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Characterization of an artisanal fishery in Argentina using the social-ecological systems framework

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Abstract: Institutional Analysis and Development (IAD) studies how institutions (the rules of the game of a society) determine the performance of a social-economic system. Elinor Ostrom extends the institutional analysis to the collective action for a particular case, the study of the social-ecological systems (SESs) (Ostrom 1990). Any group that attempts to manage a common resource (e.g. aquifers, pastures) for optimal sustainable production must solve a set of problems in order to create institutions to facilitate collective action. Some evidences show that following a set of design principles in creating institutions can lead to overcome these problems. The aim of the paper is to apply the SES framework to an artisanal fishery community in Argentina in order to: 1) describe the principal features, key variables and relations of the small-scale fishery system; 2) detect the principal drivers of a potential common-management and the leading detractors from the current communal performance; and 3) analyze the possibility that a self-governing for sustainable fishery may appear. Several drivers for potential common-management and some detractors from the current common performance are summarized. Artisanal fishery SES is currently at a bifurcation point. A common historical and cultural root, the presence of leaderships, the relevance of local knowledge, the dependence on the resource to sustainable livelihoods and the threat of big-scale fisheries area have generated incentives to collective-action. But, simultaneously, internal conflicts are the most important barrier for an integrated community-based management. The heterogeneity among actors and the relevant external conditions have resulted in two groups diverging in their self-organization. The work is framed by the project COMET-LA (COmmunity-based Management of Environmental challenges in Latin America; European Commission's Seventh Framework Programme of Research and Development), which aims to identify sustainable community-based governance for the management of natural resources that can be used in different social-ecological systems in a context of climate change and increasing competition in the use of resources.

Keywords: Coastal management, community-based management, institutional analysis, Ostrom's framework, social-ecological system

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1. Introduction

This work has been developed in the frame of the project COMET-LA (COmmunity-based Management of Environmental challenges in Latin America).[1] The aim of

[1] COMET-LA is a project funded by the European Commission's Seventh Framework Program of Research and Development (FP7).

COMET-LA was to identify sustainable community-based governance models for the management of natural resources that could be used in different social-ecological systems in a context of climate change and increasing competition in the use of resources. Argentina has an extensive coastline with major urban centers and ports, particularly, the Bahía Blanca Estuary and the Monte Hermoso – Pehuén Co coastal area (hereinafter referred to as respectively BBE and MH-PC) which are located on the southwestern coast of Buenos Aires Province (Figure 1). The region was adopted as a study case in the project, which also included the analysis of water and biodiversity systems in Colombia and forestry systems in Mexico.

Hence, the main objective for the Argentina case study in the project was to propose governance models and community-based sustainable management in marine and coastal systems. The definition of a successful governance model should be based on a complete understanding of the case. One of the tools implemented by the project to characterize the complexity of the Argentina system was the Social-Ecological System (SES) framework, developed by Elinor Ostrom.[2]

Different researches show that problems derived from self-interest, imperfect information, and incomplete markets can be overcome by following a set of design principles in creating institutions (Ostrom 1990). For instance, variables related to access and control are defined as the most relevant, playing a

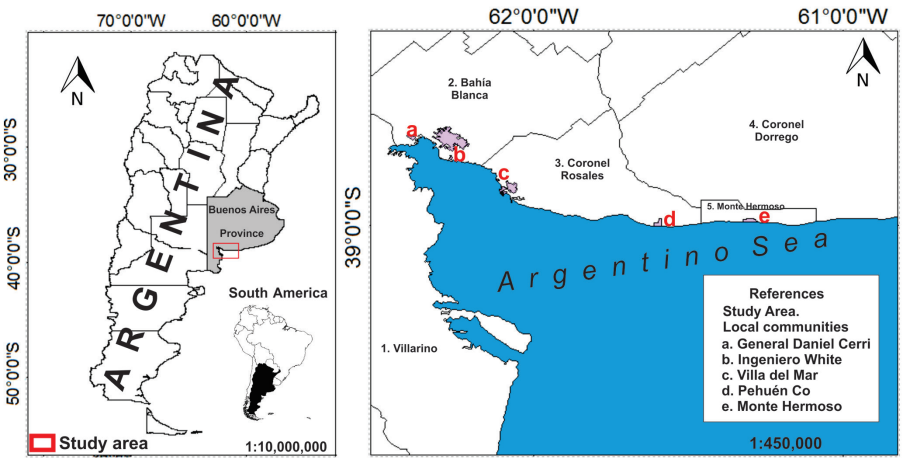

Figure 1: Location, political division and communities under study. Source: London et al. (2014)

[2] The project had been in place during three years between 2012 and 2014. The complete work involved the characterization of study cases, prospective analysis and scenarios building, concluding with the Policy Conference in México DF during November 2014. For further information, please visit the site of the project at http://www.comet-la.eu/.

central role in the management of natural resources in the case of the *Seri,* a Mexican small-scale fishing community (Basurto 2005). Also variables related to monitoring activities seem to be the key to explain local variability between communities in forest management conditions (Ostrom and Nagendra 2006). Ten key design principles related to how community-based organizations are nested within other organizations, the historical and social context, flexibility of rule-making, monitoring and enforcement are shown as the most relevant in the co-manage of coral reefs in Kenya and Madagascar (Cinner et al. 2009). In accordance with the SES framework, well-defined property rights also lead to a good management of natural resources system. The right to harvest some portion of the resource works as an important determinant of local effectiveness monitoring and sanctioning rules in forests areas of 14 different countries (Coleman and Steed 2009). Tourism is a case where non-extractive uses are dominant. Using the Ostrom framework, Blanco (2011) concludes that the presence of leadership, norms of behavior, shared mental models and substantial productivity of the resource system in the likelihood of self-organization are the most important variables to obtain a common and sustainable management. A clear understanding of rules by both, social actors and decision makers, allow establishing a successful management regimen of common-pool resources (CPR)[3] in five study cases in tropical context (Aswani et al. 2012). Finally, Basurto et al. (2013) develop a set of SES variables potentially relevant to study small-scale fisheries system and illustrate the frame throughout two cases concerning Mexican and Chilean benthic fisheries. They look for evidence about "*what combinations of SES variables were associated with fisheries' ability to self-organize and avoid overexploiting their fisheries, and which interactions led to continued over-harvesting*" (pp. 1367).

The objective of this paper is to apply the SES framework to an artisanal fishery community in Argentina in order to: 1) describe the principal features, key variables and relations of the small-scale fishery system; 2) detect the principal drivers of a potential common-management and the leading detractors from the current communal performance; and 3) analyze the possibility that a self-governing for sustainable fishery may appear.

Despite the fact that there is no common governance structure currently implemented in the area, evidence found in the application of the SES framework allow concluding that collective action could lead to a future community-based management. The identification of basic working parts and critical relations into the system is the first step to give impulse to policies in pursuing sustainable development.

Though it is beyond the scope of this paper, in future studies the variables detected through the applications of the SES framework could be employed

[3] Common-pool resources (CPRs) are humanly valuated resource systems with two main characteristics: rivalry between resources users and high costs of exclusion (Coleman and Steed 2009). Both features leads most of the time to degradation as a result of overuse (Dietz et al. 2002).

in the elaboration of data collection instruments, the fieldwork and the analysis of outcomes through scenario buildings. Following, Section 2 presents a brief description of the study area. Methodology is introduced in Section 3. A discussion of the results and conclusions are shown in Section 4 and 5, respectively.

2. Description of the study area

From the political and administrative standpoint, three different municipalities integrate the area: (i) Municipality of Bahía Blanca, including the localities of General Daniel Cerri and Ingeniero White (hereinafter referred to as Cerri and White, respectively), (ii) the Municipality of Coronel de Marina Leonardo Rosales which includes Pehuén Co and Villa del Mar, and (iii) the Municipality of Monte Hermoso with its eponymous city. However, the region is characterized by a wide range of geomorphologic, physical and socioeconomic conditions, which give the area a different conformation from and environmental and economic point of view. In this sense, two well-defined and distinguish areas can be considered: (i) the zone from Cerri to Villa del Mar is characterized by an estuarine ecological system with extensive mudflats. The economy of the whole region is based on industrial and port activities, beside artisanal fishery. (ii) The MH-PC zone is a coastal area of sandy beaches surrounded by fixed and mobile dunes with an economy based on "sun and beach" tourism plus artisanal fishery.

Various ecological issues related to the study zone have been pointed out along last years for our research team. Studies (initiated by Perillo 1997) regarding vulnerability to climate change showed that an increase, even minimum, in the mean sea level (MSL) can cause permanent flooding of all wetlands up the estuary. The work of Diez et al. (2007), Huamantinco Cisneros (2012) and Bustos (2012) clearly demonstrate that much of the coast has a high risk of erosion, although most can be assigned to areas where urban development has a direct impact on the ecosystem and the way of living of the stakeholders. Regarding to anthropic effects, Zilio et al. (2013) indicate a high socioeconomic cost of the dredging realized in the area and Rojas et al. (2014a) show how anthropic effects increase the erosion problem in the area of MH-PC.

Although the marine and coastal resources belong to the National Government and the management and control correspond mainly to the National and Provincial Government, the rest of the land is mostly private property. Unlike many cases of the literature of CPR (Nelson and Agrawal 2008; Cinner et al. 2009; Hoole and Berkes 2010; Avendaño et al. 2013; Escalante Semerena et al. 2013; Bollig and Menestry Schwieger 2014), in BBE and MH–PC resources are privately extracted and economic activities (both artisanal and industrial) are developed within the private sector. Society has very little community-based organization. Nevertheless, as shown below, the exercise of collective-action among actors from MH-PC and the existence of internal con-

flicts in the BBE zone could make a significant difference in outcomes between the two areas.

3. Methodology

3.1. Analytical frame

Over the last few decades, the Institutional Analysis and Development (IAD) framework has been used to cope with the complexity of policy analysis and to study how institutions determine the performance of a social-economic system and how outcomes differ from one type of institution arrangement to another within the same community. The IAD focuses on the analysis of an *action situation*, a conceptual unit that can be used to describe, predict and explain individual and collective behavior in a particular institutional frame (Ostrom 2011; McGinnis 2011). An action situation implies to isolate the immediate structure affecting a process of interactions between actors to explain regularities, to compare outcomes and, potentially, to reform them.

From the IAD analysis, the structure of an action situation is primarily defined by institutions. Institutions are the human constraints that structure political, economic and social interactions and reduce the inherent uncertainty in human contracts (North 1990). Rules refer to what actions are required, forbidden or permitted in a community (Epstein et al. 2013). These constraints can be devised as formal norms (constitutions, laws, property rights) or informal restraints (sanctions, taboos, customs, traditions, code of conduct), which usually contribute to the perpetuation of the *status quo*. Hence, changes in the institutional design lead to diverse results, being the informal norms the most difficult to change since they are embedded historically in a community.

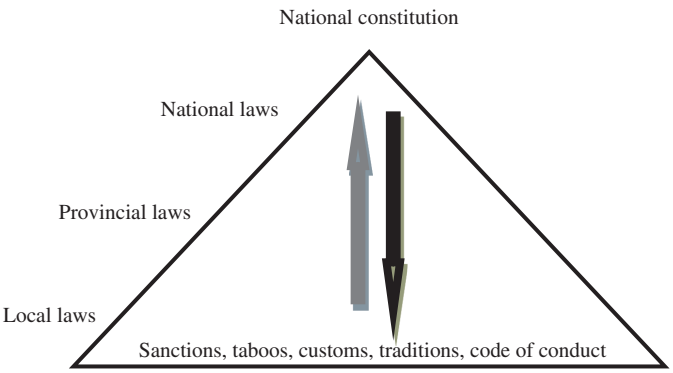

Figure 2: Hierarchical order of rules governing the Argentina case study. Source: Own elaboration.

The constraints can be represented in a pyramid graph, where rules are connected in a hierarchical way, represented by the black arrow in Figure 2.

A feedback between social (or informal rules) and formal rules is given through the human organizations (Figure 2, grey arrow). This field deals with how individuals and groups build institutions, how institutions function in practice and how they affect the social outcomes. Institutions vary slowly along time (crisis are exceptions) and the change depends basically on conflicts between actors and the capacity of different groups to face themselves (Ostrom 1990; Tohmé and London 1998).

Social control can be the most effective tool for the observation of norms. If the management of a system depends on a set of formal rules which are inconsistent with the SES features, the local vision and the base of the pyramid in Figure 2; consequently the implementation of the rules, enforcement and control will be almost impossible to address.

Elinor Ostrom extends the IAD analysis in a broader framework for *social-ecological systems* (SESs) (Ostrom 2007, 2009). The SES framework allows scientists to take a more detailed set of variables for studying ecological issues related to the system. Any group that attempts to implement a sustainable management of a CPR (e.g. aquifers, pastures) must solve a set of problems in order to create institutions to enhance collective action. A set of design principles in creating institutions can help to avoid the tragedy of the commons (Hardin 1968). The tragedy happens when the use of common resources results in the depletion of a shared natural asset. Individuals acting independently and rationally according to their self-interest can lead to overexploitation. This concept is contrary to the concept of sustainable development: development that meets human needs of the present without compromising the ability of future generations to meet their own (United Nations 1987).

The design principles are extensively discussed in Ostrom (1990, 1998). The author found that groups that are able to organize and govern their behavior successfully are marked by the following principles:[4]

- Group boundaries are clearly defined;
- Rules governing the use of collective goods are well matched to local needs and conditions;
- Most individuals affected by these rules can participate in modifying the rules;
- The rights of community members to devise their own rules are respected by external authorities;
- A system for monitoring the behavior of members exists and the community members themselves undertake this monitoring;

[4] Epstein et al. (2013) criticized the fact that "…the cumulative body of natural scientific knowledge is, however, formally absent from the SES framework, leaving the identification of biophysical causes of an outcome solely to case-based methods of reasoning" (Epstein et al. 2013, 437).

- A graduated system of sanctions is used;
- Community members have access to low-cost conflict resolution mechanisms;
- For CPR that are parts of larger systems: appropriation, provision, monitoring, enforcement, conflict resolution and governance activities are organized in multiple layers of nested enterprises.

Ostrom (2007, 2009) developed a specific methodology to analyze SESs and the possibility of a self-organization for sustainable development. "*We need to build a theoretical foundation for explaining why some resource users are able to self-organize and govern the use of a resource over time in a sustainable manner and why others fail or never make the effort*" (Basurto and Ostrom 2009, 38). Recently, Basurto et al. (2013), McGinnis and Ostrom (2014) and Hinkel et al. (2014), among other, have revised the SES framework, which still has an enormous potential of future extensions and developments.

We consider a working definition of SES as: "*…a bio-geo-physical unit and its associated social actors and institutions. Social-ecological systems are complex and adaptive and delimited by spatial or functional boundaries surrounding particular ecosystems and their problem context*" (Jahn et al. 2009, 2). Thus, the description of the topological structure and pattern of the relations between the system elements is necessary in order to define a SES.

Given the complexity of a nested system working at multiple scales, a theory is needed to guide the selection of key variables and relations. Hence, Ostrom's framework is a useful tool to identify a set of potentially relevant variables to describe a SES (Schlüter et al. 2014). It is based on multilevel variables that identify a series of core subsystems. The central idea in a SES characterization is that *actors* extract/maintain/consume *resources units* from a continuously-changing *resource system* constrained by a set of rules-in-use (formal and informal) and procedures encompassing within a *governance system*. These processes of extraction/maintenance/marketization/change of rules/ management/control are the *interactions* that take place in the center of the structure and produce different *outcomes*. All this happens in the context of (and is influenced by) a *social-political-economic settings* and the *related ecological system* (Ostrom 2009; McGinnis and Ostrom 2014).

The *resource system* comprises the environment where the main natural *resource unit* (e.g. fish, water, fodder) is produced and found. The *governance system* describes the nested set of organizations, institutions and rule configurations affecting and affected by the SES. The original SES framework describes *users* as a tier variable including direct users or consumers of the resource. But in recent revisions of the Ostrom's work (Hinkel et al. 2014; McGinnis and Ostrom 2014) that category was changed by *actors*. Researchers agree that *actors* is more inclusive than *users*, the latter being a subcategory of *actors*.

The patterns of behavior that actors exhibit can be characterized from the categories of *interactions* and *outcomes*. *Interactions* tier variable describes relevant

activities, exchanges and conflicts between actors, while o*utcomes* comprise results of the interactions among aforementioned variables.[5]

Moreover, the focal SES considered can be seen as a logical whole exogenously influences by the related ecological, social, economic and political context. The *social-economic-political setting* describes how the whole SES may affect and be affected by the larger socioeconomic, political and ecological settings in which they are embedded, while the *related ecological system* describes the connection of the considered SES with the surrounding ecosystems.

The attributes of resource system (RS), resource units (RU), actors (A), governance system (GS), interactions (I), outcomes (O), social-economic-political setting (S) and related ecosystems (ECO) describe the features of first-tier variables. These eight broad variables can be unpacked into a second-tier set of variables that have been found in empirical studies to impact diverse interactions and outcomes. The second-tier variables are not unique and the set eventually need to be adjusted for particular local conditions (Delgado-Serrano et al. 2013) and for the specific research question of interest (Ostrom 2011). Figure 3 shows a SES as a complex system which combines the eight core variables defined by McGinis and Ostrom (2014). We must describe the set of variables and its relationships, loops and feedbacks interactions and outcomes to understand the possibility that social self-organization emerges.

