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Research article

Artisanal mollusc fisheries co-management in Brazil and Italy: Institutional innovations to address environmental crisis

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ABSTRACT

Initiatives of artisanal fisheries co-management and the construction of differentiated markets for seafood products have been emerging in different parts of the world, as an institutionalized way of coping with a global fishery crisis. This paper analyses some institutionalization processes of artisanal mollusc fisheries, considering the role of co-management in two Brazilian and Italian protected areas (Resex Pirajubaé and Conero Regional Park). Within a theoretical framework aiming at moving beyond the dualism between nature and society, the methodology of multiple-case-study has been used to carry on research about mollusc artisanal fisheries co-management networks in their constitution and development. The paper analyses how these networks are organised in the two contexts and the relations social actors have been developing for a sustainable fishery as a possible way to influence and increase their capacity to address environmental crisis. In the artisanal mollusc fishery co-management experiences, fishers' participation may favour institutional innovations and the co-management networks stability may be generated by the institutions legitimacy. Furthermore, the case studies offer complementary insights to better understand the linkage between artisanal fishery institutionalization processes, common natural resources co-management and value aggregation for traditional seafood. Artisanal mollusc fishery co-management experiences should be stimulated and investigated since they can help in diagnosing early climate and environmental changes in the oceans.

1. Introduction

Bivalve mollusc production per catch is declining worldwide. Since the 1980s a decline has been recorded for oysters and clusters, since the 1990s for mussels and more recently for scallops (FAO, 2018). Ocean degradation (Pezzuto and Echternacht, 1999; Pinkerton and John, 2008; Romanelli et al., 2009; Camp et al., 2015; FAO, 2018; Prieto-Carolino et al., 2018; Alati et al., 2020), diseases (Camp et al., 2015), aquaculture development (Pinkerton and Silver, 2011; FAO, 2018), and commercial overfishing (Mattei and Pellizzato, 1996; Defeo and Castilla, 2005; Callon, 2007; Frangoudes et al., 2008; Pinkerton and John, 2008; Prieto-Carolino et al., 2018; Alati et al., 2020; Roa-Ureta et al., 2020; Petetta et al., 2021) are among the factors which have caused the decline. The situation is made even worse by the progressive increase in demand in local and foreign markets related to a globalized and commoditized food supply chain (Anderson et al., 2018; FAO, 2018), as well as by the effects of oceans acidification and warming (Badjeck et al., 2010; Mackenzie et al., 2014; FAO, 2015, 2018; Alati et al., 2020), leading to a serious metabolic rift (Clausen and Clark, 2005).

Within artisanal fishing, responses to this critical scenario have been related to institutionalization and co-management processes, embracing actions and policies for environmental protection and socioeconomic development.

This paper is particularly focused on the role of co-management of common natural resources (Vieira et al., 2005; Seixas et al., 2011) within the institutionalization process of mollusc artisanal fisheries. In order to investigate this issue, the Authors adopted a multiple case studies methodology (Yin, 2001; Gil, 2002) analysing two experiences from Brazil and Italy. The research aimed at understanding and discussing whether or not the way these experiences have been developed

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and organised with concern to the relationship between natural resources and social actors may have somehow influenced their capability to cope with environmental crisis.

In Brazil, the study involved the experience of fishery co-management of the Berbigão (clam - *Anomalocardia brasiliana*) in the district of Costeira do Pirajubaé (city of Florianópolis, in the state of Santa Catarina). This case refers to the creation of a Marine Extractive Reserve, a Brazilian protected area category that is aimed at protecting the traditional populations' livelihoods and ensuring the sustainable use of natural resources by granting territorial fishing rights to a group of artisanal fishers. The Italian case study is focused on the co-management of the *Mosciolo Selvatico* (wild mussel - *Mytilus galloprovincialis)* fishery in Portonovo, a resort that is the main tourist attraction of the city of Ancona (the capital of the Marche region), as part of the Conero Regional Park. This experience involved the creation of a brand of quality and origin that has developed alternative markets for the mollusc.

In both situations, institutions for regulating fishery production have been developed with the participation of the fisheries communities. In the Italian case, the creation of the quality certification involved the establishment of a production protocol according to the *Slow Food* Movement criteria, representing an initiative promoted by the organized civil society. In the Brazilian case, the regulation took place at the level of environmental legislation, constituting a typical process of co-management with a strong public participation from environmental agencies.

