



Fitting institutions to ecosystems: the case of artisanal fisheries management in the estuary of Patos Lagoon

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Abstract

This paper analyzes the problem of fit of environmental institutions to the conservation of fisheries CPRs and the maintenance of artisanal fisheries in the estuary of Patos Lagoon, southern Brazil. The analysis identified problems with the definition of boundaries and rights to fisheries resources and incongruities between rules and local environmental/resource conditions which can affect the sustainability of artisanal fisheries. The driving forces of misfits showed to be associated to internal and external factors including the weak and changeable institutional arrangements, socio-economic conditions, the regime structure of governance, and individual stewardship for resources. © 2002 Elsevier Science Ltd. All rights reserved.

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1. Introduction

Fundamental to understanding resource management is the fact that people form institutions (rules and rights) around the resources they exploit [1]. The term institution is used here to mean the body of rules, regulations and processes that guide management [2]. The importance of understanding institutions stem from the fact that they are often behind the causes of environmental problems and hence they play an important role in solving these problems [3]. Findings on common property resources literature show that most environmental problems (such as the tragedy of the commons) can be seen as problems of institutional failure to control access to the resource, and to enforce internal decisions for collective use [2,4]. In the last decades, facing the failure of conventional (“western”) resource management systems [5], several researchers have been investigating the links between social systems and ecological systems in order to improve resource management [6]. The development of a common-property theory [2,7–10] has been extremely relevant in understanding the social dimension of management

systems and its inter-relationship with the biophysical environment. Also relevant is co-management theory, or power-sharing between government agencies and non-government groups [11,12], as well as the field of participatory research, whereby scientists and fishermen and other community members collaborate in various dimensions of fisheries research and management. In recent decades, the above mentioned body of theory of common-pool resources (CPRs) has integrated ecological, historical, socioeconomic, and political factors [13]. Such interdisciplinary endeavors have enabled scholars to tease out the factors that influence the performance of local institutions in conserving natural resources, looking at changes of arrangements and how crisis has been adapted over time [2,8,11,14].

Lee [14] attributes the problem of resource over-exploitation to a mismatch of scales between institutions and ecosystems: “when human responsibility does not match the spatial, temporal, or functional scale of natural phenomena, unsustainable use of resources is likely, and it will persist until the mismatch of scales is cured”. Spatial mismatches occur where the boundaries of management do not coincide with the boundaries of the ecological entity. Temporal mismatches are often discussed in reference to time horizons of planners and politicians (short) relative to environmental and social changes (long). Functional mismatches are mismatches

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of scope. Resource users may have very specific desires from a highly complex ecosystem, and they may tend to focus their management actions narrowly, aiming one objective (economic and biased interests) in detriment to others (social and ecological). Therefore the “problem of the commons” can be seen as one of getting the scales right in a dynamic and adaptive fashion. Although the problem of fit between institutions and ecosystems is not explicitly emphasized in the literature of common pool resources it is important to make explicit the fact that institutions will be more effective when they match the biophysical domain in which they operate. The problem of fit thus relates to how well institutions fit into the environment they supposedly protect [3].

In the estuary of the Patos Lagoon, located in the Southern Brazilian coastal zone, artisanal fisheries are going through a tragedy of the commons. Fisheries resources are decreasing sharply compromising the livelihood of more than 6000 small-scale fishers. The crisis in artisanal fisheries represents an indicator of the overall mismanagement of coastal resources, as illustrated by over-exploitation of many fisheries resources, loss of biodiversity, poverty and loss of cultural identity of fisheries communities. Triggered by a consensus of the failure of past historical institutions to manage these resources, new institutional arrangements have been established in the area in 1996, redefining rules and rights, to manage the resources. It is represented by a forum (Forum of Patos Lagoon, a co-management arrangement) composed of different stakeholders with the purpose to (1) discuss and develop alternative actions to mitigate and/or resolve the problems of the fishers and the crisis in the artisanal fisheries sector, (2) to recover the important artisanal fisheries and (3) to share decisions to address problems more effectively.

The objective of this paper is to analyze how congruent are the environmental institutions to the conservation of the fisheries CPRs and to the maintenance of artisanal fisheries over time in the estuary of Patos Lagoon. We start the paper with a description of the fisheries CPR and their characteristics that have implications for human use and management. Then we discuss the institutions that mediate the use of CPRs and ecosystems and the identifiable misfits between institutions and the CPRs. We end the paper discussing the driving forces behind the misfits and the challenges in relation to the problem of fit between ecosystems and institutions.

2. Methods

Field work in the estuary of Patos Lagoon was carried out from April 2000 to August 2001. Data were obtained from primary and secondary sources. The primary sources of data were (1) researcher observation

of the Forum of Patos Lagoon meetings, (2) informal conversations, and (3) in-depth semi-structured interviewing. Supplemental data were obtained from secondary sources. They included analysis of scientific publications, local newspapers, meeting minutes, laws, decrees and policy statements from national profile sources such as: Federal Institute for the Environment (IBAMA) and the Federal Sub-Secretary for Fisheries Development (SUDEPE).

Interviews were done face-to-face. A total of 48 interviews were made ranging from 45 min to 3 h each. The interviewees included knowledgeable fishers, fishers colonies presidents, middlemen, the director of the Port of Rio Grande, researchers from the University of Rio Grande, public officials, the head of the environmental agency IBAMA/Brasilia, industrial fisheries entrepreneurs, and other representatives of the forum of Patos Lagoon. In addition, several fishers and other stakeholders were informally interviewed during the breaks in the Forum meetings and during the field work. The sampled population varied from people without any formal education (illiterate) and low political power to people with high level educational degrees and high political influence in the decision making process at the local and federal level of government. The interviewees were asked the permission to use a tape recorder to register the information. With one exception all interviews were recorded and transcribed. In the case where permission for the utilization of a recorder was denied the interviewer took notes. The interview followed the following questionnaire profile: (1) identification of the key issues to be addressed; (2) preparation of two or three introductory soft questions, just to give a chance to promote a more relaxed bond between researcher and the interviewee, (3) and the substantive questions. We were interested in investigating the fisheries CPRs and their characteristics; the boundaries and use rights and limits to the CPRs; the formal and informal institutions that mediate the use of CPRs and their ecosystem (rules on paper and rules in use); the identifiable misfits between institutions and the CPRs, and the main driving forces behind misfits. Participant observation focused on the agenda and dynamics of the negotiation among the Forum of Patos Lagoon representatives during the meetings. Document analysis and archival research was performed to analyze historical changes in legislation, and in the local socio-ecological system.

The analysis of the congruence between institutions and CPRs followed criteria suggested by Pinkerton [11]; Ostrom [2], FAO [15], Folke et al. [16] and Young [3] for sustainable management of CPRs. The analysis centered on the types of gears/technologies in use; the attempts to limit excess use/exploitation of resources; the protection of critical habitats for the species; the existence of mechanisms to adapt rules according to changes in resource/ecosystem conditions; monitoring

and enforcement efforts; and the definition of boundaries and property rights of resources. Data analysis was based on triangulation of data from field notes, transcribed interviews, and from external sources including documents and literature.

3. Resources and human activities

The estuarine region of the Patos Lagoon is located in the Southern Brazilian Coastal Zone (Rio Grande do Sul State), an area of the Biosphere Reserve [17]. With an area of approximately 10,000 km², the Patos Lagoon is recognized as the world's largest choked lagoon, stretching from 30°30' to 32°12' S near the city of Rio Grande where the lagoon connects to the Atlantic Ocean (Fig. 1). The estuarine region encompasses approximately 10% of the lagoon, and is occupied by diverse and abundant flora and fauna. The abundant food resources and protection against predation provided by estuarine shoals makes this region an ideal nursery ground for several commercially important fish species.

For more than a century the artisanal fishery in the estuarine region provided fish and shellfish products to be exported to the main Brazilian markets, as well as to Uruguay, the United States and several European countries [18]. Today about 6000 artisanal and 3000 industrial fishers are temporarily or permanently in-

involved in fisheries activities in the estuary and coastal waters off southern Brazil [19].

