Participatory monitoring of small-scale coastal fisheries in Brazil and the Southern Cone: a literature review

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ABSTRACT
Participatory monitoring approaches for natural resources management are increasingly being proposed by researchers, Non-Governamental Organizations and some governments. In such proposals, different levels of participation and incorporation of local/traditional knowledge can be observed. Fishers' knowledge has been considered relevant for natural resources management and pertains to all the spheres of a social-ecological system, including the environmental, operational, institutional and cultural spheres. Studies on participatory monitoring are emerging in Brazil and the Southern Cone - a geographic region encompassing Argentina, Chile and Uruguay. Some of these cases show encouraging results and have gained attention in small-scale fisheries management in recent years. In this paper, we review English, Portuguese and Spanish literature on fishers' participation and the use of fishers' knowledge, in artisanal fisheries monitoring programs in Brazil and the Southern Cone. We analized 14 case-studies exploring the types of information being collected, the sources of knowledge being used and the stages of management they inform, the level of fishers participation and the institutional arrangements in which participation and fishers' knowledge use occurs. We also discuss achievements and challenges of these iniciatives. In most cases, operational knowledge was incorporated, mainly as part of the data collection phase. Ecological knowledge was also considered in most cases, but in less degree. Cultural knowledge was poorly incorporated. The participation level ranges from cooperation to partnership (*sensu* BERKES 1994), with only one case of community-based monitoring. Monitoring of fisheries is led mostly by managers or scientits that incorporate fishers as workforce for data collection. Despite the fact that human and ecological dimensions of fishing system are interconnected, the human sphere has been underestimated when it comes to fisheries management. Cases of monitoring rarely include cultural knowledge of users and/or socioeconomic variables. The success of fisheries involves, among many factors, harmonious adjustment between its various dimensions, which has not generally being addressed by monitoring programs. In addition, institutional arrangements are largely responsible for the way in which participation occurs or lacks to occur. It is important to be attentive when technical and scientific knowledge and interests overlap with the incorporation of local knowledge, especially in top-down initiatives presented as participatory but in practice the fishers merely have a data collection role. Despite the many challenges faced in the management of artisanal fisheries, South America is moving towards greater openness in management strategies, encouraging the participation of users with significant support from universities, research institutes and Non-Governamental Organizations.

KEYWORDS: Artisanal fisheries; Local Knowledge; Monitoring & Evaluation; Participatory Monitoring; Small-Scale fisheries; South America

INTRODUCTION

Monitoring of fisheries is an important step of fisheries management. It helps to identify patterns and trends in resources and to evaluate the effectiveness of management strategies (GARCIA & LESCUYER 2008). Participatory monitoring also involves sharing power in management and benefits from a collective learning and enhancing environmental stewardship (PEREIRA *et al.* 2013; BERKES *et al.* 1995). In Brazil and the Southern Cone, some participatory monitoring cases were observed in experiences with co-management approaches.

Participatory monitoring approaches for natural resources management are increasingly being proposed by researchers, Non-Governamental Organizations and some government officials to evaluate conservation strategies. In such proposals, different levels of participation and inclusion of local/traditional knowledge can be observed (ARNSTEIN 1969; BERKES 1994; GEIGUS 1997; POMEROY & RIVERA-GUIEB 2006). In the literature, nine steps were identified in a ladder of participation regarding resource management (BURNS 2003; BERKES et al. 1994; 2001) (Table 1). In many cases, Universities and Non-Governamental Organizations are important stakeholders helping to trigger a more collaborative approach to fisheries management (SEIXAS et al. 2009a; SEIXAS et al. 2011).

A large amount of papers and authors discuss the importance of incorporating local/traditional knowledge (hereon "fishers' knowledge") in fisheries management (exemples are BERKES et al. 1995; MIRAGLIA 1998; HUNTINGTON 2000; SEIXAS et al. 2009b; NARCHI et al. 2014), including cases where resource users simply collect data for managers to an active inclusion of fishers' knowledge in designing data collection and analyzing data through direct collaboration (BURNS 2003; ORENSANZ et al. 2013).

Diverse sorts of fishers' knowledge can be considered subsidies for the management of fisheries. The traditional ecological knowledge (TEK) addresses the relationship between living beings and the environment, including people's knowledge, experience and beliefs (BERKES et al. 2000). TEK evolves by adaptive processes and is handed down through the generations (BERKES et al. 1995). On the other hand, the local ecological knowledge (LEK) refers to the knowledge acquired by a person throughout its life span observations (BERKES et al. 1995). Relevant fishers' knowledge for fisheries management pertains to all the spheres of these social-ecological systems, including the environmental (GADGIL et al. 1993), operational (fishing practices and logistics), institutional, cultural and economic spheres, among others (ORENZANS et al. 2013).

Since the 1990's, we are facing a shift in the governance of fisheries to more inclusive approaches that recognize fishers' participation and shared decision-making regarding fisheries management (POMEROY & RIVERA-GUIEB 2006). To evaluate these management strategies, the monitoring of fisheries activities is a relevant and needed tool. Studies on participatory monitoring are emerging in Brazil and in the Southern Cone - a geographic region encompassing Argentina, Chile and Uruguay. Some of these cases show encouraging results and have been gaining attention in small-scale fisheries management in recent years (BUCHELI & MARTINELLI 2014; COSTA 2014; HOMBERG et al. 2013; CONSTANTINO et al. 2012).

In this paper, we review English, Portuguese and Spanish literature on the use of fishers' knowledge in coastal artisanal fisheries monitoring programs in Brazil and the Southern Cone. We explore what types of information are being monitored (e.g. resource abundance, catch and effort, socioeconomic indicators), what sources of local knowledge are being used (cultural, ecological, institutional, operational), which stages of management they inform, the level of fisher participation and the institutional arrangements in which participation and fishers' knowledge use occurs. We also discuss achievements and challenges of participatory monitoring initiatives in small-scale fisheries management in the study region.

METHODS

Our review is based on articles found on five database platforms available on the internet: Google scholars, Scielo, Science Direct, Scopus and Web of science. We conducted the search from November to December 2014 to create an initial list of relevant articles. We used the following keywords in English, but also in Portuguese and Spanish, when possible:

Group 1: ["Co-management" OR "Community conservation" OR "Community-based conservation"] AND ["Artisanal fisheries monitoring" OR "Fisheries monitoring" OR "Small-scale fisheries montoring" OR "Artisanal fisheries assessment" OR "Fisheries assessment" OR "Small-scale fisheries assessment"] AND ["Argentina" OR "Brazil" OR "Chile" OR "Uruguay" OR "South America" OR "Latin America"]

Group 2: ["Collaborative Monitoring" OR "Community-based monitoring" OR "Participatory monitoring" OR "Collaborative assessment" OR "Community-based assessment" OR "Participatory assessment"] AND ["Artisanal fisheries" OR "Fisheries" OR "Small-scale fisheries" OR] AND ["Argentina" OR "Brazil" OR "Chile" OR "Uruguay" OR "South America" OR "Latin America"]

We searched for articles, as well as books, book chapters, abstracts presented in conferences, thesis and gray literature. We also considered already known literature and cited references in papers found. We selected 167 references by reading the abstracts. We also contacted 30 researchers working in this field in the four countries studied to ask about new cases and/or to clarify information about case studies, increasing the list to 227 references. In addition to Engish, we explored Portuguese and Spanish literature due to its importance to local managers and users, and to incorporate literature rarely accessible to the international scientific community.

We narrowed the list of references by identifying studies that presented empirical evidence of participatory monitoring of artisanal fisheries, remaining 66 references. We selected cases with: (i) monitoring iniciatives related to any dimension of fishing activity; (ii) involvement of fishers in monitoring programs; (iii) sufficient data about the monitoring phase of management. We also considered scientific research about the inclusion of fishers in monitoring programs, excluding cases where information was obtained in a purely extractive way, as for example, when fishers just answered surveys. That is, we excluded from the analysis Consultation, Informing and Government/Researchers Centralization cases (see table 1). We qualitatively analyzed the literature and categorized cases according to the ladder of participation (table 1) (BERKES 1994, 2000; BURNS 2003) and the type of local knowledge that is being incorporated into monitoring (table 2) (BAIGÚN 2013; ORENSANZ 2013).

Table 1. Ladders of Participation in monitoring programs (Adapted from BURNS 2003 and BERKES 1994).

