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MÁRCIO LUIZ VARGAS BARBOSA FILHO

CONTRIBUIÇÕES DOS PESCADORES AO PROCESSO DE COGESTÃO PESQUEIRA NA RESERVA EXTRATIVISTA MARINHA DO CORUMBAU, BRASIL

Recife-PE
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Tese apresentada ao Programa de Pós- graduação em Etnobiologia e Conservação da Natureza (UFRPE, UEPB, URCA e UFPE) como parte dos requisitos para obtenção do título de doutor.

Orientador:
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Universidade Estadual da Paraíba

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Dedico esta tese à minha amada mãe, Neliam Shaun Monteiro de Almeida, pois sem ela não teria sido possível.

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Muitos homens pescam a vida inteira sem saber que não são peixes o que procuram.

Henry David Thoreau

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SUMÁRIO

RESUMO

O objetivo desta pesquisa foi analisar o potencial de utilização do conhecimento de pescadores na construção da cogestão pesqueira na Reserva Extrativista Marinha do Corumbau (REMC), Brasil. Foram aplicadas entrevistas semiestruturadas a 222 pescadores pela utilização de um formulário. Foi observada a ocorrência da SBS na pesca da espécie de peixe recifal *Lutjanus synagris*, com os pescadores mais velhos apontando médias de capturas pretéritas superiores àquelas apontadas pelos mais jovens. Este fato viabiliza o estabelecimento de uma meta inicial a ser alcançada por meio de futuras ações locais de cogestão pesqueira. Apenas 22,5% dos entrevistados, geralmente os mais jovens, apontaram a necessidade de se estabelecerem regras específicas de manejo da espécie. Apesar de não realizarem a pesca de mergulho com compressores e se oporem fortemente à ela, alguns entrevistados (n=40) demonstraram conhecer sobre esta prática. Denunciam, assim, que esta é uma das principais razões para o declínio no rendimento da pesca local. Eles indicaram que antes do estabelecimento da REMC, embarcações de fora usavam frequentemente compressores em seu território. Contudo, embora a presença de pescadores forasteiros seja atualmente menos frequente, relatam que ainda ocorrem entradas furtivas na REMC e reclamam que ações de fiscalização ambiental marítima são raras. A maioria dos participantes (59.8%) sabia da existência da Portaria 445, que contém a lista de espécies de peixes ameaçadas de extinção e sob moratória no Brasil, sobretudo por conversas informais com colegas de trabalho e por reuniões das quais participaram. A maioria deles (74,3%) citou três ou menos nomes comuns de espécies que acreditavam estar sob moratória. Os pescadores apontaram em média 2.3 nomes de etnoespécies listadas como ameaçadas e reclamam que o poder público não tem cumprido adequadamente o papel de esclarecê-los sobre a lista. A maioria dos participantes (69.6%) apontam a realização de apresentações e palestras explicativas em reuniões como um meio efetivo de esclarecê-los. Contudo, é dever do Brasil desenvolver mecanismos para que a Portaria 445 colabore para a conservação ambiental em consonância à segurança socioeconômica e cultural dos pescadores brasileiros. Quando questionados sobre a efetividade da REMC, a maioria dos entrevistados (n=158; 79.8%) percebeu mudanças na sua qualidade de vida. Nesse sentido, foram apontados 275 modos pelos quais as mudanças se deram, sendo que 271 (98.5%) destes modos relacionam-se a uma mudança positiva no bem estar e na qualidade vida dos beneficiários. A maioria (N=176; 88.9%) deles entende que houveram mudanças no meio ambiente após a implementação da

MERC. Quando questionados como estes perceberam estas mudanças, foram reportados 242 motivos, todos denotando mudanças positivas. Não obstante, a maior parte dos entrevistados (n=139; 70.2%) revelou que atualmente existem situações que não deveriam ocorrer pois prejudicam a pesca na REMC. Em relação à estas situações, foram emitidas 233 opiniões, sendo que a persistência da invasão de barcos de outras regiões na REMC se destacou (n=70; 30%). Este fato demonstra que apesar dos conhecimentos destes pescadores propiciarem o estabelecimento da cogestão pesqueira, é fundamental que o poder público cumpra adequadamente a parte que lhe cabe neste acordo.

Palavras-chave: Pesca de pequena escala; Áreas Marinhas Protegidas; comanejo pesqueiro; Abrolhos; Bahia.

ABSTRACT

The aim of this research was to analyze the potential use of fisher knowledge in the construction of fisheries co-management at the Marine Extractive Reserve of Corumbau (MERC), Brazil. Semi-structured interviews were applied to 222 fishers by means of a questionnaire. The occurrence of Shifting Baseline Syndrome was observed in the fishing of the reef species *Lutjanus synagris,* with older fishers indicating to higher past catch means compared to that reported by younger fishers. This fact enables or establishes an initial goal to be achieved by the contribution of future local fishery research actions. Only 22.5% of the respondents, usually the youngest, pointed to the need to establish specific management rules for the species. Although they do not conduct dive fishing using compressors and strongly oppose this practice, MERC fishermen were shown to display knowledge about this practice. They, thus, blame this as being one of the main reasons for the declines observed in the local fishing income. They indicated that, prior to the establishment of MERC, outside vessels frequently used compressors in their territory. However, although the presence of foreign fishermen is currently less frequent, they report that furtive entry into the MERC is still observed and complain that maritime environmental enforcement actions are rare. Most participants (59.8%) knew of the existence of Ordinance 445, which comprises the list of endangered and moratorium fish species in Brazil, mainly through informal conversations with co-workers and attended meetings. Most (74.3%) cited three or less common names of species they believed to be under moratorium. The fishers have pointed out a means of 2.3 names of ethnospecies listed as threatened and complain that the government has not adequately fulfilled its role in elucidating information regarding the list. Most participants (69.6%) point to holding presentations and explanatory lectures at meetings as an effective means of information elucidation. However, it is Brazil's duty to develop mechanisms for Ordinance 445 to collaborate for environmental conservation in line with the socioeconomic and cultural safety of Brazilian fishers. When asked about MERC effectiveness, most respondents (n = 158; 79.8%) noticed changes in their quality of life. In this sense, 275 ways were pointed out by which changes occurred, with and 271 (98.5%) revealing a positive change in beneficiary quality of life. Most (N = 176; 88.9%) fishers understand that there have been changes in the environment after MERC implementation. When asked how they perceived these changes, 242 reasons were reported, all denoting positive changes. Nevertheless, most respondents (n = 139; 70.2%) revealed that some current situations

are in place that should not occur, as they affect MERC fishing. Regarding these situations, 233 opinions were issued, and the persistence of boat invasion from other MERC regions were noteworthy (n = 70; 30%). This fact demonstrates that despite fisher knowledge allowing for the establishment of fisheries co-management, it is essential that the public power adequately fulfill its part in this agreement.

Keywords: Small scale fishing; Marine Protected Areas; fishing co-management; Abrolhos; Bahia.

1. INTRODUÇÃO GERAL

1.1 Objetivos e questionamentos

No ano de 2016, tive a oportunidade de trabalhar com os beneficiários da Reserva Extrativista Marinha do Corumbau (REMC). Entre o ano de 2012 e 2013, havia tido uma experiência de pesquisa na Reserva Extrativista de Canavieiras (a 200km ao norte da REMC), onde pretendia também realizar a pesquisa de doutorado. Na Resex de Canavieiras, observei uma apatia e até mesmo uma resistência por parte dos pescadores nativos em relação àquela Unidade de Conservação (UC). Contudo, para minha surpresa, em 2016 constatei que, em geral, os pescadores da REMC reconheciam a relevância dessa UC e apoiavam-na. Esse apoio se respaldava, principalmente, pelo fato de reconhecerem que seu estabelecimento ter impedido que pescadores de outras regiões atuassem próximos às suas comunidades, fenômeno que na última década do século XX ficou conhecido localmente como "a invasão dos pescadores de fora" (MOURA *et al*., 2009). Pessoalmente, a atitude favorável dos nativos em relação à REMC soou como uma possibilidade factível de uma maior inserção destes nas decisões de manejo. Consequentemente, vislumbrei uma maravilhosa oportunidade de realizar meu trabalho de tese de doutorado na região e, assim, contar para o mundo sobre esta experiência exitosa de estabelecimento de Área Marinha Protegida. Também, diante de um cenário nacional de reiterados reveses na área socioambiental e de perseguição aos movimentos sociais e ao modelo de Unidades de Conservação de Uso Sustentável, em si, estudar a REMC e divulgar esta experiência de sucesso na parceria do poder público com populações tradicionais litorâneas representava para mim, um desafio que valia a pena ser encarado.

Nesse contexto, elaborei a pergunta científica que norteia esta tese: "Como o público beneficiário pode contribuir para a gestão pesqueira da REMC?". Para responder a esta questão foram realizadas entrevistas com 222 pescadores e pescadoras. Com vistas a colaborar na inserção destes no processo da cogestão pesqueira da UC, os quatro capítulos da tese tratam, em resumo, sobre:

a) - A ocorrência do fenômeno da Síndrome da mudança da linha de base (*Shifting Baseline Syndrome* - SBS) na pesca do ariocó (*Lutjanus synagris*), a principal espécie de peixe capturada na REMC

A Shifting Baseline Syndrome (SBS) refere-se a um fenômeno de natureza psicológica e sociológica em que pesquisadores (e mesmo os membros de populações tradicionais) perdem o referencial histórico que deve servir como linha de base para os estudos que visam analisar alterações ambientais (PAULY, 1995). Por exemplo, estudos vêm apontando que diversas populações de pescadores ao redor do mundo têm enfrentado uma condição cognitiva decorrente da perda de referências ambientais na qual subsequentes gerações deles aceitam um padrão cada vez mais baixo de abundância como a condição "natural" das populações de pescados explotados (THURSTAN *et al*., 2015).

A memória dos pescadores mais experientes representa, deste modo, um repositório único de informações que podem contribuir na estimação da tendência populacional de espécies explotadas, auxiliando, por exemplo, em estimativas reais das perdas decorrentes da sobreexplotação (BENDER *et al*., 2013). Nas últimas décadas, a integração do conhecimento de pescadores e dos dados científicos convencionais tem se mostrado promissora em estudos com o foco na ecologia histórica (GATTI *et al*., 2015; POWERS *et al*., 2013), sobretudo pela reconstrução de linhas de bases ecológicas relacionadas às capturas das espécies-alvo (MELLADO *et al*., 2014; SÁENZ-ARROYO *et al*., 2005; SOGA e GASTON, 2018).

Nesse contexto, a comparação das percepções entre diferentes gerações de pescadores, por meio da análise do fenômeno da SBS, tem o potencial de viabilizar a participação destes atores sociais no processo de construção da cogestão pesqueira. Por exemplo, na presente tese foi observada a ocorrência da SBS na pesca da espécie recifal *Lutjanus synagris* (Linnaeus, 1758), sendo que os pescadores mais velhos apontaram médias de capturas pretéritas superiores àquelas apontadas pelos mais jovens. Este fato, por sua vez, permite que seja estabelecida uma meta inicial a ser alcançada com a contribuição de futuras ações locais de cogestão pesqueira.

b) Seus conhecimentos em relação às ameaças à REMC pela pesca de compressores

As pescarias ilegais, não reportadas e não reguladas (*Illegal, Unreported and Unregulated Fishing - IUU Fishing*), definidas como aquelas que violam acordos de conservação internacionais ou instrumentos de gestão pesqueira regionais e locais, destacam-se globalmente como uma das principais ameaças ao uso sustentável e à

conservação dos recursos pesqueiros (PRAMOD *et al*., 2014). A pesca de arpões com o auxílio de compressores de ar é um tipo de *IUU fishing* que costuma ocorrer em países em desenvolvimento, sobretudo nas Américas (MORETZ-SOHN *et al*., 2013; PAVLOWICH e KAPUSCINSKI 2017; PRADA *et al*., 2006) e na Ásia (BARBER e PRATT, 1997; RADJAWALI, 2012), nos quais sistemas de gestão e de fiscalização ambiental costumam ser falhos (PRAMOD *et al*., 2014).

No Brasil, ainda não existem estudos que enfoquem a pesca com compressores, embora algumas pesquisas relatem superficialmente a prática. Tais pesquisas costumam ocorrer, sobretudo, no litoral das regiões norte e nordeste do país, onde estes mergulhos costumam ser direcionados à captura de organismos de elevado valor comercial como peixes recifais, lagostas e polvos (MORETZ-SOHN *et al*., 2013). Por ser proibida no país por uma lei federal (IN IBAMA 138/2007), acessar informações sobre a pesca com o auxílio de compressores apresenta-se como um desafio aos cientistas. Por exemplo, é improvável que quem pesca de compressor admita realizar a prática ou mesmo aceite contribuir como fonte de informações em um empreendimento científico. Desse modo, o presente estudo tem um caráter inovador pois, apesar dos entrevistados não realizarem a pesca de compressor, trabalham há muitos anos no mesmo ambiente em que pescadores de outras regiões vêm atuar desta maneira. Assim, os pescadores nativos da REMC desenvolveram conhecimentos que os capacita a embasar a pesquisa científica que realizamos. Mais do que isso, a abordagem científica dos conhecimentos destes pescadores pode contribuir para o combate à pesca com compressores que ainda acontece na REMC, ao longo de todo o Banco Oceânico dos Abrolhos e em outras regiões do mundo.

c) Conhecimentos dos pescadores em relação às espécies de peixes listadas como ameaçadas no Brasil

A Portaria 445/2014 (BRASIL, 2014) foi lançada pelo governo brasileiro e concede proteção integral contra a captura, manuseio, armazenamento, transporte, processamento e comercialização de 66 espécies de invertebrados aquáticos e 409 espécies de peixes consideradas ameaçadas no Brasil (BUCKUP, 2017). Deste total, 98 espécies habitam o ambiente marinho (REIS *et al*., 2016). Os desdobramentos da Portaria 445 respaldam-se na Lei 9.605/1998 e no decreto 6.514/2008, que prevêm punições

contra quem mata, pesca, caça ou se utiliza de espécies sob risco de extinção (BRASIL, 1998, 2008).

Apesar de afetar e ser afetada pela disponibilidade e diversidade dos recursos ícticos explotados (BEGOSSI *et al*., 2017), a pesca de pequena escala no Brasil apresenta, historicamente, uma baixa capacidade de articulação institucional e política (VASCONCELLOS *et al*., 2011). Além disso, nos últimos anos, o Estado brasileiro tem imposto aos pescadores artesanais medidas cada vez mais autoritárias e excludentes que dificultam o acesso destes a direitos humanos básicos, como os trabalhistas, à salvaguarda aos seus territórios ancestrais e às políticas públicas em geral (GERHARDINGER *et al*., 2017).

É provável que este cenário de precarização da atividade pesqueira artesanal pelo Estado brasileiro tenha contribuído para um quadro de pouco conhecimento dos pescadores brasileiros sobre Portaria 445 e seus desdobramentos. Contudo, ainda não existem estudos que investiguem os conhecimentos de pescadores artesanais do Brasil sobre a Portaria 445. Diante deste panorama, o trabalho que realizamos tem um caráter inovador, uma vez que aborda as possíveis implicações de se aplicar estratégias de gestão pesqueira de maneira *top-down*.

d) Percepções dos entrevistados sobre as mudanças socioambientais que eles observam decorrentes da existência da REMC

Mundialmente, a eficácia da conservação dos ecossistemas aquáticos é uma temática altamente relevante e das mais urgentes. Por sua vez, o estabelecimento de Áreas Marinhas Protegidas (AMPs) representa um dos principais paradigmas para a conservação e uso sustentável dos oceanos. A grande quantidade e variedade de modalidades de AMPs, além dos mais diversificados contextos culturais nas quais estas encontram-se inseridas, geram uma diversidade de resultados que representam uma valiosa oportunidade de avaliar as limitações e os êxitos destes dispositivos para atingir metas de sustentabilidade ecológica e bem-estar social (PENDLETON *et al.*, 2018).

Desse modo, sob os mais variados enfoques, cientistas têm desenvolvido uma infinidade de mecanismos e abordagens para investigar a efetividade das AMPs. Por exemplo, o conhecimento ecológico dos pescadores (CEP) tem sido empregado pelos cientistas para avaliarem a efetividade das AMPs. Estudos desta natureza são

especialmente necessários em países em desenvolvimento, que costumam ser pobres em informações científicas subsidiem uma adequada governança do ambiente marinho (AMORIM et al., 2019; PURCELL e POMEROY, 2015). Nesse contexto, nos últimos anos, avaliações baseadas em evidências relacionadas à efetividade de AMPs têm se concentrado nas percepções de pescadores, sobretudo em países cujos governos não possuem condições adequadas de governança e monitoramento ambiental (BENETT e DEARDEN, 2014).

Os resultados que encontramos demonstram uma maciça aceitação dos pescadores à REMC e, consequentemente, este caso de sucesso pode ser encarado como uma bandeira em favor desta modalidade de UC.

1.2 Estratégias de pesquisa

O principal desafio na construção do desenho amostral foi o fato de existir um número atualizado da quantidade de famílias beneficiárias da REMC. Além disso, até o momento os dados já publicados apresentam valores discrepantes. Por exemplo, Di Ciommo e Schiavetti (2012) apontaram um total de 452 famílias beneficiárias e no site do Instituto Chico Mentes para a Conservação da Biodiversidade (ICMBio) este número compreende um total de 650 famílias. Além disso, existem critérios para a seleção de participantes na amostra, fato que culmina para que o universo amostral seja menor que o número de beneficiários da REMC. Um dos critérios era de que o pescador no momento da entrevista tivesse no mínimo 18 anos de idade. Esperava-se, assim, selecionar participantes com suficiente capacidade de compreender os objetivos da pesquisa e decidir livremente por participar ou não. O outro critério foi que o participante em potencial capturasse peixes de maneira embarcada no interior da UC. Por usa vez, a escolha de pescadores de peixes advém do fato da pesquisa se concentrar na área da Etnoictiologia. Também, selecionaram-se aquelas pessoas que atuam em embarcações pois é de se presumir que estas conheçam mais profundamente a pesca no interior da REMC.

Ainda em relação à amostragem, buscou-se alcançar um número de participantes correspondente àqueles exigidos por Bernard (1988) para vários tamanhos de população, considerando-se um intervalo de confiança de 5%. Considerando-se que Bernard (1988) considera suficiente que se entrevistem 196 pessoas em uma população de 400 indivíduos

e 260 comunitários para um universo amostral de 800 indivíduos, considerou-se o tamanho da amostra com 222 pescadores um valor adequado.

Como foram entrevistados pescadoras e pescadores de onze diferentes localidades, a busca pela representatividade da amostra também contemplou as comunidades. Desse modo, em um primeiro momento, em parceira com as lideranças locais, buscou-se estimar a quantidade de pescadores existentes na comunidade que se enquadrasse no perfil de participantes. A partir daí, seguindo o recomendado por Bunce *et al.* (2000) para a realização de pesquisas científicas juntos a pescadores que atuam em ambientes recifais, para cada comunidade, entrevistaram-se entre 5% e 35% dos pescadores que se adequavam ao perfil de participante.

O trabalho que abordou a ecologia histórica da pesca do ariocó (*Lutjanus synagris*) permitiu a realização de testes multivariados. Por meio da aplicação do método linear generalizado, realizou-se regressão (GLM) assumindo uma distribuição de Poisson no intuito de avaliar a existência de uma relação entre a idade dos pescadores e seus anos de experiência na pesca. Como houve uma forte relação, optou-se por utilizar apenas a variável "idade do pescador" nas análises. Além disso, os dados demonstraram normalidade e violaram a suposição de homogeneidade de variações, que foram aplicados testes Welch ANOVA para comparar as melhores capturas de ariocó ao longo da vida dos pescadores de diferentes classes de idades e o tempo (número de anos) decorrido desde tais capturas.

Por não terem sido realizadas perguntas específicas sobre a pesca de compressor, tendo sido tais informações repassadas pelos pescadores quando questionados sobre outros assuntos, não foi viável a aplicação de métodos quantitativos por meio da estatística multivariadas. Deste modo, no caso deste manuscrito, quando possível, a abordagem quantitativa foi realizada apenas por meio das análises das frequências absolutas e relativas das citações. Desse modo, adotou-se uma análise de dados enfocando o modelo qualitativo proposto por Bardin (2011) denominado análise de discurso. Nesta abordagem, as declarações dos entrevistados foram interpretadas por meio da exploração dos dados brutos com a transformação e agregação da fala que, por sua vez, resulta em uma interpretação do conteúdo. Posteriormente, foi criada uma estrutura que permitiu a organização de declarações transcritas e codificadas, facilitando a categorização de todas as respostas. O conteúdo foi categorizado utilizando o critério semântico, cuja afirmações foram agrupadas com base na perspectiva da coerência e no sentido das respostas. Esta abordagem científica tem sido amplamente empregada nos estudos de ciências sociais.

Em relação ao capítulo IV, sobre a Portaria 445, optou-se por realizar uma análise quantitativa básica em relação às frequências absolutas e relativas das respostas dos pescadores em relação às principais questões constantes nos formulário. Apesar de entendermos que análises multivariadas poderiam trazer resultados mais robustos e, consequentemente, mais profundidade às discussões, entendemos que a aplicação apenas desta técnica da estatística descritiva é suficiente para se alcançar os objetivos do trabalho. Esse suficiência, por sua vez, está respaldada no fato de que, como o objetivo central do capítulo foi avaliar os conhecimentos dos pescadores, a análise das frequências das respostas trouxe informações satisfatórias. Além disso, puderam-se realizar discussões teóricas no capítulo, sem a aplicação de testes estatísticos. Fato semelhante ocorreu em relação ao capítulo V, que trata das percepções dos entrevistados sobre a efetividade da REMC. Neste, a análise das frequências de respostas dos pescadores também foi suficiente para se alcançar os objetivos do trabalho.

1.3 Estrutura da tese

A tese é composta por cinco capítulos. De acordo com o modelo adotado pelo Programa de Pós-Graduação em Etnobiologia e Conservação da Natureza, o primeiro deles denomina-se "Fundamentação Teórica" e subdivide-se em cinco tópicos.

Os outros quatro representam artigos científicos, que respondem às questões da pesquisa. Destes, o capítulo II foi publicado na revista "Ocean & Coastal Management". O capítulo III está sob avaliação na revista "Human Ecology". Os capítulos IV e V estão em fase final de preparação para o envio às revistas "Marine Policy" e "Ocean & Coastal Management", respectivamente. Abaixo, são detalhados estes trabalhos científicos:

Capítulo II: Referência Bibliográfica: Barbosa-Filho, M. L. V., Souza, G. B. G., Lopes, S. F., Siciliano, S., Hauser-Davis, R. A., Mourão, J. S. (2020). Evidence of shifting baseline and Fisher judgment on lane snapper (*Lutjanus synagris*) management in a Brazilian marine protected area. Ocean & Coastal Management, https://doi.org/10.1016/j.ocecoaman.2019.105025

Questões da pesquisa: 1) Verificam-se indícios da ocorrência do fenômeno da mudança na linha de base dos pescadores de diferentes idades sobre a pesca do ariocó? e 2) Quais

são as atitudes dos pescadores em relação à ideia da construção de ações locais para a conservação da espécie?

Objetivos: Avaliar se existem indícios da mudança de linha de base na pesca local de *L. synagris*, além de avaliar as atitudes dos pescadores em relação à conservação da espécie na REMC.

Variáveis preditoras: "Idade dos pescadores no momento da entrevista" e o "número de anos decorridos desde a ocorrência das maiores capturas da espécie".

Principal(is) contribuição(ões) do trabalho para a cogestão da Resex do Corumbau: A avaliação das percepções dos entrevistados referentes às possíveis variações na abundância da espécie ao longo do tempo apontou indícios da ocorrência do fenômeno da mudança do referencial ambiental na pesca do ariocó, principal espécie de peixe capturada na UC. Os rendimentos alcançados pelas melhores capturas dos pescadores mais velhos poderão servir como uma base inicial para o desenvolvimento de metas de conservação para *L. synagris*. Em outras palavras, futuras ações de manejo devem viabilizar que pescarias ocasionais alcancem rendimentos próximos àqueles relatados pelos pescadores mais antigos.

Capítulo III

Título: "Artisanal fishermen's knowledge and attitudes concerning compressor fishing in a Marine Protected Area mosaic region in the Southwest Atlantic".

Questões da pesquisa: 1 – Quais são as atitudes dos pescadores em relação à pesca de compressor? e 2 – Quais os conhecimentos destes em relação à prática?

Objetivos: Descrever o conhecimento e as atitudes dos pescadores da REMC sobre a atuação de pescadores de fora que pescam com compressores.

Principal(is) contribuição(ões) do trabalho para a cgestão da Resex do Corumbau: Dado que pescadores de fora pescam com compressores na região da REMC, as

informações dos entrevistados poderão contribuir no combate a esta infração ambiental. Como o estudo tem um enfoque qualitativo, não contemplou a utilização de variáveis preditoras.

Capítulo IV

Título: "Fisher knowledge and instruction is crucial for compliance with regulatory frameworks concerning endangered marine species".

Questões da pesquisa: 1 – Os participantes detêm conhecimentos sobre a Portaria 445? e 2 – Qual é o nível de conhecimento dos participantes em relação ao número de espécies de peixes sob moratória no Brasil?

Objetivos: Analisar os conhecimentos de pescadores da REMC sobre a Portaria 445 e seus desdobramentos.

Variável preditora: "Idade dos pescadores no momento da entrevista".

Principal(is) contribuição(ões) do trabalho para a cogestão da Resex do Corumbau: O estudo evidenciou que, em geral, os participantes conhecem a Portaria 445 superficialmente e por vias informais. Este fato torna os pescadores locais vulneráveis às sanções e representa um empecilho à conservação das espécies ameaçadas. Além do estudo apontar maneiras de informar os pescadores, a iniciativa de ofertar pôsteres informativos às comunidades representou uma contribuição para o comanejo da pesca local, bem como para a elevação da auto estima do público contemplado.

Capítulo V

Título: "Fisher perceptions confirm the socio-environmental effectiveness of a 20-year old Marine Protected Area in the main South Atlantic marine biodiversity hotspot".

Questões da pesquisa: Quais são as percepções dos entrevistados em relação à efetividade socioambiental da REMC?

Objetivos: Sistematizar as informações relacionadas às percepções dos entrevistados em relação à efetividade socioambiental da REMC.

Principal(is) contribuição(ões) do trabalho para a cogestão da Resex do Corumbau: Este capítulo enfocará as percepções dos pescadores a respeito da REMC e sobre os desdobramentos socioambientais desta. Dado que a maioria dos entrevistados percebeu mudanças sociais e ambientais positivas decorrentes do estabelecimento REMC, este trabalho representa uma bandeira a favor desta Área Marinha Protegida e desta modalidade de UC em si. Além disso, apontar as pressões que os pescadores da REMC ainda sofrem atualmente poderá servir de base para uma maior adequação desta AMP às expectativas destes atores sociais.

2. CAPÍTULO I: FUNDAMENTAÇÃO TEÓRICA

2.1 Os arranjos de cogestão pesqueira

Especialistas têm divulgado que a gestão pesqueira deve se centralizar nos objetivos desenvolvidos pelos atores locais, considerar as limitações e oportunidades técnicas caso a caso e desenvolver os meios operacionais que levarão ao alcance destes objetivos (CARLSSON e BERKES, 2005). Ostrom (1990) estabelece alguns princípios fundamentais (*design principles*) da estrutura de governança dos bens comuns que permitem a exploração de forma sustentável e sem violar os princípios da justiça e da posse comunitária, como: 1 - a definição de limites e responsabilidades; 2 - fronteira da comunidade para o uso desses recursos; 3 - critérios para o ingresso a grupos de usuários; 4 - regras de uso desses recursos devem ser claras e bem definidas e 5 - usuários devem ter o direito de modificar suas regras de uso desses recursos ao longo do tempo.

Para assegurar o cumprimento desses objetivos e os princípios supracitados, um dos modelos mais adequados é a implantação de um sistema de cogestão. A cogestão é definida como sendo um compartilhamento de responsabilidades, direitos e deveres entre as principais partes interessadas, em particular as comunidades locais e o Estado

(GERRARD e SOEFTESTAD, 1998). Já para Borrini-Feyerabend *et al*. (2000), a cogestão pode ser entendida como uma situação em que dois ou mais atores sociais negociam, definem e garantem entre si uma partilha justa das funções de gestão. Moller *et al*. (2004) apresentam a cogestão como um processo contínuo de acordos que envolvem vários graus de poder e de partilha de responsabilidades entre o governo e a comunidade local. Carlsson e Berkes (2005), por sua vez, afirmam que as definições e conceituações de cogestão na literatura têm alguns fundamentos em comum: associam explicitamente o conceito de cogestão com gestão de recursos naturais, sendo esta um tipo de parceria entre atores públicos e privados, em um processo contínuo e dinâmico.

A cogestão pode ser construída por diferentes arranjos institucionais, sendo um dos principais a criação de Áreas Protegidas (APs). Dudley (2008) define as APs como espaços geográficos claramente definidos, reconhecidos e geridos por meios legais ou outros meios eficazes, com o intuito de conservarn a natureza e os serviços dos ecossistemas associados e valores culturais. No entanto, entende-se que quando há um sistema gestor que concilie estratégias de conservação biológica com questões sociais, econômicas e políticas, as APs se configuram em uma importante ferramenta para criação de uma estrutura deliberativa que inclua todos os envolvidos, tais quais o Estado, comunidade, ONGs e instituições de pesquisa, para fomentar a cogestão.

No Brasil, um instrumento de cogestão que tem sido bastante utilizado nas Áreas Protegidas da modalidade Reservas Extrativista (Resex) são os Acordos de Pesca. Estes representam um conjunto de medidas específicas decorrentes de tratados consensuais entre os diversos usuários e o órgão gestor dos recursos existentes na Resex (IBAMA, 2003). Por exemplo, a Resex Acaú-Goiana implantou seu Acordo de Pesca em 2017, o qual definiu várias regras e normas como o tamanho mínimo das malhas das redes (20 mm), o uso de tarrafas com malha inferior 20 mm, a proibição do uso de redes de arrasto (mangote), a permissão do uso de lampião, facho ou lanterna, como também o uso do tingui (*Magonia pubescens*) ou de qualquer planta que em contato com a água produza efeitos semelhantes às substâncias tóxicas e também a proibição da captura do amoré (*Gobioides broussonetti*) por um ano (ICMBIO, 2017).

No Chile, foi criado uma ferramenta de cogestão denominada de Direito Territoriais de Utilização da Pesca (DTUP), uma política nacional para os recursos bentônicos que permite o acesso exclusivo a organizações de pescadores artesanais. Deste modo, os DTUPs são uma forma espacial de direitos de propriedade em que indivíduos

ou um grupo de pescadores têm acesso de captura exclusivo aos recursos dentro de uma área geograficamente definida (GELCICH *et al*., 2016).

2.2 A contribuição da Etnobiologia para o manejo pesqueiro em Reservas Extrativistas Marinhas

Em geral, grupos humanos tradicionais apresentam uma estreita relação com os recursos naturais. Os conhecimentos advindos de tais interações podem ser analisados pela perspectiva da Etnobiologia que, segundo Posey (1987), é o estudo dos conhecimentos e das conceituações desenvolvidas por qualquer sociedade a respeito da biologia. Posey (1987) ainda argumenta que a Etnobiologia tem condições de prover suporte científico às novas ideias capazes de conduzir uma política socioecologicamente responsável e que contribua para a proteção das populações tradicionais, de seus territórios e do meio ambiente como um todo.

Países em desenvolvimento, como é o caso do Brasil, costumam apresentar uma contundente limitação na capacidade de governança da pesca (BEGOSSI *et al*., 2016; FAO, 2018). Por isso, em tais regiões, faz-se necessária a adoção de um manejo adaptativo. Este representa qualquer forma de manejo que estimula, quando necessárias, mudanças periódicas nos objetivos e protocolos de manejo, em resposta aos dados de monitoramento e outras novas informações (DURIGAN e RAMOS, 2013). Para isso, costumam ser utilizadas variadas fontes de informações quantitativas, qualitativas e aquelas advindas do conhecimento etnobiológico dos pescadores (STEPHENSON *et al*., 2016). Nesse sentido, a Etnobiologia vem se destacando como uma ciência fundamental para se estudar as populações de pescadores e os modos pelos quais elas interagem com os recursos marinhos (BEGOSSI *et al*., 2016; NARCHI *et al*., 2013). Pescadores podem prover os cientistas de informações críticas sobre a sazonalidade, dieta, reprodução, comportamentos, abundância e indícios de sobreexplotação de populações de peixes (HIND, 2015).

