Master of Environmental Science and Management

Bren School | University of California, Santa Barbara

Supporting Co-Management of Brazil's Marine Extractive Reserves

Photo by Vinícius Nora

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The Group Project is required of all students in the Master of Environmental Science and Management (MESM) Program. The project is a year-long activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Group Project Final Report is authored by MESM students and has been reviewed and approved by:

Dr. Steve Gaines	Date

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Abstract

Small-scale fisheries are an integral part of coastal economies, cultures, and ecosystems. Brazil's extractive reserve system was originally created to protect the livelihoods of indigenous peoples in the Amazon rainforest, but has since been expanded to marine environments to preserve the livelihoods and cultures of coastal fishing communities. The reserve system offers promise of sustainable resource use, but these marine extractive reserves (MERs) are largely understudied and the current governance may not provide sufficient conditions for successful co-management. Brazil's communities are unique, however the challenges facing these reserves are shared with other rights-based fisheries. Leaders of similar reserves around the world have developed creative solutions that adapt to suboptimal conditions. As such, shared learning between communities has the potential to catalyze positive change in Brazil. To facilitate this transfer of knowledge, our project worked with World Wildlife Fund Brazil to distill a literature review and interviews with global small-scale fishery experts into a decision-making guide for managers. Additionally, to understand how the coronavirus pandemic has impacted Brazil's MERs, we created, administered, and analyzed results for a survey investigating COVID's impact. We aim to provide Brazil's fishing communities access to vetted management recommendations that could help them identify and achieve goals within their communities.

Explanation of MERGENTE

A quick note from the MERGENTE team:

The motivation behind this project was to provide a useful and practical resource for fishing communities in Brazil. As a constant reminder of our ultimate goal, we decided to call ourselves MERGENTE. When disassembled, “MER” represents the marine extractive reserve (MER) structure our project focuses on. “GENTE” on the other hand translates to “people'' in Portuguese. When combined, our name reflects the tens of thousands of people whose livelihoods depend on their fishing community’s success.

Thank you for reading our report.

Obrigado e saúde

- Peyton, Dylan, Elliott, and Ruben

Project Objectives & Significance

Objectives

The goal of this project is to improve the effectiveness of resource management in Brazil's co-managed marine reserve system so that the livelihoods and food security of local fishers are preserved. To better understand the complex and understudied marine extractive reserve (MER) framework, this project frames them as complex social-ecological systems. This project then synthesizes global fisheries management knowledge from experts around the world to develop recommendations relevant to MERs.

We **created a decision tree and process guide tool** with these recommendations to help Brazil's managers navigate common management challenges. The recommendations from this tool are based on successful strategies and functional knowledge shared by fisheries experts from around the world. Due to the unforeseen and unprecedented challenges presented by the coronavirus pandemic, we include analyses and recommendations specific to the **impacts and responses of MERs to COVID in Brazil**. Finally, to characterize the governance structures of reserves, we **used in depth interviews to construct an institutional profile of the MER system.**

Significance

Half of global fish catches and over 90% of people employed in fisheries come from small-scale fisheries (SSF) (1). Unlike tech-intensive industrial fishing fleets, these communities primarily employ traditional fishing techniques that are passed down over generations. For example, mangrove crabs are commonly found in numerous reserves along the coast of Brazil and are an important food source and economic resource for fishers, who hand pull each crab out of the mangrove mud.

Because the livelihoods of small-scale fishing communities are linked to local environmental resources, stewardship plays an important role in ensuring future resource availability. In Brazil, the artisanal fishing industry employs around one million registered fishers (2). Industrial fishing has grown substantially, expanding its catch range and targeting more species than ever before; this has encroached on the artisanal fishing sector's resources and markets (3). Traditional fishing communities, like those on Brazil's northern coast, continue intergenerational education of centuries-old fishing practices. The local ecological knowledge (LEK) that is passed down preserves local culture and has the potential to improve collaborative management of resources (4). Despite this potential, the challenges of common pool resource management continue to impact sustainability in Brazil's fisheries (2).

In the early 1990's, marine extractive reserves were established in Brazil to provide local communities with exclusive rights to manage their own resources. This shift from no management to bottom-up management has already resulted in the empowerment of many previously voiceless communities, such as fisherwomen that have since organized and begun to advocate for their own rights (5).

Despite the theoretical and qualitative benefits of MERs, stakeholders still often struggle to define and measure the success of these reserves. These traditional fishing communities are the bedrock of their local economy, but the majority still live in poverty. MERs give the power of resource management to communities that inherently understand the ecosystems their livelihoods depend on. Despite

widespread success of co-management practices in similar fishing regions around the world, there has been little effort to understand the dynamics of Brazil's reserves.

We believe this project has an opportunity to bridge the management gap between on the ground implementation of MERs and the growing understanding of their strengths and weaknesses. WWF and the Brazilian government recognize the importance of these fishing communities to the economic and cultural success of the country; however, the preservation of reserves in Brazil depends highly on establishing successful short-term results. Our analyses and recommendations provide WWF and partners a tool for policy advocacy and best management practices, which can be immediately implemented by fishers to inform important management decisions.

Additionally, the public health crisis driven by the coronavirus pandemic has already heavily impacted fisheries throughout Latin America (6). When asked the degree of impact COVID has had on their lives, 98% of coastal fishing community members responded they have been impacted or significantly impacted (7). We attempt to account for these impacts in our analysis. Specifically, the project investigates how fishing has been impacted and aims to understand the vulnerability of communities to the economic and social impacts of the pandemic. Understanding how fishers respond to the current situation is essential to realistic and relevant management recommendations. For this reason, a COVID survey was created and integrated into the project to help inform fisheries management and demonstrate what aid communities may require.

Background and Literature Review

To address overfishing and the numerous challenges associated with common-pool resources, fishing communities around the world have developed many different management strategies. One common approach employed today is the implementation of marine protected areas (MPA), which restrict the activities allowed in specific marine environments to improve conservation outcomes (8). This general concept of environment protection can take many forms based on who is tasked with managing the area, what resources may be extracted, and on what scale.

In parallel to approaches that restrict access in particular areas, another class of solutions seeks to enhance marine resource management by allocating exclusive fishing rights to a defined group of people. These systems are known as rights-based management. By guaranteeing access to a portion of a common pool resource, these systems diminish the “race to fish” and incentivize collective action within communities (9).

Brazil approaches small-scale fisheries management with a rights-based system called marine extractive reserves or natively, reservas extrativistas (RESEX). In these reserves, the government defines a group of beneficiaries, such as fishers, whose livelihoods depend on a particular resource. They are then granted explicit extraction rights within their reserve to that resource. These resources are managed locally, providing beneficiaries the opportunity to participate in and lead the co-management of their natural resources.

Despite their current utility in marine environments, RESEX were not designed for fishery management. Instead, their primary objective was to preserve the rights, cultures, and livelihoods of traditional extractive populations with conservation and resource management acting as secondary goals (10). The first extractive reserves were established in the Amazon to protect the livelihoods of indigenous peoples. This was the culmination of a decades-long grassroots movement led by Chico Mendes, a rubber tapper, trade union leader, and environmentalist who advocated for the rights of Brazilian indigenous communities in the Amazon. To protect these communities from expanding ranching and logging interests, plots of forest were reserved for their explicit extractive use (11). By setting aside a portion of land backed by legal repercussion, beneficiary communities received respite from the violence and habitat destruction they had faced previously (11).

In 1992, this reserve structure was applied in coastal communities to create the first marine extractive reserve (12). Despite their roots, Brazil’s RESEX closely resemble other rights-based fisheries elsewhere in the world, as they give local communities exclusive access to natural resources in a designated area. For this reason, RESEX fall into the broader category of marine extractive reserves and will be referred to as such for the remainder of the report.

Today, 24 marine extractive reserves span Brazil’s coast. Brazilian law allows for the creation of future reserves under certain conditions. For instance, to establish a reserve, communities are required to issue a formal request to the federal government through the Brazilian Institute of Environment and Renewable Natural Resources / National Center of Traditional Peoples and Sustainable Development (IBAMA/CNPT). If approved by IBAMA/CNPT and the Brazilian President, the proposed area receives governmental recognition as a MER (13). Once reserves are established, each reserve elects a

deliberative board to develop a management plan with collective objectives. Although management plans are required for MERs, not all reserves have completed plans (14).

In addition to management plans, the board must propose operating procedures and define its own role moving forward. Boards are diverse in composition pulling members from NGOs, civil servants, fishery managers, and various other backgrounds (15). That said, local fishers are required to make up at least 50% plus 1 person of the board (12). This ensures the traditional communities, for whom the reserve was created, hold majority decision making power.

Even with a unique national context, the challenges facing MERs are common to other fisheries around the world (16–18). Problems like overharvesting and lapses in governance also exist throughout natural resource management. The complexity of finding solutions through collective action is well documented by Elinor Ostrom (18). In alignment with this theory, rights-based approaches, like MERs, attempt to create the conditions for successful management through the allocation of exclusive property rights to a defined group of users. This type of co-managed system relies on participation from communities to operate effectively (13).