Ladder of Participation	Explanation
Community Self Governance	Power delegated to community
Partnerhip	Partnership of equals, joint decision-making institutionalized.
Joint Action	Community is given opportunity to participate in developing and implementing monitoring.
Advisory Role	Partnership in decision-making starts; joint action on common objectives.
Communication	Start of two-way information exchange; local concerns begin to enter monitoring programs.
Cooperation	Community starts to have input into monitoring; e.g. use of local knowledge, research assistants.
Consultation	Start of face-to-face contact; community input heard but not necessarily heeded.
Informing	Government/ researchers take decisions regarding monitoring and inform fishers (one-way information dissemination).
Government/Researchers Centralization	Power centralized into government/researchers.

Table 2. Types of local knowledge incorporated into monitoring programs (Adapted from BAIGÚN 2013).

Types of knowledge	Explanation
Cultural	Cultural and regional norms and consuetude, use and management practices, local arrangements related to fishing activity.
Ecological	Breeding and nursery grounds, migration, reproductive and feeding behavior, environmental effects on fishing resource.
Operational	Gear selectivity, target species abundance and distribution, fishing grounds and resource seasonality.

RESULTS

Study sites: What do we mean by artisanal fisheries? How does it differ between localities?

There is not a standard definition to 'Artisanal Fisheries'. It is a broad term whose specificities differ between regions, cultures and economies (ORENSANZ et al. 2013; BERKES et al. 2001; CASTILLA & DEFEO 2001). Different activities and ways in which they are performed can be considered Artisanal Fisheries (DEFEO & CASTILLA 2005). In the four countries analyzed, artisanal fisheries differs between countries and even among regions within a country. Nonetheless, some commonalities can be observed. This activity is usually performed with small or without vessels, involving low technology. In these four cases we also found that 'artisanal fisheries' are defined by common creteria such as (i) fishing gear, (ii) gross tonnage, (iii) size of

vessels and (iv) socio-economic considerations, as reported by Elías et al. (2011). In addition to families source of income, it has a great importance in providing food security. In all four countries, this is a relevant activity mainly for marginalized communities.

Literature review:
We analyzed 14 cases of participatory monitoring in Brazil and the Southern Cone (table 3). In most cases, the local knowledge incorporated was operational, regarding practices and logistics of fishing activity, mainly at data collection phase. Ecological knowledge was also considered in most cases, but to a less degree. Cultural knowledge was poorly explored. The participation level ranges from cooperation to community-based management. In the next sections we will explore the cases found in the literature. We will present: (i) the institutional context in which these cases are inserted, (ii) the variables being monitored, and (iii) the ladder of participation and the use of fishers' knowledge.

Table 3. Artisanal Fisheries Participatory Monitoring initiatives per country.

Case	Source	Period
ARGENTINA		
San José Gulf (Vieira)	Cinti et al. 2003, 2011; Orensanz et al. 2003, Orensanz & Seijo 2013, Fiorda, Trobbiani & Parma 2013	2007 - today
San José Gulf (Vieira) (Logbook Program)	Cinti et al. 2002	2002 - 2004
BRAZIL		
Corumbau Marine Extractive Reserve	Alves et al. 2012; Dutra et al. 2011; Francini-Filho & Moura 2008; Moura et al. 2007, 2009, 2013; Previero et al. 2013; Rodrigues et al. 2007; Santos 2012; Seixas et al. 2009	2001 -2006/ 2009 - ?
Costa dos Corais Protected Area (Before the closure)	Ferreira et al. 2000, 2003; Maida & Ferreira 1997; Moura et al. 2007	1998 - 2000
Costa dos Corais Protected Area (After the clusure)		2001
Southern Bahia's Territory of Citizenship	Malafaia et al. 2014	2011 - 2012
Volunteer Environmental Monitoring - coast of Santa Catarina	Bonilha et al. 1999; Foppa et al. 2011; Hoinkis et al. 2007; Matarezi & Bonilha 2000; Medeiros et al. 2007	2002
Prainha do Canto Verde	Almeida & Pinheiro 2002	2002
	Chaffee 2000; Chaffee & Phillips 2000; Schärer & Schärer 2004; Schärer et al. 2010;	2008-2010
CHILE		

Quintay Bay & Las Cruces Protected Area	Aburto et al. 2014; Aburto & Stotz 2003; Aviléz & Jerez 1999; Bandin & Quiñones 2014; Castilla & Fernandez 1998; Castilla & Defeo 2001; Castilla et al. 2007; Castilla & Gelcich 2008; Defeo & Castilla 2005; Defeo et al. 2009; Defeo et al. 2014; Gelcich et al. 2006; McLachlan et al. 2013; Moreno & Revenga 2014; Muñoz 2011; Orensanz & Seijo 2013; Sanctis & Chavés 2014; San Martin et al. 2010; Schumann 2007, 2010a, 2011	1998 - 2000
Juan Fernandéz Arquipelago	Ernest et al. 2010	2006 -2008
Tongoy Bay	Aburto et al. 2014; Aburto & Stortz 2003; Schumann 2007	1998 - 2004/ 2007-2010
Puertecillo, Navidad	Castilla & Fernandez, 1998; Defeo & Castilla 2005; Gelcich et al. 2006; Gelcich et al. 2013	Many years
URUGUAY		
Barra del Chuy (former)	Brazeiro & Defeo 1999; Castilla & Defeo 2001, Defeo 1996a,b 1998; Defeo 2003; Defeo & Castilla, 2005, Defeo et al. 2009; Defeo et al. 2014McLachlan et al. 2013;	1982 - 1990
GEF-DINARA-FAO Project (Barra del Chuy)	Project GEF-FAO-DINARA 2009-2012; Gianelli et al. 2014	2009 - 2012
Punta del diablo	Arismendi 2011; Carriquiry & Arismendi 2012; Segura et al. 2008	2005 - 2006
La Plata River	Bentancur et al. 2014a, b	2014

1. Artisanal fisheries institutional arrangements overview

In distinct countries, different restriction in access and ways that management is held were observed. In this section we present the institutional arrangement hosting participatory monitoring iniciatives in each studied country.

1.1 Argentina

In Argentina, general guidelines for fishing are under regulation of the Federal Government that encompasses regulatory agencies of fisheries at national level as described in Table 4 (ELÍAS et al. 2011; Ministry of Agriculture, Husbandry and Fishing website). Organization chart of the fishery regulatory institutions:

Federal Government
Prefectura Naval
Ministry of Agriculture, Husbandry and Fishing
- *Secretary of Agriculture, Husbandry and Fishing*
  - *Undersecretary of Fisheries*
    - *Federal Fisheries Council*

Decentralized bodies
- *National Institute for Fisheries Research and Development (INIDEP)*
- *National Service of Agricultural Quality and Health (SENASA)*

Despite that, the Federal Fisheries Law (Law 24922/1998) grants the provinces full authority to exploit marine living resources according to their own regulations if they are located from the coastline to 12 nautical miles offshore. The artisanal fishing activity is regulated by the provinces and is not centralized by federal government.

Table 4. Regulatory institutions of fishing in Argentina.

Filiation	Institution	Duties
Ministry of fisheries	Undersecretary of Fisheries	To elaborate, coordinate and execute policies
Ministry of fisheries	Federal Fisheries Council	To define national fishing policy and research priorities
Federal government	Prefectura Naval	To register vessels, care for the security of navigation and grants for fishers
Decentralized body	National Service of Agricultural Quality and Health (SENASA)	To certify processing plants
Decentralized body	National Institute for Fisheries Research and Development (INIDEP)	To plan and execute technical and scientific programmes

Monitoring cases were found only in Chubut Province. This Province is divided into four artisanal fishing management areas alongside the coast. The mobility of fishers between areas is subject to authorization under the presentation of justifiable reasons. Artisanal fishing permits are annual, precarious and not transferable and will be awarded to those native or naturalized persons with royal residence in the province of not less than three years, granting by area and type of fishing activity (Provincial Law XVII - N. 86). A research institution (The National Patagonic Center) has provided regular scientific and technical support for fisheries management since the beginning of the scallop fishery (the 1970s). Before 2001, fisheries at Chubut Province were open access, with size and season closures. Since then, a Technical Committee was created by demand of the fishing sector composed by the Fisheries Administration, scientists, and fishers represented by the Association of Artisanal Fishers of Puerto Madryn (APAPM) to discuss and agree management recommendations for local artisanal fisheries of San Jose Gulf. This committee favoured the beginning of a co-management initiative and the establishment of a limited entry program that provided exclusivity of acess to a fixed number of artisanal vessels (Orensanz et al 2007).