No Brasil, as Resex buscam valorizar o patrimônio cultural das populações nativas, bem como encorajar a utilização dos conhecimentos e práticas locais na conservação ambiental (ERLER *et al*., 2015; SEIXAS *et al*., 2019). Existem experiências exitosas da inserção dos conhecimentos etnobiológicos e práticas tradicionais de pescadores brasileiros na gestão de Resex marinhas (Resex-Mar) (ver SEIXAS e

KALIKOSKI, 2009; SEIXAS et al., 2011; VIEIRA *et al*., 2015), apesar destes saberes ainda serem subutilizados para tais fins (GERHARDINGER *et al*., 2009; SEIXAS *et al*., 2019). Nesse sentido, por meio da análise dos conhecimentos etnobiológicos dos pescadores da REMC, serão apontadas e discutidas opções de cogestão pesqueira para o contexto pesquisado. Além de valorizar estes saberes locais, os resultados poderão servir de exemplo e contribuir para o fortalecimento das parcerias entre pescadores e gestores da pesca em contextos de Áreas Marinhas Protegidas de Uso Sustentável no Brasil e em outros países onde se observam limitações de dados científicos que embasem ações de gestão.

2.3 Percepções de pescadores sobre as tendências populacionais dos recursos pesqueiros e de indícios da Síndrome da mudança de linha de base na pesca

Os países tropicais e em desenvolvimento costumam apresentar severas limitações na quantidade e na qualidade dos dados científicos sobre a pesca, fato este que dificulta a adoção de medidas de gestão (FAO, 2018; GILL *et al*., 2019; MELLADO *et al*., 2014). Nestes cenários, o conhecimento ecológico dos pescadores representa uma valiosa fonte de dados, por exemplo, sobre a história de vida das espécies de peixes (GATTI *et al*., 2015; KATIKIRO, 2014; PREVIERO e GASALLA, 2018; THURSTAN *et al*., 2015), com o potencial de contribuir para o manejo e conservação destes recursos. Por sua vez, mais do que uma oportunidade científica, representa um direito básico das populações de pescadores a inclusão dos seus conhecimentos, crenças e percepções na gestão pesqueira.

A Síndrome da mudança da linha de base (*Shifting Baseline Syndrome - SBS*) foi o termo cunhado por Pauly (1995) para designar o fenômeno em que pesquisadores, e mesmo os membros de populações tradicionais, perdem o referencial histórico que deve servir como linha de base para os estudos que avaliam alterações ambientais. Na avaliação dos estoques pesqueiros, este autor alertou a comunidade científica para o ciclo deletério no qual estudiosos da conservação marinha adotavam como referências das suas pesquisas a composição das espécies nos desembarques e as condições dos estoques pesqueiros do início de suas carreiras acadêmicas. À medida que as gerações de pesquisadores aceitavam como adequados parâmetros ambientais altamente enviesados, era praticamente impossível notar a depredação dos estoques e mesmo a extinção local de espécies outrora abundantes (KATIKIRO, 2014; PLUMERIDGE e ROBERTS, 2017;

THURSTAN *et al*., 2015). Assim, o fenômeno tem contribuído para que cientistas realizem avaliações deturpadas sobre o custo socioeconômico da atividade pesqueira e, por consequência, definam metas inadequadas para a restauração dos estoques (MAIA *et al*., 2018; MELLADO *et al*., 2014). Não menos grave, é a condição cognitiva decorrente da perda de referências ambientais na qual subsequentes gerações de pescadores aceitam um padrão cada vez mais baixo de abundância como a condição "natural" das populações de peixes explotadas (MAIA *et al*., 2018; THURSTAN *et al*., 2015).

A memória dos pescadores mais experientes representa, deste modo, um repositório único de informações que podem contribuir na estimação da tendência populacional de espécies explotadas, auxiliando, por exemplo, em estimativas reais das perdas decorrentes da sobreexplotação (BENDER *et al*., 2013; MAIA *et al*., 2018; SÁENZ-ARROYO *et al*., 2005). Nas últimas décadas, a integração do conhecimento de pescadores e dos dados científicos convencionais tem se mostrado promissora em estudos com o foco na ecologia histórica (GATTI *et al*., 2015; POWERS *et al*., 2013), sobretudo pela reconstrução de linhas de bases ecológicas relacionadas às capturas das espécies-alvo (MELLADO *et al*., 2014; SÁENZ-ARROYO *et al*., 2005; SOGA e GASTON, 2018). Um exemplo emblemático de tal cenário foi verificado na pesquisa de Sáenz-Arroio e outros (2005) no Golfo da Califórnia. Nessa região, os dados de estatística pesqueira sobre a garoupa-do-golfo *Mycteroperca jordani* (Jenkins e Evermann, 1889), coletados após uma acentuada queda na abundância da espécie na década de 1970, sugeriam, equivocadamente, um bom estado de higidez da população, pois recentes incrementos nos desembarques apontavam uma tendência de acréscimo na abundância. No entanto, por meio da análise de evidências históricas, foi possível apontar o real estado de depleção do estoque ocorrido anteriormente ao começo da coletas de dados dos desembarques pesqueiros da espécie nos anos 70 e advertir os cientistas para a possibilidade de que cenários semelhantes possam estar acontecendo em outras regiões tropicais (SÁENZ-ARROIO *et al*., 2005).

Estudos sobre o conhecimento ecológico de pescadores em várias partes do mundo têm analisado as tendências populacionais de diversos recursos ícticos recifais e a ocorrência da mudança na linha de base na pesca (ver a revisão de SOGA e GASTON, 2018). Análises desta natureza estão longe de gerar os melhores dados sobre as populações explotadas, pois atualmente existem raríssimos ecossistemas prístinos no mundo (JACKSON, 2001; MAIRE *et al*., 2016) e as informações transmitidas por pescadores restringem-se a um espaço de tempo de algumas décadas. Contudo, não raro,

as informações provenientes da memória dos pescadores mais velhos representam a única fonte de dados sobre a história da pesca de determinadas regiões geográficas.

No Brasil, pesquisas que enfocam a síndrome da mudança de linha de base ainda são poucas e recentes, com o primeiro trabalho tendo sido realizado por Bender e outros (2013) junto aos pescadores que atuam no entorno do Parque Marinho do Recife de Fora, na cidade de Porto Seguro, Bahia. Neste estudo, pela análise de depoimentos de pescadores, os autores apontaram que, ao longo do tempo, as capturas de sete das nove espécies de peixes recifais analisadas apresentaram significativas tendências de declínio. Na região de Arraial do Cabo, Rio de Janeiro, Bender e outros (2014) apontaram que os pescadores locais mais jovens e menos experientes relataram uma quantidade menor de espécies como sobreexplotadas e áreas de pesca exauridas do que os mais velhos e experientes. Com isto, sugeriram a ocorrência do fenômeno da SBS na pesca da região. Por meio de entrevistas com diferentes gerações de pescadores atuantes na região do Banco dos Abrolhos, Giglio e outros (2015) sugeriram a extinção local do peixe-serra (*Pristis pectinata* Latham, 1794), além de indícios da mudança de linha de base na pesca de peixes recifais componentes da megafauna marinha.

Esta pesquisa fornece subsídios para que os conhecimentos e percepções advindas das memórias dos pescadores sobre o histórico de capturas do ariocó (*L. synagris*) sejam utilizados para o manejo e conservação desta que é a principal espécie de peixe capturada na da REMC. Afinal, as informações transmitidas pelos participantes permitiram ajustar a linha de base ambiental na pesca da espécie o que, por sua vez, condicionou a estimação de uma meta de conservação.

2.4 A Lista de Espécies de Peixes Ameaçadas de Extinção no Brasil (Portaria 445) e suas controvérsias

A partir do ano de 2008, o governo brasileiro revisou o estado de conservação das espécies da fauna, da flora e dos principais grupos de invertebrados existentes em território nacional. O Ministério do Meio Ambiente (MMA) foi o responsável por este processo que resultou nas Portarias 443, 444 e 445, com as Listas Nacionais de Espécies Ameaçadas de Extinção em 17 dezembro de 2014 (PINHEIRO *et al*., 2015). As listas foram elaboradas a partir de um processo que contou com a participação de 1.300 pesquisadores de diversos órgãos brasileiros e internacionais, tendo se baseado nos

métodos adotados pela União Internacional para a Conservação da Natureza - IUCN (LEES, 2015).

Em uma perspectiva regional, o método empregado pela IUCN atribui onze categorias na avaliação das espécies, sendo que três delas representam diferentes escalas de ameaças de extinção, como nível elevado (Vulnerável), muito elevado (Em Perigo) e extremamente elevado (Criticamente em Perigo) (IUCN, 2014). Para categorizar determinada espécie como ameaçada de extinção, a IUCN avalia critérios quantitativos relacionados ao tamanho populacional da mesma, se esta vem sendo submetida a redução populacional, sua distribuição geográfica, o número de indivíduos maduros e a sua probabilidade de extinção (PINHEIRO *et al*., 2015).

A Portaria 445/2014 (BRASIL, 2014), lançada pelo governo brasileiro, concede proteção integral contra a captura, manuseio, armazenamento, transporte, processamento e comercialização de 66 espécies de invertebrados aquáticos e 409 espécies de peixes consideradas ameaçadas no Brasil (BUCKUP, 2017), das quais 98 espécies são peixes marinhos (REIS *et al*., 2016). Os desdobramentos da Portaria 445 respaldam-se na Lei 9.605/1998 e no decreto 6.514/2008, que prevê punições contra quem mata, pesca, caça ou se utiliza de espécies sob risco de extinção (BRASIL, 1998, 2008).

Quando a Portaria 445, que traz a lista das espécies de peixes brasileiros ameaçadas, foi publicada, entidades ligadas ao setor industrial da pesca iniciaram um processo de contestação da legitimidade da mesma (BUCKUP, 2017). Além do argumento de que ela atrapalharia o setor pesqueiro do país, a metodologia aplicada no processo de elaboração da lista também foi questionada (DI DARIO *et al*., 2015). Também, houveram contestações do setor pesqueiro artesanal brasileiro, uma vez que a imposição da moratória à pesca de inúmeras espécies de peixes utilizadas pelos pescadores artesanais pode representar uma ameaça à segurança alimentar destes e à própria pesca artesanal do país (BEGOSSI *et al*., 2017). Contudo, Di Dario e outros (2015) argumentaram que as consequências da Portaria 445 sobre a pesca não seriam tão intensas, pois ela prevê a possibilidade da explotação das espécies classificadas como Vulnerável. Para tanto, é necessário que sejam elaborados planos de gestão específicos para as espécies alocadas nesta categoria e as suas capturas estejam regulamentadas por agências federais.

Em 2015, por conta de uma ação penal impetrada por pescadores industriais organizados, a Portaria 445 foi revogada (BUCKUP, 2017). A revogação gerou uma reação acalorada por parte dos pesquisadores brasileiros, que se adiantaram em defender

o reestabelecimento da Portaria. Também, organizações internacionais buscaram sensibilizar o governo brasileiro para o restabelecimento da portaria. Não obstante, apenas em 25 de janeiro de 2017 a Portaria 445 voltou a vigorar (BUCKUP, 2017). Desde então, Portarias (Portarias 127, 129 e 292) foram lançadas no intuito de definir medidas, critérios e padrões para o ordenamento da pesca de algumas das espécies alocadas como Vulnerável.

As moratórias, estratégia de gestão padrão para pescarias em estado de sobreexplotação, influenciam as decisões de pescadores e, aparentemente, afetam a qualidade do conhecimento ecológico destes (FARR *et al.*, 2018). Além disso, demandam que pescadores assimilem conhecimentos não tradicionais. Por exemplo, o estabelecimento da moratória às capturas de *E. itajara* no Brasil, exigiu que os pescadores assimilassem novos conhecimentos como, por exemplo, ao que se refere às possíveis sanções decorrentes da captura da espécie, sobre como proceder ao fisgar um exemplar e também em relação à existência da própria moratória em si. Desta forma, viabilizar o acesso dos pescadores a informações como estas é um requisito básico para que as moratórias sejam respeitadas.

Contudo, é provável que o atual cenário de precarização da atividade pesqueira artesanal pelo Estado brasileiro (GERHARDINGER *et al*., 2017; VASCONCELLOS *et al*., 2011) venha contribuindo para um quadro de pouco conhecimento dos pescadores sobre Portaria 445 e seus desdobramentos. Ainda não existem estudos que investiguem os conhecimentos de pescadores artesanais brasileiros sobre a Portaria 445 e, principalmente, avaliem o quanto estes sabem a respeito das espécies nacionalmente ameaçadas de extinção.

O capítulo que aborda a temática representa uma iniciativa pioneira no Brasil, com o objetivo de analisar o conhecimento de pescadores artesanais marinhos da REMC sobre a Lista Nacional de Espécies de Peixes Ameaçadas de Extinção, que impôs uma moratória sobre centenas de espécies de peixes. Infelizmente, um conhecimento muito limitado sobre a Portaria 445, sobre quais espécies estão ameaçadas e também sobre as repercussões da lista foi observado entre os participantes do estudo. É possível que cenários semelhantes estejam ocorrendo em outras regiões do Brasil, o que representaria um grande impedimento à conservação de espécies ameaçadas de extinção. Assim, o estudo aponta para a necessidade de intervenções públicas para que a lista seja conhecida e compreendida pelos pescadores. Tendo em vista as sérias ameaças globais à pesca marinha e o crescente número de espécies ameaçadas de extinção em todo o mundo, este

estudo é um alerta para que as estratégias de manejo pesqueiro que limitam o acesso dos pescadores aos recursos dos quais dependem venham acompanhadas pelo estabelecimento de sérias ações de comunicação entre o poder público e estes atores sociais.

2.5 Percepções de pescadores para a análise da efetividade de MPAs

Mundialmente, a eficácia da conservação dos ecossistemas aquáticos é uma temática altamente relevante e das mais urgentes. Por sua vez, o estabelecimento de Áreas Marinhas Protegidas (AMPs) representa um dos principais paradigmas para a conservação e uso sustentável dos oceanos. Contudo, apesar de estudos comprovarem a viabilidade das AMPs em proteger ambientes costeiros e marinhos (ROBERTS *et al*., 2017; SALA e GIAKOUMI, 2018), ainda hoje perduram os debates sobre a efetividade deste instrumento de gestão em alcançar seus objetivos sociais (GILL *et al*., 2017). A grande quantidade e variedade de modalidades de AMPs, além dos mais diversificados contextos culturais nas quais estas encontram-se inseridas, geram uma diversidade de resultados que representam uma valiosa oportunidade de avaliar as limitações e os êxitos destes dispositivos para atingir metas de sustentabilidade ecológica e bem-estar social (PENDLETON *et al.*, 2018).

Desse modo, sob os mais variados enfoques, cientistas têm desenvolvido uma infinidade de mecanismos e abordagens para investigar a efetividade das AMPs Por exemplo, o rico arcabouço de conhecimentos ecológicos sobre os ecossistemas marinhos dos quais pescadores são detentores tem sido empregado pelos cientistas para avaliarem a efetividade das AMPs. Estudos desta natureza são especialmente necessários em países em desenvolvimento, dado que nestas regiões do globo as pescarias costumam ser pobres em informações científicas que subsidiem uma adequada governança do ambiente marinho (AMORIM et al., 2019; PURCELL e POMEROY, 2015). Nesse contexto, nos últimos anos, avaliações baseadas em evidências relacionadas à efetividade de AMPs têm-se concentrado nas percepções de pescadores, sobretudo para regiões onde observam-se limitações de dados científicos e os governos não possuem condições adequadas de governança e monitoramento ambiental (BENETT e DEARDEN, 2014).

De fato, reconhece-se que estudos com o foco nas percepções de grupos humanos tradicionais em relação ao ambiente podem gerar dados relevantes relacionados aos

impactos e resultados ecológicos da conservação, à legitimidade dos processos de governança e ao potencial de aceitabilidade e aderência às regras de manejo pelas partes envolvidas (AMORIM et al., 2019). Nesse sentido, pesquisas científicas que enfocam a percepção de pescadores sobre AMPs têm apontado uma infinidade de impactos positivos (OBERHOLZER *et al*., 2010; ROBERTS *et al*., 2001; SHAH *et al*., 2019) e negativos (BENETT e DEARDEN, 2014; HIND *et al*., 2010) destas na qualidade de vida de populações litorâneas e na conservação de ambientes marinhos.

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5. CAPÍTULO II - Manuscrito publicado na "Ocean & Coastal Management"

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Title Page

Evidence of shifting baseline and fisher judgment on lane snapper (*Lutjanus synagris*) management in a Brazilian marine protected area

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Highlights

. Fisher Ecological Knowledge was assessed to identify shifting baselines.

. The 222 fishers interviewed identified *L. synagris* as the main fish resource.

. There is evidence of shifting baseline syndrome on *L. synagris* local fisheries.

. Most fishers stated that the species does not need to be protected locally.

. Mainly younger fishers pointed out possible management strategies for the species.

Manuscript

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Abstract

The integration of knowledge from fishers and conventional scientific data is promising as a subsidy for the establishment of proper management procedures for fishing resources. In this context, the potential use of local ecological fisher knowledge from the Marine Extractive Reserve of Corumbau (MERC) in northeastern Brazil was evaluated regarding the shifting baseline of the lane snapper *Lutjanus synagris*. Semi-structured interviews applied to 222 fishers who identified *L. synagris* as the main fish resource used in MERC. The relationship between the maximum *L. synagris* weight caught on the best fishing day among fishers of different age categories was not significant ($p = 0.306$). However, older fishers significantly ($p < 0.001$) reported a higher time span since their best day catch. In addition, older fishers were significantly more perceptive ($p = 0.013$) to declining *L. synagris* abundance over time than younger fishers, who mostly reported that this species abundance is stable or has even increased over time. These results highlight an existing shifting baseline phenomenon for the *L. synagris* fishery in the region. Only 22.5% of the respondents, mostly younger fishers, expressed a need to establish specific management rules for the species. The proposed strategies for local *L. synagris* management included establishing a closed period, defining minimum catch sizes and creating new No-Take Zones specifically for this species protection. Trust bonds between fishers and fisheries managers, as well as scientists, require strengthening, and fisher knowledge can serve as a basis for building local targets for species conservation.

Keywords: Ethnobiology; Historical Ecology; Lutjanidae; Abrolhos Bank; Brazil.

Short title: Shifting *L. synagris* baseline and management.

1. INTRODUCTION

The establishment of management procedures in developing countries, especially in the tropical region, is severely hampered by flaws and gaps in fishery data acquisition (Gill et al., 2017). In these scenarios, fisher ecological knowledge (FEK) represents a valuable data source, with the potential to contribute to the management and conservation of these resources (Gatti et al., 2015; D'Armengol et al., 2018; Previero and Gasalla, 2018). This knowledge framework has also been termed by the scientific literature as Traditional Ecological Knowledge (TEK) (Drew, 2005; Ruiz-Mallén and Corbera, 2013), Local Ecological Knowledge (Berkes, 2008) and Indigenous Knowledge (Jardine, 2019). According to Fischer et al. (2015), FEK comprises a body of knowledge that includes ecosystem ecology aspects based on fishing resources, fishing techniques, fishing communities and livelihoods, governance and markets, and their dynamic relationships.

1.1 Fisher Ecological Knowledge (FEK) and the Shifting Baseline Syndrome in fishing

FEK has been studied in several regions worldwide, and a scientific approach concerning this knowledge can aid in conservation and fishery management programs (Lopes et al., 2010). This approach often provides biological and ecological data in a shorter time frame and at a lower cost when compared to traditional sampling protocols. When ecological data are difficult to obtain or insufficient to support fisheries management initiatives, the ichthyological knowledge of local populations is especially needed (Johannes et al., 2000; Beaudreau and Levin, 2014). In turn, rather than a scientific opportunity, the inclusion of fisher knowledge in fishery management programs represents a basic right of these populations. The inclusion of fishery populations in management systems breaks paradigms within the conventional state-centered approach to fisheries management by promoting a new way of managing resources, termed co-management (Carlson and Berkes, 2005; Seixas et al., 2019). This management approach is defined as the "sharing of power and responsibility between government and local resource users" (Berkes et al., 1991).

The memory of the most experienced fishers from a given community (older fishers) represents a unique repository of information that can contribute to estimating population trends for exploited species by, for example, helping to estimate actual losses from overexploitation (Lozano-Montes et al., 2008; Lotze and McClenachan, 2014; Fortibuoni et al., 2016; Lovell et al., 2018). In recent decades, the integration of

knowledge from both fishers and conventional scientific data has shown to be promising in historical ecology studies (Bender et al., 2014; Gatti et al., 2015; Pauly and Jacquet, 2019), mainly by reconstructing ecological baselines related to catches of target species (Sáenz-Arroyo et al., 2005a; Eddy et al., 2010; Soga and Gaston, 2018).

Pauly (1995) warned the global scientific community about the shifting baseline phenomenon. According to this author, this phenomenon represents distortions in environmental perceptions from an intergenerational perspective. The occurrence of this phenomenon can culminate in a vicious cycle with very serious consequences, such as the improper assignment of landmarks and inappropriate goal definitions for population rehabilitation in fisheries resources (Sáenz-Arroyo et al., 2005a; Pinnegar and Engelhard, 2008; Katikiro, 2014; Pauly and Jacquet, 2019). Studies concerning FEK in many countries worldwide have analyzed population trends of ichthyological resources and the occurrence of shifting baseline in fisheries (Bender et al., 2014; Ulman and Pauly, 2016; Soga and Gaston, 2018; Pauly and Jacket, 2019). Analyses of this nature are, however, still far from generating the best data on exploited populations, as there are currently very few pristine ecosystems left in the world (Lotze and McClenachan, 2014), and the information conveyed by fishers is restricted to a time span of a few decades. However, information recovered from older fishers is often the only data source on the fishing history of certain geographic regions.

In addition to FEK, various sources of information have been used to point out the occurrence of shifting baselines and to adjust historical baselines in marine fisheries. For example, one way to combat referral loss is to reconstitute past sea life conditions by using historical and less conventional data. These include old footage (Zogares and De Maddalena. 2014), news reports in the media (Francis et al., 2019), booklets and reports from former explorers (Sáenz-Arroyo, 2005b) or even photographs (McClenachan, 2009). In addition, some studies have focused on comparing FEK with historical information series from fishing landings (Sáenz-Arroyo et al., 2005a; Lozano-Montes et al., 2008; Bender et al., 2014; Fortibuoni et al., 2016) in order to adjust the environmental references of certain regions.

1.2 The relevance and fishing status of the Lutjanidae Family and *Lutjanus synagris*

Lutjanid species are among the most valued and demanded fish resources in international markets (Amorim et al., 2018). Species belonging to the Lutjanidae family occur in tropical and subtropical regions worldwide and play important roles in the ecological communities of neritic environments (Allen, 1985). The global production of lutjanid fish was of 2.1 million tons between 2006 and 2013, with Brazil presenting the third highest production volume during this period (Cawthorn and Mariani, 2017). Although lutjanids represent one of the main fishery targets by handlines in the tropical Southwest Atlantic Ocean region (Rezende et al., 2003; Messias et al., 2019), the protective strategies for these species are still scarce. For instance, the Ordinance nº 445 from the Brazilian Ministry of the Environment (Brasil, 2014) represents the only management intervention for fish species from this group in the entire national territory. It establishes the moratorium on catching, transporting, storing, and commercializing of the caranha *Lutjanus cyanopterus* (Cuvier, 1828) and the pargo *L. purpureus* (Poey, 1876) in Brazil. This Ordinance is valid for the entire Brazilian territory and comprises 409 fish species, including 98 marine species (Reis et al., 2016). Its publication generated heated scientific and political disagreements (Di Dario et al., 2015) and, due to the established moratorium on numerous small-scale fisheries, can threaten the food security and livelihoods of artisanal fishers (Begossi et al., 2017).

The lane snapper, *Lutjanus synagris* (Linnaeus, 1758), is distributed throughout the Western Atlantic Ocean, from North Carolina (USA) to southern Brazil, including the Caribbean Sea and the Gulf of Mexico (Allen, 1985; Hostim-Silva et al., 2006). Adult individuals occupy a variety of habitats but prefer clear water regions close to coral reefs with sandy bottoms (Claro and Lindeman, 2008). *L. synagris* is highly relevant to commercial and sport fishing and is captured by a variety of fishing gear (Allen, 1985; Claro and Lindeman, 2008). According to the Food and Agriculture Organization (FAO) of the United Nations, global *L. synagris* catches in 2016 yielded around 4,000 tons (FAO, 2018). However, its predictable behavior of aggregating seasonally for breeding purposed and the documentation of substantial declines in fish landings throughout its geographic distribution have contributed to its classification as "Near Threatened" by the International Union for the conservation of Nature (IUCN) (Lindeman et al., 2016). In Brazil, *L. synagris* represents one of the main reef fishery resources (Begossi et al., 2012; Freitas et al., 2014) and ecological studies have indicated that its populations are overexploited in several regions of the country (Klippel et al., 2005; Fredou et al., 2006). Unfortunately, no official data on the volume of Brazilian fishery production since 2011

are available, and, even for 2011, there is no specific information on *L. synagris* landings (Brasil, 2011).

Although the scientific fishery database for southern Bahia displays serious limitations (monitoring flaws and gaps) with regard to supporting management initiatives (Costa et al., 2003; Previero and Gasalla, 2018), some lutjanids are known to be in a severe regional overexploitation state (Klippel et al., 2005). A previous study carried out with fishers from the municipality of Porto Seguro, in northeastern Brazil, revealed a shifting in the environmental baseline of the reef fishery, and fisher testimonies indicated a depletion in the catches of some lutjanid species (Bender et al., 2013). Nonetheless, no specific regional studies on the conservation status of lane snapper are available up to now. At the Marine Extractive Reserve of Corumbau (MERC), in southern Bahia, lane snapper captures totaled 12.4 tons in 2011, making it the main fish species landed in this Marine Protected Area (MPA) (Minte-Vera and Souza-Junior, 2014).

1.1 The MERC and its fisheries management system

Two initiatives for participatory monitoring of fishing landings have been implemented at the MERC: the first between 2002 and 2006, and the second between October 2010 and December 2011. These initiatives, however, were interrupted by lack of financial resources. The MERC Use Plan was approved in 2003 (IBAMA, 2003) with the main fisheries management strategies being related to: (i) the prohibition of some fishing gear; (ii) restrictions in the effort to capture resources; (iii) the existence of restrictive areas concerning certain gears; (iv) the establishment of No-Take Zones (zones where fishing is prohibited); and (v) fish boat landings monitoring. The management strategies were built based on both scientific and traditional evidences. According to the Usage Plan document (IBAMA, 2003), the adoption of these strategies is the result of the process initiated before the MERC implementation, when the parties involved in the process sought to ensure the objectives set forth in its creation and Law 9,985/2000, establishing the National System of Conservation Units - SNUC (Brazil, 2000). The Usage Plan represents a preliminary document to the Management Plan, which governs management in Brazilian Protected Areas (Brazil, 2000). At the moment, a new fish landing system is being planned, as well as the MERC Management Plan. The Management Plan creation process began in 2017 and was completed in early 2019, and

included the participation of MERC community representatives during all development stages. The Management Plan document is currently under publication.

In this context, as the first specific regional research on the conservation status of *L. synagris*, the present study sought to mainly answer the following question: Are there indications of the shifting baseline phenomenon among fishers of different ages regarding lane snapper fisheries? Thus, the aims of this study were to evaluate shifting baseline indications in the local *L. synagris* fisheries. In addition, we also sought to analyze the judgments of the interviewed fishers concerning the implementation of local conservation actions for this species. This study contributes with new evidence concerning FEK importance as a management driver, highlighting its relevance as subsidy to fill the 8-year knowledge gap in the absence of official data concerning *L. synagris* Brazilian fishery production.

2. MATERIAL AND METHODS

2.1 Study area

The Marine Extractive Reserve of Corumbau (MERC) is located in Abrolhos Bank, at the extreme north in southern Bahia (northeastern Brazil) (Figure 1). The Abrolhos region encompasses the largest reef formations in Brazil and represents the main marine biodiversity hot spot in the South Atlantic (Cavalcanti et al., 2013). Oligotrophic Brazilian Current waters predominate in this region, where the width of the continental shelf reaches 200 m (Olavo et al., 2005). The coral reefs are very diverse in shape and size, and include shoals, fringing reefs, reef banks, and unique formations, such as “holes” and *chapeirões* (isolated coral columns that grow on the bottom of the mushroom-shaped ocean) (Cavalcanti et al., 2013). In addition, the MERC region includes unconsolidated substrates, mangroves, algae and marine grasses (Moura et al., 2009).

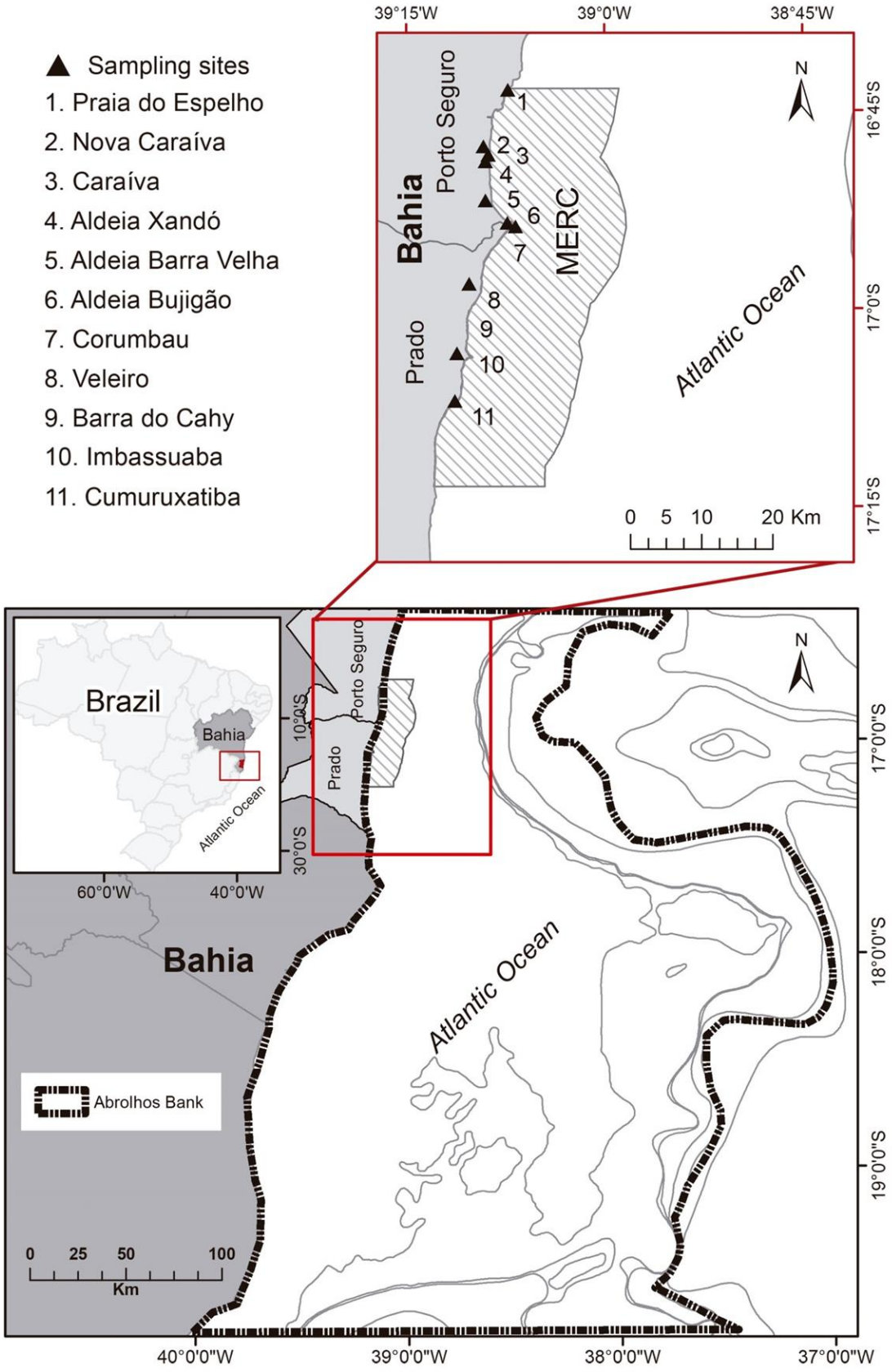

Fig. 1. Map of the Marine Extractive Reserve of Corumbau (MERC) and sampled fishing communities.

