 An alternative for the Ibiraquera Lagoon management

What can we learn from the interactions between the Ibiraquera Lagoon's ecological and socio-economic systems? How can we improve the Lagoon management?

Agrawal and Yadama (1997, p.457) suggest that although "socio-economic forces are important in influencing resource management and the condition of renewable resources, ... their influences [can] usually [be] mediated through community institutions." The Ibiraquera case shows that in the late 1990s, there was almost no local resource management institution influencing the Lagoon system. In fact, the system was being negatively affected by State policies (e.g., weak rule enforcement, no access restriction), technological factors (e.g., inappropriate fishing gears, development

[16] Sense of place is used here as in Butz and Eyles (1997).

projects), market pressures (e.g., high demand for shrimp) and population pressures (e.g., large number of local residents, outsiders and tourists).

In order to craft community institutions to mediate the negative effects of such factors, to create social and economic incentives for better Lagoon management, and to incorporate the six Lisbon principles into a new management plan, I suggest the establishment of an Ibiraquera Lagoon Management Forum through a co-management[17] process. The Forum may be a long-lasting institution able to deal with the current problems and to actively respond, through an adaptive management approach (Holling 1978, Walters 1986), to future socio-economic-ecological problems.

The Forum could be a joint effort from all the federal, state and municipal government agencies holding any responsibility for the Lagoon management and most, if not all, of the other Lagoon stakeholders (e.g., local fishers, outside fishers, local residents, tourists, and tourism businessmen). Some scientists and natural resource managers may also join the Forum. In designing and implementing management strategies, all parties should be involved in decision-making to increase the process's transparency and subsequent rules compliance (*participation principle*).

Non-governmental stakeholders may create one or more local non-governmental organizations (NGOs) to represent them in this Forum. To trigger stakeholder participation in the Forum, there is a need to develop environmental education programs to reach them. These programs might use examples from the present case-study to demonstrate that human-made impacts on the Lagoon ecosystem and its surroundings emerge later as impacts on humans themselves. That is, the *responsibility principle* may

[17] Co-management is type of arrangement in which responsibility for resource management is shared among governments, resource users and other stakeholders.

be realized from the beginning, and a mechanism that indoctrinates the community according to this principle must be implemented very early on.

Any 'development' project or management regulation may be planned so that it adheres to three conditions. First, the plan should internalize as many local monetary and non-monetary costs and benefits as possible. Second, people holding local ecological knowledge (e.g., old fishers) should be involved in planning and decision-making. Third, representatives from governments from different political scales should be involved because some costs and benefits may affect other socio-ecological systems (*scale-matching principle*). Because the long-term impacts of water pollution, deforestation, overfishing, and shrimp stocking are uncertain, a cautious approach to management design and implementation should be the rule rather than the exception (*precautionary principle*). That is, some mechanisms could be developed to incorporate the long-term ecological value of the Lagoon ecosystem services and goods into their current prices.

As the Ibiraquera case clearly demonstrates, socio-economic and ecological systems co-evolve in a non-linear, uncertain way. Hence, in designing and implementing any management plan, effort must be made to continuously monitor the social, economic and ecological systems (*adaptive management principle*). Although it is quite difficult to do so, effort must also be made to identify and allocate all of the internal and external costs and benefits (social and ecological) of alternative management plans (*full cost allocation principle*).

I propose that the Ibiraquera Lagoon Management Forum may initially address at least the following major issues: fishing activities, other sport activities, management of channel openings, sewage systems, garbage dumping, irregular buildings close to the

Lagoon margins, and deforestation along the Lagoon margins and along springs that drain freshwater into the Lagoon. For each of these issues, feasible policy instruments can be established. As Jacobs (1993, p.162) puts it:

> The appropriateness of any particular instrument in any given circumstance will clearly depend on which of the criteria [ideology, effectiveness, motivation, administrative cost, efficiency, political acceptability and distributional impact] are regarded as most important, and on the particular context and nature of the environmental damage to be prevented.

In Chapter VI, I present a policy alternative and some policy instruments that may be used to approach sustainable fisheries management at the Ibiraquera Lagoon and that may exemplify how the six principles may be addressed.

Table 4.1: Changes in the local economy of four communities from Ibiraquera region

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

[a] The economic history 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.
[b] Alphabetical order.
[c] Until the late 1970s, there were only four families living in this locality; it was not considered a community.
[d] Public services include people who work in local schools, health-care centers, post-offices, etc.
[e] Waged-labor includes people who commute from other communities to Imbituba or Garopaba to work at industries or other businesses.

Table 4.2: Fishing activities at the Ibiraquera Lagoon in the late 1990s

group	Methods & gears	Legitimacy	Field-work[a]	Light period	Seasons (main)	User groups	Target species	Fishing purpose
shrimp	cast-net (mesh ≥ 3.0 cm) & kerosene lamp	legal[b]	yes	night	close channel	sport, part- & full-time fishers local & outside fishers	shrimp	sale and consumption
shrimp	cast-net (mesh ≥ 3.0 cm) & kerosene lamp (canoes)	legal	yes	night	close channel	sport, part- & full-time fishers local & outside fishers	shrimp	sale and consumption
fish	hook and line	legal	yes	day	all year	sport fishers local & outside fishers	blue-fish grouper	consumption
large fish	cast-net (mesh ≥ 5.0 cm)	legal	yes	day night	all year (Apr. to Jul.)	sport & part-time fishers local & outside fishers	mullet	sale and consumption
large fish	cast-net (mesh ≥ 5.0 cm) (canoes)	legal	yes	day night	all year (Apr. to Jul.)	part-time & full-time fishers local & outside fishers	mullet	sale and consumption
small fish blue crab	cast-net (mesh ≥ 3.5 cm)	legal	yes	day night	all year	sport & part-time fishers local & outside fishers	mojarra sardine blue crab	consumption
blue crab	crab trap	legal	yes	day	all year (Nov. to Jan.)	sport & part-time fishers local & outside fishers	blue crab	consumption
blue crab	hand-held dip-net & kerosene lamp	legal	yes	night	all year (Nov. to Jan.)	sport & part-time fishers local & outside fishers	blue crab	consumption
blue crab	long-line	legal	no	day	all year (Nov. to Jan.)	sport & part-time fishers local & outside fishers	blue crab	consumption

[a] Fishing methods observed during fieldwork (June 1999 to May 2000)
[b] Although legally prohibited, shrimp cast-net with mesh size of 2.5 cm is usually allowed at Ibiraquera.

Table 4.2 (cont'd)

group	Methods & gears	Legiti-Macy	field-work	Light period	Seasons (main)	User groups	Target species	Fishing purpose
shrimp	cast-net (mesh < 3.0 cm) & kerosene lamp	Illegal	yes	night	close channel	sport, part- & full-time fishers local & outside fishers	shrimp	sale and consumption
shrimp	cast-net (mesh < 3.0 cm) & kerosene lamp (canoes)	Illegal	yes	night	close channel	part- & full-time fishers local & outside fishers	shrimp	sale and consumption
shrimp	cast-net (mesh ≥ 3.0 cm) & butane gas lamp	Illegal	yes	night	close channel	sport & part-time fishers local & outside fishers	shrimp	sale and consumption
shrimp	hand-held shrimp tong & butane gas lamp	Illegal	no	night	close channel	sport & part-time fishers local & outside fishers	shrimp	sale and consumption
shrimp	trap-net or hoop-net set in the open channel	Illegal	yes	night	open channel	part-time & full-time fishers local & outside fishers	shrimp	sale
shrimp	shrimp small trawl (canoes)	Illegal	no	night	close channel	part-time fishers local & outside fishers	shrimp	sale
shrimp blue crab	mini-trawl style pull-net	Illegal	yes	night	close channel	local & outside fishers	shrimp, blue crab	sale and consumption
blue crab	hand-held dip-net & butane gas lamp	Illegal	yes	night	all year (Nov. to Jan.)	local & outside fishers	blue crab	consumption

Table 4.2 (cont'd)

group	Methods & gears	Legiti-macy	field-work	Light period	Seasons (main)	User groups	Target species	Fishing purpose
small fish blue crab	cast-net (mesh < 3.5 cm)	illegal	yes	day night	all year	sport & part-time fishers local & outside fishers	mojarra, sardine, blue crab	consumption
fish	cast-net in the open channel	illegal	yes	day night	open channel	sport, part-time fishers local & outside fishers	mullet, morraja	sale and consumption
fish	gillnet (setting net, encircling net, trammel-net) (canoes)	illegal	yes	day night	close channel	part-time fishers local & outside fishers	mullet	sale and consumption (probably)
fish	beach seines (canoes)	illegal	no	day night	close channel	part-time fishers local & outside fishers	mullet	sale and consumption (probably)
fish	harpoon (or multi-pronged harpoon) & gas lamp (canoes)	illegal	no	day night	all year	local & outside fishers	large fish	consumption

Table 4.3: Price range of Lagoon shrimp according to its size, supply, demand and buyers

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

[a] Brazilian currency (Real): R$1.00 = CND$ 0.72 in April 9, 2001.
[b] Average of Lagoon shrimp marketed locally per week.
[c] Data not available.
[d] Week 10: channel opening. Week 11: Beginning of tourism high season (Christmas).
[e] Week 21: Ending of tourism high season (soon after Carnival – Ash Wednesday)

Table 4.4: Lagoon shrimp sold for local middlemen, retailers and restaurants from October 1999 to April 2000. Source: Seixas' field data, Ibiraquera region.

	Shrimp marketed during 28 weeks		
Group	**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**	

Table 4.5: Major socio-economic evolutionary events and their impacts on the Lagoon's goods and services and stakeholder well-being (partially based on Antunes and Santos, 1999).

	Major socio-economic evolutionary events				
	Innovation in fishing technologies	*Development of shrimp market*	*Overfishing*	*New regulations and strong enforcement*	*Lack of rule enforcement (illegal sewage disposal)*
Lagoon's goods & services					
Habitats and species	affected structure and diversity of fishing resource		destroyed nursing habitats	restored habitats	
Nutrient cycling and waste treatment	some gears stirs the Lagoon bottom disturbing nutrients sedimentation			ban of gears that disturb nutrient sedimentation	potential increase of Lagoon eutrophication and risk of fish and shrimp suffocation
Food	capture of larger amounts, but often smaller fish and shrimp	pressure on shrimp stocks and by-catching problems	reduced stocks	restored stocks	pollution and risk of health problems
Transportation				ban of engine vessels avoid water pollution	
Recreation			likely to decrease sport fishing	ban of engine vessels increased safety in water	risk of health problems when fishing, sailing, and bathing
Culture		disrespect for traditional practices		reduced conflict among user-groups; more just resource allocation	
Stakeholder well-being					
Who won	Commercial fishers	commercial fishers; middlemen	in short run: fishers with high rate of time preference in long run: nobody	cast-netters, local people, most tourists	few cheat people (both locals and outsiders)
Who lost	Subsistence fishers	subsistence fishers	in short run: unclear in long run: all fishers, middlemen, local people	gill-netters and tourists with jet-skis and engine canoes	most people (both locals and outsiders)

Table 4.5 (Cont'd)

	Major socio-economic evolutionary events				
	Lack of rule enforcement (illegal gears & vessels)	*Shrimp-stocking project*	*Lagoon dredging project*	*Infrastructure improvement (e.g., roads, electric power)*	*Excessive development and tourists boom*
Lagoon's goods & services					
Habitats and species	affected structure and diversity of fishing resource	killed shrimp predators (fish) using rotenone, affecting biodiversity	project interruption may affect water circulation and habitats in the Upper basin		destruction of feeding habitats and fish and shrimp migration channels
Nutrient cycling and waste treatment	use of gears that stir the Lagoon bottom disturbing nutrients sedimentation	added nutrients to feed captive shrimp interfering with natural cycles	expected to favor water circulation inside Lagoon and between it and the ocean (flushing into ocean)	bridge construction filled a channel interconnecting two basins affecting water circulation	favored increase of illegal sewage disposal; modified sandbar and affected channel openings
Food	capture of small fish and shrimp	enhanced shrimp stocks	expected to increase fish and shrimp migration into the Lagoon	favored population growth and large food demand	increased demand for food
Transportation	use of engine vessels polluting water		re-opened channels that facilitate canoe traffic	reduced the use of canoes for transportation	wealthy tourists using jet skis and engine canoes
Recreation	engine vessels put in risk people's safety in the water	enhanced shrimp stocks attracting more sport fishers	expected to allow better Lagoon water flush into the ocean reducing pollution	favored tourism development	increased the Lagoon scenic value and the economic value of its surrounding land
Culture		informed fishers about shrimp life-cycle		favored immigration of outsiders who bought new values and behaviors	displaced local people; outsiders' lack of respect to some traditional rules; lack of sense of place
Stakeholder well-being					
Who won	cheat fishers and tourists with jet-skis and engine canoes	all fishers; middlemen	most of people (probably)	locals (well-being); tourists	few businessmen and tourists
Who lost	honest fishers, locals and most tourist	unclear	perhaps fishers from the Upper basin	locals (environment and community disruptions)	most locals and tourists

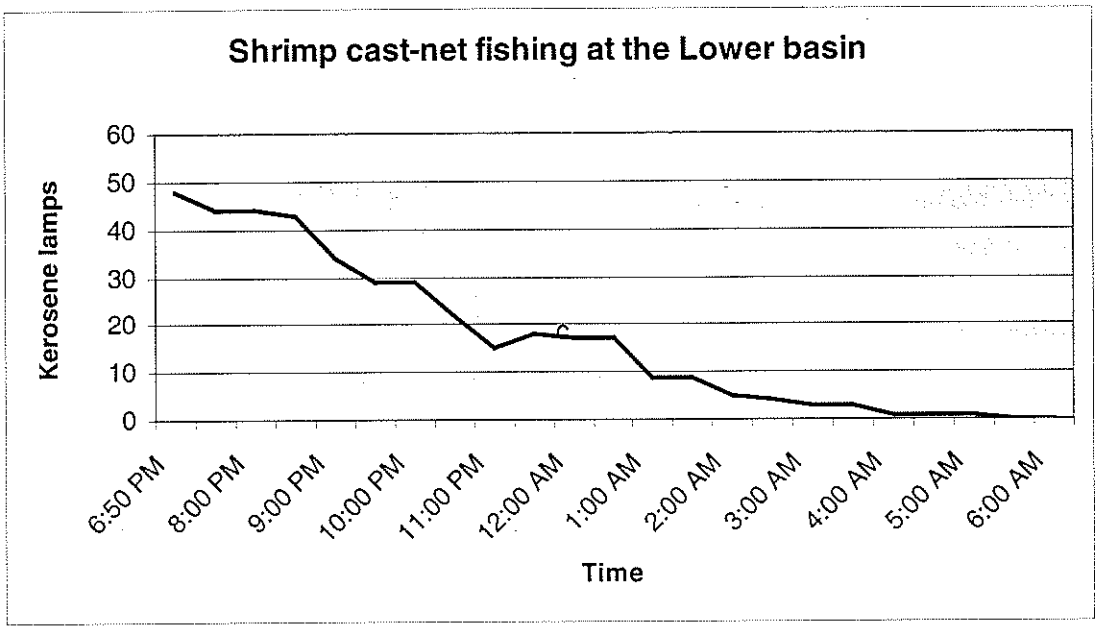


Figure 4.1: Shrimp cast-net fishery activity at the Lower basin of Ibiraquera Lagoon in April 19-20, 2000. Numbers of kerosene lamp at different night hours. (First lamp lighted at 6:15 pm. Calm wind, full moon, temperature about 22 °C.)