1.2 Brazil

In Brazil, fisheries are regulated mainly for two ministries: The Ministry of the Environment and The Ministry of Fisheries and Aquaculture. The Ministry of the Environment is encharged to manage the National environmental and water resources policy and the conservation and sustainable use of ecosystems and biodiversity; to propose strategies, mechanisms and socio-economic tools to improve environmental quality and sustainable use of natural resources; and to propose policies for the integration of the environment and production. The Ministry of Fisheries and Aquaculture. Is responsible for the fishing and aquaculture national policy and to foster and regulate fisheries and aquaculture. These two ministers have important branches related to fishing activity and conservation of stocks (Table 5). Federal agencies responsible for fisheries in Brazil:

Federal Government

Ministry of the Environment

- *Brazilian Institute of Environment and Renewable Natural Resources (IBAMA)*
- *Chico Mendes Institute of Biodiversity Conservation (ICMBio)*

Ministry of Fisheries and Aquaculture

- *National Council for Aquaculture and Fisheries*

Decentralized body

- *Brazilian Agricultural Research Corporation (EMBRAPA)*

The both Ministries perform a joint function: to set criteria, standards and management measures of sustainable use of fisheries resources based on scientific and existing data, establishing regulations; and to support, advise and participate in interaction with the Ministry of Foreign Affairs, and events involving the commitment of rights and interference in national interests on fisheries and aquaculture. The states also have an important play in fisheries management. The Coastal Management National Plan (Law 7661/1988) incentive provinces to establish management plans for fisheries (SEIXAS et al. 2009a).

Table 5. Regulatory institutions of fishing in Brazil (Law 5851/1972; 11516/2007; 11516/2007; 11958/2009).

Filiation	Institution	Duties
Ministry of the Environment	Brazilian Institute of Environment and Renewable Natural Resources (IBAMA)	To control and execute the surveillance and enforcement of fisheries
Ministry of the Environment	Chico Mendes Institute of Biodiversity Conservation (ICMBio)	To perform the actions of National System of Protected Areas (SNUC), may propose, implement, manage, protect, and monitor National protected areas; promote and implement research programs and exercise the power of environmental police for the protection of Federal Protected Areas
Ministry of Fisheries and Aquaculture	National Council for Aquaculture and Fisheries	To support the formulation of national policy for fisheries and aquaculture, propose and apply guidelines for the development of a fisheries and aquaculture action plan and propose measures to ensure the sustainability of fisheries and aquaculture activity
Federal Government	Brazilian Agricultural Research Corporation (EMBRAPA)	To create specialized centers for the research of aquaculture and fishing activities

The Protected Areas Law (SNUC – National System of Protected Areas, Law 9985/2000) established in 2000 different levels of restriction on the use of natural resources. Within this range, PAs that enable some level of resources use are entitled Sustainable Use Protected Areas. These PA aims to integrate humans livelihoods with environmental conservation. Many of these are marine and/or coastal reserves, where artisanal fisheries play an important role on local communities' livelihoods (BEGOSSI et al. 2010).

We identified monitoring cases in two different types of Sustainable Use Protected Areas. The Extractive Reserves (RESEX) goal is to safeguard traditional populations livelihoods and culture and, at the same time, to conserve natural resources and biodiversity (SNUC 2000). This category emerged in the Amazon in 1990 (Decree 98897/1990) and by 1992 was also implemented in coastal environments (CECCA, 1997). The creation of this kind of PA emerged as a bottom-up process in which decisions are made in a local level (GERHARDINGER et al. 2009). This category foster co-management approach and the incorporation of fishers knowledge into management, in which decision making are taken in a Deliberative Council, where the majority of representatives are community members (50% + 1). The effectiveness of management efforts should be measured constantly by a monitoring program. Despite that, few Marine Extractive Reserves have a monitoring program designed and operating (SANTOS & SCHIAVETTI 2014). The second category is the Environmental Protected Area (*Área de Proteção Ambiental* – APA). This PA aims to protect biodiversity, ordinate human occupation process and ensure the sustainably of natural resources use (SNUC 2000). In general, this category is less participative than the Extractive Reserves, its council is advisory and co-management incentives are less evident in the law.

1.3 Chile

In Chile, fisheries are regulated by the Ministry of Economy, Development and Tourism and its branches related to fishing (Table 6). Institutional arrangement in Chile:

Federal Government
Ministry of Economy, Development and Tourism
- *Undersecretariat of Fisheries (SUBPESCA)*
  - *Fisheries Research Fund (FIP)*

- *National Fisheries Service (SERNAPESCA)*
  - *Development Fund for Artisanal Fisheries (FFPA)*

Decentralized body
- *Fisheries Development Institute (IFOP)*

Since 2013, fisheries in Chile are regulated by the new Fishery and Aquaculture Law (*Ley General de Pesca y Acuicultura*), initially passed in 1991 introducing the concept of *Territorial User Rights for Fisheries*, but this regime was implemented only 6 years later (Decree N. 355/1995) because of political and institutional issues (SAN MARTÍN et al. 2010). This co-management initiative emerged at the whole country and is called Management Areas for the Exploitation of Benthic Resources (MAEBR). This national TURF system enables benthic resources exploitation by registered fishers' organizations (FAL 2013). Until 2013, 758 Management Areas for the Exploitation of Benthic Resources were established in Chile (SERNAPESCA 2014).

Table 6. Institutions that regulate fishing activity in Chile (MORENO & REVENGA 2014; SERNAPESCA 2014; FAL 2013).

Filiation	Institution	Duties
Ministry of Economy, Development and Tourism	National Fisheries Service (SERNAPESCA)	To enforce fishing and aquaculture activities, ensure the sanitary quality of fishery and aquaculture products export, provide information for fishing management.
Ministry of Economy, Development and Tourism	Undersecretariat of Fisheries (SUBPESCA)	To develop fishing policies and management strategies.
Ministry of Economy, Development and Tourism	Fisheries Research Fund (FIP)	To finance research to suport management.
Ministry of Economy, Development and Tourism	Development Fund for Artisanal Fisheries (FFPA)	To promote and support artisanal fishers
Non-governmental agency	Fisheries Development Institute (IFOP)	To generate scientific and technical information related to fishing activity.

The Management Areas for the Exploitation of Benthic Resources are allocated in *caletas* (coves) along the coast (until 5 miles from the coast line – being the first mile exclusively for fishers whose vessels don't exceed 12m length) of the 14 administrative regions that compose the country. Artisanal fishers are registered according their region of residence and most of them are registered in a local fishers association once Management Areas for the Exploitation of Benthic Resources are granted only by associations, not individually (FAL 2013). Artisanal fisheries monitoring is led by a consultant hired by the fishers associations. The information is sent annually to the National Fisheries Service that compiled all monitored data and sends it to the Undersecretariat of Fisheries (SUBPESCA) to develop policies and management strategies (Figure 2). In some Management Areas for the Exploitation of Benthic Resources, a more participatory approach emerged where consultants train fishers to collect data enabling an interchange of scientific and fishers' knowledge (MORENO & REVENGA 2014).

1.4 Uruguay

Fisheries in Uruguay is regulated by one branch of the Husbandry, Aquiculture and Fisheries Ministry, the Aquatic Resources National Organization (*Dirección Nacional de Recursos Acuáticos* - DINARA) and by the Naval Body (Table 6):

Federal Government

Ministry of Husbandry, Aquiculture and Fisheries

- *Aquatic Resources National Organization (DINARA)*

Ministry of National Defense

- *Uruguayan National Naval Prefecture*

Table 6. Institutional organizations that regulates fishing in Uruguay (DINARA 2015; FAO 2003).

Filiation	Institution	Duties
Ministry of Husbandry, Aquiculture and Fisheries	Aquatic Resources National Organization (DINARA)	To establish a national fishing policy and regulations, to manage and evaluate stocks, to conduct sanitary control of fishery products intended for exportation or domestic market.
Ministry of National	Uruguayan National	To enforce monitor and inspect vessels at sea, to

Defense	Naval Prefecture	control traffic vessels in port, to register fishing vessels.