Created in 2000, the MERC is a protected marine zone occupying 900 km^2 and extending along 62 km of coastline between the northern Prado Municipality and the southern Porto Seguro Municipality (Previero et al., 2013). The reserve was established in response to the demands of local fishers, who felt discriminated by what they called the *invasão dos barcos de fora* [invasion of the boats from the outside] (Moura et al., 2009). According to the Instituto Chico Mendes de Conservação da Biodiversidade, 650 families are MERC beneficiaries (ICMBIO, 2019), the majority of which are indigenous peoples of the Pataxó Ethnicity and their descendants. Those that use the MERC perform shellfish and artisanal fishing in the rivers, estuaries and sea of the region. Marine fishing is carried out mainly in reef environments and in areas presenting unconsolidated substrates using hook-and-lines, gillnets, hooks of different sizes and harpoon diving, as well as trawls used by shrimp fisheries (Moura et al., 2009).

2.2 Data sampling

Semi-structured interviews (Huntington, 2000) were applied to 222 MERC beneficiaries, comprising 213 male and nine female fishers. The interviews comprised a form (Supplemental Material A) with questions that addressed basic information about the fishers, as well as their perceptions and ecological knowledge on *L. synagris* fishing. The interviews were conducted over the course of 90 non-consecutive fieldwork days between April 2017 and February 2018. The fishers were interviewed individually to prevent the presence of other people from influencing their responses. Audio recordings of the interviews were made using a digital voice recorded, totaling about 167 hours of recording. The interviews took place at 11 communities of the two municipalities that constitute the MERC. The age of the interviewees ranged from 18 to 88 years old.

The interviewees were selected by stratified probabilistic sampling (Albuquerque et al., 2014), since the criteria for participant inclusion were to be over 18 years of age and to carry out on-board fishing within the MERC. The recommendations from Bernard (1988) for anthropological studies within a confidence interval of 95% were followed in order for the sample size to be considered representative.

The sampling design was structured as follows: (i) the first author visited the main local leaders, who indicated the names of all the people in the community who fit the established participant profile; and (ii) in possession of this list of names, the researcher visited the community fishing spots and the houses of possible participants. The data

sampling was facilitated due to a pre-existing relationship with the community (see Glesne, 1989). Between 5% and 35% of the population of fishers of each community were interviewed, as recommended by Bunce et al. (2000) for studies regarding reef fishers.

2.3 Data analysis

The fisher information analysis followed a step-by-step procedure based on *a priori* questions concerning the shifting baseline phenomenon. Firstly, pirate plots were built by using the 'yarrr' library concerning fisher age throughout the assessed communities. The normality of the data distribution used in each following step was assessed by the Shapiro-Wilk test. The relationship between fisher age and their years of fishing experience was then analyzed through a generalized linear regression (GLM) assuming a Poisson distribution (see O'Hara and Kotze, 2010).

Two questions concerning shifting baselines were analyzed considering four age categories regarding different fisher generations: young (18-30 years, n = 49), middle-aged (31-45 years, n = 75), higher-aged (46-60, n = 64) and old (≥61, n = 34). These questions addressed the relationship between the best day catch by handlines (i.e. largest weight of lane snapper specimens ever captured in a single day) and the years since the best day catch within fisher age categories. Each response variable was separately analyzed concerning fisher age (factor) by a one-way Welch's ANOVA with subsequent *a posteriori* pairwise test when applicable ('onewaytests' library). The Welch test is less sensitive to heteroscedasticity and non-normality, and is also more robust for unbalanced data (see Dag et al., 2018). The third question regarding shifting baselines addressed fisher perceptions concerning the possible diachronic variation in *L. synagris* abundance over their fishing years. These perceptions were analyzed based on the answers to the questions: (i) "Has the amount of fish caught over time changed?"; and (ii) "If yes, did it increase or decrease?". The answers were allocated into three different categories: increasing (score +1), decreasing (score -1), or stable (score 0) (see Lozano-Montes et al., 2008). Welch's ANOVA was applied to analyze fisher age variation in response to the abundance score category (+1, -1, or 0). Dunn's *a posteriori* pairwise test ('FSA' library) was performed to analyze significant relationships.

Regarding fisher attitude concerning the conservation priority for *L. synagris*, answers about the need for this species protection were scored as 1 (yes for protection) or

0 (no for protection). The non-parametric Mann-Whitney U test was used to compare the age of fishers that answered yes and the age of fishers that answered no (or do not know). Pirate plots were built ('yarrr' library) to evidence each previously addressed relationship. All analyses were performed with significance level of 0.05 by using the R statistical software (R Core Team, 2018).

Searching for a general community approach, a non-metric multidimensional scaling (nMDS) ordination, based on Bray-Curtis similarity matrices, was performed to investigate potential differences in similarities among MERC fishers considering age categories (young, middle, higher, and old). This analysis was based on all analyzed fisher attributes: (i) age; (ii) years of fishing experience; (iii) maximum weight ever caught (best day catch); (iv) years since the maximum weight ever caught; (v) perception on fish abundance changes over time; and (vi) perception on the species conservation priority. Additionally, a one-way Analysis of Similarity (ANOSIM), with 9999 permutations, was performed to test the significance of dissimilarities among fisher age categories. These multivariate analyses were performed using the statistical software PRIMER 6 (Clarke and Gorley, 2006).

2.4 Compliance with legal procedures

The present research was approved by the Committee for Research Ethics (CEP - *Comitê de Ética em Pesquisas*), from the Universidade Federal Rural de Pernambuco, concerning the research involvement of human beings (code: CAAE 65458016.0.0000.5207). Additionally, the research project was registered (authentication code number 33794187) at the System for the Authorization of Information on Biodiversity (SISBIO - *Sistema de Autorização e Informação em Biodiversidade*), as requested by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA - *Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis*). The project was also registered (registration number AB5B87A) at the National System for Management of Genetic Heritage and Associated Traditional Knowledge (SISGEN - *Sistema Nacional de Gestão do Patrimônio Genético e do Conhecimento Tradicional Associado*), as required by the federal law nº 13.123, May 20, 2015. The National Indian Foundation (FUNAI - *Fundação Nacional do Índio*) authorized the admission of the principal researcher into the indigenous area (*Terra Indígena Barra Velha do Povo Pataxó*), under code 111/AAEP/PRES/2017.

3. RESULTS

3.1 General Overview

The 222 MERC interviewees were distributed throughout the communities as following: (i) Praia do Espelho, four male fishers; (ii) Nova Caraíva, 17 male fishers; (iii) Caraíva, 34 fishers (33 male, 1 female); (iv) Aldeia Xandó, 18 fishers (17 male, 1 female); (v) Aldeia Barra Velha, 24 male fishers; (vi) Aldeia Bujigão, 24 fishers (21 male, 3 female); (vii) Corumbau, 38 fishers (37 male, 2 female); (viii) Veleiro, 12 fishers (10 male, 1 female); (ix) Barra do Cahy, two male fishers; (x) Imbassuaba, eight male fishers; and (xi) Cumuruxatiba, 40 fishers (39 male, 1 female). Fisher age was slightly different among the assessed communities (Fig. 2), while years of fishing experience were significantly ($p < 0.001$) related to fishers age in the whole MERC, as evidenced by the applied GLM (Fig. 3).

The fishers revealed that *L. synagris* is the most intensively caught fish species at the MERC. They also stated that commercial fishing of this species is essentially carried out with handlines. However, testimonials indicated that up to ten years ago large-scale fishing using gillnets set in coral reefs areas were also routinely seen in the region. According to fishers, this fishing gear "damaged" the species in a way that gillnets have been banned at MERC since 2003. In addition to being highly appreciated by fishers and their families, *L. synagris* is also marketed under the status of a 'high quality fish' with the price of a kilogram ranging from R$15.00 (U$4.00) to R$30.00 (U$8.00). This price range depends on the community, the time of year, and the length of the animal, where larger individuals are more expensive. The main names regionally attributed to *L. synagris* are *ariocó* and *vermelho* (red), but they are also referred to as *griacó* or *griocó*.

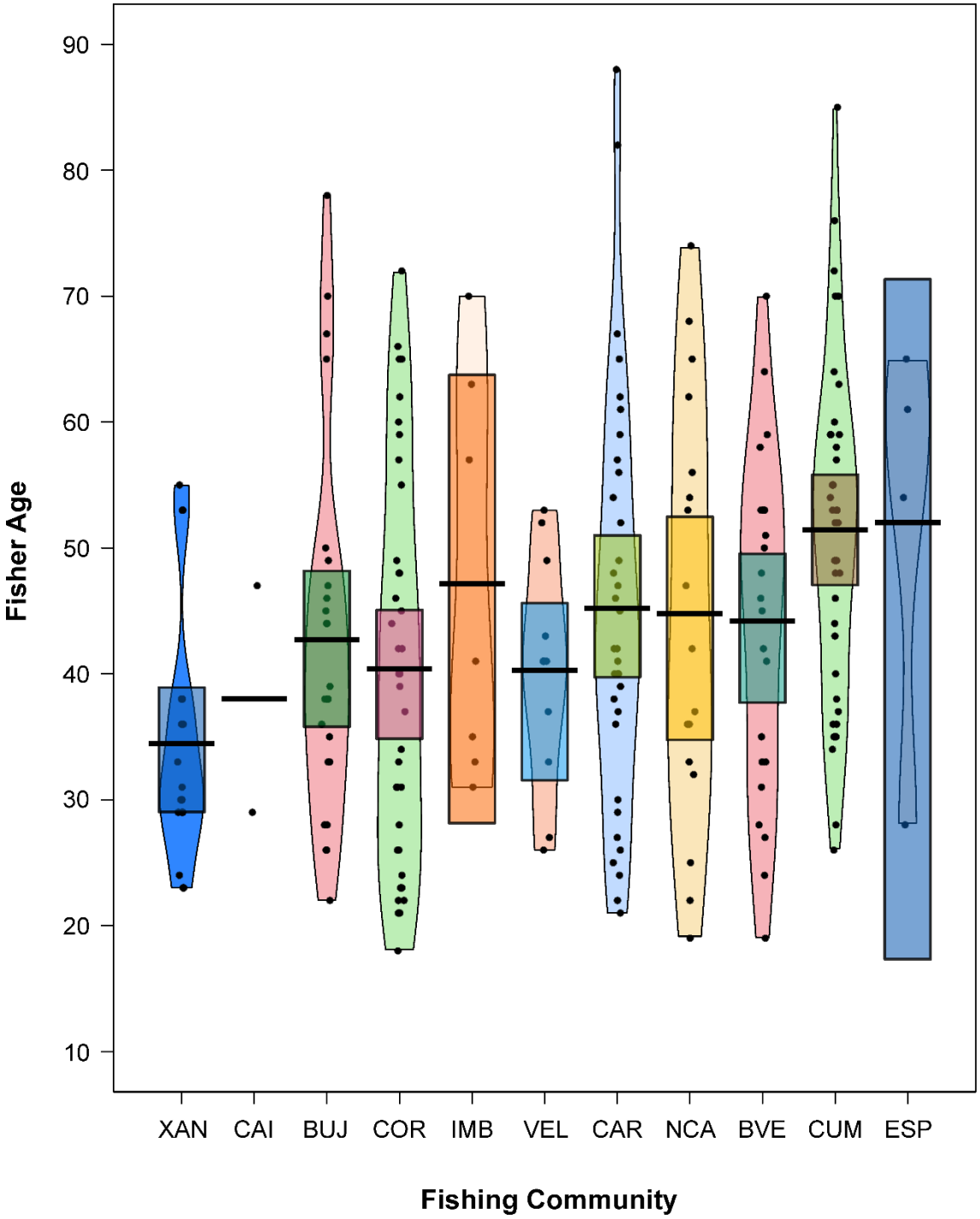

Figure 2. Pirate plots concerning fisher age within the MERC fishing communities. Plots comprise raw data points, descriptive statistics (horizontal line at the means), and inferential statistics (95% Bayesian Highest Density Intervals, and smoothed densities). XAN = Aldeia Xandó; CAI = Barra do Cahy; BUJ = Aldeia Bujigão; COR = Corumbau; IMB = Imbassuaba; VEL = Veleiro; CAR = Caraíva; NCA = Nova Caraíva; BVE = Aldeia Barra Velha; CUM = Cumuruxatiba; ESP = Praia do Espelho.

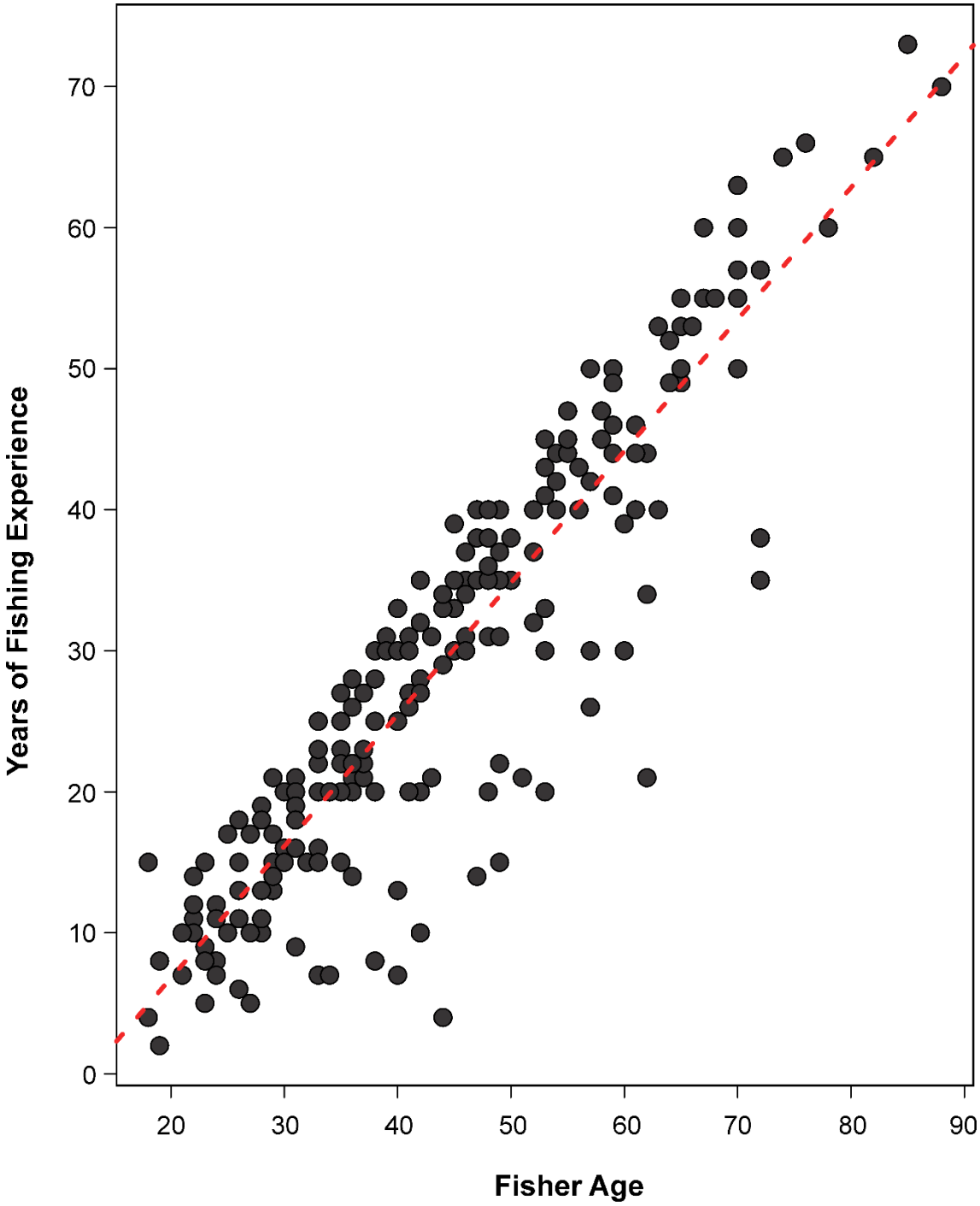

Figure 3. Years of fishing experience plotted against fisher age (red dotted GLM line, $p < 0.001$).

3.2. Shifting baseline evidence

The relationship between the maximum *L. synagris* weight caught on the best fishing day among fishers of different age categories was not significant ($p = 0.306$) (Fig. 4a). The biomass (kg) reported by the fishers as their best catch ranged from 4 to 350 kg of lane snapper. Regarding the time elapsed since the capture of the largest *L. synagris*

volume, fishers reported a timeline from less than one year to 50 years. Significant differences ($p < 0.001$) were observed among each fisher age category considering the number of years since their best day catch. Older fishers reported a higher time span since their best day catch (Fig. 4b).

Most of the interviewees (52.3%) expressed that the amount of captured *L. synagris* has decreased over the years, whereas 28.8% indicated that the yield remained stable and only 9.9% reported increases of fish amount caught over time (Fig. 5). Also, 9% of the participants were unclear or unable to answer this question. For six fishermen, *L. synagris* abundance has increased due to the MERC influence. Below are several testimonials concerning the abundance of this species over time:

> *The lane snapper catches have decreased. In fact, all fish catches have decreased! (E., 88 years old)*

> *I've fished 50 kilos of lane snapper here. You don't fish that anymore today. (V., 65 years old)*

> *In the past, there were a lot of lane snappers. Today, there aren't as many, as the area wasn't as explored as it is today. (A., 67 years old)*

> *I've fished 30 kilo lane snappers. But today nobody fishes 30 kilos anymore, no. Only after the MERC was established that lane snappers became reestablished. (J., 42 years old)*

> *Recently, lane snapper fishing has improved, as the MERC was established and outside boats were forbidden to enter. (D., 33 years old)*

> *I believe that it's the most abundant species in the region, because, since I started fishing, I've seen the amount of lane snappers here, from north to south of here, where you drop the line, you get them. (G., 31 years old)*

Welch's ANOVA evidenced significant differences ($p = 0.013$) between fisher age and their perceptions on *L. synagris* abundance variations over time. Dunn's pairwise test indicated the following results: (i) a significant difference between fishers that stated a decreasing and stable abundance status ($p = 0.001$); (ii) a significant difference between decreasing and increasing statements ($p = 0.017$) and (iii) a non-significant difference between fishers stating stable and increasing abundance ($p = 0.865$). Older fishers frequently identified declines, whilst younger fishers mostly reported that *L. synagris* abundances were stable or increased over time. The observed trend indicates the presence of the shifting baseline phenomenon concerning *L. synagris* fishery at the MERC.

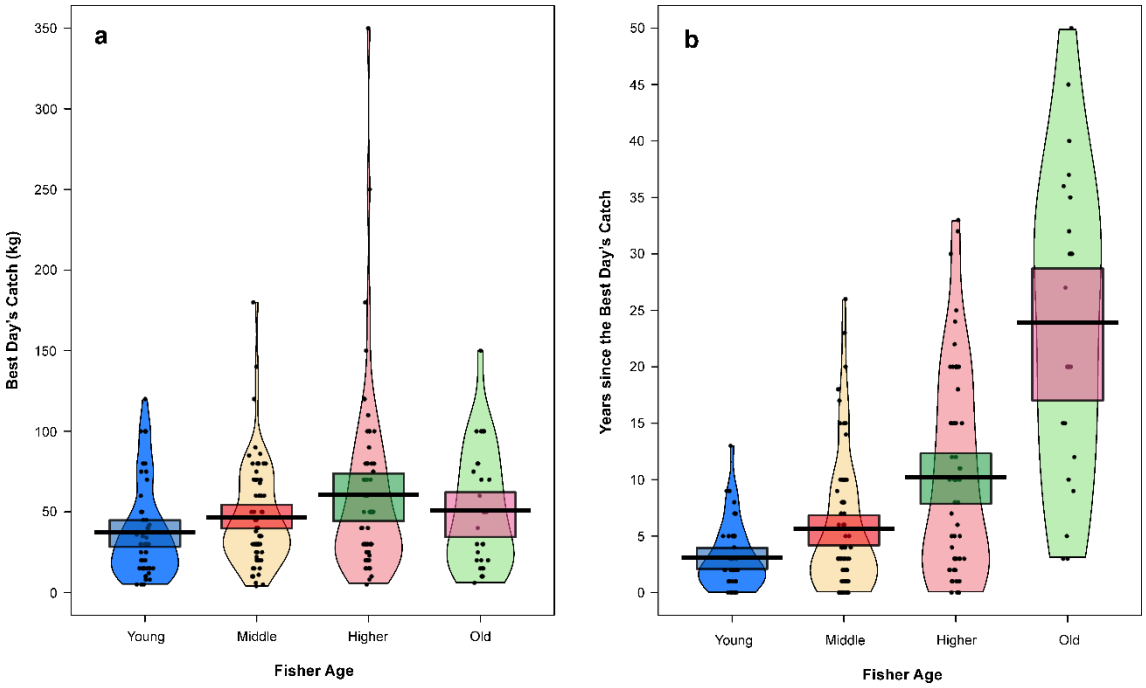

Figure 4. Pirate plots concerning (a) best day catch (kg of lane snapper) and (b) years since the best day catch reported by each fisher age category at the MERC. Plots comprise raw data points, descriptive statistics (horizontal line at the means), and inferential statistics (95% Bayesian Highest Density Intervals, and smoothed densities).

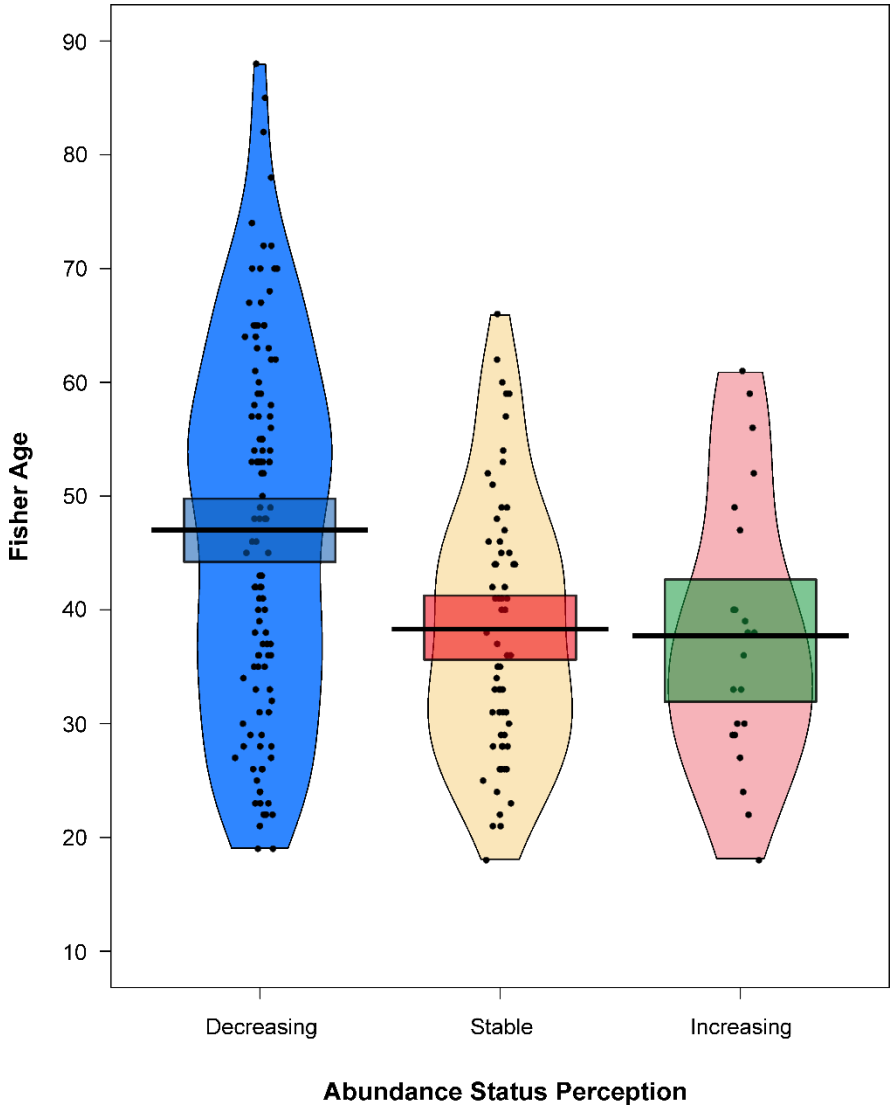

Figure 5. Pirate plots regarding fisher perception about *L. synagris* abundance status considering fisher age at MERC. Plots comprise raw data points, descriptive statistics (horizontal line at the means), and inferential statistics (95% Bayesian Highest Density Intervals, and smoothed densities).

3.3. Fisher judgment concerning the species conservation

When questioned about the need for *L. synagris* protection, 22.5% of the fishers admitted the need to adopt strategies for local conservation of the species, while 54% reported that local species protection is not needed and 23.5% of them chose to not answer the question. A significant difference ($p = 0.003$) was observed regarding fisher perception on the *L. synagris* conservation priority considering fisher age. Older fishers

mostly reported that the species dies not need protection, while younger fishers more frequently stated the need for *L. synagris* protection (Fig. 6).

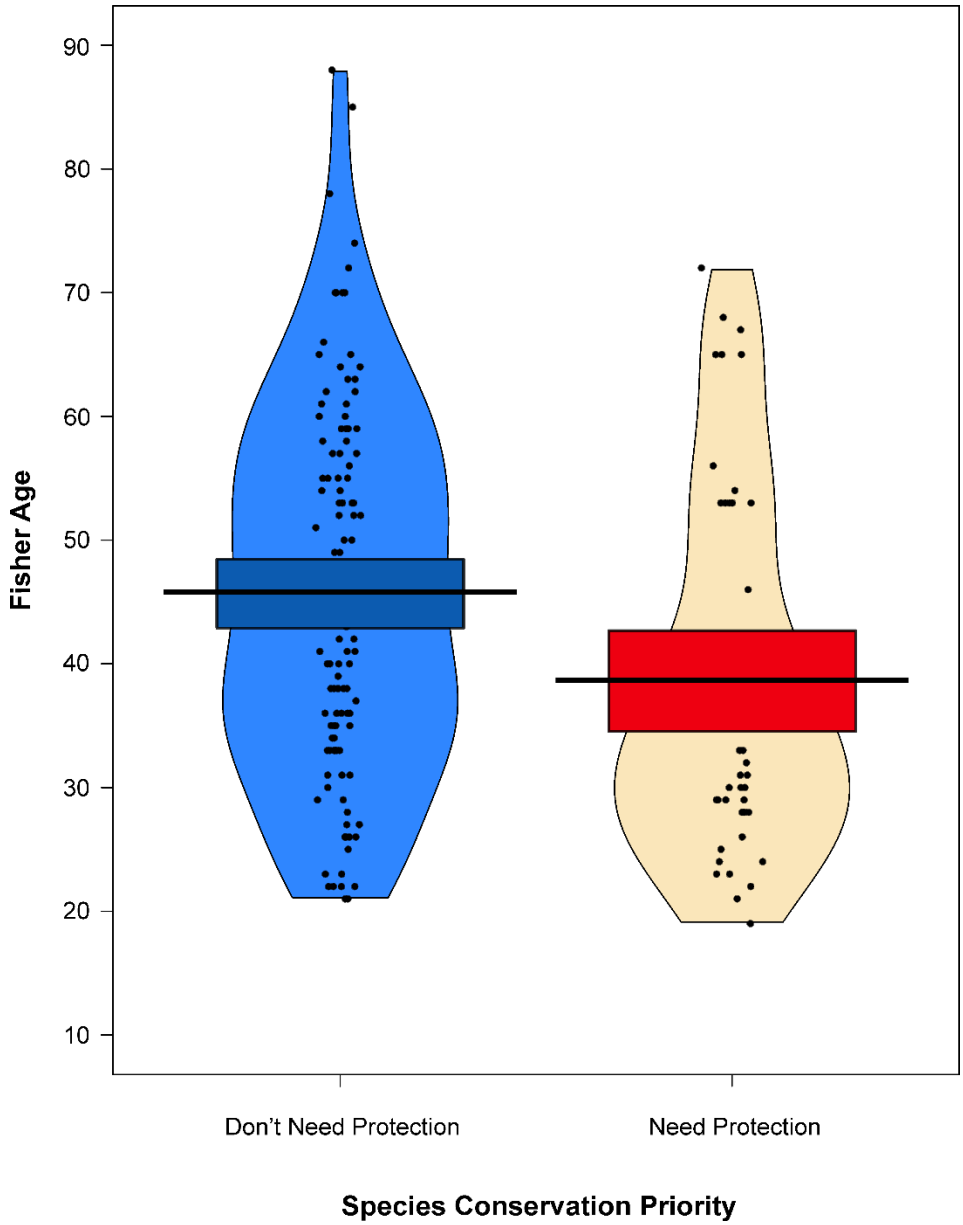

Figure 6. Pirate plots regarding fisher perception on *L. synagris* conservation priority considering fisher age at the MERC. Plots comprise raw data points, descriptive statistics (horizontal line at the means), and inferential statistics (95% Bayesian Highest Density Intervals, and smoothed densities).

Considering all fisher attributes analyzed regarding shifting baselines and fisher judgment, the nMDS ordination showed a clear separation among fisher age categories (Fig. 7). The ANOSIM evidenced a significant global difference among age categories ($p = 0.0001$; $R = 0.485$), supported by significant differences in the pairwise tests for each

age category (Table 1). This result reinforces the differences observed in the previously reported analyses.

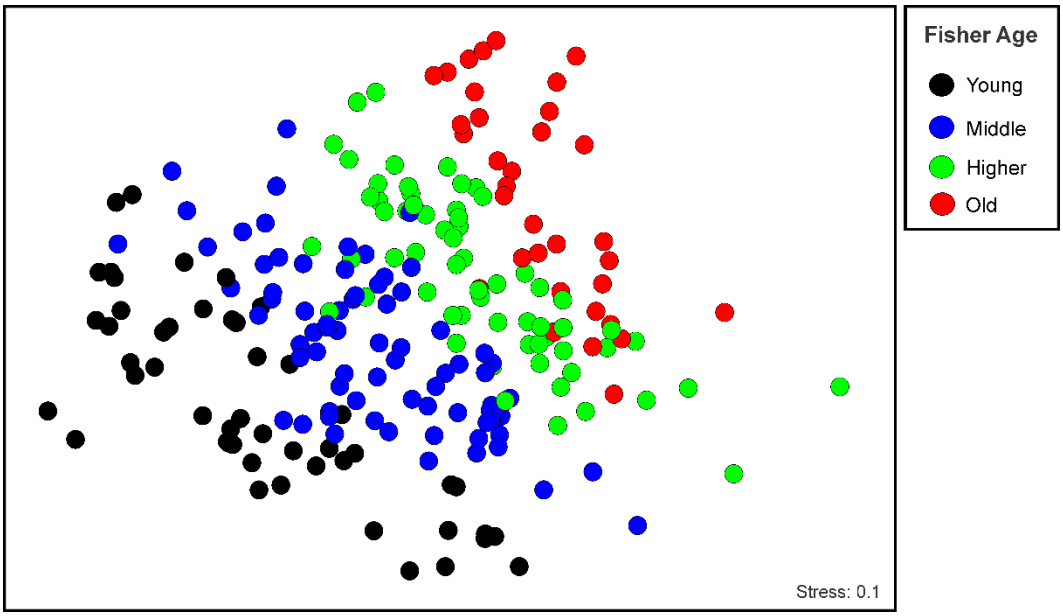

Figure 7. Multivariate ordination (nMDS) for MERC fisher attributes (northeastern Brazil) considering age category: young (black circle), middle (blue circle), higher (green circle), and old (red circle).

Table 1. One-way ANOSIM results for MERC fisher attributes (northeastern Brazil) considering age category.

Global Test

Sample statistic (Global R): 0.485

Significance level of sample statistic: 0.0001

Pairwise Test

Groups	**R Statistic**	**Significance Level**
Higher, Middle	0.313	0.0001
Higher, Young	0.710	0.0001
Higher, Old	0.267	0.0001
Middle, Young	0.363	0.0001
Middle, Old	0.685	0.0001
Young, Old	0.872	0.0001

Some respondents were reluctant to admit the need for protection, as observed in the following statements:

> *I really don't like talking about protecting lane snappers, because when they* (the government) *come they want to ban everything.* (A., 53 years old)
>
> *If they ban everything, there will come a time when we won't even be able to fish. You won't even be able to put your foot in the water.* (J., 52 years old)
>
> *Fishing as it is today, if it's forbidden fishers will starve! Because if you create a rule, no one will be able to fish anymore. "* (E., 55 years old)
>
> *I think if lane snappers are protected, the fishers will complain. It is one of the most fished fish. Now you've left me in a complicated situation.* (of being asked this question) (M., 31 years old)

However, when the researcher explained that the protection would not necessarily mean capture prohibition, the interviewee admitted the need to protect the species. Most fishers that answered positively concerning lane snapper protection affirmed that a closed fishing season and a minimum fishing weight could be effective. The frequencies of positive responses for *L. synagris* protection are in Table 2.