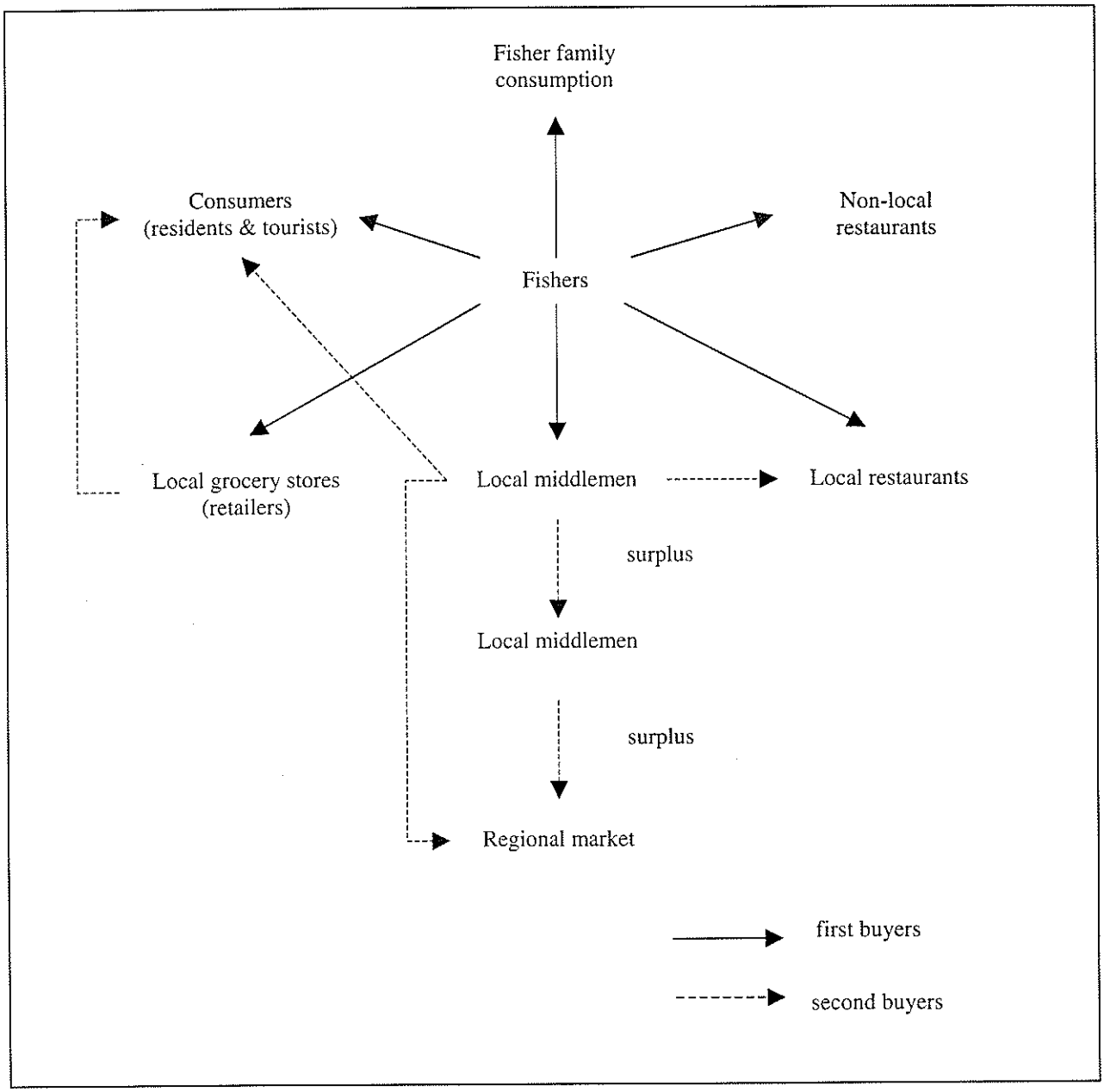
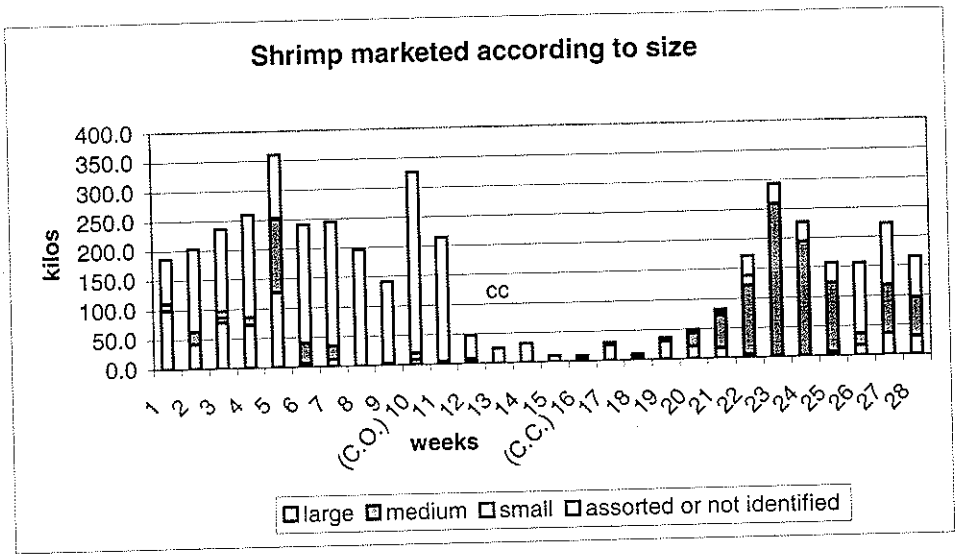


Figure 4.2: Channels of Ibiraquera shrimp marketing

(a)



(b)

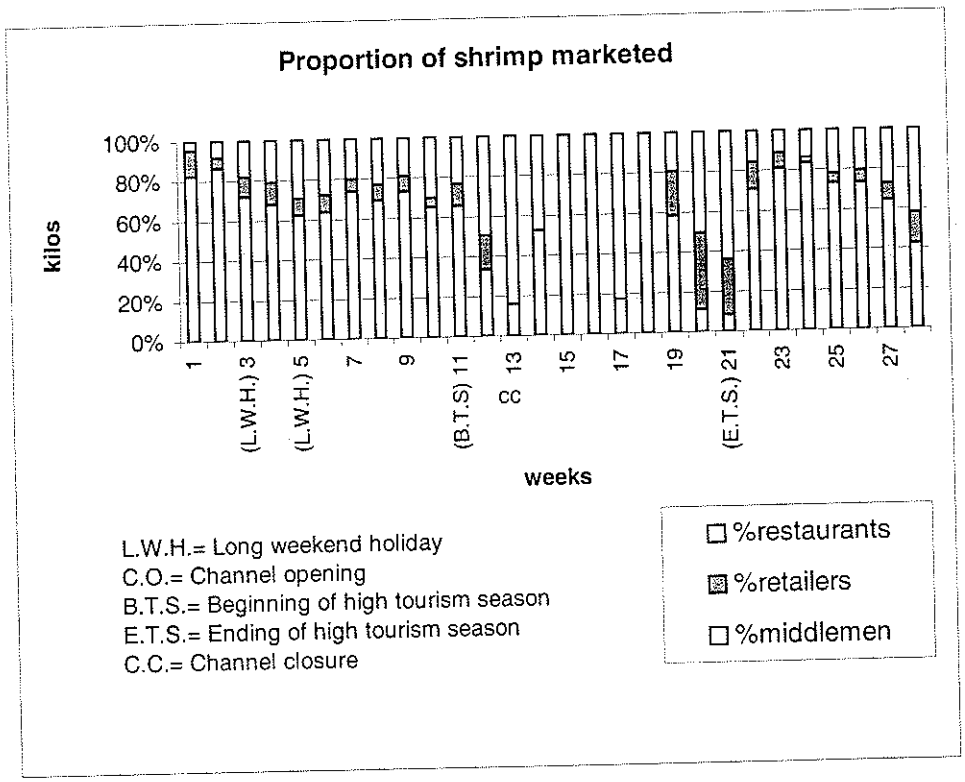


Figure 4.3: Ibiraquera Lagoon shrimp marketed locally from October 1999 to April 2000. (a) Amount of each size marketed per week; (b) Proportion among middlemen, retailers and restaurants in each week.

Chapter V

Stakeholder conflicts and solutions across political scales

Channel connecting the Ibiraquera Lagoon to the ocean. On the left, guesthouses, restaurants and summer cottages; on the right, tourists swimming and sun tanning, and sport-fishers with cast-nets (Summer 2000).

Chapter V

Stakeholder conflicts and solutions across political scales

5.1 Introduction

Coastal resources are often managed by more than one agency (e.g. different branches of the government, private and community organizations) at different political levels (local, municipal, state, national and international) and in distinct sectors of an economy (e.g. fisheries, tourism, urban development, maritime transportation, and oil drilling). For instance, fisheries departments at any government level usually deal with regulations concerning only access to, and use of, fish stocks; little attention is given to the fact that fishing areas and fishers' livelihoods are affected by other economic activities taking place at the same time and locality. This lack of coordination among different efforts to manage coastal areas usually results in conflict among user-groups, environmental degradation and resource over-exploitation. Such situations call for an improvement in both cross-scale and cross-sector efforts to develop integrated coastal management.

Efforts towards integrated coastal management may occur at different scales from the national to the local-level. An example of the national and state level effort is the Train-Sea-Coast Programme[1] in Brazil which included representatives of several national and state governmental and non-governmental organizations, environmental institutions,

[1] This programme was established in 1993 by the United Nations Division for Ocean Affairs and the Law of the Sea (DOALOS/UN) and in Brazil it is supported since 1995 by the Federal Government through the Interministerial Commission for the Resources of the Seas (CIRM) (Reis et al. 1999).

universities, and financing agencies associated with coastal and ocean development. These representatives assessed coastal problems, inadequate development of human resources involved in management, and training needs at the local/national level (Reis et al. 1999). This Program's final objective is to build the capability of coastal managers at municipal, state, and national levels to elaborate a strategy for the development of the coastal zone as an integrated system. There is no doubt that such a program crosses over political scales, administrative sectors, and organizational spectra – key factors for successful management. What is often missing in these nation-wide efforts, however, is input from resource users and other stakeholders[2]. According to Costanza et al. (1998, 1999), full stakeholder participation in formulating and implementing decisions about environmental resources is one of the key principles for promoting sustainable governance of the oceans and coastal areas (Table 5.1). This is particularly true in the case of multifaceted conflicts about resource use, which require a participatory resolution process (Hanna and Smith 1993). User-participation in decision-making helps to increase the transparency of the process (and legitimacy) and subsequently, rule compliance (McCay and Jentoft 1996).

Although acknowledging that nation-wide efforts towards integrated coastal management are very important, solutions to specific problems should be tackled at the scale that matches the problem to be solved. Thus, efforts focusing on a particular locality using participatory approaches are likely to solve local management problems more effectively than regional or national approaches. This chapter is about using participatory approaches at the local level. I suggest here that identifying stakeholder conflicts and

[2] There may be stakeholders who are not resource users, for example, business people. Government agencies are also considered stakeholders.

their origins, together with stakeholder concerns, may be a first step towards an integrated coastal management. Conflicts and concerns usually point out the weakness of the current management arrangements, the main organizations involved as well as their capacities and vulnerabilities, and the major issues that have to be addressed.

Berkes (2002) identified some promising institutional forms for cross-scale linkages in natural resources management to take stakeholder concerns and user knowledge into account through a participatory management process. They included: co-management linking communities and government; multi-stakeholder bodies; development, empowerment and co-management arrangements; institutions for linking local users with regional agencies; research and management approaches to enable cross-scale linkages; and 'citizen science' or 'people's science movements' (Table 5.2). There is not a general model that can be universally used as the best solution. The most appropriate approach, or combination of approaches, for each case will depend on the political and cultural history of the area as well as on its geographical and ecological aspects.

User-participation in management "is a way to broadening the knowledge basis on which management decisions rest and thus improving the science of management" (McCay and Jentoft 1996). Therefore, an important task towards an integrated and participatory coastal management is to build a common knowledge base upon which management decisions can be made. Such a knowledge base could contemplate scientific knowledge, resource manager practical knowledge and resource user practical knowledge. It could also include socio-economic and ecological information at local, municipal, state and national levels. Such an information base may serve at least three

major purposes: (1) provide a large set of information for decision-makers; (2) minimize differences in stakeholder understanding of problems, (3) provide information to coordinate management at a larger scale.

First, user knowledge may supplement scientific information, especially in areas where scientific knowledge is scarce, as in most developing countries (Berkes et al. 2001). This approach is feasible; resource users have ecological knowledge about species and ecosystem processes (Chapter II, Turner 1994, Calheiros et al. 2000, Olsson and Folke 2001). Moreover, using fisher knowledge and scientific knowledge together has improved management systems in several localities (Chapter II, Corsiglia and Snively 1997, Johannes 1998a, Neis et al. 1999, Olsson and Folke 2001).

Second, conflicts among user-groups and between them and other stakeholders (including government agencies), are often a result of their very different management goals, which reflect different worldviews rooted in different knowledge bases (Hanna and Smith 1993, Brown and Rosendo 2000b). Building a common and reliable knowledge base may help reshape, to some extent, stakeholder views of management problems and their management goals.

Third, sharing a locally developed knowledge base across political scale and localities (geographical scale) may lead to a better coordination and outcome of integrated coastal management at regional, state and national scales. More often than not, fisheries measures, which are usually based on scientific research performed in relatively small areas, are implemented in much larger areas disregarding the socio-economic context and ecosystem particularities affecting fisheries systems at local levels.

In this context, the aim of this chapter is to investigate stakeholder conflicts in a coastal area in order to propose a participatory resource management approach which takes into account stakeholder concerns, user knowledge[3] and government institutional frameworks. This chapter examines a small-scale coastal fishery at the Ibiraquera Lagoon, Santa Catarina State, Southern Brazil. I use analytical tools from common-property theory to investigate: stakeholder conflicts; interactions among management institutions across political scales, administrative sectors, and organizational spectra. Additionally, I investigate how these institutions help minimize or exacerbate conflict. I also explore insights from common-property theory in order to propose some mechanisms to integrate different types of knowledge.

Fieldwork was carried out between June 1999 and May 2000. Research methods included interviews, archival research and participant observation. Interviews were carried out in several formats -- structured interviews, semi-structured interviews with key informants and small groups, ethnomapping -- to elucidate fisher knowledge, stakeholder conflicts, stakeholder concerns, major management problems, actors and organizations responsible for and affected by such problems, and the main changes in the local socio-economic and ecological system in the last four decades. Archival research was done to trace changes in fisheries legislation, government organization and the local socio-economic system. Participant observation was carried out to monitor fish and shrimp catching activities and the fishing methods used, and to understand the role of fishers, tourists, tourism entrepreneurs, resource managers, fishers association,

[3] I focus on user knowledge instead of stakeholder knowledge because those who depend on a resource for their livelihood are the ones who are more likely to have a better understanding of the ecosystem that supports them (Berkes and Folke 1998).

government agents, and community councils. Data analysis was based on triangulation of data from field notes, transcribed interviews, and from external sources including documents and literature. In addition, the main findings were verified with key people including fishers, local residents, local school teachers, the fishers organization's president and a government agent working in the area.

5.2 Site profile

The Ibiraquera Lagoon is located in the municipality of Imbituba (pop. 33,000 in 1991) in Santa Catarina State, along the southern part of the Brazilian coast (Figure 1.3). This is a brackish water Lagoon, intermittently connected to the Atlantic Ocean by a channel, which is opened by human actions and closed by natural processes. The Lagoon has four basins and an area of approximately 900 hectares. Pink shrimp (*Farfantepenaeus paulensis* and *F. brasiliensis*) and mullet (*Mugil platanus, Mugil* spp.) are the main fishing resources and fishing is usually a male activity. There are no effective legal access restrictions to the Lagoon – a state property. As of the year 2000, there were about 350 licensed fishers and many other unlicensed ones living in seven communities around the Ibiraquera Lagoon: Ibiraquera (also known as Teixeira), Barra da Ibiraquera, Arroio, Alto Arroio, Araçatuba, Campo D'Una, and Grama (or Ibiraquera de Garopaba). Many of the fishers were descendants of immigrants from the Azores Islands, who arrived in this part of Brazil about 200 to 250 years ago. Fishers from other communities and municipalities also frequently fished in this lagoon.

5.2.1 Local economy

The major economic activities in each of the seven communities varied slightly, but over all, with respect to the entire region, tourism-related activities seemed to be the main source of income for most people. Small-scale fishing and household agriculture, which were the major sources of income during the 1970s, became less representative in the local economy by the late 1990s. Fishing activities, which evolved from subsistence-oriented activities in the 1950s to market-oriented in the 1970s, became both a commercial and sport activity during the 1990s. Household agriculture changed from market-oriented in the 1960s mainly to subsistence-oriented in the 1990s.

The Ibiraquera region is a hot summer spot for tourists due to its scenery, the Lagoon's warm and safe water, and its four beautiful ocean beaches (Ouvidor, Rosa, Luz and Ibiraquera). Most tourists come from Porto Alegre (State of Rio Grande do Sul), which is the largest city to the southwest. Although tourism started to develop in Ibiraquera by the late 1970s, the biggest tourism boom in the region occurred during the 1990s. For instance, the Barra da Ibiraquera community grew about ten-fold in house number between 1990 and 2000 due to summer cottage and guesthouse construction. At the Ibiraquera (Teixeira) community, summer cottages represented 8% of the houses in the community in 1979 (total=235) and 45% in 1993 (total=647) (Avellar 1993). In the year 2000, according to data obtained from the local electricity distributor (Cooperativa de Eletrificação Rural Paulo Lopes), this figure has jumped to 81% (total=1141).

5.2.2 Lagoon fisheries management

The Lagoon fishery was a resilient[4] communal management system in the early 1960s; a time when management practices were based on local ecological knowledge and enforced by social rules. During the 1970s, the Lagoon became an open-access and less resilient system due to several changes in the local socio-economy, including the development of a shrimp market. The system rebuilt resilience during the 1980s and early 1990s as a result of some key factors (Table 5.3) (Chapter III). Co-management arrangements triggered by local fishers, allowed for the incorporation of local knowledge and fisher concerns into federal government regulations (i.e., good cross-scale communication and political space for experimentation). These regulations served to optimize catch size while maintaining the stock for the future and minimizing conflict among user-groups by promoting equity in resource access. During this period, through an agreement between the federal and state government, the state hired two locals as fishery inspectors for that region (i.e. strong rule enforcement). In 1994, the inspector positions were extinguished, probably due to budget constraints, and enforcement became sporadic. The lack of personnel and equipment supplied by the Brazilian Agency for the Environment (IBAMA[5]) and the State Environmental Police led the Ibiraquera Lagoon to a mix of state-property, communal-property and open-access situations during the second half of the 1990s. The social-ecological resilience of the system was reduced again and several environment and management problems emerged, as described below.

The history of the Ibiraquera Lagoon fisheries management demonstrates that institutional instability at higher political levels negatively affected local management

[4] Resilience is here defined as the capacity of a social-ecological system to buffer disturbance, to self-organize and to learn and adapt (Resilience Alliance 2001).

(Table 5.3). Institutional instabilities were a result of frequent changes in government agencies in charge of making decisions, providing information, and enforcing regulation, as shown in Table 5.4, for the last four decades of the 20th century.

5.2.3 Lagoon fisher groups and stakeholder conflicts

As of the year 2000, the Lagoon fishers could be grouped according to: their origins (locals or outsiders), dependence on fishing (full-timers, part-timers, sport-fishers or subsistence fishers), legal status (professional fishers - licensed and allowed to sell their catches; sport fishers – licensed but not allowed to sell their catches; or unlicensed fishers), and gear-groups (cast-netters or gill-netters). These categories may overlap, as one person can be at once a local, full-time, professional cast-netter. For the purpose of this chapter, I grouped fishers into two major user-groups: local fishers (all full-timers, most part-timers and a few subsistence fishers) and outside fishers (mostly sport fishers). In both of these groups, there are cast-netters (the large majority of fishers) and gill-netters (few fishers).

In 1999, I identified three major points of conflicts concerning the Lagoon fishery management: (a) between fishers and tourists for the use of the Lagoon area; (b) between gill-netters and cast-netters; and (c) between local fishers and those who come from outside the Lagoon area to fish. In addition, there were points of disagreement between local fishers and government managers concerning some fishing regulations and locally-devised management techniques (Chapter II). These disagreements were basically the result of different understandings of Lagoon ecosystem dynamics (Chapter III).