The artisanal fishery operates in estuarine and shallow coastal waters. It is characterized by minimal fishing technology and, consequently, a smaller fishing power compared to industrial fisheries (Table 1). Fishers normally own their vessels and work together with their kin. The main types of fishing gears used by artisanal fishers are gillnets, stownets, bag nets and otter trawls. Artisanal fisheries once followed a clearly defined seasonal pattern [20]. The black drum (*Pogonias cromis*), the white croaker (*Micropogonias furnieri*), and the catfish (*Netuma* spp.) were fished in the spring; the pink shrimp (*Farfantepenaeus paulensis*) was caught in the summer and fall, the mullet (*Mugil platanus*) in the fall, and the bluefish (*Pomatomus saltatrix*), castanha (*Umbrina canosai*), and weakfish (*Cynoscion guatucupa*) in the winter. Artisanal catches accounted for over 80% of the total catches in southern Brazil in 1966. Landings declined from an historical peak of 43,600 tons in 1972 to less than 6000 tons in the late 1990s. Today, the main fisheries CPRs are either fully exploited, overexploited or depleted and catches are close to subsistence levels, with the exception of mullets and shrimps which provide sporadic good economic returns during ideal environmental conditions [21,22].

Characteristic of the resources exploited by artisanal fisheries is that they are present in the estuarine environment only during a small part of their life cycle

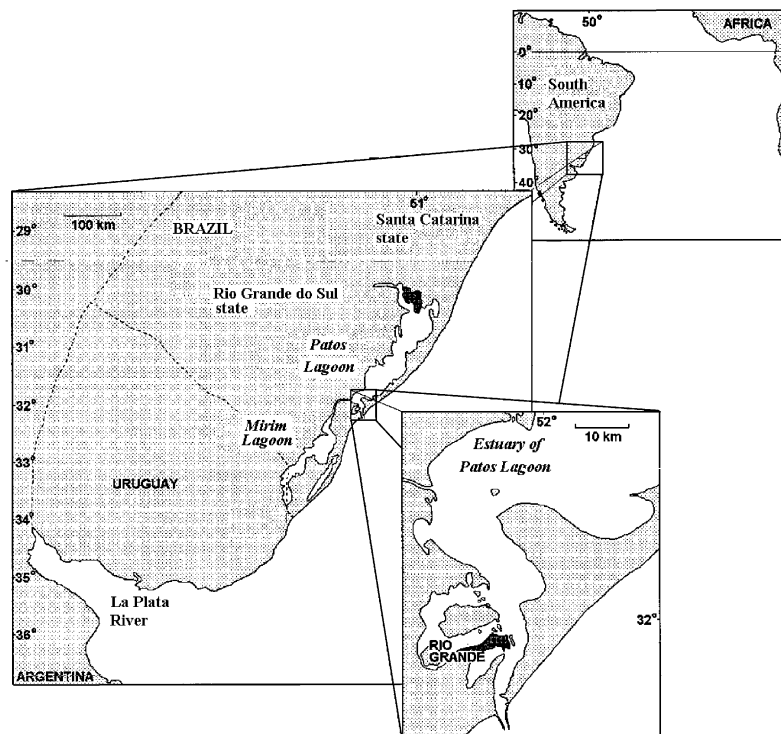


Fig. 1. Location of the Patos Lagoon estuary in Southern Brazil [19].

Table 1
Characteristics of three types of fisheries sharing fish CPRs in southern Brazil IBAMA [22,38,34]

Fishery	Artisanal	Semi-industrial	Industrial
Area	Estuary, marine inshore	Marine inshore and offshore	Marine inshore and offshore
Boat size (m)	<10	12–15	20–35
Fishers/boat	2–3	6–8	6–10
Power (HP)	10–24	90–120	250–650
Days fishing/trip	1	3–4	10–15
Capacity (tons)	<10	12–20	20–120
Gear type	Gillnets, trawling, bagnets, and stownets	Gillnets, hook and line	Trawling, gillnet, purse seine

Table 2
Distribution of the main fisheries resources exploited by artisanal fisheries (these species compose over 90% of total artisanal catches, IBAMA). The gray shaded boxes represent areas where the resource occur but is not available to fishing. Dotted boxes are areas where the resources occur and are fished by any type of fishery [21,24,34,47]

Species	Common name	Freshwater (lagoon and rivers)	Estuary	Inshore waters	Offshore waters	Other states	Other countries
FISH							
<i>Micropogonias furnieri</i>	Croaker						
<i>Mugil spp</i>	Mulletts						
<i>Netuma spp</i>	Catfish						
<i>Pogonias cromis</i>	Black drum						
<i>Macrodon ancylodon</i>	Royal weakfish						
<i>Brevoortia pectinata</i>	Menhaden						
<i>Cynoscion guatucupa</i>	Weakfish						
<i>Umbrina canosai</i>	Castanha						
<i>Paralichthys orbignyana</i>	Flatfish						
<i>Pomatomus saltatrix</i>	Bluefish						
<i>Rinobathos horkellii</i>	Guitar fish						
<i>Odontesthes spp</i>	Silverside fish						
CRUSTACEANS							
<i>Farfantepenaeus paulensis</i>	Pink shrimp						
<i>Xiphopenaeus kroyeri</i>	Marine shrimp						
<i>Callinectes sapidus</i>	Blue crab						

(Table 2). Practically all the main artisanal resources also occur in the inshore and offshore coastal areas, and some have their migratory range crossing international borders. In these areas resources are also exploited by other types of fisheries with distinct technologies and fishing power (Table 1). Another important characteristic of fisheries CPRs is their inherent variability. The interaction of climatic and oceanographic processes at different scales (local, regional, and global) can influence the productivity, distribution and availability of resources to fisheries [23,24]. One such influence is the effect that ENSO has on increasing the amount of rainfall in the region which in turn impact negatively the productivity of the shrimp fishery [23]. Fisheries also suffer from the human impacts on the coast such as pollution, contamination, dredging and loss of nursery habitats [19]. The above characteristics, i.e., the high mobility and the strong influence of the physical characteristics of the aquatic system and the effects of other coastal activities, makes fisheries one of the most puzzling CPRs [25].

4. Institutions that mediate the use of CPRs and ecosystem

The institution with the highest authority for the coastal zone management in Brazil is the GERCO (National Program for Coastal Management) that is administered by the Ministry of the Environment. The conditions set forth in the program have to be implemented by each coastal State and Municipality. The program defines the legal aspects for the management of the Brazilian coastal zone, and establishes the basis for the development of regional and local policies, programs and management plans. Estuarine areas, such as the estuary of the Patos Lagoon which was classified as an area of moderate to high environment risk, and of moderate to high actual impacts [26] were defined as areas of high management priority by GERCO.

Although fisheries are important coastal resources, GERCO has no mandate over them. The management of fisheries in Brazil is mainly the responsibility of the Federal Government, which is responsible for assessing

the status of the stocks and for setting and enforcing regulations on the use of aquatic living resources. Governmental institutional arrangements for regulating fisheries activities have been changing over the years (Table 3). The role of the Federal Government in marine fisheries management became particularly influential in the mid-1960s with the creation of the Federal Fisheries Agency (SUDEPE) of the Ministry of Agriculture. Later in 1989 fisheries became one of the agendas of the Environmental Agency (IBAMA), a subsidiary of the Ministry of Environment. In 1998 a law was approved to create another department for dealing with fisheries management and the delegation of responsibilities to manage the resources has changed once more. According to Dias Neto [27] such a change represents “one of the most anarchical moments in the fisheries management in the Brazilian history”. This anarchical situation is related to the fact that since then, management of fisheries resources is the responsibility of two agencies in two distinct ministries: IBAMA in the Ministry of Environment, and the Department of Fisheries and Aquaculture in the Ministry of Agriculture. The main responsibility of the latter is to promote and execute programs and projects to support the development of the industrial fisheries—its main objective is to promote the development of the sector and to manage unexplored fisheries resources. While IBAMA is responsible

to execute the national policies for the environment, and particularly to manage endangered and over-exploited species, encouraging the sharing and decentralization of decisions through co-management and community-based management initiatives. Its main attribution is conservation and sustainability of resources. These two agencies have different policies and different approach to resource management, that are conflictive in their mission.