Table 2. Main strategies identified by fishers (n=48) for protecting *L. synagris* at the MERC.

How should *L. synagris* be protected?	**Absolute Frequency**
"Create a closed season for the species."	20
"Implement a minimum catch weight."	16
"Close fishing in lane snapper areas."	5
"Set a fishing limit for lane snapper."	3
"The fishers must truly respect the closed MERC area."	2
"Supervise the closed areas so that no one fishes in them."	1

4. DISCUSSION

4.1 Indications of shifting baseline for *L. synagris*

No significant relationship between the maximum total weight captured on the best *L. synagris* fishing day and fisher age was observed. However, when compared to younger fishers, older fishers reported a significantly longer time elapsed since their best *L. synagris* capture day throughout their career. Older fishers also pointed more frequently to abundance declines over time. These facts indicate the occurrence of a shifting baseline in the local *L. synagris* fishery. Other studies addressing FEK in the same region have noted shifting baselines for other marine species. For example, Bender et al. (2013) found evidence of a shifting baseline among artisanal fishermen in Porto Seguro concerning reef fish species (including three lutjanid species) and argued that they deserve special attention due to high and regionally directed fishing efforts. Giglio et al. (2015) found a depletion in the abundance of marine megafauna fish species in the Abrolhos region and evidence of a shifting baseline in their fishing. Giglio and Bornatowski (2016) for this same region, found evidence of this phenomenon in the fishing activities of the golden hammerhead shark (*Sphyrna tudes* Valenciennes, 1822) when applying a FEK approach.

Thus, for the studied region, which is poor in scientific data, the FEK accessed in fisher interviews was shown to be effective for reconstructing historical ecological bases concerning exploited fish species. For this portion of the Brazilian coast, formal and even informal records applied to studies on the ecological history of certain regions are virtually non-existent. Thus, more than a scientific alternative, FEK may represent the only way to access information related to exploited marine resources.

Although several studies focusing on FEK have documented the shifting baseline phenomenon, the understanding of this cognitive condition remains incomplete (Soga and Gaston, 2018). In relation to local *L. synagris* fishing, it seems that the transmission of knowledge from older to younger fishers on the historical abundance of the species has been insufficient at the MERC, leading to limited incorporation of this information into FEK. This fact may have caused the shifting baseline regarding the current ecological situation of the species. A similar situation has been reported among Turkish fishermen in the Datça region, where older fishers have declared that they no longer communicate

with younger fishers about depleted and extinct fish species, leading to a redefinition of local fishery baselines (Ulman and Pauly, 2016).

Because shifting baselines are currently one of the key challenges for ecological restoration (Gerrero-Gatica et al., 2019), Scientists have devoted efforts to prevent and reverse this scenario. Soga and Gaston (2018) proposed a conceptual framework for understanding the causes and implications of this phenomenon, and developed four strategies to combat shifting baselines, as follows: 1 - restore the natural environment; 2 - monitor and collect scientific data; 3 - reduce the extinction of experiences in natural environments and 4 - educate the public (Soga and Gaston, 2018). Jardine (2019) argues that indigenous knowledge can contribute to implementing these four strategic recommendations and, thus, contribute to combat shifting baselines. However, no case studies addressing the possibilities of applying these strategies through FEK are available to date, indicating the opportunity to carry out pioneering work in this regard at the MERC.

4.2 Fisher judgment on local *L. synagris* management

Apparently, when first questioned, some fishers understood the term "protection" for *L. synagris* as a total catch ban. Therefore, certain negative responses can be interpreted as an adjustment of the fisher to the *top-down* prohibitionist interventions imposed by the Brazilian government (Moura et al., 2009). An example of a recent *top-down* fishing management strategy by the Brazilian government is federal government Ordinance 445 (Brasil, 2014), which placed a fishing moratorium on 409 fish species threatened with extinction. Participant knowledge of Ordinance 445 may have contributed to the fact that only a minority of the respondents admitted to the need for protecting *L. synagris*. Previero and Gasalla (2018) previously documented strong dissatisfaction demonstrations by southern Bahia fishers concerning Ordinance 445 and, consequently, a weakening of the trust between fishers, researchers and fishery managers. Given this context, it is highly recommended that researchers establish a trust relationship and closer ties with fishers, through lectures in the communities to present research results and discuss the study methods, for example. In the studied context, for example, interventions of this nature could contribute to the success of the "Monitor and Collect data" and "Educate the public" strategies proposed by Soga and Gaston (2018) to reverse shifting baselines.

On the other hand, fisher's contrary position on possible management and *L. synagris* interventions may be linked to the fact that they already live in an MPA with rules for the use of fishery resources. For example, due to the MERC implementation, the almost complete elimination of local fishing by fishers from other regions with more impactful equipment was noted, which was the main demand for the MERC establishment in the first place (Moura et al., 2009). In addition, Moura et al. (2010) described the MERC as an example of how protected marine areas can be effective in socio-biodiversity conservation, as, according to these authors, in addition to being able to stop larger-scale fishing, the MERC has politically mobilized communities and has favored the establishment of specific locally-based conservation actions. This scenario is conducive to the continuity of local fishing activity for the next generations. In turn, this allows for reducing the extinction of these fisher's fishing experience, which represents the third strategic recommendation proposed by Soga and Gaston (2018) to prevent shifting baselines.

Interestingly, although younger fishers perceived local *L. synagris* abundance depletions less often, they were more likely to recognize the need for local management actions for the species. This goes against the argument that the lack of knowledge on environmental change makes people less likely to adopt conservationist stances (Papworth et al., 2009; Soga and Gaston, 2018). This attitude by younger people may have been influenced by the fact that they grew up with the reference of local environmental impacts due to the presence of foreign fishermen and experienced the MERC establishment as a result of these impacts. On the other hand, the resistance of older people to recognize the need for protection for the species may represent an adjustment to the various negative fishing management experiences imposed by the government.

The main strategies identified by the interviewees for the protection of *L. synagris* are related to actions already implemented by the Brazilian government for the management of other fisheries resources. For example, the closed fishing period mentioned by fishers represents a temporary ban on catches of species threatened with extinction during their reproduction months. However, the fact that only 20 fishers were in favor of the establishment of this strategy evidences that this management option should be broadly discussed regionally. Fishers also highlighted the feasibility of establishing a minimum weight or length limit for *L. synagris*. By analyzing data on *L. synagris* reproduction in the region, Freitas et al. (2014) generated information that could

support the adoption of this strategy. Discussions for the establishment of this strategy in a local fishing context should be encouraged since several fishers supported the idea of returning smaller individuals, as well as pointing out that they already tend to release them.

Some fishers pointed out the need to ban fishing in some *L. synagris* establishment areas, and were in favor of the creation of No-Take Zones within the MERC specifically aimed for *L. synagris* protection. Burton et al. (2005) observed evidence of an increase in the size of the spawning aggregation of *L. analis* two years after the creation of the Tortugas South Ecological Reserve, in the United States. In another study in the same area, Domeier (2004) demonstrated the potential of this strategy as a recruitment source of the species larvae. This protected area inside the Dry Tortugas National Park was designed specifically to protect *L. analis* populations. A study carried out in and around a No-Take Zone within the MERC documented the spillover effect (see Januchowski-Hartley et al., 2013) for several reef fish species, indicating that the establishment of this area contributes to increased local fish biomass (Francini-Filho and Moura, 2008). However, the identification of potential MERC areas where the species aggregates seasonally is essential for the creation of specific No-Take Zones for *L. synagris* protection at the MERC. In this sense and given that *L. synagris* catches in the region seem to mostly occur during reproductive aggregations (Freitas et al., 2014), FEK can contribute to the identification of priority areas for *L. synagris* conservation.

4.3 Study implications

The verification of *L. synagris* abundance depletion and evidence of a local fishery shifting baseline phenomenon by the FEK approach indicates concerns regarding the ecological situation of this and other exploited fish stocks at the MERC. Nevertheless, it is possible to construct an initial parameter to support conservation goals of the studied species through this knowledge. This reinforces FEK relevance or the reconstruction of historical bases in the fishing of relevant species, especially in contexts displaying lacking scientific data to support management decisions, such as the context assessed herein.

For the analyzed fisheries context, several MERC-related initiatives contribute to the application of Soga and Gaston's (2018) key strategies to prevent and reverse the shifting baseline phenomenon. Mostly, the fact that the fishers are located within a Sustainable Use MPA (Marine Protected Area) enables a field conducive to combating

this phenomenon, as well as environmental restoration as a whole. This fact represents a flag in favor of this Protected Area modality.

In order to explain the temporal decrease in the local *L. synagris* fishery to the fishers, an outreach campaign to raise awareness among the MERC fishing communities will be conducted in early 2020. Such an approach will consider the loss of contact between older and younger fishers, also noted by Ulman and Pauly (2016). Thus, it is suggested that formal meetings for FEK sharing between active and retired fishers, which are recognized as holders of knowledge related to local ecological history, should be promoted by MERC managers as a means of reversing the shifting baseline situation. Interventions of this nature are in line with the fourth key strategy ("Educate the public") developed by Soga and Gaston (2018) to overcome threats associated with the shifting baseline phenomenon.

A participatory monitoring system for MERC fishing landings is under development, which represents one of the pillars of the management plan for this conservation unit. This initiative in itself is also in line with Soga and Gaston's (2018) proposal number 2 ("Monitor and collect data") to prevent and combat the effects of the shifting baseline phenomenon. In the long term, this initiative will contribute to the establishment of targets for the conservation of exploited marine organisms. The information provided in the present study by the fishers, especially older fishers, could serve as an initial parameter for the development of these goals for *L. synagris* conservation. In fact, the use of FEK in the reconstruction of historical fishery baselines could subside proposals for the restoration of fish stocks in keeping with their current reality. In addition, "Restore the natural environment" represents Soga and Gaston (2018) Strategic Recommendation number 1 to prevent and reverse shifting baselines. Therefore, in the specific case of local *L. synagris* fishery, possible local management actions should aim for at least occasional landings of the species that achieve daily individual incomes close to those reported by the category of "higher-aged" fishers.

There is concern that most participants reported that species-specific protection was not needed at the local level, some possibly in an attempt to defend themselves against the prohibitionist strategies applied by the government. Given this impasse between fishers and those responsible for fisheries management, as well as with the government and academia, initiatives are urgently needed to build a respect and trust relationship between the parties. In contrast, there was a tendency for younger fishers to support the idea of locally managing *L. synagris* fishing. Fishers who believe that local

species management strategies are necessary also shared relevant information on possible tactics for the protection of this resource. In this sense, it is recommended that studies be conducted in order to investigate possible reproductive aggregation areas of this species within the MERC.

5. Final considerations

The three shifting baseline phenomenon indicators analyzed in the present study seem to be sufficient to record its occurrence in the assessed marine protected area. Although the relationship between the maximum weight caught on the best fishing day for *L. synagris* among fishers of different ages was not significant, the other two indicators presented significant relationships, highlighting evident differences among fisher age categories. The shifting baseline is noticeable due to the higher time span of older fishers since their best day catch and their more frequent perception concerning *L. synagris* abundance declines over time. A clear shift of the environmental reference in *L. synagris* fishery at the MERC is, thus, noted. Given this scenario, the catch yields reached by older fishers (higher and old category) on their best fishing days could provide an initial baseline for the development of *L. synagris* conservation goals.

Some fishers expressed consistent knowledge about fishing management strategies, mainly due to their experience with institutional strategies concerning fisheries planning and management relative to the MERC. The consolidation of these new knowledge systems of these fishers can be understood as another side of the ability of traditional fisher populations to adjust to new cultural and political realities either presented or, not infrequently, imposed to their communities. However, most participants reported that no species-specific protection at the local level is required. Possibly the strictly prohibitive fishery management strategies adopted by the Brazilian public authority have contributed to this, as a way of fishers trying to protect themselves from possible future bans.

Facing this friction between fishers and those responsible for fisheries management, such as the public authority and academia, the implementation of initiatives to build a respect and trust relationship between the parties is urgent. In this sense, such actions by fishery researchers and managers should be based on empathy and be sensitive to the many difficulties faced by fishers. Finally, the high relevance of *L. synagris* for MERC subsistence and economy allows for possible management interventions for the

species. This should be based on respect regarding the reality of local fisheries and should, especially, consider extractivist expectations.

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Submission declaration

The authors declare that the work has not been published previously, that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder.

Declaration of Interest

The authors declare that there are no conflicts of interest or any kind of interest that could influence the outcome of this work.

Contributions

MLVBF collaborated in the study design, data analysis and writing of the text. GBGS collaborated with the data analysis, writing and revising the manuscript. SFL collaborated in interpretations and analyses of the data, and writing the manuscript. SS collaborated in writing and revising the manuscript. RAHD collaborated in writing and revising the manuscript. JSM collaborated in the design, writing and revision of the manuscript. All of the authors approved the final manuscript.

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Supplementary Material A - Form applied to the fishers during data sampling in MERC.

Form

Federal Rural University of Pernambuco

Postgraduate Program in Ethnobiology and Nature Conservation

Leading researcher: Márcio Luiz Vargas Barbosa Filho

PROJECT: *COMANAGEMENT IN SOCIOECOLOGICAL SYSTEMS: FISHER CONTRIBUTIONS TO FISHERY MANAGEMENT IN THE MARINE EXTRAVIST RESERVE OF CORUMBAU, BRAZIL.*

Lane snapper fishing

Fisher name_____ Age_____ Experience_____

What is the most caught fish species here?_____ Why?_____

How do you fish lane snapper in the region?_____

What is the price per kilo?_____ Why this price?_____

What was the maximum weight of lane snapper specimens caught on your best fishing day ever?_____ How long ago?_____

Has the amount (abundance) of the species decreased, increased or is it the same over your fishing years?_____

Should this fish be protected?_____ How?_____

5. CAPÍTULO III – Manuscrito enviado para "Human Ecology"*

*Enviado em 15 de janeiro de 2020. Atualmente o manuscrito encontra-se sob a primeira revisão.

Link com as normas da Human Ecology para os autores:
https://www.springer.com/journal/10745/submission-guidelines

Manuscript

Artisanal fisher knowledge and attitudes concerning compressor fishing in a South American Marine Protected Area

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Abstract

Compressor fishing causes severe human, social, economic and environmental impacts worldwide, although assessments are scarce. Fishers at the sustainable Marine Extractive Reserve of Corumbau (MERC) marine protected area (MPA), Brazil, have repeatedly denounced compressor vessel activities. Semi-structured interviews were performed to assess fishing knowledge at MERC and information on local compressor fisher performance was spontaneously offered. Interviewees do not practice and strongly oppose this activity, complaining it is a reason for local fishing yield declines, also noting fisher decompression sickness and deaths due to this practice. They also indicate frequent outside compressor vessels prior to MERC establishment, and current, although less frequent, incursions in the area. They also indicate that maritime environmental enforcement actions are rare. MPA potentials and limitations in combating illegal fishing and protecting fishers from the industrial fishing model are discussed. This prohibited practice should be vigorously battled in Brazil and in other developing countries.

Keywords: Illegal, Unreported and Unregulated fishing; compressor diving; industrial fishing; Abrolhos; Brazil.

1. Introduction

Illegal, unreported and unregulated fishing (IUU fishing), defined as activities that violate international conservation agreements or regional and local fisheries management instruments, are noteworthy as one of the main threats to the sustainable use and conservation of fishery resources (FAO 2010; Pramod *et al*. 2014). The inability of governments to monitor and supervise fishing practices in their marine territories is the main reason for the recurrence of IUU fishing (Miller *et al*. 2014). Spears fishing with the aid of air compressors is a type of IUU fishing, usually occurring in developing countries, especially in the Americas (Basurto 2006; Mesquita and Isaac-Nahum 2015; Moretz-Sohn *et al*. 2013; Pavlowich and Kapuscinski 2017; Prada *et al*. 2006) and in Asia (Bacalso *et al*. 2013; Barber and Pratt 1997; Radjawali 2012; Ismail *et al*. 2018; Khasanah *et al*. 2019), in which management and environmental oversight systems are often flawed (Hilborn and Ovando 2014).

Studies that specifically address this practice are still lacking. It is likely that the illegal character of compressor fishing in the countries, where it occurs, hinders researcher's access to this information. Compressor divers usually find more fish and obtain higher catch rates when compared to apnea dives (Pavlowich and Kapuscinski 2017). Thus, compressor fishing displays the potential to cause far more impacts to fishery resources, particularly to vulnerable or threatened populations (Ennis and Aiken 2014). In addition to environmental impacts, this type of practice represents a public health problem in several areas worldwide. Financial incentives, lack of basic knowledge concerning compressor diving and the use of inappropriate materials make fishers susceptible to accidents that often occur in compressor fishing (Prada *et al*. 2006; Moretz-Sohn *et al*. 2013; Escobar 2014).

In Brazil, compressor fishing is well described in lobster fishing (Palinuridae and Scyllaridae), especially on the northeastern coast of the country, where these dives are usually directed not only to the capture of high commercial value animals (e. g., Castro e Silva and Rocha 1999) but also in fish and octopus catches. For the northeastern region of Brazil, compressors are used as auxiliaries in harpoon fishing and coupled to vessel engines, where the head of the engine transmits air to the reservoirs generally a gas cylinder (IBAMA 2008). The cylinders comprise two valves that control the air outlet of air hoses for diver breathing (IBAMA 2008).

Compressor fishing is prohibited in the country by a federal law (IBAMA 138/2007) since, in addition to compromising fish stocks, it is also a public health problem due to severe decompression diseases, accidents and fisher deaths (Moretz-Sohn *et al*. 2013). As compressor fishing is prohibited and, therefore, people who practice it are subject to fines, imprisonment and criminal prosecution, accessing information on the subject presents a challenge to researchers. For example, it is unlikely that any compressor fisher will admit to the practice and, therefore contribute as a source of information in a scientific enterprise.

Traditional fishing with lines and hooks in reef environments has been maintained as the main fishing activity in the Abrolhos region for the last four hundred years (Olavo *et al*. 2005). For this region, the lines are employed under various configurations to capture a high diversity of reef fish species (Costa *et al*. 2003). Although the region's fishing is poor in scientific data and poorly monitored (Previero and Gasalla 2018), it has been recognized that the selectivity of traditional fishing gear has contributed to the maintenance of the way of life of northeastern coastal Brazilian populations (Olavo *et al*. 2005).

On the other hand, air compressors coupled to the engines of some vessels have been regionally verified in the last decades. This type of fishery comprises a high diving autonomy and, consequently, the capture of large amounts of fish before returning to the surface (Pavlowich and Kapuscinski 2017). Although no scientific studies in the region focusing on the impacts of compressor fishing are available, some records in the scientific literature reveal complaints from local fishers regarding the environmental impacts caused by this practice. In addition, Escobar (2014) pointed out that, given the current environmental impacts of the local marine environment, divers using compressors must work in increasingly deeper regions to obtain good fish.

A historical conflict between industrial fishers from other regions who use high fishing power vessels and local artisanal fishers is noted in northeastern Brazil (Vasconcellos *et al*. 2011). In the study area, this situation, termed "invasion of outside boats" by the local fishers, was the main motivator for the creation of the Marine Extractive Reserve of Corumbau (MERC) (Moura *et al*. 2009). Currently, MERC has a fisheries management system, compiled in a document released in 2003, which emphasizes the active participation of beneficiaries in all the discussion and construction phases of the Plan (Ibama 2003). Among the discussed management strategies, restrictions concerning resource capture efforts and certain gear are also in place, as well as the establishment of No-Take Zones, in addition to fishing monitoring (Moura *et al*. 2007). Currently, this MPA's Management Plan, an official document that will contain all the guidelines for the shared management of this MPA modality in Brazil (Brazil 2000), is in the final preparation stages.

As a Sustainable Use MPA, only indigenous fishers from the communities contemplated by the MERC have the right to use existing local resources within this area (Brazil 2000). In this context, the main aim of the present study was to describe the

knowledge and attitudes of MERC fishers on the local performance of foreign fishers carrying out illegal compressor fishing.

2. Material and Methods

2.1 Study area

The MERC is located in the extreme south of the state of Bahia, being part of the Abrolhos Bank region. This is the main marine biodiversity hotspot in the South Atlantic, comprising the largest (8844 km^2) reef formations in Brazil (Dutra *et al*. 2005). Several fishing facilities with different characteristics and capacities are found in the region (Previero and Gasalla 2018). The regional fleet consists of vessels between 4 and 20 meters in length, some displaying autonomy for over 30 days at sea and isobaths up to 1,200 meters (Santos 2015). Regional fisheries are poor in scientific data, multispecies and lacking structured and systematic programs concerning fisheries and environmental monitoring (Previero and Gasalla 2018).

Dutra *et al.* (2005) point out Abrolhos Bank contains a representative sample of the endemic ichthyofauna of Brazil and includes around 80% of all endemic southwestern Atlantic reef fish species, although the most targeted fish species in this fishery are large species belonging to the Serranidae (groupers), Lutjanidae (snappers), Scaridae (parrotfishes), Carangidae (jacks), and Haemulidae (grunts) families. The region is covered by a Marine Protected Area (MPA) mosaic, with emphasis on the Abrolhos Marine National Park, Integral Protection Conservation Unit (CU) and the Cassurubá and Corumbau Marine Extractive Reserves (MERC), which are sustainable use MPAs (Moura *et al*. 2009).

The MERC was established in 2000 and occupies 900 km^2, extending for 62 km of the coastline, between the municipalities of Prado and Porto Seguro (Previero *et al*. 2013) and reaching eight nautical miles towards the open sea. Approximately, 650 families are MERC beneficiaries (ICMBIO 2019), a group composed essentially of Pataxó indigenous natives and their descendants. Marine fishing occurs in reef environments and non-consolidated substrates areas, mainly by using lines and hooks, gill nets and apnea diving with harpoons (Moura *et al*. 2009). Regionally, subsistence fishing predominates, with the eventual sale of the surplus. However, some fishers direct their catches specifically for marketing at local inns and restaurants.

2.2 Data sampling and analysis

Semi-structured interviews (Huntington 2000) were conducted with 218 fishers (209 men and nine women) from all MERC communities (Figure 1) between April 2017 and February 2018. A questionnaire was applied, comprising questions about fisher's perceptions, attitudes and knowledge related to fishing activities carried out in the MERC. The interviewees were probabilistically selected by means of a stratified sampling (Albuquerque *et al.* 2014), in which the inclusion criteria comprised being at least 18 years old and fishing within the MERC with the aid of vessels.

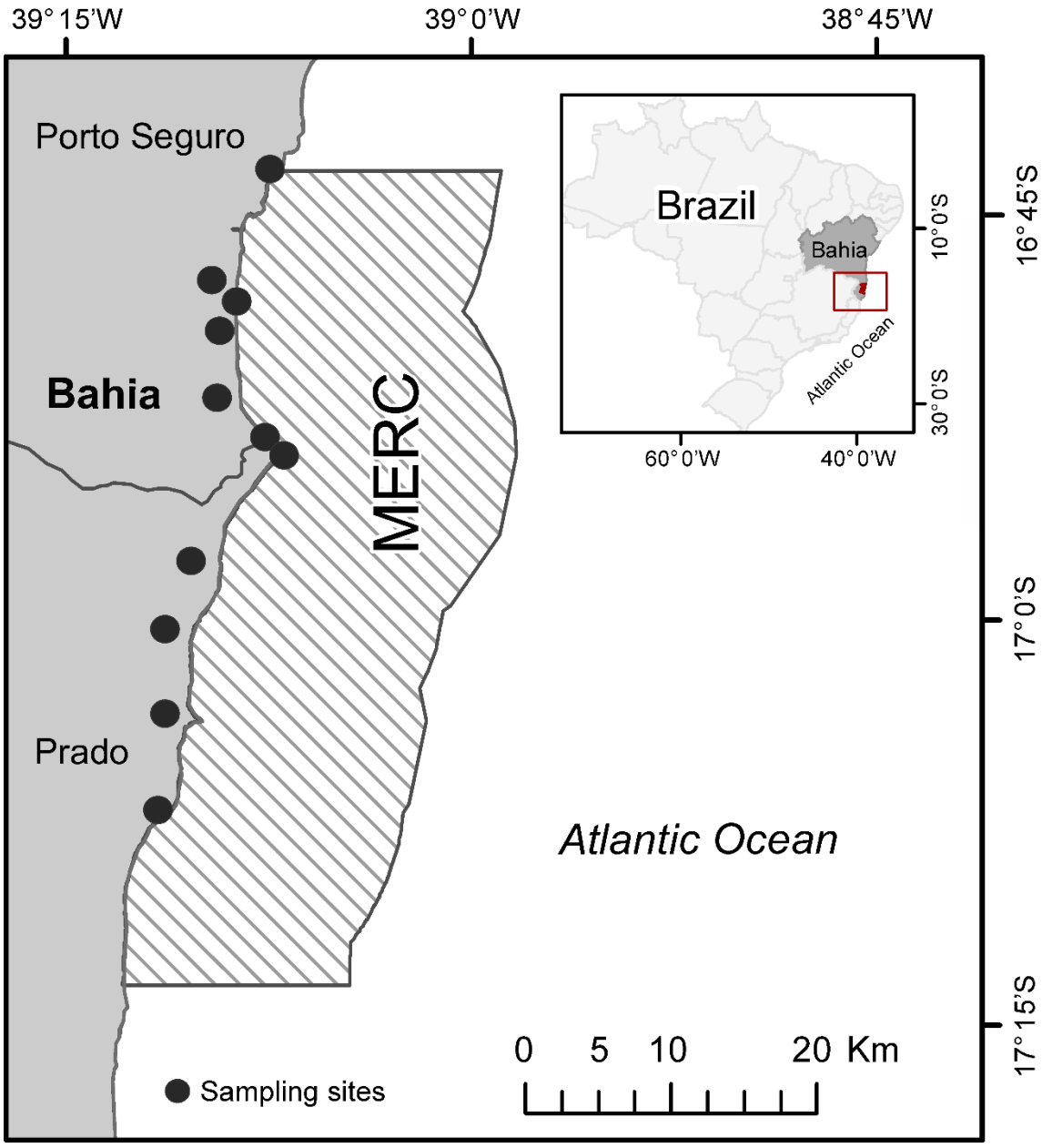

Figure 1 - Map of the MERC municipalities, indicating the sampled communities.

No specific questions on the practice of compressor fishing were asked. However, this emerged as a prominent topic when carrying out the interviews consisting of seven general fishing questions included. When answering these questions (Appendix A), 39 fishers (17.5%) cited compressor fishing practices. Thus, the sample universe of the present study comprised 39 fishers who spoke on the subject of fishing with compressors.

The content analysis proposed by Bardin (2011) was applied to the data analysis, which interprets the interviewees' statements by means of exploitation of the raw data with the transformation and aggregation of speech that results in an interpretation of the content. Subsequently, a framework was created that allowed transcribed and coded statements to be organized, facilitating the categorization of all answers. The content was categorized using the semantic criterion, where statements were grouped based on the perspective of the coherence and sense of the answers. First, each answer of each interviewed individual was given an identification code for both the answer and the question number. For example, the first fisher's answer, referring to the third asked question, received the following codes: F1Q3, where F1 refers to Fisher 1 and Q3 refers to the third question. After codifying all the interview contents, each set was arranged in frames, allowing for simultaneous assessments of the responses. This was performed to better understand the fundamental semantic convergences and/or divergences related to the classification and, therefore, categorization.

Based on this, four categories for the fisher answers were defined: 1) impacts of compressor fishing on local fishery stocks; 2) diseases and deaths involving compressor fishing in the studied region; 3) MERC's success in curbing compressor fishing in the region; and 4) Compressor fisher's insistence on acting within the MERC. All respondent citations regarding compressor fishing were transcribed and are presented in tables. The most recurring facts pointed out by the interviewees concerning compressor fishing were also analyzed using a descriptive statistics approach, focusing on the presentation of absolute and relative frequencies of fisher citations. Fish species identified as being regionally caught by compressor fishing were identified by comparing the common names used by respondents and those recorded in the scientific literature for reef fish

caught by fishing in the study region (Caló *et al*. 2009; Previero *et al*. 2013; Cetra and Petrere 2014; Previero and Gasalla 2018).

3. Results and discussion

3.1 Impacts of compressor fishing on local fishery stocks

Participants reported that MERC beneficiaries do not fish with compressors, only by snorkeling in apnea diving. However, as displayed in Figure 2, they are able to describe the instruments used in this type of practice. All participants demonstrated attitudes which denote opposition to the use of compressor and harpoon fishing, because they recognize the environmental potential and human impacts of these practices. In addition, 22 (56.4%) of the respondents complained that compressor fishing is one of the main reasons for the decline in local fishing yields over the years (Supplementary File 1).

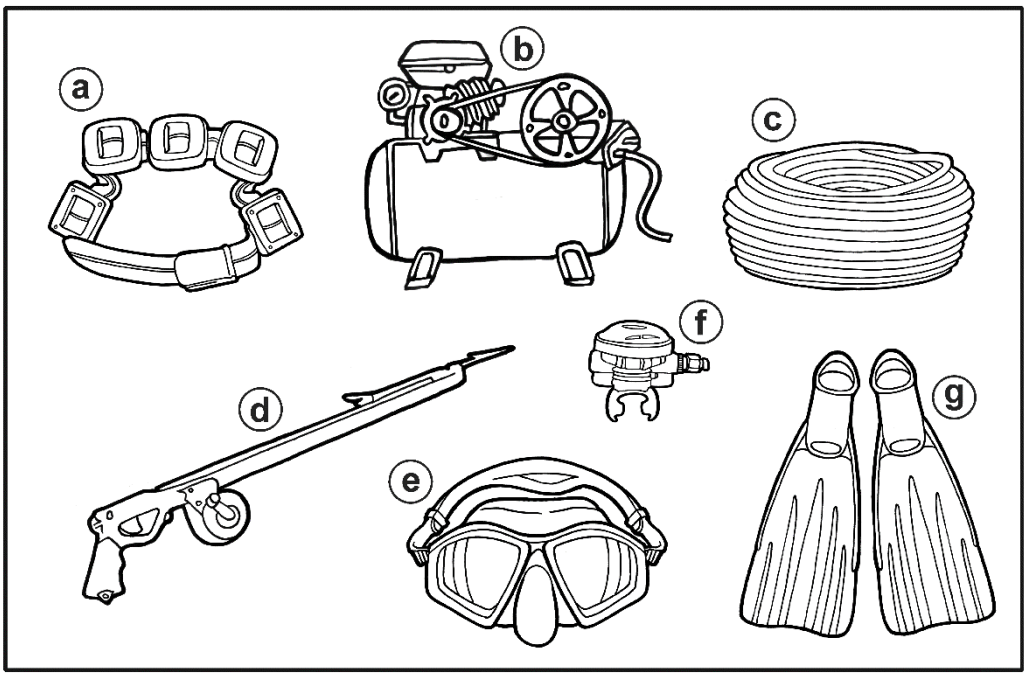

Figure 2 – Equipment used in compressor fishing. A) ballast belt; b) air compressor coupled to the fuel tank; c) hose; d) pressure cuff; e) diving goggles; f) mouth piece and g) fins.

This can be noted in the statements of the interviewed fisher who indnicates that "*All fishing sites display decreased amounts of fish. It's because those fishers scour everything down there. Hose diving, compressors!*" (F2Q1). We can also better understand the perception of fishery decreases from the following statement:

> *"Today what is exterminating these fish, the goliath grouper (Epinephelus itajara), the dusky grouper (Epinephelus marginatus), the dog snapper (Lutjanus jocu). What is exterminating these fish is diving. Whenever I talk to fishers, they agree that diving is the reason for this. The one using hoses. Before, we used to fish a lot of 15- and 20-pound groupers in the region. Today, it's very difficult to catch a grouper. It's an event when you catch a grouper. If you catch a grouper today, we throw a party. Not to mention black grouper (Mycteroperca bonaci)! And the dive fishers throw bait in the water to attract the black grouper. And when they hit a good spot, they don't leave it!"* (F19Q1).