Brazil's marine extractive reserves face the challenge of managing large geographic areas and populations. The number of users per reserve varies greatly, from a few hundred fishers to tens of thousands. Compared to other marine extractive reserve structures around the world, both ends of this population spectrum are quite large. This large size can inhibit collective action by making it difficult to organize, easier to free ride, and increasing transaction costs (19,20). It is largely unknown how this breakdown of collective action has specifically impacted Brazil's reserves.

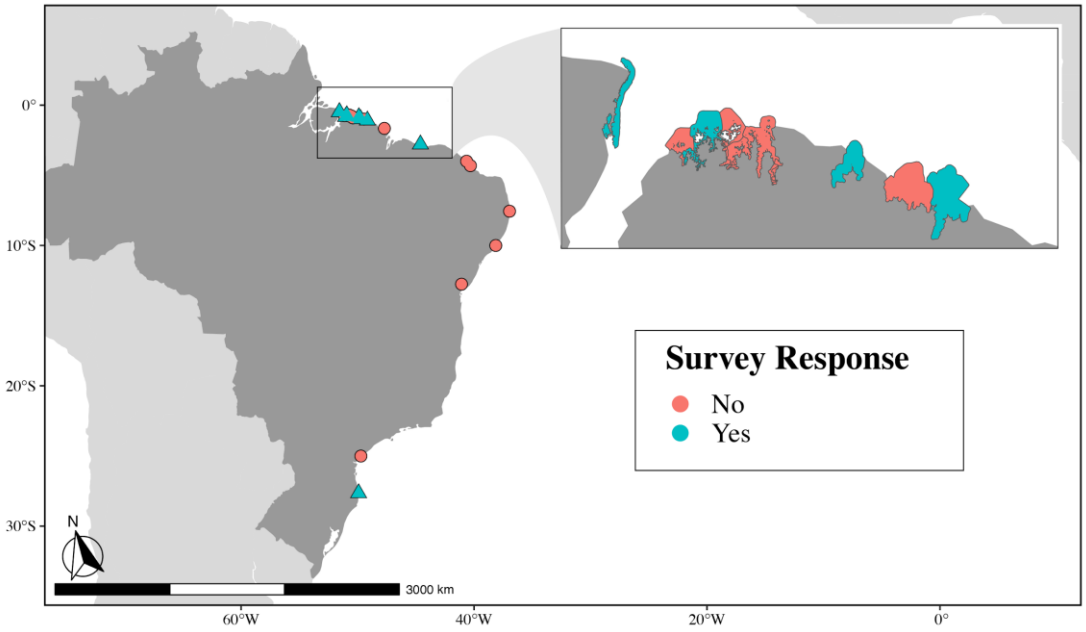
To date, results from MER implementation in Brazil have been largely unknown due to limited funding and research efforts. Several studies that have been conducted, suggest that results are unsatisfactory (13,15), even though similar rights-based fisheries around the globe in Mexico and Chile, have experienced demonstrable success (21). While some of these problems differ contextually, many are shared by other MERs elsewhere in the world. Likewise, rights-based fishery management has been touted as a useful strategy to address the social, ecological, and economic challenges global fisheries have experienced (17,22).

This global success suggests that elsewhere in the world, communities have developed creative solutions to problems that may currently hinder the success of Brazil's MERs. Academics, governments, and non-governmental organizations (NGOs), have attempted adaptive management through publications and online tools (23,24). Many of these attempts, however, have remained focused on contemporary fisheries management and focused on managing ecological systems as the primary solution. While indigenous fishing communities possess the local ecological knowledge necessary for tailored solutions, they may have limited access and ability to implement these contemporary strategies (25). As such, it is equally important to understand and manage the social and economic aspects of these systems. This project attempts to better understand the current challenges of Brazil's reserves. With an institutional grasp, we then work to distill functional and scientific knowledge that has delivered success in fisheries around the world, and apply it to the Brazilian context. This will provide managers and deliberative boards the opportunity to choose solutions best suited for their local reserve and help them to more efficiently achieve their fishing and conservation goals.

Methods

Approach and Study Area

The geographic extent of this project is within the boundaries of Brazil's exclusive economic zone (EEZ). There are 24 marine extractive reserves along Brazil's Atlantic coast, with the majority of them concentrated on the northern coast. The location of each MER, and an indication of if we received a completed COVID survey from them, is indicated on Map 1. Combined, these MERs occupy approximately 3.3 million hectares of terrestrial land, coastal ocean, and inland waterways representing 37 municipalities (26).



Map 1: *Map of all MERs along Brazil's coast with associated survey response identification. The map callout displays the boundaries of six MERs in the northern region, demonstrating the variety of sizes and shapes of MERs as well as their close proximity to one another.*

Ostrom (2009) established the standard for institutional analysis of complex social-ecological systems (SES), like fisheries management. We employed Ostrom's SES framework to guide the creation of our decision tree and process guide tool, and a brief institutional profile.

We classified the challenges faced within reserves using five categories: institutional, social, ecological, economic, and COVID impacts. We used these categories to organize the decision tree, process guide, and survey results. While the first four categories are commonly used to characterize fisheries (18,27,28), a COVID category was added in response to the coronavirus pandemic to gain insight into how resilient reserve fisheries are when exposed to significant perturbation.

We utilized two primary methodologies to approach our study. To help quantify the impacts of COVID and best determine the current status of management effectiveness within reserves, we created a

survey tailored specifically for MERs. Interviews were used to further identify successful management case studies and lessons learned within Brazil's reserve system and other similar global fisheries. These success stories were condensed and included in the decision tree and process guide tool (Appendix 1) as recommendations for common issues identified within Brazil's reserves. To use this tool, fishing communities identify a goal to work towards or use the decision tree to self-diagnose challenges they may be facing. Once a goal is identified, communities reference the process guide to investigate potential approaches, case studies, and actionable steps useful towards achieving their goals.

Survey Design & Delivery

With support from UCSB's Multidisciplinary Research on COVID-19 and its Impacts (MRCI) mini grant, we designed a 53-question survey to understand how the coronavirus pandemic has affected MERs. Although understanding COVID's impact was the primary goal guiding our survey, we included additional questions to increase our understanding of the MER system and contribute to our institutional analysis.

Most questions were developed through discussions with our client; however, around one-third were pulled from previous surveys of MER managers and deliberative board members that also focus on Ostrom's SES variables (15). These included questions about reserve management such as, "How often does the deliberative board meet?" and demographic questions like, "How much money does the average fisher make within your MER?" By reusing previous questions, our results build off Santos & Schiavetti 2014's previous research and provide insight to how marine extractive reserves change over time. As for the newly created questions targeting COVID impacts, an example is, "Have fishing days increased or decreased since 2019?"

In its entirety, this survey asks managers and board members to report on the demographics of their communities, the management effectiveness of their marine extractive reserve, impacts of the coronavirus pandemic, and the status of fisheries. We used Ostrom's SES subsystems as the indicator categories for these questions. COVID-related questions were then added as their own variable group. Table 1 shows the distribution of questions asked relative to their associated indicators.

Once we finalized a comprehensive set of questions, we input it into the survey software Qualtrics. Questions included ranged from Likert-scale multiple choice, unweighted demographic multiple choice, check all that apply, and open-ended formats. Depending on answer selection, respondents could also be prompted for additional clarifying information regarding their response. For example, if a manager answered that their reserve implemented closed seasons, their response prompted a follow up question to identify what species were targeted by the closed seasons.

Qualtrics also acted as an effective distribution tool by creating shareable links. We distributed these links to various MER managers and deliberative board members via WhatsApp and email. Contact information for survey takers was acquired with the help of our client WWF and external advisors at Rare. A copy of our survey is included in Appendix 2.

Table 1: *Survey questions and count per indicator*

Indicator	Question	(n)	Max Score
COVID	14, 24, 25, 35, 36, 37	6	15
Ecological	20, 21, 30, 31, 34	5	11
Economic	26, 27, 28, 47, 49	5	14
Institution	10, 16, 39, 40, 41, 42, 46, 7, 8	9	17
Social	11, 12, 15, 17, 38, 44, 51, 52	8	15

Survey Scoring and Analysis

To quantify and score survey responses, we followed the methodology described in Santos & Schiavetti 2014 and Faria 2004. These methods assume the use of previously selected indicators that are in line with the objectives of Brazilian MER managers and beneficiaries. Indicators were further developed by verifying them with objectives outlined in both the literature review and interview responses.

Due to the coronavirus pandemic, a fifth indicator was added to identify how the economic and institutional stability of reserves reacted to a large-scale perturbation. The ecological stability during the pandemic was also explored in case there was an underlying impact due to illegal fishing, overfishing, lack of enforcement efforts, etc. The COVID indicator was used as a proxy for cooperation within reserves and as a way to quantify how quickly reserves adapt to sudden, external perturbations. A better COVID response by communities represented better cooperation within marine extractive reserves.