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[5] Instituto Brasileiro do Meio Ambiente e Recursos Renováveis

5.2.3.1 Fishers vs. tourists

The conflict between fishers and tourists has only emerged in the last 25 years. This has come as a result of a major growth in tourism development in the communities around the Lagoon. The major points of conflicts are listed below in the section "Lagoon management problems ..." It is enough to say that the Lagoon fisheries have been impacted by several tourism development and tourists' actions, especially in the last decade. Fisher understanding of how the Lagoon and its surroundings should be managed (i.e., to improve fishery production) is quite different from tourists (i.e., to provide entertainment) or tourism entrepreneurs (i.e., to increase their profits).

This conflict is frequently expressed in the form of complaints by local fishers. The biggest problem in this situation is that local fishers feel powerless in front of tourists who usually have a higher degree of education, socio-economic status, and arguing skills. Moreover, in the past when fishers and a local community council complained about irregular constructions on the Lagoon shore they were threatened by tourism entrepreneurs.

Overall, this situation is a result of conflicting goals and a different degree of dependence on resources. Ultimately, it expresses: a lack of empowerment of fishers and local councils to improve the Lagoon management; a lack of government personnel and equipment resources to enforce regulations; and a mismatch of scale of Lagoon management problems (i.e., local level) and the regulatory and enforcement agencies (i.e., municipal, state or federal levels) (Folke et al. 1997, Brown and Rosendo 2000) (Table 5.5).

5.2.3.2 Cast-netters vs. gill-netters

The conflict between gill-netters and cast-netters has existed at least since the 1940s. The conflict was, and still is, about resource allocation since gill-netters (few individuals) captured much more resources with less human effort than cast-netters (most individuals). During the 1950s and 1960s, this was also a conflict among local communities as gill-netters were concentrated on the west side of the Lagoon (close to the road) and most cast-netters lived on the eastern, more isolated, side (close to the ocean). In 1971, an attempt was made to solve this conflict by allowing gillnet fishing in only two of the four basins of the Lagoon. For about three years, a voluntary fishery inspector enforced the informal agreement. After his resignation, however, the conflict restarted as gill-netters started to fish in prohibited areas. By the end of the 1970s when fishing became a market-oriented activity, the conflict reached a peak; intense use of several gillnets attached together and used as beach seines along the Lagoon shore, and other destructive gears led the fishery system to collapse. According to some informants, at that time there was a clear difference in the socio-economic status of gill-netters (richer) compared to cast-netters (poorer). After gillnet use was banned by government regulations in 1981 as a result of cast-netters' requests, the conflict between gill-netters and cast-netters temporarily disappeared from 1981 to 1994 due to strong regulation enforcement provided by state and federal agencies. The conflict flared up again as enforcement became weak from 1994 to 2000.

As of 2000, gill-netters were both local and outside fishers. According to some fishers, however, they were mainly locals spread across all of the Lagoon communities. Interestingly enough, local cast-netters can name local gill-netters although gillnet fishing

is an illegal activity. For instance, there existed about 10 gill-netters fishing at the Upper basin (Fig. 1), eight of which have major sources of income other than fishing. To avoid verbal or physical confrontations, gill-netters often run away when they are approached by cast-netters. Over the past five decades, most conflicts appeared in the form of verbal offences, with few episodes of physical confrontation and shotgun threats.

No movement towards the legalization of gillnet fishery was observed, although few individuals suggested it. This probably happened because even former gill-netters admitted that the unrestricted use of gillnets was the major cause of the fishery collapse. In addition, a former federal fishery agent, who researched the area, argued that the small depth of the Ibiraquera Lagoon does not sustain a gillnet fishery, particularly in face of an increased number of fishers. Hence, this conflict is essentially a result of the lack of strong regulation enforcement and penalties for cheaters (i.e., gill-netters). Until 1998, penalties were basically the apprehension of illegal gear and sometimes a small fine – which encouraged fishers to take risks. Since then, according to the Nature Law (number 9605), fines were increased and jail terms were added. The problem was that many fishers were still taking risks in face of a weak enforcement at the Lagoon, i.e., penalties were heavy but transgressors were not being caught.

5.2.3.3 Local fishers vs. outside fishers

Outside fishers started to come to the Lagoon about two or three decades ago when access to its shore became available due to road construction. The conflict only started to build up when the sport-fisher populations (mainly outsiders) increased, especially during the 1990s. The conflict between locals and outsiders, however, is quite understated as all

local fishers acknowledge the outsiders' rights to fish at the Lagoon – a state property – and physical confrontations rarely occur. From the point of view of most outsiders interviewed, there seemed to be no conflict among them and local fishers. Nevertheless, many locals have complaints about outsiders. First, some locals argue that outsiders are the ones who usually introduce new destructive (and more efficient) gears into the Lagoon, which are later used by both some locals and some outsiders. Second, some locals say that outsiders account for most of those using banned gears such as gas lamps, small-mesh cast-nets and shrimp small-trawls. Third, local fishers respect each other's fishing activities more than outsiders, especially concerning fishing spots and first-comers' rights. Finally, because most outsiders are retired from other professions and only fish for sport and their own consumption, some full-time local fishers argue that these outsiders should give them priority in getting a fishing spot.

Therefore, the conflict in this case is about fishing rights, dependence on fishing, and resource allocation. Again, the weak enforcement of regulations contributes to the conflict because it allows for the use of banned gears.

5.2.4 Lagoon management problems in the late 1990s and their roots

Resource users are quite aware of the major environmental and management problems affecting their livelihoods. According to some Ibiraquera fishers and local residents, intensification of tourism and lack of enforcement of environmental regulation resulted in several problems during the late 1990s, as presented in Table 5.5. First, illegal gears (e.g., gillnets banned since 1981) and fishing methods (e.g., cast-net fishing at the channel mouth, which prevents fish entering the Lagoon) were commonly used in the Lagoon

affecting resource stocks and triggering conflicts among fisher groups. Second, motor vessels (banned since 1995 to avoid oil spills and noise that disturb fishing) and windsurf boards were being used by tourists and interfering with fisheries, causing conflicts between fishers and tourists. Third, the Lagoon started to be polluted due to an increase of tourists and fishers, who used the Lagoon margins as garbage dumps. Fourth, the increase of summer cottages with either poorly constructed septic tanks which led to contaminating the watertable or draining sewage into the Lagoon, aggravated pollution. Fifth, as pollution became a problem during the tourism season, conflicts about managing channel openings arose. Tourism-related personnel wanted to have the channel open during peak seasons, so that it served to flush out the Lagoon's polluted water. Fishers, on the other hand, wanted to open the channel at different periods to improve the Lagoon fish and shrimp stocks, as traditionally done. Sixth, unregulated tourism development resulted in illegal constructions inside the Lagoon and along its margins. Seventh, unplanned development and unregulated construction were also causing deforestation along the Lagoon margins, along springs that drain freshwater into the Lagoon, and on the rest of the secondary forest present on the hills surrounding the Lagoon area. Eighth, both unplanned construction and deforestation around the Lagoon were causing siltation of shrimp/fish migratory channels inside the Lagoon and affecting fisheries. Ninth, communal trails up and down nearby hills to access the Lagoon margins were being closed by landowners from outside (*Estradas públicas por onde o povo passava*).

As Table 5.5 demonstrates, there are several agencies from different political scales and sectors in charge of environmental and management problems affecting the Ibiraquera Lagoon and its surrounding area. It is worth noting, however, that this was not

an attempt to map the entire institutional framework affecting resource management in that region. The purpose here was to record some institutions and organizations related to the Lagoon environment and management problems pointed out by fishers. Mostly, the problems resulted from a lack of coordination among these many management agencies and their ineffective management capabilities. For instance, the Santa Catarina State Environmental Foundation (FATMA) office in Tubarão – whose jurisdiction encompasses Imbituba – had, in April 2000, only seven personnel and one vehicle to monitor 18 municipalities concerning deforestation and water quality, among other issues. Another example is the State Environmental Police in Maciambu – a jurisdiction that encompasses Imbituba – who had, in early 2000, only one group of four policemen to monitor fisheries issues in 13 municipalities.

Table 5.5 also shows several stakeholders who cause or intensify management problems and those who are the most affected by such problems. What is clear is that all these problems are common dilemmas leading to collective action problems – "a situation where there is a divergence of interests between what is rational for the collectivity and for the individual" (Acheson 1998, p.43-44). They exist because the current institutional arrangement allows free-riding and cost externalization of problems to a third party; that is, individual rational behavior generates communal problems.

5.3 Solving collective action problems

If individual responses cannot solve a commons dilemma, the task for the group is to organize themselves and to change from a situation of individual action to one of collective action. Such a strategy will provide joint benefits but lower joint costs (Berkes

et al. 2001, p.181). Solutions to collective action problems involve the establishment of rules constraining individual behavior. How management rules should be created depends on the scale and scope of each problem (e.g., political and ecological boundaries of an area, the property-rights regimes, ability to limit access, and the size and diversity of user-groups). According to Acheson (1998, p.51), collective action problems may be solved by decentralized solutions, in which "people may cooperate to provide rules by informal agreements" (i.e., community-based management) or by centralized solutions, in which people ask "the state to provide such regulations". The former may occur as a result of distributional conflicts, but "the nature of boundaries, ability to limit entry, political entrepreneurship, group size and social capital all play a role" (Acheson 1998, p.51). The latter may occur when there is a lack of access control, insufficient property rights and large and heterogeneous user-groups. It is important to note, however, that centralization and decentralization, *in the above sense*, are only two ends of a continuum of possible arrangements, and trade-offs exist among them.

> If management is too centralized, valuable information from the resource, in the form of feedbacks [from users to decision-makers], may be delayed or lost because of the mismatch in scale. If management is too decentralized, then the feedback between the user-groups of different resources, or between adjacent areas, may be lost (Berkes 2000, p.1).

Considering the above, it seems reasonable to argue that the principle of subsidiarity may be an appropriate guide to solving conflicts resulting from collective action dilemmas. That is, any decision-making should be taken by the lowest organizational level capable of solving the problem. For example, conflicts involving only local people and non-migratory resources may be solved at the municipal level, while conflicts involving outsiders or migratory resources may be solved at a higher political levels (e.g., by the state or federal government).

5.4 Proposing an alternative management for the Lagoon

Up to this point I have discussed institutional instability at higher political levels, the great diversity of ineffective management agencies, and the lack of coordination among government agencies from different levels and sectors. This has resulted in stakeholder conflicts, environmental degradation and resource overexploitation at the Ibiraquera Lagoon and the surrounding area. As well, I have observed that stakeholder conflicts reflect: a divergence in management goals; a degree of dependence on resources; disagreement about fishing rights and resource allocation; a lack of personnel and equipment resources to enforce regulations; a mismatch of scale of problems and regulatory and enforcement agencies; the lack of empowerment of fishers and local councils; and different understandings of Lagoon ecosystem dynamics. I now turn to the question: *what may be done to overcome such problems in order to develop an integrated and participatory management plan for that area*?

Any promising solutions to these problems depend first upon the willingness of governments at different political scales to deal with the issues. This may require the governments to modify their current structures in order to: (a) coordinate actions at different levels to minimize discrepancies in management goals and policies; (b) allow stakeholder concerns to be addressed; and (c) to incorporate user knowledge into management. The first task may be initiated by efforts such as the Train-Sea-Coast Programme in Brazil, which helps build the capability of coastal managers at different scales. Tasks (*b*) and (*c*) may be accomplished by setting off a participatory management process for the Ibiraquera Lagoon.

I suggest the establishment of an Ibiraquera Lagoon Management Forum to address stakeholder concerns and conflicts, and to build a knowledge base upon which management decisions can be made through a *co-management* process - a shared responsibility among governments, non-government organizations and resource users. The Forum could be a long-lasting institution able to deal with current problems and to actively respond, through an *adaptive management* approach (Holling 1978, Walters 1986) to future socio-economic and ecological problems. As well, this could be a joint effort from all of the federal, state and municipal government agencies holding responsibility for Lagoon management and all the other Lagoon stakeholder-groups (e.g., local fishers, outside fishers, local residents, tourists, and tourism businessmen). Some scientists and natural resource managers may also join the Forum in order to provide information, methods and tools to be used in each one of the co-management phases: planning, implementation, monitoring, evaluation and adaptation.

The Forum may search for promising conflict resolution measures across different political scales. For instance, it may work to empower community councils and other local organizations or it may work to set up agreements between groups of stakeholders. Additionally, the Forum may promote co-management between local resource users and government agencies. It may also serve to mediate discussions about resource use among local users and community councils, and the municipal government may legitimize agreements reached in such discussions (i.e., it may turn an informal agreement into a municipal by-law). In another instances, the Forum may instigate the federal government to promote decentralization of the enforcement function from federal and state governments to the municipal government, or even to community councils and the Forum

itself. This can result in a more effective, and possibly less expensive, enforcement regime, as local inspectors are more familiar with the local conditions than are outsiders.

5.4.1 Establishing a Forum for conflict resolution and resource management

Much has been written about co-management and participatory management processes, especially concerning fisheries management (Jentoft 1989, Pinkerton 1989, Hanna 1996, McCay and Jentoft 1996, Sen and Nielsen 1996, Pomeroy and Berkes 1997, Singleton 1998). Many case studies have been described for different world regions (Table 5.6). These have reported on the positive and negative experiences with fisheries co-management, and the major issues that need to be addressed in such arrangements. The latter includes: questions of representation of participants and their motivations; relationship building; power in decision-making; process legitimacy; local socio-political and cultural context; stakeholder values, interests, and conflicts; boundaries; resource condition; goals; costs, funding and budget allocation; capacity-building; institution-building; time-frame; information gathering; monitoring, enforcement and compliance; evaluation measures; and adaptive learning (Table 5.7).

All of these issues may be addressed when establishing an Ibiraquera Lagoon Forum (ILF). In this chapter, however, I center my attention on proposing a way to build a knowledge base to bridge user concerns and knowledge with manager concerns and knowledge. The major point here is that conflict resolution can be based on a common understanding of environmental and management problems. As Hanna and Smith (1993, p.66) pointed out, "a discussion of the various perceptions of the problem [is needed] to

arrive at a consensus of the true nature of the problem and on a common principles that will structure the [co-management] process. The consensus includes recognition by each group that the other group's objectives are viable and thus supportable."

To create an Ibiraquera Lagoon Forum and a knowledge base, I have built a governance model (Figure 5.1) based on the Brazilian fisheries management structure in 2000. The central office of the Brazilian Agency for the Environment (IBAMA) in Brasília – the nation's capital - was responsible for approving all changes in fisheries regulation, while IBAMA's offices at the state level were in charge of presenting proposals of new regulations but did not have any power in decision-making.

First of all, I argue that government authority and responsibility may be transferred from the IBAMA's central office to its state-level offices through an administrative decentralization (i.e. a de-concentration process) (Pomeroy and Berkes 1997). Managers working at the state-level office need to have the necessary skills to enter into a co-management process. Capacity-building is needed for managers to: (a) understand the important contribution stakeholders may have in management design, implementation, monitoring, evaluation and adaptation; and (b) learn tools and techniques to conduct workshops, to research stakeholder concerns and user knowledge, and to manage conflicts among user-groups (or even between themselves and users).

It is important to clearly recognize that each knowledge system is valuable in providing different kinds of knowledge and different perspectives. Making resource users confident of their knowledge can increase user participation in decision-making and in providing local solutions for management problems. Solutions to problems, based on local knowledge, are more likely to be accepted by local communities (Antweiler 1998).

In addition, increasing resource users' confidence in their knowledge may even strengthen their ability to "co-operate with external institutions on an equal basis" (Antweiler 1998, p.490).

Capacity-building may be provided by specialists or scientists working with local knowledge and social organizations in coastal systems. Scientists may also play a role in providing scientific information to complement user and manager practical knowledge. Hence, government fisheries managers may invite both natural and social scientists from nearby universities or research institutes to be a part of the co-management process. After partnerships are established between government managers and natural and social scientists, the identification of stakeholders may be undertaken. To help establish a co-management Forum at the Lagoon, managers may describe each step of the process and the actors involved in it, and point out the benefits, costs and risks of such a process for each stakeholder group and for the society in general. Because in many cases, stakeholders are not well organized, managers may need to encourage them to get organized in order to be a part of the process. Stakeholder representation and the decision-making process could then be negotiated. Stakeholder misrepresentation may create bias in the decision-making process (Jentoft et al. 2001) and a consequent lack of compliance to management measures, as in the case of the Forum of Patos Lagoon in south Brazil (Box 5.1).

It is important to understand that not all management decisions can be made locally by the Forum. Indeed, in many cases the Forum will only provide a knowledge base and suggestions of promising solutions to government agencies at higher political

levels, which in turn will make decisions while taking into account matters involving other areas and groups of people – the subsidiarity principle.

5.4.2 Co-managing practical and scientific knowledge

If an Ibiraquera Lagoon Forum can be created, there will be a need for a 'working team' to build a knowledge base upon which decisions can be made. Initially, the team can define research tools, techniques, and samples to search and compile information about the Lagoon management system, including stakeholder concerns and user knowledge. Information-gathering techniques and sampling strategies may vary according to the local socio-political context and diversity of resource uses. In fisheries, for example, "the complex range of factors that probably influences fishers' [knowledge] means that reliance on a small sample could result in limited and perhaps biased data" (Neis et al. 1999, p.222). The literature provides several techniques (e.g., semi-structured interviews, focus groups, ethno-mapping, participant observation, etc.) and sampling methods (e.g., most knowledgeable users, users from different user-groups, gender, etc.) which may be used individually or complementarily to collect user local knowledge (e.g., Neis et al. 1999, Usher 2000, Berkes et al. 2001).