The fact that the participants complained about illegal fishing in the interior and adjacent MERC areas indicates their persistence and efforts in defending their ancestral fishing zones against foreign fishers, the purpose behind the establishment of the MERC

in the year 2000 (Moura *et al*. 2009). Nevertheless, the respondents' argument that compressor fishing is one of the reasons for the reduction of local fish catches contrasts with that reported by compressor diving fishers in the city of Alcobaça, located 80 km from the MERC, representing the main compressor fishing center in the region. The latter defend the idea that this practice is quite selective due to the possibility of choosing the size of the captured animal (Escobar 2014). On the other hand, in the city of Caravelas, also in the Abrolhos region, Zambonim *et al*. (2009) reports the position of a fisher who compares the practice with an epidemic, where compressor fishers "sweep" everything in their operating fishing zone.

On the coast of the state of Ceará, northeastern Brazil, conflicts between small-scale local fishers, who point to compressor fishing as the reason for the decline in fish production, and those that use compressors (locally called pirate fishers), have already caused several deaths on both sides since the 1980s (Moretz-Sohn *et al*. 2013). The reasons given for this situation (known locally as "the lobster war") are related to the insistence of businessmen who send compressor boats to the area for a catch, as well as the failure of the inspection system (Kalikoski *et al*. 2008).

Studies worldwide pointed to higher compressor-based fishing yields when compared to other fishing methods. For example, indiscriminate fishing with compressors by non-resident fishers in the San Andres Archipelago, Colombia, combined with poor environmental control contributed to decreased biodiversity and productivity at the islands and was also adhered to by local fishers (Prada *et al*. 2006). In a study in the Danajon Bank region, located on the central coast of the Philippines, fishing for fish with hand lines represented only 10% of catch per unit effort of compressor fishing (Bacalso et al. 2013). For the Spermonde Archipelago, Indonesia, similar numbers were found for fishers using handlines and those working with compressors (Radjawali 2012). At this

locality, entrepreneurs and fishing patrons provide the equipment to local fishers to increase their fishing yield, culminating in an enormous debt that they will have to pay with fishing productions (Radjawali 2012). In a study concerning Dominican Republic fishers, Pavlowich and Kapuscinski (2017) realized that the introduction of this type of equipment in the early 1990s allowed fishers to access much deeper and more productive habitats, historically subjected to lower fishing pressures.

Fishes belonging to the Serranidae (Figure 3) and Lutjanidae families represent some of the main fishery resources in the tropical west Atlantic Ocean region, and are noteworthy concerning their role as food chain top predators in coral reef regions. (Allen 1985; Sadovy 1994; Coleman *et al*. 2000; Bender *et al*. 2013; Amorim *et al*. 2019).

Figure 3 – Schematic drawing of a compressor diver capturing an *E. marginatus* specimen (Serranidae).

The species cited by the interviewees (Table 1), in fact, represent some of the main fish resources captured by commercial fishing at the Abrolhos Bank (Previero and Gasalla 2018). However, the pressure of commercial fishing does not exclusively affect these species, and other marine organisms are possibly also constantly being caught in regional compressor fishing.

Table 1 - Conservation status of reef fish species identified by the respondents as caught in compressor diving.

Family	Species	Common name	Citations (n)	IUCN status	Brazil status
Serranidae	*Mycteroperca bonaci*	Badejo	4	NT	VU
Serranidae	*Epinephelus itajara*	Mero	3	VU	CR*
Lutjanidae	*Lutjanus jocu*	Dentão	3	DD	N/A**
Serranidae	*Epinephelus marginatus*	Garoupa	2	VU	VU
Lutjanidae	*Lutjanus synagris*	Ariocó	1	NT	N/A**
Scombridae	*Scomberomorus cavalla*	Cavala	1	LC	N/A**

*Criticamente em perigo (= Critically Endangered) and **Not available

Half of the species cited by respondents are classified as threatened in Brazil's Red List of endangered fish species and are, therefore prohibited, from being caught nationally (Brasil 2014). Thus, it is a challenge for the Brazilian government to combat these catches, whether by compressor diving or not. Most of the species belonging to the Lutjanidae-Serranidae complex in Abrolhos Bank are allocated under some threat status according to the IUCN Red List (Previero and Gasalla 2018). This pattern can be verified

for the investigated region, with studies indicating population declines for species belonging to the Lutjanidae-Serranidae complex (Francini-Filho and Moura 2008; Bender *et al*. 2013; Barbosa-Filho *et al*. 2020). Given this fact, and the illegal, unregulated and unreported fishing of compressor dives continuing to occur massively in the Abrolhos region, the establishment of new Marine Protected Areas and the proper compliance with national fisheries management rules is urgently required (Freitas *et al*. 2011; Simon *et al*. 2016).

3.2 Illnesses and deaths related to compressor fishing

Six interviewees (15.4%) recognize the occurrence of fisher diseases and deaths (Supplementary File 2) as a result of the practice. Cases known to fishers include accidents that leave sequelae and even deaths from both known people and even close family members, as noted in the following excerpt:

> *"You're asking to die! You make money, but ... My cousins there in (the central region of one of the cities that make up the MERC) are all crippled, 30-year-old guys. Pulmonary embolism ... Lumps in the body ... Some died. Gangrene, you "forget" an arm, "forget" a leg ... A 30, 35-year-old guy who looks like he's 80! And that's not counting those who died. Some three of my cousins have died already. And those are the ones I know (family), right?"* (F23Q2).

For the Abrolhos region, fishing with compressors is, in particular, a public health problem. Frequent deaths and health problems do not seem to frighten those who carry

out this practice. In a journalistic report for the year 2014, Escobar (2014) interviewed compressor accident victims and relatives in the Abrolhos region. The financial stimulus from fishing for large volumes of reef fish with a high commercial value encourages regional fishers to dive to depths of over 50 meters (Escobar 2014). Studies worldwide also pointed to the occurrence of accidents and deaths from fishing with compressors. This scenario is mainly due to the lack of basic safety knowledge in the performance of autonomous dives and the use of improvised equipment (Basurto 2006; Motetz-Sohn *et al*. 2013; Prada *et al*. 2006).

3.3 MERC's action to curb compressor fishing in the region

Some participants (n=7; 18.4%) reported that before the MERC establishment they constantly observed outside boats' compressor fishing in their fishing territory. Because this MPA modality provides for the prohibition of outside vessel operation, their presence is currently less frequent. Supplementary File 3 includes testimonials from fishers regarding the history of the performance of compressor boats in the local marine territory and the influence of MERC in curbing this type of practice. One can also notice the perception of the increase in reef fish populations due to the decrease of influence of this practice on MPA in these testimonies:

> *"A bit after they created the MERC, stone fish increased a little, because the guys used to compressor-dive there."* (F6Q5)

Given that participants in this study reported the contribution of the MERC in combating the fisheries practice prohibited by fishers in this territory, studies focusing on

the evaluation of the influence of this MPA on biodiversity conservation and local fisher well-being are required. Due to the fact that the Abrolhos region presents a limitation concerning fishery data (Previero and Gasalla 2018), studies that focus on the establishment of historical ethno-focused baselines regarding the exploitation of local fish stocks, should be encouraged. In a more pragmatic perspective, discussions regarding the establishment of a buffer zone for the protection of the existing MERC resources are also a necessity.

3.4 The insistence of compressor fishers in operating within the MERC

Sixteen fishers (42.1%) reported the stealth entry of fishers from other areas with illegal compressors, inside the MERC and in contiguous zones (Supplementary File 4). Therefore, they complain that maritime environmental enforcement actions are very rare in the region, as verified in this statement:

> *"I've seen many boats from the outside entering the MERC. Compressor boat also enters the MERC's borders, nine miles (nautical). From nine to eight (which is the MERC limit), only one mile. So, it's at the limit. But there's a lot of fishing out there within the eight miles they go too. Even during the day. No inspection is carried out."* (F20Q6).

In 2015, the Natuna district in Indonesia imposed a fishing policy to combat illegal fishing, which included the use of potassium cyanide with the help of compressors, and

was proven effective (Ismail *et al*. 2018). These comrpised environmental enforcement initiatives, criminal prosecution, high fines, deportation of foreign fishers and the sinking of fishing boats (Ismail *et al*. 2018). Thus, the development of vigorous actions of this nature to protect the verified ecosystems along the Abrolhos bank, as well as the livelihoods of the native population that lives from fishing, is suggested herein. In aquatic ecosystems, fishers can be seen as predators (Marques 2001). Thus, from a human ecology perspective, fisher's insistence on the use of compressors can be seen as risk-sensitive predation (Ricklefs 2003) where they recognize that, even with the possibility of falling victim to accidents or suffering sanctions from public authorities, these are still viewed as a positive balance concerning compressor diving. Thus, avoiding the use of compressors should be based on strict environmental enforcement actions, both at sea and in local ports, and fines should also be implemented. In addition, representative agencies should carry out educational actions aimed at fishers, to alert them of the risks of depletion of natural resources when using compressors. Actions of this nature should be directed, above all, to younger fishers.

4. Final considerations

The implementation of frequent monitoring actions at the MERC region is urgent. In addition, it is essential to carry out actions to combat the entry of fishers from other regions within the MERC and the practice of compressor fishing in the Abrolhos region as a whole, especially at night. After all, as Agardy (2017) points out, the failure of an MPA to achieve its basic objectives is a factor that contributes to credibility eroding and the loss of stakeholder confidence in environmental management and resource conservation actions. Thus, the recurrence of an understandable complaint by native

fishers against the entry of unauthorized fishers into their fishing territory represents an obstacle towards maintaining a healthy partnership between these social actors and the Brazilian State. This fact also configures a factor of political disintegration and of the sense of belonging to a Sustainable Use MPA.

Submission declaration

The authors declare that the work has not been published previously, that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if
accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder.

Declaration of competing interest

The authors declare that there are no conflicts of interest or any kind of interest that could influence the outcome of this work.

Declarations

Permissions: The present study was approved by the University of Pernambuco Research Ethics Committee involving human beings (Platform Brasil), under code CAAE 65458016.0.0000.5207. All research participants gave their permission by signing the Free and Informed Consent Form. Additionally, the research project was registered

(authentication code number 33794187) at the System for the Authorization of Information on Biodiversity (SISBIO - Sistema de Autorizaçao ~ e Informaçao ~ em Biodiversidade), as requested by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA - Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renovaveis). The project was also registered (registration number AB5B87A) at the National System for Management of Genetic Heritage and Associated Traditional Knowledge (SISGEN - Sistema Nacional de Gestão do Patrimônio Genético e do Conhecimento Tradicional Associado), as required by the federal law nº 13.123, May 20, 2015. The National Indian Foundation (FUNAI – Fundação Nacional do Índio) authorized the admission of the principal researcher into the indigenous area (Terra Indígena Barra Velha do Povo Pataxó), under code 111/AAEP/PRES/2017.

Data availability

All data generated or analysed during this study are included in this published article as Supplementary Information Files number 1, 2, 3 and 4.

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Appendix

Appendix A – Interview form used in the field, highlighting the questions that generated information on compressor fishing, in bold.

Form

Pernambuco Rural Federal University

Graduate Program in Ethnobiology and Nature Conservation

Responsible Researcher: Márcio Luiz Vargas Barbosa Filho

1 – General fisher information and socioeconomic profile

Date	City	Location
Name	Age	Fishing Time

Community/Association Schooling

Income from fishing General income

2 - Fishing Characterization

Name of the Vessel Do you own the vessel? Type Length

Fishing Art Number of Arts Fishing Area

Fishing frequency? Days at sea? Fishers per fishing trip?

Fished fish

Q1 - Has fishing income decreased over the years? Why?

3 - Attitudes concerning the MERC and its fisheries management policy

What is the Resex?

Q2 - Why did you decide to create a Resex in the area?

Before the Resex, did you notice fishers from outside working here in the area? What did you think of that?

Q3 - Before the MERC implementation, what equipment did external boats fish with?

Q4– What do you think about the MERC today? Why?

If you could change anything at the Resex, would you? What? Why?

Do you think that with the Resex has changed anything in your life?

For better or for worse? How?

Q5 - Do you think that the Resex creation changed anything concerning nature protection? What? Why?

Q5 - Do you think the Resex has changed anything concerning fish protection?

What? Why?

Do you think something should be done to improve fishing at the Resex?

Q6 - Does anything currently happen in the local fishing scenario that should not happen? What?

Is there anything that does not happen today in fishing that should happen?

Do you think that the current fishing is very harmful to fish?

What? Why?

Q7 - Are you satisfied with the inspection that takes place today at the MERC? Why?

Captions for illustrations

Figures

Figure 1 - Map of the MERC municipalities, indicating the sampled communities.

Figure 2 – Equipment used in compressor fishing. A) ballast belt; b) air compressor coupled to the fuel tank; c) hose; d) pressure cuff; e) diving goggles; f) mouth piece and g) fins.

Figure 3 – Schematic drawing of a compressor diver capturing an *E. marginatus* specimen (Serranidae).

Table

Table 1 - Conservation status of reef fish species identified by the respondents as caught in compressor diving.

Supplementary Files

Supplementary File 1 – Interviewee testimonials on the impact of compressor fishing on local fish stocks. (F = Fisher; Q = Question. Ex: F1Q1 = Fisher 1 Question 1)

Code	Compressor fishing as a reason for decline in local fishing
F1Q1	The dives are ending, exterminating all the fisheries. The other fishers arrive here with their hoses and catch everything.
F2Q1	All fishing sites display decreased amounts of fish. It's because those fishers scour everything down there. Hose diving, compressors!
F3Q2	It's a type of fishing that will only exterminate everything. Where it is carried out, where fish are, they will end it all.
F4Q1	Predators! Predators! This is what exterminated our whiting, our grouper, our lobster, these dive boats. They catch everything, man. And with the GPS, they always come back to that rock he knows that fish gather around. So, you won't be catching much. When fish gather around, they go there and take it. So, it's they who are the predators, these guys. Predators! It's an illegal fishing activity, do you understand me? But it has taken hold of the Descobrimento Coast region nearby. The folks from (*a neighboring Brazilian state*) went in huge numbers to (*names of four municipalities in the region*) and they can comb through the entire region.
F5Q2	It's a diver ... there's a boat that goes in and puts in steel! There are boats that enter this area here and take ... I am telling to you, there are boats that enter this area. Are you recording or not, I'll tell you and I don't ask it to be a secret: Boats come here and in 4 or 5 days take a thousand kilos of ariocó (*Lutjanus synagris*).
F6Q6	We see the boats that fish by compressor diving, which kills a lot of groupers (*Epinephelus itajara*) e take away only the steaks!
F7Q2	That is called end-all-fish. It lasts almost two hours underwater. They catch everything! They catch octopus, lobster, all kinds of fish species.
F8Q1	Compressor diving is what catches the most fish! Lines do not fish everything, the fish eats the bait if he wants to. Now in compressor diving, no. The fish are bound to die!

F9Q6	I do not agree with compressor fishing, because they will kill all the small fish and everything else they see!
F10Q2	They came here, from (city in the region). It seems they're afraid of fishing with nets or waiting with lines. They'd rather go down there, see a dog snapper (*Lutjanus jocu*), put the harpoon in its face, and then shoo, instead of catching it. Then it gets hard, because the fish are all gone.
F11Q6	What scares the fish today is diving fishers. Fishers that out there, dive with compressors and catch all the fish. Because the guy goes down there and stays half an hour below water, and the fish he sees, he kills.
F12Q1	Here the southern grounds (reef fisheries in the southern part of the MERC) are no longer yielding as they once were. Due to the influence of boats that dive with compressors, right? They are killing the fish from the southern fishing grounds.
F13Q2	That fishing exterminates everything, right? Whatever's down there, they're over. I will say that I am against it, because this type of fishing really exterminates it all!
F14Q6	I am against it, because it brings a lot of damage to nature! It is forbidden and if the Navy catches them, it'll take all the equipment.
F15Q3	If the outside fishers find out where the native fishing spots are and dives there with compressors, that's it. The compressor hinders our fishing because it runs captures all types of fish, it doesn't choose size.
F16Q1	The dives exterminated local fish a little. Those that dive with the compressors, they exterminate all fish!
F17Q2	The compressors have exterminated a lot of the reef fish where I fish. Lobster, whiting (*Mycteroperca bonaci*), dog snapper (*Lutjanus jocu*), killed a lot of grouper (*Epinephelus itajara*) in the past. Divers are the plague for all the fish there! You can see a lot of compressor sout there, but inside the MERC they only come at night. They come from (*cites the names of four cities in the region*).
F18Q3	The amount of fish has decreased in all the fishing spots that I go to. It's because, divers search all the way down at all these points. Compressor Diving! It's the compressors!

F19Q1	Today what is exterminating these fish, the sea bass (*Epinephelus itajara*), the grouper (Epinephelus marginatus), the dog snapper (*Lutjanus jocu*). What is exterminating these fish is diving. Whenever I talk to fishers, they agree that diving is the reason for this. The one using hoses. Before, we used to fish a lot of 15- and 20-pound groupers in the region. Today, it's very difficult to catch a grouper. It's an event when you catch a grouper. If you catch a grouper today, we throw a party. Not to mention black grouper (*Mycteroperca bonaci*)! And the dive fishers throw bait in the water to attract the black grouper. And when they hit a good spot, they don't leave it!
F20Q1	The compressors, that is what is exterminating everything (...) There are always people in the area diving.
F21Q3	The diver goes there, sits down there ... by hose diving. Today he is messing it up, you no longer catch a whiting (*Mycteroperca bonaci*), you no longer catch a mackerel (*Scomberomorus mackerel* Cuvier, 1829).
F22Q6	Diving is a problem here. The one with compressors, they go down there and do what they want, stay as long as they want. Choose what they want to do.

Supplementary File 2 - Testimonials related to diseases and deaths involving the practice of compressor fishing in the study region. (F = Fisher; Q = Question. Ex: F23Q2 = Fisher 23 Question 2)

Code	Occurrence of diseases and deaths from compressor fishing
F23Q2	You're asking to die! You make money, but ... My cousins there in (*the central region of one of the cities that make up the MERC*) are all crippled, 30-year-old guys. Pulmonary embolism ... Lumps in the body ... Some died. Gangrene, you "forget" an arm, "forget" a leg ... A 30, 35-year-old guy who looks like he's 80! And that's not counting those who died. Some three of my cousins have died already. And those are the ones I know (*family*), right?
F24Q1	It's dangerous, the guy can even die. Some friends I had, some even died and others became crippled in (*name of a city of the region*) there were a bunch of crippled guys, like this!
F25Q2	The guys dive as I'm telling you, they dive using compressor. The guys dive whenever they want to. Then two or three died. A boy who always came here at the São Benedito party every year. Water bubbles (*confusion between water and air bubbles*) in his lung, it was really quick, he then died.
F4Q6	My brother died using a compressor. My brother died 69 meters in depth. The guy hesitated, cut the hose in the propeller. How does he go up then?
F5Q1	It's very dangerous. Any hesitation, a dead man will rise. Almost all of my relatives died of diving like this.
F6Q2	If the guy doesn't know how to decompress, after three years he dies. If he doesn't die, he becomes crippled.

Supplementary File 3 - Quotations that point to MERC's success in curbing compressor fishing in the region. (F = Fisher; Q = Question. Ex: F26Q3 = Fisher 26 Question 3)

Code	The influence of MERC in reducing compressor fishing in the region
F26Q3	The guys came over and killed 4 tons of fish a day! It the very shallow areas, the guys dived with compressors and killed everything. Those boats destroy everything.
F27Q2	This compressor fishing was happening here in the region. Too much! Compressor boats came here from every corner. Too much compressor fishing in the area!
F28Q3	It (*the MERC*) was created to further preserve our region more, because there were a lot of people from outside who came here. With compressor diving and then it's over. That's why we created this MPA.
F29Q3	We created the MERC to expel those compressor fishers, which came here to end everything!
F30Q4	The boats on the MERC border are decreasing. But they still influence this area, right? (...) Compressors killing everything! So, this is what is ending fishing, not us.
F6Q5	A bit after they created the MERC, stone fish catches increased a little, because they used to compressor-dive here.

Supplementary File 4 – Testimonials from fishers regarding the insistence of compressor fishers in operate within the MERC. (F = Fisher; Q = Question. Ex: F31Q5 = Fisher 31 Question 5)

Code	Insistence of compressor fishers in invading the MERC
F31Q5	They used to come here a lot. But after the MERC, the frequency became reduced. However, it is not over yet, as they sometimes still fish there.
F32Q6	There are guys that come from outside, dive, kill fish, kill, kill, kill, inside the MERC. And then they go away and nobody does anything (*to curb the practice*). The people are very much upset by this.
F33Q6	Outside boats enter the MERC and fish hidden. We see it too, but we are afraid because the outsiders come armed. They are a threat. Outsider fishers take risks because the area is more coveted, because of a trend for higher fish yields.
F34Q7	Inspections here in the region are very weak, so people come from outside and enter the MERC to fish. There are a lot of boats out there, the guys come in with a compressor. Those lobster boats have a compressor at the bottom of, those big boats, right?
F35Q6	The guys fish within a radius of four miles (*the MERC limit is eight nautical miles*), the industrial compressor fishers.
F36Q6	What should happen here is that outsiders should not fish, but they do (...) Fishing a lot using compressor.s I've seen that.
F37Q6	It is a predatory fishing activity. It happens right here in the front. We don't see it, but it happens. The guys come from outside.
F38Q7	Inspection is virtually absent in the MERC. Inspection is zero. I mean, it happens from time to time during the summer. When the fishers is there (*MERC beneficiaries*), supervision comes. When the outsiders are there, inspections are not enough ... The outsiders have a compressor, and they fish at night too and no inspections are carried out.
F39Q4	There is this law, which is not fully enforced, and the compressor boats still come,
F4Q6	Compressor fishing. Those guys don't stop. There is no supervision for this activity. They usually keep moving, moving from port to port and only come

	in at night. Then, we should let them leave the port and have people waiting for them at each port.
F20Q6	I've seen many boats from the outside entering the MERC. Compressor boat also enters the MERC's borders, nine miles (*nautical*). From nine to eight (*which is the MERC limit*), only one mile. So, it's at the limit. But there's a lot of fishing out there within the eight miles they go too. Even during the day. No inspection is carried out.
F26Q3	They say they created the MERC for outside ships not to enter. Because if a lot of boats come here, it will end it all. However, out therem IBAMA doesn't care. The guys come from (*two cities in the region*) with a compressor boat and dive near these rocks all the time. They still dive today.

6. CAPÍTULO IV – Manuscrito a ser enviado para "Marine Policy"

Link com as normas para os autores: https://www.elsevier.com/journals/marine-policy/0308-597x/guide-for-authors

Title Page

Fisher knowledge and instruction is crucial for compliance with regulatory frameworks concerning endangered marine species

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Highlights

Fishers were questioned on the Brazilian List of Species of Endangered Fish.

A few of them was aware of the list and recognized some fish species in moratorium.

Hence, fishers are at risk and species are poorly protected locally.

Imposing moratoria demands that proper communication with fishers should be established.

A clarification action has been taken and others are feasible and necessary.

Manuscript

Fisher knowledge and instruction is crucial for compliance with regulatory frameworks concerning endangered marine species

Abstract

Top down management strategies, such as imposing moratoriums, tend to generate serious conflicts and socioeconomic impacts. This study aimed to assess the feelings and knowledge of fishers from the Marine Extractive Reserve of Corumbau (MERC) concerning Ordinance 445 in Brazil, which imposed a fishing moratorium on 409 fish species in the country in 2014. Semi-structured interviews were applied to 214 fishers and actions were taken to clarify ordinance information. Most participants (59.8%) knew about the existence of Ordinance 445. However, they complain that the public power has not adequately fulfilled the role of clarifying information concerning the moratorium and its consequences. Respondents also complain about the lack of communication and sensitivity of the Brazilian government when imposing the aforementioned ordinance. Most fishers (74.3%) cited three or fewer common names of species they believed to be under moratorium, and averaged 2.3 names (SD = 1.5). Most participants (69.6%) indicated presentations and explanatory lectures in meetings as effective means of clarifying information on the imposed moratorium. A researcher initiative to leave posters in communities with photographs and common names of endangered species pleased the fishers and can easily be replicated in other Brazilian regions. In addition, the possible impacts of the moratorium on local ecological knowledge of small-scale fishers are discussed, as well as their potential to contribute to the development of co-management

actions and to the socioeconomic consequences arising from the imposition of such strategies.

Keywords: Ordinance 445; moratorium; top down fisheries management strategies; local ecological knowledge.

1. Introduction

1.1 Global crisis and fisheries management challenges in developing countries

The current scenario regarding marine fisheries is highly unfavorable, and it is estimated that about 60% of the world's fish stocks have been fully exploited (FAO, 2018). This indicates that fisheries governance institutions have not been able to sustainably manage commercial fisheries (ROBERSON et al., 2019). These problems are especially true in developing countries (FAO, 2018), in which fisheries problems are often due to lack of organization, structure, and basic data on exploited resources, as well as inadequate policies and management (BERKES et al., 2001; DEGNBOL; MCCAY, 2006; NILSSON et al., 2019). For example, the fisheries management model widely applied worldwide is based on the application of quantitative methods related to the population dynamics of the target species (SPARRE; VENEMA, 1997; WARD et al., 2001). Such approaches are based on historical series of fisheries statistics, which is not usually the reality of developing countries who, in general, present poor basic scientific data (CASTELLO, 2008; GILL et al., 2017).

Historically, another serious obstacle to achieving success in fisheries management worldwide is the imposition of top-down fisheries management strategies. Top-down management measures are instituted in a centralized, hierarchical manner and

disregard one or more parties that, invariably, will face the consequences of the implemented actions (VAN GINKEL, 2005; DEGNBOL; MCCAY, 2006). In addition, these strategies are often based on sociologically simplistic assumptions that, in general, run counter to fisher interests (BERKES, 2007; GRAFTON; KOMPAS, 2014). Because of this, in general, such arrangements are environmentally and socially ineffective, especially when the focus is on small-scale fisheries (CASTELLO, 2008; ARCEO et al., 2013). On the other hand, in the last few years, fisheries managers have realized the low success viability of management strategies, precisely because they do not lead to fisher adherence and participation in compliance with laws and regulations (DEGNBOL; MCCAY, 2006; ACHESON, 2011).

In this sense, the growing perception of the need for greater participation of resource users for effective governance has contributed to the development and application of various global decentralized management arrangements and policies (JENTOFT; MCCAY, 1995; RUIZ-MALLÉN; CORBERA, 2013). One of the models most often used to ensure fair participation by all parties in the construction and enforcement of governance policies is the implementation of fisheries co-management systems. This type of management structure can be understood as a situation in which two or more social actors negotiate, define and guarantee a fair sharing of management functions among themselves. (BORRINI-FEYERABEND et al., 2000). In general, initiatives of this nature have been employed to respond to the failure of management strategies designed as top down (BERKES, 2007).

1.2 The role of Local Ecological Knowledge (LEK) in the management of artisanal fisheries

Artisanal fishing employs over 90% of the world's fishers, with women representing half of this contingent (FAO, 2015). In this way, this fishing sector provides food and nutrition security, work and financial investments to the local economies of developing countries, sustaining the livelihoods of countless poor coastal communities. (FAO, 2018). Faced with this scenario of dependence and intimacy in relation to the natural environment, artisanal fishers possess a vast and complex framework of empirical ecological knowledge, which is transmitted intergenerationally through socialization (MARQUES, 2001; ECHEVERRIA; THORNTON, 2019). Studies on the local ecological knowledge (LEK) of fishers focus, above all, on the ways in which these social actors use and appropriate fishing resources in the management systems they develop, as well as their knowledge, perceptions, beliefs, behaviors and even the ways to name and classify the natural world (BERLIN, 1992; MARQUES, 2001; KARR et al., 2017; BARBOSA-FILHO et al., 2020).

For this reason, in recent years, the scientific community has increasingly sought to combine fisher LEK with scientific data, in order to achieve the objectives of fisheries co-management (BERKSTRÖM et al., 2019). LEK has been shown to be similar to scientifically collected information (LE FUR et al., 2011). For this reason, and for having as one of its main paradigmatic pillars the construction of more flexible management systems in comparison to conventional ones (BERKES et al., 2000), this epistemological union can contribute to the development of fishing management strategies with a higher chance (SILVANO; BEGOSSI, 2012; D'ARMENGOL et al., 2018). This fact gains particular relevance when the focus is on the management and conservation of overexploited or threatened species (GERHARDINGER et al., 2009; WEDEMEYER-STROMBEL et al., 2019).

1.3 The influence of management systems on LEK

In recent years, literature reviews have reported numerous success stories in the application of Local Ecological Knowledge as an auxiliary tool in the construction of fisheries management (see RUIZ-MALLÉN; CORBERA, 2013; D'ARMENGOL et al., 2018; SEIXAS et al., 2019). On the other hand, LEK, a relevant and modern component of the conservation toolkit, is undergoing increasing loss in indigenous communities worldwide (ASWANI et al., 2018; TURVEY et al., 2018). This loss represents a complex and multidimensional phenomenon, which usually goes hand in hand with the cultural, social and economic changes to which the globalization process and the contact with Western cultural norms subject local human groups worldwide (KODIREKKALA, 2016; TANG; GAVIN, 2016). The global biodiversity crisis is also an important factor in LEK erosion, as it culminates in the progressive degradation of ecosystems and in the weakening of relations between local communities, the different components of the natural world (ASWANI et al., 2018). Thus, scientists have dedicated themselves to investigating the current serious risks of LEK erosion.

Although numerous recent surveys address how LEK can influence management, only some are dedicated to analyzing the role of regulatory management measures in LEK construction, maintenance and dissemination (FARR et al., 2018). Since LEK is maintained in a given population through the daily practice of its components (HUNN, 1999), it is plausible to assume that actions that limit or prevent the use of certain resources or access to certain regions will have a direct impact on this knowledge framework. For example, studies have pointed out that legal limitations on access to timber forest resources have contributed to the LEK erosion in rural populations in different regions of the globe (CHARNLEY et al., 2008; ZUCHIWSCHI et al., 2010; SONAK, 2014). When the focus is on fishing, one of the best scientifically documented

cases is reported in the state of Maine, in the United States, where regulatory restrictions that include catch control actions by limiting fishing licenses have been continuously and increasingly eroding local fisher LEK (BREWER, 2011; FARR et al., 2018).

1.4 The history of fisheries management in Brazil and the case of Ordinance 445

Brazil has always presented severe limitations regarding public fishery resource management and conservation policies (VIEIRA et al., 2015; BEGOSSI et al., 2017). For example, no national fishery monitoring and statistics system on the volume of fish produced in Brazil has been implemented since 2011 (FREIRE et al., 2014), a pitiful scenario that makes it difficult to carry out basic analyses on fish stock conditions. In addition, national fisheries management strategies have generally been established o few inflexible top-down strategies (CASTELLO, 2008; SILVANO; BEGOSSI, 2012; VIEIRA et al., 2015), which restricts the credibility of public power with fishers, unsettles the legitimacy of government initiatives and limits their potential positive conservation effects (CASTELLO, 2008, MOURA et al., 2009, PREVIERO; GASALLA, 2018).

The main Brazilian models adopted for fisheries management are related to the establishment of Marine Protected Areas (MPA) and resource fishing restrictions and/or prohibitions for certain species (VIEIRA et al., 2015). Examples of regulatory structures that limit or prevent access to resources include the closed fishing period during the breeding season for some shrimp species (BRAZIL, 2009) and an ordinance established in 2002 imposing a moratorium on grouper reef species and the Atlantic goliath grouper *Epinephelus itajara* (Lichtenstein, 1822) throughout the country. However, studies focusing on the ecological knowledge of Brazilian fishers have pointed out the dissatisfaction of these social actors with those management strategy, with arguments that the government has imposed inadequate prohibition periods, as they do not respect

regional specificities related to the reproductive biology of certain fish species (DORIA et al., 2008; VASQUES; COUTO, 2011).

Brazil's artisanal fishing generates work and food for over 1.7 million people and is responsible for 55% of the national fish production (GERHARDINGER et al., 2017). Although small-scale Brazilian fishing affects and is affected by the availability and diversity of exploited fish resources (BEGOSSI et al., 2017), it historically presents a low capacity for institutional and political articulation (CORDELL, 1989; VASCONCELLOS et al. 2011). Furthermore, the Brazilian State has, in recent years, imposed increasingly authoritarian and exclusionary measures on artisanal fishers, hindering their access to basic human rights, such as labor, safeguarding their ancestral territories and public policies in general (GERHARDINGER et al., 2017). Ordinance 445, for example, disregarded the need for consultation and collective construction with artisanal fishers, disrespecting their established legal rights.

