Applying SocMon to Bycatch Monitoring and Management: A Brazil Case Study

An addendum to the Global Coral Reef Monitoring Network (GCRMN) Socio-economic Manual for Coral Reef Management

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This addendum, *Applying SocMon to Bycatch Monitoring and Management: A Brazil Case Study,* is an update to the Global Coral Reef Monitoring Network (GCRMN) Socio-economic Manual for Coral Reef Management (Bunce et al. 2000). This case study for reference has been developed through the Centre for Resource Management and Environmental Studies (CERMES) at The University of the West Indies (UWI), Cave Hill Campus, Barbados, to provide an example of how the SocMon methodology can be applied to monitoring by-catch of small-scale fisheries. The case study complements the Global Coral Reef Monitoring Network (GCRMN) Socio-economic Manual for Coral Reef Management.

Technical advice and guidance

The Global SocMon initiative (www.socmon.org) can provide technical advice, guidance and share experiences on the application of SocMon/SEM-Pasifika to small-scale fisheries monitoring. Contact Peter Edwards at peter.edwards@noaa.gov for further information.

Reproduction

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Copies of *Applying SocMon to Bycatch Monitoring and Management: A Brazil Case Study* can be downloaded from the global SocMon website (www.socmon.org).

Comments and feedback

Comments on this addendum and feedback on how it was applied would be most appreciated. Please send to Maria Pena at maria.pena@cavehill.uwi.edu.

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BACKGROUND

Small-scale fisheries and SocMon

Small-scale fisheries (SSF) are difficult to measure and monitor by conventional means (FAO and WorldFish Center 2008). In order to better understand how to make fisheries sustainable for the benefit of ecosystems, fisheries resources, and people, as well as advance the process of policy and practice for sustainable livelihoods, socio-economic information is critical (Edwards et al. 2019). This addendum to the Global Coral Reef Monitoring Network (GCRMN) Socio-economic Manual for Coral Reef Management (Bunce et al. 2000) provides a case study on the application of the Global Socio-economic Monitoring Initiative for Coastal Management (SocMon) methodology to the challenge of managing shrimp trawl fisheries to reduce bycatch in Brazil.

SocMon aims to advance global and regional understanding of human interactions with and dependence on coastal resources. Its flexible and participatory methodology enables fisheries and coastal managers to identify potential problems and shocks, mitigate negative impacts, and focus management priorities accordingly to achieve management objectives. SocMon is a means of promoting the use of social and economic data in fisheries and coastal management decision-making. It is designed to be combined with many approaches and tools (Edwards et al. 2019).

Global and national concerns on the impact of trawl fishing and fishing discards

Shrimp trawl fisheries have generated concerns both in Brazil and globally on how to implement management strategies to cope with their impacts on marine biodiversity. Despite its productive capacity in terms of biomass, trawling is recognized as a non-selective harvesting method that leads to a number of environmental impacts. Degradation of the seabed with resuspension of sediments, alterations of the habitat structure, and loss of areas of marine vegetation are among the main impacts. However, the incidental capture of non-target species, including juveniles of commercially important target species and species with vulnerable life cycles such as sharks, turtles, and invertebrates, among others, is at the core of all concerns.

These unintended species are called bycatch and can be differentiated into two categories. Those with socioeconomic importance, called byproduct, are inserted in the fish supply chain or consumed by resource users. While others, are discarded overboard, and deemed as having no use either for consumption or other economic purposes. In tropical shrimp trawling, much of the bycatch is composed of small fish, mainly young individuals of commercial species (Alverson et al. 1994). The percentage of bycatch can reach up to 90% of the catch, varying according to the fishing gear technology, fishers' behaviour, seasonality, and fishing grounds. The capture of bycatch may lead to reduction in fish stocks and consequently, to an over-exploitation of target species.

Conversely, the evolution and historical consolidation of trawl fishing regionally and locally, especially in small-scale fisheries, has created a strong socioeconomic and nutritional dependence on the bycatch. In addition to its biophysical aspects, understanding the role and impact of the human dimensions of bycatch on local communities becomes fundamental. In many fishing villages, such as in Brazil, for example, the bycatch is the main, if not the only, source of animal protein for many families. The different forms of collaboration and reciprocity through the donation of components of the bycatch create activating opportunities for new links in the fish supply chain.

When considering the ecosystem and human dimensions of bycatch - far beyond aspects of the conventional fisheries science parameters, concentrated on biological aspects of target species - the bycatch is an important component of marine biodiversity. Thus, integrating fisheries management with biodiversity conservation, especially in marine protected areas (MPAs), should include bycatch reduction strategies.