Due to the emergence of a growing number of environmental issues – including a global fishery crisis and ocean degradation - the need for interdisciplinary research based on theoretical approaches aiming at identifying relationships between social and biophysical factors has become even more evident (Stuart, 2016). A holistic theoretical-methodological framework aiming to go beyond the dualism nature/society has been used in this comparative research (Stuart, 2016). Without necessarily abandoning categories altogether, nor choosing one paradigm specifically, this study has taken inspiration from both the socio-ecological systems resilient theory (Holling, 1973; Berkes et al., 2003; Walker and Salt, 2006), the Actor-Network Theory - ANT (Callon, 1986, 2007; Law, 1992; Latour, 1994, 2001, 2012) and the Common Pool Resources - CPR framework (Ostrom, 1990), focusing on the role of co-management in the sustainability of social-ecological systems.

The next sections of the manuscript examine the theoretical and analytical approaches considered and outline the methodological path of the research. Following these, the two cases are described and their management and institutionalization processes are analysed, leading to the possibility of mutual learning.

2. Theoretical background: institutionalization and co-management of artisanal fisheries

In the context of small fishery, co-management refers to a form of partnership in which public institutions, fishers, resource users at the local level, external agents and other actors share responsibility and authority within the decision-making of the resources management (Vieira et al., 2005). This usually leads to the creation of public arenas focused on the arrangement of environmental management instruments for fishing, with an important institutional mediation and the support from both the technical-scientific and the local knowledge (Defeo and Castilla, 2005; Frangoudes et al., 2008; Pinkerton and John, 2008; Osti and Silvestri, 2009; Van Holt, 2012; Spínola et al., 2014; Santos and Schiavetti, 2014; Trimble and Berkes, 2015; Rocha and Pinkerton, 2015; de Araújo et al., 2017; Léopold et al., 2019). A central role in these processes is represented by institutions which, in co-management studies, are often defined as a set of rules, norms, beliefs, role, laws and mechanisms that constraint and facilitate human organization and actions, eventually reinforcing the objectives of the resource management (Feeny et al., 1990; Ostrom, 1990).

With special concern to fisheries, co-management can emerge or benefit from institutional innovations because these can bring about the construction of alternative markets for local and traditional seafood products (Goodman, 2003; Campbell et al., 2014; McCleanachan et al., 2014; Marsden, 2018; Salladarrè et al., 2018; Makuta, 2018; Chiodo et al., 2019), as it has also been observed in the case studies.

These theoretical perspectives have allowed the Authors to highlight the interdependence between natural factors and social actors, by focusing on the strategies that can improve the actors' capability to deal with natural thresholds and environmental changes. More generally speaking, when the actors involved in the institutionalization process come to an agreement, a common project is expressed and starts to be disseminated, somehow contributing to the durability and stability of the co-management network itself. Vice versa, when the representativeness of these actors involved is questioned, discussed or rejected, socio-technical controversies emerge thus threating the stability and durability of the relations within the public arenas (Callon, 1986, 2007, 2007; Latour, 2001). Therefore, the institutionalization process within the framework of co-management can work as a means to both manage common pool resources and address socioeconomic issues (Galappaththi and Berkes, 2015; Nursey-Bray et al., 2018).

Then, the institutional production is part of a negotiation process in which some actors seek to define the level of importance and the roles of others according to a specific objective (Callon, 1986, 2007). These actors can concentrate power in decision making and are called actor-worlds (Callon, 1986). Particularly in socio-ecological systems, which are dynamic and subject to complex and uncertain influences, the effectiveness of institutions, with respect to management outcomes, is inseparable from the institutional building process itself (Léopold et al., 2019).

If we read these processes from an ANT perspective, we can realize the equal acting potential for human and non-human factors, which are no longer considered mere "inputs", but active forces in social relations. According to it, entities such as institutions, for example, are generated by heterogeneous networks composed of various actors, not exclusively human, which are called socio-technical networks and correspond to a community of actors who mobilize around a common project (Law, 1992; Latour, 1994). In this framework, innovation is conceived as a collective action whose success depends on the adaptations and transformations occurred along the institutionalization process (Callon, 2004).

The study hypothesis is that institutional innovations associated with co-management strategies involving fishers' communities can better ensure the conservation of common pool natural resources and confer a certain stability to the socio-ecological systems of artisanal mollusc fishing, addressing environmental crisis (Ogier et al., 2016).