From 2008, the Brazilian government reviewed the conservation state of fauna and flora species and the main invertebrate groups present in the country. The Ministry of the Environment (ME) was responsible for this process, which resulted in Ordinances 443, 444 and 445, alongside the National Lists of Endangered Species on December 17, 2014 (PINHEIRO et al., 2015). The lists were developed from a process attended by 1,300 researchers from several Brazilian and international organizations, based on the methods adopted by the International Union for Conservation of Nature - IUCN (LEES, 2015).

When Ordinance 445, which lists threatened Brazilian fish species, was published, entities linked to the fishing industry began to contest its legitimacy (BUCKUP, 2017). In addition to the argument that it would disrupt the country's fishing industry, the methodology applied to the list-making process was also questioned (DI DARIO et al., 2015). In 2015, due to a criminal action brought about by organized industrial fishers,

Ordinance 445 was revoked (BUCKUP, 2017). This generated a heated reaction by the Brazilian researchers, who defended its reestablishment. In addition, international organizations sought to sensitize the Brazilian government in order to restore the Ordinance. However, only on January 25, 2017 did Ordinance 445 come into force again (BUCKUP, 2017). Since then, other Ordinances (127, 129 and 292) have been launched in order to define measures, criteria and standards for the fishing management of some species classified as Vulnerable.

Ordinance 445/2014 (MMA, 2014) grants full protection against the capture, handling, storage, transportation, processing and commercialization of 66 aquatic invertebrate species and 409 fish species considered threatened in Brazil (BUCKUP, 2017), 98 species of which are marine fish (REIS et al., 2016). The consequences of Ordinance 445 are supported by Law 9605/1998 and by Decree 6,514/2008, which indicate punishment against those who kill, fish, hunt or use endangered species (BRAZIL, 1998, 2008). The launching of the list culminated in numerous political and scientific disagreements (ESCOBAR, 2015), with the fishing sector arguing that this ordinance would represent an obstacle to the development of the national fishing industry (DI DARIO et al., 2015). In addition, the imposition of a moratorium on numerous fish species used by artisanal fishers may represent a threat to their food security and to the artisanal fishing activities carried out along the Brazilian coast (BEGOSSI et al., 2017).

Therefore, this study aimed to assess the depth of fisher knowledge on Ordinance 445 and the moratorium concerning the capture of numerous fish species they interact with during their daily activities. In addition, this study also comprises a case study in which the establishment of top down fisheries management structures may be unhelpful, in addition to representing an obstacle to the cultural reproduction of small-scale fisher populations, as well as to the development of fishing co-management actions.

2. Material and methods

2.1 Study area

The Marine Extractive Reserve of Corumbau (MERC) is located at the extreme south of the state of Bahia, north of the Abrolhos Bank. This region is noteworthy as the main marine biodiversity hotspot in the South Atlantic, comprising the largest coral reef formations in Brazil (DUTRA et al., 2005). Almost 300 fish species have been recorded in the Abrolhos region (MOURA; FRANCINI-FILHO, 2006). MERC occupies 900 km^2 of marine area between the municipalities of Prado and Porto Seguro (MOURA et al., 2009), created in 2000 due to local fishers demands, who felt that they were harmed by what they called an "invasion of foreign boats" (PREVIERO et al., 2013). The Chico Mendes Institute for Biodiversity Conservation (ICMBio), the Brazilian government's environmental agency responsible for managing the country's Protected Areas, estimates a total of 650 families benefiting from the MERC (ICMBIO, 2019), a public comprised essentially of indigenous people from the Pataxó ethnic group and their families.

MERC represents an effective Marine Protected Area (MPA) concerning the protection of natural resources in line with the livelihoods of its beneficiaries, since it refrained large scale fishing and has politically organized the communities for the adoption of local fishing management initiatives (MOURA et al., 2009). This MPA presents a Plan of Use approved in 2003. Its revision should have been performed until 2006, which did not occur. The construction process of the MERC Management Plan, which documents Conservation Unit management in Brazil (BRAZIL, 2000), was concluded in 2018. Currently, MERC's public awaits as official Management Plan publication by the federal government. In general, MERC beneficiaries are registered in

one of the three fisher colonies near the MPA (VIEIRA et al., 2015), namely the Z-23 Fisher Colony in the Prado municipality, the Z-56 Fishers Colony of Itamaraju and the Z-22 Fisher Colony of Porto Seguro. In addition, many are members of existing Fishers Associations in some MERC communities, although local fishers are commonly linked to entities representing the entire fishing class.

Marine fishing within the MERC is essentially artisanal and multispecific. The most targeted fish species belonging to the Serranidae (groupers), Lutjanidae (snappers), Scaridae (parrotfishes), Carangidae (jacks), and Haemulidae (grunts) families (DUTRA et al., 2005). In addition to fish captures, octopus and lobster catches are mainly geared towards subsistence. These animals can also be traded between neighbors and to restaurants and inns in some communities. Commercial shrimp fishing is noteworthy in the Corumbau and Cumuruxatiba communities. These resources are captured using vessels equipped with trawls and are usually sold to other cities in Bahia and other Brazilian states. In recent years, tourism has become a relevant source of income for the population of most MERC communities.

2.2 Data collection and analysis

Semi-structured interviews (HUNTINGTON, 2000) were conducted with 214 MERC fishers, 205 men and nine women. A survey was applied to the interviewees (Appendix A) with questions regarding extractivist socioeconomic profile and their knowledge regarding Ordinance 445 and its repercussions. The interviews took place over 90 non-consecutive days of sample effort, between April 2017 and February 2018. Interview audios were recorded using a digital voice recorder. MERC beneficiaries from

11 communities in the two municipalities that make up the MPA were interviewed (Figure 1).

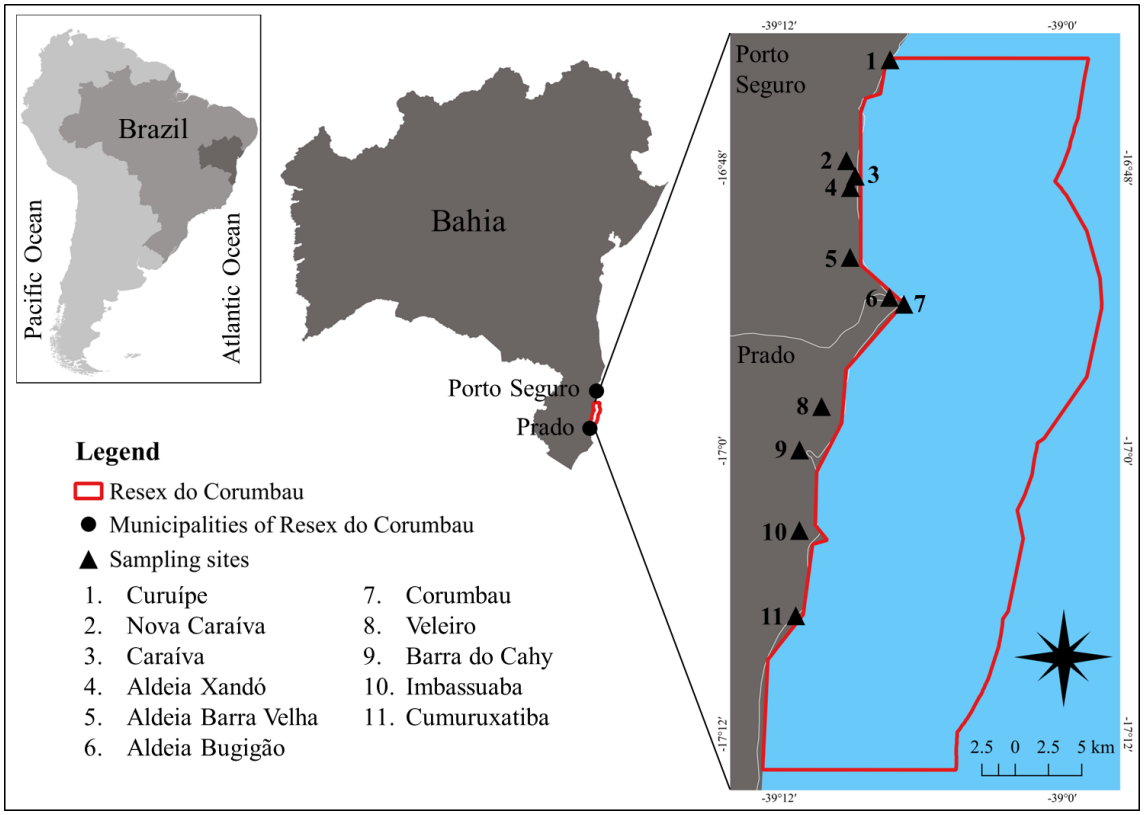

Fig. 1. Map of the Extractive Reserve of Corumbau, indicating the communities where the data were collected.

Inclusion criteria for participants comprised being at least 18 years of age and fishing with the aid of vessels at the MERC. Ages varied between 18 and 88 years old. The sample size followed the recommendations indicated by Bernard (1988) in order to obtain a representative number for anthropological studies, with a confidence interval of 95%. The sampling design was established as follows: the researcher visited the community leaders, which indicated inhabitants fitting the inclusion criteria. With a list of names of potential participants, the indicated people were sought out in their homes and in specific community areas where fishers usually meet. It should be noted that the interviewer had previously lived in the region between March and July 2016, when he

participated in a Technical Assistance and Rural Extension work, carried out by the Brazilian federal government, with fishers from four MERC communities. Because of this previous experience, the researcher participated in numerous MERC meetings, where he met leaders from other communities. Thus, a rapport was already in place between the researcher and the research subjects (GLESNE, 1989), which facilitated data collection.

The data were analyzed based on a descriptive approach, by using both qualitative and quantitative methods. Under the qualitative approach, excerpts from the statements of some fishermen were used as a way to illustrate the ways in which these social actors deal with certain ideas in relation to Ordinance 445. Regarding the quantitative approach, descriptive statistics techniques were applied through, mostly, the analysis of absolute and relative fisher citation frequencies regarding the main issues developed herein.

The common names cited by fishers as attributed to species under moratorium were compared to common names recorded in the scientific literature for fish species caught in regional fishing (CALÓ et al., 2009; PREVIERO et al., 2013; CETRA; PETRERE, 2014; PREVIERO; GASALLA, 2018), in order to identify which scientific species they refer to. For common or generic names assigned to designate marine organisms that do not correspond to fish, we sought to their identification under the least comprehensive taxonomic category possible.

2.3 Compliance with legal procedures

The present study was approved by the University of Pernambuco Research Ethics Committee involving human beings (Platform Brazil), under code CAAE 65458016.0.0000.5207. Following REC guidelines, before each interview, a Free and Informed Consent Term was read by the researcher and signed by the participant.

Following a guideline from the National Indian Foundation (Fundação Nacional do Índio - FUNAI), a federal agency linked to the Ministry of Women, Family and Human Rights, researcher admission to the Barra Velha Pataxó People's Indigenous Land was authorized prior to the beginning of the data collection (authorization code: 111/AAEP/PRES/2017). According to Federal Law No. 13,123, of May 20, 2015, the research project was registered in the National Genetic Heritage and Associated Traditional Knowledge Management System (Sistema Nacional de Gestão do Patrimônio Genético e do Conhecimento Tradicional Associado - SISGEN) (Registration No. AB5B87A).

The project was also registered at the System of Authorization and Information on Biodiversity (Sistema de Autorização e Informação em Biodiversidade - SISBio) (authentication code number 33794187), as determined by the Brazilian Institute of Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais - IBAMA).

3. Results

3.1 Fisher knowledge on the moratorium list and its repercussions

Almost all participants (n = 208, 97.8%) practice fishery activities with lines and hooks, in addition to gill nets (151; 70.5%). Other fishing tools used to capture fish are longlines (41; 19.1%) and harpoons used in free dives (22; 10.3%). Half of the participants do not own their own vessel and they are fishing in vessels belonging to others. According to the interviews, vessel lengths range between 3 and 10 meters, but half are less than six meters in length. Regarding schooling, 30% (n = 64) did not attend school, 30% studied five years or less and only 15% (n = 33) finished high school.

A total of 128 participants (59.8%) had heard about a list containing fish species whose catches are currently banned by the Brazilian government. The means by which they accessed this information were varied, being mostly related with local chatting and meetings (Table 1).

Table 1 – Means that participants (n = 128) learned about the list of banned fish species in Brazil. AF = Absolute Frequency (in n), RF = Relative Frequency (in %).

How did you hear about the list?	**AF (RF)**
Through comments from known people	42 (32.8)
In meetings	41(32.0)
Through television media	25 (19.5)
Technical assistance agent advisory	9 (7.0)
Saw the list in fishmonger or fisher colonies	8 (6.2)
On the radio	4 (3.1)
Saw the list on the internet	2 (1.6)
Heard about it in a Navy course in which they participated in	2 (1.6)

In general, the interviewees were concerned with the publication of a list of new prohibited fish species, because they fear for the future of artisanal fishers and, thus, predict catastrophic consequences as a result of these moratoriums. Key testimonials in this regard are transcribed below.

What will the people who live through this live with? Then it will happen the same way it always does: everyone becomes a criminal, the police go on catching and killing, just like we see today. (36 years old)

Forbid it and what will the guy live on? The guy will starve... (70 years old)

If they ban this, how will we live through fishing? (44 years old)

The government has to look our way, as it is difficult. Because it's like many friends of mine say, that the way will be to put a gun in your hand and go around mugging. (22 years old)

How are we going to survive? You see my boat there, it's humble. I have wanted to reform it for some time. We have no conditions. Now they want to ban it ... I'll tell you: there are days when we spend a day, week, that we can't even buy bread in the morning. (49 years old)

What do you have to give the fishers to stop? What has to keep this family stable to stop fishing and not become a dealer in life? The government is taking the bread out of people's mouths! (36 years old)

Will this study of yours serve to harm fishers in some way (questioning by a fisher's wife when witnessing the interview)

When asked if communications from public authorities to warn and clarify local fishers on the list were adequate, most participants (n = 193; 90.1%) answered "No", while other 15 (7%) interviewees understood that the communication was adequate, and six were unclear in their responses. Some statements denote a lack of communication by public authorities in order to clarify fishers about the species listed in the ordinance, also demonstrating their concerns regarding the risks of catching fish under a moratorium without knowing that they are prohibited:

If I know it's forbidden and I go fishing, it's my mistake, right? Now, what if I don't know? I arrive at the port without knowing and the inspection says that I am under arrest, I will be fined without my knowledge ... I think we have to know everything. (57 years old)

In order to apply the fine, they have to inform us first. (32 years old)

They forbade it and did not indicate the reason for the ban, nor did they come here to raise awareness. You have to warn me, otherwise you're deceiving us! (41 years old)

> *Today it got easier with internet, television. But there are some who will die fishing without knowing!* (55 years old)

> *Some things we already know* (which are against the law)*, it's ok to fine us. But what we don't know is unfair!* (62 years old)

Although they were not specifically questioned, 33 (15.4%) fishers pointed out that the ordinance was built and published without their effective participation, and that they only learned about its existence after it had already been published. In addition, they denounce the lack of sensitivity and interest of the public authorities in dialoguing with the artisanal fishing sector when developing the list, as follows:

> *There's a lack of communication. Because I think that before they make these laws, they have to have at least one communication. I think we will never win, at least inform us beforehand.* (24 years old)

> *We (MERC fishers) have to create a management plan ... We have to defend ourselves! The government doesn't care about us. The government will hear who sends them the report saying that it is running out (fisheries managers) and that's it! You have to make a plan and show the president that we are doing sustainable fishing. Tell him: "We need your respect".* (41 years old)

For those who are up there earning 15, 20 thousand reais it is easy to say: "Ah let's end this! Pass me the pen!" The guys are earning 20, 30 thousand! And what are the fishers earning? (55 years old)

And there isn't anyone there (in the government) for us, everyone is against us! (52 years old)

They (the government) don't say a word to anyone and when we get it, they are already closing or will close the deal. Then it gets hard! (26 years old)

Because when we fishers find out, an ordinance has already been implemented indicating prohibited species. There's no conversation. It's already done, from top to bottom, it's forbidden and it's over! (36 years old)

I didn't even look at that list! Do you know why? Because I was so insulted, I didn't even want to look! I think it's a list that went in effect so suddenly and that has no justification, there is no reason for this, there was no study. (36 years old)

The fisher cannot be notified when the closure has already taken place. He has to know first, to be able to organize him/herself and try to legally slow down the process. (28 years old)

When questioned about which fish species are banned, most respondents (n = 202; 94.4%) scored at least one species. In total, 499 citations were recorded among 42 different common names used to designate these species (Table 2).

Table 2 - Common fish names, scientific names, frequency and conservation status (from IUCN and Brazil) from the species cited by the participants (n = 202) as under moratorium. AF = Absolute Frequency (in n), RF = Relative Frequency (in %).

Common names	**Corresponding species***	**AF (RF)**	**Status (IUCN/BR)**
Mero	*Epinephelus itajara*	180 (89.1)	(VU/CR)
Budião azul	*Scarus trispinosus*	57 (28.2)	(EN/EN)
Badejo	*Mycteroperca bonaci*	49 (24.3)	(NT/VU)
Tartaruga	Chelonioidea	46 (22.8)	---
Garoupa	*Epinephelus marginatus*	22 (10.9)	(VU/VU)
Lixa	*Ginglymostoma cirratum*	19 (9.4)	(NT/VU)
Cação	Selachimorpha	18 (8.9)	---
Arraia	Batoidea	16 (7.9)	---
Ariocó	*Lutjanus synagris*	9 (4.5)	(NT/**)
Martelo; Guaiúba	Sphyrnidae*; Ocyurus chrysurus*	8 (3.9)	--- ; (DD/**)

Lagosta	Palinuridae	7 (3.5)	---
Golfinho; Robalo	Delphinidae; *Centropomus sp.*	6 (3.0)	--- ; ---
Bagre	Ariidae	5 (2.5)	---
Baleia; Dentão	*Lutjanus jocu*	4 (2.0)	(DD/**)

*Refers to the species or to the less comprehensive taxonomic category. / ** Does not appear in Ordinance 445.

The epithets “beijupirá” e “biquara” both received three citations. The names “piracema”, “guaiamun”, “bagre branco”, “tainha”, “arraia roxa” and “arraia pintada” were mentioned twice each. The epithets “ciliares”, “mero-gato”, “peixe-frade”, “caranha”, “marlim”, “cherme”, “budião-verde”, “cação-branco”, “cação-verde”, “cação-barriga-branca”, “arraia-chita”, “arraia jamanta”, “cioba”, “dourado”, “garoupa-pintada”, “viola” e “pescadinha” were quoted once each.

Most respondents (n = 159; 74.3%) cited three or fewer common names of species they recognize as banned. The average number of cited banned species per fisher was of 2.3 names (SD = 1.5).

3.2 Ideas on possible enlightenment strategies and an initiative put into practice

Participants pointed out many ways in which public authorities could contribute to improve local fisher knowledge concerning the list of endangered species and its consequences (Table 3). Most of them (69.6%) mentioned that lecturers at the communities or colonies would be most helpful. Around 17% of the fishers provided unclear or unknown (no idea) answer, as the remaining interviewees cited different ideas.

Table 3 - Participant citation frequencies (n = 214) on possible ways to clarify fishers regarding the list of endangered fish species. AF = Absolute Frequency (n), RF = Relative Frequency (%).

Ways to clarify fishers regarding the list	**AF (RF)**
Lectures at the communities or Colonies	149 (69.6)
The answer was not clear	24 (11.2)
No idea	12 (5.6)
Leaving lists of prohibited species at the communities	9 (4.2)
Performing interventions for fisher awareness	7 (3.3)
Displaying the list in the media	5 (2.3)
Leaving a poster at the communities	5 (2.3)
Hiring more people to work at the MERC	3 (1.4)

Considering the aforementioned results, the main researcher developed a graphic art containing photos and the common and scientific names of 33 marine fish species (18 bony fish and 15 elasmobranchs) listed in Ordinance 445 and potentially captured in the study region. The photographs were taken from Fishbase (FROESE; PAULY, 2018). Nine posters (Appendix B) sized 140 centimeters in length by 120 centimeters in height were printed on canvas and donated to be affixed in common fisher areas from different MERC communities. The posters were given at fisher meetings in four communities and the researcher had the opportunity to hold a lecture on Ordinance 445 and later listen to the fishers present in this regard.

4. Discussion

The interviewed fishers feel disrespected and disregarded by the imposition of Ordinance 445. It is clear that they see this as a threat to the food security of all artisanal fishers and to the very future of this fishing culture. They also point out that no adequate actions were taken by public agencies to clarify fishers about ordinance details, and so the little they know about it usually came from informal means. For example, this fact is reflected in the limited recognition of which species are under moratorium. In view of the top-down establishment and the subsequent lack of clarification actions by the public authorities, it is not an exaggeration to assume that the artisanal sector of Brazilian fisheries as a whole, that generates work and food for over 1.7 million people and is responsible for 55% of the national fish production (GERHARDINGER et al., 2017), is not yet aware of the details of the developments of Ordinance 445.

Although 60% of the respondents reported having knowledge on a list of banned endangered fish species, it is clear that the recognition of which species the list comprises is superficial. Most fishers knew of the list by circumstantial means, for example, through conversations with known people or through television. In addition, the participants themselves understand that communications with the public authorities concerning the list is not adequate. In this sense, it is clear that, in addition to having built and imposed this fishing management strategy in a top down manner, Brazilian public authorities, apparently, have not been able to or even interested in adequately dialoguing with this class of workers. For this reason, the Brazilian Society of Ichthyology published a motion in favor of Ordinance 445 in 2015, in which it requested public powers to improve communication concerning the Ordinance by the publication and unrestricted availability

of evaluation sheets and booklets that facilitate rule understanding by fishers (BRAZILIAN SOCIETY OF ICHTHYOLOGY, 2015). Given the lack of fishing control in Brazil (HAIMOVICI, 2011), adequate public power communication with fishers concerning Ordinance 445 is even more urgent.

Local fishers are vulnerable to the application of severe sanctions for possible catches of species under moratorium without knowing that they are classified as such. Furthermore, the lack of knowledge of which species are under moratorium means they will continue to be fished. As demonstrated by Ruiz-Mallén and Corbera (2013) through case studies, scenarios such as this, of disregarding traditional communities in decision-making spaces, tend to threaten the resilience and capacity of these populations to adapt to socio-environmental changes and culminate in failed conservation initiatives. In the context of MERC fishing, the indignation felt by the interviewees denotes an understandable loss of credibility in government institutions, despite the fact that this MPA has become a good example of political construction and social mobilization to combat industrial fishing and develop actions fisheries management (MOURA et al., 2009). In fact, the case of the imposition of Ordinance 445 by the Brazilian government contains all the elements that usually contribute to the failure of nature management and conservation strategies, as well as generating serious political and social impacts for the fisher class.

The adoption of fishing moratoriums directly affects those who survive from the productive chain of fishing resources (OLNEY et al., 2008), and case studies have reported that moratoriums can cause conflicts and socioeconomic impacts both in developing and developed countries. In Indonesia, for example, which in 2015 implemented a moratorium for foreign vessels and for new trawling licenses, many crew and fish traders found difficulties in finding new jobs (SIAR et al., 2017). Nevertheless,

Siar et al. (2017) also point to positive moratorium impacts, which, coupled with adequate government monitoring and inspection actions, enabled better catches in later years and a greater supply of shrimp from artisanal fishers to the processing industry in the Arafura region. The atlantic goliath grouper, *Epinephelus itajara*, was the first species subjected to moratorium in Brazil, and its catches have been banned nationally since 2002. However, data have shown that in several parts of Brazil considerable catches of the species continue to occur (GIGLIO et al., 2014) and there is no evidence of population recovery (ZAPELINI et al., 2017).

An emblematic example of the imposition of a moratorium policy that has had disastrous socioeconomic and cultural impacts is the case of the northern cod *Gadus morhua* (Linnaeus, 1758) in Canada (DEGNBOL; MCCAY, 2006). The fish stocks of this species collapsed in the last decades of the twentieth century, and the fishing moratorium established in 1992, which did not seek to reconcile social objectives with those of catch reconstruction, brought serious unemployment problems and the displacement of thousands of fishers in the Newfoundland region (PALMER; SINCLAIR, 1997, HAEDRICH; HAMILTON, 2000). However, recent analyses by the Canadian Department of Fisheries and Oceans (DFO) indicate that stock recruitment is still in a critical zone (DFO, 2018). The Mortaponi River fish moratorium in Virginia, United States, directly impacted non-fishers by preventing the construction of a water reservoir that would supply water for over 600,000 people (OLNEY et al., 2008). After the refusal, the construction of quantitative models indicated that the impacts would be negligible and, even in the face of proposals to mitigate such losses, the work was not carried out.

Begossi et al. (2017) argue that in Brazil, small-scale fisheries have focused on numerous species of fish currently listed as endangered, which threatens the livelihood

maintenance of coastal fisher populations. For example, Barbosa-Filho et al. (2020), while interviewing MERC fishers found that, possibly due to the imposition of Ordinance 445 in a top down manner, only a minority of fishermen admitted the need to build local protection measures for *Lutjanus synagris* (Linnaeus, 1758), the main fish species caught in the MPA. Indeed, in recent years, due to numerous uncertainties and discussions related to Ordinance 445, a weakening of the confidence between fishers in southern Bahia and fishery managers and scientists has been noted (PREVIERO; GASALLA, 2018).

The fact that local fishers carry out small-scale fishing and rely heavily on fish intake as a source of protein indicate a complex management scenario (BERKES et al., 2001). This scenario demands high sensitivity from public power agents regarding relations with artisanal fishers when it comes to the threatened species. However, the Brazilian State has, in recent years, imposed increasingly authoritarian and exclusionary measures on artisanal fishers, hindering their access to basic human rights, such as labor, safeguarding their ancestral territories and public policies in general (GERHARDINGER et al., 2017). Ordinance 445, for example, disregarded the need for consultation and collective construction with artisanal fishers, disrespecting their established legal rights.

The establishment of regulatory restrictions has the potential to contribute to the erosion of local ecological knowledge (BREWER, 2011) and, thus, also limit the potential for the development of such initiatives. In the face of the global fisheries crisis, a trend in which management systems increasingly restrict fisher access to resources is noted, interfering in the ways in which they interact with the different elements of the ecosystem and, thus, directing LEK production (FARR et al., 2018). For example, in the fishing context of Maine, United States, the government has intensely limited the release of licenses for fishing specific fishing resources each year (FARR et al., 2018). Farr et al. (2018) point to a positive relationship between the complexity of fisher LEK and the

number of licenses they have. They also point out that, although research on the subject is lacking, evidence points to the influence of management systems on LEK and, consequently, on its potential to contribute to management. Thus, a scientific demand to monitor the possible influence of Ordinance 445 on the LEK of Brazilian fishermen is clearly noted.

Fishers use a wide variety of common names to designate species recognized as banned.

Previero et al. (2013) found a wealth of common names used by MERC fishers to designate marine fish species, terming this complex ethnotaxonomic classification system as a "Tower of Babel". This fact can be an additional challenge for fishers to recognize which species are, in fact, under moratorium. On the other hand, citations were concentrated on some common names, such as “mero”, “badejo”, “garoupa” and “budião azul”, attributed to *Epinephelus itajara*, *Mycteroperca bonaci* (Poey, 1860), *Epinephelus morio* (Valenciennes, 1828) and *Scarus trispinosus* (Valenciennes, 1840), respectively. The fisheries for these species are historically relevant in the studied region (MOURA; FRANCINI-FILHO, 2006, FREITAS et al., 2017, PREVIERO; GASALLA, 2018). Most fishers recognized the ‘mero’ (*E. itajara*) as being banned, as a specific moratorium on the fishing of this species throughout the national territory has been in place since 2002. For this reason, a smaller number of interviewees who know about Ordinance 445 was noted compared to those who pointed out at least one species in moratorium in Brazil.

Most (59.5%) common names were cited three times or less. In addition, four other names are used in Brazil to designate animals that are not fish (whale, dolphin, turtle and lobster). Taking into account that, on average, each participant cited the common names of banned species 2.3 times and that 98 species of marine fish are listed in Ordinance 445, fisher knowledge concerning the number of species under moratorium was determined as extremely low. It is possible that the legal impasse in the country,

responsible for repeated Ordinance 445 validations and invalidations in recent years, also contributes to this lack of knowledge.

The little knowledge local fishers have on Ordinance 445 implications draws even more attention when considering that they are the beneficiaries of a sustainable use Protected Marine Area, a MPA modality that has as one of the basic premises a proximity relation between public power and traditional populations in the search of adequate natural resource management practices (BRAZIL, 2000). Taking into consideration this regrettable context, it is relevant to assume that the knowledge of small-scale fishers at Brazilian coast locations not contemplated by MPAs belonging to this category is even more limited than that observed for the participants of this study. Studies evaluating this assumption should, therefore, be performed in other Brazilian regions.

This limited recognition of which species are under moratorium represents a serious impediment to their local conservation. In addition to the moratorium on species consumed and commercialized that, in itself puts at risk the cultural reproduction of artisanal fishers throughout the Brazilian coast (BEGOSSI et al., 2017), the ignorance concerning which species are listed in the Ordinance 445 can lead to serious financial losses by imposing fines on local fishers. According to the Environmental Crimes Law (BRAZIL, 1998), the fine per individual captured belonging to the species listed in official lists concerning the fauna threatened with extinction is R$ 5,000.00 (U$ 1,197.00). For these fishers, who mostly practice subsistence fishing and live in small communities, receiving punishments from public power may have catastrophic socioeconomic and moral impacts.

The initiative to offer posters containing photos and the popular names of some of the marine fish species under moratorium pleased and generated significant interest in fishers from different MERC communities, and was praised. Therefore, it is

recommended that similar initiatives be developed in other Brazilian regions. In the MERC fishing context, it is advisable to carry out scientific investigations to assess if this initiative was successful concerning species recognition by the participants. Thus, a comparative study is proposed through interviews with the same fishers interviewed in 2017, to evaluate the before and after in relation to the number of common names attributed to the fish species under moratorium.

5. Final considerations

The fact that the interviewed fishers feel disregarded in the construction and publication process of Ordinance 445 may become an obstacle to the development of future co-management structures at the MERC. In addition, as several studies have shown, policies that regulate fisher access to resources can contribute to LEK erosion and to a lower resilience and capacity for these social actors to adapt to socio-environmental changes. It is possible that similar contexts may be noted in other fisher communities along the Brazilian coast. Thus, the top-down imposition of Ordinance 445 by the Brazilian government contains all the elements that usually contribute to the failure of management and conservation strategies of nature, while also generating serious political and social impacts for the fisher class. In general, study participants were only superficially and informally familiar with Ordinance 445. Furthermore, the recognition of which fish species are under moratorium was extremely low when compared to the total number of marine species that are, in fact, listed in the Ordinance. This represents a serious obstacle to the local conservation of endangered species. In addition, this non-recognition makes local fishers vulnerable to possible fines, arrests and other negative implications. It is possible that similar scenarios are occurring in other Brazilian regions,

which should be investigated. Thus, the preparation of scientific studies using similar approaches and in other Brazilian other areas is strongly recommended.

Given these facts, in the coming years efforts must be applied by the Brazilian public powers to evaluate the possible effects of the moratorium on the conservation of endangered species. In the face of an institutional and political crisis panorama in Brazilian fisheries, the country has, for example, for several years, been unable to generate basic data on the volume of fish caught in its Exclusive Economic Zone, and it is, thus, unlikely that these demands will be adequately addressed. Efforts are also required to analyze the possible influences of moratoria on the ecological knowledge of Brazilian fishers, as well as to assess the socioeconomic and cultural impacts of this fishery policy, especially on artisanal fishers.

The initiative to offer informative posters to the communities can be replicated in other regions, as it was liked and praised by local fishers. Nevertheless, it is necessary to evaluate its concrete effect on species recognition by local fishers. It is imperative that, rather than merely informing fishers of fisheries management policies, Brazilian public authorities should also develop mechanisms that allow for the effective participation of fishers in the development of marine management and conservation strategies. In addition, it is urgent that the consequences of Ordinance 445 on the quality of life and the culture of Brazilian artisanal fishers be monitored.

6. Conflicting interests

The authors declare no conflicting interests.

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Appendix A – Survey applied to fisher during data collection in the MERC.