Shrimp trawling in Brazil is present along the entire Brazilian coast and is quite diverse. A variety of species are typically exploited, these include; the Atlantic seabob shrimp (*Xiphopenaeus kroyeri*), the white shrimp (*Litopenaeus schmitti*), the Argentine red shrimp (*Pleoticus mulleri*), the argentine stiletto shrimp (*Artemesia longinaris*), and the pink shrimp (*Farfantepenaeus paulensis* and *Farfantepenaeus brasiliensis*). These species represent the main targets on the south-southeastern coast. The bycatch is composed of about 200 taxa, mainly finfishes, crustaceans, and mollusks.

Small-scale fishing vessels include single and/or double rigged trawlers that explore the sea bottom along the south-southeast Brazilian coast (Figure 1). Trawlers also vary in boat size and engine power. The hauling time varies according to the characteristics of the fishing site, fishing gear technology, and fishery socioeconomics, such as selling strategies and use of bycatch. Additionally, the fishing strategies - fishing time and use of fishing grounds - are influenced by the fishers' perceptions on shrimp abundance and the rate of bycatch.

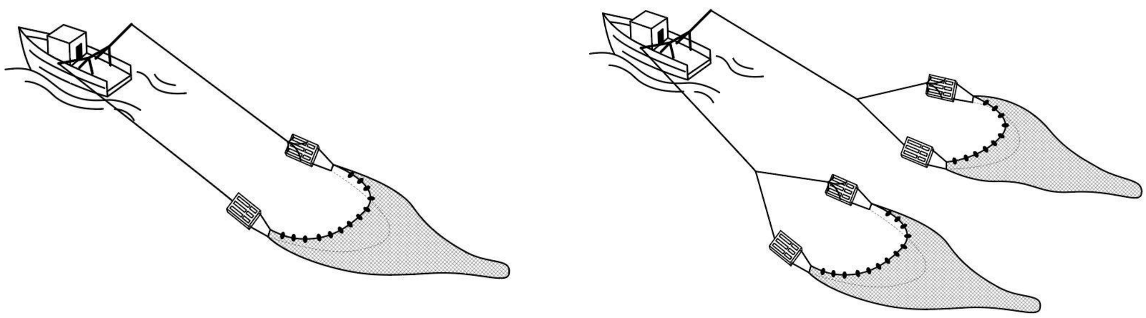

Figure 1 Single and double rigged shrimp trawlers

The control of trawling fishing effort is regulated by fishing gear restrictions (type and dimensions), minimum catch size limits, temporal and spatial closures, and limitation of fleet size. However, although present in national plans as guidelines, the reduction of bycatch is not clearly addressed in the management of trawl fisheries.

BYCATCH REDUCTION AND MANAGEMENT TOOLS

One of the main challenges in managing trawl fisheries is that it relies on establishing measures to reduce the environmental impact of the fishery discards. Efforts have been made to shift trawl fisheries to more sustainable pathways. This will require more diversification of management tools that encourage moving from Brazilian narrow management perspectives that are mostly limited towards a broader definition of no-take zones and/or closed seasons.

Technological modifications, such as bycatch reduction devices (BRDs), are examples of an alternative approach to conventional fisheries management. BRDs are structural modifications both in the body and codend[1] of the trawl net, which can exclude mechanically unwanted specimens or separate species by differences in behaviour. Experiments have demonstrated efficient bycatch reductions in biomass and/or species diversity without significant loss in target species.

The relationship of fishing communities with the byproduct and discards has implications for the development of management strategies and their implementation and compliance. Therefore, information on trawl fisheries and the composition and socioeconomic dependence on bycatch is essential to draft adequate regulations and responsibilities in a fisheries co-management process. Hence, the need to build participatory approaches to address the issue of bycatch in fisheries' management in marine protected areas is fundamental.

Fisheries and Marine Protected Areas Policy

Currently, MPAs are among the main management tools for the conservation of marine ecosystems. National and international experiences have shown that the integration between fisheries management and MPAs can promote satisfactory results for biodiversity conservation (Westlund et al. 2017; Prates and Blanc 2007).

In Brazil, MPAs include fishing closure zones created by fishery management instruments (Brasil 2009) and protected areas established by the National System of Protected Areas (SNUC; Brasil 2000). MPAs play an important role in regulating fisheries in an innovative fashion that is distinct from the limited perspectives observed in conventional fisheries management in Brazil. Integration with fishers can stimulate the crafting of regulations fitted specific to the local, social and ecological dynamics.

Some MPAs have been open to scientific experimentation and research, followed by better acceptance of new alternatives related to fisheries management, such as the use of BRDs. Based on the Brazilian context, BRDs can only become possible through great flexibility in supporting innovative initiatives.