The government has identified the need to implement institutional arrangements that facilitate the participation of fishers in decision making, monitoring and control of fishery resources (Project GEF-FAO-DINARA 2009-2012). In 2013, a federal law "Promoting Responsible Fisheries and Aquaculture" (Law 19175) was approved. One of its aims is to create Regional Fishing Councils composed by representatives of the Aquatic Resources National Organization, local governments, the maritime authority and fishers' unions in order to discuss fisheries management, constituting an opportunity to co-management of fisheries in Uruguay (TRIMBLE & BERKES 2013).

2. What has being monitored and what for?

The results of monitoring characteristics of selected case studies are summarized in Table 4.

Table 4. Monitoring goals and variables.

Case-study	**Resource/ Fishery**	**Monitored Variables**	**Use of information**	**Phase of monitoring in which fishers participate**	**Monitoring participants**
ARGENTINA					
San José Gulf (Vieira)	Diving/ Scallop (*Aequipecten tehuelchus)*	Visual counting along transects. Size and density structures. Catch data, fishing effort, fishing grounds (for all a season)	Start a co-management iniciative, support fisheries management - establishing catch quotas	Planning, data collection, discussion of results and decision making	Government, Fishers and Researchers
BRAZIL					
Corumbau Marine Extractive Reserve	Local artisanal fisheries	Catch data; structure of reef fish assemblages	Decision making regarding fishing activity & Establishment of a no-take zone inside the RESEX	Planing, data collection, discussion of results and data storage	NGO, Researchers community and government
Costa dos Corais Protected Area (Before the clusure)	Local artisanal fisheries	CPUE, season of the year, kg of catch, abiotic variables (direction of the wind, tide and water temperature, salinity and transparence) and tourist flow	Establish a no-take area inside the RESEX for 3 years	Planing, data collection and decision making	Fishers trained and Researchers

Costa dos Corais Protected Area (After the clusure)	No-take area compared to fishing grounds	Abundance of fish, octopus and lobsters inside and outside the closed area	Evaluate the importance of fishing to local food security and the impact of fishing activity		
Southern Bahia's Territory of Citizenship	Reef fishes / hook and line fishing	Fishing grounds, Fishing Effort (days fishing and number), Catch by weight (total and per species), CPUE, Biometrics (fork length and total length to the nearest centimeter) and the weigh of the gonad	Foment traditional knowledge of fishers; acquisition of biological data on the spawning aggregation of target reef fish far from the shore	Data collection, use of data to plan fishing activity	Researchers and Fishers
Volunteer Environmental Monitoring - coast of SC	Local artesanal fisheries	Tide conditions, Fishing grounds, Fishing effort, catch data, vessels structure, fishing gears.	Consolidate a method for the monitoring of Provincial fisheries production	Planing and data collection	Government, Fishers and Researchers
Prainha do Canto Verde	Lobster fisheries	Number of Fishers that own their own vessel; Participation of fishes; Fishers that know and agree with the Community Regulation on Fisheries; Fishers that think it is important not to fish small lobster; Fishers with fishing gear allowed; Illiteracy and education; Fishers who like their profession.	Assess the sustainability of the lobster fishery in the community for certification by the MSC	Design monitoring, data collection, data analysis and discussion of results	NGO, Researchers and Community
		Fishing effort, Catch data, Lobster price on local markets, costs (maintenance, loss or theft of equipment), investments, source of funding	Document and record data to support the RESEX Fisheries Management Plan	Data collection, data analysis and discussion of results	
CHILE					

Quintay Bay & Las Cruces Protected Area	Muricid gastropod "loco" (*Conchapelas concholepas*)	Benthic invertebrate stocks, landing data, CPUE	Test human's impact on coastal systems and determine whether *Concholepas* was indeed a keystone species. Test a comanagement regime.	Data collection	Government, Fishers and Researchers
Juan Fernandéz Arquipelago	Spiny Lobster (*Jasus frontalis*)	CPUE, fishing ground, season	Establish a relative abundance index and subsidize management.	Defining indicators, Data collection, data analysis	NGO, Researchers, Fishers
Tongoy Bay	Surf clam (*Mesodesma donacium*)	Landing data and direct assessment	To establish maximum catch quota of the resource and adaptive management	Designing of monitoring, Data collection, use of information	Government, Fishers and Researchers
Puertecillo, Navidad	Bull-kelp ‘‘cochayuyo’’ (*Durvillaea antarctica*)	Yearly biomass yields from each individual parcela	To manage sizes or layouts of the parcelas	Designing of monitoring, Data collection, Data analisys; discussion of results; use of information	Community
URUGUAY					
Barra del Chuy (former)	Yellow clam (*Mesodesma mactroides*)	CPUE, size and abundance of the resource, fishing effort	Establish catch quotas and allowed fishing grounds	Parte of data collection e evaluacion	Government, Fishers and Researchers
GEF-DINARA-FAO Project (Barra del Chuy)	Yellow clam (*Mesodesma mactroides*)	Abundance and biomass of clam population	Establish catch quotas	Data collection, data analysis, use of information	Government, FAO, GEF, Fishers
Punta del diablo	Red shrimp (*Pleoticus muelleri*)	By-cath, CPUE, Fishing effort, Mean trawling time	Implementation of a more selective fishing net for shrimp fishery	Data collection, data analysis, use of information	Government, Fishers and Researchers

				and evaluation of the device	
La Plata River	Brazilian codling (*Urophycis brasiliensis*) & Conger (*Conger orbignianus*)	Cacht data, Fishing effort, Sea lions' impact on catches and/or gear damage	Evaluate device effectiveness	Defining project goals, designing monitoring, data collection, data analysis, use of information and evaluation	POPA* (Community, Government, University)

2.1 Argentina

In Argentina, the only running case of participatory monitoring of coastal artisanal fisheries found is held in San José Gulf, Chubut. This iniciative is an attempt to maintain the vialibity of the scallop (*Aequipecten tehuelchus*) fishery and establish catch quotas for each season (CINTI et al. 2002; ORENSANZ et al. 2003; FIORDA et al. 2013). This is one of the most important bivalve mollusks for artisanal fishers in the region. The monitoring focus on stock availability, distribution of the scallop in the gulf and its biometrics. It is also a way to involve fishers in monitoring activities, establishing rapport and improving legitimacy in management decisions.

Participation of fishers started in 2002 through a pilot voluntary logbook program led by a research institution to obtain spatially explicit catch and effort data, to complement official fishery stadistics. Boat captains collaborated in providing fishing trip information detailing the catch, number of diving hours, fishing zones, among other. The program also included the collection of catch biological sampling (CINTI et al. 2003). This program aimed to monitor fishing activities actively involving fishers in data collection, and develop management recommendations. After two years of implementation, the program was discontinued due to lack of funding. However, it was a first step to infuse participation. Fishers started to participate again in 2007 in a regular monitoring program of resource abundance used to estimate catch quotas, conducted each year by the same research institute in collaboration with the Fisheries Administration (see section 3). The program is still running although with increasing difficulties due to disincentives trigerred by intermittent State support and resourse scarcity.

2.2 Brazil

The Corumbau Marine Extrative Reserve was created by request of fishers who identified a decline in fish stocks and high presence of outsiders fishing in the region (MOURA et al. 2007). Since 2001 fisheries monitoring is being conducted at Corumbau Marine Extrative Reserve. These program were conducted by Non-Governamental Organizations and/or researchers and the participation of fishers started in 2003. In 2006, a Participatory Fishing Monitoring Project proposed by a local fishers' association was approved by the Fishery Ministry. Local fishers were hired to collect catch data, recorded daily in spreadsheets. Monitoring results have been

regularly presented to fishers, supporting the evaluation of conservation and management strategies, as well as the possible adoption of new measures of management. Monitoring results were particularly important to guide decisions regarding the revision of the Reserve Management Plan (ALVES et al. 2012). This initiative was an example for two other Marine Extrative Reserves in the region, Canavieiras and Cassurubá, where fisheries monitoring also started to be conducted through a participatory approach (ECOMAR & CI 2009). The main achievements were the great integration among stakeholders and the empowerment of the community, which had an important increase in participation rates atthe Corumbau Marine Extrative Reserve council meetings (SEIXAS et al. 2009a).

At Costa dos Corais Protected Area, local monitoring started as a participatory research project conducted by the University of Pernambuco Fishers trained by researchers and researchers themselves started to monitor artisanal fishing and tourism flow (Table 3) for two years (1998 – 2000). Then, researchers and the community decided through a popular assembly to establish a no-take zone for three years in order to evaluate the impact of fishing activity and also the importance of fishing to local food security and to subsidize management decisions. After the aprovval of The Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), they continued the monitoring comparing the abundance of fish inside and outside the no-take area (MOURA et al. 2007).