Surveys were analyzed per response rather than grouped and summarized by MER. This was done in order to show different actors' perspectives from within the same reserve. This method allows for further analysis of variability in responses from different deliberative board members, different reserve managers, as well as cross comparisons between the two groups.

Following previous work, we split indicator scores into five levels of performance, using a standardized scale (Table 2) that divides possible scores into achievement standards (15,29). Questions were then categorized by criteria established for the evaluation of the assessment indicators. Based on literature, we assigned values to each question and answer, pooled questions into five variables, and scored each respondent by variable (Appendices 3-7). The highest value score corresponds to the most desirable condition or optimal scenario, and the lowest corresponds to the least desirable condition or scenario. Scores depended on the number of possible responses and context of the question. Questions left unanswered were assigned the lowest possible score, as lack of knowledge or information would be in conflict with optimal management (Santos & Schiavetti, 2014).

In order to maintain normalization across questions and indicators we used a series of equations to analyze survey results. We used Equation 1 to determine the percent score per question.

(Equation 1) $$Pt \div Mx = Pct$$

Pt represents the points obtained for a particular question, *Mx* represents the maximum points available for that question, and *Pct* represents the proportion of points received for that question. Equation 2 is used to determine the proportion of points received for each indicator.

$$\text{(Equation 2)} \quad Sum(Pct) \div n \times 100 \; = \; Ind$$

Sum(Pct) represents the sum of all the questions within a particular indicator category, *n* represents the number of questions in that category, and *Ind* represents the indicator score. Equation 3 is used to determine the overall score for each response.

$$\text{(Equation 3)} \quad Mean(Ind) \; = \; Ovr$$

Mean(Ind) represents the mean of all the indicator percent scores and *Ovr* represents the overall percent score.

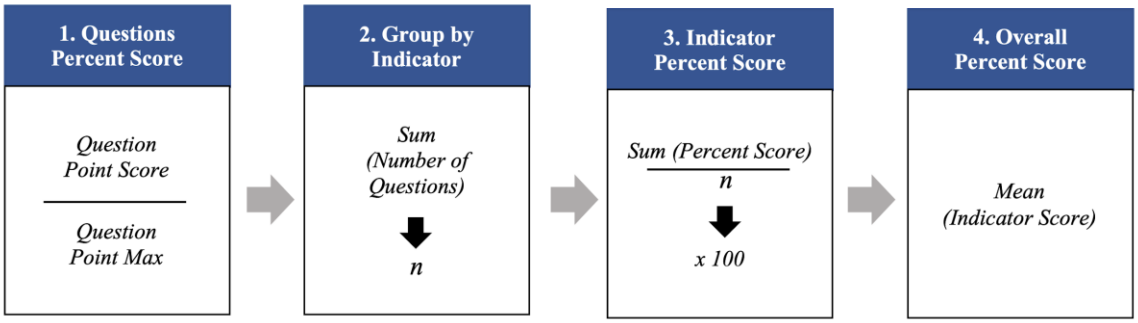


Figure 1: *The calculations used to calculate the indicator percent score and the overall percent score are represented as four steps.*

To account for the variability in scores and the number of questions per indicator, we calculated the percentage of total points received for each question within each variable using Equation 1. An average of these proportions was then taken for each indicator category. These percentages were then ranked via Faria 2004's metric from a score of "very inferior standard" to "standard of excellence" (Table 2).

Table 2: *Survey Qualification Scale (Faria, 2004)*

Percentage (%)	Achievement Standard
Less than or equal to 40.99%	Very Inferior Standard
Between 41% - 54.99%	Inferior Standard
Between 55% - 69.99%	Average Standard
Between 70% - 84.99%	High Standard
Greater than or equal to 85%	Standard of Excellence

In addition to the overall percentage earned by each MER, different patterns were studied across all sites. Open-ended questions had too much variability in responses specific to each particular reserve to be quantified. Instead, open-ended responses were used as supplemental information to add context and verify the success and failures of a particular reserve. They also provided anecdotal evidence of challenges induced by COVID and conflicts among users which helped inform our institutional analyses.

Semi-structured Expert Interviews

To identify lessons learned that might be useful to MER communities, 16 semi-structured interviews were conducted with Brazilian stakeholders and global experts in small-scale fisheries and community-based management. Each interview lasted approximately one hour, was recorded with permission via Zoom, and archived in the project's Google Drive. To validate interview responses, they were characterized using the SES framework (18). Furthermore, they provided insight into the successes and failures of similar fishery management systems around the world.

Interviewees were chosen based on their prior working experience in social, ecological, economic, or institutional aspects of fishery systems; this included a focus on stakeholders who currently work or previously worked in Brazil. While experts tended to have experience in multiple areas, they were categorized by their primary area of expertise. The number of experts were distributed as evenly as possible across these categories.

Interviews followed a diagnostic process employed by previous SES researchers in Brazil's marine extractive reserve system (30). Initial questions were tailored to each expert based on their primary expertise (institutional, social, ecological, etc). Notes were collected during interviews to identify large takeaways and patterns, specific problems, solutions, and quotes. Interviews were recorded for verification, including validation of quotes, when needed. After completion, interviewee responses were discussed and categorized by SES first- and second-level variables. For example, the first-level variable governance systems (GS) includes second-level variables like collective-choice rules (GS6), government organizations (GS1), and monitoring and sanctioning processes (GS8). Major takeaways from each interview were condensed into a single document for comparison, variable analysis, and synthesis into the process guide.

For expert insights to be included as support in the decision tree or process guide tool, they first needed to be validated. Validation occurred when two or more interviewees shared a problem or challenge that

corresponded to the same second-level SES variable. We performed a qualitative analysis, using categorized SES variable sheets and a major takeaway document that synthesized interviews. By ensuring multiple experts supported a specific recommendation or insight, the team felt comfortable incorporating it into our process guide. Of note, this process was also applied to identify problems or areas of improvement in reserves.

Decision Tree & Process Guide Tool

Both the decision tree and process guide are tangible, hard copy documents (Appendix 1). This was done to ensure that fishing communities could access the tools regardless of their access to electricity or internet.

We created the decision tree to help fishing communities identify challenges that their marine extractive reserve may be facing as well as goals they can set to improve their livelihoods. It is based on a synthesized literature review of similar co-managed fisheries around the world. Although no two fisheries are the same, there are common challenges co-managed fisheries share. We organized guidance for these challenges into three groups: social, ecological, and economic. Guidance for each branch was distilled into intuitive visual diagrams to quickly and easily help users understand the premise and direct themselves to the information most relevant to their situation.

The guide's purpose is to provide more detailed guidance with practical and actionable steps for communities to pursue, if they choose. As an example, guidance often included why a recommendation was suggested, additional information needed for implementation, and any applicable case studies.

Some fisheries around the world are better documented than others. Where possible, our literature review of case studies and management strategies informed a recommended action. Any additional holes in our understanding were informed as best as possible through semi-structured interviews.

Results

COVID Survey

The survey was created during the summer of 2020. It was distributed via Qualtrics survey links on WhatsApp and email. We accompanied this outreach with follow up communications throughout the year to gather new responses. The survey was sent to both deliberative board members and managers of the reserves. We received 12 fully completed surveys that represented 11 MERs in total.

Figure 2 illustrates a large spread in the performance of marine extractive reserves across all five indicator categories. This demonstrates the potential for shared learning even between the reserves in Brazil; however, further research to uncover the drivers of these discrepancies is needed (Figure 2).

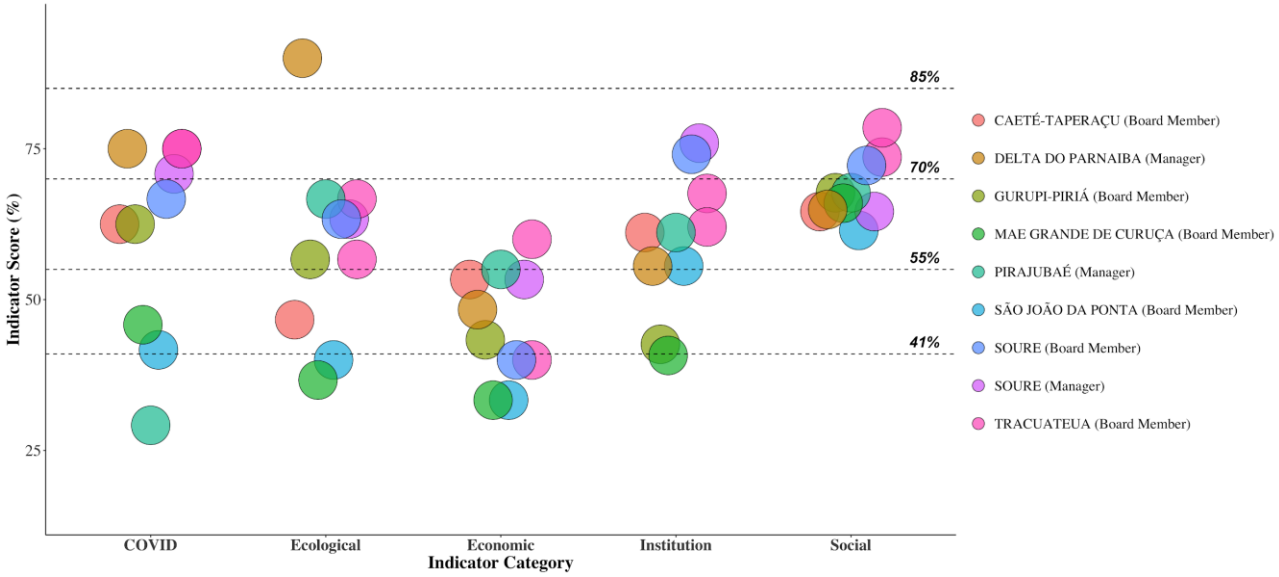


Figure 2: *The score each response received is shown across all five indicators above, with color representing the reserve and role of respondent each circle represents. The dotted lines and percentages represent the levels of the qualification scale which can be seen in Table 2.*

While four reserves met the high standard in one or more categories, no reserve achieved an overall high standard. Only one reserve met the standard of excellence in any category — Delta do Parnaíba in the ecological management category. Because the Tracuateua marine extractive reserve had surveys filled out by two different representatives, we were able to compare the variation between responses. As the survey continues to receive more responses, more intra-reserve patterns can be explored.