Bycatch reduction in the context of managing fisheries within MPAs

The Environmental Protection Area of Anhatomirim (EPAA) is a Federal MPA – managed by the Chico Mendes Institute for Biodiversity Conservation (ICMBIO) - covering marine and terrestrial regions in the municipality of Governador Celso Ramos in Santa Catarina. It was created for the protection of the resident population of the Guiana Dolphin, Sotalia

[1] The "codend" is the narrow end of a cone-shaped trawl net which retains the catch after each towing.

guianensis, the Atlantic Forest, water resources, and fishing communities. This area covers 4,750.39 hectares, of which 58.8% comprises the marine environment.

The main targets of local small-scale fisheries are species dependent on estuarine and shallow waters, with emphasis on the Atlantic seabob shrimp, white shrimp, white mouth croaker (Micropogonias furnieri), and mullet (Mugil liza). One of the main productive activities in the region is the small-scale shrimp fishery that is primarily conducted by drift gillnets and trawling.

The EPAA management seeks to foster a relationship of mutual involvement with small-scale fishers in the MPA. Regular meetings, interactions with fishers at fishing sites, and participatory decision-making are carried out, particularly with the support and engagement of its advisory management council – formed by representatives of governmental and non-governmental organizations. In order to improve fishers' participation and fisheries management within the MPA boundaries, ICMBIO local managers created the Community-Based Fisheries Forum or Fórum Comunitário de Pesca (FCF).

The practice of participatory management was decisive for the elaboration of the management plan in 2013. The EPAA management plan resulted in a series of regulations that emerged from social agreements, which requires participatory monitoring, and represents the outcome of a process characterized by great social participation, especially by small-scale fishers.

The elaboration of the management plan began in 2009 and involved a series of meetings and workshops held in the EPAA communities. Social agreements were mainly based on the diagnosis and synthesis of the main conflicts and potentialities of the fishing sector, a survey of zoning proposals and planning for the region, and proposals for actions and programs aimed at promoting the sustainability of economic activities.

The ecological-economic zoning (Figure 2) included nine defined management zones, five in the marine area and four in the terrestrial area. The criteria used to define these zones included attributes of the biophysical environment and use and occupation of land and water. The studies carried out in the EPAA, as well as the knowledge and experience of its managers, fishing communities, and local leaderships, allowed the identification of areas with common characteristics that, associated with the different forms of uses and degrees of conservation, resulted in the delimitation of the management zones.

The creation of the Trawling Regulation Zone (ZNPA), an ecologically sensitive marine area but also an important fishing ground, is among the established management zones. With the management objective of reconciling socioeconomic development with conservation of biodiversity, the plan defined the encouragement of technical or technological strategies to mitigate the impacts of trawl fishing. According to the management plan, trawling is also subject to regulations deriving from experiments combining scientific and fishers' knowledge, aiming to establish more environmentally friendly fishing strategies.

Figure 2 Ecological-Economic Zoning of the environmental protection area of Anahatomirim (ZNPA is highlighted

In this management zone, research and socio-ecological participatory monitoring joint efforts between the EPAA and ICMBIO managers (including managers from the National Center for Research and Conservation of Marine Biodiversity – CEPSUL), small-scale fishers, and researchers have been conducted since 2011. The main focus of the group is the creation of a collaborative network that bridges traditional and scientific knowledge, aimed at reducing the ecological and socioeconomic impact of trawling through the use of bycatch reduction strategies. Experiments were conducted jointly with fishers on their boats, testing Nordmore Grids, escape panels, and square mesh in the codends. The modified nets were tested against their daily used nets and the results were shared and lessons learned have been used to nurture the creation of management strategies and their implementation.

IMPLEMENTATION OF SOCMON TO ASSESS FISHING DISCARDS AND DEPENDENCY ON BYCATCH

The SocMon Bycatch project (Figure 3) was conceived to support the implementation of the Trawl Fishing Regulation Zone (FIGURE 3). Addressing the bycatch problem was one of the priorities defined – with participation of fishers – in the management plan development process. After approval in the management council, fishers were engaged through community workshops in order to define variables and strategies for monitoring. Evolution of SocMon steps were based on a continued dialogue with fishers through workshops and demonstration of results, which allowed for a better understanding and engagement. Workshops to collect additional information and share results were held after concluding and systematizing the information from the interviews and experiments.