A monitoring program at Southern Bahia's Territory of Citizenship was also implemented by a participatory research between 2011 and 2012. Its main objective was to involve fishers in the research process on spawning aggregations of reef fish. The idea of the research was to promote the appreciation of the traditional knowledge of hook and line fishers, and the acquisition of inaccessible biological data on the spawning of reef fish. These informations are of a great value to management once these fishes are the main target of line fishing. Data collection included information on the fishing ground and data related to relative abundance index for this fishery. Trying to obtain information about the reproductive dynamics and spawning aggregation sites of reef species, biological sampling was also carried out, including biometrics fish and collecting gonads on board (MALAFAIA et al. 2014).

A Governmental Project entitled “Participatory monitoring of marine artisanal fisheries of Santa Catarina state, Brazil” aimed to establish a participatory approach to generate information about fishing activity. This project derived from former initiatives of fishing monitoring in the region (see BONILHA et al. 1999 and MEDEIROS et al. 2007). Daily data were collected related to production, vessels structure, fishing gears, fishing grounds and environmental conditions. Fishers collected data voluntarily by fulfilling “fishing books”. These books were analyzed by the Research and outreach company on agricultural and livestock issues of the state of Santa Catarina (Empresa de pesquisa agropecuária e extensão rural de Santa Catarina, EPAGRI) and later returned to fishers as a way to stimulate the recording of fishing information. This monitoring program was extended to local schools due to a partnership between municipal government and a local Non-Governamental Organization, initiating an environmental monitoring program held by students (ARAUJO et al. 1999). No further data were found regarding fishers’ participation and use of fishers’ knowledge.

Prainha do Canto Verde community has a historical participation on numerous projects in the social, economic and ecological spheres (JUVENCIO et al. 2003). Community members were claiming along with Non-Governamental Organizations (NGOs), researchers and the government for the protection of lobster fishing sustainability, excluding outsiders illegal fishers (compressor and trawling) from the area. In 2002, a participatory monitoring of the sustainability of lobster fishing was held as an participatory-action research project. They monitored fishers' perception on the importance and their wellbeing related tolobster fishing, their level of education, illegal gears and fishers participation on meetings. The certification process triggered the creation of the Prainha do Canto Verde Marine Extrative Reserve in 2009 (Decree S/N, from 05/06/2009).
Furthermore, from 2008 to 2010, economic monitoring of lobster fishing was being conducted by a local NGO and fishers in order to provide information to support the Fisheries Management Plan of the Extrative Reserve in addition to statistical landing data held by the government.

2.3 Chile

In Chile, participatory monitoring approaches were identified in many cases inside Management Areas for the Exploitation of Benthic Resources systems. Between 1976 and 1981, a demand on the world market by the muricid gastropod and government incentives encouraged the exploration of this resource in a open access regime, period known as the "loco fever" (CASTILLA & GELCICH 2008). This resulted in the "loco" fishery crisis leading to the closure of the fishery between 1989 and 1992. Facing this crisis, scientist of the Pontificia Universidad Catolica de Chile established an experimental no-take area (Las Cruces) (NAVARRETE et al. 2010; AVILES & JEREZ 1999) in order to test humans' impact on coastal systems and determine whether *Concholepas* was indeed a keystone specie (CASTILLA & DURÁN 1985). Some years later, in 1998, scientists decided to shift their focus from basic to applied science initiating a co-management regime in collaboration to fishers and government where benthic invertebrate stocks were monitored (CASTILLA & DEFEO 2001).

Nowadays, at most Management Areas for the Exploitation of Benthic Resources monitoring programs, fishers' knowledge is poorly incorporated. Inside the Management Areas for the Exploitation of Benthic Resources, monitoring consists in analising the performance of this conservation system of benthic resources. As imposed by government, periodic monitoring reports should include the types and efectiveness of management strategies, types of fisheries performed and the status of target resources (SUBPESCA 1995). In some cases, a more participatory approach emerged (Aburto et al. 2014; Aburto e Stortz 2003; Schumann 2007; Ernest et al. 2010). The Management Areas for the Exploitation of Benthic Resources experiences involved capacity building of fishers and their participation in data collection. But, in general, it reveals most one-way information dissemination of technical and scientific knowledge to fishers rather than two-way exchange of knowledge between fishers and consultants. Moreover, in many cases there is a mistrust of fishers regarding consultants' reliability and their interaction with governmental agencies (SCHUMANN 2010). In this sense, this co-management experience is characterized by a division of labor rather than the sharing responsibilities and exchange knowledge (SCHUMANN 2007). Nonetheless, exemples where fishers participation is greater also occur and some are presented below.

At Juan Fernandez Arquipelago, an interesting bottom-up lobster fishing monitoring emerged. Lobster fishery is managed under an informal traditional tenure system with regulation of access

and spatial effort. A local fishers' organization, facing a scenario of discontinuous and costly monitoring and assessment projects led by the governenmet (SERNAPESCA), developed its own indicators of stock status and fishery performance. In 2006, fishers and scientists discussed toghether the possibility of initiating a Logbook Program in partnership with the support if a NGO. The program is voluntary, fishers can share the monitored data with the local fishers association. Data are compiled by fishers with the help of independent researchers. The idea was to make these informations available to government and be used in fostering strategies compatible with local reality. In this sense, data are analised creating an index of relative abundance of the lobster and was made available to fisheries authorities in order to subsidize decision making regarding local fisheries (ERNST et al. 2010).

At Tongoy Bay (north central Chile), a Management Areas for the Exploitation of Benthic Resource for exploitation of surf clam was established in 1999. Fishers, university researchers, government and the navy worked collaboratively to define a participatory management plan (ARBUTO & STOTZ 2003). One of the management actions was to monitor and analyze clam fishery overtime. Fishers association developed its own database to monitor landings and improve the commercialization process. Evaluation of surf clam banks and landing data were collected by fishers, supported by the government. Furthermore, fishers established surf clam price all together, controlling the market and making fishery economically viable for all fishers. Monitoring results were used collectively to establish a maximum catch quota of the resource, which is reformulated each year (ARBUTO et al. 2014).

Beyond the Chilean TURF system, a Traditional Common Property Right Regime of bull-kelp fishery at Puertecillo (VI Region) include a monitoring program. Within this system, communities' members access fishing grounds in a rotation regime legitimized by local social and cultural norms.. They also monitor the yearly biomass yields from each individual parcela, and are able to readjust the sizes and layouts of the parcelas if necessary (GELCICH et al. 2006; 2013). Since 2004, Puertecillo is under the Management Areas for the Exploitation of Benthic Resource regime, changing fishers traditional management and the role and contribution of fishers knowledge to bull kelp management (GELCICH et al. 2006).

2.4 Uruguay

In Uruguay there are attempts towards co-management initiatives. One of them ocured at Barra del Chuy related to the yellow clam fisheries. In the 80's, this resource was overfished, culminating with the closure of fishing between 1987 and 1989. In the early 90's, fishing was reopened under a management system which established catch quotas per season, an area rotation and catch minimum legal size (DEFEO 1993). In this closure period a participatory management experiment took place in order to investigate the effects of fishing on yellow clam demography. This experiment included a monitoring program of catch data and fishing efforts. This experiment was also an attempt to involve fishers into management and start a regime of co-management (DEFEO 1993; CASTILLA & DEFEO 2001).

Another co-management initiative is a government project in partnership with the Global Environment Facility (GEF) and the Food and Agricultural Organization (FAO) entitled "Piloting of an Ecosystem-based Approach to Living Aquatic Resources Management" (hereon FAO-DINARA-GEF Project). The overall objective of the project is to promote a long-term

design for fisheries management in Uruguay and biodiversity conservation. In the scope of this project, another monitoring of yellow clam at Barra del Chuy have started. The variables monitored are the catch of the yellow clam with the intention of establishing catch quotas (GIANELLI et al. 2014).

Beyond these efforts, we found two participatory monitoring cases regarding the implementation of a device to reduce the impact of fisheries. Both initiatives are related to a participatory research. At Punta del Diablo, there is an attempt to use a deivice to reduce by-catch at red shrimp (*Pleoticus muelleri*) fishing. This is a research project entitled "Design, construction and participatory monitoring of selective fishing gear: the artisanal fisheries of Punta del Diablo" that bring together the government technical staff, fishers and researchers to monitor and evaluate the effectiveness of the device (ARISMENDI 2011). The variables monitored were related to the by-catch percentage and escape of red shrimp to compare with fishing without the device , evaluating its effectiveness.