More than one resource system, relevant unit of resource or actors' groups can be identified in a region (McGinnis and Ostrom 2014). For this work and following Basurto et al. (2013), the delimitation of the space under study was made by the Resource System (RS): the small-scale fishery sector. The application of the frame looks for the potential drivers which could lead to a sustainable and common management of the artisanal fishery.

3.2. Putting the method into practice

The first step to improve the applicability of the framework to the study case of the project in Argentina is to define properly all the second tier variables. The framework proposed by Ostrom (2009) of 8 first-tier categories and 53 second-tier variables was adapted by Delgado-Serrano et al. (2013). They propose a more detailed description of the 53 variables, subdividing many of them in more sub-tier variables.[6] For the case of the BBE and MH-PC coastal area, this adapted frame was revised and variables were defined as it can be found in Annex 1. Some definitions were found in the literature and others defined according to paper goals and the particularities of the SES.

[5] *Interactions* and *outcomes* are implicitly describing the *action situation* of the IAD framework. SES framework suggests that the action situation needs to be explicit in a more inclusive setting, taking into account a dynamic structure where feedbacks with contextual variables are constant.

[6] This more complete framework has been provided by the UCO research team within the Comet-LA Project, after different discussions with partners of Argentina, Colombia and México. For more detail of variables, see the cited Deliverable at http://www.comet-la.eu//.

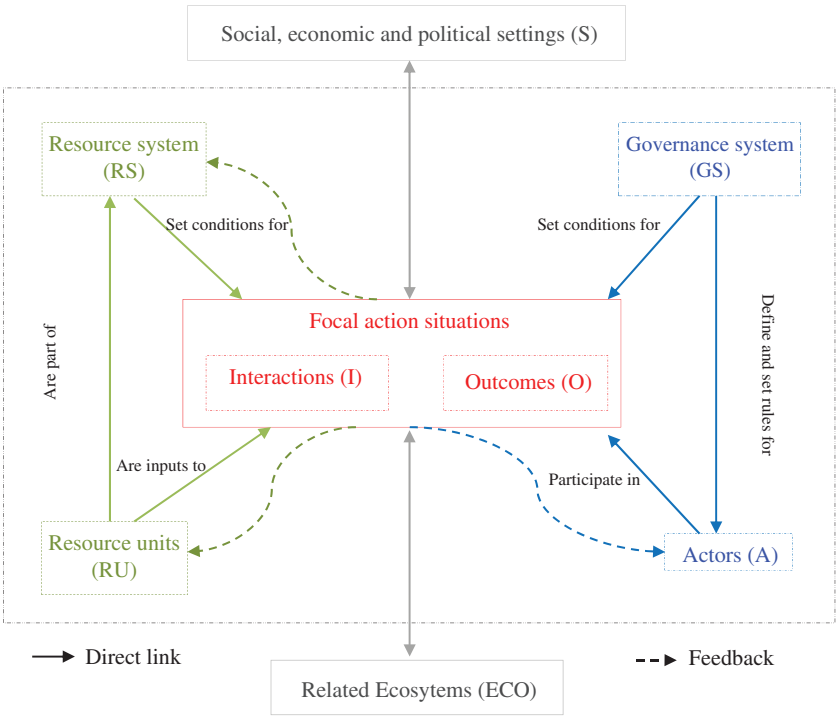

Figure 3: Revised core subsystems for the analysis of SES. Source: McGinis and Ostrom (2014).

The multidisciplinary research team in Argentina used many information sources to complete the Ostrom's framework. The socio-economic data was collected from National Census 2010, the Encuesta Permanente de Hogares (EPH – INDEC), Centro Regional de Estudios Económicos de Bahía Blanca (CREEBBA) and other similar from the Instituto Nacional de Estadísticas y Censos de Argentina (INDEC). Previous work carried out by the Instituto Argentino de Oceanografía (IADO) provided geospatial and biophysical data. The description of institutional and governance system was realized taking into account the institutional information available at government sites and formal laws.

Moreover, the realization of unstructured interviews of relevant stakeholders in each group and several workshops with actors was a relevant input to complete the characterization. The selection or mapping of actors is an essential stage in any participatory process aiming to involve key stakeholders. The identification and the active involvement of all important stakeholders in the project make its outcomes and impacts more relevant, not only for the project development but also for the SES evolution. Stakeholder mapping should be understood as a continuous process of identifying individuals or groups that have an impact on or are impacted by the studied SES. The information obtained during this process is also

used to assess how the stakeholders should be addressed, how their importance should be evaluated and how they influence or are influenced by the SES.

The process starts with a thorough identification of all groups, organizations and persons by direct observation. Then, the initial contacts with the actors give us additional information with respect to other relevant stakeholders.

They were analyzed for a better understanding of their features and their relationships to the SES. Also, they were prioritized following the criteria defined by the project, focusing on actors related to fishing and coastal management process. Two selection criteria were used during the mapping: pertinence and representativeness. Pertinence was assessed by the users' relationships with resources, their knowledge about the SES and their capacity to affect the SES. Representativeness was defined according to the level of how well or how accurately someone reflects upon the sample. Note that the most representative user from a group seems to be who has the best knowledge of the SES. For instance, leaders of fishermen associations were considered as the most representatives actors of the group. Relevant groups were first identified, and secondly leader or those who had greater knowledge of the SES were invited.

According to their role in the system, the actors have different perspectives and knowledge of the SES. Social actors were chosen in order to have representatives from different localities and associated with different activities of use and management of resources.

Internal and external stakeholders (i.e. decision makers) were evaluated under the same criteria. Internal are those who make a direct use of the resources; while external actors are those who have some power to influence them but do not use them directly. In this case of study, external actors mostly represent government agencies and decision makers. Some of the most important groups identified were: fishermen, neighbourhood groups, rangers, teachers, fire fighters (as internal to the SES); and municipalities, government agencies and Petrochemical Industrial Pole representatives (as external).

During the first year of the fieldwork, about 4 workshops were carried out allowing conclude the process of mapping social actors and start with the characterization of SES. In the second year, another 4 workshops were conducted, with the main objective of concluding the characterization of SES and identify the most relevant variables in terms of the perceptions and interpretations of stakeholders. These meetings were conducted on the basis of participatory research methodologies, still relevant identification main objective of each workshop. The tools used in the workshops were: work with focus groups, visual techniques, construction of matrices conflict, brainstorming and a final discussion to triangulate information.

Finally, information collected from primary and secondary data sources were analyzed by Argentina team at the project. Considering the interest issues of different researches (economists, oceanographers, biologists, geologists, among others), we worked on sub-groups in order to complete the Ostrom's matrix distributing the information by topic. When the characterization of some variable

was incomplete, the sub-group tried to complete the information using secondary sources. The partial and final outcomes were discussed along several meetings realized once a week of the whole research team. The final result of the Ostrom's Framework with all the relevant information is in the Annex 2, which resumes the description of the sub-tiers variables and the corresponding information sources. Following, the discussion of the main findings about the matrix are exposed.[7]

4. Discussion of the results

The Ostrom matrix analysis makes sense when all tier variables are considered as a whole. Each tier variable can affect the others via a double causality, and the isolate discussion about one variable can lead to incomplete or wrong statements. Outcomes depend on the Setting, result from some Interactions, condition the Resource System, and others. As long as the research team completes the matrix with the definition of sub-tier variables, the "photo" obtained of the SES was the origin of several discussion meetings about relationships and causalities.

In this part, the discussion of results was divided into: *Setting and characterization of Actors; Governance Systems and their influence on the SES; Resource System, Resource Units and their regulation related to fishery; Conflicts related to management of resources and artisanal fishery and Actors' Responses to the conflicts.*

Along the exposition, the variables used in the analysis conducting certain statements are noted between brackets and also in Annex 2.

Figure 4 summarizes the most relevant second-tier variables in the explanation of the SES behavior. They are not the only variables considered in the discussion, but are those which greatly conditioned the results.

4.1. Setting and characterization of actors

Five settlements are extended along the Atlantic coast over a stretch of 100 km (RS3/RS9). Cerri is situated at the inner reach of the BBE area (Figure 1). From west to east, we can find Ingeniero White (15 km from Cerri); Villa del Mar (18 km further); Pehuén Co (50 km from Villa del Mar) and Monte Hermoso (20 km from Pehuén Co). As was mentioned in Part 2, these villages belong to three different geo-political orders (S2g).

Despite political divisions, the area can be divided in two areas by the geographical proximity, similar historical origins (S2g/A3) and ecosystem features. While Cerri, Ingeniero White and Villa del Mar have received the direct influence of Bahía Blanca (an industrial medium-size city, with around 300,000 inhabitants), Pehuén Co and Monte Hermoso were born as quiet and rural touristic villas

[7] It is important to note once again that this paper reflexes only one step on the Comet-LA Project development. More details about the participative methodologies, actors mapping, workshops and information sources can be seen at www.comet-la.eu.

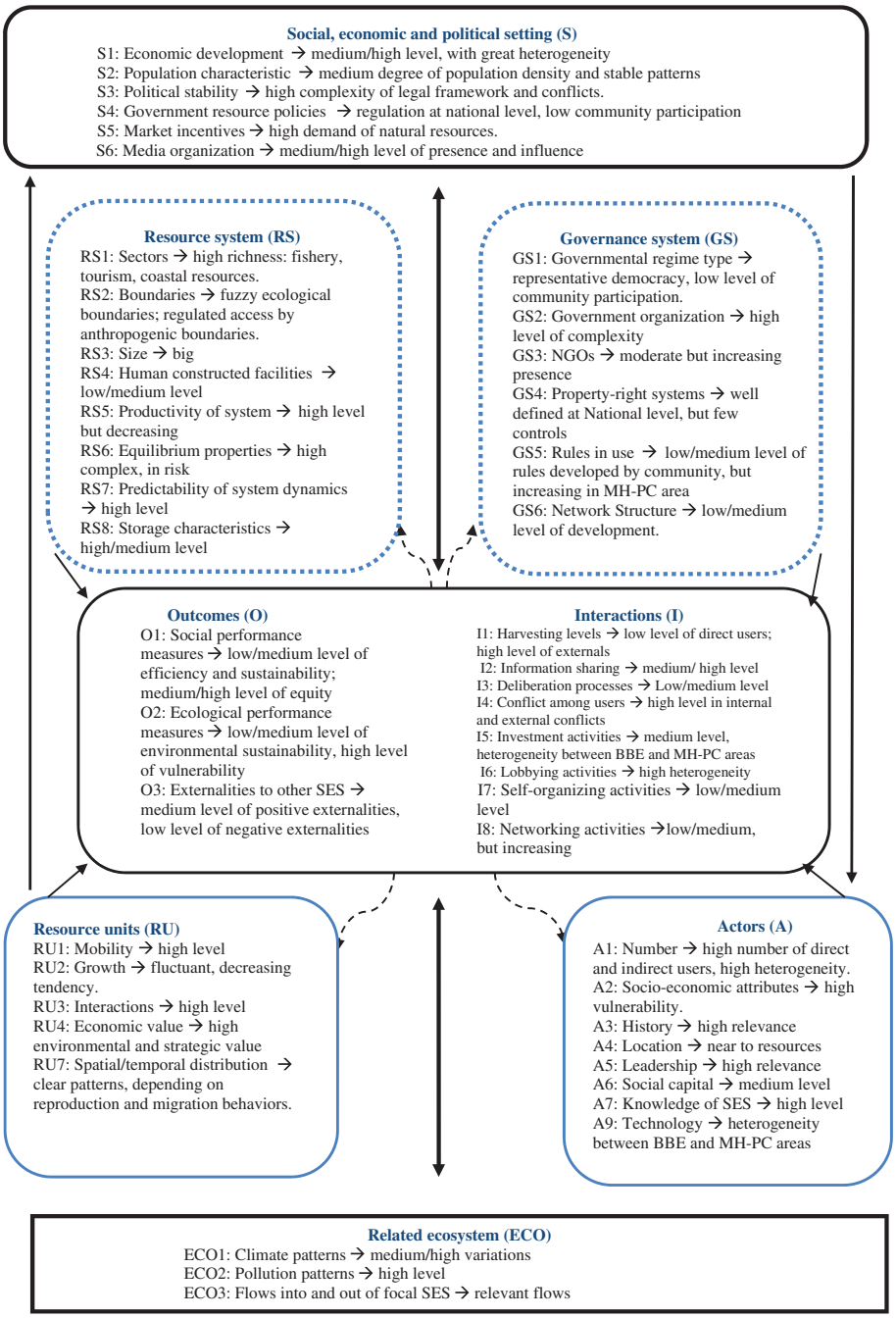

Figure 4: Ostrom's framework for the Argentina coastal SES: most relevant second-tier variables. Source: Own elaboration.

in the 1940s and 1950s. Moreover, Cerri, White and Villa del Mar are under the influence of the estuarine environment; whereas Pehuén Co and Monte Hermoso are situated outside the area of the estuary, which determines differences in biological and physical conditions between both areas (RS1). Nevertheless, the estuarine waters play a major role in establishing the natural conditions that help to attract tourists to their coasts (Perillo and Piccolo 1991).

Bahía Blanca was founded in 1828. In the same year, Ingeniero White was born as the city port. Some years later, in 1876, the fort of Cerri was established to protect Bahía Blanca and Ingeniero White against the last Patagonian natives. White and Cerri grew and became relevant during the first half of the 20th century due to the European immigrant flows (S2g). Nowadays, they have almost 10,000 inhabitants each (S2a).

Related to economic activities, wool and meat processing plants were the first developed industries in White and Cerri. Lately, gas and petrochemical industries were consolidated as the main activities (S1a). The Petrochemical Industrial Pole represents more than a half of the industrial production of Buenos Aires Province. Petrochemical and rural products are traded through the deep-water harbor of Ingeniero White. Income sources are diverse in Cerri and White, being artisanal fishery the main activity of local actors in the primary sector (S1a/A21c). According to official data, fisheries were generating 150 jobs in 2012, with a register of 30 *yellow boats* (Figure 5) (A1b). Nevertheless, fishermen establish that almost 1000 of people depend (directly or indirectly) on fishing in Cerri, White and Villa del Mar.

Villa del Mar is a small seaside town with almost 350 inhabitants and a decreasing population trend. It is located 5 km from Punta Alta, capital of Coronel Rosales Municipality.

Pehuén Co was born as a touristic villa of Punta Alta during the 1940s. The land in the MH-PC area was given up to landowners around the middle 20th cen-

Figure 5: Yellow boats in White (left picture) and Villa del Mar (right picture). These boats are characteristic of artisanal fisheries in Argentina. Source: Own elaboration.

Table 1: Summary of the main features of the study area.

	Bahía Blanca Estuary (BBE)	Monte Hermoso-Pehuén Co (MH-PC)
Habitants	300,000	8700 up to 100,000 in peak seasons
Environment	Estuarine Ecological System Mudflats	Coastal area Sandy beaches Fixed/mobile dunes
Estuary	Inside	Outside
Port	Yes	No
Economic activities	– Wool and meat processing – Gas and petrochemical industries – Cerri and White: Artisanal fishery	– Tourism – Artisanal fishery
Number of direct users	1000 families	45 families
Society	Internal conflicts	Collective actions

Source: Own elaboration.

tury (S2g). Pehuén Co has tripled its population in the last 20 years because of the migration from urban sectors (S2e/S2f). It has approximately 700 inhabitants (S2a) but it can reach up to 15,000 during the summer period. With a stable population of 8000 inhabitants, Monte Hermoso receives tourists from Bahía Blanca and others urban sectors during the summer. Population grows up until 100,000 in high seasons (December–March) (S2a/S2e/S2f). The economic activities in MH-PC are based on artisanal fishery and tourism (S1a). Four families out of five hundred live exclusively on fishery in both areas (A1b).

The entire region shows moderate levels of some development indicators, such as per capita income (S1b) and access to public services (S1d). Nevertheless, a structural feature of the socio-economic profile of communities is the heterogeneity in opportunities (S1c/S1d/S1g) and the consequent inequality of income (S1e).

During the last 200 years, power groups and governments have looked inland, giving few strategic and economic values to coastal and marine resources. Land appropriation in the south of Argentina was marked by the extermination of prehispanic cultures and the implementation of a private property regimen defined by rural production. The coastal management was a secondary issue in the agenda of successive governments until the 1970s and 1980s.[8] The exception was the implementation of port development policies in order to facilitate exports of cereals, grains, meat and agro-industrial goods (S1a/S5a).

The *big-push* of population growth was the consequence of external interwar migration flows and the subsequent internal migration (S2f), although in the last 20–30 years Argentina has received major immigration from bordering countries like Bolivia and Paraguay, as well as from other Latin American countries (i.e. Peru, Colombia). The outcome of such historical process has been a relevant level of heterogeneity among internal and external actors (A1b/A1c) and the absence of a unique cultural root which has reduced the capacity to create shared codes and

[8] The first law regulating fishery at national level was the Fishery Law of 1967.

common rules between all the users (A2f). Given the differences in sectors and interests, the notion about the *common* has remained unclear and weak.