3. Materials and methods

This research has used qualitative tools and it is based on multiple-case-study research design (Gil, 2002). In multiple case studies, the analytical integration of cases is only conducted after an individual study of each case. In this way, a deeper knowledge of the phenomenon under study and the theoretical approach is reached, allowing the capture of both differences and similarities between cases (Yin, 2001). Multiple case studies based on an environmentally holistic approach assume that the practices of the actors constitute the focus and that they produce some important categories or variables for the analysis. Therefore, the methodology relies on the researcher's ability to map the network of relationships between actors.

The main data refers to the collection of thirty in-depth interviews with key informants, including fishers (18), researchers (3), market agents (2), environmentalist (1), *Slow Food* activists (3) and technicians from environmental, fishing and sanitary public control agencies (3).

The research technique of in-depth interviewing is considered non-

standard as it is flexible and the questions can be rearranged according to each interviewee's role and availability to cooperate in the research. Therefore, instead of referring to a closed and standardized set of questions, the Authors have interviewed their informants on the basis of a list of themes (Supplementary material) grouped around the following macro-dimensions:

(a) Economical and organizational dimensions of traditional fishery;
(b) Socio-political aspects and the institutionalization process;
(c) Environmental aspects;
(d) The role of tradition – fishers' life style (anthropological aspects).

In addition to the interviews, the research has also gained in-depth analysis thanks to direct observation. The researchers have taken part both in fishers' communities' activities (mollusc production and marketing in particular), in ecological field research, in institutional management meetings and in public/academic events in both countries. These observations have provided further empirical material (Supplementary material). The field research was conducted between 2016 and 2018, as along with the bibliographical and documental survey. The main academic online research platforms mostly referring to articles published during the last ten years were accessed for bibliographic research using the following keywords: artisanal mollusc fishing, sustainable mollusc fishing, mollusc fishing co-management, Resex Pirajubaé and *Mosciolo Selvatico*. The documents related to each of the study cases have been provided by the researchers, technicians and *Slow Food* activists, who have been interviewed.

In line with this methodological framework, the Authors divided the main category of co-management into some main elements highlighting 6 sub-issues for the analysis of molluscs fisheries management in both case studies, such as: (1) relation between technical-scientific and traditional knowledge; (2) existence of arenas for collective deliberation; (3) adaptation of rules to fishing livelihoods; (4) role of the markets within the institutionalization process; (5) ecological sustainability of the resource; (6) fishing community organization capacity and the role of non-human factors such as artisanal fishing techniques, sea polluting agents and contaminants, sanitary and environmental regulations and others.

4. Results and discussion

4.1. Description of the cases

4.1.1. The case of the Berbigão fishery in the Pirajubaé Marine Extractive Reserve - Brazil

The Pirajubaé Marine Extractive Reserve (Resex Pirajubaé) was the first conservation unit of this category created in the Brazilian marine environment in 1992 (Fig. 1). Its creation derives from a co-management process started in the late 1980s, which involved artisanal fishers, scientists and environmental public agencies in a pilot project of fishery of the Berbigãoclam *Anomalocardia brasiliana*. The project was based on an applied research aimed at evaluating the impact of the use of a fishing gear for a "rational use" of the mollusc (AREMAPI, 2001).

At the end of the five year pilot project, the research proved that the fishery in the way it had been tested was ecologically sustainable. The