Survey

Federal Rural University of Pernambuco
Postgraduate Program in Ethnobiology and Nature Conservation
Leading researcher: Márcio Luiz Vargas Barbosa Filho

PROJECT: COMANAGEMENT IN SOCIOECOLOGICAL SYSTEMS: CONTRIBUTIONS OF FISHERS TO FISHERY MANAGEMENT IN THE MARINE EXTRAVIST RESERVE OF CORUMBAU, BRAZIL.

Fishing spot_____ Fishing gear_____

Type of fishing (subsistence or commercial) Do you have a boat?

What is its length? Education level?

Do you know of any banned fish? Which one(s) cannot be fished?

Did you hear about IBAMA's new species list? How did you hear of this?

How is the communication between the government and the fishers concerning the list?

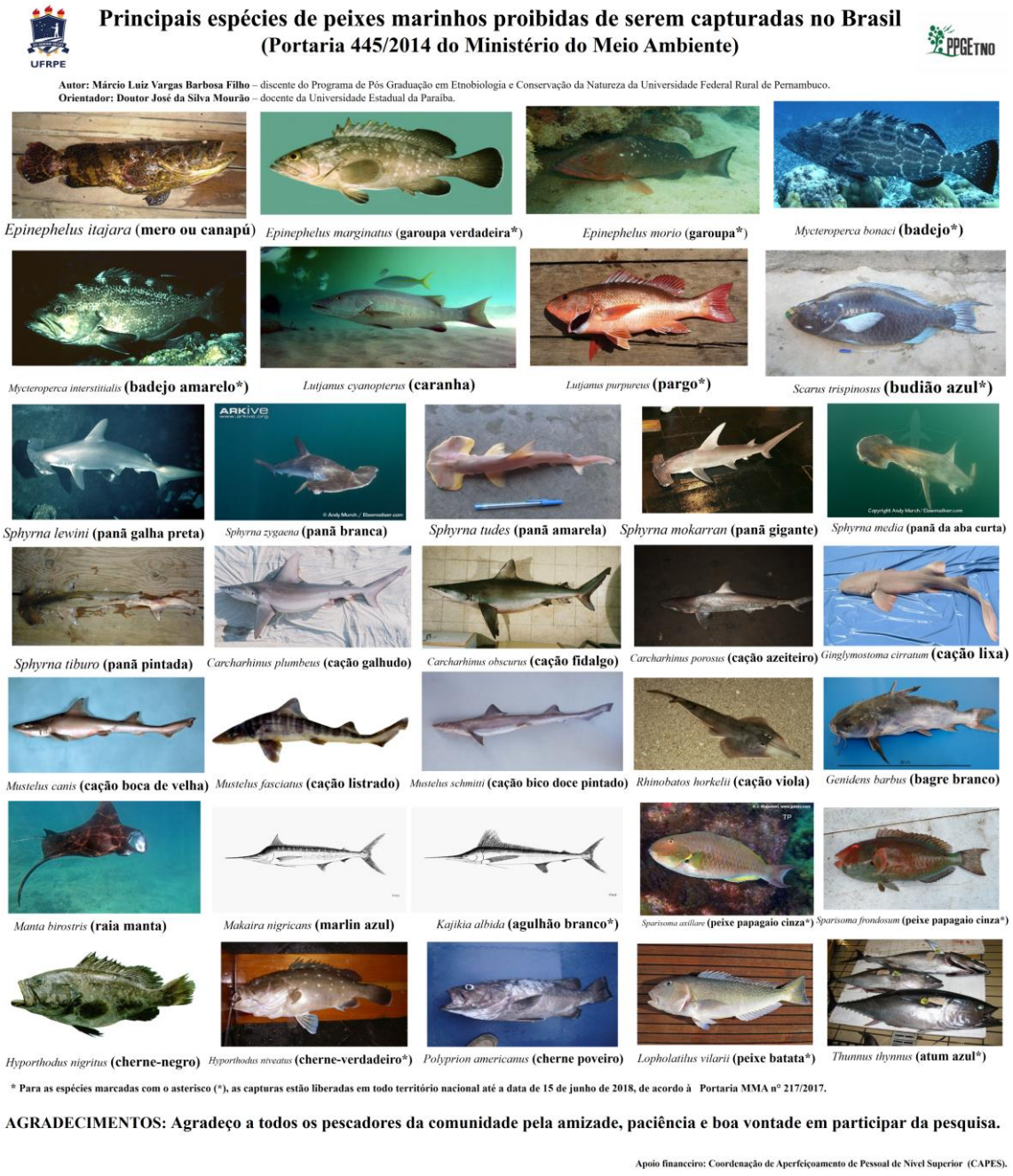
If it is not good, what can be done to improve communication?

What happens to the fisher if he/she is caught by environmental inspectors with a banned fish?

What to do if you catch a banned fish and it is still alive?

What to do if you catch a banned fish and it is dead?

Appendix B – Poster affixed to the walls in the Fishers Union at different MERC communities.*



***The authors enable the use and modification of the poster for scientific and clarification purposes.**

7. CAPÍTULO V – Manuscrito a ser enviado para "Ocean & Coastal Management"

Link com as normas para os autores: https://www.elsevier.com/journals/ocean-and-coastal-management/0964-5691/guide-for-authors

Title Page

Fisher perceptions confirm the socio-environmental effectiveness of a 20-year old Marine Protected Area in the main South Atlantic marine biodiversity hotspot

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Highlights

Fisher perceptions confirm the MPA socio-environmental effectiveness.

Most fishers (80%) noticed social benefits related to the MPA.

Most fishers admitted positive environmental changes.

Many fishers admitted that there is still problems in the MPA.

Manuscript

Fisher perceptions confirm the socio-environmental effectiveness of a 20-year old Marine Protected Area in the main South Atlantic marine biodiversity hotspot

Abstract

Studies on fisher knowledge, attitudes, and perceptions have been previously employed to assess the effectiveness of Marine Protected Areas (MPAs). In the present study, a total of 198 beneficiaries of the Corumbau Marine Extractive Reserve (MERC), Brazil, were interviewed to assess their perceptions regarding this MPA. Fishers understand the objectives and display positive attitudes about the MERC. Most of the respondents (n = 158; 79.8%) noticed changes in their quality of life due to the MERC, and they thanks to the prohibition of local industrial fisher activities from other regions. In addition, most (n = 176; 88.9%) understand that positive environmental changes incurred after the MERC establishment. Concerning this point, arguments prevailed that the MERC aids in preserving the area and that outside boats that carried out deleterious activities stopped operating in the region. Thus, although more in-depth studies are required to address new nuances of the MERC success case in curbing industrial fishing and generating positive socio-environmental impacts, the basic information contained in this study, more than enabling an updated baseline for the local context, represents a banner in favor of MPAs that contemplate the sustainable use of fishery resources.

Keywords: Local ecological knowledge; small-scale fishing; fishing territory; Abrolhos; Brazil.

Short title: Fisher perceptions about a MPA

1. Introduction

In recent years, continuous worsening of problems affecting world marine fisheries have been noted, mainly due to fishing resource depletion, environmental coastal areas degradation and the historic inefficiency of activity management strategies (FAO, 2018). In turn, the establishment of Marine Protected Areas (MPAs) represents one of the main adopted alternatives to reverse this situation (Chapman et al., 2013; Maccauley et al., 2015). Therefore, the analysis of the effectiveness of the establishment of MPAs concerning marine environment and fishing resource management is a highly relevant and crucial topic. However, despite several studies proving the feasibility of MPAs in protecting coastal and marine environments (Lester et al., 2009; Roberts et al., 2017; Sala and Giakoumi, 2018), debates on the effectiveness of this management tool in achieving its social and ecological goals are still observed (Edgar et al., 2014; Gill et al., 2017).

Thus, under the most varied approaches, scientists have developed a multitude of mechanisms and approaches to investigate MPA effectiveness. For example, several studies conducted worldwide with a focus on assessing MPA effectiveness have addressed the relationships between fishers and MPAs using different methodological approaches (Pita et al., 2011). In fact, since even restricted-use MPAs are influenced by fishing (Starr et al., 2015), investigating fisher knowledge, feelings and perceptions can be critical to the success of these management tools (FAO, 2011; Horta et al., 2013). In addition, the large number and variety of MPA modalities, as well the most diverse cultural contexts in which they are inserted, generate a diversity of results that represent a valuable opportunity to evaluate the limitations and successes of these devices in achieving ecological sustainability and social well-being goals (Pendlenton et al., 2017).

The rich local ecological knowledge (LEK) framework on marine ecosystems that fishers hold has been applied by scientists in assessing MPA effectiveness. Studies of this nature are especially necessary in developing countries, given that fisheries in these areas tend to be poor in scientific information that support an adequate governance of the marine environment (Purcell and Pomeroy, 2015; Chrysafi and Kuparinen, 2016; Amorim et al. 2019). In this context, evidence-based assessments related to the effectiveness of MPAs in recent years have focused on fisher perceptions (Benett and Dearden, 2014).

In fact, it is recognized that studies focusing on the perceptions of traditional human groups in relation to the environment can enable relevant data related to ecological impacts and conservation results, the legitimacy of governance processes and the

potential for acceptability and adherence to management rules by the involved parties (Benett, 2016). In this sense, scientific research that focuses on fishers MPA perceptions has evidenced a multitude of positive (Roberts et al., 2001; Leisher et al., 2007; Oberholzer et al., 2010; Shah et al., 2019), as well as negative (Hind et al., 2010; Benett and Dearden, 2014; Brueckner-Irwin et al., 2019) impacts on coastal population quality of life and marine environment conservation.

Marine Extractive Reserves (MERs) are noteworthy as the most significant effort supported by the Brazilian government to protect the common property resources on which traditional fishers depend on, although few research on the efficiency of this MPA model still exists in the country (Seixas et al., 2009). The idea of establishing an MPA in this region originated from native fishers in the second half of the 1990s, who claimed serious social, cultural and, mainly environmental damage caused by what they termed "invasion of outside boats" (Moura et al., 2009). These fishers demanded the creation of a Extractive Reserve (ER) conservation unit by the Brazilian government Accordingly, after many discussions, the MERC was established in response to this demand on September 21st, 2000.

The invasion of outside boats in the area began in the late 1980s, a time when medium and large vessels from neighboring cities and even from other Brazilian states began to operate in the coastal zone of this region, resulting in environmental impacts from the use of non-selective fishing gear and various social disorders in local communities (Diegues, 2008). Thus, this MPA was established with the aim of safeguarding the livelihood and culture of the native extractive population, whose quality of life is intrinsically linked to sustainable resource use. In fact, the National Conservation Unit System (SNMPA) defines Extractive Reserves as areas used by traditional extractive populations that aim to protect the livelihoods and culture of these populations, in addition to guaranteeing the sustainable use of local natural resources (Brasil, 2000). Thus, fisher exclusivity and in the use of natural resources in the area in this MPA modality is guaranteed for these populations.

In addition, another characteristic that defines this MPA modality in Brazil is a deliberative beneficiary participation character, giving these social actors the chance to to be protagonists in decisions related to resource use and conservation, as well as in the construction of management rules (Brasil, 2000). A Deliberative Council that usually meets every three months, made up of representatives from fishing communities, organized civil society, non-governmental organizations and public entities, is notably

present at the MERC (Moura et al., 2009). This MPA has a Use Plan, which was approved in 2003 (Ibama, 2003). The main fisheries management strategies set in this document are related to the prohibition of certain fishing gears within the MPA, restrictions in resource capture efforts, the existence of areas where certain gears are restricted and the establishment of new take zones, in addition to fishing landing monitoring, aiming at adaptive management (Moura et al., 2007). At the moment, a new fishing landing system is in the planning process and the MERC Management Plan, a document that governs the management of Brazilian Conservation Units (Brazil, 2000), is in the final preparation stages.

Even 20 years after the MERC implementation, there is still little information about its effectiveness. Moura et al. (2009) point out that, although the MERC has stopped industrial fishing in the region and has been a political mobilization factor for the construction of local fisheries co-management initiatives, there is still a lack of basic information regarding its socioeconomic effectiveness related to improving the lives of the MPA's beneficiary families. In turn, only one study on the effectiveness of MPA on the protection of fishery resources is available, carried out by Francini-Filho and Moura (2008). These authors compared the before and after abundance of reef species in relation to the establishment of a no-take zone within the MERC, and verified an increase in the biomass of certain species of commercial interest and an overflow effect for areas underlying the no-take zones after implementation (Francini-Filho and Moura, 2008). Given this context, this study aimed to analyze MERC beneficiary perceptions in relation to its socio-environmental effectiveness in order to create a baseline related to this theme for this MPA 20 years of its establishment.

2. Methods

2.1 Study area

The Corumbau Marine Extractive Reserve (MERC), on the Brazilian east coast, is located at the northern end of the Abrolhos Ocean Banks (Fig. 1). This is the main biodiversity hotspot in the tropical South Atlantic and contains the largest coral reef formations (8844 km^2) in Brazil (Kikuchi et al., 2010). The Abrolhos Ocean Banks are noteworthy for their strategic relevance in reef fish fishing, as they house relatively large populations of marine species with high commercial value, such as whiting, groupers, redfish, lobsters, shrimp and crabs (Dutra et al., 2011). On the other hand, fishing in the

region has not yet been well evaluated, is multispecific, and lacks systematic and structured programs in relation to environmental and fisheries monitoring (Previero and Gasalla, 2018). The Abrolhos Ocean Banks region is covered by a mosaic of Marine Protected Areas (MPAs), with an emphasis on the Abrolhos National Marine Park, in addition to the Cassurubá and Corumbau Marine Extraction Reserves (Moura et al., 2009).

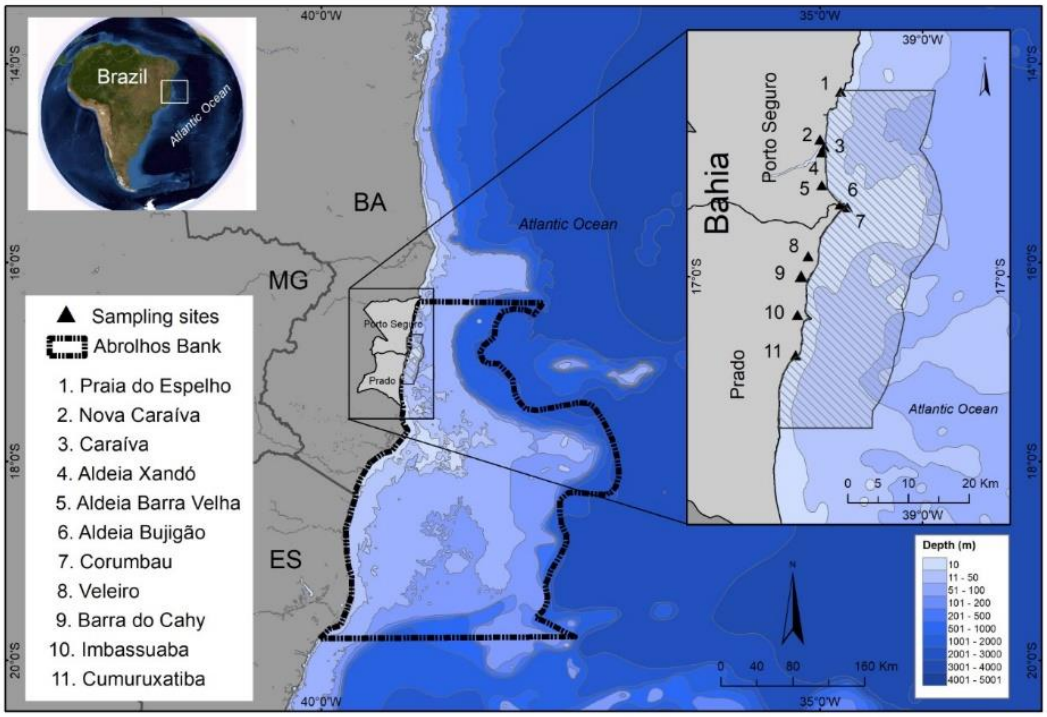

Fig. 1. Map of the Marine Extractive Reserve of Corumbau (MERC) and sampled fishing communities.

The MERC was established in 2000 and occupies 900 km^2, extending 62 km from the coast, between the municipalities of Prado and Porto Seguro (Previero et al., 2013), reaching eight nautical miles towards the open sea. Approximately 650 families are MERC beneficiaries, a group composed essentially of indigenous Pataxó individuals and their descendants (ICMBIO, 2019). The main economic activities verified in the study area are tourism, family farming and fishing, the latter occurring, mainly, in reefs and in unconsolidated substrate areas, through the use of hand lines, surface longlines, harpoons and diverse nets, in addition to motorized seine fishing (Diegues, 2008). Regionally, subsistence fishing predominates, with the eventual sale of the surplus. However, some fishers target their catch specifically for marketing at local inns and restaurants.

2.2 Data sampling and analysis

Semi-structured interviews (Huntington, 2000) were applied to 198 MERC beneficiaries, comprising 193 men and five women. A survey (Supplementary Material A) was applied to the interviewees, concerning questions focused on the interviewees' perceptions regarding the MERC. The interviews took place during 90 non-consecutive days, between April 2017 and February 2018. Fishers were individually interviewed, to prevent the presence of other people from influencing their responses. The interview audios were recorded using a digital voice recorder. The interviews took place in eleven communities in the two municipalities that make up the MERC.

The inclusion criteria for research participants comprised being over 18 years of age and conducting boat fishing at the MERC. The sample design consisted in a researcher visit to the main local leaders, who indicated the names of potential community collaborators who fit the established participant profile. With this name list, the researcher visited the community fishing spots and the homes of possible participants. Data collection was facilitated since a rapport was already in place, due to prior researcher visits in the assessed communities (Glesne, 1989). The sample size follows that recommended by Bernard (1988), considered representative under a 5% confidence interval in anthropology field studies.

The data were analyzed based on descriptive statistics by using quantitative methods. It involved calculating the absolute and relative frequencies of fisher quotes in relation to their knowledge, attitudes, and perceptions regarding the MERC effectiveness.

2.3 Legal procedure compliance

This study was approved by the Universidade Federal Rural de Pernambuco Research Ethics Committee (CEP - *Comitê de Ética em Pesquisas*) for research with humans (code: CAAE 65458016.0.0000.5207). The research project was also registered (authentication code number 33794187) at the Brazilian System for the Authorization of Information on Biodiversity (SISBIO - *Sistema de Autorização e Informação em Biodiversidade*), as demanded by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA - *Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis*), at the National System for Management of Genetic Heritage and Associated Traditional Knowledge (SISGEN - *Sistema Nacional de Gestão do Patrimônio Genético e do Conhecimento Tradicional Associado*) (registration number AB5B87A). The principal researcher was allowed admission into the indigenous area

(*Terra Indígena Barra Velha do Povo Pataxó*) by the National Indian Foundation (FUNAI - *Fundação Nacional do Índio*) (code 111/AAEP/PRES/2017).

3. RESULTS

When asked about the MERC role, 18 fishers were unable to answer, while 180 (9.1%) respondents who pointed out the MERC's functions gave 288 opinions. Four different response categories were noted (Table 1). Most of the fishers affirmed that MERC acts to preserve nature (46.5%) and protect fishers (34.4%).

Table 1 - Frequencies of respondents' opinions (n = 288) about MERC functions:

MERC functions	A. F. (R. F.)*
Preserve nature	134 (46.5)
Protect fishers	99 (34.4)
Banish outside fishers who fished in the region	54 (18.8)
To divide fishers	1 (0.3)
Total	**288 (100)**

(* A. F. = Absolute frequency; R. F. = Relative frequency, in %.)

When asked about their thoughts on MERC, most fishers (n = 187; 94.4%) affirmed that this MPA is good or excellent. Five fishers pointed out the existence of positive and negative points in relation to the MERC, four indicates that its existence is a bad thing and only two were indifferent. Table 2 indicates the 271 opinions given by the interviewees to justify such attitudes, totaling 261 in favor and 10 against:

Table 2 - Fisher opinions (n=271) on the fact that the MERC exists.

Positive opinions	A. F. (R. F.)*
It removed outside fishers who destroyed	115 (42.4)
It increased nature protection	79 29.2()
It increased fisher protection	57 (21)
It increased native politicization/awareness	10 (3.7)
Negative opinions	

I brought prohibitions through rules.	4 (1.5)
Many promises that were not kept were made	1 (0.4)
Fishers from Barra Velha persecute those from Corumbau	1 (0.4)
It removed outside trucks that bought fish	1 (0.4)
It increased conflict between natives increased	1 (0.4)
It forbade natives to make money from tourism.	1 (0.4)
MERC only serves to raise money from the government.	1 (0.4)
Total	**271 (100)**

(* A. F. = Absolute frequency; R. F. = Relative frequency, in %.)

3.1 Perceptions concerning socio-environmental MERC effectiveness

A total of 36 fishermen (18.2%) did not notice changes in their quality of life after the MERC was implemented and four did not know how to answer this question. However, most respondents (n = 158; 79.8%) noticed changes in their quality of life after MERC implementation. When they were asked how MERC changed their quality of life, 275 ways were pointed out, with 271 (98.5%) indicating a positive change in fisher quality of life and only 4 (1.5%) reporting negative changes (Table 3).

Table 3 - Ways (n = 275) in which MERC altered interviewee lives (n = 158).

Positive	N	%
It prohibited the action of outside fishers in the region	87	31.6
It yields more fish today	48	17.5
Native fisher protection has increased.	36	13.1
Nature protection has increased	31	11.3
It brought benefits to native fishers	20	7.3
It brought rights to native fishers	15	5.5
It brought knowledge to the natives.	11	4
It made native fishers more aware	9	3.3
It better organized fishing	8	2.9
It valued fish, as fewer people fish today	2	0.7
It organized the fishers	2	0.7

Today only the natives gain from tourism.	2	0.7
Negative		
It brought prohibitions that hampered native fishing	3	1.1
It forbade cattle breeding and harmed those who raised it.	1	0.4
Total	**275**	**100**

Fishers were also asked if they noticed changes in the environment after the MERC implementation, and most (N = 176; 88.9%) indicate that changes did indeed occur after the MERC implementation. When asked how they perceived these changes, 242 reasons were reported, and all of that denoting positive changes. Only 16 (8.1%) of the fishers pointed out that nothing has changed in the environment after the MERC implementation, and only six were unable to answer the question. Those who did not notice environmental changes attributed twelve reasons. The frequency of each response, both in relation to the reasons for the change and for the non-change in the natural environment, is displayed in Table 4.

Table 4 – Fisher perceptions (n=242) in relation to environmental changes and non-changes resulting from the MERC implementation.

Arguments related to environmental change	**N**
The MERC aided in preserving the area.	85
The outside boats that destroyed the area were driven out.	77
The amounts of fish are increasing.	40
The MERC prevented outside boats from continuing their destruction	16
The MERC rules prevent wrong things from happening	12
Increased fish breeding is ocurring after the MERC implementation	5
The MERC made fishermen more aware	3
Shrimp are gathering again after the MERC implementation	2
The restingas are more protected.	2
Arguments related to environmental non-change	
There is no supervision to prevent wrong things from happening	7
Fish continue to decline	2

Nobody respects the rules	1
The trawl net continues to destroy nature	1

3.2 Points to be strengthened in the MERC management

Fishers were also asked whether they currently perceive something to be happening in a context of MERC fishing, but that they understand that it is wrong and that, therefore, should not be occurring. Most (n = 139; 70.2%) revealed several situations that should not occur, while 53 fishermen (.8%) understand that there is nothing wrong with local fishing and another six did not know how to answer. Regarding the situations they consider inappropriate, 233 opinions were issued. The frequency in which they were cited for each answer is shown in Table 5:

Table 5 - Fisher opinions (n = 233) in relation to situations that should not occur at the MERC.

Fishing situations that should not occur at the MERC	**N**	**%**
Invasion of outside boats.	70	30
Illegal fishing.	25	10.7
Lack of supervision.	23	9.9
Rule breaches	22	9.4
Shrimp trawling.	16	6.9
Disunity among fishers.	9	3.9
Lack of incentives for fishers.	7	3
Corumbau people trawling in front of the community.	6	2.6
Mobile outsider nets who remove native nets.	5	2.1
Beach access closure by those who buy land on the beach. / Lost or abandoned nets on reefs that kill animals.	4/each	1.7/each
People who do not fish posing as fishers to gain benefits/People posing as beneficiaries even without having the rights/Eucalyptus plantations drying out springs, dams and wells/Foreign fishers who steal native nets.	3/ each	1.3/each
Rules being imposed in the wrong way/Anchors placed on the reefs/MERC headquarters are located far from the MERC/The fishing rules are very weak/Foreign fishers selling fish in	2/each	0.9/ each

MERC communities/Danger due to eucalyptus barges passing through native fishing areas.		
Lack of communication within the community/Fisher selfishness in wanting to catch all the fish/Irresponsible nautical traffic on rivers/Few fisher access to information concerning MERC rules/Leadership of communities that do not share the benefits/Few employees working at MERC/Risk of fishing without documents, as the Brazilian government currently does not make new fisher documents/Very strict MERC rules/MERC employees wanting to decide without understanding fishing/Cattle being raised in river sources/Natives who are against the MERC are also against the idea of a land MERC/Cars that illegally roam the beaches/Inspection officers who point guns at native fishers during boarding at sea/Difficulty in selling fish production/Pesticides from eucalyptus plantations destroy river springs and mangroves/Benefits are poorly distributed within communities/Eucalyptus barges that kills a lot of whales./The presence of outside armed fishers within the MERC causes native fear.	1/each	0.4/each
Total	**233**	**100**

Discussion

This assessment discusses new reflections on the MERC, by approaching the knowledge, attitudes and perceptions of its beneficiaries regarding the socio-environmental developments occurred at this MPA twenty years after its establishment. In turn, the strong support from interviewees to the MERC represents a banner in favor of MPAs, a fisheries management instrument with the potential to collaborate in maintaining the culture of small-scale fishermen in the face of the pressures and impacts of industrial fishing and large economic enterprises to which these companies are subjected to (Bené et al., 2005; Charles, 1992; James et al., 2018; Thomson, 1980). In addition, the data contained in this study represent new evidence that, even in the face of a rapid process socioeconomic and cultural transformation to which they are subjected to

(Menon et al., 2018; Nayak and Berkes, 2019), human groups comprising artisanal fishers have been politically organizing themselves in search of maintaining their ways of life. Respondents perceive positive changes due to the existence of the MERC. On the other hand, they indicate certain problems that still exist in the local socio-ecological system that make it difficult to achieve the intrinsic objectives of a sustainable use MPA.

When asked what the MERC purposes are, fisher responses focused mainly on the claims that it serves to protect nature, followed by the argument that its role is to protect fishers. In fact, in Brazil, the National System of Conservation Units recommends that Extractive Reserves aim at the conservation of natural resources in line with the guarantee of maintaining the ways of life of native populations (Brasil, 2000). Thus, the predominance of responses of this nature suggests the familiarity of these social actors with the MERC. The need to expel fishers from other regions triggered the process of creating the MERC leading to many responses about the MERC's functions along these lines. It is clear, therefore, that the interviewees, in general, display knowledge concerning the history of the MERC creation, given the gravity of the situation they faced with the presence of outsiders.

Furthermore, the expulsion of outside fishers was preponderant concerning the strong positive attitude of the interviewees regarding the MERC. Fisger views and feelings about the MERC existence are aligned with their knowledge related to the basic objectives of an MPA of this nature. This association, in itself, already represents an indication of its effectiveness. Responses related to the recognition of greater protection for nature and fishers by the MPA are also noteworthy. Significantly, a recognition that the MERC contributed to a greater politicization and awareness of the beneficiary public was also noted, a fact already pointed out by Moura et al. (2009). It is recognized that due involvement in management decisions is crucial for the greater cohesion and resilience of local populations to socio-environmental changes, in addition to increasing the chances of successful governance (Ruiz-Mallén; Corbera, 2013; Berkes, 2017; Nursey-Bray et al., 2018). In turn, a meta-analysis addressing local fisheries co-management schemes revealed that, in general, arrangements that have government support, appropriately sized teams and funding display a generally positive influence on the socioeconomic indicators of the assessed communities (Whitehouse and Fowler, 2018).

The interviewees' positive attitudes seem to stem from their perceptions of socio-environmental improvements arising from the MERC establishment. Regarding positive social impacts, the massive expulsion of outside fishers as noted in fisher testimonies is

again, noteworthy. In this sense, the increase in fishing income and nature protection as a whole is often attributed to the absence of "outsiders". In turn, the recognition of positive social impacts due to the MERC is usually linked to the recognition of positive environmental impacts and *vice versa*. Given that these fishers are part of a socio-ecological system, this finding should not be surprising or even worth noting. Nevertheless, the effectiveness of MPAs is usually studied under a purely biological approach, with MPAs that exclusively meet environmental conservation goals being presented as "successes" (Agardy et al., 2003; Giakoumi et al., 2018). On the other hand, it is recognized that, in the long run, social factors usually determine the biological success of MPAs and that, therefore, social science studies are essential in assessing the effectiveness of these management instruments (Christie, 2004).

It should be noted that fishers also observe certain positive social changes that are less materially tangible, such as greater access to their rights, knowledge, awareness and the organization of fishing and themselves as a category, as pointed out by Moura et al. (2009). Basic socio-economic information of MERC beneficiaries is practically non-existent, following the pattern of data scarcity of this nature for artisanal fisheries in Brazil (Vasconcellos et al., 2011) and in other developing countries (FAO, 2015). Thus, it is strongly recommended that this type of data be collected at the MERC in future assessments, especially to more deeply understand the influence of this MPA on the quality of life and well-being of its beneficiaries.

In relation to environmental conservation, positive perceptions also prevailed in interviewee testimonies. MERC's prohibition of outside fishers was a crucial factor for such perceptions, since the interviewees refer to these outsiders as "causing destruction". Therefore, after the MERC implementation, the interviewees recognized an increase in fish catches. Francini-Filho and Moura (2008) reported an increase in the biomass of certain reef fish species at the MERC, and the spillover effect within a no-take zone for adjacent areas. However, for the Abrolhos region, the limitation of biological data on the life history of commercial species still represents an obstacle for fisheries management (Dutra et al., 2005; Previero; Gasalla, 2018). Therefore, the consolidation of a monitoring system for fishing landings is required for the study area, allowing for stock assessment of exploited target species.

Despite high fisher satisfaction and the recognition of positive socio-environmental impacts resulting from the MERC implementation, several situations which fishers still consider inappropriate or harmful still occur in the region. A total of

39 different situations were pointed out that fishers believe damage the welfare of these social actors and/or the quality of the local environment. Situations related to marine fishing were the most noteworthy. However, they complain of situations that, although not directly linked to fishing, make it difficult to reproduce their ways of life. In fact, the main long-term threats to the maintenance of the biodiverse coastal and marine ecosystems of the Abrolhos region are the non-implementation and non-compliance with the laws and regulations of the existing MPA mosaic and inefficient fisheries management, in addition to major projects related to cellulose and oil industries (Dutra et al., 2005). In fact, studies have pointed out that factors cited by fishers, such as those related to the low governmental capacity to enforce regulations and curb external socio-economic pressures, as crucial to the inefficiency of MPAs worldwide (Guidetti et al., 2008; Leverington et al., 2008; Ruiz-Mallén and Corbera, 2013; Masud, 2019).

At the MERC specifically, the weak government presence and the delay in making judicial decisions on the formal granting of rights to use maritime territory allows for the strengthening of partnerships between large businessmen and community members and discredit MERC as a governance instrument for promoting equity and improving local quality of life (Moura et al., 2009). The scenario of pressures for the advancement of real estate speculation contributes to the community breakdown and appears to be a pattern for artisanal fisher communities in Brazil, who have been forced to dispose of their lands and move to cities (Vasconcellos et al., 2011). The invasion of outsiders with vessels of high fishing power, often equipped with banned fishing equipment, still represents the most recurring complaint. Thus, fishers point out that the lack of environmental inspection and monitoring actions by the responsible bodies is the main reason for these facts.

Along the southern coast of Bahia, several records of complaints by small-scale fishers regarding the lack of environmental inspections that facilitate the work of foreign fishermen in their territories are noted (Dutra et al., 2005; Alarcon et al., 2009; Moura et al., 2009; Cardozo et al., 2012; Andrade and Schiavetti, 2014; Barbosa-Filho et al., 2017, 2020). With regard to MPAs established in Brazilian reef areas, the scarcity of human and financial resources is the main limitation for the effective contribution of MPAs towards marine biodiversity conservation and fisheries improvement of Dutra et al., 2005). FAO (2018) points out that unfair competition from industrial fishers in relation to small-scale fishers is one of the main threats to the livelihoods and food security of these populations. In turn, illegal fishing currently represents the main threat to the

sustainable exploitation of global fisheries resources, to the food security of fishers in developing countries and to marine ecosystems as a whole (Agnew et al., 2009), in addition to representing a serious impediment to the success of fisheries management efforts (Macfadyen et al., 2019).