4.2. Governance system and its influence on the SES

Governance is exercised through a representative democracy with low civic participation and few elements of community-based government (GS1). Moreover, political stability is marked by extended periods without democratic practices and several military coups (S3e). Looking to avoid any subversive movement, military governments used repressive violence against associative forms. A large number of states of siege were declared, the last even during a democratic government in December 2001. In that context, network structures have been broken (GS6/I8a/I8b) and the capacity to join spontaneously in groups and self-organize (I7) has been lost in the middle of a long period of prohibition and political repression.

Formal norms have not been determined by using social norms (GS5), and traditional knowledge and mental models from direct users (A7), as in many illustrative cases in the literature of commons (Basurto 2005; Basurto and Ostrom 2009; Cinner et al. 2009, Basurto et al. 2013, among others). Institutions that can help in embedding collective-choice into the formal constitution of rules have not been developed (GS5c). There is no decision-making mechanism at communal level, such as permanent assemblies or regular consultation tools, whose mandate is able to translate internal norms in formal rules. Contrary to a community-based idea, the regulation about the access and use of resources emanates from a very complex structure of multi-level government (S3a/S4b). Several laws and sanctioning rules are created at high levels of government and distant from local problems (S4a/S4b). Often, formal rules are even inconsistent with the community rules-in-use (GS5a).

4.3. Resource system, resource units and their regulation related on the fishery

Resource system includes the estuary and the coastal area up to 3 nautical miles (nm) from the mouth of the estuary to Monte Hermoso (RS1) within the study area. The offshore marine area near the BBE and MH-PC coasts is known as *El Rincón* (Figure 6). Only a small portion of El Rincón belongs to the focal SES (see the artisanal fishing area marked in the map). However, the whole zone is extremely relevant for the SES given the existence of biological, physical, social and economic interactions. Several species migrate from Brazil to the Antarctic through El Rincón. Spawning occurs in this area from middle-spring to middle-autumn (RU7a). Larvae use the estuary as a nursery zone and migrate again across El Rincón and the Atlantic as juveniles or adults (RU7b). These ecological features determine its high environmental (RU4b) and strategic value (RU4c).

Beaches and coastal areas are public property and access to the resource system is regulated by government authorities (GS4a/RS2c). Formal rules and norms relative to the access, monitoring and sanctioning are established by a

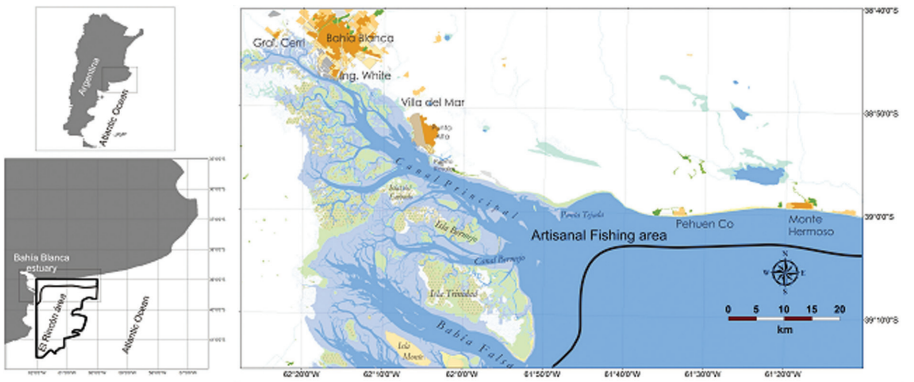

Figure 6: Left panel: BBE, MH-PC and El Rincón areas localization. Source: own elaboration. Right panel: BBE and MH-PC areas. Source: Melo (2009).

top-down process, with very scarce communal participation. Differences in geographical and political features establish differences in access conditions. Becasue of its central touristic areas and reserve zone, access to the coast is free in MH-PC throughout the beach (RS2c). On the other hand, the port area near BBE has been licensed. The Consortium of Management of Bahía Blanca Port (CGPBB, for its acronym in Spanish) controls the access to the resources system, restricting the capacity of artisanal fisheries to determine their own operational access to the sea (GS3a).

Government establishes who can fish, where and how much resource can be extracted through the awarding of licences (GS4a/GS4b). Law also specifies the techniques that must be used and the space exclusively reserved for artisanal fishery (S4a). Trawling is forbidden within the 3 nm limit from the baseline and government establishes a close season for the rest of the area of El Rincón from October to March (RS5c). Likewise, artisanal boats cannot exceed the BBE and the 3 nm due to their operational limitations.

4.4. Conflicts related to management of resources and artisanal fishery

Because of regulations, bottom trawl boats frequently invade the inner area looking to increase their catch (I4b). The scarcity of economic resources available to governmental organisms (GS5d), the size of the resource system (RS3), the fuzzy natural boundaries (RS2a), the non-coincidence between natural and anthropogenic boundaries (RS2b), the forms of access to the resource system (RS2c) and the high mobility of the resource units (RU1) make monitoring and sanctioning activities more costly and self-organization more difficult to achieve (Ostrom 2009). Artisanal fishermen are the ones who inform the authority (GS2) about the presence of non-authorized vessels in the exclusive area or about excessive

catches (GS5d). But, obviously, they do not have policy power to ensure rule enforcement and excludability (GS4b).

But, frequently, artisanal fishermen are the ones who break the norms, reaching off-shore areas with a greater abundance of resources. In that sense, users have developed a set of operational and harvesting rules, regardless of what the formal institutional framework says (GS5a). Work with other peers and the mutual protection is an essential tool in facing the risk of the activity in offshore marine areas.

The traditional forms of artisanal fisheries compete against big fisheries, whose environmentally harmful techniques permit to harvest resources at a more profitable scale. The composition of berths by type of fleet shows a very unequal carrying capacity in favor of big-scale vessels (I1a). The excessive charge of the resource affects directly the regeneration rates (RU2/RU5). Overfishing and the consequent reduction in fishery is the principal outcome of trawling (O2b).[9] Big-scale fisheries also have lower costs in the appropriation and production. Then, they can offer lower prices (in accordance with international markets) in internal markets (S5a), reducing the competitiveness of small fisheries.

The SES shows a high vulnerability level (O2k). Besides trawling, the resource system is subject to other important pressures that are altering the equilibrium properties (RS6c) and intensifying competition over the use of resources. Urban pollution (O2i/ECO2b), industrial activity (ECO2a) and port dredging (I4b) have impacted on the estuary and coasts affecting the ecological and biological features of the SES (O2a/O2c). Climate patterns have also changed. Temperature has increased (ECO1c), while seasonal (ECO1e) and rain patterns (ECO1d) have altered their behaviors.

Over-harvest, pollution patterns (ECO2a/ECO2b), climate change and dredging consequences have caused several environmental modifications (ECO1b/ ECO1c/ ECO1e) and the drop in resource units (RU5). Moreover, the high level of interactions among resources (RU3) can generate a *cascade effect* (Lopez Cazorla et al. 2014) with alterations in the composition of species, migrations trends, shifts in the reproductive behavior and species extinction (O2e). Then, artisanal fishermen are showing a high level of socio-economic vulnerability (A2e) due to the high level of dependency on resources for their livelihood (A2a/A8a).

4.5. Actors' responses to conflicts

Against the resource depletion and the increasing risk for artisanal fishery, some *unifying forces* (Skogen and Krange 2003) have regained strength among a partial group. But, simultaneously, strong internal conflicts have appeared (I4a). The consequences of such counterbalancing forces could lead to a common-based organization or to a complete collapse of artisanal activity at local level.

[9] During 2012, 14 factory vessels were registered in the Bahía Blanca port. Only one of them was considered as local production (CREEBBA 2014).

Small-scale fishery in the entire region is linked to Italian and Spanish migrants, whose forefathers handed down sustainable fishing methods from father to son (A3). Fisheries rely on family structures, traditional knowledge and the maintenance of traditions (A2f). Users have similar processes of exploitation and differences in technology have been induced by government interventions (A9b). Fishermen work from shore or from small boats in coastal areas, using traditional techniques as hand lines, trammel nets, gill nets or shrimp nets (GS5a). Women work at home, manage fish trade and make fishing nets with extreme expertise (A2c). All these features give certain *social cohesion* to the fishermen group in the middle of the great social heterogeneity described above.

Despite fishermen not having high levels of formal specialization (S1f), they exhibit a great empirical knowledge about biology and ecology (A7a/A7d) and the over-harvesting effects (A7b). The complete notion about how the system works allows actors to make good predictions about the SES behavior (RS7). The high level of attitudes toward conservation (A5b) and the level of acceptance and decision power of leaders (A5a) help to maintain the internal control and make more feasible information dissemination (I2a). Leaders have a key role at deliberation processes in conflicts among actors (I3a) or in connecting local actors with government (GS3b).

Fishermen from MH-PC area are discovering the benefits of collective-action to counteract the effects of pressures over SES. The need to work together with other fishermen in order to increase productivity of the activity, to minimize risk, to impose sustainable practices among them and to control the outsiders has improved the mutual understanding, truth, trustworthiness and, thus, cooperation (I8c). Development of such social capital has allowed the configuration of a set of *internal* norms that rule the activity among direct users.

The MH-PC fishermen have given shape to a strong group that is able to maintain interaction with governmental institutions and is successful in breaking the status quo of the top-down process in the elaboration of norms. For instance, the demand for longer closure periods was recognized for the government few years ago. Recently, artisanal fisheries from MH-PC stop a governmental authorization for big-scale vessels to enter to the estuarine zone.

Environmental and social organizations, including artisanal fishermen chambers, have emerged. NGOs have now a medium presence in the region (GS3a) enhancing collective action (GS5b). The relevance of internal community interactions (I8a) and the presence and impact of the local media (S6a) have been essential in order to generate networks and contacts.

Nevertheless, the reaction in the area of BBE has been considerably different. The distinct access conditions (RS2c) have restricted the use of the resources by direct users in White, Cerri and Villa del Mar more than in MH-PC area. The estuary is a highly sensitive system with low resilience levels (O2j). Dredging, pollution and over-harvesting have had more severe consequences on BBE resources. In addition, the power groups related to port activities and industry possess a

higher level of lobbying capacity than artisanal fishery (I6), increasing the level of conflicts with externals in this area (I4b).

The compelling situation has lead actors in White, Villa del Mar and Cerri to make negotiations with different power groups and governmental institutions to restructure the artisanal fleet by turning into trawling vessels. Even, some fishermen in BBE have received an early retirement premium from the government to leave the activity.

While 3 million pesos (about 300,000 dollars) were given by the national government in order to turn artisanal boats into industrial vessels in the BBE area, the largest public investment done in MH-PC area (about 1.5 million dollars) was destined to the installation of a fish processing plant. The processing plant project has been financed by a national subsidy given to the Artisanal Fishery Chamber of Monte Hermoso – Pehuén Co (I5a). The type of investment shows a clear difference with respect to the policies implemented in both areas. While the first "Ecological Artisanal Fishing Terminal of Monte Hermoso and Pehuén Co" has been built, fishermen from BBE could begin to implement non-sustainable techniques, with the complete disagreement of their neighbors (I4a).

5. Conclusions

The Ostrom's framework was used in order to characterize a small-scale fishery SES in Argentina. Several drivers for potential common-management and some detractors from the current common performance were summarized. Despite small-scale fisheries in the region have been considered as a single group of actors given its common history and interactions over the years, we should recognize that artisanal fishery system is at a bifurcation point. The working definition mentioned in Section 3 characterizes a SES as a *bio-geo-physical unit… delimited by spatial or functional boundaries.* Today, small-scale fisheries in BBE and MH-PC coastal area might be breaking as an entity and facing a reconfiguration of its functional boundaries.

The heterogeneous preferences among users (Cinti et al. 2010) and the divergent characteristics of the SES gave rise to different responses to the problem of resource management: the increasing collective-choice and collective-actions towards sustainable management in MH-PC *vs.* the instauration of non-sustainable practices in BBE. This internal conflict creates the incapacity to build strong trust and reciprocity among all users in the SES, being an important barrier for an integrated community-based management.

Communities can arrive at local self-organization through distinct combination of conditions, or results can vary in different periods of time for the same community (Basurto et al. 2013). The study shows that the focal SES in BBE and MH-PC area may become a comprehensive system with community-based management, in two different focal SESs with dissimilar outcomes, or it can even result in the complete depletion of artisanal fishery. The heterogeneity among actors and external conditions has induced a divergence in the self-organization

ability between two groups. Once internal conflicts are deeply rooted, complex causations may generate interactions and outcomes resulting in two dissimilar governance systems.

By adapting the general Ostrom's framework (Annex 1), new tiers variables were necessary to represent the heterogeneity of actors and their interactions, the relevance of a complex social-politic-economical settings and the multiplicity of anthropogenic effects on the resource system.

We clearly identified direct user (fishermen) together with other actors directly involved in the SES, living in the same place, taking decisions about the use of the resource units, competing for the access to the resource system (i.e. tourism, industry, commerce) and interacting. For instance, an important related SES in the area is the tourism. Although fishery and tourism can be treated as two focal interrelated SESs, tourism supposes the intensive use of coastal resources and actors involved in tourism compete against fishermen for the use of the beach and access to the coast. Tourism has negative environmental impacts on fishery (i.e. waste, traffic, noise pollution), although it improves fishing activity by increasing the seasonal demand for fish and for sport activities. The development of new governance system should consider not only the heterogeneity of fishermen, but the whole group of stakeholders since fishery SESs is not isolated. In the same way, the behavior of El Rincón (which can be considered as another related SES) should be taken into account when designing management plans for sustainable use of resources since both, the estuarine environment and the surrounding sea region, have close interaction.

Considering direct users, a common historical and cultural root, the presence of leaderships, the relevance of the local knowledge, the dependence on the resource to sustainable livelihoods and the threat of big-scale fisheries invading exclusive fishing area generated reciprocity and moderate levels of trust among fishermen. But, some external and internal processes eroded the social capital when collective actions seemed to be growing faster, leading to a divergent path. BBE fishermen have ignored internal norms and processes of community decision-making, confronting the MH-PC fishermen.

History is a crucial factor to understand the scarce participation of stakeholders in politics and governance. The description of the setting and the governance system shows how a bad performance of the institutional frame (i.e. the sequence and importance of military coups and the absence of democratic processes) has undermined the development of a community-based management.

However, some collective actions and internal rules arose as a more or less automatic response to the inefficient governmental control. In accordance with the extended literature cited above, variables related to the governance system as monitoring, enforcement and sanctioning processes are shown as too relevant for determining the management of natural resources. In our case, informal monitoring rules and sharing information have helped artisanal fisheries to survive. Recently, institutional learning allowed actors from MH-PC to make operative some decision-making processes.

In accordance with the eight principles of Ostrom (2009), rules governing the use of resources are not well matched to local needs and conditions since most individuals affected by these rules cannot participate in their modification. The rights of community members to devise their own rules are hardly respected by external authorities since governance system is based on a top-down process. Sanctioning processes also fail. Nevertheless, a system for monitoring the behavior of members is being shaped and a fraction of the community members themselves are undertaking this monitoring. Social capital is deepening in that group of the SES. Boundaries seem to be redefining. If actors in BBE and MH–PC coastal area are able to develop conflict resolution mechanisms at low costs, they can come together in a more powerful group to negotiate and formalize their rules, moving closer towards the goal of a community-based management.

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Annex 1: First, second and third variables of the SES – Working definition.