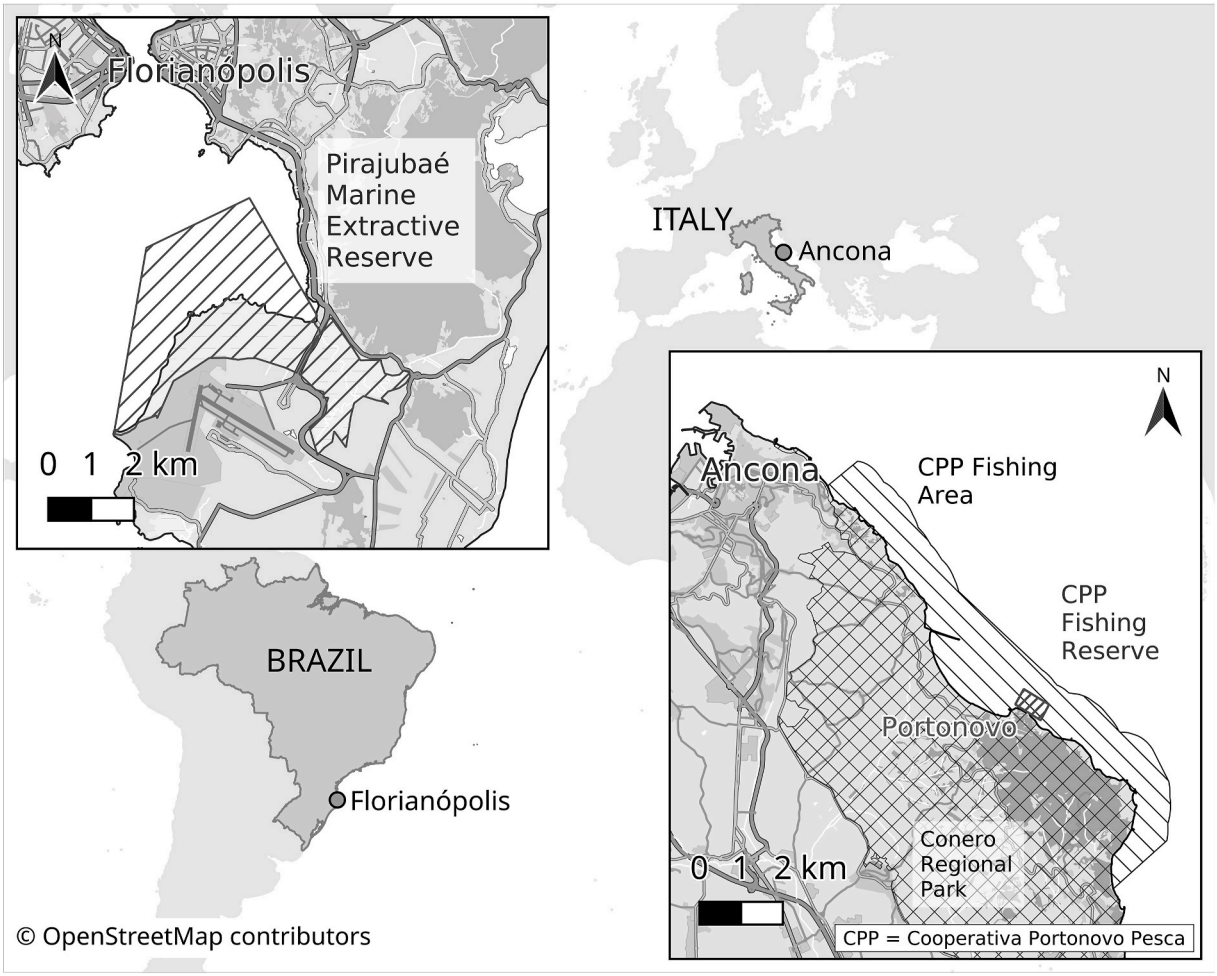

Fig. 1. Location of the case studies: Pirajubaé Marine Extractive Reserve (Brazil) and *Slow Food* Presidium of the Portonovo *Mosciolo Selvatico* (Italy).

results of the research gave rise to a management plan containing the rules of extraction and fostering the process of state regulation of the clam fishery (AREMAPI, 2001).

The "rational use" as a scientific "fact" involved a set of negotiations of interests between different actors. Clam fishing began to be influenced by technical-scientific knowledge practices, following a kind of training for sustainable fishing. In this process, the adherence of the fishers to the pilot project was fundamental for carrying out the research. At the same time, it constituted a strategy for social reproduction, since the authorization for commercial extractivism through the use of the new instrument was conditioned by the participation in the project. Also the commercial arrangement was endorsed by the pilot project, which aimed to control the quantities and quality of the molluscs caught.

The creation of Resex Pirajubaé had the active participation of artisanal fishers, who began to declare themselves the "traditional population" in the expectation of protecting their territory and improving their living conditions, in a sustainable way. Fishers experienced new forms of collective organization in this process, founding the Pirajubaé Marine Extractive Reserve Association, AREMAPI in 1995.