The team would need to be involved in data collection, organization and communication, as well as the discussion of such data with the public. The knowledge base would incorporate three main sources of information. These would include: (1) resource users, who would provide practical local knowledge; (2) managers, who would provide practical knowledge at local and/or regional scales, and scientific knowledge; and (3) scientists, who would provide scientific knowledge (Figure 5.2). To integrate user and

manager practical knowledge with scientific knowledge, all information must be collected, organized and communicated in a comparable way. User and manager practical knowledge can be organized in a systematic way, and distinction must be clearly made between observations and inferences (Usher 2000). Moreover, the process of collecting and organizing information must also include techniques of validation (e.g., data triangulation). Particular attention may be given to information directly relevant to conflicts among user-groups, since user statements may be 'politicized' (Neis et al. 1999). Practical information provided by users and managers must be accountable on an equal basis to scientific information.

All compiled information, including both practical and scientific knowledge, may be presented to all actors involved in the co-management process. Additionally, sufficient time may be provided for the groups to digest or check such information. For instance, resource users need time to assimilate external knowledge by testing it in their everyday practices. As Antweiler (1998, p.489) pointed out,

> Communities must have the opportunity in terms of time and social institutions to discuss the given information and integrate it into their system. They need to gain their own experiences with the application of external knowledge along the lines of their socialization practices. This normally demands an adequate time frame and has often led to impatient reactions of practitioners, who need to achieve quick results, particularly in the case of an endangered natural environment.

Giving time to resource users, managers and scientists to assimilate information about an entire fishery system (including socio-economic and ecological information at the local and regional scale) may also encourage their search for more creative and viable management strategies and solutions to problems. As well, this may reduce the time stakeholders spend arguing with one another about their own, often limited, views of the system.

Information gathering may take place during several phases of the co-management process, including: (a) defining management goals; (b) building an initial knowledge base concerning the economic, social and ecological aspects of the system; (c) compiling suggestions of, and deciding about, management and conflict resolution measures while considering its costs, benefits and risks; (d) compiling suggestions of, and deciding about, ways of implementing and enforcing such measures; (e) compiling new data (through monitoring) to evaluate the implemented measures; (f) compiling new suggestions about how to improve the implemented measures, and so on. Ideally, the Forum could work towards an adaptive management, in which new information could be incorporated into the knowledge base and help decision-makers to propose more appropriate management measures (learning-by-doing).

The continuous process of planning, implementation, monitoring and evaluation is necessary because resource systems are 'non-linear in nature, cross-scale in time and in space, and have an evolutionary character' (Holling et al. 1998). Moreover, resource systems are complex in behavior, unpredictable, and in some cases, chaotic (Wilson et al. 1994). Therefore, management measures have to be adjusted in order to adapt to changes in the resource system. As well, measures also have to adapt to changes in the socio-economic system, especially when stakeholder conflicts arise.

The key idea of such a co-management Forum is to present and discuss knowledge and the values and concerns of users, other stakeholders, managers and scientists. This is done in order to propose and decide upon viable socio-economic and ecological solutions for the existing management problems, and to improve the Lagoon management system. Such a process is a multi-way interaction pattern for providing

information and decision-making that may result in learning and knowledge adaptation for users, other stakeholders, managers and scientists.

A co-management forum along the lines summarized above is one way a new Lagoon governance may be conceived and structured. In reality, the interactions among government agencies and other stakeholders may result in a different kind of multi-stakeholder body with a different mandate or structure. Indeed, co-management is an interactive process that may arise from negotiation, joint problem-solving and mutual learning (e.g., Kendrick 2000, Blann et al. 2002).

Conflict management has many aspects. The aspect dealt with in this chapter is building a knowledge base to help find common ground among stakeholders. It is possible that stakeholder interactions may never emerge out of interest-based politics, to build such a knowledge base. The point, however, is that if a common knowledge base can be built, this would help resolve or manage conflicts more effectively.

Table 5.1. The Lisbon principles – key principles to promote sustainable governance of the oceans and coastal areas (source: Costanza et al. 1998, 1999).

Lisbon principles	
Responsibility principle	the responsibility of individuals or corporations to use environmental resources in an ecologically sustainable, economically efficient and socially just manner
Scale-matching principle	the importance of assigning decision-making to the scale of governance which has the most relevant ecological information, which considers ownership and actors, and which internalizes costs and benefits
Precautionary principle	the need to take uncertainty about potentially irreversible environment impacts into account
Adaptive management principle	the requirement to continuously monitor social, economic and ecological systems because they are dynamic and have some level of uncertainty
Full cost allocation principle	the need to identify and allocate all internal and external costs and benefits (social and ecological) of alternative uses of environment resources
Participation principle	the importance of full stakeholder participation in the formulation and implementation of decisions about environmental resources

Table 5.2: Promising institutional forms for cross-scale linkages in natural resource management (based on Berkes 2002).

Institutional forms	
Co-management linking communities and government	combine the strengths of government-level and local-level resource management and mitigate the weaknesses of each
Multi-stakeholder bodies	link multiple user-groups and interests (local and regional) with the government, and provide a forum for conflict resolution and negotiation among users
Development, empowerment, co-management arrangements	emphasize development and empowerment (co-management is a result), the involvement of NGOs or other capacity-building bodies, and the presence of lateral as well as cross-scale linkages
Institutions for linking local users with regional agencies	bring local issues to the regional and international arena. Examples include epistemic communities (groups of scientists, government experts and NGOs people) and funding agencies
Research and management approaches to enable cross-scale linkages	may impact local and higher-level institutions. Examples include adaptive management, ecosystem-based management, participatory rural appraisal (PRA) and participatory action research (PAR)
'Citizen science' or 'people's science movements'	combine local knowledge and inputs from university scientists into alternative resource and environmental assessments

Table 5.3: Key factors that have affected the social-ecological resilience of Lagoon management (after Chapter III)

Key factors affecting social-ecological resilience
Build resilience
Strong institutions (leadership and rule enforcement)
Good cross-scale communication (co-management of scientific and local knowledge)
Political space for experimentation
Equity in resource access
Use of (local people's) memory and knowledge as source of innovation and novelty
Weaken resilience
Breakdown of locally-devised institutions and authority system
Rapid technological changes leading to more efficient resource exploitation
Rapid changes in the local socio-economic system
Institutional instability at higher political levels negatively affecting local management

Table 5.4. Government agencies responsible for Lagoon fisheries management during the past four decades.

GOVERNMENT AGENCIES	Political level	Period
Fisheries regulations		
Decision-makers		
• Service for Fishing and Hunting [a] (SCP)	Federal	1960 - 1967
• Federal Fishery Agency [b] (SUDEPE)	Federal	1967 - 1989
• Brazilian Agency for the Environment [c] (IBAMA)	Federal	1989 - 2000
Information providers		
• Fishery Research Institute [d] (IPEP)	State	1980s
• State Association for Fishery Credit and Assistance [e] (ACARPESC)	State	1980s
• Federal University of Santa Catarina [f] (UFSC)	Federal/State	1992-1998
• Santa Catarina State Research Agency [g] (EPAGRI)	State	1992-1998
Enforcers		
• State Department of Fishing and Hunting [h] (DECP)	State	1960 - mid 1970s
• Navy District Office [i]	Federal	1960s
• SUDEPE	Federal	1967 - 1989
• IPEP	State	1982 - 1984
• ACARPESC	State	1984 - 1989
• State Environmental Foundation [j] (FATMA)	State	1991 - 1994
• State Environmental Police [l]	State	1994 - 2000
Channel openings		
Decision makers and enforcers		
• Navy District Office	Federal	1960s – 1988
• Municipal Government	Municipal	1988 – 2000

Agencies: [a] *Serviço de Caça e Pesca do Minitério da Agricultura;* [b] *Superintendência do Desenvolvimento da Pesca do Ministério da Agricultura;* [c] *Instituto Brasileiro do Meio Ambiente e Recursos Renovaveis;* [d] *Instituto de Pesquisa e Extensão da Pesca;* [e] *Associação de Crédito e Assistência Pesqueira de Santa Catarina;* [f] *Universidade Federal de Santa Catarina,* [g] *Empresa de Pesquisa e Difisão Tecnológica do Estado de Santa Catarina;* [h] *Departamento Estadual de Caça e Pesca;* [i] *Capitania dos Portos;* [j] *Fundação do Meio Ambiente do Estado de Santa Catarina;* [l] *Companhia de Policia de Proteção Ambiental*
Observation: In fact, during the 1960s, regulations decision-making, information provision, and enforcement were all performed by the local communities. As well, channel opening decision-making and opening action were performed by local fishers and/or Fishers Organization (Colônia) from the 1960s until 1988; and from 1993 to 2000 (Chapter III).

Table 5.5. Major environment and management problems affecting the Ibiraquera Lagoon fisheries during the late 1990s.

Problems	**Regulatory and/or enforcement agencies**	**Government level**	**Stakeholders responsible for them**	**Most affected stakeholders**
Illegal fishing gears and methods affecting resource stocks and triggering fisher conflicts	Brazilian Agency for the Environment (IBAMA)[a] Environmental police [b]	federal state	local fishers outside fishers	full-time and part-time, local fishers
Motor vessels and windsurf boards in the Lagoon	City Hall	municipal	tourists	fishers
Garbage dumping at the Lagoon margins	City Hall	municipal	tourists fishers	fishers local residents tourists
Sewage drainage into the Lagoon and poorly constructed septic tank contaminating the water table	State Environmental Foundation (FATMA)[c] City Hall	state municipal	tourism industry	all fishers local residents tourists
Management of Lagoon Channel openings	City Hall Fishers organization [d]	municipal	tourism industry tourists	fishers
Illegal construction inside and around the Lagoon (*areas de Marinha*)	Department of State Properties (DPU)[e] City Hall	federal municipal	tourism industry tourists	fishers local residents
Deforestation of Lagoon margins, along springs, and on hills; and consequent landslide	IBAMA FATMA Environmental Police	federal state state	tourism industry	local residents fishers
Siltation of shrimp/fish migratory channels due to deforestation and poorly- planned construction around the Lagoon	IBAMA DPU FATMA Environmental Police City Hall	federal federal state state municipal	tourism industry	fishers
Lagoon access trails closure by tourist landowners	(regulatory gap)	---	tourists outsiders	fishers local residents

Agencies: [a] *Instituto Brasileiro do Meio Ambiente e Recursos Renovaveis;* [b] *Companhia de Policia de Proteção Ambiental;* [c] *Fundação do Meio Ambiente do Estado de Santa Catarina;* [d] *Colônia de Pescadores Z13 – Imbituba;* [e] *Delegacia do Patrimônio da União.*

Table 5.6: Some fisheries co-management cases reported in the literature.

Country	References
Bangladesh	Ahmed et al. 1997
Brazil	Reis and D'Incao 2000 Barbosa and Hartmann 1998 Hartmann and Campelo 1998 Christensen et al. 1995
Canada	Campbell 1996 McDaniels et al. 1994 Berkes et al. 1991
Fiji	Virdin 2000
Norway	Jentoft 1985
Philippines	Agbayani et al. 2000 Sunderlin and Gorospe 1997
Sri Lanka	Lowry et al. 1999
Tanzania	Andersson and Ngazi 1995
Thailand	Nickerson-Tietze 2000
United State	Singleton 1998 Hanna 1996 Pinkerton 1992
Melanesia (Vanuatu)	Johannes 1998b
West Indies	Sandersen and Koester 2000

Table 5.7. Important issues that may be addressed in establishing co-management regimes. [a]

Issues of concern		
participation (user-groups and other stakeholders)	⇒	depend on the history of participation, structure and process of participation, resource conditions, and characteristics of the program (Hanna 1996)
	⇒	representation; degree of involvement (community support); scale and scope of users participation
	⇒	organization of user-groups (core groups) and other stakeholders
representation	⇒	cohesiveness and differences inside a community (differences within user-groups/ difference among user-groups)
	⇒	heterogeneity of users (socio-economic, gender, race, religion, literacy level, etc)
participants' motivation and commitment	⇒	social and economic incentives to cooperate
	⇒	compensations to change the status-quo
	⇒	early actions increase motivation
building relationships	⇒	trust, respect, open communication (dialogue), bridging historical gaps, continual process of confidence building
	⇒	negotiation posture: flexibility, patience on the part of all stakeholders
decision-making power	⇒	decision-making level; structure of decision-making; decision rules and distribution of authority
	⇒	uneven power; power sharing; power transfer
process legitimacy	⇒	accountability; credibility; responsibility
	⇒	transparency of management decisions
local socio-political and cultural context	⇒	social norms; political culture; cultural difference and misunderstanding; political and economic inequality
	⇒	authority system, stewardship; leadership
	⇒	rights (e.g., traditional rights) and property
stakeholder values, interests, and conflicts	⇒	public interest; private interest; common interest; heterogeneous interest
	⇒	perceptions, preferences and behaviors of user-groups
management boundaries	⇒	physical (ecological), social, technical, economic, political criteria
resource condition	⇒	scarcity, abundance
goals	⇒	clearly defined goals
costs, funding and budget allocation	⇒	shared cost of development projects
	⇒	private and social costs may diverge; search costs (cause and scope of problems), bargain costs, monitoring and enforcement costs; transaction costs
time-frame	⇒	slow enough for the full consideration of co-management issues
capacity-building	⇒	at government level: training facilitators
	⇒	at local level: environmental awareness training
institution-building	⇒	nested institutions
information gathering	⇒	technical information
	⇒	local knowledge ('time and place' information)

Table 5.7 (cont'd)

Issues of concerns		
monitoring, enforcement	⇒	monitoring indicators
and compliance	⇒	self-imposed regulation; voluntary compliance
evaluation measures	⇒	sustainability: institutional, economical and ecological
(criteria)	⇒	sustainability: stewardship, resilience, efficiency, equity (Hanna 1996) o stewardship (time horizon, monitoring of behavior, enforcement) o resilience (rule flexibility, structural adaptation, adaptation to markets) o efficiency (cost-effectiveness: information costs, coordination costs, enforcement costs) o equity (representation, process clarity, compatible expectation, distribute effects)
	⇒	productivity
learning	⇒	adaptive learning, social learning, mutual learning: learning-by-doing

[a] Also known as: collaborative management, participatory management, joint management, and joint stewardship

Box 5.1
Participatory management: The Forum of Patos Lagoon, Brazil

An attempt to develop a participatory, cross-scale and cross-sector management effort in South Brazil was the establishment of the Forum of Patos Lagoon in 1996. The Forum is a multi-partner entity encompassing 21 organizations from distinct political, economic and legal sectors, which involved the civil society to evaluate fisheries management and enforcement in order to propose new regulations and management alternatives (Reis and D'Incao 2000). Although this Forum represents a very important step towards a participatory and integrated management, Reis and D' Incao (2000, p.589-591) reported several issues that question the fishers real participation in the process and the decision-making process itself:

> Fishermen representatives are restricted to coordinators of fishermen organizations and fishermen unions who are not necessarily active fishermen. Therefore, decisions within the Forum may be taken apart from daily reality. It is also difficult to expect that only one person ... may represent equally well five or more communities [or different fisher-groups] ..." As a consequence, "despite the regulation was discussed for more than 3 years, there are fishermen that misunderstand it or that think it is somehow harmful to their activity." Moreover, " fishermen are not used to considering themselves responsible for regulations. So, an intense program to make fishermen conscious of the important role that is expected from them has to be developed by [the Forum].

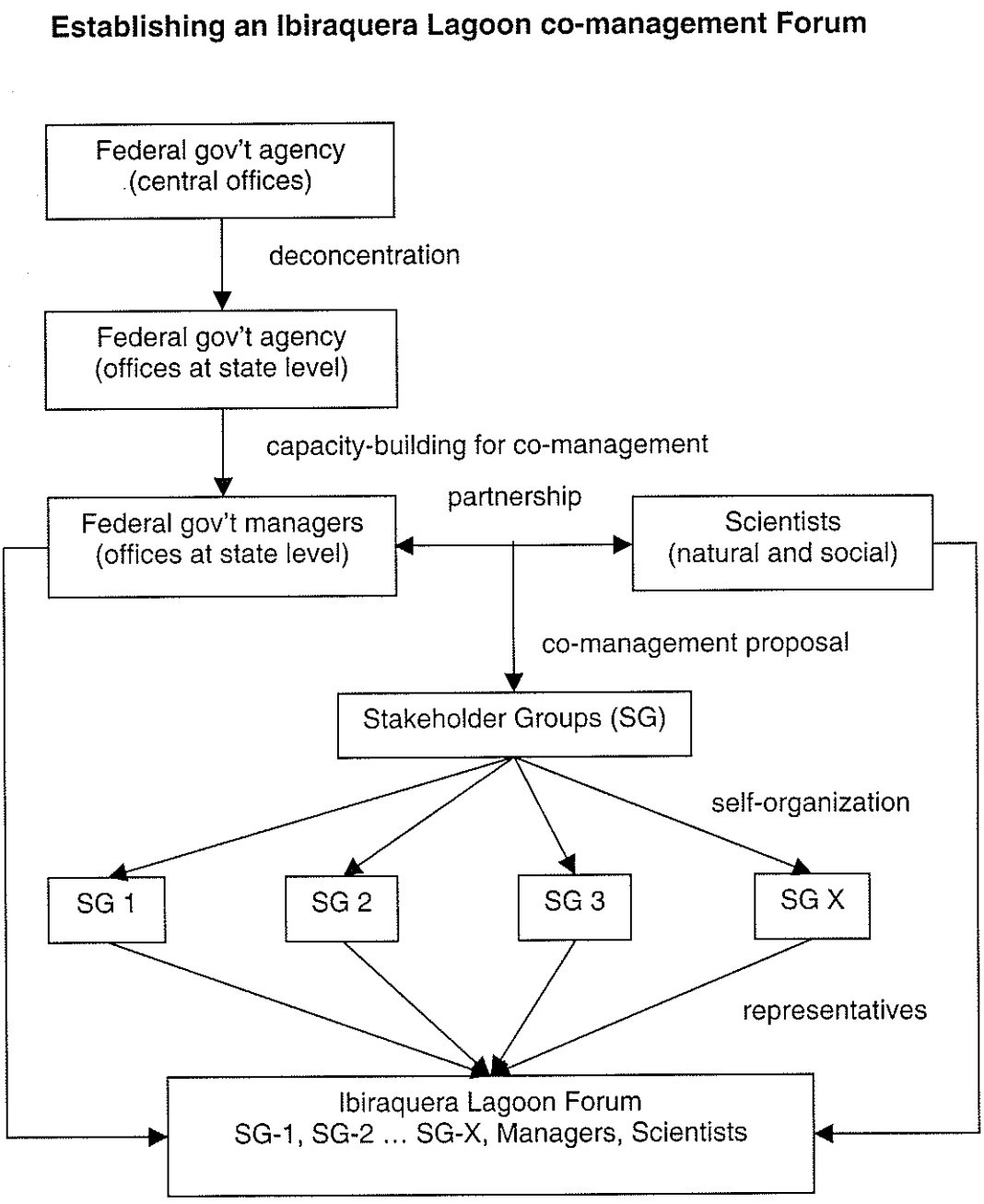

Figure 5.1. Establishing the Ibiraquera Lagoon co-management Forum. Stakeholders may include: different fisher-groups, community councils and other local non-governmental organizations (e.g., representing tourists, small farmers, guesthouses and restaurants, constructors, nautical sports, etc); as well as, municipal government and any other state or federal government agency holding any responsibility for the Lagoon management.