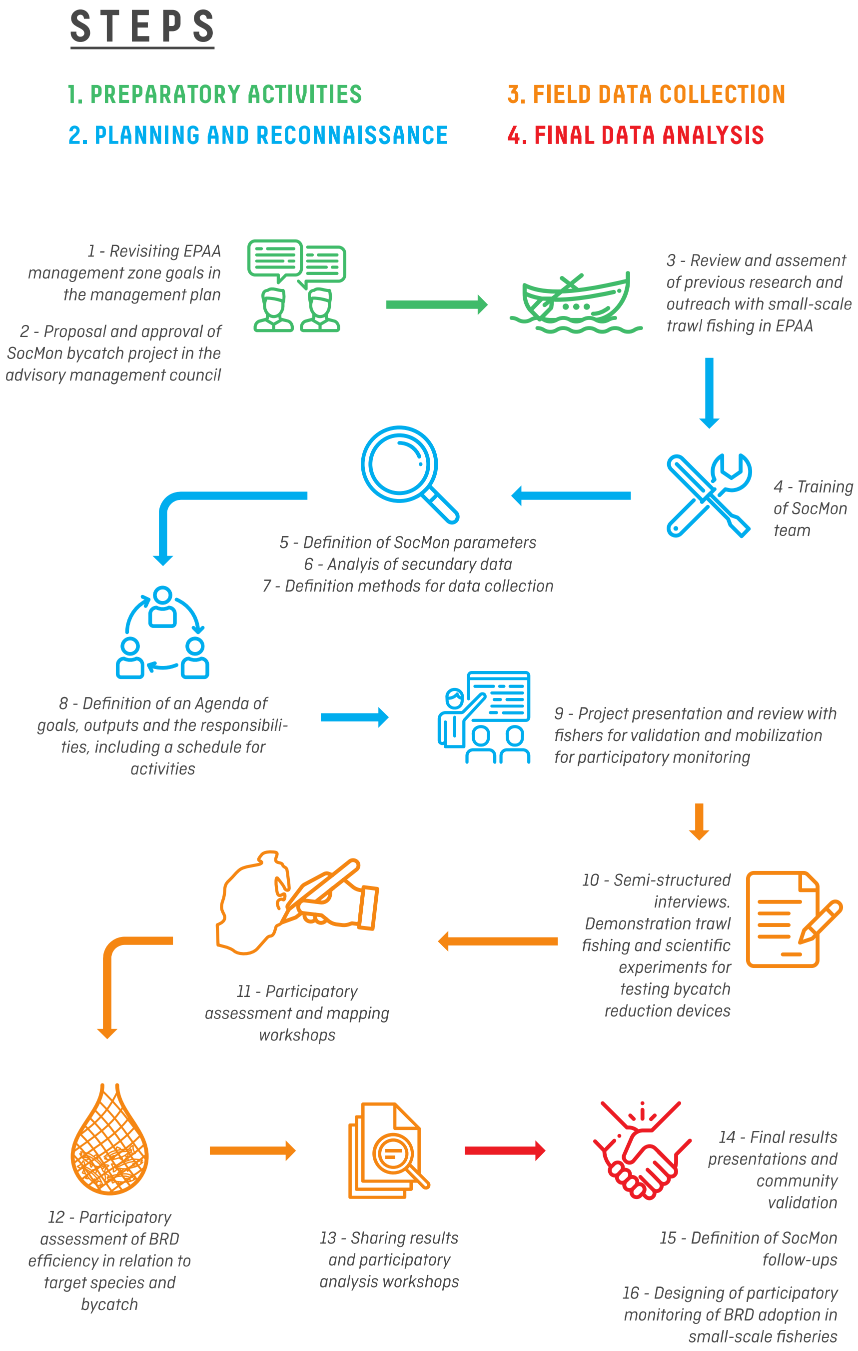

Figure 3 SocMon steps in the implementation of bycatch monitoring

The monitoring was designed to measure socioeconomic and ecological parameters (Table 1) - primarily to provide a comprehensive understanding on fishery dynamics, dependence on bycatch and opportunities and constraints to implement bycatch reduction devices. Thereby, from a SocMon perspective, the monitoring transcended the data-collecting perspective to an engagement – information – learning – action rationale to support decision-making in MPA governance and management.

Table 1 Defining variables and monitoring

Specific indicators of bycatch parameters were mainly based on existing SocMon variables.
SD = Secondary data ; Sur = Survey ; Obs = Participant Observation ; FT = fieldtrip; WS =Workshops

Parameters	Variables	Bycatch specific indicators	Data collection	SocMon index
Demographics	Study area	Geographical aspects; ecosystem characteristics	SD	K1
	Gender	Women's role in fisheries; different types of work in the fish supply chain	Sur, Obs, FT	K6
	Population	Number of fishers	Sur	K2
	Number of households	Household size; number of fishers in the household	Sur	S8
				K3
	Age	Age of fishers and fisherwomen in the household	Sur	K5 S1