The success of the pilot project and the stability of the Resex institutional arrangements were, however, temporary. The representative legitimacy of the state environmental agency (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis - IBAMA) was strongly questioned by the fishers when it granted authorization for the construction of a landfill and highway over its fishing territory. The authorization allowed the removal of seven million cubic meters of sand from the banks located within Resex. The dredging covered almost 100 ha of productive area for fish, shrimps and clams, whose monthly production exceeded 12 tons (AREMAPI, 2001). There was a significant demise of marine fauna. The traditional population was denied the right to a voice. The consensus and alliances that legitimized the institutional arrangements were dissolved on this occasion, amidst the socio-technical controversy generated, exposing the contradictions of the environmental agency and the power of political and economic interests in the decisions about the road. As a result, a situation of environmental conflict and socioeconomic vulnerability of fishing families, which were not properly consulted and compensated for the impact of the project, was triggered.

Since this event, the socio-technical network of sustainable clam fishery has become destabilized, although scientific research and co-management processes have continued as part of the process of institutionalization of the Resex (Spínola et al., 2014; Pezzuto and Silva e Souza, 2015). The rules for the collection of clams have suffered changes over time, and controversies between scientific parameters and the needs of fishing from families have arisen. The limitation in the number of fishing licenses and the incompatibility between some rules and the ecosystem dynamics affected the work routines and the insertion of young people in fishing activities.

The fishers proceeded with commercial clam capture, defending their rights. The extraction of clams began to be carried out in a decentralized way by different family nuclei, which generated work and income, especially for women.

However, in a context of greater capture pressure, researchers drew attention to the significant and continuous decline of clam biomass in the Resex over fifteen years of monitoring (from 1996 to 2011) (Pezzuto and Silva e Souza, 2015). With the exception of the pilot project, when capture and marketing were centralized and monitored, commercial relations between fishers and middlemen occurred a part from the institutional arrangements previously negotiated.

From the first regulation actions to date, the number of fishers authorized to carry out commercial clam fishing has ranged from 12 to 30 people. Currently, there are 25 people licensed for clam fishing.

With the creation of the Resex deliberative council in 2009, the main decision-making space for the protected area was institutionalized, chaired by the Chico Mendes Institute for Biodiversity Conservation – ICMBio, the public agency of the federal administration in charge of the management of protected areas. The creation of the council enabled the integration of new actors into the network. During this period, the *Slow Food* Movement promoted a discussion on the traditionality and quality of clam food, encouraging short marketing channels and higher added value for the *berbigão* clam.

Initiatives to promote socioeconomic development in the clam fishery chain from 2009 onwards were interrupted by the unexpected mortality of a large part of the Resex's clam population, as well as in other sandbanks in the Florianopolis region, in the summer of 2015. This event disrupted the socioeconomics of clam fishery once again and exposed the ecological fragilities of the coastal-marine ecosystems in the region. Among the main hypotheses for the causes of death are diseases, chemical contamination and extreme weather events.

Since the mortality, the prices of both the clam meat and the fresh clams, which were already growing progressively, skyrocketed (Ribas, 2014; Pezzuto and Silva e Souza, 2015). With the fishing crisis caused by this disaster, new actors joined the network, articulating themselves around this new problem. Currently, the aim is to broaden knowledge about the possible causes and impacts of the mortality on the populations of the species. Similarly, the feasibility of restocking with clam "seeds" produced in laboratories is being discussed. Both human and non-human factors (scientists, technicians from environmental and rural extension agencies, NGOs, fishers, clam, diseases/parasites, contaminants and climate events) have their own role in the negotiations on the management of common resources. The notion of sustainable use is now articulated around the possibility of recovering mollusc populations.

4.1.2. *The case of the Slow Food Presidium of the Portonovo Mosciolo Selvatico- Italy*

The creation of the *Slow Food* Presidium of the Portonovo *Mosciolo Selvatico* took place in 2004, benefiting from a cooperative and territorialized commercial fishing experience. This project has involved the establishment of a production protocol agreed between *Slow Food* and the producing community, which may result in the adoption of the *Slow Food* Presidia's trademark with the possibility of differentiation and adding value to the product.

The creation of the *Slow Food* Presidium supported the fishermen organized in the Cooperativa Portonovo Pesca - CPP and in the parallel marketing structure of the Portonovo Pesca company. Cooperativism among Portonovo fishermen dates back to the 1970s and was considered an inevitable way for professional resistance and quality of life improvement of its members (Giovagnoli, 2012).