Table 3: *Management effectiveness scores by response and indicator*

	Overall Management		COVID	Ecological	Economic	Institution	Social
	%	Std.	%	%	%	%	%
DELTA DO PARNAIBA (Manager)	66.8	Average Standard	75.0	90.0	48.3	55.6	64.9
TRACUATEUA (Board Member)	66.6	Average Standard	75.0	56.7	60.0	67.6	73.6
SOURE (Manager)	65.6	Average Standard	70.8	63.3	53.3	75.9	64.6
TRACUATEUA (Board Member)	64.4	Average Standard	75.0	66.7	40.0	62.0	78.5
SOURE (Board Member)	63.3	Average Standard	66.7	63.3	40.0	74.1	72.2
CAETÉ-TAPERAÇU (Board Member)	57.6	Average Standard	62.5	46.7	53.3	61.1	64.6
PIRAJUBAÉ (Manager)	55.9	Average Standard	29.2	66.7	55.0	61.1	67.7
GURUPI-PIRIÁ (Board Member)	54.6	Inferior Standard	62.5	56.7	43.3	42.6	67.7
SÃO JOÃO DA PONTA (Board Member)	46.4	Inferior Standard	41.7	40.0	33.3	55.6	61.5
MAE GRANDE DE CURUÇA (Board Member)	44.5	Inferior Standard	45.8	36.7	33.3	40.7	66.0

Table 3 presents a spread of average and inferior standards, with no reserve reaching the overall high standard or standard of excellence. Conversely, no reserve fell into the very inferior standard. Regardless, these results indicate that each reserve surveyed has areas they can improve. Because the results are separated by indicator category, managers can easily identify where their time and resources might be best used to provide aid to their MER.

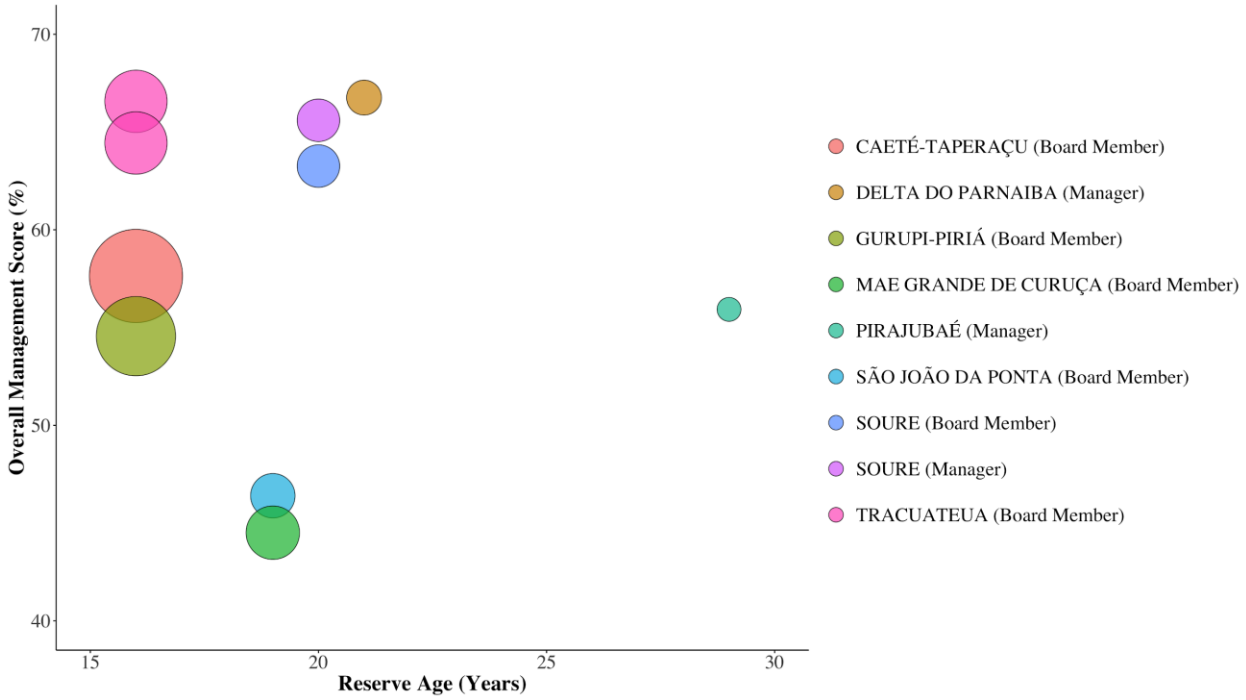


Figure 3: *Overall management effectiveness score, as a percentage, is shown across all reserves, relative to age of the reserve in years since establishment. Color is used to represent the reserve and role of the respondent. Size of the circle, indicates the number of users associated with each reserve.*

Figure 3 shows overall management scores relative the maturity of the reserve and the number of users it serves. Currently with very few responses, it is difficult to observe any major trends. However, it does appear that reserves established more recently have increased in size. With more responses and more data to visualize we hope to see more confident correlations between these variables.

Semi-structured Expert Interviews

We selected and interviewed 16 global fisheries experts and Brazilian stakeholders, based on their prior experience working with social, ecological, economic, or institutional aspects of fishery systems. Interviewees were able to speak to previous small-scale fishery work in various locations, to include the Philippines, Barbuda, Mexico, Hawaii, and Tonga. Responses provided advice that included concrete examples of deliberative management, stakeholder engagement, government-NGO interactions, low-cost ecological monitoring, key ecological processes, and case studies of value-added measures to increase fisher livelihoods. All interviews were recorded and validated with Ostrom's SES framework. They were then congregated to identify common recommendations and cautions (Appendix 8).

While our guide does not separate into all the subsystems of the SES framework, we quantify which SES variables our interviewees shared. These variables determined what solutions we included and prioritized within the decision tree and process guide tool. For example, within the governance systems (GS) subsystem, more than two-thirds of interviews mentioned the importance of monitoring and sanctions (GS8). Specific supporting responses include spatial expert Andy Estep's detailed account of

how important monitoring a no-take zone from illegal fishing is for its success and social scientist Anastasia Quintana's insights of how to organize a crew of fishers to conduct enforcement by paying for surveillance and boat fuel. In this manner, monitoring and sanctions recommendations were incorporated into the guide.

An additional and important takeaway from our interviews is that the large number of users commonly seen in MERs are a major issue. Both local stakeholders and global experts saw a need to manage the size of Brazil's MERs and several interviewees questioned how plausible managing Brazil's reserves is. A couple examples of recommendations to help address this challenge were working with community ambassador leaders or fisher-led outreach.

Decision Tree

Interviewees considered compliance, participation, and conflict management as a few of the most essential social components to successful management. They also emphasized that managers are often not explicitly trained or equipped with tools to address these complex issues. As such, we focused the social decision tree branch on crucial components of management development like the creation of a management plan and enforcement of rules. Boonstra et al's 2017 characterization of common fisher motivational postures — committed, reluctant, creative, and resistant — was also discussed to illustrate how managers can improve interactions with beneficiaries to work towards management goals.

The ecological decision tree relates more directly to fisheries management and addresses natural resource management challenges. This section is the most well documented within literature and established fisheries science. The ecological tree was broken into two main sections: determining ecological patterns and evaluating management options. To adapt this discipline to our context, we narrowed our scope to include only strategies that require minimal physical and financial resources, in terms of implementation and enforcement. We also prioritized recommendations related to initiating local monitoring efforts as local contacts indicated this as a major challenge for MERs.

Small-scale fishery markets and their supply chains can be incredibly complex (31). Due to these complexities and the constrained project completion timeline, we knew we could not provide responsible economic recommendations in a decision tree format. Despite this challenge, we were comfortable presenting economic advice as a series of case studies. These case studies document specific examples of adding value to products or implementing other creative solutions fishers in marine extractive reserves may find useful. Instead of guiding managers through a decision process, these stories are provided as an additional resource for managers to learn from and blend lessons learned with pre-existing local ecological knowledge.