Parameters	**Variables**	**Bycatch specific indicators**	**Data collection**	**SocMon index**
	Ethnicity	Citizenship of family members	Sur	K9 S3
	Occupation	Occupation of family members; types of fisheries performed in the household	Sur	K12 S7 S10
		Women's occupation in the household		S2
	Household income	Dependence on fisheries	Sur	S9
Community infrastructure and business development	Community infrastructure	Fisheries support structures; fishing gear and boats characteristics	Sur, Obs	K13
Coastal and marine activities	Activities	Types of fisheries and mariculture; how the fisheries work	Sur, Obs, FT	K14
	Goods and services	Productivity data	Sur, FT	K15
	Types of use	Resource uses	Sur, Obs, FT	K16
		Bycatch destination		B1
	Goods and services market orientation	Catch processing types; selling places	Sur	K18
	Use patterns	Harvest season	Sur	K19

Parameters	Variables	Bycatch specific indicators	Data collection	SocMon index
	Levels and types of impact	Trawling fleet impacts	Sur, Obs, FT, WS	K20
		Bycatch reduction devices performance		B2
Governance	Stakeholder participation	Participation on management actions; role of stakeholders in decision making	Sur, Obs, WS	K31
	Community and stakeholder organizations	Participation in fishers' organizations	Sur	K32

Main results

Specific exploration of SocMon Bycatch indicators was mostly based on interviews that focused on the socioeconomic aspects related to the communities' dependence on the use of the bycatch. In addition, the perception of fishers on the effectiveness of BRDs and their participation in the development of bycatch mitigation strategies were assessed. For example, from SocMon Bycatch indicators, results demonstrated that younger fishers have vessels with higher power engines (Figure 4). For young people (men) to enter into fishing there needs to be the attraction of bigger engines (and probably also more fishing technology generally) which increases effort. Managers want fishing to continue, but not for effort to increase as a result.

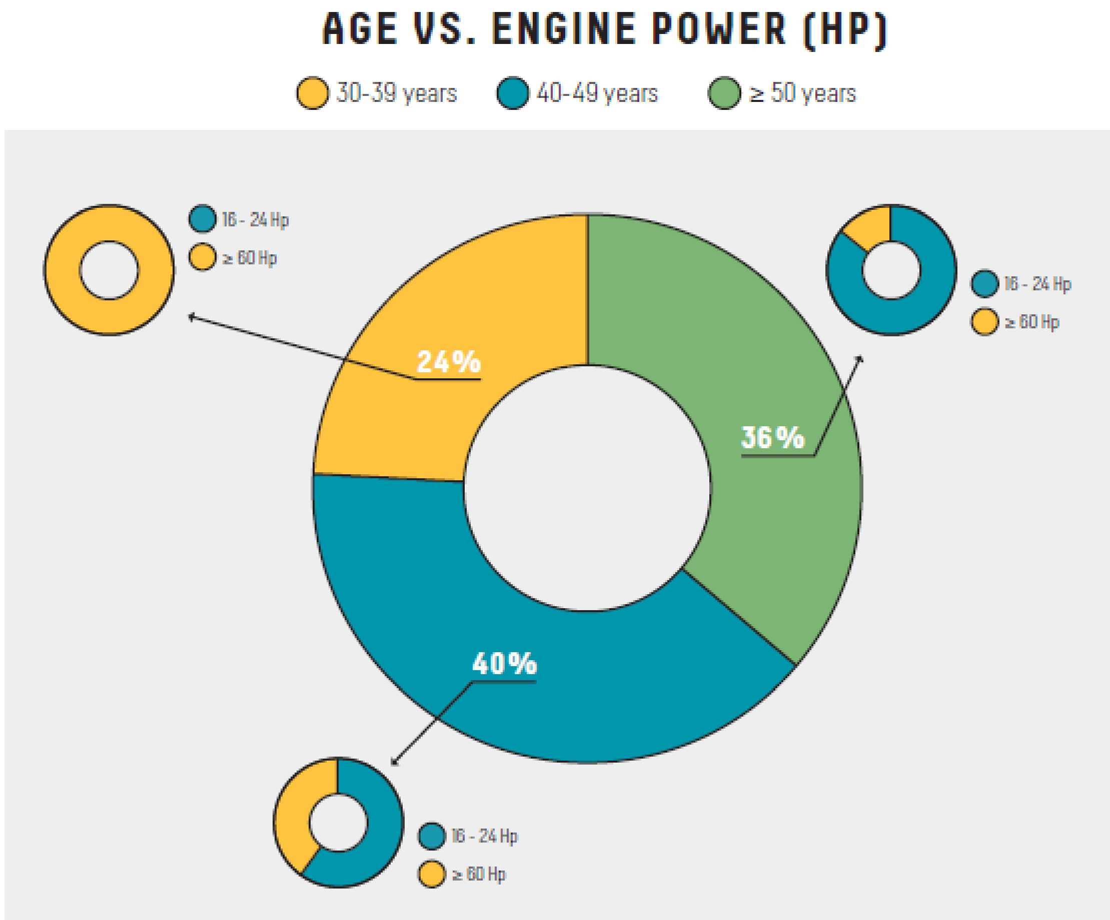

Figure 4 Proportion of vessel power according to the age ranges of Anhatomirim fishers