In terms of property rights, coastal zones are composed of natural resources or ecosystems under different property rights regimes. These include open access, communal property, state property, and private property. Some of the coastal resources, such as fisheries for instance may fall under any of several management regimes, depending where it is located and harvested, although it is formally considered a public open access resource by the Brazilian constitution [28].

Given the failure of the above institutional arrangements to sustain artisanal fisheries, and benefiting from the current process of decentralization of IBAMA, a new institutional arrangement has been formed to co-manage the local resources in the estuary of Patos Lagoon. The local co-management arrangement referred to as the Forum of Patos Lagoon was set up (1) to organize the artisanal fisheries sector in relation to fisheries administration policies; (2) to prompt partnerships within the sector in order to implement action

Table 3
Evolution of governance system and fishing technologies in use in the estuary of Patos Lagoon and coastal waters

	Early 1960s	1970	1980	1990	Present
<i>Governance</i>					
Local	Rules in estuarine fisheries mostly locally devised			Forum of Patos Lagoon created (1996)	Legitimization of the Forum of Patos Lagoon as a local co-management arrangement
National	SUDEPE, Ministry of Agriculture (1967–1989)	→		IBAMA, Ministry of Environment (1989–1998)	IBAMA, Ministry of Environment and DPA, Ministry of Agriculture (1998–present)
<i>Technologies in use</i>					
Estuary	Artisanal trawling Gillnets Bag nets Artisanal beach seine	Intensification of gillnet fishing Introduction of stownets	→		
Coastal waters	Artisanal beach seine Industrial trawlers and purse seiners	Intensification of industrial pair-trawling, otter trawling and purse seining		Development of a semi-industrial gillnet fishery Double-rig trawling, long-lines and traps	Opening access to foreign industrial trawlers

plans to rebuild the productive capacity of the fisheries resources in the Patos Lagoon; (3) to establish criteria that allow the fishing effort control as one mechanism for rebuilding fisheries resources; and (4) to encourage the collective organization for the support of local sustainable artisanal fishing communities (Forum of Patos Lagoon Mission Statement, 1998). The Forum is composed of 21 institutions representing fishermen organizations, fishermen unions, religious movement, fishing industries union, official environmental institutions, law enforcement units, universities, state government, public defender, NGOs, technical assistant organizations and municipalities. Since the establishment of the Forum, fisheries regulation has been debated redefining rules and rights to local resource use in the estuary of Patos Lagoon. Measures such as

fishing effort limit, minimum mesh size, closed season, among others, have been exhaustively discussed and agreed as a first initiative of this co-management arrangement (Decree IBAMA 171/98; Table 4).

Table 4 presents a summary of the laws and decrees that control the use of local CPRs in the different aquatic environments where they occur. It describes the established rules regarding how much, when, and how different resources can be harvested, involving management functions such as licensing, timing, location and vessel or gear restriction to prevent over-exploitation [11], as well as rules to protect critical habitats and water quality from damage to preserve health of the resource. From Table 4 one concludes that access to the majority of artisanal fisheries resources is being limited by license control in all areas. The exceptions are the

Table 4
Summary of norms and decrees controlling the use of CPRs in different aquatic environments [SUDEPE; IBAMA; Ministry of Environment] [56]

	Freshwater	Estuary (Decree 171 22/12/98)	Inshore	Offshore
Limited areas	In the convergence of river and lagoons	No	Trawling inside 3 miles Fishing crabs 6 km around the mouth of Patos Lagoon Fishing bluefish inside 3 miles	Trawling by foreign fleets inside the 200 m isobath
Limited access	Fishing in the Mirim Lagoon to fishers who live in the area	Licenses restricted to full-time fishers that live around the estuary	License control for demersal fish trawling License control for shrimp trawling	
Seasonal limits restrictions	During spawning migrations (only allowed with hook-and-line fisheries)	Pink shrimp: 1 Jun–31 Jan Mulletts: 1 Jun–31 Jan Croaker: 1 Feb–30 Sep Catfish: 1 Jun–28 Feb No fishing from 1 Jun–30 Sep	Shrimps: 1 Mar–31 May Bluefish: 1 Nov–31 Mar (or 1 Dec–31 Mar for vessels < 10 m inside 10 nm) Catfish: 1 Jan– 31 Mar	
Size limit	Pink shrimp (90 mm); mulletts (35 cm); croaker (35 cm); catfish (40 cm); silversides (20 cm); flatfish (35 cm); blue crab (12 cm, males only)		Pink shrimp (90 mm); bluefish (40 cm); castanha (25 cm); flatfish (30 cm); black drum (50 cm); silversides (20 cm); royal weakfish (25 cm); weakfish (30 cm); mulletts (35 cm); catfish (30 cm)	
Fishing gear restrictions	Bottom gill net Trawling, seine nets and electric-fishing Min. mesh sizes (50–70 mm) Max. 1830 m of nets per fisher in the Mirim Lagoon	Trawling of any kind Max. of 10 shrimp nets/fisher Max. length (1830 m) and height (100 meshes) of gill nets/fisher Min. mesh size shrimp and fish nets (24–140 mm) Max. length shrimp nets (15 m)	Min. mesh size pink shrimp trawl (30 mm) Min. mesh size mar. shrimp trawl (24 mm) and max. length of nets (12 m)	Min. mesh size fish trawl (90 mm) Use of Turtle Exclude Device (TED) in shrimp trawlers > 11 m
Quota	No	No	No	Max. 5% incidental catch of rockfish in foreign trawlers
Habitat protection	Protection of creeks and lakes; standards for water quality/use Protection of riparian habitats	Protection of estuarine shoals; standards for water quality/use Protection of mangrove and salt marsh habitats	Federal laws to prevent pollution by oil spills and other contaminants [28]	Federal laws to prevent pollution by oil spills and other contaminants [28]

semi-industrial fisheries based on gillnets and industrial purse seine fisheries for which access to use of the resources is still open. The most common rules on paper are those determining fishing seasons, size limits and the characteristics of fishing gears. The regions differ however on the number of restricting rules—the fisheries in the estuary of Patos Lagoon present the largest number of rules controlling fishing seasons and gear characteristics. Another notable feature in Table 3 is the absence of management quotas in practically all regions (the exception is a by-catch quota established for deep water species caught by foreign trawlers) and the absence of fisheries management rules defining marine habitat protection. Habitat protection rules for terrestrial ecosystems that are relevant for fisheries CPRs are defined by State and Federal environmental agencies. They set the standards for water quality, rules to prevent water pollution, and to regulate the types of use in estuarine and freshwater systems for protecting critical habitats such as marshes and riparian ecosystems. There are no similar rules for habitat protection in inshore and offshore marine areas.

5. Misfits between institutions and the CPRs

To address the question of how congruent are management rules with the sustainability of local resources and the maintenance of artisanal fisheries over time, the analysis is centered on two aspects. First the definition of boundaries and the rights to fisheries CPRs and, second the (in)congruence between rules on paper and rules in-use and the characteristics of the fisheries CPRs.

5.1. The challenges of defining rights to fisheries CPRs

Defining boundaries over resources is a way to deal with the issue of property rights. As put by Ostrom [2], the definition of boundaries can be thought of as a first step in organizing for collective action. As long as the boundaries of the resources and/or the individuals who can use the resource remain uncertain, no one knows what they are managing or for whom (right to what, right for what, for whom, against whom). If this is not well defined and established it will be difficult to maintain life support systems and resource users livelihood. The basic and probably universal factor of environmental regimes in fisheries is the limitation of access to the resource [29]. Without some kind of access limitation, a productive fishery sooner or later attracts enough fishermen to render it unproductive [30,31]. The current crisis faced by the artisanal fisheries community of the estuary of the Patos Lagoon relates to the historical problem of access limitation—or the lack of it.