Process Guide

To determine what recommendations were included in the process guide we used Ostrom's SES variables to categorize interview questions and responses (Appendix 2). In the interest of brevity, this section only contains two examples of recommendations we included in our tool. For a complete account, reference the process guide located in Appendix 1.

Our first example focuses on the ineffective use of time and decreased functionality some MER deliberative board meetings exhibit. To help address this challenge, the Canavieiras MER implemented a working group strategy (32).

Working groups are created at the request of deliberative board members to investigate and assess a desired topic or focus area. They are composed of community members, board members and invited guests. These members can be tasked to address any range of topics, from fishing activities like trawling to important social issues like domestic violence (32,33). Once defined, this group coordinates outside of deliberative board meetings to research and discuss their assigned focus area. After reaching a consensus, they report their findings back to the deliberative board for deliberation or any applicable next steps.

This solution is powerful for multiple reasons. First, it allows for more efficient use of time during deliberative board meetings. Additionally, with a less severe time constraint, groups can thoroughly investigate their assignment resulting in a recommendation just as if not more informed than the alternative. Finally, this process involves more people in management decisions.

Lack of fishing regulations and monitoring was another challenge identified in MERs for which we were able to provide a more stepwise recommendation. For data-poor fisheries, understanding the size characteristics or target species and introducing a size limit is an achievable, low-tech solution (34). When implementing a size limit within a reserve, it is important that managers explain to beneficiaries the need for fecund fish and the detriments of catching juveniles (35). Additionally, before a size limit can be implemented, the current lengths of caught fish must be known. In Tonga, managers collect this data by holding a "Biggest Catch" of the month contest. To participate, fishers are required to log the length of all catches for one month. Photo evidence is also encouraged. At the end of the month, the fisher with the largest logged catch wins.

In addition to incentivizing data collection over a month, these competitions can build connectivity between fishers and the community governance.

Institutional Profile

To better understand the current outcomes for and contributing factors in MERs, we conducted seven interviews with local experts in Brazil. In order to document and preserve our enhanced understanding of these systems we constructed a brief institutional profile. Through this profile, we attempt to explain two primary outcomes observed:

1) Brazil's MERs are substantially larger than other marine extractive reserves systems
2) Brazil's MERs exhibit low levels of participation and cooperation

To provide the necessary context for these outcomes, we first describe the major rules and actors at play within Brazil's MERs. There are also substantial unknown outcomes we briefly acknowledge in hopes that targeted research and monitoring efforts will provide clarity to these areas of uncertainty.

Rules

The rules that functionally govern Brazil's marine extractive reserves fall primarily within two categories — those set by the federal government and those that deliberative boards formally decide. As stated previously, communities must organize and issue a formal request for a MER in their local community, and if approved by IBAMA/CNPT and the Brazilian President the area will become a MER. Within an individual MER, rules are first established by the management plan. Moving forward, the deliberative

board makes any additional required policy decisions during regular meetings. “Regular” meetings range between annually to monthly. Our research found quarterly meetings to be the most common interval.

By law, deliberative boards represent the community since 51% of voting members are required to be from the beneficiary community. The remaining 49% are made up of NGO representatives, government employees, scientists, and other various stakeholders. Although this structure was made to incorporate the community’s voice in management decisions, rules are often created without their crucial community input (36). For this reason, social capital and norms influence which rules are followed.

Common regulations within MERs include no-take zones and size limits. Nearly all MERs define no-take zones; however, it is unknown how well they are respected. Furthermore, some communities ignore catch rules because they have yet to see a decline in fish catch and do not believe that their stock is being depleted (36).

Despite what we have learned, we still do not know how deliberative board leaders are elected or selected, nor how many serve for each reserve. We are also unsure how new users gain property rights to fishing grounds. This can be at least in part attributed to the opaque registry system. For example, if a MER fisher has a child, it remains unclear how and when that child would become a beneficiary of the MER. The same goes for an established fisher who moves into an MER community, either from another reserve or from a community with no MER.

Successful rules in MERs can have long-serving impacts. If rules are widely accepted between deliberative boards and the government, they can be transitioned into regional policy via management agreements (10). Due to the lack of federal regulation produced by other means, interviewees noted the importance of this bottom-up approach in tackling the national challenges facing Brazil’s marine environments (10,37)). An in-depth analysis of local MER governance would enhance our understanding of the role that both written and social rules play in MERs.

Actors

Marine Extractive Reserve Beneficiaries

This group of actors includes anyone in a MER whose is granted exclusive access to a resource located within that reserve. Unlike other rights-based fisheries management systems, fishers are not the only beneficiaries within an MER. Other beneficiaries may include marine tourism, craftsman, and marine renewable energy professions, among others (10). This web of beneficiaries further increases the transaction costs of reserve-wide deliberative processes.

Government Managers

Although we have a sense of the governmental MER managers’ role, we were only able to speak with a few. As such, our understanding of these actors is limited. What we do know however is that each MER is assigned at least one governmental manager from the Chico Mendes Institute for Biodiversity and Conservation (ICMBio), a branch of IBAMA/CNPT. Their primary responsibilities are to act as an intermediary between the government and communities, and to facilitate deliberative board meetings (38).

Interviewees noted that the individuals who become managers are often not from the regions that they are later assigned to manage. This can result in cultural differences that both beneficiaries and managers must navigate. Furthermore, because managers are asked to represent numerous

communities with limited federal resources, they are often overloaded and can struggle to meet the needs of MERs. Interviewees also shared that managers arrive with insufficient training related to deliberative facilitation and that their knowledge of natural resources varies greatly (39).

NGOs

NGOs, such as the World Wildlife Fund and RARE, aim to support MER communities in various ways. Examples include paying transportation costs to attend deliberative meetings (39), paying for cost saving gear like basquetas (discussed in Appendix 1)(10), and supporting work like ours to inform management decisions.

Outcomes

Why are Brazil's MERs so large?

As previously mentioned, MER designation is driven by community proposals subject to approval by the federal government. Though it may seem straightforward, the MER creation process is labor intensive and bureaucratic. It can also be politically motivated. Together, these challenges create high barriers to entry which incentivize many communities to group together during the initial request. Because a line is drawn around the edges of these communities to create the resultant MER border, this can lead to larger reserve sizes (32). Though there are likely other factors that come into play regarding MER size, we believe this relationship is a significant contributor.

Low levels of participation and cooperation

Multiple local experts detailed low levels of compliance and participation as major challenges facing MERs (10,33,36). This is linked to the large size of reserves as discussed above. A reserve covering a large geographical area results in increased transaction costs associated with participation and cooperation. MERs serving multiple communities have greater difficulty planning meetings in a central location that is accessible to all of the communities. Many beneficiaries don't have the time or funds to make it to these meetings resulting in less-than-optimal community participation (39). This also results in difficulties for deliberative board members who are tasked with representing groups of people. Board members might be faced with the task of representing members of multiple communities simultaneously who also might have differing perspectives (36). This also increases the costs associated with interacting with constituents, which may result in decreased quality of decision making.

Poor communication among managers, board members, and the community also inhibits participation. For instance, in some reserves board members are alerted by phone calls between gatherings as to when their next official meeting will take place. Beyond this, there is little or no "marketing" of the event for fishers in the community (36). As such, community members must initiate contact with leaders or hope board members inform communities in a timely manner to become aware of meetings. MERs lack a streamline method of alerting reserve beneficiaries about meeting times (36); however, participation is further complicated by groups of fishers who do not trust the deliberative process. Again, this varies across reserves, but most MERs contain some number of reluctant fishers who distance themselves from the community governance (36).

Outcomes for Further Study

Gender Equality

MER fisher registries enable fisher women to formally register as fishers or other beneficiaries. This recognition is said to have allowed for the economic empowerment of these women, allowing them to organize, establish themselves as leaders within the community, and even escape domestic violence at

home (5). Many expert interviewees noted the importance of involving women for successful management. In other fisheries around the world, initiatives like savings clubs and financial literacy programs are often led by women as they are frequently in charge of managing the home's finances (40). Women have also been documented to be more sympathetic to conservation arguments that involve preserving the resource for future generations, causing them to act as champions and social enforcers for regulations like no-take zones (41). While we gathered some anecdotal evidence regarding the progress of women in Brazil's MERs, specifics remain unknown. Efforts to collect data on women's representation in fisher registries, deliberative board meetings, and the board itself can significantly enhance our understanding of this important issue.

Age group dynamics

We received various and sometimes contradicting insight into the age group dynamics within MERs. For example, one interviewee shared that because older fishers remember when fish were more plentiful, they are more amenable to ecological rules (37). Conversely, some elders do not perceive the same catch disparity and as a result may be suspicious of data collected and associated catch rules (36). That said, the majority of interviewees who brought age dynamics up perceived older generations to be more engaged in governance while younger generations did not participate as much. Further research can expound on the spectrum of opinions amongst older fishers.