First tier	Second tier		Third tier	
Social, economic and political setting (S)	S1	**Economic development** – Sustained, concerted actions of communities and policymakers improving the standard of living and economic health of a specific area / the quantitative and qualitative changes in an existing economy	S1a	Economic sectors in the study area
			S1b	Per capita income
			S1c	Employment per sector
			S1d	Access to public service (health, education, electricity, drinking water, etc.)
			S1e	Income dispersion
			S1f	Time allocation among the different economic activities
			S1g	Specialization of stakeholders (in one of different economic activities)
	S2	**Population characteristics** – Development, changes and status of the human population	S2a	Number of inhabitants
			S2b	Population density
			S2c	Gender ratio
			S2d	Demographic structure
			S2e	Population tendency (growth or declining)
			S2f	Migration trends
			S2g	Settlement patterns
	S3	**Political stability** – Eventual existence of a core regulatory framework for the country or area / eventual existence of defined laws / the regularity of the democratic processes	S3a	Core legal framework (national constitution and core laws)
			S3b	Level of norm compliance (norm stability, capacity of reinforcement, knowledge of norms)
			S3c	Type of conflicts
			S3d	Security and risk
			S3e	Respect for democratic values (e.g. human rights, corruption)
	S4	**Government resource policies** – Type of resource policies adopted by the national, regional and local governments (top-down approach)	S4a	Governmental regulatory framework (for natural resources management and use)
			S4b	Environmental policies (at national, regional and local levels/ implementation level)
			S4c	Environmental regulatory and policy frameworks compliance
	S5	**Market incentives** – Market functioning for natural resource management and conservation	S5a	Influence of global/local markets in the area (e.g. levels of dependency of external markets, price definition)

Annex 1 (continued)

First tier	Second tier		Third tier	
			S5b	Type of products (e.g. commodities, certified products, other kind of labelling)
			S5c	Access to markets (distance, commercialization channels and networks, marketing)
			S5d	Demand for natural resources (from local, regional, national and international markets)
			S5e	Market incentives for natural resource conservation (e.g. existence of taxes, fees and charges, tradable permits, eco-labelling, financial mechanisms, liability and compensation schemes)
	S6	**Media organization** – Number, diversity, freedom... of private and public media	S6a	Communication networks (e.g. existence, presence)
			S6b	Media deterrence capability
			S6c	Interest of media in socio-environmental issues
Resource systems (RS)	RS1	**Sector(s)** – Different biological production systems		
	RS2	**Clarity of system boundaries** – Clarity of the system's geographical, social and legal boundaries, describing if the boundaries of the studied resource system are clear, fuzzy or undefined	RS2a	Natural and ecological boundaries
			RS2b	Anthropogenic boundaries (e.g. concessions, conservation areas)
			RS2c	Access to the resource system through boundaries
	RS3	**Size of resource system** – Spatial extent of each component of the resource system (private, club, open access or common pool resources)		
	RS4	**Human constructed facilities** – Anthropogenic structures facilitating resource management	RS4a	Human constructed facilities in access
			RS4b	Human constructed facilities in transformation and storage
	RS5	**Productivity of system** – General estimation of the resource system productivity	RS5a	Productivity of the resource system (high, medium, low, exhausted)
			RS5b	Resource regeneration period
			RS5c	Resource extraction period

Annex 1 (continued)

First tier	Second tier		Third tier	
	RS6	**Equilibrium properties** – Influences (positive and negative) on the equilibrium of the resource system (interaction between species, in social systems, or between biological and anthropological systems)	RS6a RS6b RS6c	Equilibrium properties Natural hazards occurrence (frequency and magnitude) History of equilibrium properties (evidence of impacts in sub-systems and its effects)
	RS7	**Predictability of system dynamics** – Capacity to estimate the evolution and dynamics of the resource system and the impact of interventions or external influences on them		
	RS8	**Storage characteristics** – Storage (memory) of the effects of disturbances on a system or sub-systems	RS8a RS8b	Storage of the effects of anthropogenic pressures Storage of the effects of natural disturbances
	RS9	**Location** – Geographical location; special and temporal distribution patterns of resources units.		
Governance systems (GS)	GS1	**Governmental regime type** – Which actors have authority to take decisions and how they are elected (e.g. democratic, autocratic, etc.) at local, regional and national levels		
	GS2	**Government organizations** – Permanent or semi-permanent institutions with governmental authority controlled by (national, regional and local level)		
	GS3	**NGOs** – Different types of interacting NGOs (e.g. social, environmental, technical organizations)	GS3a GS3b GS3c	Presence and capacity building (i.e. institutions with mandate to increase the ability of direct users to govern the access and use over the resource units) Linking (i.e. Institutions operating across governance scales) Bridging (i.e. Institutions operating within the same governance level)

Annex 1 (continued)

First tier	Second tier		Third tier	
	GS4	**Property-rights systems** – Presence or absence of formal property right systems for the resources (e.g. exclusive fishing rights)	GS4a	System of property right
			GS4b	Excludability (i.e. possibility to exclude potential users from using the resource, as territorial use privileges)
			GS4c	Substractability (i.e. whether resource appropriation by one user reduce availability to others)
	GS5	**Rules-in-use** – Formal and informal rules in practice shaping human behavior and governing social interactions	GS5a	Operational rules (i.e. community rules established for the extraction, management, access and use of natural resources)
			GS5b	Collective-choice rules (i.e. collective-choice rules used to change the day-to-day operational rules related to the resource management)
			GS5c	Constitutional rules (i.e. the process through which collective-choice procedures are defined and legitimized)
			GS5d	Monitoring rules and process (i.e. mechanisms to observe and report changes in SES)
			GS5e	Sanctioning rules and process (i.e. mechanisms to enforce the rule or punish the rule breaker)
	GS6	**Network structure** – Connections among the rule-making organizations and the population subject to these rules	GS6a	Horizontal (i.e. link actors with each other to act collectively for a common propose)
			GS6b	Vertical (i.e. link actors with other organizations or the government across levels)
Resource Units (RU)	RU1	**Resource unit mobility** – Resource unit mobility		
	RU2	**Growth or replacement rate** – Growth/ replacement rate based upon the resource unit's life cycle (e.g. reproductive age, harvesting age, growth rate)		
	RU3	**Interaction among resource units** – Interaction among resource units (e.g. competition, collaboration)		

Annex 1 (continued)

First tier	Second tier		Third tier	
	RU4	**Economic value** – Economic value of the resources	RU4a	Market value
			RU4b	Environmental value
			RU4c	Strategic value (e.g. economic, social, geopolitical, cultural, symbolic)
	RU5	**Number of units** – Number of resource units / amount of resource harvested or that could be potentially harvested		
	RU6	**Distinctive characteristics** – Markings or behavioral patterns that can be identified in resource units and affect actors' behavior toward them.		
	RU7	**Spatial and temporal distribution** – Availability of the resource in space and time	RU7a	Reproduction
			RU7b	Adult life
Actors (A)	A1	**Types of relevant actors –** Actors affecting or being affected by decision-making processes related resources or resources harvesting.	A1a	Direct users
			A1b	Number of direct users
			A1c	Other actors in SES (consumers, actors in related SESs, etc.)
	A2	**Socio-economic attributes of direct users** – Characteristics of direct users related to social and economic dimension affecting fishing dynamics.	A2a	Sources of income (linked or not with the resource)
			A2b	Consumption patterns (e.g. local resources, local/imported food, shopping)
			A2c	Women rights
			A2d	Access to health and education
			A2e	Vulnerability (e.g. social, economic, institutional, environmental)
			A2f	Cultural identities (e.g. language, food, celebrations, traditions)
			A2g	Housing and sanitation conditions
	A3	**History of use or past experience** – Chronological description of resource extracting methods, crisis and duration of the use of resources (i.e. past interactions which affect current behavior)		

Annex 1 (continued)

First tier	Second tier		Third tier	
	A4	**Location** – Geographical location or dispersion patterns of direct users in relation to the resources and the market (e.g. settlements, villages, dispersion)		
	A5	**Leadership/entrepreneurship** – Existence of, and attitude towards leadership and entrepreneurship among actors	A5a	Leadership patterns (e.g. level of acceptance, prominence, leadership models)
			A5b	Attitudes toward conservation (e.g. entrepreneurship, maintenance, sustainable use)
	A6	**Social capital** – Levels of social interaction, reciprocity and trust among actors	A6a	Degree of support or assistance (e.i. degree by which individuals can draw upon or rely on others for support or assistance in time of need)
			A6b	Traditional forms of collaboration (e.g. norms, habits, traditions, customs)
	A7	**Knowledge of SES/mental models** – Level of knowledge, understood and sense on SES conditions, perturbance patterns and possible effects	A7a	Local knowledge on SES (based on traditional or scientific knowledge)
			A7b	Knowledge of the effect of over-harvesting
			A7c	Knowledge of the effect of social attitudes (toward resource management on the SES)
			A7d	Knowledge of the effect of biological shocks
			A7e	Mechanism to share knowledge about fishery
			A7f	Mental models related to SES management (e.g. conservation, exploitation, human-nature relationships)
	A8	**Importance of resources** – Importance of resources for livelihood	A8a	Economic dependence (i.e. in which level the resource constitutes a source of monetary income and plays a major role in fishermen's ability to sustain their livelihoods)
			A8b	Cultural dependence (i.e. in which level the resource constitutes a source of cultural values, practices and services)
	A9	**Technology used** – Type of technology used to extract, harvest and manage the resource, as well as differences in access among direct users based on access to different technologies	A9a	Ownership of different types of technology by fishermen
			A9b	Homogeneity (i.e. degree by which fishermen use the same technology)

Annex 1 (continued)

First tier	Second tier		Third tier	
Interactions (I)	I1	**Harvesting levels of diverse users** – Quantity of the resource(s) harvested by different users	I1a	Harvesting level and effects on SES
			I1b	Free-riding
	I2	**Information sharing among direct users** – Any present scheme of information sharing among users.	I2a	Knowledge dissemination (i.e. information about the SES variations)
			I2b	Information/knowhow sharing (i.e. about the SES variations)
	I3	**Deliberation processes** – Deliberation process used among direct users	I3a	Deliberation processes among direct users
			I3b	Knowledge about participation mechanisms and rights
	I4	**Conflicts among actors** – Existing conflicts among actors (e.g. conflict based on greed, grievance, scarcity, technology, access, power, information)	I4a	Conflicts among direct users (i.e. existing conflicts among artisanal fishermen)
			I4b	Conflicts with externals (i.e. existing conflicts between direct users and other relevant actors in SES)
	I5	**Investment activities** – Investments for improving and managing the resources (investor, amount invested and destination of investment)	I5a	Type of investment (i.e. amount and destinations of investments in harvesting, managing, transformation of products, etc.)
			I5b	Degree of dependency on external investments (i.e. in which level fishermen depend on external actors' investment -public or private- in order to improve their activity)
	I6	**Lobbying activities** – Lobbying activities (internal, external, influence capacity, actors involved, expected outcomes)		
	I7	**Self-organizing activities** – Self-organization activities among users for extracting resources. Include description of any solidarity activities		
	I8	**Networking activities** – Networking activities of the actors within and outside the community to managing and harvesting.	I8a	Internal networks
			I8b	External networks
			I8c	Partnership and cooperation
			I8d	External communication channels

Annex 1 (continued)

First tier	Second tier		Third tier	
Outcomes (O)	O1	**Social performance measures (e.g. efficiency, equity, accountability, sustainability)** – Impact of different activities on social performance taking into account the welfare of users.	O1a	Efficiency
			O1b	Equity (i.e. distribution of benefits of the activity between users)
			O1c	Socio-economical sustainability (i.e. distribution, access to SES and improving of social-economical conditions along the time)
			O1d	Accountability (i.e. control of power exercised over decision makers)
			O1e	Effects of deliberation processes
			O1f	Empowerment (including gender analysis)
			O1g	Adaptation strategies to climate change
	O2	**Ecological performance measures (e.g. overharvesting, resilience, biodiversity, sustainability)** – Measure the ecological performance and impact of different activities in the environmental context	O2a	Environmental sustainability
			O2b	Pressure on resources (e.g. increasing demand, new actors, overharvesting)
			O2c	Natural habitat (e.g. biodiversity indexes, species richness, connectivity, habitat conservation/degradation/fragmentation)
			O2d	Effect of SES management on natural hazards (e.g. changes in type, frequency, pattern)
			O2e	Structure and function of resources (e.g. changes, interactions among resource units, trophic chains)
			O2f	Soil (e.g. erosion, degradation, improvement)
			O2g	Water (e.g. quality, availability)
			O2h	Air (e.g. quality)
			O2i	Pollution (e.g. waste generation, frequency of occurrence)
			O2j	Resilience
			O2k	Vulnerability
	O3	**Externalities to other SES** – Positive or negative impacts on other SESs without previous agreement or request	O3a	Positive externalities (e.g. water protection, biodiversity conservation, etc.)
			O3b	Negative externalities (e.g. water pollution, waste occurrence, etc.)

Annex 1 (continued)

First tier	Second tier		Third tier	
Related Ecosystems (ECO)	ECO1	**Climate patterns** – Climate patterns affecting the considered SES (e.g. precipitation, temperature, sea level, extreme events, seasonal changes)	ECO1a	Extreme events (i.e. heat events and/or winter chill, extreme rainfall , drought or flooding events)
			ECO1b	Sea level or coastal variations
			ECO1c	Temperature (variation in temperature of sea water at the estuary and coastal ocean)
			ECO1d	Annual precipitation variations (changes in historical annual patterns)
			ECO1e	Season changes (changes in historical season patterns)
	ECO2	**Pollution patterns** – Pollution patterns affecting the considered SES (e.g. water, waste, soil, air)	ECO2a	Pollution patterns from production (e.g. industry, fishery, tourism, etc.)
			ECO2b	Pollution patterns from social activities (e.g. sewer discharge, waste, etc.)
	ECO3	**Flows into and out of focal SES** – Flows from other SESs affecting the focal SES and vice versa (economic pressures, environmental effects and social effects)		

Source: Own elaboration, adapted from London et al. (2013).

Annex 2: Description of relevant variables to characterize the fishery SES.

Variable	Description	Source
Social, economic and political setting (S)		
Economic development (S1)		
– Economic sectors in the study area (S1a)	High level of heterogeneity There are diverse sectors with enormous differences in technology applied and commercialization levels. Primary sector is comprised of artisanal fishery, high seas bottom trawl fisheries or off-shore fisheries (in the whole area) and horticulture in Cerri. Artisanal fishery and horticulture is labor-intensive sector, while off-shore fishery depends greatly on capital and technology. Secondary sector consist of petrochemical industry, gas, electricity and fish processing plants (mainly concentrated around White and Cerri). Finally, tertiary sector is represented by foreign trade and commerce (mainly through the White Port), and tourism (in Monte Hermoso and Pehuén Co area). The main channel (*Canal Principal)* of the Estuary houses the largest and deeper harbor system in Argentina from which most of the grain and other industrial exportations are made	INDEC; own data from unpublished survey; London et al. (2012)
– Per capita income (S1b)	Medium level of per capita income The population percentages by monthly per capita income are: less than $500: 4%; between $500 and $1000: 5%; between $1,000 and $3,000: 44%; between $3,000 and $5,000: 26%; between $5,000 and $8,000: 8%; more than $8,000: 1% (8% of the population ns/nc) (all values expressed in Argentinean pesos)	INDEC; own data from unpublished survey
– Employment per sector (S1c)	High level of heterogeneity Official data corresponds to the whole Bahía Blanca Municipality: 1% of employment belongs to primary sector, 7% to secondary sector and the rest to tertiary sector. Despite the low participation of primary and secondary sectors, employment in those activities is concentrated in the area of White, Cerri and Villa del Mar. In Pehuén Co and Monte Hermoso, employment is concentrated in tourism, other service sectors and fishery	CREEBBA; workshops and own data from unpublished survey
– Access to public service (S1d)	Medium to high level of access to public services. High level of heterogeneity among actors Each town has primary and secondary public school. There are two public national universities and a provincial public university in Bahía Blanca. Between 5% (Monte Hermoso and Pehuén Co) and 8% (White, Cerri and Villa del Mar) of the population has no instruction. Also hospitals or medical facilities are present in the whole area. The 95% of population has electricity. Gas natural net and sewer service exist in Monte Hermoso, Villa del Mar, Cerri and White. In Villa del Mar, White and Cerri 0.4% of the population has not access to drinking water. In Monte Hermoso and Pehuén Co 51% of the population has access to potable water by piping, 41% of the population has access to potable water through wells and 8% of the population lacks access to potable water	INDEC; workshops and own data from unpublished survey

Annex 2 (continued)

Variable	Description	Source
– Income dispersion (S1e)	Medium to high level of inequality and poverty In 2013, the 29.3% of the total urban population in Bahia Blanca was under the poverty line and 6% was indigent. Income inequality derived from the Kuznets relation 1:10 was 18.9 in the same year. The Gini index for the region of Bahía Blanca was around 0.46. There is no official data for each town	CREEBBA – INDEC
– Time allocation among the different economic activities carried out in the area (S1f)	High concentration of time allocation to principal activities, with seasonality fluctuations in tourism and fishery People declare to be full-time workers at industry, commerce, fishery and tourism. Secondary activities (mainly services and construction) regained relevance during low season in the case of fisheries and tourism	Own data from unpublished survey and interviews
– Specialization of stakeholders (S1g)	High level of heterogeneity between stakeholders in their specialization degree There are different levels of specialization depending on the activity. Fishermen do not have a formal training, but a high traditional knowledge. In tourism, the number of professionals with formal training is even low. In commerce and service, formal education degree is high. Industrial sector exhibits a high internal level of heterogeneity in specialization	Own data from unpublished survey and interviews
Population characteristics (S2)		
– Number of inhabitants (S2a)	Low to medium level of demographic burden Data from last census (2010) shows the following numbers of inhabitants: White: 11,115; Cerri: 13,946; Pehuén Co: 674; Villa del Mar: 353 and Monte Hermoso: 6,499. According to national definition, a population is considered as urban if it has 2,000 or more inhabitants. Then, White, Cerri and Monte Hermoso are urban populations, while Villa del Mar and Pehuén Co are still rural populations, despite they exhibit several urban features. By tourist flows in peak season, population increases up to 60,000 in Monte Hermoso (74% of dwelling houses are second homes)	INDEC; Corbella (2011)
– Population density (S2b)	Medium degree of population density Last census shows a density of population by municipality about 134.2 inhab/km² for Bahía Blanca, 38.3 inhab/km² for Coronel Rosales and 31.1 inhab/km² for Monte Hermoso Municipality. The inter-census variation exhibits an increasing tendency in all cases. Official data for Pehuén Co is about 24.36 inhab/km². Despite there is no official data for Cerri, White and Villa del Mar, density of population would be far below estimations for Bahía Blanca and Coronel Rosales	INDEC; workshops

Annex 2 (continued)