The other case is a participatory research leaded by the POPA Group (For Artisanal Fisheries) composed by fishermen, researchers, government and other actors. This group was formed within the framework of participatory research in 2011, where an action research took place in Piriapolis related to local artisanal fisheries issues. The members participated of each stage of the investigation and actions taken (BENTANCUR 2014a). The project "Mitigating artisanal fisheries impact on sea lions" involved a participatory monitoring of artisanal fisheries. The project goal was to design a new gear (pot-traps) and assess its feasibility to mitigate the interaction between sea lions and coastal artisanal fisheries at the Río de la Plata, Uruguay. The variables recorded were related to catch data and sea lions impact as also described in table 3 (BENTANCUR 2014a, b).

3. How participative is fisheries monitoring? How fishers' knowledge is included?
The results of monitoring characteristics of selected case studies related to the level of participation and to the types of fishers' knowledge used are summarized in Table 5.

Table 5. Ladder of Participation (BERKES 1994; BURNS 2003) and Types of Local knowledge (BAIGÚN 2013; ORENSANZ 2013) included into Monitoring initiatives per country.

Case	Ladder of participation	What type of local knowledge is being used?
ARGENTINA		
San José Gulf (Vieira)	Joint action	Ecological and Operacional
BRAZIL		
Corumbau Marine Extractive Reserve	Joint action	Ecological and Operational
Costa dos Corais Protected Area (Before the clusure)	Communication	Ecological and Operacional
Costa dos Corais Protected Area (After the clusure)		

Southern Bahia's Territory of Citizenship	Communication	Ecological and Operacional
Volunteer Environmental Monitoring - coast of Santa Catarina Province	Insuficient data	Operational
Prainha do Canto Verde	Joint Action	Cultural, Ecological and Operational
CHILE		
Quintay Bay & Las Cruces Protected Area	Cooperation	Insuficient data
Juan Fernandéz Arquipelago	Partnership	Cultural and Ecological, Operational
Tongoy Bay	Partnership	Ecological and Operational
Puertecillo, Navidad	Community self governance	Cultural and Ecological, Operational
URUGUAY		
Barra del Chuy (former)	Communication	Ecological and Operational
GEF-DINARA-FAO Project (Barra del Chuy)	Cooperation	Ecological and Operational
Punta del diablo	Cooperation	Operational
La Plata River	Partnership	Ecological and Operational

3.1 Argentina

In Argentina, the monitoring of scallop at San Jose Gulf can be placed at the *Joint Action* ladder of participation. In 2000 fishers proposed their involvement in the monitoring and sharing systematized knowledge about the resources they exploit. They also suggested that the fees paid by licensee should at least be partly reinvested in the costs of implementing the monitoring system. Ecological and Operational knowledge of fishers are involved in this monitoing system. The projection of these activities into the future is central to the allocation of use rights and participation of fishers in a formal program of co-operation (ORENSANZ et al. 2003), where researchers and government play an advisory role to decision making related to monitoring and fisheries management.

3.2 Brazil

At Corumbau Marine Extractive Reserve experience, fishers proposed monitoring, collected data and participated in decision making process. Researchers were responsible for the compilation, analysis and presentation of results to the community. Since 2006, monitoring database is based at the fishers' associations (ALVES et al. 2012). Ecological and Operational knowledge were involved in different stages of this monitoring, such as data collection and decision making process. Long-term monitoring is understood as an important tool in order to support decision-making by the Deliberative Council of the Corumbau Reserve, adjusting management decisions regularly. One example was the expansion of the no-take area inside the Corumbau Reserve coordinated by the Deliberative Council based on data already monitored (MOURA et al. 2007). In this sense, this case is placed in a high participation ladder, joint action mainly between fishers Non-Governamental Organizations and researchers, but also with participation of government.

The case of Costa dos Corais Protected Area can be considered at the Communication ladder of participation once fishers contributed to design monitoring regarding their operational knowledge of fishing activity. Some fishers also participated in data collection and the community as a whole was involved in decision making process through the popular assembly.

On decision making process and data collection, ecological knowledge of fishers was also being included together with scientific knowledge.

Fishers ecological knowledge was the focus of the monitoring hold at Southern Bahia's Territory of Citizenship. Operational knowledge regarding line fishery and ecological one related to fishers perception on the gonads stage were important to data collection and discussions about monitoring results. Some of the more experienced fishers got a research fellowship (category of Local Researcher) from a funding agencies for scientific research of the state of Bahia (Fundação de Amparo à Pesquisa do Estado da Bahia, FAPESB) to collect data. Monitoring results were presented to the whole community and the results were discussed together. The cooperation established between fishers and researchers contributed to open discussions related to sustainable use of fishing resources and can be classified at the communication ladder of participation. At the end of the project, fishers evaluated the work developed. Fishers found difficult to collect data and conduct fishing at the same time and pointed other failures that can be adjusted to other experiences. One of the fishers continued collecting data even after the fellowship ended. For him, the monitoring experience was usefull to understand his activity and plan future fishing (MALAFAIA et al. 2014).

At the economic monitoring program at Prainha do canto Verde, two community members collect data and participate on data analysis and all fishers discuss the results together. The sustainability of fisheries monitoring program was designed by a participatory approach in which fishers, technical staff and researchers defined jointly the monitoring goals and indicators. Both programs are participative, involving fishers' concerns and different types of knowledge in several stages of monitoring. The ladder of participation can be categorized as joint action.

3.3 Chile

At Las Cruces experiment, the evaluation of benthic invertebrate stocks and the planning of biological, ecological and fishery observations was held jointly by fishers and scientists (CASTILLA & DEFEO 2001; FERNÁNDEZ & CASTILLA 1997). Despite that, no information regarding what type of fishers' knowledge and a more detailed description of the roles of fishers and researchers within this joint action was found. As fishers participated as research assistance, it can be inserted at the cooperation level of participation. In addition to the creation of Management Areas for the Exploitation of Benthic Resources, this experience strenghtened the relationship between fishers, scientists and managers (CASTILLA & DEFEO 2001).

At Tongoy Bay the monitoring program at the Management Area for the Exploitation of Benthic Resources was held collaboratively by scientists, fishers and government. Fishers Ecological and operational knowledge were considered. Decision making based on monitoring results was also taken jointly (ABURTO et al. 2014). Considering these features, this case could be placed at the partnership ladder of participation. Foremost, this participatory approach enabled fishers' organization to manage local fisheries. They had control of landings and underwater monitoring. However, resource unsustainability led surf clam fishery to a not economically profitable activity, resulting in a crisis of the social system formed (ARBUTO et al. 2014).

The logbook-sampling program hold at Juan Fernandez Islands is characterized by a collaborative effort between fishers, fishers association and independent scientists. Some fishers

were reluctant, but half of fishers have joined the initiative. Ecological, operational and cultural knowledge were considered in this program. These different types of fishers' knowledge were useful to the creation of indicators, data collection design and the respect to the local traditional tenure system in which lobster fisheries occur. Fishers also take advantage of monitoring results by having significant information to discuss management decisions with authorities. Fishers, represented by their local association, are requesting the creation of a Protected Area around the islands. In addition, the monitoring is useful in divulgation and sale of lobster, derived from an environmentally responsible fishing (ERNST et al. 2010). This case can be understood as a *Partnership* between fishers, researchers and NGO, trying to involve government into traditional management of local fisheries.

Monitors of the bull-kelp fishery at Puertecillo are accountable to the fishers or are the fishers themselves. Fishers recoginize algae lifecycle and understand ecosystem conditions, incorporating this knowledge into management strategies and monitoring system. They are also aware of dynamics into the traditional institutions and cultural and social norms related to bull-kelp fishery. This case is a community-based monitoring system in which different types of fishers knowledge are involved. However, this system was incorporated into the system Management Area for the Exploitation of Benthic Resources, and could lose their traditional characteristics if it prevails a top-down approach (GELCICH et al. 2006).