The estuary of Patos Lagoon was the site of a productive small-scale fishery until the early 1970s. Fisheries communities had their rights exercised in the management of the resources through different mechanisms. One such mechanism was the definition of fishing territories. Territories are sometimes defined based on pragmatic grounds, i.e., which micro-environments are best suited for which technologies, and sometimes defined as the result of informal and formal rules establishing where and how to fish. These use patterns reflect practical and informal resource management strategies developed by a community of fishermen through years of experience, and represent important methods to control spaces and resources [32]. In the estuary of Patos Lagoon there were fishing practices used by artisanal fishers that had important significance to the definition of fishing territories and rights. Fishing practices involved interrelated mechanisms such as the definition of fishing areas, periods and technologies. Table 3 presents a summary of the evolution of fishing gears in use in the estuary and coastal waters.

The pink shrimp was fished during the summer using different gears, each with a specific location in the estuary. The *coca*, which is a manual type of trawling dragged by two fishers, was used mainly in estuarine shallow waters and considered a very clean net due to its low bycatch. Bag nets (*rede de sacco*) were fixed around the estuarine channels and caught shrimp by passively filtering the ebb currents of the estuary. Fishers had delimited specific locations in the estuary to fix their nets, which were agreed and respected among them and recognized by legislation. With the advent of power engines, some fishers started using otter-trawling (*prancha*) and pair-trawling from boats mainly in the deeper waters of the estuary. Since 1973 all types of trawling fisheries were forbidden to minimize the bycatch of fish and the impact in the nursery areas. Since then a new type of gear was formally institutionalized by the Federal Government, the *aviãozinho*, which is a fixed stownet placed in shallow waters that use light attraction to catch shrimps at night. Since the implementation of this technology the above traditional forms of resource use were disrupted as well as the informal rules devised to control access and use. Control over fishery became an attribution first of SUDEPE and later of IBAMA which still determines the maximum number of nets and the specific location for each fisher to fix their nets, following to some extent their traditional access rights. The introduction of stownets had some impacts over the fishing activity and the territoriality in the estuary. It opened access to occasional fishers, people who work in the cities and farmers, that have never lived from the fishery activity but that began to catch shrimp as an alternative source of income [33]. According to Asmus [33], three factors led to this: the high prices of shrimp in the market, the easy access to

fishing grounds (the city of Rio Grande, for instance, is surrounded by two important shallow water bays used as shrimp fishing grounds by city workers), and the considered simple fishing technique which requires only one fisher and a small boat to operate the nets. We add to this the fact that there were no rules in place at that time to avoid new entrants to the fishery. The opening access associated to non-compliance and non-enforcement of rules regarding the maximum number of nets per fisher, resulted in the overcrowding of the lagoon shallows during the shrimp season.

Opening access to new entrants, and spreading of stownets around the lagoon redefined fishing territories and created unintended access limitation problems to some artisanal fishers, mainly to those that continue using trawling and bag nets. This was due to the lack of space for new shrimp nets, the difficult navigation in the fishing ground overcrowded with nets, and the fact that most shrimp are caught before migrating out of nursery grounds in shallow waters. Stownets are highly efficient in capturing shrimp due to the effect of light attraction, and few shrimps escape to be caught by other fishing techniques. Moreover, a great portion of fishers consider stownets a rather difficult and expensive kind of technology. They argue that the investment in the gear does not pay off because it can only be used to catch shrimp in the estuary, while trawling for instance can also be used to catch shrimp on the coast. Finally, it is widely accepted by fishers that stownets are inappropriate because they are used in nursery areas and kill large quantities of small juvenile fish, which was more effectively avoided by the use of their traditional technologies such as the *coca*.

Mulletts were fished during spawning runs in the autumn at specific locations in the estuary, where large schools concentrated before migrating out of the estuary. The fishery followed a system of orderly beach seine shots (lances), where each fishing unit (*parelha*) was given the right to fish once. After completing its beach seine shot, a fisher would move to the last place in line, and give the turn to the next *parelha*. This common use of the resource became formalized as a decree in 1969 (SUDEPE No. 406 05/11/69), which also established the places and the number of *parelhas* that could operate in each beach annually. This management system broke down due to many factors. Improvements in technology and materials (nylon) and the widespread of gillnets made artisanal fishers start chasing fish in other areas of the Lagoon and over longer periods. Since 1962 large purse seiners (20–24 m long) from Santa Catarina started operating in the inshore areas of Rio Grande do Sul and to capture mulletts during the spawning run [34]. Both factors probably contributed to exasperate resource scarcity in the last four decades and erode local management systems.

A problem of great concern to many artisanal fishers today is the definition of territorial rights in the channel waters of the estuary and in the inshore coastal areas. Both areas have always been used by artisanal fishers as important fishing grounds, because fish (mulletts, catfish, croaker, black drum) concentrate in these areas during migration in and out of the estuary and during spawning. One conflict over the rights to use channel water arises between the fisheries and port and navigation activities. The latter has received priority by the Port Authority, who restrict fishing in order to guarantee a safe and clear transit in the area. The access of artisanal fishers to the coastal areas is also prohibited by the Port Authority because small scale artisanal fishing boats usually do not comply with the norms and safety requirements to operate in open waters. The environmental agency (IBAMA) on the other hand excludes the right to use the 3-miles zone to trawling in order to protect the resources. This rule affects a recently developed artisanal trawling fishery for marine shrimps which occur in the area during autumn and winter months. Therefore, due to port activities and attempts to protect resources, artisanal fishers have lost the rights to extract the resources in areas that were frequently used in the past and that are still very important for them.

A factor of important consequence to the definition of property rights to fisheries CPRs in southern Brazil was the development and activity of industrial fisheries. Industrial fisheries benefited from economic development policies adopted by the Brazilian government, especially after the implementation of the Law 221/1967 by the Federal Agency for Fisheries Development (SUDEPE), of the Ministry of Agriculture. SUDEPE was charged with implementing a development plan for fisheries, which included as the main objectives the increase of fisheries production and profitability of the fishing sector; the increase in the number of jobs, and the improvement of socio-economic conditions of fishers. One of the most important development policies adopted by the government as a result of Law 221/1967 was the tax incentives to the fisheries sector [35]. Abdallah [35] calculated that fiscal incentives given to fisheries from 1967 to 1986 summed up to US \$ 1,015.8 millions, 24.5% of it invested in southern Brazil [36]. From the total capital incentives, 51% were invested in the industry sector, 20% in the fish resource capture, and the rest in the commercialization of fish products and administrative expenditure [35]. Practically nothing was invested in management research or data gathering to monitor the resource conditions. Abdallah [35] concludes that government fisheries policy in the period was not concerned with conservation of resources but aimed at economic growth of the industrial fishing sector. It is important to note that no incentives were given to small-scale fishing sector. Interests lay solely in

creating the conditions to establish the modernization of the activity and the extraction of resources [35,37].

The activity of industrial fisheries intensified in southern Brazil particularly in the early 1970s, as a result of the tax incentives and also due to the limited access of Brazilian trawlers to fisheries CPR in territorial waters of Uruguay and Argentina [38]. Industrial fishing vessels have a fishing capacity considerably higher than artisanal vessels, which can be seen by the characteristics described in Table 1. As pointed by Haimovici et al. [38] and IBAMA [21], the intensive activity of large trawlers in southern Brazil was one of the main causes of decline in many of these fisheries CPRs between 1975 and 1985. Indirectly industrial fisheries also affected the territoriality of artisanal fisheries in the estuary. Heavy fishing in the coastal waters have decreased the amount of fish entering estuarine waters. Artisanal fishers were therefore forced to gradually intensify fishing in the coastal waters, to the point where a new semi-industrial gillnet fleet was created in the early 1980s [20]. The decrease in abundance of CPRs also disrupted the traditional fishing calendar, which followed once the seasonal availability of the different resources in the estuary. This calendar served conservation purposes because it controlled the overuse of a specific resource by limiting the fishing period for each species. Due to the overall scarcity and increased competition for resources fishers are now forced to fish for longer periods to sustain their living, consequently increasing pressure over resources.