Variable	Description	Source
– Gender ratio (S2c)	High degree of gender equity According to the last census, the masculinity rate (the number of males for each 100 females) is 104.8 in Monte Hermoso, 92.2 in Bahia Blanca and 95.8 in Coronel Rosales Municipality	INDEC
– Demographic structure (S2d)	Middle-aged population patterns Ratios of dependence (population between 0–14 years old and 65 or more years old with respect to the total population) are 51.8, 55.6 and 57.9 for the municipalities of Bahía Blanca, Coronel Rosales and Monte Hermoso, respectively. Population between 0–14 years old represents the 21, 24.6 and 23.6% for Bahía Blanca, Coronel Rosales and Monte Hermoso, while population with 65 or more years old is about 13.1, 11.1 and 13.1%. Moreover, the average age of population is about 36.9, 33.4 and 35.5. The area of Bahía Blanca has the most elderly population in the area. Monte Hermoso and Pehuén Co have the youngest and most dynamic population, while Villa del Mar presents the eldest population	INDEC, workshops and interviews
– Population tendency (S2e)	Increasing in Monte Hermoso and Pehuén Co; stable in the rest of the study area Total area of Monte Hermoso Municipality showed inter-census variations of 55.4% (from 1990 to 2001) and 16% (from 2001 to 2010); while Coronel Rosales and Bahía Blanca exhibited variations of 4.6 and 5.9%, and 2.3 and 2.1% between 1990–2001 and 2001–2010, respectively	INDEC
– Migration trends (S2f)	Stable migration trends Historically, the *big-push* of the population growth was the consequence of external interwar migration flows. Population in White and Cerri increased during the expansion of Petrochemical Pole and the harbor area in the 1980s and 1990s. In Monte Hermoso and Pehuén Co, the population growth has occurred due to migration from bigger cities such Bahía Blanca and Buenos Aires. Nowadays, the tendency is unclear	Workshops and interviews
– Settlement patterns (S2g)	Middle–sized settlements patterns The five settlements located from west to east over the coast are: General Cerri, Ingeniero White (15 km from Cerri; both belonging to Bahía Blanca Municipality); Villa del Mar (18 km from Ingeniero White); Pehuén Co (50 km from Villa del Mar; both belonging Coronel Rosales Municipality) and Monte Hermoso (20 km from Pehuén Co). Land appropriation in the area began around 1828, marked by the extermination of pre-hispanic cultures and the implementation of a private property regimen defined by rural production. All the villages have urban characteristics. White was founded in 1828. It has four distinguish settlement zones: the commercial center, the *Boulevard* (the oldest area, where reside the immigrants' descendants and many of the fishermen), the *26 de Septiembre* (a working-class neighborhood) and *Saladero* (the lowest-class neighborhood).	Workshops and interviews; Prieto (2011)

Annex 2 (continued)

Variable	Description	Source
	Ingeniero White is located 10 km from the city of Bahia Blanca. Cerri was established in 1876 and is located 15 km to the west of Bahia Blanca. Villa del Mar is a small seaside town, located 5 km from the capital of the Coronel Rosales Municipality (Punta Alta). Monte Hermosos and Pehuén Co are relatively new communities (middle 20th Century). Pehuén Co is a maritime town, located at 47 km in a straight line for the coast from Punta Alta and about 70 km by road. It has an extension of 10 km along the beach. In Monte Hermoso, the population is settled along the coast in an extension of 32 km from East to West and	
Political stability (S3)		
– Core legal framework (S3a)	High complexity level of core legal framework and too low participation level of the community in its establishment National Constitution, Provincial Constitution and a complex set of national, provincial and municipal laws represents the core legal framework. Local laws and regulations are subject to national laws. Nevertheless, the respective duties and mandate areas often are overlapped. Formal rules are established by top-down processes	Workshops and interviews; Rojas et al. (2014b)
– Level of norms compliance (S3b)	Medium to low level of norms compliance Actors usually have a partial knowledge of formal norms. Particularly, fishermen have a good knowledge about formal rules concerning access and extraction of resources (fishing quotas, bans and taxes). The actors' perception points that law is broken because no formal effective punishment is applied	Workshops and interviews
– Type of conflicts (S3c)	High level of conflicts related to political stability Conflicts related to political stability are consequence of disagreements between different levels of government, political parties' representations or power groups	Workshops and interviews
– Security and risk (S3d)	Medium to high level of political risk Public policy shows a high level of instability (Tommasi 2010). The Index of Economic Freedom of the Fraser Institute places Argentina at 4th in volatility. At national level, the rate of insecurity has increased. Argentina is considered a moderate risk country according to the Political Risk Index, although this analysis shows an increasing tendency. Workshops allow us to conclude that actors' perception coincides with these observations	Tommasi (2010); Marsh-Maplecroft Political Risk Map 2014; workshops and interviews

Annex 2 (continued)

Variable	Description	Source
– Respect for democratic values (S3e)	Medium to low level of respect for democratic values The situation has improved substantially during the last 25 years. Successive military-civic coups against national government occurred between 1930 and 1983 (in 1930, 1943, 1955, 1962, 1966 and 1976), besides several civic, political and economical crises that continue to the present days. Human rights have been violated several times and corruption is recognized by stakeholders as a truly difficult institutional problem to avoid. Between the first military coup in 1930 until the ending of the last dictatorship in 1983, military governments ruled the country for 25 years, imposing 14 dictators in successive military-civic coups against national government. From 1930 to 1983, all democratically elected government could not conclude its mandate, being interrupted by coups Although the institutional situation changed dramatically after 1983 due to the return to democracy, however, many problems related to previous period (hyperinflation, external debt and institutional crisis) contributed to the fall of President Raúl Alfonsín, who handed over his position before finishing his administration to President Carlos Menem. During the Presidency of Carlos Menem, several neoliberal structural reforms took place, leading the country to the highest unemployment rate and economic recession of latest decades. His successor, President Fernando de la Rúa, resigned amid a popular uprising. After two year of high political instability, Néstor Kirchner assumed the presidency. Argentina is governed by the Kirchnerismo since 2003. Institutional crisis seems to be deepening in the last few years	Workshops and interviews; London et al. (2013)
Government resource policies (S4)		
– Governmental regulatory framework (S4a)	High level of complexity of governmental regulatory framework Argentina has a representative democracy with a presidential system. Particularly, there is neither self-governed community with general assembly nor public decision power over the use of resources in the area. The management and preservation of resources are legislated by the national, provincial and municipal governmental levels. The Government of Buenos Aires Province has jurisdiction over the living resources in the territorial waters adjacent to their coast up to a distance of 12 nautical miles (NM) from shore, while the remaining areas within the Economic Exclusive Zone (out to 200 NM from the baseline) are under the jurisdiction of the Federal Government. The Federal Fisheries Law 24.922 (LFP) and its Regulatory Decree 748/99 governs competition for fisheries resources between each legal community (federal and province) by setting limits on fishing and create the Consejo Federal Pesquero (CFP, see GS2). The provincial law Nº 11,477 regulates the activity under the provincial domain	London et al. (2012); Conde et al. (2009); Villasante et al. (2015)

Annex 2 (continued)

Variable	Description	Source
	Artisanal fishery is defined by law as that activity carry out "with the objective of product commercialization, through the use of horse-drawn vehicles, undecked vessels without length limit or decked vessels up to 13 m length". Artisanal techniques are also regulated by law and differ from those practices by commercial fishery. Given the precariousness of artisanal vessels, fishery is not permitted out to the Estuary and the area until 3 NM from the coast. Exceptionally, they are authorized by Prefectura Naval Argentina (PNA, see GS2) to go out to the bordered area	
– Environmental policies (S4b)	Medium level of development of environmental policies Formal legislation framework which regulates the use and control over common resources emanates from a very complex structure of organisms corresponding to the three levels of political jurisdictions (local, provincial and national). Annually, CFP fixes the maximum permitted catches by species according to sustainability parameters. The INIDEP (see GS2) should determine annually the maximum sustainable yield of species and recommend biologically acceptable catch to CFP. Provincial laws fix the ban periods for high seas bottom trawl fisheries (currently, between 1 October to 31 March). The OPDS (see GS2) is a provincial organism responsible for develop environmental policies. Bahía Blanca Municipality monitors emissions through the CTE (see GS2). There is no climate change specific mitigation strategy and a few controls on sewage	London et al. (2012); Rojas et al. (2014a)
– Environmental regulatory and policy frameworks compliance (S4c)	Low to medium level of environmental regulatory and policy frameworks compliance Actors in the area show a medium level of compliance with the environmental framework. Environmental policies such as emission control and extension in ban periods are in accordance with users' demands. Nonetheless, actors claim for sewage waste treatment thrown into the estuary, the redefinition of fishery areas and the design of a management plan for the sustainable use of resources	Workshops and interviews
Market incentives (S5)		
– Influence of global/local markets in the area (S5a)	High level of influence of local markets in fishery and tourism. Low level of influence of global markets in artisanal fishery. Relevance of global markets for activities related to industry and port Activities such as corn and meat exports, industry and agro-industry show a high dependency of external markets Local prices of fishery are set by local demand fluctuations *plus* some influence of international prices. Artisanal fisheries sell their products in local markets. Errazti et al. (2009) estimated that 84% of sales of artisanal fishery in Buenos Aires Province are made to intermediaries, 6% to fish shops and 10% are retail. The results of our workshops and interviews show the same pattern of commercialization. Artisanal fishermen sell to intermediaries competing against other big fisheries with participation in external markets, who fix their prices taking into account international prices. Then, international markets have an indirect influence on the fixing local prices	Workshops and interviews; Errazti et al. (2009); London et al. (2012)

Annex 2 (continued)

Variable	Description	Source
– Type of products (S5b)	Large variety of products The products commercialized are: services (tourism, financial services and transportation), agriculture and livestock (grains and cereals, meat), horticulture, industrial products (oil, gas, petrochemical products) and fishery products (industrial and artisanal)	CRREBBA, workshops and interviews
– Access to markets (S5c)	High level of heterogeneity between actors in the access to markets High added value products (i.e. industrial products) are exported. Commercialization channels, marketing and networks have a high degree of development and the access to market is ensured. Most of the fishery products are retailed directly to consumers or through cold-storage chambers placed in White. The rest of the product is sold to processing plants in Mar del Plata city (about 470 km northeast from the area). Marketing and networks present a low development degree, despite four national routes and one provincial route linking the cities with a relevant influence area and the rest of the country	Workshops and interviews
– Demand for natural resources (S5d)	High demand for natural resources Artisanal fisheries demand fishery resources. External fishing fleets invade the area to exploit fishery resource Tourism is based on the exploitation of beaches and coastal areas. Industry demand gas, oil and water	Workshops and interviews
– Market incentives for natural resource conservation (S5e)	Low level of market incentives for natural resources conservations Mechanisms such as payments for ecosystem services or pollution quotas do not exist. There is a lack in governmental direct intervention to create market incentives for conservation	Workshops and interviews
Media organization (S6)		
– Communication networks (S6a)	High presence of media Except Villa del Mar, all towns have local radios, relay antennas and local television programs. All actors have access to radio and TV	Workshops and interviews
– Media deterrence capability (S6b)	Medium to high level of media deterrence capability The influence of local media is relevant and higher than the influence of national media	Workshops and interviews
– Interest of media in socio-environmental issues (S6c)	High interest of local media in socio-environmental issues Important facts seek to be disseminated by different media and the success of the events is measured through this presence	Workshops and interviews

Annex 2 (continued)

Variable	Description	Source
Resource systems (RS)		
Sector(s) (RS1)	High degree of heterogeneity and richness The resource system includes the estuarine area and the coastal area until 3 NM, from Cerri to Monte Hermoso. Resources system has characteristics of common-pool resource (Ostrom and Ostrom 1977). The estuary contains a wide range of valued coastal resources, among which fisheries, open spaces, natural reserves and wildlife habitat can be stressed. The estuary is a series of major NW-SE tidal channels which separate extensive coastal wetlands and islands. The mesotidal range on a low relief area gives place to large tidal flats and both Spartina and Sarcocornia marshes which allow adequate conditions for benthic infauna and the development of particular biological structures which are unique on a worldwide basis. The wetland of Villa del Mar is influenced by the dynamics of the estuary and is home to species of native wildlife and some endangered species. Birdwatching is very different consisting mostly of flamingos, herons, gulls and cook crab, oystercatchers, lapwings and migratory birds like ducks to plovers and sandpipers. The fauna is completed with franciscana dolphins, sea lions and sea turtles. Pehuén Co and Monte Hermoso are located outside the area of the estuary. Both have sandy beaches, although buildings have modified completely the coastline dune system. The off-shore area near the Estuary and coasts of Monte Hermosos and Pehuén Co is the zone known as "El Rincón" (Figure 6). El Rincón does not belong specifically to the SES under study and can be seen as another focal SES itself; it has an extreme relevance because of the biologic, physical, social and economic interactions between both areas. El Rincón extends from the coast to a 50 m depth (not including the estuary). This zone can be divided into two domains, the coastal or inner shelf and the outer shelf. The coastal waters, delimited by the 40 m isobaths, exhibit generally homogeneous temperatures and salinities in both seasons. Commercial species founded in those areas are several types of fishes (i.e. Argetine hake, cuvier, croaker, weakfish, different types of rays, conger, among others), shrimps and prawns	Perillo and Iribarne (2003); Guinder et al. (2010); Zilio et al. (2013); Lopez Cazorla et al. (2014); Villasante et al. (2015)
Clarity of system boundaries (RS2)		
– Natural and ecological boundaries (RS2a)	Fuzzy natural and ecological boundaries Historically, species catches by artisanal fishery were concentrated in the estuarine area and along the coast, up to 3 NM from the line. Nevertheless, biophysical characteristics are suffering severe transformations due to pollution, change in climate patterns, overexploitation and erosion process, leading species farther to the coast	London et al. (2012)

Annex 2 (continued)

Variable	Description	Source
– Anthropogenic boundaries (RS2b)	Clear anthropogenic boundaries Despite marine area is not granted by concession; artisanal fishery has the exclusive right to exploit resources until 2 NM from the line (Provincial law-ranking Decree 3237/95). Moreover, trawling and the entry of ships of +25 m in length are forbidden until 3 NM territorial seas. Any type of fishery is also forbidden or limited in conservation areas: Reserva Provincial Natural Bahía Blanca, Bahía Falsa y Bahía Verde (it covers parts of the estuary and wetlands of Villa del Mar), Reserva Costera Municipal de Objetivos Definidos (located in the estuarine area) and the Geological, Paleontological and Archeological Provincial Reserve Pehuén Co-Monte Hermoso (about 17 km W of Pehuén Co to the eastern border of Monte Hermoso)	Errazti et al. (2009); London, et al. (2012); Rojas et al. (2014a)
– Access to the resource system through boundaries (RS2c)	Regulated access to the resource system through beaches and sea boundaries, with the exception of certain areas of MH-PC beaches; limited access through land in the area of BBE In the case of fishermen from Cerri, White and Villa del Mar, the access to the resource system is highly limited by land since the port is concessioned (it is not an open-access resource system). Only fishermen with permission can access to the resources system through the port. The coast is an open-access resource in some areas of MH-PC (with the exception of the central urban area and the reserve area). Boats access to the sea directly throughout the beach. Access is regulated but subject to fewer controls in marine areas. The open space permits outsider fleets enter to the BBE and MH-PC coastal zones, even without permission. Then, marine area looks like an open-access resource system, when access is actually regulated.	Workshops and interviews; London et al. (2012)
Size of resource system (RS3)	Big size of the resource system The zone affected by artisanal fishery is extended along the Atlantic coast over a stretch of more than 100 km from Cerri to Monte Hermoso. Bahía Blanca Estuary has an area of 3,000 km^2; 30,000 Ha of inland and 180,000 Ha of watershed corresponds to the Reserva Provincial Natural Bahía Blanca, Bahía Falsa y Bahía Verde. The Geological, Paleontological and Archeological Provincial Reserve Pehuén Co-Monte Hermoso covers land areas belonging to the municipalities of Coronel Rosales and Monte Hermoso along over 40 km of beaches from the mouth of the estuary and Monte Hermoso. The Reserva Costera Municipal de Objetivos Definidos covers only 3 km^2	Perillo and Iribarne (2003); London et al. (2012)
Human constructed facilities (RS4)		
– Human constructed facilities in access (RS4a)	Medium to low level of human constructed facilities The Estuary area has 5 piers, although most of that infrastructure is prepared for big ships and industrial activity. Monte Hermoso and Pehuén Co do not have any pier or mole. Vessels are trailed by pickup trucks or vehicles through the beach until the coast	Workshops and interviews; London et al. (2012)

Annex 2 (continued)