The results also demonstrated the dependence on bycatch as well as the willingness to collaborate and to use BRDs varies according to fishers age and boat size, household structure, such as the number of children (under 7-years old), and satisfaction with overall MPA management performance. It was also observed that 92% of the interviewees find the byproduct important. Some use it for consumption and others for sale confirming the extreme relevance of bycatch as previously identified.

Main outcomes

The SocMon perspective on monitoring and more broadly, on supporting the implementation of the ZNPA in the management plan, was considered a crucial process to a less-contentious and more participatory perspective on fisheries management in the EPAA. Fishers and managers agreed on an adaptive and learning process of building fishing regulations for reducing bycatch. Also, the EPAA experience as a SocMon site created opportunities for a national perspective of SocMon – as a “proxy” for supporting fisheries management in federal MPAs.

Recently, workshops were conducted with fishers and managers to a mid-term evaluation of SocMon initiative in the Environmental Protected Area of Anhatomirim. After revisiting the management and monitoring objectives for the ZNPA, managers agreed on the importance SocMon and the resulting partnerships among fishers, researchers and managers from the joint effort its implementation.

Fishers also experienced changes in the perception about bycatch dependence and willingness to adopt bycatch reduction strategies. Regarding the different types of net modifications for reducing discards, in a recent survey 52% believe that they can work. However, most of the interviewees who did not believe that these modifications could work had never heard about them or their use. Despite not having full comprehension, acceptance of net modification increased substantially, since rejection of BRD use was close to 100% when the project started. In addition, seven fishing behaviours or net modifications were also considered important by the fishers for discard reduction without affecting shrimp yields (

Figure *5*). Hence, 88% were willing to try nets that have already been tested and nets with adaptations recommended by them. This changing perspective was mainly attributed to the participatory approach in the monitoring and research procedures (SocMon) – where fishers were aware of what had been done, also finding opportunity to engage in SocMon actitivities.

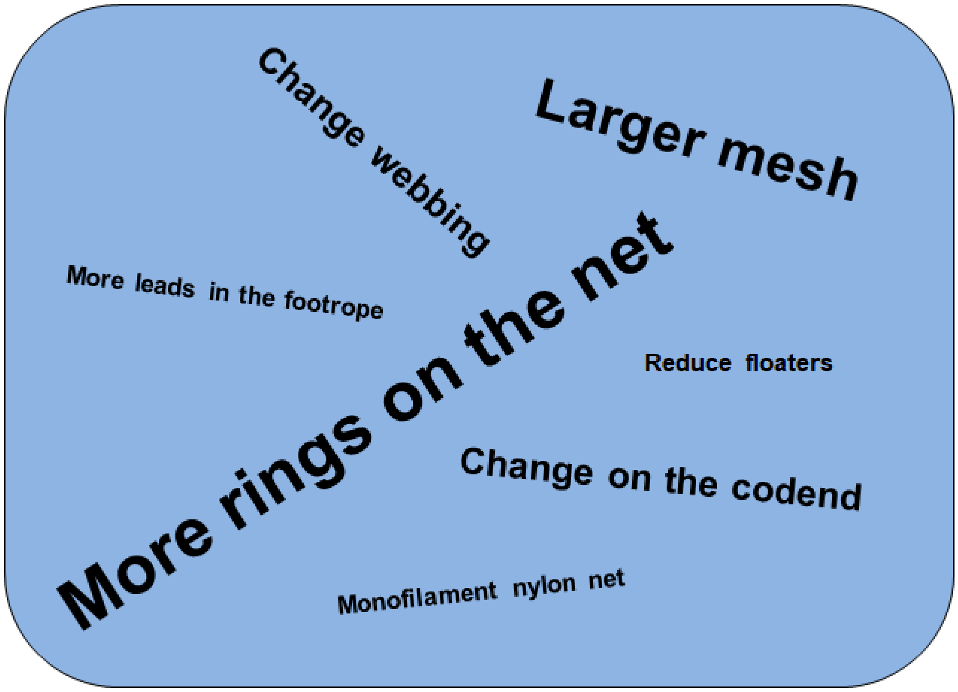

Figure 5 Possible net adaptations suggested by the Anhatomirim EPA fisheries to reduce bycatch

A framework was developed between 2014 and 2015 to support research and the dissemination of actions related to bycatch management (Guanais et al. 2015). The rationale on how to evolve the idea of BRDs beyond scientific experiments was applied to this guideline. From then, the project's actions were conducted according to this plan. Based on experiences from 2012 to 2016 and the methodological developed framework, three combinations of net modifications were agreed on. These are explained below. In 2017, experimental scientific tests were conducted based on the perspective of the expected degree of bycatch exclusion.