Accelerated technical modernization during the same period stimulated the adoption of motorized boats and compressed air equipment, replacing rowing boats and the use of snorkelling for shellfish capture. In this context, commercial fishing of the wild mussel reached its peak in the 1980s, being carried out by about a hundred vessels operating in the bays of Ancona (Giovagnoli, 2012). At this time, the first environmental rules for wild mussel capture were defined and an exclusive mollusc capture reserve was established for the CPP by the local fishing authority within the wider fishing area (Fig. 1).

After its peak, the commercial fishing went into decline due to factors such as the growth of mussel farming, state bureaucracy and the difficulty of generational turnover of fishers. According to the Italian public body for fisheries control, there are currently 45 vessels with authorization to fish for wild mussel but it is estimated that no more than 15 vessels are operating intermittently in this fishery in the Ancona region.

The transformation of a traditional food into a brand of quality met the specific criteria developed by the *Slow Food* Presidium and its production was guided by a protocol. This protocol associated the quality of the food with factors such as health and safety, product traceability, maintenance of the species' stocks in their natural habitat, food traditions and the promotion of short marketing chains. According to the fishermen interviewed, the production protocol did reflect their usual

practices of fishing, processing and marketing the product, reinforcing their autonomy and territorial ties. It provides for collaboration with the regulatory authorities of the fishing activity and the health control agencies, which implies the adaptation and compliance with their specific regulations. It also determines the production of annual reports as a means of monitoring experience.

The creation of the Presidium promoted a quality brand and allowed the cooperative to add value and to access national and international markets, with short marketing chains concentrating most of its sales. Nowadays, the *Mosciolo Selvatico* can reach a price that is almost twice of *Mytilus galloprovincialis* cultivated in the region.

The quality brand created began to favour new production and consumption relationships and territorial links. The superior nutritional and organoleptic qualities of wild mussel, the positive environmental attributes of Portonovo's sea water and the fishing tradition in this territory were explicitly linked to *Mosciolo Selvatico*, bringing national and international recognition to CPP/Portonovo Pesca and to local restaurants.

The creation of the Presidium brand represents the moment of mobilisation (Callon, 2007) in which the common project was diffused following a process of negotiation of interests and identities, and stabilisation of consensus among the actors involved.

Unfortunately, two years after the creation of the brand, scientists recorded an unprecedented occurrence of the dinoflagellate algae, *Ostereopsis ovata*, producer of a thermostable biotoxin (ovatoxin) (Totti et al., 2010). The scientific discovery of the toxic algae sounded as an alarm with the health control agencies which began to include an analysis of its biotoxin in their periodic monitoring of water quality and wild mussel meat, with increased attention to blooming events of the species. If the proliferation of the algae is intense and contamination occurs, the public monitoring agencies communicate with the municipal administration which issues an ordinance banning the fishing and marketing of molluscs and even sea bathing. The embargo expresses the principle of caution, but there is no dialogue between municipality, fishers, monitoring agencies and civil society, which often remains uninformed and worried about ecological changes in the waters around Ancona. This situation has caused difficulties for CPP/Portonovo Pesca, which has had its credibility questioned and its activity paralyzed several times since the discovery of the algae.

As the field work has revealed, the contestation of the quality and food safety hitherto certified by the quality brand of *Mosciolo Selvatico di Portonovo* represents a socio-technical controversy that exposes conflicts between technical/scientific and traditional knowledge practices. Fishermen claim to fish in places other than those monitored and argue that the tests used are inaccurate and time-consuming. This situation harms them economically. Technicians from public health control agencies also admit the length of procedures and the need to improve the methods of analysis, while scientists recognize that it is important to broaden knowledge about the effects of ovatoxin on human health. However, they emphasize the need for caution and defend the embargo on fishing in case of doubt. On the one hand, fishermen require reliable procedures and results from scientists and technicians, but on the other, they want their own knowledge and practices to be legitimized. The controversy remains, insofar as inclusive decision-making arenas on the subject have not been identified, which exposes fragility in the management of this fishery.

In this context, fishing families demonstrate their resistance in a discursive and practical manner (Scott, 2011), interfacing with the technical-scientific community and broader society in events and public debates, academic publications and articles in the local press.

4.2. A comparative analysis of the cases

In order to point at innovations and possibilities able to guarantee artisanal fishers' response to crisis, the category of co-management has been interpreted according to the six sub-issues already listed in the methodological section, which have been used as the base of a comparative analyses between the two cases.