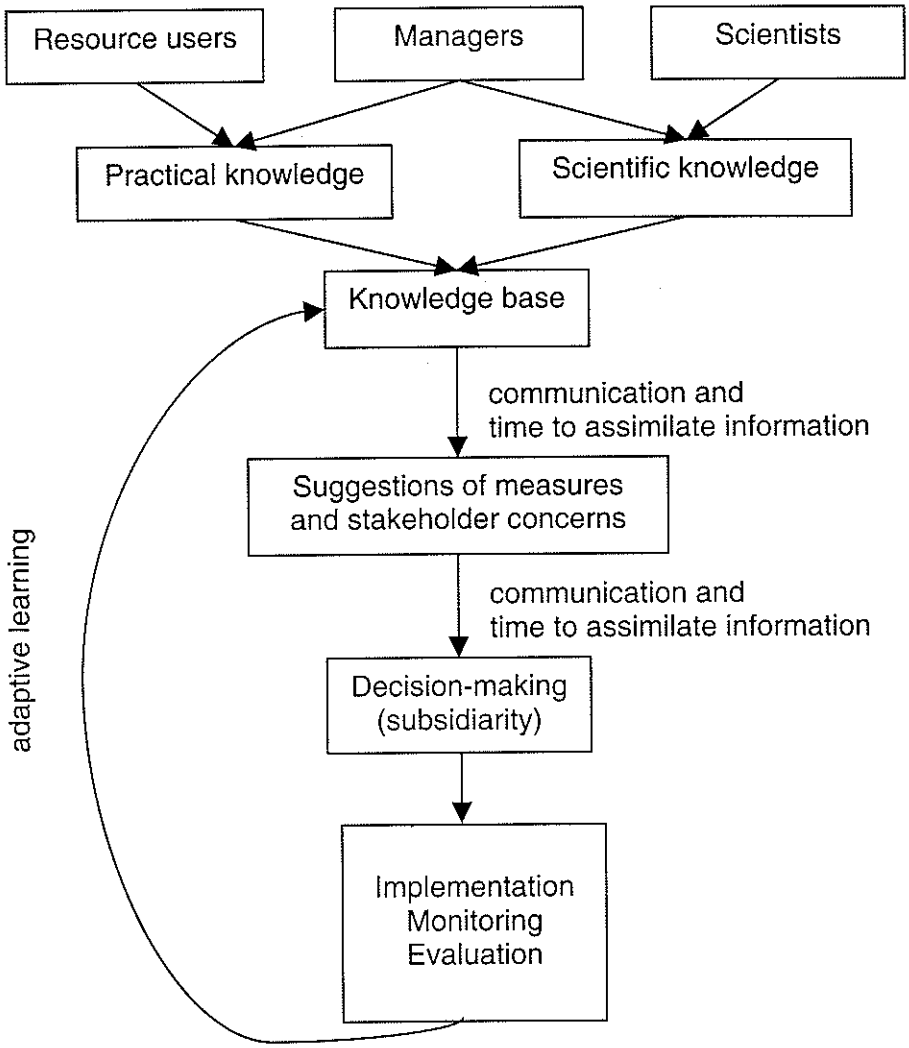

Figure 5.2. Building a knowledge base for co-management (partly based on Mackinson 2000)

Chapter VI

Extractive Reserves for marine conservation: A policy alternative for the Lagoon management

A fisher throwing his cast-net for shrimp in the early evening on the Ibiraquera Lagoon (Fall 2000).

Chapter VI

Extractive Reserves for marine conservation: A policy alternative for the Lagoon management

6.1 Introduction

Various kinds of marine protected areas (MPAs) have been proposed and implemented in various parts of the world (NRC 1999). However, there has been little discussion of the Brazilian concept of extractive reserves in regard to their potential for implementation as MPAs. *Can the extractive reserves model be used for marine conservation*?

To address this question, I first introduce the concept of extractive reserves, then, I present some cases of extractive reserves for marine conservation and address some issues and problems from these experiences. Second, I explore the idea of extractive reserve as a policy alternative for the Ibiraquera Lagoon management system in South Brazil, and propose some policy instruments to manage this reserve.

The idea of extractive reserves was initially proposed during the 1970s and 1980s by the 'rubber tappers' or 'extractivists' social movements in the Brazilian Amazon as a way to promote social justice and environmental protection (Brown and Rosendo 2000, Diegues 2001). It emerged in response to the development model for the Amazonian region proposed by the Brazilian government during the 1970s (Cunha 2002). The government development model was based on deforestation and expansion of cattle ranches into cleared areas to promote regional economic growth. This kind of 'development' displaced forest people, reduced biodiversity and proved to be

unsustainable (Barbira-Scazzochio 1980, Fearnside 1983, Diegues 2001). The idea of extractive reserves, by contrast, was based on the sustainable use of forest products by local people (Diegues 1993).

Extractive reserves are defined as "territorial spaces destined [*destinados*][1] for self-sustained exploitation and conservation of renewable natural resources by extractivist populations" (Brazilian Federal Decree 98.897/1990). Thus, an extractive reserve is an area in which access to the resource is controlled. The local population has 'use rights' [*usufruto*] in the area, while entry by outsiders is regulated. Resource management is a joint effort between government and the local population; and local knowledge, rules and institutions may be used in such management (Begossi 1998).

What distinguishes extractive reserves from other types of conservation units, such as State and National Parks and Marine Protected Areas, is that the former are based on the use and conservation of resources, while the latter focus on the preservation of ecosystems. Extractive reserves are unique in that they contemplate the active involvement of resource users in the planning, implementation, monitoring, enforcement and evaluation of management plans, and help ensure the permanence of extractivists in their traditional areas (Cunha 2002). The institutionalization of extractive reserves as part of Brazilian environmental policy started in 1990 (Federal Decree 98.897/1990). Since then, 16 extractive reserves have been created in the Amazon and the establishment of 20 others is being considered (Cunha 2002).

In addition to forest conservation, the idea of extractive reserves has also been applied to marine conservation. In 1992, the first marine extractive reserve, *Reserva*

[1] The Portuguese term *destinado,* translatable as 'destined', is used by the Brazilian government. However, the term 'designated' would probably be a better translation.

Extrativista Marinha do Pirajubaê, was established in Brazil, on the coast of Santa Catarina State. Since then, five other marine extractive reserves have been created, and 34 other sites are being investigated by federal agencies (Cunha 2002).

According to the guidelines provided by the National Center for the Sustainable Development of Traditional People (CNPT[2]) – a section of the Brazilian Agency for the Environment (IBAMA[3]) (2002), the first step in the creation of an extractive reserve is a letter of intent from the local population. The letter of intent serves as evidence that there is local demand for an extractive reserve. This letter shall be presented through local organizations to the CNPT-IBAMA. The CNPT will then evaluate the social and ecological aspects of creating a reserve in the area and, if approved, a process to expropriate the land and compensate private landowners is initiated. The next step is the development of a 'Management Plan' [Plano de Utilizacao] for the extractive reserve, which has to be developed jointly by the local population and CNPT-IBAMA, sometimes with the help of scientists. This management plan shall specify 'how', 'when', 'where' and by 'whom' each resource can be exploited. It sets out the rights and duties of each party in the extractive reserve. Enforcement of this plan shall be a joint effort among local population, IBAMA officers, and other municipal or state government agencies (CNPT-IBAMA 2002).

The process of creating a marine extractive reserve is sometimes facilitated in cases where the reserve encompasses only ocean waters and coastal areas owned by the State, and no expenditure is needed for expropriation of land. This, in fact, was the case of a marine extractive reserve created to manage small-scale artisanal fisheries on the

[2] CNPT: Centro Nacional de Desenvolvimento Sustentado das Populações Tradicionais.
[3] IBAMA: Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis.

coast of Rio de Janeiro State (RESEX Arraio do Cabo 1996), as well as the case of another potential reserve in a nearby area (RESEX Itaipu-Itacoatiara-Piratininga 1999).

The Chilean Fishing and Aquaculture Law of 1993 presented a concept similar to the Brazilian marine extractive reserves under the name of "Management and Exploitation Areas (MEA)" (Castilla and Fernandez 1998). These MEAs are reserved for only small-scale (artisanal) fisheries and were created to resolve the conflict between artisanal and industrial fleets. Accordingly, the Chilean government confers exclusive fishing rights in defined areas to registered organizations (e.g., fishers' unions) or communities of artisanal fishers. A management plan for each MEA has to be developed by the local fishers or their organizations and has to be approved by the government. That is, this is a co-management arrangement as in the case of the Brazilian extractive reserves.

The effectiveness of MEAs as a conservation measure for marine policy is discussed by Castilla and Fernandez (1998). In their study, a comparison between a MEA and an open-access fishing ground showed that benthic resources captured inside the MEA were larger than in the open-access fishing ground, and the mean catch per unit of effort (CPUE) for those resources was also higher inside the MEA. The authors call attention, however, to differences underlying the conscious values and concerns about conservation between resource users and scientists:

> Of course, the [fishers'] main motivation to avoid overexploitation is to obtain the maximum revenue from the MEA, even if it implies perturbation of the system. One of the major problems we may face in the Chilean small-scale fishery is that although fishers have some idea of ecosystem functioning (through experience), their objectives are completely different from those of scientists. Fishers, if allowed, will try to modify the system in order to obtain the maximum revenue: for instance, the removal of predators of the target resource (p. 129).

A similar argument is presented by Almeida (1994), who observes that some extractivists, such as rubber tappers, are not only driven by a conservation ethic but also by economic opportunities which may lead them to violate such an ethic. This means that in elaborating a management plan for an extractive reserve, issues concerning the economic viability of such management must be addressed.

Concerning the success of an extractive reserve as a conservation measure, Brown and Rosendo (2000, p. 36) point out that "the legal provisions for the establishment of extractive reserves have by no means guaranteed their effective implementation." A good example of this is presented by Pinho (2001), who analyzed the 10-year management history of the *Reserva Extrativista Marinha de Pirajubae*, a marine reserve in Brazil, and found several current problems. These include, among others, a lack of knowledge by extractivists about their rights to engage in decision-making and enforcement activities; a misrepresentation of users on the local decision-making association (the board of the association was filled only by part-time extractivists instead of full-time extractivists); and a lack of an effective rule enforcement, which in turn created other problems such as pollution in the mangrove area and over-harvesting of some plant and animal species. That is, if sustainable management is to be achieved, the incorporation of the extractivists as *real* actors is essential (Castilla and Fernandez 1998). Another key factor to achieve sustainability is the ability of resource users to learn from their experiences and adapt the appropriate policy instruments for each scenario. In the following sections I address these and other key factors to approach sustainability by proposing the establishment of an extractive reserve for the Ibiraquera Lagoon management system in South Brazil.

6.2 Ibiraquera Lagoon fisheries system

The Ibiraquera Lagoon is located in the municipality of Imbituba (pop. 33,000 in 1991) in Santa Catarina State, along the southern part of the Brazilian coast (Figure 1.3). This is a brackish water Lagoon, intermittently connected to the Atlantic Ocean by a channel. The Lagoon has four basins and an area of approximately 900 hectares. Pink shrimp (*Farfantepenaeus paulensis* and *F. brasiliensis*) and mullet (*Mugil platanus, Mugil* spp.) are the main fishing resources, followed by blue crab (*Callinectes sp.*). Cast-net is the main fishing gear, and dugout canoe is the main vessel. Fishing is usually a male activity.

The Lagoon is legally a state property, there are no effective legal access restrictions. Thus, it is effectively an open-access resource. As of the year 2000, there were about 350 licensed fishers and many other unlicensed ones living in seven communities around the Ibiraquera Lagoon: Ibiraquera (also known as Teixeira), Barra da Ibiraquera, Arroio, Alto Arroio, Araçatuba, Campo D'Una, and Grama (or Ibiraquera de Garopaba). Many of the fishers were descendants of immigrants from the Azores Islands, who arrived in this part of Brazil about 200 to 250 years ago. Fishers from other communities and municipalities also frequently fished in this lagoon.

The Lagoon fisheries system has experienced several management cycles since the 1960s: it has gone from a community-based management regime during the 1960s to an open-access situation from 1970 to 1981, then to a co-management system between local fishers and the federal government during the 1981-1994 period, and finally, to a mix of state-property regime, communal-property regime, and open-access situation during the 1994-2000 period (Chapter III). The latest scenario is a result of a lack of regulation

enforcement, an increase in the number of outside fishers, and several conflicts caused by a boom in tourism activities interfering with the fishery system during the 1990s.

The history of the Lagoon fisheries management shows in two instances that *there is a demand to improve fisheries management by local fishers*. First, during the 1981-1994 period, fishers organized themselves and demanded three different gear restrictions, which were approved by the federal government fishery agency (SUDEPE-IBAMA) and helped to restore the Lagoon's stocks (Chapter III). Second, facing a lack of enforcement by the state and federal government, local fishers organized themselves into groups to patrol the Lagoon in 1998. Nonetheless, this activity did not last long because fishers did not receive the legal support to do so. On several occasions, they called the IBAMA and the Environmental Police to stop illegal fishing, but to no avail. Moreover, monitoring groups were sometimes threatened with shotguns by those fishers using illegal gears (Chapter III). These two examples demonstrate that Ibiraquera fishers can and do engage in fisheries management, and are able to work jointly with government officers – two key factors to establish an extractive reserve.

6.2.1 Shrimp market and fisher behaviour in the late 1990s

Ibiraquera shrimp are marketed locally, directly to consumers or through middlemen, while mullet, crab and other fishes are used mainly for subsistence. The relationship between supply and demand forces in the Ibiraquera shrimp market does not match the predictions of neoclassical economic theory. Ibiraquera shrimp demand is mainly determined by the stage of the tourist season (peak versus off-season). Shrimp supply is highly dependent on the Lagoon channel-opening management, which in turn depends on

rainfall and the movements of shrimp larvae and post-larvae in the ocean. Hence, shrimp supply is subject to ecological uncertainties and shocks. Generally under these conditions one would expect potential negative supply shocks to drive up the market price for a commodity. In this case, however, ecological uncertainties do not add economic value to the product; instead, they decrease shrimp prices and fishers' profits. I suggest here that this happens because the Lagoon shrimp market is dominated by only three middlemen, who usually pay less for shrimp than do retailers, restaurants and probably tourists, but who purchase shrimp year-round instead of buying it only during the tourist season. Because shrimp harvests may peak during the tourist off-season, some fishers prefer to sell shrimp to middlemen for reduced prices during the tourist season to ensure that they will have a buyer during the off-season – the period when tourism-related jobs decrease. If this is the case, then the dynamics between demand and supply in the Ibiraquera shrimp market can be viewed as operating to provide an "income-insurance mechanism".

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 adult shrimp stock would return to the ocean for reproduction. The problem is that lack of regulation enforcement (concerning how, where and when to fish, and who is allowed to fish) makes the Lagoon a *de jure* common property resource but a *de facto* open-access situation. Individuals have privilege but no rights in using the resource (Bromley, 1989). In the late 1990s, locals harvested shrimp primarily for commercial purposes, while, for most outsiders, fishing served mainly as entertainment. Since most

outsiders and sport-fishers had no economic dependence on the Lagoon resource, they had no economic incentives to use large mesh nets and prevent overfishing. In the face of an open-access system where anyone holding a professional fishing license could fish, local fishers, both full-timers and part-timers, also had no social or economic incentive to use large meshes and prevent overfishing. In addition, there also existed some profit-maximising 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.

Hence, in order to increase the size (and price) of shrimp marketed and avoid overfishing, new incentives and constraints are needed. A new institutional arrangement should provide fishers with signals that incorporate the costs of their fishing activities, for example, by charging a user fee of some sort. Indeed, a new arrangement could incorporate policy based on both property-rights and market instruments.

6.3 Extractive Reserve policy for the Ibiraquera Lagoon

It is unlikely that the Lagoon system will ever approach sustainable use under an open-access situation (i.e., unrestricted number of fishers). This is because lack of restriction to access is a probable cause of resource overexploitation even when fishing rules concerning 'how to fish' are appropriate and effectively enforced. Because the extractive reserve concept seems to be an appropriate instrument for marine conservation, and as extractive reserves are already part of Brazilian environmental policy, it seems feasible to propose the creation of an extractive reserve at the Ibiraquera Lagoon as a way to: (a) restrict the number of fishers with 'use rights', (b) seek better enforcement of regulations,

and (c) limit the tourists' negative impacts on the Lagoon (Chapter IV, Table 4.5). By creating an extractive reserve, the Ibiraquera Lagoon system may be transformed from an open-access situation (*res nullius*) into a common property regime (*res communis*), where 'use rights' are controlled by a group of users and other parties (e.g., government) (Begossi 1998). Indeed, extractive reserves provided a combination of common-property and state-property regimes (Begossi 1998). In such a co-management arrangement, responsibility for resource management is shared by organizations of resource users and the state.