1. *Square mesh codend* (Figure 6).
   Exclusion expectation: low to medium.
   Exclusion objective: a reduction in the catch of juvenile fish and shrimps. This is a modification proposal that does not require major transformations in the net structure, except in the codend and the web material that connects it to the body of the net.

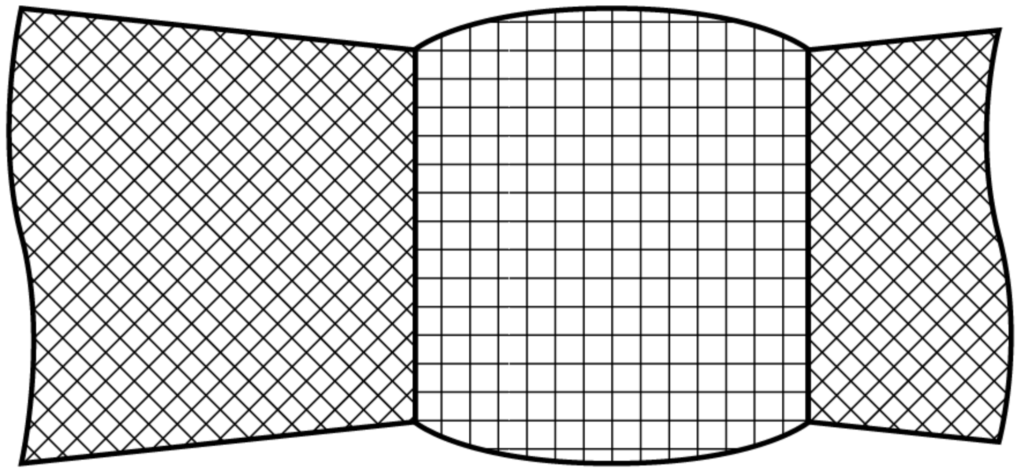

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Figure 6 Square mesh balloon

2. *Nordmore Grid 30mm with painted codend* (
3. Figure ***7***).

   Exclusion expectation: medium to high.

   Objective: reduction in the catch of fish and invertebrates without a significant loss in byproduct capture. This is a modification proposal that requires changes in the net structure, with a concept of discard reduction, however, with the retention of part of the byproduct.

4. *Nordmore Grid 17mm with painted bagger* (
5. Figure ***7***).

   Exclusion expectation: high. This is a proposed modification that enhances the exclusion of bycatch.

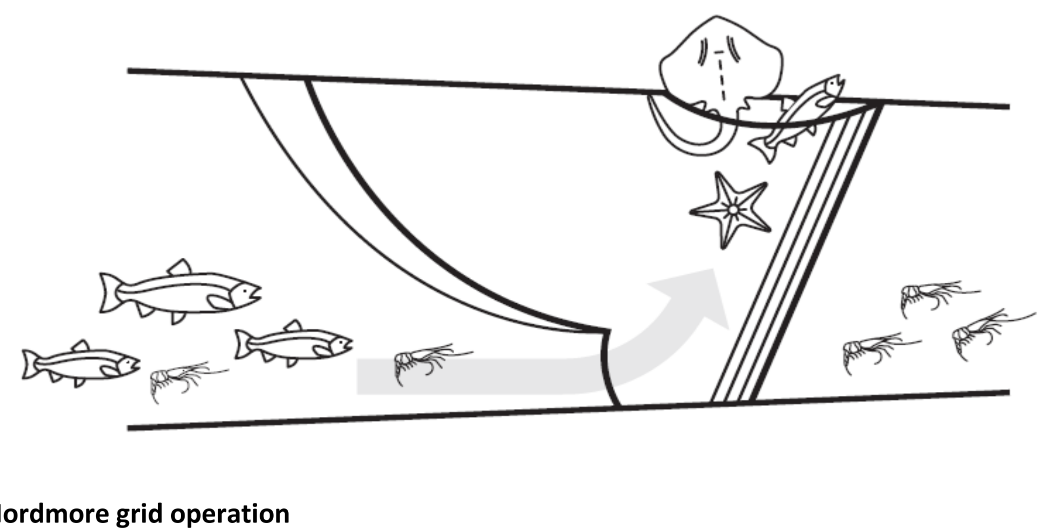

Figure 7 Nordmore grid operation

APPLYING SOCMON TO MANAGE BYCATCH: LESSONS LEARNED

Since its initiation as a SocMon study site, the Environmental Protected Area of Anhatomirim has a history of experiences with the use of technological modifications to reduce the bycatch in the trawling fleet. The interaction between fishers, managers, and researchers based on the proposed framework was an important factor for increasing the legitimacy of decisions. Thus, a key part of the proposal is to assess to what extent the use of BRDs is feasible as an instrument of fisheries management for this region.