With reference to the relationship between technical-scientific and local traditional knowledge (sub-issue 1), in both cases the relationship between technical-scientific and local traditional knowledge has given rise to an attempt at cooperation and eventually to conflict in case of environmental crises. In Resex Pirajubaé fishers, scientists and environmental agencies worked together on the elaboration and implementation of the rules, but the arrangements did not prevent the degradation of coastal-marine ecosystems and a severe impact on traditional fishery due to urban growth over the Reserve. In the case of the *Mosciolo Selvatico* there has been a clear cooperation between the *Slow Food* experts and the fishermen, but conflict between CPP, scientists and public health monitoring agencies.

Concerning the collective participation and deliberation within social arenas (sub-issue 2), in the Brazilian case the community participation has been formally institutionalized since the environmental agencies have promoted the operationalization and legitimization of the Resex management instruments through formal deliberation arenas and fishing regulation, whereas in the Italian case participation has been more informal and only related to some meetings between CPP and *Slow Food* technicians. The institutional arrangement proposed by the public policy of the Brazilian marine Resex has brought important innovations in fisheries co-management because it has formally recognised and granted the territorial usage rights to fishers, thus promoting the democratization of public resource management. In contrast, in the Italian case the weakness of the institutional deliberation arenas in dealing with the impact of algae on fishing and on the quality of *Mosciolo Selvatico,* introduced a socio-technical controversy and exposed a fragility in the Presidia brand institutional arrangement.

The adaptation of rules to fishing livelihood (sub-issue 3) within the Resex Pirajubaé has been only partial, because rules have often interfered with the dynamics of work and generational turnover, especially after the environmental conflict outbreak. In relation to the *Mosciolo Selvatico*, instead, the Praesidium brought the definition of a consistent protocol with the fishing and marketing practices of the CPP.

Also the role of the marketing channels (sub-issue 4) has been quite different between the two cases. In the Brazilian Resex Pirajubaé, they were linked to some institutionalization processes only during the pilot project. In the *Mosciolo Selvatico,* instead, there has been a predominance of short and local marketing channels, favoured by the institutionalization of the *Slow Food* quality brand. The *Mosciolo Selvatico* brand mobilized a group of actors that collectively established some alternative relations of production and consumption with the construction of markets for quality traditional foods. The institutionalization process promoted by *Slow Food* has generated socioeconomic benefits, contributing to the fishers' economic autonomy and to the appreciation of a specific territorial identity.

Referring to the ecological sustainability of the fishing resource (sub-issue 5), institutional arrangements aiming at guaranteeing the ecological sustainability of the fishing resources in the Brazilian case have failed as they could not halt the degradation caused by urbanization; in the Italian case the production protocol and the quality brand have somewhat contributed to the conservation of *Mytilus galloprovincialis.*

The ability of the fishing community to organize over time (sub-issue 6) has been variable in the Brazilian case, whereas in the Italian one has appeared as continuous. The fishers' consistent organization ability emerged as a key factor for promoting the innovation.

Aside from this previous analysis, an ANT perspective has been also adopted to look at the cases. According to this, the two socio-technical co-management networks studied reveal an important set of non-human actors that influenced the institutional building process, as shown in Table 1. Among these, the emerging institutions have been especially considered. The *Slow Food* Presidium production protocol, the mark of quality, the clam management plan and the environmental regulations for fishing at Resex Pirajubaé are important elements within

Table 1
Institutional production from the perspective of ANT - Brazilian and Italian cases.

	Resex Pirajubaé	*Mosciolo Selvatico* Presidium
Non-human actors	Clams, fishing gear, clam management plan, environmental regulations, highway.	Mussels, algae (biotoxin), *Slow Food* Presidium production protocol.
Actor-world	Environmental agencies.	*Slow Food.*
Mobilisation/Innovation	Pilot project with respective management plan and creation of Resex.	Creation of the *Slow Food* Presidium.
Socio-technical controversies	In the environmental conflict, in the definition of regulations, in the environmental monitoring and in the situation of death of the clam.	In the identification of algae that produce biotoxins and in health controls.
Co-management network stability	Encouraged by state action.	Encouraged by relationship with *Slow Food* and the markets.

the co-management networks. These institutions can be conceived as instruments for coordinating multiple knowledge and practices, especially those of fishers, scientists, technicians and development agents. The institutions created can act on the network itself, reinforcing the proposed objectives for the mollusc fisheries management, such as sustainable use (Brazilian case) and food quality (Italian case). These objectives were established through a collective work and the institutions created stabilized the network, even temporarily, generating effects such as innovations and favouring the participation of fishing families.