Variable	Description	Source
– Human constructed facilities in transformation and storage (RS4b)	Medium level of human constructed facilities in transformation and storage Although the presence of several processing plants and cold storage in White and Cerri, the situation is quite different in Monte Hermoso and Pehuén Co. Nowadays, a processing plant which include fishery of both towns is being built by the Cámara de Pescadores Monte Hermoso – Pehuén Co (see GS3a). Currently, fishermen of those cities depend on Mar del Plata cold storage (396 kms from Monte Hermoso) in order to sell and process their product	Workshops and interviews
Productivity of system (RS5)		
– Productivity of the resource system (RS5a)	High productivity of the resource system A typically measure of productivity is the annual catch per unit effort (CPUE) expressed in kg day^{-1}. (CPUE = C/f, being f the unit of effort as a fishing day per boat, and C the total catches). Lopez Cazorla et al. (2014) shows a continue decreasing tendency in the CPUE in the estuarine area from 1992 to 2003. Starting on 2004, there was a net increase of the CPUE (mean CPUE = 247 kg day^{-1}). Yields in El Rincón area CPUE between 2002 and 2009 presented an important increase (mean CPUE = 163.8 kg day^{-1}). Errazti et al. (2009) classified the area as one of high productivity. Fishermen declare a high but a decreasing tendency in the productivity of the resource system. There has been an increase in discards, mainly juveniles. For example, in the case of Argentine hake, discards represented between 11% and 24% of total landings during the period 1990–1997. In economic terms, this represents annual losses in USD of 11–77 million	Workshops and interviews; Errazti et al. (2009); Lopez Cazorla et al. (2014); Villasante et al. (2015)
– Resource regeneration period (RS5b)	Stable resource regeneration period Regeneration of different species happens mainly between spring to mid-autumn (since October to April), in the middle and external zone of the estuary (see RS6a)	Workshops and interviews; Sardiña and Lopez Cazorla (2005)
– Resource extraction period (RS5c)	Stable resource extraction period Artisanal fishing is permitted during all the year. Fishermen declare that highest catches are obtained in summer season (December–March), coinciding with the banned season for bottom trawl fisheries. For shrimps and prawns the resource extraction period is mobile, but the *fixed-by-law* banned season for off-shore fishery is during spring season	Workshops and interviews

Annex 2 (continued)

Variable	Description	Source
Equilibrium properties (RS6)		
– Equilibrium properties (RS6a)	High complexity of equilibrium properties and high level of risk in its maintenance Calm waters and nutrient richness create favorable conditions to several migratory fishes that stay in the estuary for its feeding during youth. The inner reach of the estuary is the sector where the trophic chain of the system initiate based on a winter bloom of phytoplankton which is directly related to calm winds, no waves, higher light penetration and lower concentration of suspended sediments. Spawning occurs in El Rincón area, from spring to mid-autumn. Small juveniles entry and remain in the estuarine area until late spring (in coastal waters less than 25 m depth). Then, they move to deeper waters (25–50 m) in late autumn (age 0+). They stay there for the next 1–2 years before joining the adult stock's seasonal movements	Sardiña and Lopez Cazorla (2005); Conde et al. (2009)
– Natural hazards occurrence (RS6b)	Medium to low level of natural hazards occurrence The SW winds dominate the area with a great intensity and frequency, exceeding in almost 50% in hours of occurrence in relation to SE winds. But the effects of the SE winds in combination with high spring tides generate floods in the area once or twice a year. These storms, locally known as "sudestadas" (strong southern winds and large waves) usually cause several damages in the localities and prevent the fishery	Workshops and interviews; London et al. (2012)
– History of equilibrium properties (RS6c)	Stable equilibrium properties until 1970s; relevant changes since then Equilibrium properties described in RS6a have been maintained for centuries. Nowadays, anthropic and natural factors are affecting the equilibrium properties. The dredging process, pollution and climatic change cause an increase in the trophic levels in the estuarine waters, modifying the species' diet and type, quantity and quality of species. Moreover, climatic variability (i.e. higher wind speeds, more frequent wind rotations, and larger number of severe storms) in conjunction with anthropic actions (i.e. buildings on the coastal dune system and dredging) have modified the coastal geomorphology in the bathing areas, making a higher number of shoals and channels emerge	Londo et al. (2012); Sardiña and Lopez Cazorla (2005)
Predictability of system dynamics (RS7)	High level of predictability of system dynamics Actors have a great capacity to estimate the evolution and dynamics of the resource system and the impact of interventions or external influences due to their historical knowledge. Fishermen know when a season will be better than other depending on rainfalls, temperatures or storms. They show capacity to predict the temporal or permanent absence of some species due to overexploitation or natural conditions. Fishermen recognize that some extreme changes could be not expected by them, as the complete absence of clams during the last 10 years. Nevertheless, there is a learning-by-doing in the practice of the activity. For example, clams are now reappearing and fishermen are studying if changes in clams' behavior are part of a cycle which would repeat in the future	Workshops and interviews

Annex 2 (continued)

Variable	Description	Source
Storage characteristics (RS8)		
– Storage of the effects of anthropogenic pressures (RS8a)	High level of storage Anthropogenic effects have consequences along large periods. During workshops, fishermen assure that only 4 years of uncontrolled high seas bottom trawl fisheries are necessary to exterminate the fishery because natural cycles are not able to compensate for the cumulative effects of anthropogenic effects. The ban area was stablished in 2004. From 2009, the biomass is yet decreasing. In the other hand, the dynamic of the estuarine system dilutes the sewer discharge and fluids influences. For that reason, the estuary still has a high level of self-depuration	Workshops and interviews; Carozza and Fernandez Araos (2009); London et al. (2013)
– Storage of the effects of natural disturbances (RS8b)	Medium level of storage Natural disturbance as increasing in rains or changes in tides seem to offset itself along some years. There is a fewer knowledge about new natural disturbances as changes in temperatures	Workshops and interviews
Location (RS9)	SW Buenos Aires Province The area is located in the southwest of Buenos Aires Province (Argentina). More precisely, the Bahía Blanca Estuary is located between 38°45′ and 39°25′ S and 61°15′ and 62°30′ W. The area of "El Rincón" is between 39°S and 41°30′ S (Figures 1 and 6)	Piccollo and Perillo (1990)
Governance systems (GS)		
Governmental regime type (GS1)	Clear governmental regime type, although with low direct participation of actors Power is exercise though a representative democracy. Each jurisdictional order has deliberative organisms and an authority with executive power (President at national order, governor at provincial order and mayor or intendent at municipal level). They are elected by open and regular political election processes. In general, formal rules are performed by top-down processes where governmental authorities take decisions about formal rules in managing and control the SES. There is a low level of civic participation and few elements of community-based government	London et al. (2013); Rojas et al. (2014b)
Government organizations (GS2)	High level of complexity In fishery, the main governmental organizations are the Under-Secretary for Fisheries and Aquiculture (SSPyA) (under the Ministry of Agriculture, Livestock and Fisheries) and the Fishery Federal Council (CFP), which consists of one representative from each coastal province, the Secretary of Fisheries, a representative of the Secretariat of Environment and Sustainable Development (SAyDS), a representative of the Ministry of	London et al. (2012); Rojas et al. (2014b); Villasante et al. (2015)

Annex 2 (continued)

Variable	Description	Source
	Foreign Affairs, and two representatives of the National Executive. The SSPyA is the enforcement authority of the LFP (see S4a). The CFP is advised by technical committees of the various fisheries, in which scientists and technicians, mainly of the National Institute for Fisheries Research and Development (INIDEP) and the provinces, are involved. The SSPyA and the CFP establish formal norms, coordination rules, catch limitations, research and development priority areas. The INIDEP and the National Service of Health and Food Quality (SENASA) are the most relevant decentralized national organizations. The coast guard organism is Prefectura Naval Argentina (PNA). It is dedicated to safeguarding navigation at sea, protecting the marine environment within the EEZ by monitoring of maritime, river, and port areas. At provincial level, the main governmental organization is the Provincial Office for Fisheries (depending on the Ministry of Land Affairs). The Provincial Organism for Sustainable Development (OPDS) is the provincial authority in environmental policy. OPDS should guarantee the sustainable and correct management of the environment, the preservation of biodiversity and the implementation of sustainable development planning. At local level, the municipalities of Bahía Blanca, Coronel Rosales and Monte Hermoso are divided into several interest areas. In Bahía Blanca, the environmental area presents four governance organisms: Sanitation, Epidemiology, Technical Executive Committee (CTE) and APELL Process	
NGOs (GS3)		
– Presence and capacity building (GS3a)	Moderate but increasing presence of NGOs. Heterogeneity in the level of decision power In the area of White, there are three organizations related to the fishery activity: the Chamber of Owners and Shipowners Fisheries of Bahía Blanca Estuary, the Association of Artisanal Fishermen of Bahía Blanca Estuary and the Chamber of Artisanal and Commercial Fishermen of Ingeniero White, Puerto Rosales and Bahía Unión. While the first one represents the interest of shipowners and largest businessmen, the other two organizations reflect the interest of fishermen. The last two integrated a unique NGO and divided into two institutions after a conflict in 2009 (see I4a). In the area of Monte Hermoso and Pehuén Co, it is the Chamber of Artisanal Fishermen of Monte Hermoso and Pehuén Co. At national level, local organization group around UAPA (Unión Argentina de Pescadores Artesanales) NGOs with environmental purpose are AquaMarina, Foundation for the Reception and Assistance of Marine Animals (FRAAM – Villa del Mar), Wildlife Foundation (Fundación Vida Silvestre) and The Network of Young Leaders for the Marine Conservation. AquaMarina and Wildlife Foundation protect and advances in the conservation of marine biodiversity and health of coastal ecosystems, and promote the sustainable use of marine resources. FRAAM has the aim to recover, assist and reintroduce marine specimen victims of stranding by catch, accidents, etc. The Forum for the Conservation of the Patagonian Sea and Areas of Influence create the Training Program for Young Leaders for the Marine Conservation	London et al. (2012, 2013)

Annex 2 (continued)

Variable	Description	Source
	On the other hand, the Consortium of Management of Bahía Blanca Port (CGPBB) is on charge of the operation and management of the port since their foundation in 1993. Although the CGPBB is integrated by 9 actors from different groups, none of them are fishermen. The Chemical Industrial Association of Bahía Blanca (AIQBB) is made up of industrial representatives Commerce, hotels and gastronomy are united in the Chamber of Commerce and Industry of Monte Hermoso and in the Chamber of Commerce and Tourism Development of Pehuén Co. There are also two informal neighbor associations of relevance: the Residents Association of Ingeniero White and the Neighbor Forum of "Cerri de Pie" particularly interested in environmental care In many cases, organizations are born in "spasmodic" processes. Some NGOs were created in response of certain conflict (as Cerri de Pie, which appears as a neighbor association moving against the LNG plant project) and became extremely relevant for community along some period of time. But then, institutions begin a lethargy process which implies that NGOs' common actions not held in time	
– Linking (GS3b)	Low level of linking There are few institutions operating across different governance scales. Leaders of the fishermen associations have tried to show a major presence in provincial governmental levels by transmitting directly their demands. The functioning of the formal system of rules is sometimes inefficient and modern institutions do not generate the levels of face-to-face interactions that community-based institutions can generate	Errazti et al. (2009); Rojas et al. (2014a)
– Bridging (GS3c)	Low to medium level of bridging Interactions within the same governance level are complex. A "silo mentality" problem can be generated if linking is not developed. There are clear coordination fails and overlapping competencies	London et al. (2013); Erazzti et al. (2009)
Property-rights systems (GS4)		
– System of property right (GS4a)	Well-defined formal property right system The dominion of resources belongs to the Provincial (until 12 NM) and National Government (from 12 to 200 NM). Dunes, reserves and coastal areas are mainly subjected to the provincial jurisdiction. The rest of the land near the coast is mostly private property. Fishing license automatically authorize the appropriation of the resources by users at the harvest moment	London et al. (2012)

Annex 2 (continued)

Variable	Description	Source
– Excludability (GS4b)	Medium level of excludability Fishery can be conduct only with a license provided by CFP (see GS2), which assign catch quotas by species and vessel type for each authorized fishermen. Licenses are personal and not transferable to other fishermen. The allocation of quotas is based on the amount of local labor employed, effective local investments and the history of capture and processing. By law, unloading of products should be made in port areas. Despite of the establishment of license and laws which delimitate the fishing areas (see S4a), the level of excludability is reduced for two reasons. First, in the area of Bahía Blanca Port and inside the marine areas controls fail. Users without license extract resources, or extract more than the permitted amount or species authorized by license. Second, the non-existence of port in the area of Monte Hermoso and Pehuén Co, make it impossible the conduct of landings in government-controlled areas	Workshops and interviews; Conde et al. (2009); London et al. (2013); Villasante et al. (2015)
– Substractability (GS4c)	High level of substractability The resource appropriation by one user reduces the availability to others, especially when off-shore fisheries enter to the artisanal fishery area	Workshops and interviews; London et al. (2012)
Rules-in-use (GS5)		
– Operational rules (GS5a)	Medium level of operational rules The rule framework is stablished by law (see S4). Nevertheless, there are a medium level of development of community rules for the extraction, management, access and use of resources. Showily, some of these rules are in conflict with formal or legal rules. The activity is hardly ever realized individually. The techniques in use are hand line, trammel net, gill net, shrimp net or dock. Nets are funnel shaped and present lateral wings, a central bag and three different mesh sizes. Nets are placed at anchor by small boats, deployed when the tide goes out and are checked every two hours. As fishery depend on the resources availability, actors go to fish every day in high season (October to March), except when weather conditions do not permit the activity. In winter, fishermen reduce the amount of hours dedicated to fishing and devote time in related activities as the reparation of boats and nets. When resource is superabundant fishermen embarked for several days. During the last years, fishermen have changed some practices due to the reduction in resource units. They go farther away because catches are low in the inner marine zone, which also made the activity more dangerous when vessels are not prepared for off-shore areas. Even some actors work without license or outside the 3 NM area without PNA authorization. The protection and help among peers is highly valuable in these cases, because it increase the risk of the activity. Also, they have introduced the use of climate forecast tools from local or international weather stations	Workshops and interviews; London et al. (2012, 2013)

Annex 2 (continued)

Variable	Description	Source
– Collective-choice rules (GS5b)	Low to moderate level of collective-choice rules Rules-in-use have been established throughout the practice, rather than by a deliberative process of collective-choice. The level of collective decision is increasing due to conflicts with externals (see I4b). Fishermen observe that the power of collective action can counteract the power of groups as industrials or even government. The increasing in collective-choice is consistent with a greater presence of NGOs. Artisanal fishermen agree how the distribution of fishery zones will be done between users	Workshops and interviews; London et al. (2012, 2013)
– Constitutional rules (GS5c)	Low to medium development of constitutional rules processes National, provincial and municipal laws determine who, how, when, and where the actors must have access to natural resources and which are the sanctions for break regulations. Internal norms are defined by three different processes: into fishermen association, by assembly or formal meeting; by the imposition of the custom and practice (eventually, leaderships are who lead the adoption of such rules and their opinion is crucial to legitimize the collective-choice); or by spontaneous meetings (i.e. when an extreme event happen). There is no mechanism of direct civic participation, such as permanent assemblies or regular consultation mechanisms, which embed collective-choice within formal constitution of rules over the use of resources	Workshops and interviews; London et al. (2012, 2013)
– Monitoring rules and process (GS5d)	Low level of formal mechanisms of monitoring in use; medium level of informal monitoring rules in use PNA acts as auxiliary police to control fisheries and ecological changes. The CGPBB also has the police power to control the vessel traffic. Two radars located in Pehuén Co and Coronel Rosales Port help CGPBB to monitor the access to the estuary. However, the CPGBB has recently decided to change the whole monitoring system and both radars are not currently operating. PNA mentioned the scarcity of economic resources to control all the marine space. Then, formal monitoring process fails. On the other hand, artisanal fishermen are who inform the access of non-authorized vessels to the exclusive area or about excessive catches. Actors perceive that the largest control is done by fishermen themselves. They have not policy power to enforce the rule	Workshops and interviews; London et al. (2012, 2013)
– Sanctioning rules and process (GS5e)	Low level of formal sanctioning; medium level of internal sanctioning process Formal sanctioning implies the take-off of the license and economic punishment. But as well as control fails, the enforcement and punishment is not effective. A formal community process of sanctioning neither exists. The social sanctioning is imposed by fishermen if a peer breaks their set of (accepted) formal and informal operational rules. The removal of associations and exclusion are the social punishment usually implemented	Workshops and interviews; London et al. (2012, 2013)

Annex 2 (continued)

Variable	Description	Source
Network structure (GS6)		
– Horizontal (GS6a)	Medium level of horizontal network structure Network structures are relatively new. Links between internal actors are increasing as responses to external threats. NGOs as Aquamarina and FRAAM work together with fishermen in conservation activities	Workshops and interviews
– Vertical (GS6b)	Low level of vertical network structures Fishermens associations are frequently in contact with municipal and provincial government. But in workshops and interviews fishermen expressed that their communications with government are in order to "take actions against decisions already impose from superior levels" in the structure of decision making. In reference to laws that regulate the management and use of resources, there is a clear lack of meeting points between users and different governmental levels	Workshops and interviews
Resource units (RU)		
Resource unit mobility (RU1)	High level of mobility Fish species can move and migrate depending on their normal behavior, but they are affected by environmental conditions causing fish capture fluctuations. Shrimp migrates outside of the Estuary at the end of spring to spawn in deep-water. Several species of fishes (demersal species) spawn in the El Rincón area. Tides lead larvae to the Estuary, where they develop until juvenile stage. They migrate out to the Estuary as adult specimens (+1 year)	Conde et al. (2009)
Growth or replacement rate (RU2)	Growth and replacement rate are fluctuant, with a decreasing tendency Artisanal fishermen observe a decreasing of some species and an increasing presence of other. Conde et al. (2009) show a heavy drop in catches from 1984 to 2007, with a slight recovery since 2002 until the end of the period	Workshops and interviews; Conde et al. (2009)
Interaction among resource (RU3)	High level of interaction among resource units Fishery resources are linked in the same food chains, making ecosystem damageable and highly vulnerable. There exist competition and predation situation between resource units. [For a complete detail by species see Lopez Cazorla (1985)]	Lopez Cazorla (1985)