Therefore, government policies gave rights for new entrants to use fisheries CPRs that were already informally managed by others. Resource availability and the carrying capacity of the system became jeopardized by the increasing pressure to exploit the resources, created by the growing number of people chasing the same resource, along with the changes in technology that tremendously improved the efficiency of resource extraction in the last four decades. The last past years of fish scarcity have erupted a conflict over resources territoriality in the region, especially between artisanal small-scale fisheries and medium and large scale industrial fisheries. Conflict over use of resources escalated even further when the Department of Fisheries and Aquaculture opened access to foreign trawlers to operate in shelf waters of southern Brazil.

Few attempts have been made to regulate inshore and offshore fisheries and to minimize conflicts over the use of resources between artisanal and industrial fisheries. Although rules exist on paper to regulate inshore and offshore fisheries (e.g. limited areas, license control, size limits, gear restrictions; Table 4), in fact the management of fisheries CPR off the estuary of Patos Lagoon has been ineffective or absent. Rules for license control, which were only recently established to freeze the number of trawlers in the area, are clearly insufficient to allow for the recovery of resources given the already

large fishing fleet capacity [21]. On the other hand, rules that limit trawling in the 3-miles zone are not respected and enforced, while large purse seiners with high capacity to resource extraction are free to operate inside this area.

By assigning the responsibility of managing fisheries to SUDEPE (and later in 1989 to IBAMA), government centralized the making of rules that were before locally devised by fishers. Informal management systems present up to that point in time were disrupted when government adopting the economic model of the open-access fisheries intruded, leading too quickly to the changes in the sector caused at some extent by policy incentives to industrial fishing sector, corporate interests and international situations (it is noteworthy the role that international organizations such as FAO had in encouraging the international trade and the “better” management of fisheries through the use of modern technologies to maximize resource extraction disregarding local fishing practices and the sustainability of resources [39,40]). One can speculate that there were no effective local mechanisms at that time to cope with and foresee the effects of these external influences on the delimitation of boundaries and the sustainability of fisheries activities.

Recognizing the need for dealing with boundaries definition as an important issue for the crisis in the local activity and in the light of the lack of an overarching institutional mechanism in which local rules could be designed, a group of stakeholders involved in the governance of the CPRs in the estuary of Patos Lagoon have opted to engage in a co-management regime (Forum of Patos Lagoon). The demands in the estuary was for some kind of sharing of power and responsibility in such a way that the power of centralized management agencies could be partly redistributed to local-level institutions and balanced, not eliminated. The first step of building this new institution was related to design resource boundaries and individual rights to use the resource as well as to devise rules to give rights to local users to exclude outsiders.

Among the rules established in the Forum (Decree 171/1998, Table 4) was the definition of using rights of the estuarine resources. The historical momentum was appropriate because of government’s willingness to decentralize the decision making process of governance of natural resources in the Brazilian coast [41]. There was a consensus among representatives of the Forum of Patos Lagoon that licensing had to be done in such a way that could help control fishing effort, hence limiting entry. Fishing licences are given annually only to those who proved: (a) to be residents in the estuarine region of the Patos Lagoon; and (b) that fishing was their main activity and source of income (Table 4). These rules are related to the rights of local fishers to refuse access to other fishers, mainly those from the neighbour state

(here referred to as “Catarina fisher”). This access limitation rule was challenged by Catarina fishers on the grounds that fisheries are considered public resources by the federal constitution and are open to any Brazilian who holds a valid fisher license. The Forum however succeeded in having the limiting entry rule accepted by the Federal Government.

Regulation developed by the Forum paid close attention to defining resource boundaries and the rights to exclude other fishers to fish in the estuary. However they have not yet taken into account the fact that most resources exploited in the estuary also occur and are intensively fished in coastal waters by semi-industrial and industrial fisheries, i.e., management boundaries do not coincide with fisheries CPR boundaries (Tables 2 and 4). Although there are rules established by the central government to limit access to fish extraction in the 3-mile zone, these rules on paper do not address the very question of access rights because it does not consider the differences in fishing power capacity of industrial/semi-industrial and artisanal small-scale fishers. Therefore the benefits to defining boundaries and limiting access within the estuary may be threatened if local fishers continue facing the risk that any benefits they produce by their efforts will be reaped by others who have not contributed to those efforts and who have not shared the same management interests. Protection of fisheries CPR from overfishing and the maintenance of artisanal small-scale activity will not be achieved if this problem of misfit is not addressed.

5.2. The congruence of management rules and CPR conditions

In addition to limit the appropriation of common pool resources through rights and boundaries delimitation it is also important that rules are congruent with the characteristics of the exploited resources and ecosystem. This section describes some mismatches that were identified in the management of fisheries CPRs that can potentially affect resources sustainability in the estuary of Patos Lagoon.

5.2.1. Harvest technologies and environmental characteristics

Fisheries can impact ecosystems in many different ways, e.g. by exploiting resources beyond their carrying capacity, by damaging habitats that are important for nursery and production, and by capturing species that are not the main target of the fishery (bycatch) [42]. Bycatch is an important issue in the management of shrimp fisheries and as such it has determined rules that restrict the use of certain fishing methods. In the estuary of Patos Lagoon the gears allowed to catch shrimp (stownets and bag nets) are considered adequate by IBAMA because they produce relatively low by-catch

rates per net compared to what is known about other types of gears such as trawling. Vieira et al. [43] estimated that on average only 6% of the total catch in stownets is composed of juvenile fish (mostly croaker and catfish), which are discarded. However the total amount of juvenile fish discarded at the end of shrimp season can be considerably high, in the order of 600 tons. This happens because according to the formal established rules each fisher is allowed to use 10 nets (Table 3). In practice each use more than 15, and there are cases of 200 nets per fisher. Many of the ca. 3000 licensed fishers and the considerable number of unlicensed fishers in the estuary use this fishing technology to catch shrimp. As a result, more than 15,000 nets are placed and allowed in the shallow waters which are the nursery grounds of the estuary of the Patos Lagoon [43]. The reality is, therefore, that the shrimp fishery with fixed nets can produce harmful levels of bycatch. The decision making process that by law established this as the technology to be used was narrowly defined because it has taken into consideration only the characteristics of the fishing gear and failed to account for the difficult problem of limiting the right of entry and use of resources. The opening of access and the lack of monitoring and enforcement contributed to increase the pressure on the resource over the years.

These are unintended consequences of imposing rules from outside. Although these rules were revised and accepted by the Forum of Patos Lagoon representatives, there is a consensus among fishers that stownets are inappropriate because they are placed in the nursery areas of the estuary and are responsible for killing large quantities of juvenile fish. The bycatch of trawling, which is still used by many fishers, can also be high although no formal evaluation has been conducted since it became prohibited in the estuary of Patos Lagoon in 1973. According to fishers, artisanal trawling can produce little bycatch depending on the characteristics of the otter board and the height of the net—the higher the net in the water column the higher the bycatch. Fishers have found ways to reduce the amount of bycatch (because it increases the handling time of the catch on board) by decreasing the height of the net, and also avoiding areas with high bycatch rates, such as shallow estuarine waters and specific locations off the coast which are known as nursery areas. Bycatch is not only an issue in artisanal shrimp fisheries. It is particularly important in industrial trawling fisheries that operate along the coast. Haimovici [34] estimated that the total discarded bycatch of pair-trawlers and otter trawlers fishing in the region during the early 1980s summed up to 46% of the total catch in weight, most of it composed of juvenile weakfish, royal weakfish and castanha. The discarded bycatch in twin rig trawlers is in the order of 50% of the total catch and is composed of small sharks and fishes. A rule limiting the minimum

mesh size of fish trawling nets to 90 mm was later adopted to remedy the bycatch of juvenile fish [44] (Table 4).