Conceiving protocols and rules as products of a network of relationships in which interests are negotiated does not mean assuming intrinsic power symmetry in the decision-making processes involved in their creation. On the contrary, the case studies unveil actors who have concentrated power in their hands (actor-world), as well as actors and situations that have destabilized the co-management network by introducing controversies in the institutionalization process (according to Table 1). In this context, it is considered important to evaluate the pragmatic result of the interactions among the different actors and their respective knowledge and practices in co-management, with respect to ensuring the participation of the fishing families as well as their economic benefit. The experiences analysed demonstrate that the generation of institutional innovations in co-management can increase the actors' capability in responding to crisis. However, the lack of ability to deal with environmental conflicts and the difficulty in ensuring the effective participation of fishers in the decision-making arenas indicate weaknesses in the institutionalization building process (Table 1).

Also the literature shows how co-management experiences in artisanal mollusc fishing have helped to avoid over-exploitation and to establish a fairer relationship with the markets when the cultural values and knowledge of fishing communities were recognised and considered, going beyond the pure creation of environmental regulations. This was the case in guaranteeing territorial rights of use to Chilean and Mexican traditional fishers (Defeo and Castilla, 2005; Basurto, 2006), investments in training for fisheries management among Galician fishers (Frangoudes et al., 2008), continuous co-management programs based on mutual learning and collaboration (Roa-Ureta et al., 2020) and social participation with flexible local rule making, which enabled rapid responses and continuous monitoring in the United States (Hanna, 2000). The recognition and appreciation of women as central players in this type of fisheries also is a positive effect of co-management processes (Frangoudes et al., 2008; Rocha and Pinkerton, 2015), as well as the exclusion of non-local fishers using destructive fishing gear around lake Chiuta in Malawi (Donda, 2017).

In this regard, it is assumed that challenges in cooperation and innovation will be overcome as far as artisanal fishing knowledge, livelihoods and organization are recognised and strengthened. This implies supporting the right of fishing communities in defining the principles and forms of deliberation in co-management, as well as the strategies for enhancing fisheries socioeconomic benefits. Severe environmental impacts created by State projects, as happened in RESEX Pirajubaé, can seriously undermine the institutions and co-management initiatives legitimacy, as well as the cooperation required for innovation.

The stability of the co-management networks and the innovations studied have been closely related to the legitimacy of the institutions created. The experience of the *Mosciolo Selvatico* brand is based on a more stable co-management arrangement, preserving higher conditions of participation and incorporation of fishers' knowledge and practices over time, as well as a greater capability to address environmental crisis. Still, unforeseen acute environmental changes in the oceans affected both cases, introducing challenges to shellfish fisheries' sustainability. Thus, it is necessary that the co-management processes and participatory arenas be strengthened and expanded.

5. Conclusions

Some interesting insights emerge from the analysed case studies, concerning specifically their capacity to face environmental crises. Both the care of local and quality seafood and of the environmental sustainability need the construction of alternative markets for artisanal fishing, able to recognize the specificity of the management systems in terms of product value. Further integrated environmental monitoring actions would be necessary in order to favour fishers' communities' participation. It has been recognised that when an environmental issue is opened, an open dialogue between different knowledge and practices should be favoured, as a key for the development of institutional innovation.

Another issue emerging from both case studies is, indeed, the need to involve external actors in the co-management practices, broadening the co-management networks beyond the local context, to face an emerging environmental crisis and the conflicts arising from it.

Finally, it can be concluded that the study of multiple cases has allowed the capturing of similarities and differences between the co-management processes of artisanal mollusc fisheries, deepening the knowledge of each experience and generating academic and political implications. From the academic point of view, wider knowledge about the institutionalization processes of artisanal fisheries was disclosed, contributing to theoretical-methodological innovations in the field of management studies of common natural resources. From the political point of view, the study of multiple cases showed the potentialities and limitations of co-management of local resources in a context of increasing socio-ecological complexity.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2021.112671.

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