Annex 2 (continued)

Variable	Description	Source
Economic value (RU4)		
– Market value (RU4a)	Low to high market value, depending on the species and the added-value With respect to substitute goods, the fish filet price exceeds only the chicken price at national market, whereas other meats (beef, pork) have higher prices. Price varies according to abundance. In 2013, prices dropped about 50% as the industrial fishery ban in Monte Hermoso was lifted. Nevertheless, the price obtained by fishermen is often low in contrast to the final consumer price. Most price appropriation is carried out by cold storage plant when they take part in the marketization. This situation could change in Monte Hermoso and Pehuén Co, where artisanal fishermen are building a cooperative processing plant	Workshops and interviews; London et al. (2012)
Environmental value (RU4b)	High environmental value The estuary is a place of nursery for many species which then migrate to other zones around the entire Argentinean coast. While the value of environmental services has not been studied in general for the area and there is no clear data, Zilio et al. (2013) note that the social cost for the loss of the nursery service if the dredging project and construction of the LNG plant on the coast of General Cerri were carried out would be about €807.565 per year	London et al. (2012); Zilio et al. (2013)
– Strategic value (RU4c)	High strategic value The area is relevant as spawn, reproductive and nursery zone. Then, the related SES of El Rincon is taking as reference to define ban periods and regulations on fisheries techniques and vessels conditions. The strategic value is also important for activities in conflict with artisanal fisheries: geomorphologic conditions allow the development of a protected deep-water harbor for industry and maritime services	London et al. (2012); Zilio et al. (2013)
Number of units (RU5)	Decreasing number of units, but without official data The number of units has reduced since middle 1980s, with increases in 1990–1992 and 2001–2002 (Conde et al. 2009). But there is no estimation of the currently available units. Fishermen have observed that the number of prawns and large species such sole and gatuso have increased their number, maybe for the extension of the ban period	Conde et al. (2009); London et al. (2012)
Distinctive characteristics (RU6)	Clear distinctive characteristics The main characteristic is the total length of adult fish ranges by species. Fishermen discard juveniles. Other distinctive feature is the gill color, which can be altered in the estuarine area due to anthropic effects	Workshops and interviews

Annex 2 (continued)

Variable	Description	Source
Spatial and temporal distribution (RU7)		
– Reproduction (RU7a)	Clear patterns of spacial and temporal distribution in reproduction Most of the species spawn during middle-spring to middle-autumn in the boundary of the estuary and El Rincon area	Zilio et al. (2013); Lopez Cazorla et al. (2014)
– Adult life (RU7b)	Heterogeneous patterns of spacial and temporal distribution in adult life Resources are present among all the year, with variations of species. Micro-localization (i.e. position of species within the area) varies according to natural and anthropic conditions. Shrimp, prawn and weakfish are in less deeper areas. There are presence of shrimp and prawn during December to mid-June and mid-July to September, weakfish during mid-August to late September (sometimes also during March and April), narrownose smooth-hound during mid-September to late November; slick bonefish during mid-August to late September, sand smelt during June and July at low tide and September on the marshes and white croaker during November to March. Soles and rays are present all year	Workshops and interviews
Actors (A) Types of relevant actors (A1)		
– Direct users (A1a)	Artisanal fishermen from Cerri, White, Villa del Mar, Pehuén Co and Monte Hermoso	London et al. (2013)
– Number of direct users (A1b)	High number of direct users From workshops and interviews, four to five hundred of families live exclusively from fishery in Pehuén Co and Monte Hermoso. On the other hand 1.000 of people depend (directly or indirectly) on fishing in Cerri, White and Villa del Mar. In 2011, fishermen confirmed the existence of 128 boats in the area of Bahia Blanca Estuary. Fishermen from Pehuén Co and Monte Hermoso declare a fleet of around 100 vessels. Nevertheless, according to 2012 official data, boats registered were 30 in White (with 150 registered jobs), 40 in Monte Hermoso and 15 in Pehuén Co (CREEBBA)	Workshops and interviews; CREEBBA
– Other actors in SES (A1c)	High number of other actors and high heterogeneity In Monte Hermoso and Pehuén Co, tourism activity and related commerce employ almost the rest of people not involved in fishery. Other actors related on resources management are lifeguards and rangers. Also, tourists are important given the increasing affluence and their role as direct consumers of fishery products. In Cerri, White and Villa del Mar important actors are those related to industry, production chain of fishery and involved in environmental institutions. In all the area, decision makers and governmental actors are relevant	Workshops and interviews

Annex 2 (continued)

Variable	Description	Source
Socio-economic attributes of direct users (A2)		
– Sources of income (A2a)	High dependence on the resource to sustainable livelihoods The principal source of income for direct users is the artisanal fishery	Workshops and interviews
– Consumption patterns (A2b)	Medium consumption of local resources All localities are close to important urban centers. Then, actors use to acquire their consumer goods (food, clothing and others) in local markets and big markets alternately	Workshops and interviews
– Women rights (A2c)	Medium to high level of respect for women rights Women are important in household management, in fish trade and in the fabric of fishery nets. Despite of men recognize the importance of women in the social structure, they do not have a significant representation in fishermen's associations	Workshops and interviews
– Access to health and education (A2d)	Medium to high access to health and education Sanitation and education conditions are good in general (see S1d) and there is no impediment for fishermen to access those services. Young and child assign less time to acquire knowledge or formal education when they are helping their families in fishery. However, the effect seems not to be severing since high season coincides with their school breaks	Workshops and interviews
– Vulnerability (A2e)	High level of socio-economic vulnerability Life style is simple and fishermen seem to show medium to high poverty levels relative to the rest of the population. Fishery belongs to the informal sector of the economy, with the consequent repercussions over social conditions (see, for example, the difference in the number of boats registered and the number recognized by fishermen in the area of Bahia Blanca in A1b). Errazti et al. (2009) estimated that 30% of ships and boats are not authorized by PNA. Harvesting of shrimps and prawns constitutes the core of the informal labor market in fishery, involving a lot of women and children working in related activities. Informal users have also serious difficulties in credit access. Environmental vulnerability influence on socio-economic vulnerability because of the high dependence level on resources to sustainable livelihoods (see A2a)	Workshops and interviews; Errazti et al. (2009); London et al. (2012)

Annex 2 (continued)

Variable	Description	Source
– Cultural identities (A2f)	Medium to high signs of cultural identities All communities speak the same language and have similar consumption patterns. However, fishermen feel as a particular group, which clearly distinguished from others. The heterogeneity between all actors and the absence of a unique cultural root have reduced the capacity to create shared codes and common rules between direct users and other relevant actors living in the area and sharing the SES. Fishery arts, familiar structures, empirical knowledge, histories about sea, holidays and festivals form part of the cultural identity of fishermen and the maintenance of traditions	Workshops and interviews
– Housing and sanitation conditions (A2g)	Medium level to housing and sanitation conditions All actors have real or potential access to electricity and gas. Sanitations conditions are good. Most of the families have TV, TV cable, stereo, cellular phone, refrigerator (fridge). Most of the population also has motorized transportation	Workshops and interviews
History of use or past experience (A3)	High relevance of the history and paste experience. Recent relevant changes Artisanal fishery started in the area of Bahía Blanca early 20th centuries due to the arrival of Italian and Spanish immigrants whose forefathers handed down sustainable fishing methods from father to son. In 1937 they grouped in the first cooperative "Asociación Pescadores de Ingeniero White", with 150 members. Elderly fishermen remember that they could access to resources directly from the beach and fish was found in great abundance in the inner area of the estuary. The activity started around the 1950s in Monte Hermoso and Pehuén Co. During several years, fishery was destined to internal markets. The exploitation of fisheries resources for commercial purposes began in 1978 (see Villasante et al. 2015). During the last four decades, Argentina's commercial fishery has grown significantly to the detriment of artisanal fishery. In 2013, only 14 fisheries accounted for 98% of landings. The reducing in resources availability led to the closure in 1999 of the Cooperativa Pesquera Whitense. Between 2000 and 2004, the artisanal fishery in the whole south of the Buenos Aires Province collapsed. In 2004, the government implemented fishing closures in El Rincon area as a reaction to the overexploitation and the decrease in biomass. The granting of new license is also suspended. Fishery around the area of the estuary appreciably improved after those changes in institutional framework Nevertheless, a severe conflict dominates relations between fishermen from Monte Hermoso – Pehuén Co and Bahia Blanca Estuary area since 2010. In 2010, provincial government created an official register to give eight permissions for trawling fishery to artisanal fishermen in Bahia Blanca. The change in technology was already asked for fishermen in White area	Workshops and interviews; London et al. (2012, 2013); Rojas et al. (2014b); Lopez Cazorla et al. (2014); Villasante et al. (2015)

Annex 2 (continued)

Variable	Description	Source
	With new, bigger and better prepared vessels, they could extract resources in off-shore areas. In 2012, a grant agreement was signed between the Ministry of Production of the Buenos Aires Province, the CGPBB and the Fishermen Chambers of Ingeniero White for restructuring the fishing fleet of White and for moving the entire artisanal fishing from Bahía Blanca Port to Coronel Rosales Port. The project implies the change of the classical yellow boats for trawling vessels. The idea of introducing harmful techniques causes the reaction of other internal users. The fishermens association in White was divided and fishermen from Monte Hermoso – Pehuén Co area went to the Supreme Court to seek for the abolition of the project	
Location (A4)	Medium to high concentration in the location of direct users Most of the fishermen live in the area of El Sauce, 2 or 3 km to the east of the heart of Monte Hermoso. In White, they concentrate in Saladero and Boulevard neighbor (see S2g). In Pehuén Co, Villa del Mar and Cerri are more scattered	Workshops and interviews
Leadership/entrepreneurship (A5)		
– Leadership patterns (A5a)	High level of acceptance and decision power of leaders Leaders used to be adult fishermen with experience and tradition in the activity. During conflicts among users and decision makers, they conduct actions to defend the access to resources and the sustainable management. They also are the nexus with government organizations. Sometimes leaders representing different groups enter in internal conflicts	Workshops and interviews
– Attitudes toward conservation (A5b)	High level of attitudes toward conservation Leaders control the activity during the ban and report the presence of trawl boats in forbidden areas. They have also spearheaded initiatives against the dredging project and extended ban periods. These attitudes may change in the case of fishermen from Bahia Blanca Estuary (see A3)	Workshops and interviews
Social capital (A6)		
– Degree of support or assistance (A6a)	Medium level of support or assistance The intra-family bonds and the nearest group ties are important. They share information and cooperate with each other. Instead, the extra-group links are less strong. Artisanal fishermen do not always trust in other fishermen belonging to different groups	Workshops and interviews

Annex 2 (continued)

Variable	Description	Source
– Traditional forms of collaboration (A6b)	Medium level of collaboration among actors Artisanal fishermen work in groups, which makes more feasible the access to the resource and reduces the risk of the activity. They form fleets of boats and help one another during the working day. When one of them does not achieve a profitable landing, other helps economically or offer him jobs in their vessel. These collaborative forms are usual between relatives or friends, although it is less regular between strangers	Workshops and interviews
Knowledge of SES/mental models (A7)		
– Local knowledge on SES (A7a)	High level of knowledge of the system and the effects of disturbances The knowledge is mostly traditional, although in recent years fishermen have turned to high-education and research institutions for the analysis of anthropogenic effects	Workshops and interviews; Rojas et al. (2014a)
– Knowledge of the effect of over-harvesting (A7b)	High knowledge of the effect of over-harvesting There is a high level of awareness about the consequences of overfishing and the use of aggressive techniques such as trawling	Workshops and interviews
– Knowledge of the effect of social attitudes (A7c)	Medium level of knowledge of the effect of social attitudes Particularly, fishermen do not recognize their own responsibility with respect to the overuse of resources or other ecological damages	Workshops and interviews
– Knowledge of the effect of biological shocks (A7d)	High level of knowledge of the effect of biological shocks Fishermen can anticipate the consequences of some biological impacts. They predict how shrimp move according to the winds, or how the resource reacts in periods of extreme rainfall or drought	Workshops and interviews
– Mechanism to share knowledge about fishery (A7e)	Medium level of development of mechanism to share knowledge Information and knowledge are transmitted by word of mouth, mainly inside the intra-family or nearest groups (seeA6a), or in associations' meetings. There is no formal media mechanism	Workshops and interviews
– Mental models related to SES management (A7f)	High understanding of the complexity in SES management Fishermen know that the surrounding sea region affects and depend on estuarine and coastal area. Particularly, in the description of a management plan for the sustainable use of resources, they consider that the whole SES and the related SES (El Rincon area, beaches and tourism and even the marine area beyond El Rincon) should be taken into account, as well as all interested actors should be included in the discussions	Workshops and interviews

Annex 2 (continued)

Variable	Description	Source
Importance of resources (A8)		
– Economic dependence (A8a)	High relevance of the resource as income source Fishery sustains the livelihoods of artisanal fishermen	Workshops and interviews
– Cultural dependence (A8b)	High level of cultural dependence Actors identify themselves with the activity, which generate a high level of relevance of resources as source of cultural values	Workshops and interviews
Technology used (A9)		
– Ownership of different types of technology by fishermen (A9a)	Low level of concentration of ownership of technology Artisanal fishermen hold small or medium vessels with a low or medium level of technology. There is a relatively equality in ownership. Private property dominates the activity, with the exception of the new processing plant in Monte Hermoso. Although the property of the terminal will remain under the municipality government, it will be administrated by a tripartite organization formed by: agents from municipality, artisanal fishermen and a technical manager	Workshops and interviews
– Homogeneity (A9b)	Medium level of homogeneity in the use of technology Although artisanal fishing is performed by minor boats, the techniques used are diverse (see GS5a). Investments in improvement of fleets and human constructed facilities (RS4) in the area of Bahia Blanca establish difference in the level of technology with respect to Monte Hermoso – Pehuén Co area	Workshops and interviews
Interactions (I)		
Harvesting levels of diverse users (I1)		
– Harvesting level and effects on SES (I1a)	Medium to low harvesting level of artisanal fishery; high level of harvesting of bottom trawls fisheries in related SES (El Rincón) Technical conditions allow extracting a.c. 10–20 crates of product a day, while trawlers are able to capture 150–200 crates a day (its mean 3–4 tns). Lopez Cazorla et al. (2014) provide that the maximum artisanal catch in Bahía Blanca Estuary during 1992–2009 was 189.6 tns in 1992. After this year, catches decreased up to a minimum of 0.6 tns in 2001–2004. Catches seem to increase steadily since 2004 reaching 61 tns for 2009. Conversely, landings in El Rincón area (its mean, off-shore fishery) increased from the 1992–1993 period (being the mean 2,632 tns) to higher values between 1994 and 2002, where the highest landing was 9,623 tns in 2001. Since 2003, landings dropped to lower values, with a mean of 4,305 tns. Official data for 2010 (Sánchez et al. 2012) describe a	Interviews and workshops; Sánchez et al. (2012); Lopez Cazorla et al. (2014)

Annex 2 (continued)

Variable	Description	Source
	harvesting level of a.c. 3910 tns declared in Bahía Blanca Port. Nevertheless, the composition of landings by type of fleet shows a very unequal capacity of charge. Landings from off-shore fisheries represent about 3550 tns, while only 360 tns correspond to in-shore fleets. During the last years, trawling has been widely extended, increasing the overharvesting	
– Free-riding (I1b)	High presence of free-riding The absence of strong controls causes the existence of free-riding, especially fisheries without license from other areas. Due to the extension of the area and fails in controls, external can access to the resource system by the sea	Interviews and workshops; London et al. (2012)
Information sharing among direct users (I2)		
– Knowledge dissemination (I2a)	Medium to high level of knowledge dissemination The exchange of information is doing by word of mouth and through fisheries associations. Actors emphasize the relevance of leaders in the knowledge dissemination	Interviews and workshops
– Information/ knowhow sharing (I2b)	Medium to high level of information sharing Information about spatial and temporal resource availability, the fishing areas with high productivity, the presence of free-riders or the weather warnings probability (storms, wind rotations) are sharing between users	Interviews and workshops
Deliberation processes (I3)		
– Deliberation processes among direct users (I3a)	Low development of mechanisms of deliberations processes Deliberation processes occur in frequent meetings of fishermen associations. Nevertheless, processes of decision making have not been mostly formalized. Leaders have a prominent presence and relevance on deliberation processes. There is a low level of integration with other relevant actors in deliberation processes	Interviews and workshops; London et al. (2013)
– Knowledge about participation mechanisms and rights (I3b)	Medium level of knowledge about participation mechanisms and rights The level of participation is increasing, as well as knowledge about participation mechanisms and rights	Interviews and workshops; London et al. (2013)
Conflicts among actors (I4)		
– Conflicts among direct users (I4a)	Low level of conflicts within the communities of Monte Hermoso and Pehuén Co; high level of conflicts between them and fishermen from Bahia Blanca area	Interviews and workshops; London et al. (2012); Rojas et al. (2014a)

Annex 2 (continued)