When older leaders do implement catch rules, they rarely communicate new policy to the larger fishing community. Without knowledge of why new rules are in place, and their rationale explained, younger fishers may not comply and begin to distrust the system (36). This may factor into the participation of younger generations in MERs. Investigating these relationships, in addition to the role of disenchanted younger fishers would bring important insight into better understanding MERs. Furthermore, understanding the age distribution of engaged beneficiaries would provide valuable insight into who will play influential roles in these reserves moving forward.

Discussion

Decision Tree & Process Guide Implementation

The target audience for our decision tree and process guide tool are deliberative board members and MER-specific government managers. It is important to note that by including deliberative board members we are including fishers and other beneficiaries within the intended audience. The decision tree was designed to be a quick reference tool used to identify both challenges or potential improvements for MER communities, while the process guide provides more in-depth discussion and actionable steps to work towards these goals. Due to this synergistic relationship, we recommend that both tree and guide be included in a single document as seen in Appendix 1.

With the help of our client, the document will be translated to Portuguese. Once translated, the document will be printed in color, ideally on waterproof paper, bound with a ½ inch spiral metal binding, and distributed to MERs by WWF. If feasible for WWF, we recommend that they deliver the guide in person to foster relationships with communities.

Many recommendations from our work will take time for communities to deliberate on and implement. It will be important for WWF to support communities during this process. WWF should have many opportunities to do this. For example, if a community has deliberated and decided to create a local fisher registry, WWF should offer their expertise without transaction cost. For this reason, it is imperative for WWF to maintain good relationships with MER managers and active liaisons within these communities.

Partnerships

In addition to in person deliveries, we believe WWF has several opportunities to increase the value of this project. Perhaps the most significant is through shared learning and cooperation with universities and other NGOs such as Rare. Though it focused on Brazilian MERs during our project, the general framework of our decision tree and process guide allows it to be tailored to other similar fishing reserves around the world. Developing relationships with universities and other NGOs, provides an opportunity to share our tool and improve shared learning on a larger scale. We believe the facilitation of shared learning has the potential to expedite knowledge transfer in fishing communities and subsequently improve their resilience to perturbation. If our survey tool is utilized during this process moving forward, WWF will receive data which can objectively assess the effectiveness of shared learning.

Updating the Guide

Our tool will require updates over time so that recommendations incorporate new research, case studies, and fishery management practices. We recommend WWF maintain annual notes on these innovations as well as the performance of the decision tree and process guide tool. This should include annual survey distribution with subsequent analysis via our reproducible code. While minor adjustments can be disseminated to communities via personal communications, we suggest a new revision of the tool be printed and distributed every three to five years. This revision would also be a wonderful opportunity for WWF to strengthen partnerships with other NGOs such as Rare by allowing these entities to provide feedback and potentially add to the existing recommendations.

Survey

The results from our survey demonstrates that Brazil's MERs appear to vary greatly in terms of management effectiveness. This further demonstrates the opportunity for shared learning within Brazil, where high performing reserves could share successful strategies and adaptations with lower performing reserves. Unfortunately, due to complications related to COVID and not being able to administer surveys in person, we were not able to collect as many survey responses as we would have liked. Our sample size of twelve responses is too limited to draw conclusions about overarching trends in Brazil; however, with enough responses, our analysis demonstrates the survey's potential to elucidate trends in MERs over time. To assist future use of this tool, we have created a reproducible code that will quickly and easily process new survey data and produce a report summarizing the updated results. This provides WWF an opportunity to consistently pursue survey responses and better understand changes in MERs over time. Moreover, by comparing changes in reserves that have and have not used the process guide, this code can also be used as a tool to assess the process guide's impact in communities.

Conclusion

Due to its significant impact on ocean health and food security for millions of people, management of small-scale fisheries has been pushed to the forefront of global fisheries management in recent years. This shift has illuminated the value of local and traditional knowledge as well as demonstrated the potential for community-based management structures to empower communities to manage their own resources. Brazil's marine extractive reserves are a community-based management structure that attempt to do just that.

In Brazil, the network of 24 MERs aims to empower coastal communities and protect the livelihoods of indigenous people. Although property rights allocation is an important first step towards achieving this outcome, established MERs face many other challenges. For example, after exclusive rights are awarded, collective action problems, limited data-collection, and income disparity hinder resource management. Other marine extractive reserves and fisheries around the world face similar problems. For this reason, we believe shared learning informed by these similar fisheries can greatly help Brazil's small-scale fishing communities adapt to their challenges.

Our project harnesses knowledge from global fishery management solutions and local community-driven strategies to help improve the performances of Brazil's marine extractive reserves. To communicate what we have learned in an accessible way, we created a decision tree and process guide tool to offer potential solutions and actionable steps related to issues they may be facing. Our tool will not alleviate the adversities facing these fisheries on its own; however, we hope that in the hands of managers and community board members, it catalyzes the positive change desired within communities. We also hope our work will further stimulate ongoing dialogues between universities, NGOs, governments, fishery scientists, and fishing communities around the world who see the value of shared learning within co-management.

References

1. FAO. The State of World Fisheries and Aquaculture 2020 [Internet]. FAO; 2020 [cited 2021 Mar 8]. Available from: http://www.fao.org/documents/card/en/c/ca9229en
2. Elfes CT, Longo C, Halpern BS, Hardy D, Scarborough C, Best BD, et al. A regional-scale Ocean Health Index for Brazil. [Internet]. Vol. 9, PLoS ONE. Public Library of Science (PLoS); 2014 [cited 2021 Feb 4]. p. e92589. Available from: https://doaj.org
3. Pauly D, Christensen V, Guenette S, Pitcher TJ, Sumaila UR, Walters CJ, et al. Towards sustainability in world fisheries. Nature. 2002 Aug 8;418(6898):689.
4. Gerhardinger LC, Godoy EAS, Jones PJS. Local ecological knowledge and the management of marine protected areas in Brazil. Ocean Coast Manag. 2009 Mar 1;52(3):154–65.
5. Santiago I. Mãe do Mangue - Trabalhos e desafios das mulheres marisqueiras da RESEX de Canavieiras. 2018 Jun.
6. Bennett NJ, Finkbeiner EM, Ban NC, Belhabib D, Jupiter SD, Kittinger JN, et al. The COVID-19 Pandemic, Small-Scale Fisheries and Coastal Fishing Communities. Coast Manag. 2020 Jul 3;48(4):336–47.
7. COVID-19 and Coastal Fisheries – Rare [Internet]. [cited 2021 Mar 8]. Available from: https://portal.rare.org/en/global-covid-19-fisheries-survey/
8. Halpern BS, Lester SE, McLeod KL. Placing marine protected areas onto the ecosystem-based management seascape. Proc Natl Acad Sci. 2010 Oct 26;107(43):18312–7.
9. Birkenbach AM, Kaczan DJ, Smith MD. Catch shares slow the race to fish. Nature. 2017 Apr;544(7649):223–6.
10. Nora V. Vinícius Nora Marine Extractive Reserve Expert Interview. 2021.
11. Hall A. Extractive Reserves: Building Natural Assets in the Brazilian Amazon. In: Boyce J, Narain S, Stanton EA, editors. Reclaiming Nature [Internet]. London: Anthem Press; 2012 [cited 2021 Feb 3]. p. 151–80. Available from: https://www.cambridge.org/core/product/identifier/CBO9781843313465A017/type/book_part
12. De Moura R, Minte-Vera C, Curado I, Francini-Filho R, Rodrigues HCL, Dutra G, et al. Challenges and Prospects of Fisheries Co-Management under a Marine Extractive Reserve Framework in Northeastern Brazil. Coast Manag. 2009 Nov;37(6):617–32.
13. da Silva PP. From common property to co-management: lessons from Brazil's first maritime extractive reserve. Mar Policy. 2004 Sep 1;28(5):419–28.
14. Faro C. Discussion with Caio Faro. 2021.
15. Santos CZ, Schiavetti A. Assessment of the management in Brazilian Marine Extractive Reserves. Ocean Coast Manag. 2014 Jun 1;93:26–36.
16. Allison EH, Ratner BD, Åsgård B, Willmann R, Pomeroy R, Kurien J. Rights-based fisheries governance: from fishing rights to human rights. Fish Fish. 2012 Mar;13(1):14–29.
17. Lubchenco J, Cerny-Chipman EB, Reimer JN, Levin SA. The right incentives enable ocean sustainability successes and provide hope for the future. Proc Natl Acad Sci. 2016 Dec 20;113(51):14507–14.
18. Ostrom E. A General Framework for Analyzing Sustainability of Social-Ecological Systems. Science. 2009 Jul 24;325(5939):419–22.
19. Poteete AR, Ostrom E. Heterogeneity, Group Size and Collective Action: The Role of Institutions in Forest Management. Dev Change. 2004 Jun;35(3):435–61.
20. Viana DF, Gelcich S, Aceves-Bueno E, Twohey B, Gaines SD. Design trade-offs in rights-based management of small-scale fisheries. Conserv Biol. 2019;33(2):361–8.