3.4 Uruguay

Ladders of participation and use of fishers knowledge on Uruguayan cases are distinct one another. The former co-management initiative of yellow clam fishery at Barra del Chuy, is characterized by DEFEO et al. (2009b) as an instructive co-management. Monitoring was held by scientists and fishers, where fishers participation was mainly in data collection phase. Nevertheless, fishers knowledge was essencial to establish a spatial management scheme, considering heterogeneity in resource abundance and fishing effort (CASTILLA & DEFEO 2001). Ecological and operational knowledge of fishers regarding spatial distribution patterns of stock abundance and spatial dynamics of the fishing process was central to local management and monitoring. Fishers, managers and researchers have agreed that in order to facilitade the application of co-management, the scale of the management unit should ideally be that of each fishing community (FERNÁNDEZ & CASTILLA, 1997). Furthermore, joint discussion between fishers and researchers regarding operational knowledge, such as fishing effort provides valuable information about how to interpret catch per unit effort estimates (CPUE), improving the reliability of monitoring results (DEFEO, 1993a). In this sense, the montoring program developed in the Defeo et al. (2009b) can be considered into an "instructive co-management" context, and could be placed in our classification at the *communication* ladder of participation regarding the monitoring.

At the FAO-DINARA-GEF Project, beyond data collection, fishers have participated in independent evaluations of the fishery where the abundance and biomass of clam population were evaluated. Fishers were involved in collection and field samples analysis, and subsequent analysis of the data. From these assessments fishing quotas were set out. Due to logistical and financial constraints, fishers can not always participate in both instances (Ignacio Gianelli personal communication). In this sense, fishers participation could be placed at *cooperation* ladder of participation. Fishers cooperate with the data collection, and in some situations there is

a greater communication flow on data analysis. Fishers operational knowledge was the most incorporated to the monitoring at data collection phase. But, in some situations, ecological knowledge was also included, mainly at data analysis phase.

Arismendi (2011) analyzed fishers participation on Punta del Diablo case. Even though the project proposal highlights the importance of fishers participation, Arisnendi (2011) has found that all fishers participated in the project, but only one truly feels part of the research team. Other fishermen understand that they help as fishers, but technically not. Ariemendi used Wiber et al. (2004) classification placing the participation of fishers in a research assistant category. In our classification, it corresponds to the *Cooperate* ladder, where fishers participated on the designing of the device and data collection, but not really at data analysis and decision making process. Fishers ecological and operational knowledge was incorporated to the monitoring process, asfishers have great empirical knowledge about local atmospheric and oceanic conditions, fish species, as well as the history and changes in species at the local level (SEGURA & ARISMENDI personal communication).

A more participative approach occurred on POPA case. Monitoring emerged as collective demand in this initiative. Moreover, fishers participated at all steps of the project: defining project goals, designing monitoring, data collection, data analysis, using the information to evaluate the effectiveness of the device and possible solutions to sea lions impact. Fishers cultural, ecological and operational knowledge were involved at the design of the device and in its monitoring. This is a pioneering project in Uruguay with these features (BENTANCUR 2014b), characterizing a partnership of equals.

DISCUSSION

Participatory monitoring is not a management step emphasized in the literature. For Brazil and the Southern Cone, few of the studies analyzed give special attention to this subject, however co-management experiences as a whole are well documented. In the case-studies presented, monitoring of fisheries is led mostly by managers or scientists that involve fishers as data collectors. Besides that, Non-Governamental Organizations also play an important role in small-scale fisheries monitoring.

Monitoring goals and variables

The Southern Bahia's Territory of Citizenship was the only case that included the promotion of local knowledge as one of its main goals. Most of the monitoring programs are concerned with the ecological sustainability of fishing. Data monitored are mainly related to ecological and biological aspects of stocks and catches, aimed at providing information to guide decision making. Several cases used this information (i) to establish catch quotas (e.g. San José Gulf in Argentina, Tongoy Bay in Chile, and Barra del Chuy in Uruguay), (ii) to evaluate a less harmful fishing gear to local environment (La Plata River, and Punta del Diablo in Uruguay); or (iii) to create a no-take area for stock recovery and conservation (Costa dos Corais Protected Area, Corumbau Marine Exrative Reserve in Brazil, and Las Cruces in Chile). This type of information was considered imperative for a proper management of these fishing systems.

Despite that, fisheries are social-ecological systems where conservation of stocks and their environment are so important as human needs (BERKES 2011). In this perspective,

socioeconomic aspects of fishing must also be addressed in monitoing programs. Examples are the monitoring of food security at Costa dos Corais Protected Area case and the socioeconomic monitoring at Prainha do Canto Verde. In Brazil, a recent initiative is in progress towards socioeconomic monitoring. Three pilot areas are designated to start the implementation of *The Global Socioeconomic Monitoring Initiative for Coastal Management – SocMon* (BUNCEN et al. 2000) in Brazil. *SocMon* is a global initiative to establish local programs of socioeconomic monitoring at the coastal zone, complementary to biological and ecological monitoring. SocMon main goal is to empower managers incorporating the socio-economic context into decision making process of coastal management. Despite the engagement of communities and efforts of some government officials and researchers in designing this monitoring program in a participatory way one of the pilot areas is currently unable to implement this program due to institutional instabilities and divergent opinions in decision making.

Fishers' knowledge and phases of monitoring it informs

Most monitoring programs include fishers operational knowledge as part of the data collection phase for providing information about their activity (e.g. production and effectiveness/impacts of a fishing gear). Ecological knowledge is also incorporated in data collection and discussion about the results. This empirical knowledge is related to natural history of the species and environmental conditions. Fishers' ecological knowledge is based on years (or even centuries if we consider traditional knowledge) of observation of species, its behavior and location (e.g. Southern Bahia's Territory of Citizenship case). Scientific knowledge can be enhanced when combined with local knowledge, and viceversa (BERKES 1994). Furthermore, technical knowledge of managers can help to use the information generated in the context of fisheries management.

Cultural knowledge is less considered in monitoring programs. At Prainha do Canto Verde, community participation in fisheries management has a cultural driver. Fishers are engaged and lead many initiatives related to local fisheries and the welfare of the residents. The monitoring programs are mixed with actions to improve the sustainability of the community, always with the fishers participation and other supportive organizations. In Chile, two Traditional Common Property Right regimes were found: at Juan Fernandez Arquipelago which emcompasses lobster fishery and the other one at Puertecillo regarding bull kelp fishery. These cases include culturally adjusted monitoring programs. Cultural knowledge encompasses different phases of monitoring, including designing and identifying indicators to discuss and apply results. Fishers' knowledge, is regarded as an holistic (not fragmented into subjects and categories) understanding of the socioecological system in which fisheries are inserted (GERHARDINGER et al. 2009), cultural aspects are as important as ecological ones in the context of fisheries.

Participation and Institutional arrangements

Many monitoring initiatives emerge as a reaction of fishers or the government to stock decline and/or the presence of outsiders in local fishing gounds, exemplas are the San Jose Gulf in Argentina, the Corumbau Marine Extractive Reserve and the Costa dos Corais Protected Area in Brazil, Tongoy Bay in Chile and Barra del Chuy in Uruguay. Other driver that triggered participatory monitoring initiatives are scientific researches to subsidize management decision making (e.g. Costa dos Corais PA in Brazil, Punta del Diablo and POPA group research in Uruguay); to understand ecological and biological aspects of target species (e.g. Southern

Bahia's Territory of Citizenship in Brazil); and/or to investigate community perceptions of government failure in monitoring (e.g. Juan Fernandez Islands). We also identified one case of community-based monitoring (the bull kelp management in Chile).

To encourage genuine participation, independently if the monitoring emerged as a bottom-up or a top-down initiative, monitoring should make sense to the fishers and the demand for monitoring must exist (BUNCEN 2000). In other words, monitoring must be useful. One example is the Southern Bahia's Territory of Citizenship case, that after the research finished, one fisher continued collecting data because it was useful to him. The incorporation of fishers knowledge is a critical way to stimulate participatory processes of fisheries management (FAO 2013).

In Argentina, the descentralization of fishing governance from the federal level to provincial level may bring decision-making closer to the place where problems occur. In spite of this, fisheries management in Chubut province faces many challenges, mainly regarding State support for monitoring and enforcement (ELÍAS et al. 2011).

In Brazil, participatory management of artisanal fisheries occured in most cases into Protected Areas. The Marine Extractive Reserves, for example intend to operate under a co-management approach, requested by fishers communities. Despite that, few Marine Extractive Reserves have implemented a monitoring program to evaluate the effectiveness of its management strategies (SANTOS & SCHIAVETTI 2014). Fishers claim for more support from the government. At Corumbau Marine Extractive Reserve, for example, programs of monitoring have not being possible due to budget restrictions from the government (ALVES et al. 2012).