To develop and implement a management plan for the Ibiraquera Lagoon Extractive Reserve (ILER), a co-management forum could be created, as proposed in Chapters IV and V. This forum could serve as an arena for negotiation, joint problem-solving and mutual learning among local resource users, government agencies, researchers and other stakeholders. The co-management forum should address the major categories of policy instruments for sustainable fisheries management as presented in the section 6.4. The specific policy instruments that I discuss regarding the extractive reserve are addressed in section 6.5. Potential issues in the design of this policy, such as administrative costs, enforceability, effectiveness, distributional effects, and use of revenues will also be addressed.

6.4 Major categories of policy instruments

Jacobs (1993) outlines four classes of policy instruments for natural resource and environmental management: (1) regulations, (2) financial incentives (also known as market mechanisms), (3) voluntary mechanisms and (4) government expenditures. In

fisheries, *regulations* may encompass standards concerning 'where', 'when' and 'how' (technological standards) to fish as well as 'how much' to fish (e.g., fishing quotas). Monitoring and enforcement along with punishment (by fines or imprisonment) are imperative for the effectiveness of regulations. Acheson and Wilson (1996) argue that controlling 'how' people fish reduces information and enforcement costs relative to controlling 'how much' people fish.

Financial incentives use price mechanisms to obtain management goals. In fisheries, at least two types of financial incentives may be applied: resource depletion taxes and tradable permits (or their variant, licenses). By increasing the cost associated with resource use, taxes encourage lower and more efficient use of the resource and its conservation. *A depletion tax* levied on the fishery harvest "is set at the rate which reduces extraction to the sustainable (or otherwise defined) level" (Jacobs 1993, p.139), though governing authorities may have to iteratively adjust the tax rate from year to year to approach this theoretical ideal. In a *tradable permit system*, the governing authority fixes the aggregate fishery harvest (presumably at the sustainable level), and then allocates rights to the aggregate harvest by issuing permits among fishers. Fishers can reallocate rights to portions of the harvest by buying and selling permits among themselves. Fishers who buy permits take on a cost associated with harvesting above the level represented by their initial permit allocation. The information needed to establish total allowable catch (TAC) is quite costly, as is the monitoring and enforcement of the permit system. *A license* is a type of permit that may be tradable but which has no defined TAC attached to it. License prices may be used to exclude ineffective fishers from the system, thereby reducing the number of fishers. A comparison between two types of

tradable permits, fishing quotas and fishing licenses, is presented in a following sub-section.

Voluntary mechanisms cause "actions unenforced by law and unpersuaded by financial incentives, which individuals, groups and firms take to protect the environment" (Jacobs 1993, p.134). The most prevalent form of voluntary mechanisms is the provision of information, often in a persuasive manner, with the idea that economic agents will behave sustainably when informed about the effects of their behavior. Another common form of voluntary mechanisms is the allocation of property rights to people close to a resource, in the hopes that they will then voluntarily manage the resource sustainably. In fisheries, voluntary mechanisms may include environmental education of resource users that may be interfering with or negatively affecting fishing activities and the ecosystem itself (e.g., aquatic sports performers and water polluters). Voluntary mechanisms may also appear in fisheries when 'ownership' and control of fisheries management is transferred to the local population, who "are likely to regard the environment as a source of long-term survival, which therefore needs protection" (Jacobs 1993, p.136).

Government expenditures are monies spent to manage resources in a sustainable way. In fisheries, government expenditures may include information costs to define TAC and appropriate regulations on 'how to fish,' enforcement costs, other management costs, and subsides for fishers to engage in alternative livelihoods. Government expenditures differ from regulations and financial incentives in that "the cost of environment protection is borne by the taxpaying community as a whole", while in the latter cases, the cost is borne by primary resource users (Jacobs 1993, p.137).

In the design of fisheries management policies, a combination of policy instruments is often needed in order to obtain the desired management goals. The appropriateness of each instrument will depend on the social-political context in which it will be implemented and on the goal(s) it will be expected to achieve. Of these four classes of policy instruments, I focus on regulations and financial incentives including licensing.

6.5 Policy instruments to manage the Lagoon fisheries

It was suggested in section 6.3 that a co-management Forum should be responsible for running the Ibiraquera Lagoon extractive reserve (ILER). Because any change in fishing regulations has to be approved by the Brazilian Agency for the Environment (IBAMA), the Forum may present IBAMA with more appropriate suggestions about 'how', 'where' and 'when' to fish in the Lagoon. Decisions about how regulations can be enforced and about earmarking expenditures could be made by the Forum. That is, there will be a need for devolution of decision-making power from the central offices of IBAMA to the Ibiraquera Lagoon Forum (which should have at least one IBAMA officer). The Forum may also decide who may or may not fish (regulations), and under what 'price' (financial incentives). I expand on this later issue in the next section.

6.5.1 Defining user-groups and 'use rights'

The Lagoon fishers can be classified according to their legitimacy (professional licensed fishers, sport licensed fishers, or unlicensed fishers), their dependence on fishing (full-

timers, part-timers, sport-fishers, or subsistence-fishers) and their origins (locals or outsiders). Use rights to the ILER should be given only to local fishers holding a professional or sport fishing license. Locals are likely to encompass all full-timers, most part-timers, some subsistence fishers, and very few, if any, sport fishers. Indeed, the baseline differentiating local subsistence fishers (who fish for domestic consumption) from local sport fishers (who fish for entertainment) is very unclear; in both cases, fishers are forbidden to sell their catches. Hence, I reason that local subsistence fishers can be included in the local sport licensed fishers category. Fishers from outside represent most sport fishers, licensed or not. Fishers from outside should not have use rights to the ILER.

Basing use rights on a distinction between local fishers and fishers from outside requires defining 'local fisher'. To determine this, I recommend, first, that a survey be conducted in each of the seven communities to identify full-time, part-time and sport fishers. To determine which of these fishers is local, the criterion may then be the testimony of three other local, non-relative fishers. Another criterion may be birth, or a minimum of ten years of residence in one of the seven communities, or marriage to a local person in the past five years. Of course, the specifics of the design must be defined by the Forum; the above are only suggestions.

One important question about use rights is how they are to be transferred from one generation to another. While this decision rests with the Forum, some considerations are suggested here. Use rights should initially be vested in local individuals and may only be transferable to other local individuals with the Forum's approval. If all descendents of those who hold the first 'use rights' were eligible to inherit the same rights, the Lagoon system would again be overwhelmed by a large number of local fishers in a short time.

Based on the case of a Sri Lanka shrimp fishery (Amarashinghe et al. 1997), I suggest that, to avoid this situation, each use rights holder be allowed to bequeath those use rights to only one descendent. In the absence of a descendent, the right of inheritance is automatically discontinued with the death of a fisher.

6.5.2 Implementing a licensing system

Although the ILER may limit the number of fishers with use rights, it may not be sufficient to ensure sustainable fishing. In this section, I propose a combination of regulations and financial incentives to achieve the goal of sustainability. In addition to these, two other policy instruments may be used in managing the ILER. First, the transfer of control of resources, at least in part, to the local population, is expected to induce local users to voluntarily conserve those resources, as they are likely to see the long-term benefit of doing so. Second, government expenditures should occur, especially to build capacity, in the process of creating a Forum to manage the ILER.

By awarding use rights to only local fishers, the extractive reserve will limit the number of fishers, but the reduced number may still represent a very large fishing effort for the size of the Lagoon and its stocks. One way to solve this problem is by further limiting the number of fishers through a licensing system specific to the ILER. In the ILER licensing system that I propose, any fisher must *buy* ILER fishing licenses to fish in the Lagoon. That is, holding a use right' is necessary but not sufficient to permit someone to fish in the Lagoon; local fishers with use rights must still buy a license to legally fish in the Lagoon, but under their use rights designation they will be guaranteed a license (provided they pay for it). License prices and the purchase eligibility criteria can restrict

the number of fishers using the Lagoon; and license prices can fluctuate annually according to resource conditions and environmental and market uncertainties.

There could be two types of fishing licenses in the ILER licensing system: annual fishing licenses and daily fishing licenses. Fishers holding an annual license may be allowed to fish for shrimp, mullet, crab or other species. Daily licenses, on the other hand, may be specific for each species and priced accordingly. In the first attempt to restrict fisher numbers, the system may account for both fishers with use rights and fishers with no use rights. That is, outsiders would still be allowed to purchase any leftover of daily licenses to fish at the Lagoon. However, only local fishers would be allowed to buy annual licenses. Additionally, outsiders would pay higher prices than local fishers for daily licenses. (The higher payment works to incorporate the dynamic costs of fishing activity into outsiders' present decision about whether to fish.).

The proposed ILER licensing system may work to accomplish sustainability goals. The fact that fishers can be charged a significant price to fish (instead of fishing for free (except for their equipment and time costs)) leads us to believe that only those who can profit from fishing or who are willing to pay for entertainment would buy a license. Inefficient commercial fishers (i.e., full-timers and part-timers) who could not profit from fishing after paying the license fee would probably not enter the system. Commercial fishers holding annual licenses would have the incentive to wait and fish for large (high-priced) shrimp or mullet instead of catching small individuals early in the season. Moreover, commercial fishers (either locals or outsiders) who bought daily licenses, would probably risk fishing only after being convinced that large (high priced) individuals were present in the Lagoon. Thus, effort in capturing small individuals could

be reduced by this licensing system. However, sports fishers might still fish for small individuals as they have no economic incentive to fish for large individuals.

Based on the above discussion, the pricing of different types of licenses could follow certain principles. First, prices could be tied to target species. Daily licenses for each target species (shrimp, fish, or crab) could reflect market prices for these species. Second, pricing could be fair. Daily licenses could be accessible to local subsistence fishers, and annual licenses should ensure fishers enough profits to maintain their livelihoods. Third, prices could discriminate between locals and outsiders. Daily licenses for locals (who hold use rights) should be cheaper than for outsiders. Fourth, prices could vary with resource conditions. License prices in one year may be higher or lower than the year before based on monitoring of Lagoon stocks in the year before (see below). Fifth, prices could account for environmental and market uncertainties. Part of a license price could be a type of insurance against a year of very low production or of very low market prices. I expand on this when discussing the earmarking of license revenues.

An alternative way of limiting fishing effort in the ILER may be the establishment of an annual or seasonal total allowable catch (TAC), which could then be implemented through the allocation of fishing quotas such as Individual Transferable Quotas (ITQs) among fishers. ITQ is a type of tradable permit that specifies catch amounts and may, according to Hartwick and Olewiler (1998), lead to an optimal amount of effort and harvest.

However, the licensing system I propose is more appropriate to the Ibiraquera Lagoon than the often-advocated ITQ system because ITQs must be established based on a TAC. Determining TAC for the Ibiraquera Lagoon is infeasible due to three factors.

First, the Lagoon's production is highly dependent on environmental factors and channel openings; hence, there is a high degree of uncertainty in each season – the TAC could vary widely from season to season, and it would be impossible to know this (at a reasonable cost level) in time to set the TAC each season. Second, as most of the Lagoon margins (over 20 km) are easily accessible to anyone, surveying all fisher landings would be difficult, thus making monitoring and enforcement of an ITQ system overly costly. Third, because many fishers sell shrimp directly to consumers, estimating the Lagoon's total production from middlemen's booklets is inaccurate. These last two factors also make a resource depletion tax inappropriate for maintaining the Lagoon resource at a sustainable level.

6.5.2.1 Potential issues concerning the ILER policy

In designing any policy, some issues must be discussed. In the rest of this section, I address issues relating to administrative costs, enforceability, effectiveness, adaptations to approach sustainability, distributional effects, and use of revenues at the ILER.

Administrative costs

The administrative costs for managing the ILER will probably be high at first because of the costs of establishing the co-management Forum. However, after awhile, if the policy is well designed, the system may be financially self-sustaining. That is, revenues raised from selling licenses and charging fees from transgressors may be able to cover all administrative costs. Initial costs for setting up a Forum may include costs related to capacity building of both government and non-government personnel (including fishers),

administrative infrastructure (including physical space and technological resources), and preliminary research to define who are the local fishers and other major stakeholders. Government expenditures could be used for these purposes. Annual administrative costs would encompass costs of resource monitoring and other information gathering to decide upon license prices and policy design from year to year, costs of regulation enforcement, and costs of running the Forum and its meetings.

Enforceability

The proposed policy design is based mainly on two instruments: fisheries regulation and a licensing system. Enforcement of regulations concerning 'how to fish' and 'who is allowed to fish' is one of the first problems the Forum might have to deal with. Heavy penalties for transgressors, including stiff fines and imprisonment, already exist in the case of regulations concerning 'how to fish' (Nature Law, number 9605). The problem to date has been a lack of resources and personnel to enforce them. One possible solution to this problem may be achieved by creating two fishery inspector positions for the ILER. Inspectors should be familiar with the region and its fisheries problems. They should gain legitimacy through their official ties to the competent, local authority (the Forum). This would make enforcement more effective. It will be essential to pay inspectors adequately to remove any temptations they may face to accept payoffs for not reporting or penalizing transgressors. In addition to controlling 'how to fish', inspectors may also control 'who is allowed to fish' and penalties to transgressors can be stipulated concerning the licensing system.

Effectiveness

To assess the effectiveness of the policy design, some criteria should be defined *a priori*. For instance, what will be considered as a sustainable level of resource use can be determined so that license prices can be adjusted accordingly over time. Because monitoring fishing efforts and assessing stocks in the Lagoon are infeasible (as explained earlier), I suggest the following measure of sustainable resource use: enough stock exit the Lagoon at the end of a harvest season to generate offspring that will return to the Lagoon. It is clear that some research would have to be undertaken to calculate such a stock. This criterion seems, in my opinion, reasonable to be monitored; for example, data collection may take place in the channel connecting the Lagoon to the Ocean during the first five days after channel opening (the period when most shrimp and fish leave the Lagoon). Of course, the Forum may devise other criteria.

Policy adaptations to approach sustainability

The persistence of overfishing after the first year of management would indicate that the number of licenses issued was too large (i.e., their prices were too low) or that regulations were inadequate (e.g., mesh size of nets were too small), and that fishing effort in the Lagoon needs to be further reduced. One way to reduce fishing effort is to increase license prices for the next season. At increased prices, fewer fishers will be willing to pay for licenses; that is, only very-efficient or wealthy fishers would buy licenses.

A second way to further reduce effort is to decrease the number of annual licenses available in each year, and the number of daily licenses available for locals and for outsiders in each month. Moreover, daily licenses for outsiders may not be available

during certain months because local fishers have priority in fishing at the ILER. Limiting the number of licenses available demands an auction scheme in which fishers can bid for a license. All annual licenses could be sold at once and daily licenses could be sold monthly at two steps: first local fishers bid for licenses, and, second, outsiders can bid for the licenses that are left. In all cases, licenses should have a minimum price, but the price paid by a fisher will depend on the number of fishers entering the competition and on each fisher's confidence about how much he can profit from fishing or on how much he is willing to pay for entertainment. Again, this mechanism is likely to exclude inefficient fishers from the system (see the shrimp fishery case at a Sri Lanka estuary presented by Amarashinghe et al. 1997).

A third way to reduce fishing effort is changing fisheries regulations on 'how', 'where' and 'when' to fish. For instance, fishing seasons may be shortened. Shrimp fishing may only be allowed two months after the channel closes – minimum time needed for shrimp to grow from post-larvae to young adult; and fish harvests may only be allowed during closed channel seasons as the practices used in this fishery may repel fish back to the ocean during open channel season. In proposing new fisheries regulations, both fishers' ecological knowledge and scientific knowledge may be used (Chapter II).

Distributional effects

What are the probable distributional effects of the proposed policy design? Charles (1988, 281) reviews some critiques of limited entry regulatory mechanisms in fisheries and points out that "there may be losses as well as gains from limited-entry programs" concerning their social consequences. It is clear that some people's well-being will

decline when implementing an extractive reserve, but the cumulative decline may be at least compensated for by the corresponding cumulative welfare gains received by other people. For example, some local fishers may directly benefit from this management approach through increased incomes, while other local residents, tourists and fishers from outside may indirectly benefit from it through the improved long-term ecological sustainability of the Lagoon. In the case of the Ibiraquera Lagoon, it is likely that fishers from outside are the ones whose well-being will decrease. The majority of fishers from outside do not make their living from fishing (i.e., sport fishers from oustide) and are often wealthier than full- and part-time local fishers. Therefore, though more socio-economic research needs to be conducted on the distributional effects, it is expected that limiting access to the Lagoon in the proposed manner will improve local fisher well-being without decreasing the welfare of fishers from outside by an amount that is harmful and thus unfair.

If the minimum license prices, established by the Forum, are constantly increased in order to reduce fishing effort, they might reach a price that only relatively wealthy fishers would be able to pay, excluding local, subsistence and commercial fishers who depend on fishing from the system. In this case, the management system will flip from a market-oriented shrimp fishery to a sport-oriented fishery. The Forum then could direct revenues from fishing license sales toward finding alternative livelihoods for those local fishers highly dependent on fishing.

To avoid such a flip in the fishery system, restriction of licenses issued and a bid mechanism is proposed above. The distributional effect of this new design in comparison to the extractive reserve alone is not quite clear. As licenses will be limited, fewer local

fishers will directly benefit from the system; however, the same number of local and outside people will indirectly benefit from the sustainable use of the Lagoon. Fishers from outside are likely to lose even more well-being in this new design than the originally proposed one. However, what the new design offers is a better chance of increasing the well-being of future generations by ensuring sustainable resource use, without decreasing the welfare of present generation to an amount that may threaten people's livelihood.

Use of revenues

The revenue raised by selling fishing licenses and by charging regulation-infraction fees could be earmarked to improve both Lagoon management and local fisher welfare. For instance, it could be used to fund the Forum's administration, pay fishery inspectors, and monitor resource use. As well, the part of license sales revenue representing the insurance against environmental and market uncertainties could be used to provide small loans for full-time fishers during shrimp and fish off-season, reducing their dependence on middlemen and giving them the freedom to trade their product for the best prices year-round. License sales revenues may also be used to investigate economic alternatives for fishers who reduce their fishing effort at, and therefore their income from, the Lagoon (as in the case of San Miguel Bay in Philippines (Sunderlin and Gorospe 1997)). In addition, license sales revenues may be used to investigate potential markets for the other Lagoon fishes and crabs.