21. Aceves-Bueno E, Cornejo-Donoso J, Miller SJ, Gaines SD. Are Territorial Use Rights in Fisheries (TURFs) sufficiently large? Mar Policy. 2017 Apr 1;78:189–95.
22. Barner AK, Lubchenco J, Costello C, Gaines SD, Leland A, Jenks B, et al. KEYNOTE LECTURE. Solutions for Recovering and Sustaining the Bounty of the Ocean: Combining Fishery Reforms, Rights-Based Fisheries Management, and Marine Reserves. Oceanography. 2015 Jun 1;28(2):252–63.
23. Dowling N, Wilson J, Rudd M, Babcock E, Caillaux M, Cope J, et al. FishPath: A Decision Support System for Assessing and Managing Data- and Capacity- Limited Fisheries. In: Quinn II T, Armstrong J, Baker M, Heifetz J, Witherell D, editors. Assessing and Managing Data-Limited Fish Stocks [Internet]. Alaska Sea Grant, University of Alaska Fairbansk; 2016 [cited 2020 Nov 5]. Available from: https://seagrant.uaf.edu/bookstore/pubs/item.php?id=12335
24. Oyanedel R, Macy Humberstone J, Shattenkirk K, Rodriguez Van-Dyck S, Joye Moyer K, Poon S, et al. A decision support tool for designing TURF-reserves. Bull Mar Sci. 2017 Jan 1;93(1):155–72.
25. Johannes RE. The case for data-less marine resource management: examples from tropical nearshore finfisheries. Trends Ecol Evol. 1998 Jun 1;13(6):243–6.
26. Unidades de Conservação - Unidades de Conservação (2019) - 2° semestre.csv - Portal de Dados Abertos do MMA/SFB [Internet]. [cited 2021 Mar 18]. Available from: http://dados.mma.gov.br/en/dataset/unidadesdeconservacao/resource/9c661f5d-400e-4188-a67f-0a6b09105408
27. Boonstra WJ, Birnbaum S, Björkvik E. The quality of compliance: investigating fishers' responses towards regulation and authorities. Fish Fish. 2017 Jul;18(4):682–97.
28. Deacon RT. Fishery Management by Harvester Cooperatives. Rev Environ Econ Policy. 2012 Jul 1;6(2):258–77.
29. Faria HH de [UNESP. Eficácia de gestão de unidades de conservação gerenciadas pelo Instituto Florestal de São Paulo, Brasil. Aleph. 2004 Aug 13;xxi, 401 f. : il.
30. Partelow S, Glaser M, Arce SS, Barboza RSL, Schlüter A. Mangroves, fishers, and the struggle for adaptive comanagement: applying the social-ecological systems framework to a marine extractive reserve (RESEX) in Brazil [Internet]. Vol. 23, Ecology and Society. Resilience Alliance; 2018 [cited 2021 Feb 4]. p. 19. Available from: https://doaj.org
31. Estep A. Andy Estep Marine Extractive Reserve Expert Interview. 2020.
32. Viana DF. Daniel Viana Marine Extractive Reserve Expert Interview. 2021.
33. Carvalho F. Felipe Carvalho Marine Extractive Reserve Expert Interview. 2021.
34. Harford B. Bill Harford Marine Extractive Reserve Expert Interview.
35. McDonald G, Wilson M, Veríssimo D, Twohey R, Clemence M, Apistar D, et al. Catalyzing sustainable fisheries management through behavior change interventions. Conserv Biol. 2020;34(5):1176–89.
36. Martins B. Bruna Martins Marine Extractive Reserve Expert Interview. 2020.
37. Fernandes W. Willian Fernandes Marine Extractive Reserve Expert Interview. 2021.
38. Prado DS, Castro F de, Seixas CS. The Dramas of the Marine Extractive Reserve Managers in Brazil: Navigating through Multiple Institutions. Soc Nat Resour. 2020 May 3;33(5):651–68.
39. Marone E. Enrico Marone Marine Extractive Reserve Expert Interview. 2021.
40. Sanchez-Tirona R. Rocky Sanchez Tirona Marine Extractive Reserve Expert Interview. 2021.
41. Gaines S. Steve Gaines Discussion. 2021.

Appendices

Appendix 1: *Decision Tree & Process Guide Tool*

The team will continue to revise iterations of the main deliverable throughout the spring quarter. The full text will be added here when the final tool is completed. Addition of the tool will be completed prior to our commencement in June 2021.

Appendix 2: *Survey Questions*

53 Question Survey		
#	Variable	Question
1	Consent	Do you consent to to participation in this survey, in which your answers will be used as a part of graduate student fisheries research?
2	Research	Would you like data from this survey sent back to you?
3	Research	If Yes, what email address should results be sent to?
4	Resource System	What would you say it is your main role in the RESEX?
5	Resource System	What is the name of the RESEX you use or live in?
6	Actors	How many fishers work within your RESEX?
7	Government System	Is there a Management Plan for your RESEX?
8	Government System	Are RESEX objectives and targets tracked?
9	Government System	If so, how are these goals tracked?
10	Resource System	Are borders of your RESEX clearly defined?
11	Resource System	Are the borders of your RESEX respected by fishers?
12	Interactions	How often does the Deliberative Board meet?
13	Covid	What are the biggest challenges your RESEX has faced in the last 4 months?
14	Extractive Reserve Perception	How much do you agree with the following statement: My Extractive Reserve's management is capable of enduring fishery challenges that have come about in 2020.
15	Interactions	Does the RESEX have community strengthening programs of any kind for users?
16	Government System	Is the number of licensed fishers limited in your RESEX?
17	Actors	Are there different fisher groups within the RESEX?
18	Actors	If Yes, how many groups have clear leaders?
19	Resource Units	Please list what primary gear type is used within your RESEX.
20	Resource System	What type of vessels do MOST fishers rely on?

Continued

Appendix 2: Survey Questions – CONTINUED

53 Question Survey - CONTINUED		
#	Variable	Question
21	Resource Units	How many target species are fished within your RESEX?
22	Resource Units	Please list 1-5 main target species caught within your RESEX.
23	Covid	Have fishing days decreased from 2019 to 2020 in your RESEX?
24	Covid	Has demand for fish decreased in from 2019 to 2020 in your RESEX?
25	Resource Unit	Have you observed an increase in illegal fishing in the last four months?
26	Interactions	How many fishers rely on middle men to sell their catch?
27	Interactions	Where does most catch from your RESEX get sold to consumers?
28	Supply Chain	How much leftover catch goes unsold?
29	Supply Chain	What do fishers do with leftover catch?
30	Government System	Does your RESEX have any catch or gear limits?
31	Government System	Does your RESEX have any form of a closed fishing season?
32	Government System	Please list what species there are informal agreements for.
33	Government System	Please list what species there are formal agreements for.
34	Resource System	Does your RESEX have a no-take zone?
35	Covid	How much do you agree with the following statement: Over the last 4 months, fishers that are part of a RESEX have been able to endure economic challenges better than fishers who are not a part of your RESEX.
36	Profession Stability	How much do you agree with the following statement: Fishers within the RESEX have been able to supply families with sufficient food over the last 4 months.
37	Actors	Over the past 4 months, were RESEX users able to pursue income alternatives other than fishing?
38	Interactions	Do fishers have conflicts with? Please check all that apply.
39	Interactions	Does your RESEX sanction fishers from outside the RESEX who fish within the reserve
40	Government System	Are there penalties for fishers violating RESEX agreements?

Continued

Appendix 2: Survey Questions – CONTINUED

53 Question Survey - CONTINUED		
#	Variable	Question
41	Government System	What level of surveillance does the RESEX have?
42	Interactions	Who carries out surveillance in your RESEX?
43	Actors	In what ways do fishers paricipate on the management of your RESEX?
44	Interactions	Do managers and fishers share knowledge with each other within your RESEX?
45	Interactions	If Yes, how do fishers and managers exchange data with each other?
46	Government System	Has your RESEX received aid from any of the following institutions?
47	Actors	What was the average income of fishers in your RESEX in 2019?
48	Resource Units	Aside from fishing, what other ways are ecosystems (e.g. mangroves) used by RESEX users?
49	Actors	Is there a community-based tourism market within the reserve?
50	Resource System	Is there fish farming within the RESEX?
51	Resource System	Are there any significant cultural sites within the RESEX?
52	Government System	About how many fishers are trained in sustainable use management?
53	Follow Up	Is there anything else you wish to share about your RESEX? Share as much as you like.