Both artisanal and industrial fisheries use harvest technologies that can have grave consequences to ecosystems and fisheries CPRs. The shrimp fishery with stownets shows an example of incongruence between rules and the local characteristics of the ecosystems. The case of artisanal trawling in estuarine waters shows an example of a rule that is apparently congruent with the resource conditions but it is not followed by fishers. A combination of factors shows to be responsible for the lack of compliance. First because fishers believe that trawling in the channel waters is less damaging than fishing with fixed nets in shallow waters. Second, because the shallow waters are already occupied by thousands of fixed nets, therefore for many fishers there is no other available way to catch shrimp. Third because fishers were never consulted or involved in the rule making and do not have the authority to set and modify the rules to better fit them to the specific characteristics of their setting. Finally, fishers seem to be trapped in the rationale that ‘if I don’t do it others will do it’, which when combined with the lack of enforcement leads to non-compliance with the rules. The industrial trawling shows an example of a fishing technology that is incongruent with the sustainability of resources. Rules have been devised to alleviate the damaging effects of this fishery, such as the 3 miles exclusion zone and the mesh size limits, but in fact there have been little compliance with these rules and no enforcement.

5.2.2. Fishing calendars

One of the most widely used rules to limit the appropriation of CPRs is the definition of fishing calendars. In the estuary of Patos Lagoon fishing calendars define the timing of artisanal fisheries for each of the main resources (Table 3). The shrimp fishery calendar is tied to a fixed opening that happen every year on February 2nd, although fishers, scientists and managers acknowledge the fact that the cycle of shrimp growth and production varies between years and areas. Manager officials have based the fixed opening on monthly shrimp production data which indicate that March and April are the months when on average most shrimps are fully developed [45]. According to them the opening in February would benefit the fishery in terms of the total weight of shrimp caught. Although the fishery occurs mostly after February, in reality some fishers follow their own traditional calendar and start catching shrimps earlier in the year depending environmental/resource conditions. The lack of feedback mechanisms to adapt rules to the characteristics of the resource and to the climatic conditions, often generate conflicts between fishers and officials. Fishers ask for annual revisions of the rules and for distinct openings by

areas, since shrimp production varies along the estuarine shallows and is tightly related to the hydrological conditions (Forum of Patos Lagoon, minutes 08/12/1999). Changing the *status quo* to an adaptive calendar would require a more complex system of monitoring, which is viewed as unfeasible by the official agency (Forum of Patos Lagoon, minutes 08/12/1999). On the other hand, attempts to adapt rules to resource conditions have failed because of fierce discussions between scientists and fishers about when the stock would achieve the adequate fishing size [22]. There is still a perceived institutional barrier to be broken to allow the sharing of responsibilities between officials and resource users in the monitoring of shrimp conditions and in the management of the activity (Forum of Patos Lagoon, minutes 08/12/1999).

Another identified incongruence in the decree IBA-MA 171/98 revised by the Forum relates to the calendar for catfish. The established formal rule is that the fishing season starts in March and ends in May. The fishery traditionally started in August and lasted until December, the period when the species enters the estuary to mature and reproduce [46]. Fishers consider the current calendar inadequate because it makes them catch catfish in a critical period in the species life cycle, when adults are incubating the young in their mouths. After spawning in estuarine and coastal waters in late spring, male catfish incubates the eggs and the fry for up to 2 months in their buccal cavity [46]. The incongruence in the catfish calendar is particularly threatening to the maintenance of this long-lived resource, which suffered from intense overfishing in the last decades and requires strong conservation measures to recover [22]. After a formal request made by fishers to the Forum of Patos Lagoon to change the fishing calendar, the rule is being revised to include an additional opening season from October to November (E. Reis pers. comm.). Similar requests have been sent to the Forum of Patos Lagoon by fishers organizations (Colônia de Pescadores Z3; Forum of Patos Lagoon, minutes 22/01/2000) to alter the fishing calendar for mullets (opening the fishery from October to May) and croaker (October to February).

5.2.3. Limiting excess exploitation of resources

Most of the fisheries CPRs traditionally targeted by artisanal fisheries are currently classified as either fully exploited, overexploited or depleted [20,21,34,47]. The abundance of croaker has been decreasing steadily in the last two decades and current exploitation rates are considered unsustainable [22,34]. Resources such as black drum and catfish were overexploited in the 1970s and the fishery in the estuary of Patos Lagoon collapsed in the early 1980s [20]. The stock of pink shrimp also shows signs of overfishing. Despite the high natural variability in catches, the average landings have declined

from 4016 tons to 2152 in the early 1990s [20]. The resource is expected to decline even further if the excess exploitation by industrial and artisanal fisheries is maintained in the near future [21,22]. Not much is known about the status of mullet stock in southern Brazil; landings are highly variable but show a clear declining trend from a peak of 4291 tons in 1975 to ca. 500 tons in 1998 (IBAMA).

Recognizing the need to recover the productivity of estuarine fisheries, the Decree 171/98 defined measures to control the excess resource exploitation in the estuary (e.g. license control, effort control, closed seasons; Table 4). The expected effect of these rules in alleviating the excess exploitation and allowing the recovery of depleted stocks is highly uncertain. At best the rules in place are expected to maintain the *status quo* conditions, which are worrisome for their potential impact on some resources, such as catfish and black drum. There is no action plan defined with specific strategies to recover the depleted resources. More importantly is the fact that all species exploited by the artisanal fishery in the estuary migrate to shelf waters of southern and southeastern Brazil (some to Uruguayan and Argentine waters) where they are also exploited and subjected to other less restrictive management rules (Table 4). A complicating factor to the effectiveness of management rules is the overall lack of enforcement.

5.2.4. Deficient monitoring and enforcement

Institutional behavior is not only defined by its intentions, political rhetoric, and the policies that it enacts, but it is also largely defined by the extent to which these policies are implemented and monitored. Monitoring constitutes a vital source of feedback in the management process. Many contend that Brazil has one of the most advanced bodies of environmental laws in the world, yet implementation and enforcement of these laws is exceptionally weak and ineffective [48]. As it can be observed in Table 3 a number of rules exist for regulating fisheries activities in southern Brazil, but enforcing these rules has been ineffective. Many factors contributed to the deficient monitoring of resource conditions and the enforcement of regulations in the estuary of Patos Lagoon and coastal areas. Beginning with the fact that with the centralization of fisheries management both monitoring and enforcement became the responsibility of a single federal agency (SUDEPE and later IBAMA) which has always lacked structure and human resources to carry the functions effectively. It is known that contravention is usually tolerated by officials, who are often unwilling to enforce rules impartially. Industrial fishers who want to avoid rule enforcement have considerable opportunity and means to obtain the help of officials in obstructing such enforcement, thus undermining any effort to support new local institutions. It has been proposed that the

efficiency of this source of feedback (who monitors resource conditions and how) is increased with the inclusiveness and accountability of the resource users [2]. This has not been considered yet by the local institutions. On the other hand, efforts to overcome the problem of infrastructure and the monitoring of illegal fishing in estuarine and coastal areas were recently done by a concerted action between IBAMA and the Navy. The results of this initiative, which are to be analyzed in the future, will serve as important mechanism to evaluate how these management functions could be better performed over time by the different institutions.

5.2.5. The lack of a systemic view

Fisheries management is still sectorial, and does not include in its structure the possible interference from other activities and institutions. There are multiple sources of human impacts that can alter the carrying capacity of the estuary of Patos Lagoon, and potentially impact artisanal fisheries. These include

5.2.5.1. Destruction of vital habitats. Estuaries provide vital habitats for nursery of aquatic organisms. Seagrass beds, for instance, are a nursery ground in which postlarval stages of many invertebrates and fish species concentrate and develop. Salt marshes are important producers of organic matter that is either exported to the estuary and coastal area, or recycled in the marshes by herbivores and detritivores organisms that are important food sources for juvenile fish and birds that rest in the estuary [49]. Although legally protected (Table 4), seagrass and salt marsh habitats have been destroyed by the filling of intertidal and shallow water flats in the lower estuary for port, residential, and industrial development. It is estimated that filling along estuarine margins and around small islands has destroyed as much as 10% of the total salt marsh area of the estuary [50]. Other important man-induced impacts to salt marshes, which has not yet been quantified, is the large-scale grazing by livestock on marginal marshes. Estuarine habitats are also lost due to sedimentation processes, which could be natural or man-induced, the latter related to the misuse of agriculture land in the watersheds. Over the last two centuries it is estimated that the water area of the estuary has decreased by ca. 11% due to deposition of fine sediments from the Patos Lagoon in shallow estuarine shoals [50].