6.6 Conclusion

Can the extractive reserves model be used for marine conservation? This chapter has shown that the extractive reserves concept, by definition, restricts the number of resource users and may help implement policies leading to sustainability. The implementation of an extractive reserve, however, is an insufficient condition to guarantee its sustainability. Several policy instruments must be used jointly to achieve such goal.

In the case of Ibiraquera Lagoon, I discuss an alternative policy consisting of the establishment of an extractive reserve to restrict the number of fishers and a combination of regulations and a licensing system to operate such a reserve. The reasons for using licenses to regulate the number of users and to improve management are that license prices can exclude inefficient fishers, can account for resource conditions as well as environmental and market uncertainties, and can generate revenues that can be used to improve management, and to improve living standards of fishers. The licensing system is a complement, and not a substitute, for other management regulations concerning 'how', 'when', and 'where' to fish. Although there is no optimal management alternative, I argue that the best alternative is developed collaboratively among all stakeholders in a way that incorporates, all, or at least most, of the Lisbon principles (Constanza et al 1998, 1999) as discussed in Chapter IV. These are: participation, responsibility, scale-matching, precautionary, adaptive management, and full-cost allocation. Specifically, I advocate the creation of a highly representative Forum in whom management rights would be vested. Finally, unless government supports local actions, by creating political space for experimentation, and provides legal mechanisms for access restriction, the Ibiraquera Lagoon will never approach sustainability.

Chapter VII

Conclusions

7.1 Introduction

This dissertation is a study of the social-ecological dynamics in a common-pool resource management system and the linkages between the social and the ecological aspects of such a system in order to contribute to the efforts for sustainable natural resources and environmental management. The study focuses on the history of the Ibiraquera Lagoon management system in Brazil. In particular, I address five major issues in this research including: (a) the significance of local knowledge for participatory management; (b) the key factors that build or threaten the social-ecological resilience of the Lagoon management system; (c) the incentives and constraints to development of the local social-ecological system; (d) some possible solutions for stakeholder conflicts about the Lagoon use; and (e) the use of extractive reserves model for marine conservation.

The objective of this chapter is to recap the key concluding points of each of the five main chapters in order to present the major theoretical, methodological and policy contributions of this dissertation to literature.

7.2 Major findings

7.2.1 Local knowledge for participatory management

What is the significance of local knowledge for participatory management? Is it useful in designing, assessing and implementing management plans?

Chapter II shows that local knowledge may play an important role in designing, implementing and assessing adaptive management plans. This is not to say that local knowledge can replace scientific knowledge in adaptive management; they should be complementary. Indeed, this case study shows that the effective fishing regulations implemented during the 1980s were based on the co-management of local and scientific knowledge.

Local knowledge has several aspects. Local resource users may provide a valuable set of information about ecosystem dynamics and the resources they use (e.g., species diversity, species life cycles, species interactions, and environmental factors affecting species development). Moreover, local management practices may provide insightful information about the concerns, values, and ethics of resource users. Understanding local social values and ethics is necessary before proposing official regulations in order to increase compliance (Palmer 1994). This case study indicates that when user knowledge and concerns are incorporated into official regulations, these regulations are more likely to succeed than otherwise.

Local management practices may serve different purposes. Not all practices may promote conservation. For instance, some practices may serve to minimize conflicts among users or optimize catches. It is worth noting that some practices that may promote conservation in the eyes of local resource users may not be seen as conservation measures

in the eyes of many western-trained researchers. This happens because the two groups may have a different understanding of both the resources and the ecosystem dynamics. In these cases, a close investigation of the ecological and socio-economic benefits (and costs) of each measure is recommended.

Resource users are not a homogenous group nor is the local knowledge they provide. Moreover, local knowledge is not a static set of information. It is constantly reshaped by users' own experiences and by scientific information and practices brought to them by government agents, researchers, or even by local individuals who are more interested in scientific approaches. Hence, it is difficult to separate knowledge gained through experience and information achieved from outsiders.

Just as local knowledge is reshaped, local management practices also tend to be reshaped to attend new management demands. One important contribution of this research is to show that both user knowledge and local management practices can, and do, usually adapt in response to crises or the perception of crises. Hence, they may serve as an important source of information for participatory adaptive management.

7.2.2 Social-ecological resilience

What are some of the key factors that help build social-ecological resilience in the lagoon management structure, and what are some key factors that threaten it?

The Ibiraquera Lagoon case study demonstrates that it is possible to study the dynamics of integrated social-ecological systems. Chapter III reveals that although the cycles of changes in the social system and the ecological system may occur at different paces, they are intimately related to one another and feedback interactions can be clearly

observed. The resilience of the management system is analyzed through cycles of change; adaptive renewal cycles are used as a heuristic (not a predictive) model to understand these cycles of changes.

Management practices concerning the release and renewal phases of ecosystem dynamics may trigger critical ecosystem processes. For example, practices that produce small-scale disturbances may help prevent larger-scale disturbances later. This is the case of some of the Ibiraquera Lagoon management practices based on local knowledge. These practices help to avoid ecological surprises, performing as insurance mechanisms for maintaining the Lagoon biodiversity.

Changes in the property rights regime have consequences for social-ecological resilience and resource sustainability. Chapter III shows that over the past four decades, Ibiraquera Lagoon shifted from a resilient, community-based management system to an open-access situation with low resilience. This situation led the system to experience a management crisis. In response to this crisis, a co-management arrangement between local resource users and government agencies was created, rebuilding resilience into the system. Later, institutional instability across political scales has directed the system to a mix of state property, communal property and an open-access situation, reducing resilience again.

In analyzing social-ecological resilience through cycles of change, it is possible to identify some key factors that build resilience into the system and some that threaten it. In this case study, five key factors that strengthen resilience were identified. These are: strong institutions (robustness, enforcement, and leadership), good cross-scale communication (about the status of, and threats to, the resources, and co-management

between scientific and local knowledge), political space for experimentation, equity in resource access, and the use of memory and ecological knowledge as a source of innovation and novelty. In addition, four key factors that weaken resilience were detected. They include: the breakdown of local institutions, rapid technological change, rapid socio-economic change, and institutional instability across political scales. Other comparative studies would probably come out with other factors.

Although I attempt to analyze the resilience of a social-ecological system according to the property regime under which it was managed, resilience may be viewed in a longer time scale as the ability of a system to turn successive resource crises into opportunities for a new round of institutional renewal. This is the case of the Ibiraquera Lagoon management system in the past four decades.

7.2.3 Social-ecological development: incentives and constraints

Which incentives and constraints have affected the development of the local social-ecological system? That is, what is the ecological economics of the area?

Chapter IV investigates the ecological economics of Ibiraquera communities. This study shows several feedback interactions between the socio-economic system and the ecosystem. The local socio-economic system can be intensively influenced by (a) the values and ideas brought by outsiders (e.g., changes in market institutions, decrease of social sanctions, and disruption of social life), and (b) the new economic opportunities that outsiders create. As well, fluctuations in resource availability and in resource markets may also influence socio-economic institutions. For example, the existence of middlemen in the Ibiraquera shrimp market provides an "income-insurance mechanism" for fishers in

face of ecological uncertainties and the dynamics between demand and supply in this market.

Socio-economic incentives and constraints may affect resource management systems in several ways. First, an increase in market demand for fishing products may lead to species by-catching (which may cause ecosystem disruption) and to an unsustainable use of resources because it may put fishers' private interests (i.e., profit-maximization) upon social goals (sustainability). Second, a community's infrastructure improvements and development projects, if not well planned, may result in ecosystem degradation, increased pressure on resources, and conflict of interests between locals and outsiders. Therefore, all the socio-economic and ecological benefits and costs of any development intervention must be investigated *a priori*. Third, technological innovations may have either a positive or a negative effect in resource management (Ravetz 1986). Technological innovations may promote unfair resource distribution, as it may not be affordable by all users. Alternatively, technological restrictions may promote more just resource distribution. As well, technological innovations may result in more efficient resource use, but, if not properly used, they may cause over-harvesting and ecosystem disruption.

Changes in management institutions may also create incentives or constraints to resource sustainability, ecosystem dynamics, and social welfare. For instance, the history of the Ibiraquera Lagoon management illustrates that new regulations based on fishers' ecological knowledge and concerns and an appropriate enforcement system proved to restore the Lagoon's structure and dynamics, to reduce user-group conflicts, to promote more just resource allocation, to increase people's safety, and to avoid pollution. On the

other hand, a lack of regulation enforcement led the system to an open access situation. In face of a lack of constraints (e.g., lack of regulation enforcement), resource users do not have any incentives to use appropriate gears, to avoid over-harvesting, or to prevent pollution. Hence this open access situation can disrupt ecosystem natural dynamics, lead to over-harvesting, increase the risk of pollution and directly affect the well-being of resource users. Often, most people bear the cost of the actions of just a few cheaters. This situation calls for some new management measures including enforcement of regulations, restriction on the number of resource users and environmental education.

Creating new management institutions may help mediate the influences of local socio-economic factors in the social-ecological management system. In this sense, I propose the establishment of a co-management Forum for the Ibiraquera Lagoon, in which government agencies, resource users and other stakeholders would be involved. The Forum may address the six Lisbon principles concerning: participation, responsibility, scale-matching, precautionary, adaptive management, and full-cost allocation (Costanza et al. 1998, 1999). To incorporate such principles within the Lagoon fisheries management, I propose the creation of an extractive reserve and a combination of fisheries regulations and a license system to pursue sustainable use of fishing resources. A detailed explanation of these measures is presented in Chapter IV.

7.2.4 Possible solutions for stakeholder conflicts about Lagoon use

What policies across organizational scales may help solve stakeholder conflicts over resource use?

Chapter V shows that institutional instability at higher political levels, the great diversity of ineffective management agencies, and the lack of coordination among government agencies from different levels and sectors results in stakeholder conflicts, environmental degradation and resource overexploitation at the Ibiraquera Lagoon and the surrounding area. These stakeholder conflicts reflect: a divergence in management goals; a degree of dependence on resources; disagreement about fishing rights and resource allocation; a lack of personnel and equipment resources to enforce regulations; a mismatch of the scale of problems and the scale of regulatory and enforcement agencies; the lack of empowerment of fishers and local councils; and different understandings of Lagoon ecosystem dynamics between government managers and local fishers.

To overcome management problems and stakeholder conflicts I suggest the establishment of an Ibiraquera Lagoon Management Forum. This Forum could address stakeholder concerns and conflicts, and build a knowledge base upon which management decisions could be made through a *co-management* process. This knowledge base could bridge user concerns and knowledge with manager concerns and knowledge. Details about this co-management process are presented in Chapter V. The key idea of such a Forum is to present and discuss knowledge and the values and concerns of users, other stakeholders, managers and scientists so that conflict resolution can be based on a common understanding of environmental and management problems. Of course, conflict management has many other aspects, but if a common knowledge base can be built, this may help to solve or manage conflicts more effectively. As well, resource governance has many aspects.

The co-management Forum that I propose is only one possible way that a new Lagoon governance may be conceived and structured. Effective co-management arises from negotiation, joint problem-solving and mutual learning (e.g., Kendrick 2000, Blann et al. 2002) when political space for experimentation is created. Simply having a structure or arrangement is no guarantee of effective co-management. Rather, co-management may be seen as an interactive process, a "tango" (Pomeroy and Berkes 1991). The dynamics of institutions across scales in distinct periods of time may create different political spaces, which lead to different management arrangements.

7.2.5 Extractive reserves for marine conservation

Can the extractive reserves model be used for marine conservation?

By definition, extractive reserves provide use-rights over a certain area for a limited number of resource users, and they allow for participatory management involving users and government agencies. Chapter VI indicates that the concept of extractive reserves can be a useful mechanism leading to sustainability. However, property-rights instruments, such as extractive reserves, are a necessary but not a sufficient condition to achieve sustainability. Several policy instruments, including market-based ones, need to be used jointly.

In this context, I discuss an alternative policy for the Ibiraquera Lagoon consisting of the establishment of an extractive reserve to restrict the number of fishers, and a combination of regulations and a licensing system to operate such a reserve. The reasons for using licenses as a mechanism to manage the Lagoon are that license fees can (1) help exclude inefficient fishers, (2) account for changing resource conditions and market

uncertainties, and (3) generate revenues that can be used to improve management. The licensing system provides a complement, and not a substitute, for other management regulations concerning 'how', 'when', and 'where' to fish. To manage the Lagoon, I recommend the creation of a co-management Forum representing the stakeholders.

However, other participatory management arrangements are also possible, and may emerge from the interactions between resource users and government. What is really important is (a) to create political space for experimentation in participatory management, (b) to provide legal mechanisms for access restriction, and (c) to provide government support for local action. Given the intensive use of the area and the conflicts among user-groups, governance approaches along these lines will lead towards sustainability in the Ibiraquera Lagoon.

7.3 Contributions to literature

This section recaps the major contributions of this dissertation in three areas: contributions to theory, to methodological approaches and to policy.

7.3.1 Theoretical contributions

This research aims to contribute to a better understanding of the complexity, dynamics and behavior of social-ecological systems for sustainable natural resource management. It does so by combining the use of analytical tools from several interdisciplinary areas: common property theory, ecological economics, resilience and panarchy thinking within complex systems theory, and the adaptive management approach. The study provides

insights about the interactions between, and within, social and ecological sub-systems across space, time and political scales – a key feature of the panarchy approach (Holling 2001, Gunderson and Holling 2002). Although social and ecological aspects of a dynamic management system are interconnected, each sub-system may have its own speed of change and adaptation. Indeed, the analysis of both social and ecological aspects of a management system through a historical perspective, with a sequence of adaptive renewal cycles (with crises and recovery stages), is useful in informing policy for sustainable management. As pointed out by Holling (2001, p. 402),

> One of the principal aims [of a historical approach] is to define where in their respective adaptive cycles each of the sub-system is now. Action that would be appropriate at one phase of the cycle might not be appropriate at other phases. Knowing where you are helps you to define what actions need to be taken.

The ultimate contribution of this research is to show that a management system becomes more resilient and sustainable as it becomes more flexible, diverse and capable of learning and adapting in the face of social and ecological disturbance. Conversely, a management system loses resilience and sustainability as it becomes more 'brittle' and less capable of learning and adapting to disturbance.

7.3.2 Methodological contributions

The analytical framework used in this research provides some useful tools to investigate the various aspects of complex natural resource management systems, as well as their feedback interactions across space, time and political scales. These aspects include: ecological features and processes of the resource system; components of the socio-economic system (people, technologies, and markets); the knowledge system (including both local and scientific knowledge); management institutions at local and government

levels; and adaptations (or maladaptations) of the management system. The study illustrates the use of one approach for the investigation of social-ecological dynamics. In particular, it addresses changes concerning crisis and recovery of a management system, by focusing on both human responses and environmental feedbacks, from a historical perspective – a key approach in proposing sustainable management, according to Holling (2001).

7.3.3 Policy contributions

The primary policy contribution of this dissertation concerns building adaptive capacity and resilience for sustainable resource use. Based on this case study, I point out some of the key issues that could be addressed in the context of the Brazilian environmental agenda. These include:

1. The urgency of addressing the mismatch between problems at the local level and the higher level at which the regulatory and enforcement agencies operate, which is often at the scale of state or federal governments. This is the scale-matching principle of Costanza et al. (1998) which states that solutions to specific problems should be tackled at the scale that matches the problem to be solved.
2. The need for incorporating the *subsidiarity principle* into government policies and cross-scale institutional arrangements. This principle proposes that governance should include "as much local level management as possible; only so much government regulation as necessary" (Berkes et al. 1991).
3. The importance of *participatory approaches*. Many co-management experts would argue that true participation goes beyond informing and knowledge-sharing, and

would require formal arrangements for sharing decision-making power (Borrini-Feyerabend et al. 2000). Participation could include the incorporation of users' concerns and ecological knowledge into regulations as a way of improving compliance and making regulations more effective.

4. The importance of building a common knowledge base for resource management in order to: (1) provide a shared information set for decision-makers; (2) bridge differences in stakeholder understanding of problems, (3) minimize stakeholder conflicts, and (4) provide information to coordinate cross-scale management.
5. The need for using appropriate policy mechanisms (including property-rights arrangements, regulations and market-based instruments) to approach sustainability at the local level.
6. The need for effective enforcement. Such effective enforcement would require frequent monitoring by agents familiar with the area and its problems, and would not exclusively rely on government enforcement.
7. The importance of taking into consideration both costs and benefits of developments and 'improvements' of the physical environment. Assessments should include ecological costs, as well as human benefits, of such interventions.

Finally, I suggest that the six Lisbon principles (Costanza et al. 1998, 1999) provide a useful approach to address not only coastal management but natural resource management in general, and could therefore be used as guidelines for the environmental policy agenda in Brazil and elsewhere.

7.4 Concluding comments

What can one learn from investigating the dynamics of changes in social-ecological systems and the linkages between social and ecological aspects of such systems for building resilience and sustainability in management systems?

The social-ecological dynamics of common-pool resource systems have several aspects. The findings of this dissertation point out: the significance of local knowledge for participatory management; the need to understand the key factors that build social-ecological resilience; the need to address the ecological economics of resource systems; the importance of addressing stakeholder conflicts; and the importance of combining different policy mechanisms (property-rights arrangements, market-based instruments and government regulations) to approach sustainability. A management design that builds resilience in social-ecological systems and may lead to the sustainable use should address these and other aspects of social-ecological dynamics. Above all, common-pool resource management plans should be participatory and adaptive, and they should provide a match between the scale of management institutions and the scale of the resource itself. In order to be adaptive, management institutions must create opportunity for learning and for building capacity to adapt to change.