Appendix 3: *COVID Indicator*

COVID (n = 6)		
Question	Response	Score
How much do you agree with the following statement: My Extractive Reserve's management is capable of enduring fishery challenges that have come about in 2020.	[1] Strongly agree	4.0
	[2] Somewhat agree	3.0
	[3] Neutral	2.0
	[4] Somewhat disagree	1.0
	[5] Strongly disagree	0.0
Has demand for fish decreased in from 2019 to 2020 in your RESEX?	[1] Demand increased	1.0
	[2] Demand remained approximately the same	1.0
	[3] Demand decreased	0.0
	[4] Unsure	0.0
Have you observed an increase in illegal fishing in the last four months?	[1] Yes	0.0
	[2] No	1.0
	[3] Unsure	0.5
How much do you agree with the following statement: Over the last 4 months, fishers that are part of a RESEX have been able to endure economic challenges better than fishers who are not a part of your RESEX.	[1] Strongly agree	4.0
	[2] Somewhat agree	3.0
	[3] Neutral	2.0
	[4] Somewhat disagree	1.0
	[5] Strongly disagree	0.0
How much do you agree with the following statement: Fishers within the RESEX have been able to supply families with sufficient food over the last 4 months.	[1] Strongly agree	4.0
	[2] Somewhat agree	3.0
	[3] Neutral	2.0
	[4] Somewhat disagree	1.0
	[5] Strongly disagree	0.0
Over the past 4 months, were RESEX users able to pursue income alternatives other than fishing?	[1] Yes	1.0
	[2] No	0.0
	[3] Unsure	0.5

Appendix 4: *Ecological Indicator*

Ecological (n = 5)		
Question	Response	Score
What type of vessels do MOST fishers rely on?	[1] Canoe	1
	[2] Sail	1
	[3] Motorized	0
	[4] Other	1
	[5] None	2
How many target species are fished within your RESEX?	[1] 1 Species	0
	[2] 2-5 Species	1
	[3] 6-9 Species	2
	[4] 10+ Species	3
Does your RESEX have any catch or gear limits?	[1] Yes, and they are enforced	2
	[2] Yes, but are not enforced	1
	[3] No	0
Does your RESEX have any form of a closed fishing season?	[1] Yes, formal closure agreements	2
	[2] Yes but closure agreements are informal	1
	[3] Both formal and informal	1
	[4] Neither	0
Does your RESEX have a no-take zone?	[1] Yes, and it is enforced	2
	[2] Yes, but not enforced	1
	[3] No	0

Appendix 5: *Economic Indicator*

Economic (n = 5)		
Question	Response	Score
How many fishers rely on middle men to sell their catch?	[1] None	4.0
	[2] Less than half	3.0
	[3]About half	2.0
	[4] More than half	1.0
	[5] All	0.0
Where does most catch from your RESEX get sold to consumers?	[1] Global markets	1.0
	[2] Regional Markets	2.0
	[3] Local Markets	3.0
	[4] Unsure	0.0
How much leftover catch goes unsold?	[1] None	4.0
	[2] Less than half	3.0
	[3] About half	2.0
	[4] More than half	1.0
	[5] All	0.0
What was the average income of fishers in your RESEX in 2019?	[1] Less than 1 minimum wage	0.0
	[2] 1 minimum wage	1.0
	[3] 2+ minimum wages	2.0
	[4] Unsure	0.0
Is there a community-based tourism market within the reserve?	[1] Yes	1.0
	[2] No	0.0
	[3] Unsure	0.5

Appendix 6: *Institution Indicator*

Institution (n = 9)		
Question	Response	Score
Is there a Management Plan for your RESEX?	[1] Yes, with programs fully underway	3.0
	[2] Yes, with programs in development	2.0
	[3] Management plan is under prepartion	1.0
	[4] No Plan	0.0
Are RESEX objectives and targets tracked?	[1] Yes	1.0
	[2] No	0.0
Are borders of your RESEX clearly defined?	[1] Yes, defined on maps	1.0
	[2] Yes, defined by physical markers	1.0
	[3] Yes, defined by GPS	1.0
	[4] Not defined	0.0
	[5] Yes, other	1.0
Is the number of licensed fishers limited in your RESEX?	[1] Yes	1.0
	[2] No	0.0
	[3] Unsure	0.5
Does your RESEX sanction fishers from outside the RESEX who fish within the reserve	[1] They are always sanctioned	4.0
	[2] They are often sanctioned	3.0
	[3] They are sometimes sanctioned	2.0
	[4] They are rarely sanctioned	1.0
	[5] They are never sanctioned	0.0
Are there penalties for fishers violating RESEX agreements?	[1] Yes	1.0
	[2] No	0.0
	[3] Unsure	0.0

Continued

Appendix 6: Institution Indicator - CONTINUED

Institution (n = 9) - CONTINUED		
Question	Response	Score
What level of surveillance does the RESEX have?	[1] Routine Surveillance	3
	[2] Sporatic Surveillance	2
	[3] Rarely Surveillance	1
	[4] No Surveillance	0
Who carries out surveillance in your RESEX?	[1] Fishers	1
	[2] Deliberative Board	1
	[3] Hired Security	1
	[4] Other Community members	1
	[5] Environmental Police or ICMBio	1
	[6] No one does surveillance	0
	[7] Unsure	0
Has your RESEX received aid from any of the following institutions?	[1] Brazilian Government	1
	[2] Private Companies	1
	[3] Non-government Organization	1
	[4] None	0

Appendix 7: Social Indicator

Social (n = 8)		
Question	Response	Score
Are the borders of your RESEX respected by fishers?	[1] Yes	1
	[2] No	0
	[3] Unsure	0
How often does the Deliberative Board meet?	[1] More than once a month	4
	[2] 1x per month	3
	[3] 3-6 times per year	2
	[4] Once per year	1
	[5] Never	0
	[6] Unsure	0
Does the RESEX have community strengthening programs of any kind for users?	[1] Yes	1
	[2] No	0
	[3] Unsure	0
Are there different fisher groups within the RESEX?	[1] Yes	1
	[2] No	0
	[3] Unsure	0

Continued

Appendix 7: Social Indicator – CONTINUED

Social (n = 8) - CONTINUED		
Question	Response	Score
Do fishers have conflicts with? Please check all that apply.	[1] non-RESEX fishers	1
	[2] Divers	1
	[3] Other RESEX fishers	1
	[4] Trawlers	1
	[5] Tourism boatmen	1
	[6] Navy	1
	[7] Port	1
	[8] Middlemen	1
	[9] No Conflicts	9
	[10] Other	1
Do managers and fishers share knowledge with each other within your RESEX?	[1] Yes	1
	[2] No	0
	[3] Unsure	0
Are there any significant cultural sites within the RESEX?	[1] Yes, they've been preserved	1
	[2] Yes, and they've been degraded	0
	[3] No	1
About how many fishers are trained in sustainable use management?	[1] 0-20%	0
	[2] 21-40%	1
	[3] 41-60%	2
	[4] 61-80%	3
	[5] 81-100%	4

Appendix 8: ***Interview Variable Data***

Interview Variable Mention Frequency		
Subsystem	Second Level Variable	Mention Count
Resource System (Total Mention = 63)		
Resource System (1)	Sector	12
Resource System (2)	Clarity of system boundary	8
Resource System (3)	Size	13
Resource System (4)	Human Constructed facilities	3
Resource System (5)	Productivity of system	5
Resource System (6)	Equilibrium properties	8
Resource System (7)		2
Resource System (8)	Storage characteristics	
Resource System (9)	Location	10
Resource Unit (Total Mention = 44)		
Reource Unit (1)	Resource unit mobility	7
Reource Unit (2)	Growth or replacement rate	
Reource Unit (3)	Interactions among resource uints	0
Reource Unit (4)	Resource value	13
Reource Unit (5)	Number of units/amount of resources	12
Reource Unit (6)	Distinctive Characteristics	0
Reource Unit (7)	Spatial and temporal distribution	5

Continued

Appendix 8: Interview Variable Data - CONTINUED

Interview Variable Mention Frequency - CONTINUED		
Subsystem	Second Level Variable	Mention Count
Actors (Total Mention = 65)		
Actors (1)	Relevant actors	15
Actors (2)	Socio-economic attributes of users	4
Actors (3)	History or past experiences	5
Actors (4)	Location	2
Actors (5)	Leadership/entrepreneurship	5
Actors (6)	Norms/social capital	11
Actors (7)	Knowledge of SES/mental models	6
Actors (8)	Importance of resources	9
Actors (9)	Technologies available	8
Governance Systems (Total Mention = 59)		
Governance Systems (1)	Government organizations	9
Governance Systems (2)	NGOs	8
Governance Systems (3)	Network Structure	11
Governance Systems (4)	Property-rights systems	8
Governance Systems (5)	Operational rules	4
Governance Systems (6)	Collective-choice rules	9
Governance Systems (7)	Constitutional rules	0
Governance Systems (8)	Monitoring and sanctioning processes	10

Continued

Appendix 8: Interview Variable Data - CONTINUED

Interview Variable Mention Frequency - CONTINUED		
Subsystem	Second Level Variable	Mention Count
Interactions (Total Mention = 64)		
Interactions (1)	Harvesting levels	7
Interactions (2)	Data Sharing	9
Interactions (3)	Delberative Processes	11
Interactions (4)	Conflicts	5
Interactions (5)	Investment Activities	7
Interactions (6)	Lobbying Activities	3
Interactions (7)	Self-organizing Activities	6
Interactions (8)	Monitoring activities	8
Interactions (9)	Evaluation Activities	