5.2.5.2. Changes in primary production. The main primary producers in the estuary of Patos Lagoon are emerged and submerged macrophytes (salt marshes, sea grasses), benthic and floating macroalgae, cyanobacteria and microalgae (including phytoplankton). Conservative estimates of net primary production indicate that salt marsh plants, macroalgae and cyanobacteria are

responsible for as much as 86% of the total addition of carbon to the estuary [19]. There is no direct evidence of changes in primary production in the estuary of Patos Lagoon. On one hand, a decrease in primary production may occur due to the destruction of salt marshes and seagrass habitats during the last century (see above). On the other hand, excess nutrient loads from domestic and industrial effluents and agricultural runoff are responsible for the eutrophication of the estuary with the development of blooms and changes in phytoplankton composition [50]. Eutrophication has as a side effect the decline of submerged macrophyte biomass in estuarine embayments, due to the attenuation of light penetration, which can also decrease the overall primary productivity.

5.2.5.3. Changes in freshwater flow. The growing utilization of freshwater that discharges into the estuary can modify the seasonal variation of flow rates that is essential for flushing and maintaining the balance of salinity and nutrients in the estuary [50]. It is estimated that during 1968–1969 the water demand for irrigated rice cultivation and for the population living in the watersheds of the Patos Lagoon was ca. 6% of the annual runoff. Today, as much as 13% of the total natural water runoff may be diverted during drought periods as a result of an increase in the population of 37% and a 120% increase in the area of rice cultivation [50].

5.2.5.4. Pollution and contamination of estuarine waters. The estuary presents high risks of contamination by chemical substances due to the large number of petrol-chemical and fertilizer industries settled in its margins, the trade and transportation of toxic substances in the port of Rio Grande, landfills, and the excessive use of agricultural pesticides in the farm lands around the lagoon. One of the most recent and important incidents in the port of Rio Grande was the acid spill from the Maltese freighter, MV Bahamas. The ship entered the port of Rio Grande on August 1998, carrying 22,000 tons of sulphuric acid to supply the local fertilizer industries. A hole in the MV Bahamas caused water from the estuary to get inside the freighter, and react with the acid to produce a highly explosive gas. Considering the risks of explosion and the economic costs to take alternative measures, a decision was made by local authorities (port and governmental organizations, Port Authority, municipality and the university) to release about 9000 tons of acid in the estuarine environment. The consequences to fisheries activities were extremely grave. Artisanal fisheries activities were prohibited in the estuary, compromising part of the fishing season for croaker and shrimp. The accident revealed the lack of contingency plans in port activities and the absence of care of local authorities for the environment and the populations which depend on resources extraction. Seeliger and Costa [50] also cite as

important pollution sources in port activities the washing of vessel tanks which release into the estuary different types of toxic hydrocarbon forms. Yet another source of contaminants to the estuary is the landfill of the city of Rio Grande. The municipal district of Rio Grande produces 110,000 tons of garbage per year, which has been deposited on salt marshes at the margins of the estuary during the last 20 years. There are no prospects of waste treatment in the near future, which poses serious threats for the health of the local people and the environment.

The above examples show the complex reality of the estuary of Patos Lagoon, where artisanal fisheries are subjected to the cascading impacts of other human activities in the watershed and estuarine areas. To be effective the co-management regime established in the Patos Lagoon has to find ways to protect not only the fish stocks as it has been the issue of concern but also their habitats. There is little point in planning the enhancement of stocks if in the process the community cannot protect its environment and the habitats on which the stocks depend for spawning and nursery [11,3]. Existing fisheries management institutions pay little attention to this aspect when defining rules for the conservation of fisheries CPRs (Table 4). On the other hand efforts to the management and conservation of coastal habitats through their federal and state institutions have narrowly defined goals and indicators that disregard the impacts of coastal activities on the living resources, such as fisheries. This demonstrates a lack of an integrated coastal zone management plan which also intensifies the actual misuse of the natural resources and aggravates the disruption of the estuarine and coastal environment in the area [51,52].

6. The driving forces

Whether a renewable resource is managed sustainably depends largely on how property rights or use rights are assigned and the pattern of incentives they create for conservation or depletion. A key issue on governing the commons relates to the ability of developing institutional arrangements that enhance the likelihood that individual incentives lead participants toward sustainable use rather than imprudent uses [4]. The history in the Brazilian coastal zone management and the outcome of resource management in the locality of Patos Lagoon has proved that use rights and pattern of incentives has lead the resources to depletion. The weakening of access limitation to small-scale fishers and opening to industrial fisheries, the failure to implement rules which are compatible to the maintenance of the resources, legitimized and complied, and the strong incentives to overexploitation instead of conservation, all represent causes of the current situation.

What can we learn from the estuary of Patos Lagoon case study, concerning the misfits between the institutions and the management of fisheries CPRs and their implication for better management strategies for the future? Ostrom's [2] argument is that some individuals have broken out the trap inherent in the commons dilemma, whereas others continue remorsefully trapped into destroying their own resources. The same author states that differences exist between those who have broken the shackles of a commons dilemma and those who have not. According to her, the differences may have to do with factors internal to a given group and/or with factors outside the domain of those affected [2,4].

The story of the Patos Lagoon is similar to other stories of disruption of fragile CPR situations, which can be told for many other parts of the world. An attempt has been made to change the decision making process in the management of artisanal fisheries at the local level with the establishment of the forum of Patos Lagoon to co-manage the resources use and to break the shackles of the local tragedy. Despite this change there are still some important institutional misfits that have to be dealt with in order to break the trap of the commons dilemma.

What are the factors behind the misfits? Our study has identified inter-related internal and external factors that play a role in hindering local management of artisanal fisheries. They are organized as follow

6.1. The historical weak institutional arrangement to deal with a diversity of interests and types of activities in the area

Fishers' ability to organize for collective action has a number of prerequisites, essentially involving the question of local institutions. Not all groups of fishers have appropriate local institutions. Any co-management initiative will necessarily start with institution building, as it was the case in the estuary of the Patos Lagoon. But institution building is a long-term and costly process. Experience in other CPR management systems shows that community organization can take 3–5 years, in some cases even more, before a self-sufficient institution is in place [53]. Such experiences indicate that unless governments and decision makers who implement government policies can be convinced of the desire and the ability of users to manage themselves, not much progress can be made in co-management. It is often pointed out that government resource managers are reluctant to share authority [53]. To convince managers that local-level management is possible, however, part of the responsibility falls on the resource users themselves. The ability for self-management, in turn, partially depends on the ability of the local community to control the resource in question. In this context the local co-

management initiative (Forum of Patos Lagoon) is still young and face many challenges to its organization.

A key question for co-management is what management functions are best handled at the local or communal level, as opposed to the national government level only [11]. The establishment of partnership makes co-management a strong alternative to manage resources under complex conditions, multiple interests, and power imbalances situation. Because co-management is a middle course between government and community-based management, this characteristic makes co-management a stronger arrangement to deal with complex systems similar to the estuary of the Patos Lagoon. A total of 21 institutions involved in the management of natural resources are invited to participate (with a right to vote) in the Forum of Patos Lagoon. Each one has specific interests and responsibility over the fishery sector that could be turned into practical actions based on the issues raised by the Forum. Some changes towards this direction are observed (e.g., more management oriented research, based on questions raised in the Forum, is being carried by the university; government financing programs are becoming available for small scale fishers), but there is still a long way to go before management functions are shared more effectively. Institution representatives are still trapped into old ways of doing things, with a strong cultural organization that impedes different forms of management. Also, some of the 21 institutions invited to participate were either absent or rarely present in the meetings, including the Fishing Industries Union, Industrial Fishermen Unions, Public Ministry, Port Authority, and law-enforcement unit. These are institutions that, as it was showed in the paper, have an important role in determining the course of decisions and the success of any attempt to manage fisheries locally.