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Appendix I

Details of methods used and data analysis

Interviews

Key informant and small group, open-ended interviews

These interviews were carried out with approximately 90 people during fieldwork, including:

- fishers (different user-groups)
- owners of fish stores and restaurants
- the president of the fisher's organization (Colônia de Pescadores Z13)
- the vice-president of the fisher's organization
- the treasurer of the fisher's organization
- a former president of the fisher's organization
- two former fishery inspectors
- a former federal fishery agent (from SUDEPE)
- a current federal fishery agent (from IBAMA)
- a former fishery researcher from SUDEPE
- two members of the research team involved in the shrimp larvae stocking program
- local people (all ages)
- council presidents of two communities
- Imbituba's Municipal Secretary of Agriculture, Fisheries, and Environment; and other Municipal government officials from the Municipal Secretaries of Health Care, Planning, and Management
- State and Federal government officials from different departments (IBAMA, FATMA, Capitania dos Portos, Polícia Ambiental)

Archival research

Archives and materials researched include:

- Colônia de Pescadores Z13 meeting register books
- Annual reports of fishery production in Santa Catarina State
- The current and former fishing regulations from IBAMA (Brazilian Institute for the Environment), SUPEDE (a former Federal Fishery Agency: 1967-1989), Divisão de Caça e Pesca (a former Federal Fishery Agency)
- Imbituba City Hall Archives
- Electrical power companies (CERPALO, CELESC).

Data analysis of field notes, interviews and archival data

The dissertation works was carried out in Portuguese, the local language and the researcher's first language. Interviews, field notes, and archival material were not translated into English until the writing stage. The steps of analysis include:

- Step 1: coding and transcription of all field notes (about 450 pages of median-size notebooks) into a file (fieldnotes-todas.doc) organized according to the main issues (categories) (Note: the codes emerged from the data, i.e., the categories were not pre-established).
- Step 2: transcription of recorded open-ended interviews (21 one-hour tapes).
- Step 3: coding (categories) of each paragraph of the transcribed interviews.
- Step 4: organization of all paragraphs of transcribed interviews according to the main issues (categories) into a file (entr-todas.doc).
- Step 5: extracting the information from field notes and transcribed interviews into a file (pré-resumo-dados.doc)
- Step 6a: steps 1, 2, 3, 4 and 5 were first performed from December/1999 to February/2000 as a portion of the data was then collected (file: pré-resumo-dados.doc). The main findings were resumed in another file (res-hist-pesca.doc), which was submitted for verification to 12 people who had some type of relationship with the Lagoon.
- Step 6b: steps 1, 2, 3 and 4 were again performed with the rest of the data (collected after step 6a was finished) in June/July 2000.
- Step 7: analyzing of all information to produce a final resume of data. During this process, I reviewed information from my field notes, from the transcribed interviews, and from the comments of the 12 people who checked my first main findings. The results are presented in a file (resumo-final.doc). (Note: During this analysis, information was filtered by the researcher's understanding of the facts and processes after one year of fieldwork. That is, whenever some information was too discrepant from the others or did not make sense to the researcher perceptions, it was not considered in the analysis).

Appendix II

Interview guides

(Translated from the original in Portuguese)

Interviewee: President of the Fisher's Organization (Colônia de Pescadores Z13)

Interview 1: The fishery system at the Ibiraquera Lagoon

- When were you first elected for this position?
- What factors have led you to run for this position?

Past and current situations of the fishery system at the Ibiraquera Lagoon (I.L.):

- What was the fishery situation at the I.L. by the time you were first elected as president of this organization? What was the situation before your election?
- What gear types and vessels were used in the fishery?
- Who fished at the I.L.? Were there any outsider fishers?
- Were there any types of conflicts amongst fishers from the I.L.? What about between the I.L. fishers and outside fishers?
- Were there any formal or informal fishing rules or regulations? If so, how were these enforced?

Changes in fishing rules:

- How did the process of changing local fishing rules take place?
- Who was involved?
- Whose initiative was this?
- What proposals of change appeared?
- Which of these were approved and which ones were rejected?
- Why did fishers decide to fish only with cast-nets?
- Why did fishers decide to increase the minimum mesh size for shrimp cast-net fishing from 25 to 30 mm between knots?
- Why did fishers decided to fish only with kerosene lamps and not with butane gas lamps?

Reaction to changing rules:

- How did the I.L. fishers (those living around the lagoon) react to these changes in fishing rules?
- How did the outside fishers (from other communities or other municipalities) react to these changes in fishing rules?

Enforcement:

- After fishing rules were changed, did any enforcement activity take place?
- Who was, and who is, part of the I.L. enforcement structure?
- Are there any poachers?
- What kind of punishment are poachers subjected to?

The process:

- How long did the process of deciding and enforcing changes in fishing rules last?

Interviewee: President of the Fisher's Organization (Colônia de Pescadores Z13)

Interview 2: The shrimp larvae-stocking project at the Ibiraquera Lagoon

Initiative:

- How did this project idea emerge?
- Who was first contacted to develop this project? (i.e., did the Colonia contact somebody or some organization or did some organization or someone first contact the Colonia?)

The project:

- When did this project start?
- What were the objectives of this project? (Economic and/or ecological sustainability?)
- How did the project develop?
- What were the species used in this project?
- How long should this project last?

Funding:

- Who funded this project?

Local participation:

- Did fishers know that this project would take place at the I.L.?
- How were they informed?
- Did they approve or disapprove of this initiative?
- Have they collaborated with this project?

Results:

- What are the main results that this project has obtained so far?
- How much has this project increased the shrimp production at the I.L.?

Other issues:

The linking channel (barra da lagoa)

- How is the linking channel opened and who decides when it should be opened? (A historic perspective)

The dragging activities at the I.L.

- Why has the I.L. been dragged?
- Whose idea was this?
- What organizations are involved in this dragging project?
- In your opinion, what are the effects of these dragging activities on the lagoon system?

Interviewees: Fishers living in communities around the Ibiraquera Lagoon

Fishery history I:

- How was the fishery during your parents and grandparents' generation?
- What kind of gear did they use?
- What species did they fish?
- Did they sell their catches or did they fish only for their own consumption?
- Were there any fishing rules? Who decided when, what, where and how to fish?
- Was there any type of conflict amongst fishers living around the I.L.?

Fishery history II: questions that appeared after the first set of questions were answered.

- When did they fish with:
    - Casting nets (*tarrafa*)?
    - Gillnet type I (*rede de emalhar - rede de espera presa nas duas pontas*)?
    - Gillnet type II (*manjuaba - rede de espera presa numa ponta só*)?
    - Encircling gillnets (*rede de emenda*)?
    - Seine nets (*rede trolhada*)
    - Several gillnets attached together used as beach seines (*rede de arrasto*)?
    - Pull-nets (*coca de puxar*)?
    - Trap nets and hoop nets (*aviãozinho ou coca fixa*)?
    - Shrimp trawlers (*gerival ou berimbau*)?
    - Butane gas lamps (*luz de liquinho)*?
- Before several gillnets attached together came to be used as beach seine in this fishery system, did the conflicts between cast-netters (*tarrafeiros*) and gill-netters (*redeiros*) already exist?
- Who started fishing with: several gillnets attached together used as beach seines? Pull nets? Trap nets and hoop nets? Shrimp trawlers? Gas lamps?
- By the time these people started to fish with several gillnets attached together used as beach seine, why didn't the older fishers prohibited them?

Changes in fishing rules:

- When did you start to perceive that large nets (gillnets, seine nets, beach seines, trap nets, hoop nets, pull nets) were depleting fish stocks (destroying the I.L.)? What about the gas lamps?
- Whose idea was it to prohibit the use of large nets but cast-nets in this lagoon?
- How did the process of increasing shrimp cast-net's mesh size to 30 mm start? Whose idea was this?
- How did the process of prohibiting gas lamp start? Whose idea was this?

Enforcement:

- Is there, or was there, any type of enforcement of fishing rules in this lagoon?
- How is, or was, this enforcement done?
- Do local fishers also monitor for poachers in the lagoon?

Organizations:

- Are there any local community organizations here?
- Do local fishers currently have meetings? Do they meet often or only when there is an issue to be dealt with?

The shrimp larvae-stocking project:

- After shrimp larvae were put in the lagoon, have you noticed changes in the number (or extinction) of any other animal or plant in the lagoon?

Interviewees: Middlemen in the Lagoon shrimp market

The evolution of Lagoon fish and shrimp market

- Are you currently a fisher? Were you a fisher in the past?
- Since when have local fishers started to sell their catches?
- When did you start to sell fishing products?
- What fishing products sell the best?
- Is there a particular fishing product that is used only for fishers' own consumption and which is not commercialized?
- Is there any difference in the species you buy and sell during the summer and the winter?
- Where do you sell your products the most: ie. the communities around the I.L., other communities in the same municipality, outside this municipality?
- Do you buy fishing products from other municipalities to sell here? If so, which kind of products do you buy and which municipality do you buy them from?
- Is there any difference in the localities where you buy and sell fishing products during the summer and the winter?
- How many fishing retail stores exist around the I.L.?
- Do you have any control of the amount of each species you buy and sell each month?
- Do you have any arrangements with any of the local fishers to have them sell their products exclusively to you? What is this arrangement?
- If so, how many fishers fish only for you at the I.L.?

Other issues:

- When were roads built to access each community around the I.L.?
- When was electrical power installed in each community around the I.L.?

Interviewee: members of the research team involved in the shrimp-stocking project

Initiative:

- How did this project idea emerge?
- Who was first contacted to develop this project? (i.e., did the research team contact someone in the Lagoon or did someone from the Lagoon first contact the research team?)

The project:

- When did this project start?
- What were the objectives of this project? (Economic and/or ecological sustainability?)
- How did the project develop?
- What were the species used in this project? What is their life cycle?
- How long should this project last?

Funding:

- Who funded this project?

Local participation:

- Did fishers know that this project would take place at the I.L.?
- How were they informed?
- Did they approve or disapprove of this initiative?
- Have they collaborated with this project?

Results:

- What are the main results that this project has obtained so far?
- Do you have dates of catches and Lagoon stocks taken during the time this project is running?
- How much has this project increased the shrimp production at the I.L.?

Interviewee: Officer of IBAMA – Regional office in Laguna/ State office in Florianópolis

IBAMA and State Environmental Police:

- What is the role of IBAMA in fisheries management?
- What is the geographical area covered by this regional office?
- How many agents are in this office?
- How many agents work in regulation enforcement in the area covered by this office?
- What is the role of State Environmental Police in fisheries management?
- What is the area covered by this office of the Environmental Police?
- How many officers are in this office of the Environmental Police?
- How many officers work in regulation enforcement in the area covered by this office?

Ibiraquera Lagoon:

- Were you involved in the process of regulation changes concerning fishing rules in the Ibiraquera Lagoon?
- If so, could you tell me how it happened?
- Whose idea was this?
- Who was involved in this process?
- How did SUDEPE (Ibama) accept such a claim?
- What are the IBAMA regulations that apply to the Ibiraquera Lagoon?

Interviewee: Former fishery inspector

- When did you become a fishery inspector?
- Which organizations did you work for during the time you were a fishery inspector?
- What was the geographical area that you monitored? And how many fishery inspectors were working the same area?
- What fishing regulations were applied for the Lagoon at that time?
- When were such regulations first implemented?
- How was enforcement carried out?
- How did fishers behave in response to the monitoring (enforcement)?
- For how long did you hold this inspector position? Why were you withdrawn?
- What were the main problems that you faced as an inspector?
- During the time you were an inspector, did you notice if the Lagoon fish catches increased or decreased? Why? And today, how are fish catches?
- During the time you were an inspector, did you notice if the Lagoon shrimp catches increased or decreased? Why? And today, how are shrimp catches?
- Has there ever existed, or does there currently exist, any type of monitoring (rule enforcement) done by the fishers themselves?

Interviewee: Former federal fishery agent

- What role did you play as a SUDEPE agent?
- During what period did you work for SUDEPE/IBAMA? During what years were you involved with the research and meetings at the Ibiraquera Lagoon in Imbituba?
- Could you tell me how the process of banning large nets from the Lagoon occurred?
  a. Whose initiative was it?

b. What type of research was carried out there?
c. What were the results of such research? Where can I find them?
d. How long did the process for the banning of large nets last?
e. Who was involved?
f. Where did the meetings occur and how many meetings took place?
g. Was there any research (data collection) on the Lagoon catches or stocks before or after the banning of large nets occurred? Where can I find such data?
h. Were there any alternative proposals for the total banning of large nets? Which ones? Why were they not approved?

- What about the process of banning butane gas lamp from the Lagoon?
  a. Whose initiative was this?
  b. Was there research carried out concerning the efficiency or predatory capacity of such gear? If so, what type of research was carried on there?
  c. What were the results of such research? Where can I find them?
  d. How long did the process for the banning of gas lamps last for?
  e. Who was involved?
  f. Where did the meetings occur and how many meetings took place?
  g. Was there any research (data collection) on the Lagoon catches or stocks before or after the banning of gas lamps? Where can I find such data?
  h. Were there any alternative proposals for the total banning of gas lamps? Which ones? Why were they not approved?
- Were you involved in the process of increasing the mesh size of shrimp cast-net to 3 cm? If so:
  a. Whose initiative was this?
  b. Was there any research carried out concerning the efficiency of catch or predatory capacity of mesh sizes 2.5 cm and 3.0 cm? If so, what type of research was performed?
  c. What were the results of such research? Where can I find them?
  d. How long did the process for increasing cast-net mesh size last?
  e. Who was involved?
  f. Where did the meetings occur and how many meetings took place?
  g. Was there any research (data collection) on the Lagoon catches or stocks before or after the change in cast-net mesh size? Where can I find such data?
  h. Were there any alternative proposals for this change in cast-net mesh size? Which ones? Why were they not approved?
- What about crab fishing with long-lines in the Lagoon? Was there an attempt to ban that type of fishing? If so:
  a. Whose initiative was this?

b. Was there any research carried out concerning the efficiency of such gear or on its predatory capacity? If so, how was this research carried out?
c. What were the results of such research? Where can I find them?
d. How long did the attempt to ban this gear last?
e. Who was involved?

- When you worked at the Lagoon, did you notice if fishers used:

Hoop nets: Trap nets: Pull-nets:

Shrimp sucker: Shrimp trawls:

Interviewee: Board member of Colônia Z13 (Fisher organization)

- When did you become a board member of Colonia?
- What position do you hold on the board?
- What is your role in this position?
- Who is responsible for the accounting and payment transactions at Colonia?
- Does the President call for board meetings? In what circumstances?
- What is your view on the board participation in the Colonia administration?
- What is your view of the Colonia presidential performance?
- Do you or any other board member disagree with the way the Colonia is managed? In what sense?
- Do you intend to be a candidate for a board position in next year's Colonia election?

Interviewee: Heads of community council

- When did this Council start?
- Who was the first head (president)?
- Since when were you a head of this council?
- Who was the head before you?
- How often are the head and board are changed?
- Are there elections? Who are allowed to vote?
- Is there a register book of council meetings? May I look at it?
- What is the role of this council in the community?
- What is the area this council is responsible for?
- When did the last meeting happen?
- What issues were dealt with?
- Are you a fisher?

Appendix III

Structured interviews

Shrimp fishery: Data: _____ Interview #:_____

Are you:

A full-time fisher in this lagoon?_____

A full-time fisher but do not fish exclusively in this lagoon?_____

Retired but do also fish in this lagoon?_____ (Part-time or full-time fisher)

Do you have another job but do also fish in this lagoon?_____

Which job: _____ (Part-time fisher)

On average, how many nights per week do you fish shrimp in this lagoon:

Hot months (from October to March)?_____

Cold months (April to September)?_____

What time do you usually start fishing? Hot months:_____ Cold months:_____

What time do you usually stop fishing? Hot months:_____ Cold months:_____

How long have you been fishing in this lagoon?_____

Is there any other place where you fish often? _____ What place? _____

Where do you live? _____

Do you have your own house? ____ Do you have a house close to this lagoon? _____

How do you travel to this lagoon? walking ___ bike ___ motorcycle___ own car___

getting a ride ___ bus___ horse chart___

Do you have: your own canoe in this lagoon?___ bike___ motorcycle ___ car___

freezer__ telephone__ satellites antennas__ cows___ (how many?___)

Do you sell your catch? _____

To whom do you sell most of your shrimp?

Middlemen in Ibiraquera _____ name: _____

Restaurants nearby the lagoon: ____ name: _____

Other middlemen in this municipality: ____ name: _____

Other restaurants in this municipality: ____ name: _____

Middlemen in other municipalities: ____ municipality: _____

Restaurants in other municipalities: ____ municipality: _____

Friends and relatives ____

Do you have a fishing license?____

Are you member of the fishing association (Colonia)?___

Have you been to any of the Colonia meetings in the last two years?___

Are you a member of any other association in your community?___

Changes in fishing rules: Date: _____ Interview #:_____

Do you fish: Shrimp (__) Fish (__) Crab (__)

How long have you fished in this lagoon?_____

Before banning gill-nets from this Lagoon, did you use to fish with gillnets (___)

What type?_____

With cast-nets? (___) What mesh size did you use for: shrimp?:_____ fish?:_____

After banning gillnets in this lagoon, do you fish:

(___) more shrimp (___) less shrimp (___) the same amount of shrimp

Obs:_____

(___) more fish (___) less fish (___) the same amount of fish

Obs:_____

Do you agree with the banning of gillnets?_____

Before banning gas lamps in this Lagoon, did you use to fish with gas lamps? (___)

After banning gas lamps in this lagoon, do you fish:

(___) more shrimp (___) less shrimp (___) the same amount of shrimp

Obs:_____

Do you agree with the banning of gas lamps?_____

Before the shrimp cast-net's mesh size increased to 3 cm, which mesh size did you fish with? _

After this increase in mesh size, do you fish:

(___) more shrimp (individuals or kg) (___) less shrimp (individuals or kg)

(___) the same amount of shrimp (individuals or kg)

Obs:_____

Do you agree with the 3 cm mesh for shrimp cast-net?_____

After the enforcement structure, represented by two local fishery inspectors, was broken down do you fish:

(___) more shrimp (___) less shrimp (___) the same amount of shrimp

Obs:_____

(___) more fish (___) less fish (___) the same amount of fish

Obs:_____

In your opinion what are the main problems of this Lagoon fishing system? Why?

_____

_____