Another important factor, resulting from the first, is the development of a proposal that integrates research and outreach into the management process from the beginning. As a result, this is the first case of a fishery management instrument in Brazil that formally addresses the BRD as an integrated measure as foreseen in the management plan.

Being a SocMon pilot site had a relevant role in the implementation of the management measure focused on the use of BRDs. Therefore, workshops to evaluate the results and their consequences for fisheries management were implemented. The workshops were conducted in two groups, managers and fishers. The latter was held along two meetings with the intent to cover different communities.

The appreciation of the fishers' opinions stimulated and ratified the participatory management process that was being implemented in the EPAA. This trajectory was fundamental to improve and make this procedure more transparent and robust, that is, more applicable and characterized by dialogue. Moreover, the experiments served to underpin decision-making, which occurred in a shared way among the actors involved in the project.

This adaptive methodological guideline for the joint construction of management measures counted on the definitions of work stages throughout the application process in the communities. This contributes to the goal of SocMon, which seeks to adapt assumed objectives and data collection to the dynamics of a socio-ecological system.

In addition, community engagement in the monitoring process has created a link between the fishers and the unit's management. This process brings favourable conditions to increase sampling and the credibility of collected information and contributes to a participatory and legitimate monitoring for participatory management.

The application of the SocMon methodology contributes to the opening of spaces for dialogue between managers, researchers, and communities, and demonstrates that community involvement is important to generate possibilities to outline new objectives.

The current phase involves the establishment of proposals elaborated in the management process. However, there is no definition of what will be the subsequent procedures for the adoption of BRDs by fishing communities and the implementation of these devices as a measure in the MPA.

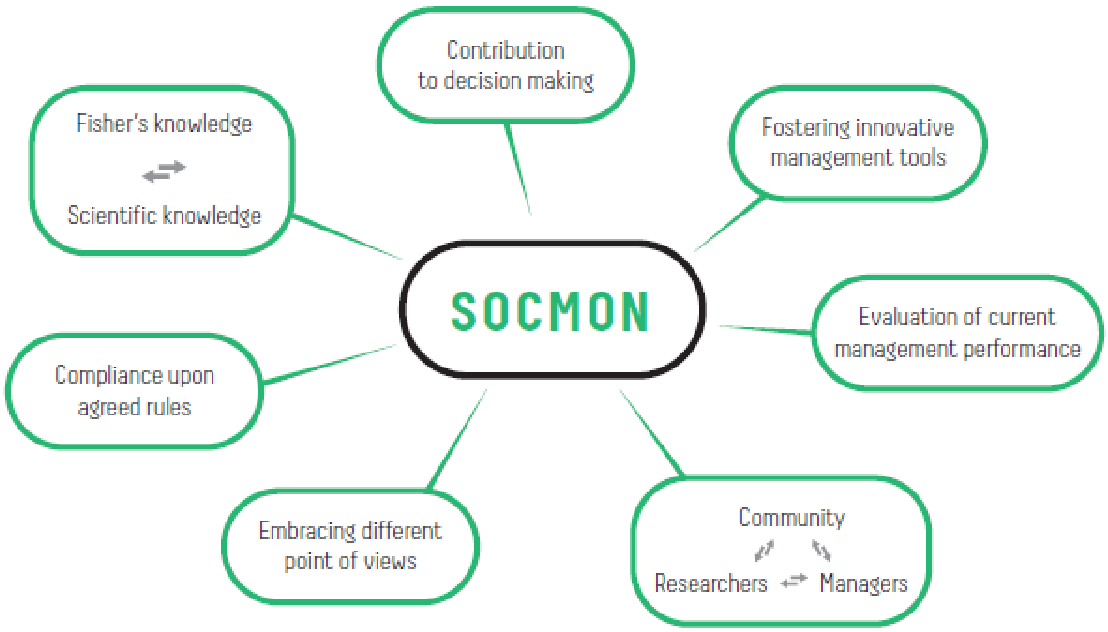

Figure 8 Lessons learned

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