Variable	Description	Source
	Fishery in Cerri, White and Villa del Mar are more affected by the overharvesting of trawling fleets, the lack of control over catches, the dreadging and the industrial pollution and sewage. Then, a group of users want to turn the artisanal fleet into bottom trawl vessels, with the objective of participate in El Rincon area and increase their productivity (see A3). Fishermen from Monte Hermoso, Pehuén Co and some from Bahia Blanca react against the restructuring because it will mean a greater pressure over resources	
– Conflicts with externals (I4b)	High level of conflicts between direct users and other relevant actors in SES The asymmetry in the access to resources between industrial (with powerful engines and storage capacities that exceed 40 tns) and artisanal fisheries have caused the increases in the economic and politic power of industrial fisheries. Some of those fisheries are from Mar del Plata, an adjacent zone of our SES. Given the exhaustion of fishery resources around the area of Mar del Plata, fishermen from that community want provincial government to reduce the currently 6 months ban to 3 months in El Rincon, to reduce the restriction area and to allow trawling within 3NM The conflicts between users are frequent in White because of pollution (fishermen *versus* industry interest) and their effects on the fishery resource, as well as due to the restricted access to the port and coastal area fishermen *versus* local decision makers). In 1989–1991, the navigation channel of Bahía Blanca Estuary was dredged to a depth of 13.5 m (45 ft) from a previous 10 m, and its development has promoted the settlement of several industries that have formed one of the most important petrochemical centres of Argentina. It supposes a large volume of sediment to be dredged and dumped on the adjacent wetlands constantly in order to maintain the channel, which modify the biological and morphological conditions of the estuary. The conflict worsened when the federal government, associated with the national oil company, planned a major Liquid Natural Gas (LNG) plant in the inner portion of the estuary. The plant would receive imported LNG from very large ships which require specific navigation conditions. Therefore, a major dredging project was designed to work in the most sensitive sector of the estuary where the very first steps in the food chain of the system occur. There was significant opposition from community and scientists, which included legal actions. The dredging could affect more than 1500 families that live directly or indirectly on the artisanal fisheries resulting in a loss of over 5 million dollars within the first 10 years after the dredging (Zilio et al. 2013). However, the project was rejected by OPDS and alternative locations are under consideration. Fishermen had confronted the municipal government and authorities of the port, interrupting communication routes or even placing the fishing boats before the dredge tasks zone	Interviews and workshops; Sunye (2006); London et al. (2012, 2013); Rojas et al. (2014b)

Annex 2 (continued)

Variable	Description	Source
	In Monte Hermoso and Pehuén-Co fishermen demand the building of a new local road to facilitate the commercialization of products between both localities. Nevertheless, other relevant actors (rangers, tourism sector and local decision makers) argue that such a road could damage the reserve area, increasing the erosion and having negative effects on tourism. Also tourism sector claims for a more bounded use of the coast and beach by artisanal fishermen in order to develop their own activity	
Investment activities (I5)		
– Type of investment (I5a)	Medium level of investment; high level of heterogeneity between areas The government has done the biggest investment effort in fishery during the last years. While 3 million pesos were invested to convert artisanal fishing boats in industrial vessels in BBE area, the largest investment done in MH-PC was the installation of a fish processing plant (it required an investment of 1.5 million dollars). The processing plant project has been financed by a national subsidy given to the Artisanal Fishery Chamber of Monte Hermosos – Pehuén Co	Interviews and workshops; London et al. (2013)
– Degree of dependency on external investments (I5b)	High level of dependency on external investment As said before, investment was realized by federal and provincial government. Fishermen do not have reinvestment ability	Interviews and workshops; London et al. (2013)
Lobbying activities (I6)	Low level of direct users in lobbying activities; high level of external and other relevant actors AIQBB is perceived as a pool of the largest industries of the Petrochemical Pole, whose lobbying power is turned to their own advantage. Industrial sector in Bahia Blanca has prevented local initiatives of fishermen to avoid industrial pollution and to recover the coastal access. Direct users also recognize the existence of lobbying activities by externals in fishery (i.e. fisheries entrepreneurs linked with many trawling vessels acting illegally in the area have contact with provincial decision makers). Lobbying activities could also be at the basis of conflicts related on the formal establishment of ban and forbidden areas	Interviews and workshops; London et al. (2012)
Self-organizing activities (I7)	Low to medium level of self-organizing activities The number of self-organized activities eventually rises when community have to face a conflict. Social organization is not spontaneous because the low level of collective action and the weakness of network structures	Interviews and workshops

Annex 2 (continued)

Variable	Description	Source
Networking activities (I8)		
– Internal networks (I8a)	Medium and increasing development of internal networks Fishermen and neighbor associations are increasing their participation in the community and extending the contact between them, above all in MH-PC region	Interviews and workshops
– External networks (I8b)	Low development of external networks Fishermen from Monte Hermoso and Pehuén Co are currently building networks with external actors. They recognize their relevance in knowledge and information exchange, lobbying activities and power group formation	Interviews and workshops
– Partnership and cooperation (I8c)	Medium and increasing level of cooperation and joint activities in MH-PC area; low level in BBE Joint activities are increasing in MH-PC area. The relationship of fishermen with the neighborhood association in Pehuén Co and Cerri, the communication between fishermen and Coast Guard, the building of the processing plant as a cooperative, show a better performance in cooperation. The need to work together with other fishermen and even with other actors' groups has improved the mutual understanding, truth, trustworthiness and, thus, the cooperation	Interviews and workshops
– External communication channels (I8d)	Medium development of external communication channel Media has a relevant role as communication channel between externals	Interviews and workshops
Outcomes (O)		
Social performance measures (O1)		
– Efficiency (O1a)	Low to medium level of efficiency Conde et al. (2009) mentioned a decrease in the fishery yield. Fishermen recognize the existence of an increment in discards of both juvenile of target species and species of no or reduced commercial value. Moreover, the area for artisanal fishery has been reduced (see A3), concentrating the fishing effort of artisanals in a smaller area. Actors also admit that the reduce level of common organization influence the low level of efficiency in the activity	Workshops and interviews; Conde et al. (2009)
– Equity (O1b)	Medium to high level of equity The distribution of benefits is made among direct participants in fishery	Workshops and interviews
– Socio-economical sustainability (O1c)	Medium to low level of socio-economical sustainability As a consequence of the environmental sustainability decrease (see O2a), socio-economical conditions of local communities are in risk	Workshops and interviews

Annex 2 (continued)

Variable	Description	Source
– Accountability (O1d)	Low level of control over the power of decision makers The accountability depends on the availability of mechanisms of common control over governmental institutions. Such mechanisms are perceived by users as extremely weak	Workshops and interviews
– Effects of deliberation processes (O1e)	Low to medium effects of deliberation process Deliberation processes with respect to the management of resources are incipient and collective action is not beat policy making processes	Workshops and interviews
– Empowerment (O1f)	Medium level of empowerment; mainly increasing in MH-PC If empowerment is understood as the community ability to participate *effectively* in decision-making processes improving the common-based management, then, knowledge about SES, the increasing civic participation and cooperation, the rise in NGOs presence and a better self-organization, all are increasing the empowerment in MH-PC	Workshops and interviews; Rojas et. al. (2014a,b)
– Adaptation strategies to climate change (O1g)	Low level of development of adaptation strategies No formal strategy has been implemented. Fishermen change the species and areas of catches according to fluctuations	Workshops and interviews
Ecological performance measures (O2)		
– Environmental sustainability (O2a)	Low to medium level of environmental sustainability The extension of ban period has shown that species are capable of regeneration. Nevertheless, sustainability depends on the overharvesting control. The effects of the dredging as well as the vessel circulation and maintenance of the channel and harbors could sensibly reduce the ecosystem value. Potentially, these modifications of the system will be able to introduce such irreversible changes that will fully alter the ecological conditions of the whole estuary. Zilio et al. (2013) estimated the possible loss of nursery service through the added value of the fishery sector at producer prices for Bahía Blanca if the deepening of dredging process will be made. The social cost was valued in €807,565.5 per year, whereas the total cost for loss of nursery service and loss of employment sources was calculated in €3,343,487 (in an intermediate scenario)	Zilio et al. (2013), Rojas et al. (2014a)
– Pressure on resources (O2b)	High level of pressure on resources In 2001, CFP forecasted a tendency toward reduction in biomass. Overharvest conducted by bottom trawl fisheries, pollution and dredging process into the estuary, all mean heavy pressure factors on resources. The problem with the intensification of fishing efforts outside of the SES area is that this might neutralize the conservation objectives inside the area, especially when the access is not controlled	CFP (2001), Lopez Cazorla et al. (2014)

Annex 2 (continued)

Variable	Description	Source
– Natural habitat (O2c)	Low level of natural habitat conservation Natural habitat has suffered degradation, especially in the estuary area due to pollution and dredging. Species richness has been reduced. Started links of trophic chains are on risk, being on risk all the natural system of the SES and related SES	London et al (2013); Rojas et al. (2014b)
– Effect of SES management on natural hazards (O2d)	Low to medium level of users' capacity to face natural disasters Type, frequency and patterns of storms have changed. Fishermen detected more intensive storms but of minor duration. Contact with PNA and other institutions permits fishermen to access to technology of prediction and localization of storms into the sea	Workshops and interviews
– Structure and function of resources (O2e)	Medium to high level of changes in resource units' interactions The capture proportion of fish species has changed. Lopez Cazorla et al. (2014) mentioned the possibility of trophic cascade effects due to the overfishing and the degradation of the benthic environment produced by bottom trawls. Alterations in the composition of species and migrations trends, shifts in the reproductive behavior and species extinction can be the outcomes of the trophic cascade effects	Workshops and interviews; Lopez Cazorla et al. (2014)
– Soil (O2f)	High to medium level of erosion and degradation in coastal areas For further information see Rojas et al. (2014b)	Rojas et al. (2014a,b)
– Water (O2g)	Medium to high level of water pollution Water pollution in the estuary area is due to untreated sewage discharge. Other relevant source of pollution are the open-air garbage disposal (located in Coronel Rosales and Monte Hermoso) and the industry	London et al. (2013)
– Air (O2h)	High quality level of air in Monte Hermoso and Pehuén Co; low to medium level quality in the area of Bahía Blanca Air quality reduces in Bahia Blanca area due to fumes and ashes from Industrial Pole	London et al. (2013)
– Pollution (O2i)	Medium to high level of pollution Urban pattern pollution (see ECO2) affects directly the estuarine and coastal area, having more severe effects over the BBE zone	London et al. (2013)
– Resilience (O2j)	Low level of resilience The area of the estuary has a very low residence time (estimated in 28 days), any suspended sediment concentration that will be removed during the dredging will have a long residence time within the area and necessarily affect the levels of light penetration and, consequently, phytoplankton, zooplankton and benthic populations growth causing the disappearance of the resource from the beginning of the trophic chain	Piccolo and Perillo, (1990); Zilio et al. (2013).

Annex 2 (continued)

Variable	Description	Source
– Vulnerability (O2k)	High level of vulnerability The complexity of tropic chain, the characteristics of the area (migration patterns of species, different stage of the life cycle in different areas, etc.), the anthropic effects and the biological and morphological conditions make the SES extremely vulnerable. In fact, estuaries are one of the most vulnerable ecosystems in marine areas	Sladek-Nowlis and Friedlander (2004); Zilio et al. (2013)
Externalities to other SES (O3)		
– Positive externalities (O3a)	Medium level of positive externalities into the SES Fishermen help to preserve turtles and other non-commercial species, protecting the biodiversity. They notify when a turtle or dolphin have been caught by their fishing net, allowing environmental associations to monitor the species	London et al. (2013)
– Negative externalities (O3b)	Low level of negative externalities Fishery produces certain level of pollution due to cleanup of species at the beach. Also, noise and air pollution on the beaches of Monte Hermoso and Pehuén Co are consequence of the trawl machine of vessels. Mortality of non-commercial species or juveniles catching by nets are other negative externalities	London et al. (2013)
Related ecosystems (ECO)		
Climate patterns (ECO1)		
– Extreme events (ECO1a)	Medium level of occurrence of extreme events The strongest storms associated with winds from the S-SE-SW occurred during July (winter), December and January (summer). Winds were recorded up to 100 km/h	London et al. (2013).
– Sea level or coastal variations (ECO1b)	Medium to high variations in sea level and coastal characteristics Analysis of tides records of the study area show that the mean sea level increase for Argentina is estimated in 1.6 mm/year from data starting in 1900. Lopez Cazorla et al. (2014) found significant variations in salinity in the estuarine area, from 1992 to 2009	London et al. (2013); Lopez Cazorla et al. (2014)
– Temperature (ECO1c)	Medium to high level of variations in temperature of air and water The study zone has temperate climates: annual temperatures between 14 and 20 °C. Four seasons well defined: spring, summer, autumn and winter. The mean temperature in January (summer) is 24 °C and in July (winter) is 8 °C. The frosts are extended from May to the beginning of October. In the last 50 years (1951–2000), the Bahia Blanca Estuary has registered an increase of 0.7 °C (0.14 °C per decade) in mean annual temperatures. In the estuary, the air temperature presents mean daily values of 20.5 °C (maximum temperatures), 14.5 °C (mean	London et al. (2013)

Annex 2 (continued)

Variable	Description	Source
	temperatures) and 8.7 °C (minimum temperatures). In Monte Hermoso the mean temperature of 2008–2011 period was 15.2 °C. While in Pehuén Co was 14.3 °C. In Monte Hermoso variations in the annual mean temperature were observed with an increase of 0.6 °C from 2008 to 2009 and a decrease of 1.4 °C for 2010. In Pehuén Co the annual mean temperature has an increase from 12.5 °C in 2005 to 15.3 °C in 2009. The mean water temperature for the period 2000–2007 (14.5 °C) is lower than mean annual values of 15.2 °C and 15 °C registered in Puerto Cuatreros (period 1967–1984) and in Ingeniero White (period 1979–1985), respectively. The mean water temperature in the estuary is of 7 °C in winter and 26 °C in summer. In the zone of Pehuén Co and Monte Hermoso these extreme values change between 7 °C in winter and 27 °C in summer. The maximum temperatures registered in the coastal cities of Monte Hermoso and Pehuén Co occurred in January (summer) with values up to 40 °C. The largest duration of heat wave lasted 8 days with minimum temperatures of 30 °C during the night. The historical coldest wave was registered in winter with values of –10 °C	
Annual precipitation variations (ECO1d)	Medium to high changes in historical annual patterns of precipitations The period 2005 to 2011 was characterized by a drought that affected all the study area. In general, the study area is characterized by alternating wet and dry periods. The precipitations in the zone vary between 500 and 1000 annual mm. The coastal cities of Monte Hermoso and Pehuén Co were characterized since 2005 to 2011 by predominant dry periods. Monte Hermoso in 2010 registered the maximum precipitations with 525.6 mm. In Pehuén Co the rainiest year was 2007 with 490 mm. Currently, precipitation seem to be increasing heavily	London et al. (2013)
Season changes (ECO1e)	Medium to high changes in historical season patterns Particularly, winter and summer are longer than usual, while autumn and spring become short	London et al. (2013)
Pollution patterns (ECO2)		
– Pollution patterns from production (ECO2a)	High levels of pollution from production Although petrochemical effluents were high from the 1970s to middle 1990s, strong regulations and control over the industries have resulted in a significant reduction of the industrial pollution in the estuary. Nonetheless, levels continue being high	London et al. (2013)
– Pollution patterns from social activities (ECO2b)	High levels of pollution from social activities Untreated sewage discharge is very relevant in all communities. Also there is a medium level of waste generation in coastal areas due to tourism	London et al. (2013)

Annex 2 (continued)

Variable	Description	Source
Flows into and out of focal SES (ECO3)	High relevance of flows into and out of focal SES Given the migratory cycle of species, overexploitation in the area of El Rincón affects directly the spawn and reproduction of species catched by artisanal fishery in the coastal area until 3 NM and into the estuary. Similar conditions of harvesting levels affect the rest of the Argentinean coast near the area. From 1992 to 1998 the number of industrial vessels targeting striped weakfish at the northern continental shelf of Argentina has doubled, and the amount of effort measured in fishing hours has quadruplicated (Ruarte et al. 2000). Lopez Cazorla et al. (2014) conclude that the landings of the artisanal fishery operating in the Bahía Blanca Estuary were affected by the increasing fishing pressure exerted by the industrial fishery fleet of El Ricnón area. The overexploitation along the whole marine area of the Buenos Aires Province affects directly the outcome into the estuary and coastal zone. At the same time, the estuary mouth is the spawning ground for many species which migrate toward the rest of the marine areas in Argentina, Uruguay and Brazil. Then, it is generating a positive and very relevant flow out of the focal SES Other focal and relevant SES in MH-PC is the tourism, which supposes the intensive use of coastal resources. Actors involving in tourism compete against fishermen for the use of the beach and the access to the coast	Ruarte et al. (2000); Perrotta et al. (2007); London et al. (2012); Lopez Cazorla et al. (2014)

Data from INDEC corresponds to *Censo Nacional de Población, Hogares y Viviendas 2010* and *Dirección Provincial de Estadística y Planificación General 2005,* database: Redatam + SP. See http://www.indec.gov.ar. Data from CREEBBA can be consulted at http://www.creebba.org.ar.
Source: Own elaboration.