However, it is worth to mention that in Brazil, successful cases of inclusion of fishers knowledge into co-management of fisheries including monitoring programs are being performed in the Amazonian Forest rivers. Governamental programs related to fisheries participatory monitoring are concentrated in this region (SEIXAS & KALIKOSKI 2009). The classic example is the Pirarucu (*Arapaima gigas*) monitoring at Mamirauá Protected Area, where fishers developed a method to assess pirarucu stock when these fishes rise to the surface of rivers to breathe (CASTELLO 2004; CASTELLO et al. 2009). Inland fisheries management in Brazil should be taken as an exemple to be repeated in coastal zone.

In Chile, consultants, in some cases with the participation of fishers, are monitoring stock data (such as distribution and quantification of benthic populations) and socioeconomic aspects of the organization in charge of the Management Area for the Exploitation of Benthic Resources (Decree N. 355 - 1995/2010). Monitoring reports are required by the government and data are sent to SUBPESCA that design management strategies and establish annual catch quotas for the target species (SAN MARTÍN et al. 2010; SCHUMANN 2010). There is a long way from the data collected within the Management Area for the Exploitation of Benthic Resources and to the decision making process at the government sphere. In this process, there is a loss of ecological and other kinds of fishers' knowledge that could be important to an effective management of Management Areas for the Exploitation of Benthic Resources (MAEBR) and the sustainability of resources. Furthermore, in Management Areas for the Exploitation of Benthic Resources frequently occurs illegal fishing that is not recorded,. Another challenge is faced in cases where a

sustainable catch is not compatible with the community's economic needs (ABURTO *et al.* 2014; BANDIN & QUIÑONES 2014).

It is also important to adress the Traditional Common Property Right Regime of bull-kelp fishery at Puertecillo. This system is being changed by the implementation of the Management Area for the Exploitation of Benthic Resources (MAEBR). Fishers, to mantain their exclusive right to extract this resource, had to adhere to the new institutional arrangement, formalizing its fishing grounds into an MAEBR. In this process, fishers knowledge is not incorporated directly to management anymore. It must go through the administrative process before the decision-making be made, weakening their traditional system (GELCICH et al. 2006). Fishers knowledge could be more explored if monitoring programs were less complex enabling better participation of fishers and reducing consultants dominance (SCHUMANN 2010).

Despite all challenges, we identifyed some more participatory cases that provide significant subsides to its management and integration of local, scientific and technical knowledge such as occurred in Tongoy Bay (ABURTO et al. 2014). Furthermore, studies showed that efforts toward fishers' participation on monitoring along with consultants have enhanced environmental stewardship as the case analyzed (SCHUMANN 2007) and provided fishers a better participation in decision-making processes. Fishers involvement in the management of their activity include the establishment of catch quotas; the price resources will be sold and the number of buyers; and how income will be distributed within fishers (LEIVA & CASTILLA 2002; GELCICH *et al*. 2007; CASTILLA & GELCICH 2008). Those decisions are made regarding information derived from monitoring.

In Uruguay, a change in fisheries governance towards co-management is providing the beginning of participatory approaches and integration of local knowledge in management. Furthermore, international incentives to co-management in Uruguay have been occurring. Examples are projects of the Aquatic Resources National Organization (DINARA) in partnership with Food and Agriculture Organization (FAO) and the Global Environment Facility (GEF), but it requires the building of confidence to promote stakeholders participation. As identified by Trimble (2011) the university outreach is a way to deal with these issues and assist in the effective implementation of co-management in Uruguay.

Monitoring of artisanal fisheries in the case-studies presented occurs mainly in non-open-access systems, such as the Sustainable Protected Areas in Brazil or Management Areas for the Exploitation of Benthic Resources in Chile. This fact is due to the purpose of most monitoring programs which focus on evaluation of management action regarding conservation concerns and sustainable use of resources (see table 3). The University and some Non-Governamental Organizations also play an important role in implementing or supporting the implementation of co-management (SEIXAS et al. 2011), which is assessed in few situations by a participatory monitoring of its performance (SANTOS & SCHIAVETTI 2014). As identified by Seixas et al. (2009a) we also found that supportive organizations play an important role in mediating dialogue and interactions between fishers and government, mainly the Non-Governamental Organizations (e.g. Corumbau Marine Extractive Reserve, Prainha do Canto Verde) and Universities or Research Centers (e.g. Costa dos Corais Protected Area, Quintay Bay & Las Cruces Protected Area, San Jose Gulf, Tongoy Bay).

Achievements and challenges of participatory monitoring initiatives in Coastal Small-Scale Fisheries

The long-term maintenance of monitoring is an important challenge faced by most monitoring initiatives presented. Most of the long-term monitoring programs found had emerged where the community identified a need for fisheries monitoring (e.g. San Jose Gulf in Argentina, Prainha do Canto Verde in Brazil, Puertecillo and Tongoy Bay in Chile). Beyond the motivation of the fishers, the financial support is an important issue. Some programs depend on funding of a research project or from the government. At Corumbau Marine Extractive Reserve, for example, some monitoring programs stopped due to a cut in resources that used to be provided by the government (ALVES et al. 2012).

The motivation of fishers and incentives to fishers participation in monitoring can be discouraged when it generates evidence that fishing is not economically sustainable. Some monitoring programs paused when facing a period of crisis (e.g. The *loco* experience in Chile). This finding is corroborated by Ernst et al. (2010) in their study at Juan Fernandez Arquipelago. The same was identified inside Management Areas for the Exploitation of Benthic Resources in Chile in a study conducted by Cinti (2006) in the IV region. Cinti (2006) found that in areas with low economic performance, fishers had difficulties to work together and to fulfill management requirements (including monitoring). A similar response is being observed in the case of the San Jose Gulf in Argentina, with weakened fishers organizations and decreasing rates of participation due to resource scarcity due to the State inneficacy to support management and enforcement actions.

Another factor to consider is that within a community there are many different opinions (as we can see at Juan Fernandez Arquipelago case). People may not agree with the way in which management is being conducted. Thus, participation is not homogeneous. The different points of view should be considered and discussed to develop a monitoring program in all its stages: definition of goals, operationalization, interpretation and use of results. In adittion to incorporate different perspectives of community members, it is important to consider peculiarities of each case.

Furthermore, the standardization of fisheries management can suppress local knowledge, dictating fishers participation by imposing technical and scientific knowledge. To support the understanding of the coastal zone complexities, a degree of standardization in monitored variables is important for the data to be comparable. However, monitoring must consider the local peculiarities (BUNCEN et al. 2000). At Corumbau Marine Extractive Reserve, researchers have conducted a baseline study to understand local taxonomy of target resources and promote the inclusion of fishers knowledge in co-management before starting to delineate a fisheries monitoring program. They concluded that to establish a common language, emphasizing local knowledge is the first step to start a participatory monitoring program of fisheries (PREVIERO et al. 2013). In this sense, a major impediment to the use of local knowledge is that it must be recognized by scientists or by the government (ERNST et al. 2010).

CONCLUSIONS

Despite the fact that human and ecological dimensions of fishing systems are interconnected, the human sphere that includes cultural and socioeconomic aspects is generally underestimated in fisheries management. Cases of monitoring rarely include cultural knowledge of users and/or socioeconomic variables. The success of fisheries involves, among many factors, harmony among its various dimensions, which based in our analysis has not yet being achieved in monitoring programs in the study region.

In addition, institutional arrangements are largely responsible for the way in which participation occurs. The most participatory cases found were related to more participatory institutional arrangements, open to discuss management proposals, such as the Extractive Reserve models in Brazil and the decentralization of management in artisanal fisheries in Argentina (under a collaborative approach as Chubut Province). The high participation also occurs in cases with a bottom-up emergence as occurred in some Management Areas for the Exploitation of Benthic Resources in Chile and through participatory research in Uruguay. When talking about legitimity, it is also important to be attentive when technical and scientific knowledge/interests overlap the incorporation of local knowledge specially in top-down initiatives, which in theory has been declared participatory, but in practice the fishers role has been nothing more than a labour force in data collection. Despite the many challenges faced in the management of artisanal fisheries marked by advances and setbacks, South America is moving towards greater openness of co-management strategies, encouraging the participation of users with significant support from universities and other research institutes, and Non-Governamental Organizations.

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