Attempts to local management will also face difficulties whenever artisanal fishers interests conflict with the interests of other activities such port and industries. The problem of the fishery is in this case beyond the scale of the fisheries management. There is no compatibility between the institutions dealing with fisheries and the institutions related to other activities in the estuary. These institutions are not nest organized in an integrated coastal zone management plan for the region. The effort made to recover the fishery and maintain artisanal activity may be challenged by this institutional scale.

6.2. The fact that most artisanal fishers are poor, powerless and marginalized from decisions, which gives them less opportunity to control the use of CPRs, and also impede the use of fishers knowledge in the design of management norms

A strong driving force that triggered overexploitation of local fisheries CPRs was the government's

intervention in fisheries management. Government intervention led to the widespread design of rules that were incongruent because they did not account for local resource conditions, as well as for local informal management rules. One example of such intervention, was the effect of government incentives to industrial fisheries which changed the structure of property rights to use CPRs and created *de facto* open access regime in the estuarine and coastal areas. These actions were taken in a top down manner, driven mainly by political or economical decisions without either ecological or social concerns.

The historical marginalization of artisanal fishers from decision arenas has facilitated the above scenario [37]. Pauly [54] relates the marginality of small-scale fishers to their geographic, socio-economic, and ultimately, political remoteness from decision makers in major population centers. According to the author, socioeconomic remoteness from the mainstream of society is related in part to the low income of small-scale fishers in most developing countries and to the fact that they often belong to social classes of low status. This is often compounded by illiteracy or limited formal education which often mask the traditional ecological knowledge possessed by small-scale fishers, which serves as a basis for traditional community-based fisheries management.

It is well known that the knowledge held by fishers in many areas of the world, especially in traditional societies in which such knowledge accumulates by cultural transmission, may be extremely detailed and relevant for resource management. Indeed, it is the complementarity between such local knowledge and scientific knowledge that makes co-management stronger than either community-based management or government management [53]. Despite this reality, there is still a weak involvement of the fishers in the management of the resources; fishers were not fully involved in the process of designing and modifying the new set of rules in place for the estuary proposed by the Forum of Patos Lagoon (Decree 171/98). Measures such as fishing effort limit, minimum mesh size, minimum landing size, closed season, among others, have been exhaustively discussed and agreed as a first step for community-based management. In spite of a consensus reached by the Forum representatives at the time of elaborating this Decree, few fishermen were consulted and gave inputs on the rules launched. The measures for fisheries management in place in the estuary seem not to fully meet fishers purposes, therefore they are not supported by a large number of Patos Lagoon fishers (Colônia de Pescadores Z3, Pelotas, RS; Colônia de Pescadores Z8, São Lourenço do Sul, RS). As put by Ostrom [2], if the individuals who directly interact with one another and with the physical world can modify the rules over time so as to better fit them to the specific

characteristics of their setting, a successful outcome has proved to happen and rules better tailored to local circumstances in many CPR management systems over the world. This has not been the case here yet. What is usually observed during the Forum meetings is that the fishing community is informed of the results and decisions made through meetings with the researcher and technicians [22]. The culture of working for the fishers instead of working with the fishers may be identified as a major observed problem that still has to be overcome.

These problems are exasperated by the politics which are still top-down and driven by certain interests. Those sectors that want to avoid rule enforcement have considerable opportunity and means to obtain the help of officials (local and central) in obstructing such enforcement thus undermining the efforts of new local institutions. Small-scale fishers do not have the same means and do not share the help of officials. The problem becomes then what is behind the governance process and to what group interests do the governance serve? What happened in the estuary of the Patos Lagoon represents an example of how actions taken by local management institutions can be eroded by political power through federal agencies.

6.3. *The regime structure of governance which centralizes final decisions to the Federal Government*

The history of fisheries management in the estuary has shown that many practices, which seemed to be consistent with conservation, were abandoned and/or transformed with the introduction of the centralization of management and the expansion of the industrialized sector during the 1960s and 1970s. This can also be observed in other areas along the Brazilian coastal zone [55]. The year 1967 established a mark in fisheries management in Brazil, when formal management was introduced and the rule making became exclusive to the Federal Government. In the estuary of the Patos Lagoon, this process of centralizing decisions created a change in the boundaries and rights to use the resource. As in other areas of Brazil, policies set up in this period to support development and exploitation of resources were made not free from conceding privileges to some particular interests groups (industrializing fishing sector) over others (small-scale fisheries) [37].

Incentives to decentralize fisheries management in recent years have created opportunities to co-management initiatives, such as the Forum of Patos Lagoon. A key issue for the success of such initiatives is the government willingness to share power when devising rules and enforcing them [53]. Provided the external governmental officials give at least minimal recognition to the legitimacy of such rules, the fishers themselves may be able to enforce the rules themselves. But if

external officials presume that only they have the authority to set the rules, then it will be very difficult for local appropriators to sustain a rule-governed CPR over the long run [2]. This design principle of co-management has not been fully met yet in the estuary of Patos Lagoon. The first concrete outcome of the Forum of Patos Lagoon was the Decree 171/98 which devised rules for managing estuarine resources. The legitimization of Decree 171/98 by IBAMA (central agency) may be seen as a positive sign of decentralization and commitment to co-management. Although power was delegated to the local level (Forum), the process of creating rules locally was not certainly consensus-based, as it can be seen from the number of identified incongruities between rules and local and scientific knowledge, and by the fishers requests for revision of the Decree. On the other hand, one of the most important rules in Decree 171/98 (the access limitation) was challenged by the Federal Government on the grounds of constitutional resource use rights to every Brazilian. This specific problem, which was later overcome by the Forum through political lobbying, shows the strong influence that central government still has on local decisions. Also at the federal level, the split of power between IBAMA and the Ministry of Agriculture has moved the process of licensing away from the local agency of IBAMA. As a consequence, access control and the monitoring of artisanal fisheries activities (both associated with licensing), which were before on the hands of the Forum of Patos Lagoon, became jeopardized. All of the above give the opposite sign that management power is not yet shared by resource users, and that decisions are still largely influenced by the Federal Government. On the other hand, facing problems of representation, legitimacy and recognition is creating a positive feedback through an institutional learning where participants of the Forum of Patos Lagoon are developing the means to achieve a better internal organization to cope with the external influences, and therefore to strengthen the co-management arrangement.

6.4. Stewardship for resources

Fishers stewardship for resources is an important yet difficult issue to analyze. At first sight one would say that there is a lack of conservation ethics among fishers given that they practice a predatory fishery, i.e. catch fish below the minimum size, use gears that are forbidden, do not follow fishing calendars. However it became evident in interviews and Forum meetings the many concerns they have with the sustainability of the resources, the inadequacy of fishing gears, the capture of young and spawning fish, the requests for more enforcement and more rigid rules for offshore fisheries, among other issues which indicate a sense of care for

resource conditions and for the future of their activity. This apparent contradiction makes us believe fishers may be trapped into a system that is predatory due to the many external and internal factors or driving forces raised before, particularly their socio-economic reality. It is interesting to note that given the crisis in resource management many actions are currently been taken to revert the situation, such as the proposed creation of a marine protected area, the adaptation of gears to minimize bycatch, and the development of an enforcement policy, demanded by fishers, and carried by an interinstitutional effort of IBAMA, the environmental police and the Navy to patrol illegal fishing in the 3-mile zone. The success of these initiatives, which are mediated by the Forum of Patos Lagoon, may serve as a strong incentive to change the pattern towards a more sustainable use of fisheries resources in southern Brazil.

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