In developing countries, the fight against illegal fishers must include the design of strong policies and practical and organized actions that contribute to the risk-benefit ratio for offenders (Ghazali et al., 2019; Okafor-Yarwood, 2019). For example, in 2015, a harsh fishing policy to combat illegal fishing was imposed in the region of the Natuna district, in Indonesia, which has been shown to be effective in combating the illicit activities of national and foreign boats (Ismail et al., 2018). The implemented policy, which eradicated illegal fishing and, consequently, contributed to increases in fishing production, income and even the political and productive organization of native fishers, included the performance of ostensible inspection actions and contemplated the deportation of foreign fishers, the opening of criminal cases, the payment of high fines and even vessel sinking (Ismail et al., 2018).

Final considerations

Despite the lack of organization by the Brazilian federal government to effectively deal with the management of MPAs and artisanal fisheries as a whole, it is clear that there is still strong support for the MERC among native fishermen. The fact that this MPA almost eliminated the presence of non-native fishermen from the MERC seems to be a major factor in the support of this public towards the MPA. Therefore, this MPA can be seen as a success case in combating large-scale fishing, especially activities carried out in coastal regions, which have increasingly been causing serious environmental impacts and conflicts worldwide. Thus, this is a challenge for the Brazilian government and for fisheries managers to carry out coordinated and interdisciplinary efforts to adapt the points that the interviewees believe require improvement.

The fact that respondents in general perceive positive socio-environmental impacts arising from the MERC makes this fisheries management experience into a banner in favor of sustainable use MPAs, both nationally and internationally. This is an even more notorious fact when one considers that a disintegration process of the formerly internationally applauded Brazilian environmental policies has been noted in the last years (Fearnside, 2016; Crouzeilles et al., 2017; Escobar, 2019). In this context, small-scale fishing seems to be relegated to the last of the Brazilian government's priorities

(Gerhardinger et al., 2017). From a global perspective, this success case points to the potential for MPAs of this modality to contribute in maintaining the resilience of small-scale fishermen's societies in the face of the overwhelming challenges inherent to the Anthropocene.

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Submission declaration

The authors declare that the work has not been published previously, that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder.

Declaration of Interest

The authors declare that there are no conflicts of interest or any kind of interest that could influence the outcome of this work.

Contributions

MLVBF collaborated in the study design, data analysis and writing of the text. GBGS collaborated with the data analysis, writing and revising the manuscript. SFL collaborated in interpretations and analyses of the data, and writing the manuscript. SS collaborated in writing and revising the manuscript. RAHD collaborated in writing and revising the manuscript. JSM collaborated in the design, writing and revision of the manuscript. All of the authors approved the final manuscript.

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Supplementary Material A - Survey applied to the fishers during data sampling in MERC.

Survey

Federal Rural University of Pernambuco
Postgraduate Program in Ethnobiology and Nature Conservation
Leading researcher: Márcio Luiz Vargas Barbosa Filho

PROJECT: *COMANAGEMENT IN SOCIOECOLOGICAL SYSTEMS: FISHER CONTRIBUTIONS TO FISHERY MANAGEMENT IN THE MARINE EXTRAVIST RESERVE OF CORUMBAU, BRAZIL.*

Fishing spot_____ Fishing gear_____

Type of fishing (subsistence or commercial) Do you have a boat?

What is its length? Education level?

Do you know what is the MERC purpose? Why does it exist?

Could you please tell me the MERC history since the beginning?

What is your opinion on MERC existence?

Do you think MERC changed something positively or negatively on fisher lives? If so, what?

Do you think MERC changed something positively or negatively on the marine environment where you are fishing? If so, what?

Do you think something is happening in the region that should not? If so, what?

8. CAPÍTULO IV - CONSIDERAÇÕES FINAIS

8.1 Principais conclusões

Os resultados da pesquisa denotam diversas nuances dos desafios, limitações e, principalmente, da capacidade de organização política do público beneficiário da REMC. Desse modo, verifica-se que estes são capazes de participar ativamente da cogestão pesqueira e de desempenhar um papel central na construção de mudanças socioambientais positivas no sistema socioecológico do qual são integrantes. O interesse de zelar pelo seu território pesqueiro e seus modos de vida são demonstrados por estes atores sociais desde quando se uniram e se organizaram para demandar do poder público o estabelecimento de uma Área Marinha Protegida no fim da década de 1990. Embora nos últimos anos poucas pesquisas tenham sido realizadas no intuito de avaliar a efetividade da REMC na melhoria da qualidade de vida, na conscientização e na mobilização política dos beneficiários, o apoio e senso de pertencimento destes atores sociais em relação à REMC fica nítido ao longo dos diferentes capítulos da tese.

Os graves problemas decorrentes atuação de pescadores de outras regiões, que levaram aos nativos das comunidades locais lutarem pela expulsão destes forasteiros, foi em grande parte superado por conta do estabelecimento da REMC. Nesse sentido, os pescadores revelam que logo nos primeiros anos após o estabelecimento da AMP as frequente ações de monitoramento e fiscalização ambiental do poder público para combater a entrada de pescadores forasteiros, surtiram efeito. Por isso, as entradas furtivas destas pessoas no território da REMC diminuíram consideravelmente em relação ao período pré REMC, embora ainda aconteçam. Esta diminuição da "invasão dos pescadores de fora" é o fator central no apoio dos pescadores à AMP. Aliás, como demonstra o Capítulo V, os pescadores percebem mudanças socioambientais positivas decorrentes da REMC. Contudo, é preciso avaliar tais informações com mais profundidade e pela aplicação de outras metodologias.

Como é possível verificar no capítulo II, que teve seu foco na espécie *L. synagris*, impactos ambientais decorrentes da atuação dos pescadores de outras regiões ainda são notados no contexto da pesca local. É provável que este impacto também tenha se dado sobre outras espécies de peixes e outros organismos marinhos, sendo que são necessários outros estudos que abordem esta temática. Tais impactos ocasionados por pescadores forasteiros também são documentados no capítulo III, no qual os pescadores denunciam

que aqueles que ainda invadem a REMC realizam, dentre outras pescarias altamente impactantes, a pesca de mergulho com o auxílio de compressores no interior da AMP. De fato, a pesca com compressores tornou-se uma prática recorrente em todo o nordeste do Brasil. Para a biologicamente rica região do Banco de Abrolhos, a prática se alastrou e gera impactos ecológicos e humanos catastróficos e ainda pouco mensurados. Este tipo de pesca está disseminada em vários países em desenvolvimento, sobretudo nas Américas e na Ásia, e a conservação dos ecossistemas marinhos demanda que esta prática seja combatida de modo enérgico.

Em contrapartida, os pescadores foram enfáticos em reclamar que o poder público não tem sido capaz de combater a atuação de pescadores de fora que entram na REMC para pescar com compressores. As reclamações dos participantes em relação à incapacidade do Estado brasileiro cumprir seu papel de salvaguarda do ambiente local e da proteção dos modos de vidas das populações locais é uma constante nos diversos capítulos da tese. Por exemplo, após da publicação da Portaria 445, os gestores da pesca na REMC e demais órgãos de classe não foram capazes de realizar ações para informar e sensibilizar os pescadores em relação às espécies ameaçadas no Brasil, bem como sobre a moratória imposta a elas. Este fato fica evidente no capítulo IV, onde é verificado um baixo reconhecimento dos participantes de quais são as espécies contempladas pela moratória.

No capítulo V, a recorrência das alegações dos participantes em relação à infinidade de acontecimentos negativos e pressões a que ainda encontra-se submetido o público da REMC, também denota a incapacidade ou a falta de interesse das instituições brasileiras em gerir a pesca de modo adequado. Diante deste grave contexto, é fundamental que o país invista adequadamente na gestão da REMC. Nesse sentido, é bem provável que contextos semelhantes estejam ocorrendo nas diversas AMPs existentes ao longo do litoral brasileiro. Diante desta grave realidade, nota-se que o grande potencial humano verificado nesta pesquisa para contribuir na gestão da REMC, infelizmente, está sendo desperdiçado. Por sua vez, torna-se difícil imaginar um país próspero e que viabilize uma boa qualidade de vida à sua população, tendo suas riquezas sendo tão mal gerenciadas.

8.2 Contribuições teóricas e/ou metodológicas da tese

A presente pesquisa enfocou o conhecimento ecológico de pescadores e pescadoras da Reserva Extrativista Marinha do Corumbau, Brasil, com o objetivo de analisar o potencial da utilização deste arcabouço de saberes na construção da cogestão pesqueira. Os resultados encontrados nos diferentes capítulos demonstraram-se altamente relevantes e passíveis de contribuir na construção deste arranjo de gerenciamento pesqueiro. Desse modo, esta tese contribui com informações semelhantes àquelas que têm sido veiculadas em diversos estudos que demonstram, mais do que a viabilidade, a necessidade de que sejam garantidos os direitos das populações nativas litorâneas em decidir sobre a gestão dos recursos que utilizam e dos territórios nos quais encontram-se inseridos. Nesse sentido, o conhecimento ecológico dos quais os pescadores da REMC são detentores viabiliza que estes participem de modo direto na construção e fortalecimento da cogestão da pesca nesta AMP, fato veementemente debatido entre os cientistas da pesca em uma perspectiva global.

O capítulo II, que abordou as percepções dos entrevistados sobre a história ecológica da pesca de *L. synagris*, revela que, tal qual observado em diversas regiões do mundo, além desta espécie figurar como um dos principais alvos da pesca de pequena escala, a população destes peixes também encontra-se em declínio. Além disso, o estudo aponta indícios do fenômeno da mudança de linha de base na pesca de *L. synagris*. Foi possível, também, construir pontos de referências e definições mais apropriadas para as metas de reabilitação da população deste recurso pesqueiro, uma vez que as informações repassadas no presente estudo pelos pescadores mais experientes podem servir como um parâmetro inicial para o desenvolvimento de metas de conservação para *L. synagris*. Assim, as ações locais de manejo devem ter a meta de que ao menos desembarques ocasionais alcancem rendimentos individuais diários próximos àqueles relatados pelos pescadores mais experientes. Apesar de a síndrome de mudança de linha de base ser atualmente um tema em voga na ciência pesqueira, até o momento têm sido raros os estudos que atribuem uma meta para a conservação de recursos que são explorados em contextos onde ocorrem este fenômeno.

O capítulo III, sobre os conhecimentos e atitudes dos pescadores em relaçã à atuação de pescadores forasteiros com equipamentos de compressor, traz informações relevantes sobre este tipo de prática. Ao menos no Brasil, ainda não existiam trabalhos que enfocassem esta temática com a profundidade que a gravidade da situação demanda.

Apesar de existirem estudos realizados na Ásia nos quais pescadores de compressor são entrevistados, no Brasil, onde a prática é proibida, poucos estudos citaram a ocorrência desse tipo de pescaria. Possivelmente, a proibição de se pescar dessa maneira, inibe pescadores de compressor em participar desse tipo de empreendimento científico. Assim, o capítulo a este respeito inova, gerando dados a partir de pescadores que não atuam com compressores, mas sentem-se prejudicados pelos impactos decorrentes da prática. Desse modo, esta parte da tese reforça a teoria de que pescadores de pequena escala desenvolveram a prática do manejo tradicional, figurando com mantenedores da biodiversidade. Assim, pode-se encarar a espontaneidade e interesse dos participantes em defender seu território denunciando práticas nocivas como mais uma nuance do manejo tradicional dos recursos dos quais dependem.

O capítulo IV abordou os conhecimentos dos pescadores sobre a Portaria 445, na qual consta a lista de espécies de peixes ameaçadas no Brasil e, por isso, sob moratória. Neste estudo, a necessidade do desenvolvimento de estratégias de gestão de maneira participativa é demonstrada. A construção da Portaria sem a participação da classe dos pescadores brasileiros tem sido alvo de muitas polêmicas e disputas judiciais nos últimos anos. O fato de ter sido imposta por meio de um processo *top-down* (de cima para baixo) abriu margem para que pescadores, sobretudo os industriais, contestassem a lista. Além disso, aparentemente, como demonstra este estudo, é provável que os pescadores brasileiros não estejam muito familiarizados no reconhecimento das espécies que estão na lista. Este fato, por sua vez, pode inviabilizar o sucesso dessa estratégia e, assim, causar mais impactos ecológicos e também sociais, pelo risco dos pescadores serem punidos com multas severas. Desse modo, este representa um estudo de caso, como raros que existem no mundo, que apontam para a ineficácia de impor moratórias na pesca sem que estas sejam desenvolvidas com a participação de pescadores.

O capítulo V, sobre as percepções dos pescadores a respeito da efetividade da REMC, demonstrou uma ampla aceitação destes atores sociais a ela e que estes percebem a predominância de impactos positivos decorrentes do estabelecimento desta AMP. Pesquisas em diversas partes do mundo têm demonstrado uma variedade de posturas de pescadores em relação às AMPs. Contudo, a ênfase dos entrevistados em apoiar a REMC é incomum, em relação a estes estudos. O fato de REMC ter restringido contundentemente a atuação de pescadores industriais é o principal ponto gerador deste apoio. Além de demonstrar que pescadores podem apoiar e se envolver na gestão de AMPs, este estudo reforça a teoria de que AMPs podem ser capazes de frear a pesca de grande escala em

determinadas regiões. Também, denota como AMPs de uso sustentável podem contribuir para mobilizar politicamente populações de pescadores de pequena escala e trazer impactos socioambientais positivos em sistemas socioecológicos pesqueiros.

8.3 Principais limitações do estudo

A principal limitação do estudo é o fato de não ter sido possível alcançar o objetivo de contribuir para a construção do Plano de Manejo da REMC. Esta era uma das metas iniciais do projeto. Contudo, a construção do Plano de Manejo se iniciou antes do começo da coleta de dados e o fim do processo se deu em 2018, logo após o fim da fase de coletas. Assim, não foi viável ter as informações devidamente analisadas e estruturadas para que servissem de auxiliares na construção do Plano de Manejo. Outras limitações são listadas a seguir:

- No passado, mais precisamente entre 2009 e 2011, a REMC contava com um sistema de monitoramento e estatística de desembarques pesqueiros, que foi interrompido por falta de verbas. Assim encontra-se até o momento. Atualmente, a gestão da REMC se prepara para reativar este sistema, que prevê a participação dos pescadores na coleta de dados. Espera-se que este seja um dos pilares do novo sistema de gestão da REMC. A pesquisa, infelizmente, não contemplou a investigação dos conhecimentos dos pescadores a respeito dos sistemas de monitoramento e estatística de desembarques pesqueiros. Também, não contemplou questões sobre as atitudes destes em relação à possibilidade de reativação deste sistema local.

- Apesar da doação de pôsteres informativos com fotos de algumas espécies de peixes listadas na Portaria 445 e que ocorrem na região, apenas em quatro comunidades a entrega foi acompanhada de palestras a respeito da Portaria e suas implicações. Nas outras, ainda não foi possível realizar ações desta natureza, que ocorrerão na forma de devolutivas ao fim da pesquisa.

- Por motivos diversos, não foi possível contar com a colaboração das duas pessoas que constam como coorientadores no projeto inicial. Este fato foi um desafio substancial na construção da tese e, possivelmente, representa uma limitação na qualidade da mesma.

- O fato de não terem sido aplicadas questões específicas a respeito dos conhecimentos dos entrevistados sobre a pesca de mergulho com compressores limitou as possibilidades de abordar a temática em uma perspectiva quantitativa. Este fato limitou a qualidade do estudo e, consequentemente, da tese.

- Foram coletadas informações suficientes para embasar ao menos mais três capítulos. Contudo, o tempo restante para a integralização do curso de doutorado não permitiu a escrita destes três artigos científicos:

Artigo 1: Este abordará os conhecimentos, atitudes e percepções dos pescadores em relação às zonas fechadas para a pesca (*No-Take Zones*) no interior da REMC.

Artigo 2: Sob uma perspectiva etnográfica, o trabalho abordará os conhecimentos dos pescadores e suas práticas em relação à pesca tradicional. Mais especificamente, este abordará a prática dos pescadores em marcarem os pontos em terra para encontrar as zonas de pesca recifais e também os segredos que existem relacionados à tais zonas. Nesse trabalho, será possível analisar tais práticas sob uma perspectiva diacrônica, para entender como o advento de novas tecnologias e as mudanças culturais na pesca local têm influenciado a marcação e o segredo sobre as melhores zonas de pesca.

Artigo 3: Este trabalho abordará as percepções dos pescadores em relação ao número de espécies de peixes em situação de declínio, sob o enfoque do fenômeno da mudança da linha de base. Por sua vez, buscar-se-á relacionar o número de espécie reconhecidas por cada pescador como em situação de declínio com seus indicadores de atitudes em relação às regras que limitam o esforço de pesca de peixes na Resex.

Desse modo, o fato de não ter sido possível escrever estes três trabalhos para fazerem parte da tese representa uma limitação da mesma.

8.4 Propostas de investigações futuras

Abaixo são listadas algumas temáticas de interesse para a pesquisas relacionadas ao comanejo pesqueiro na REMC:

- Investigação sobre os conhecimentos e atitudes dos pescadores a respeito dos sistemas de monitoramento e estatística de desembarques pesqueiros e em relação à possibilidade da reativação do sistema local de monitoramento.

- Pesquisa que aborde os conhecimentos e percepções dos pescadores sobre a época estabelecida para o defeso da pesca de camarões. Existem muitas críticas dos pescadores locais de que a época estabelecida não é a adequada à proteção deste recurso pesqueiro.

- Estudo que aborde os atuais conflitos entre os pescadores locais e alguns de fora que ainda insistem em adentrar os limites da Resex.

- Pesquisa sobre os desafios dos pescadores em acessar as zonas de praias por meio de alguns caminhos e estradas tradicionalmente utilizadas e que hoje encontram-se no interior de propriedades privadas.

- É necessária a realização de pesquisa relacionadas a indicadores sociais que objetivem avaliar a influência da REMC na qualidade de vida dos seus beneficiários.

- Faz-se necessário investigar a influência e os impactos advindos do agronegócio, sobretudo pelo plantio de eucalipto, pimenta, mamão e outras culturas vegetais, além da criação de gado, sobre os rios locais.

- Representa, também, uma demanda a realização de um estudo etnográfico a respeito das diversas pescarias realizadas pelos índios da Etnia Pataxó.

É digno ressaltar que as propostas de pesquisas supracitadas partiram da observação do pesquisador e dos depoimentos dos pescadores durante as entrevistas e em reuniões.

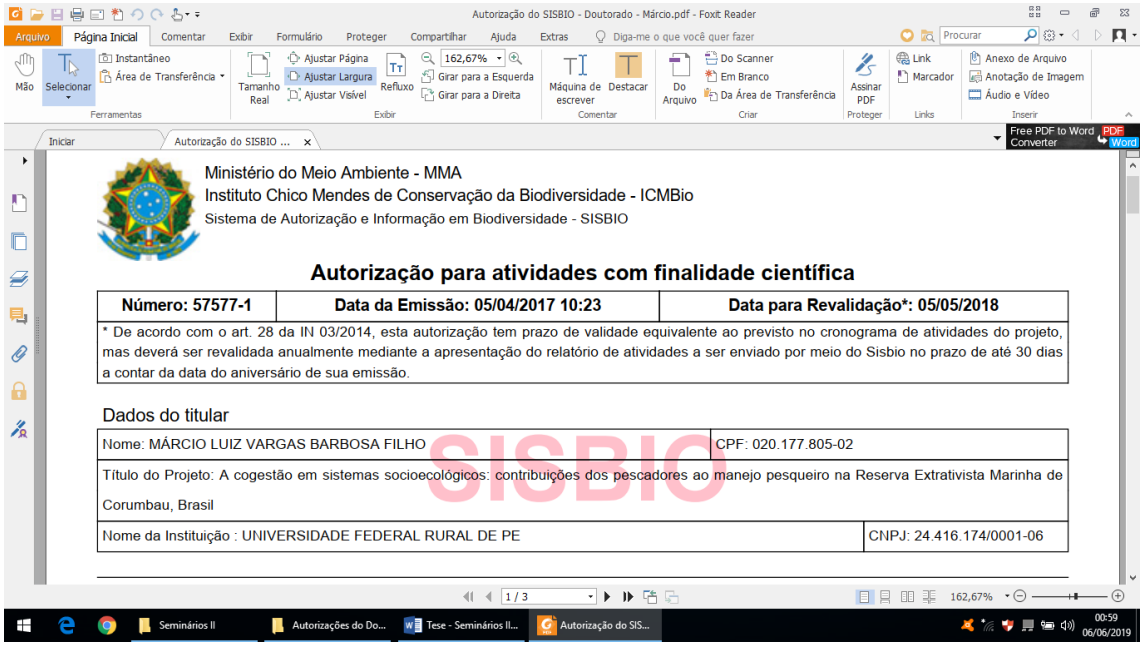
8.5 Orçamento (custo do projeto)

Custos estimados para amostragem por entrevistas na REMC

O presente trabalho foi realizado com apoio da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Código de Financiamento 001. Este apoio se deu na forma de bolsa de doutorado ao aluno Márcio Luiz Vargas Barbosa Filho. As despesas para amostragem por meio de entrevistas incluem a compra de combustível, aluguel de residências e alimentação. Foram gastos cerca de R$ 26.400,00 em 90 dias de coleta, o que representa um custo médio diário de R$ 293,33. Com esse investimento diário, foram realizadas 222 entrevistas a pescadores e pescadoras de onze diferentes comunidades da Reserva Extrativista Marinha do Corumbau. Assim, em média, para cada entrevista foram gastos R$118,92. Deste valor total, foram gastos ainda R$1.120,00 com a impressão de 11 pôsteres em lona com fotos de 33 espécies de peixes marinhos ameaçados de extinção. Os referidos pôsteres foram doados para cada uma das comunidades participantes em momentos de atividades devolutivas.

9. ANEXOS

Anexo 1 – Autorização do SISBIO para a realização de pesquisa científica na Reserva Extrativista Marinha do Corumbau.



Autorização do SISBIO - Doutorado - Márcio.pdf - Foxit Reader

Ministério do Meio Ambiente - MMA
Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio
Sistema de Autorização e Informação em Biodiversidade - SISBIO

Autorização para atividades com finalidade científica

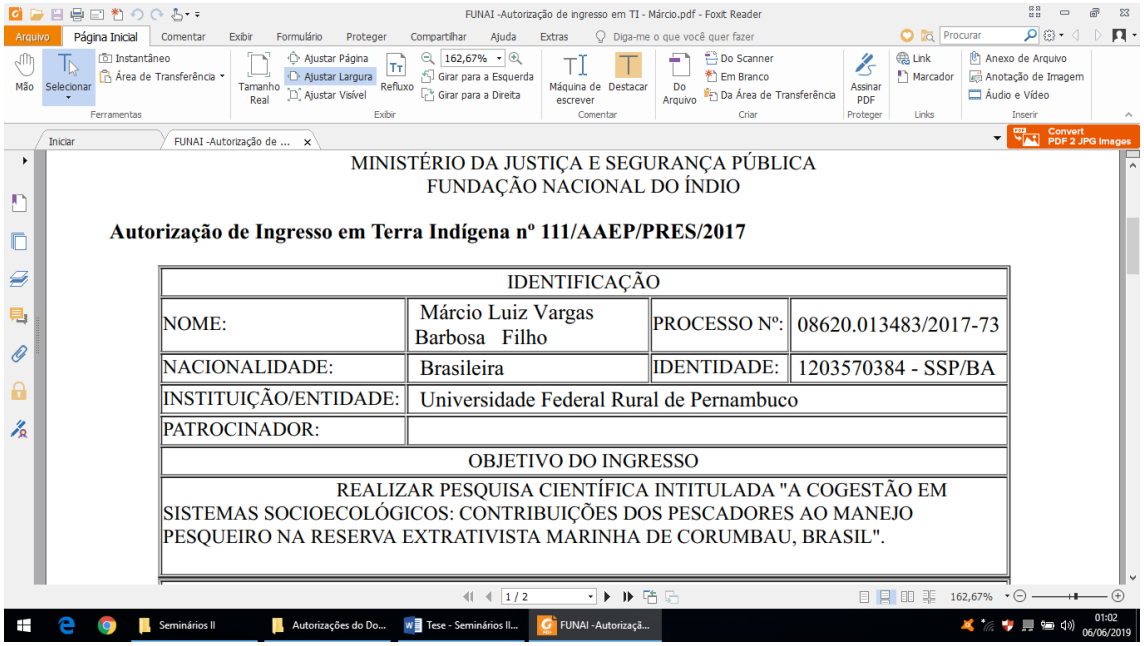
Número: 57577-1	Data da Emissão: 05/04/2017 10:23	Data para Revalidação*: 05/05/2018

* De acordo com o art. 28 da IN 03/2014, esta autorização tem prazo de validade equivalente ao previsto no cronograma de atividades do projeto, mas deverá ser revalidada anualmente mediante a apresentação do relatório de atividades a ser enviado por meio do Sisbio no prazo de até 30 dias a contar da data do aniversário de sua emissão.

Dados do titular

Nome: MÁRCIO LUIZ VARGAS BARBOSA FILHO	CPF: 020.177.805-02
Título do Projeto: A cogestão em sistemas socioecológicos: contribuições dos pescadores ao manejo pesqueiro na Reserva Extrativista Marinha de Corumbau, Brasil	
Nome da Instituição : UNIVERSIDADE FEDERAL RURAL DE PE	CNPJ: 24.416.174/0001-06

Anexo 2 – Autorização da Fundação Nacional do Índio (FUNAI) para o ingresso do pesquisador na Terra Indígena Barra Velha do Povo Pataxó, Porto Seguro, Bahia.

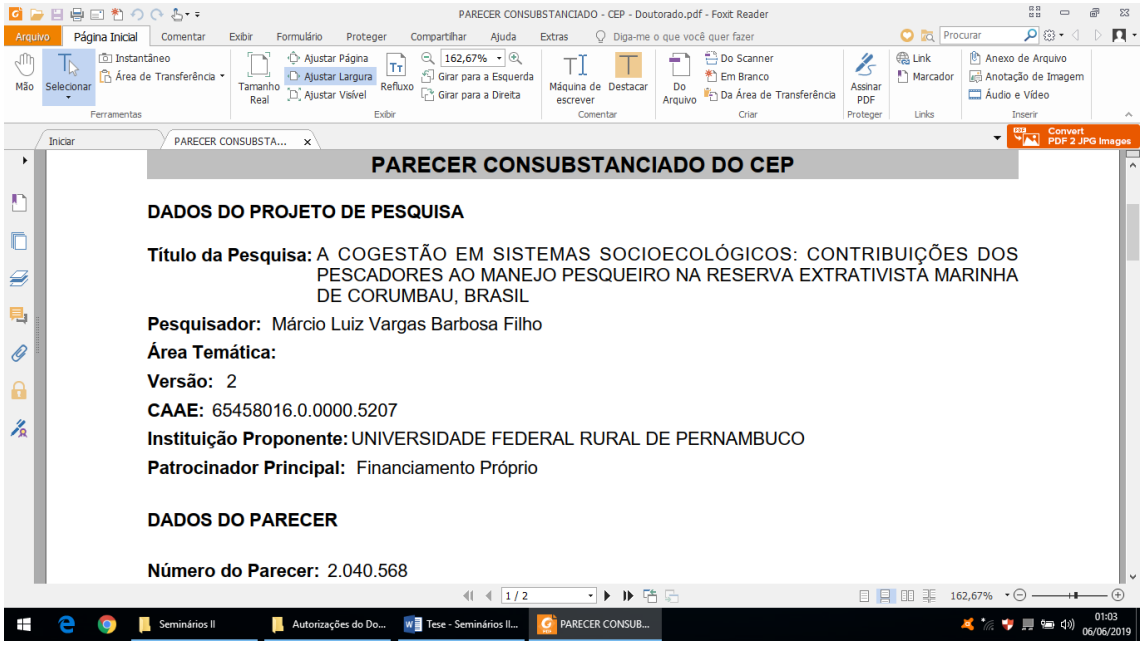


MINISTÉRIO DA JUSTIÇA E SEGURANÇA PÚBLICA
FUNDAÇÃO NACIONAL DO ÍNDIO

Autorização de Ingresso em Terra Indígena nº 111/AAEP/PRES/2017

IDENTIFICAÇÃO			
NOME:	Márcio Luiz Vargas Barbosa Filho	PROCESSO Nº:	08620.013483/2017-73
NACIONALIDADE:	Brasileira	IDENTIDADE:	1203570384 - SSP/BA
INSTITUIÇÃO/ENTIDADE:	Universidade Federal Rural de Pernambuco		
PATROCINADOR:			
OBJETIVO DO INGRESSO			
REALIZAR PESQUISA CIENTÍFICA INTITULADA "A COGESTÃO EM SISTEMAS SOCIOECOLÓGICOS: CONTRIBUIÇÕES DOS PESCADORES AO MANEJO PESQUEIRO NA RESERVA EXTRATIVISTA MARINHA DE CORUMBAU, BRASIL".			

Anexo 3 – Autorização do Comitê de Ética em Pesquisa com Seres Humanos da Universidade de Pernambuco.



PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: A COGESTÃO EM SISTEMAS SOCIOECOLÓGICOS: CONTRIBUIÇÕES DOS PESCADORES AO MANEJO PESQUEIRO NA RESERVA EXTRATIVISTA MARINHA DE CORUMBAU, BRASIL

Pesquisador: Márcio Luiz Vargas Barbosa Filho

Área Temática:

Versão: 2

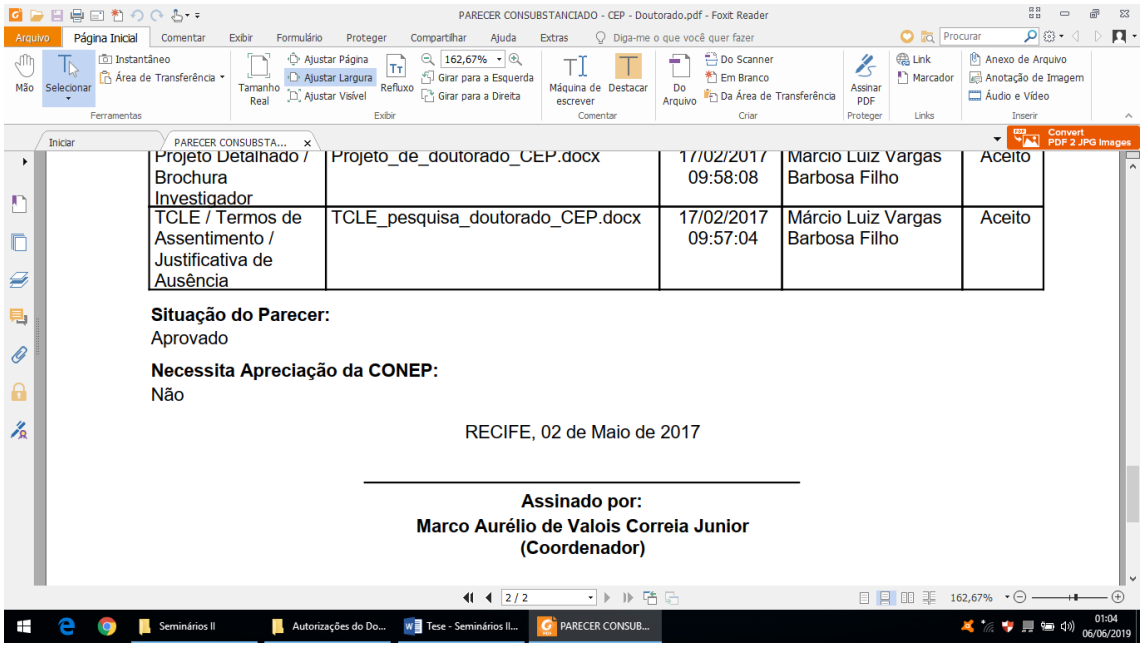
CAAE: 65458016.0.0000.5207

Instituição Proponente: UNIVERSIDADE FEDERAL RURAL DE PERNAMBUCO

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 2.040.568



Projeto Detalhado / Brochura Investigador	Projeto_de_doutorado_CEP.docx	17/02/2017 09:58:08	Marcio Luiz Vargas Barbosa Filho	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_pesquisa_doutorado_CEP.docx	17/02/2017 09:57:04	Márcio Luiz Vargas Barbosa Filho	Aceito

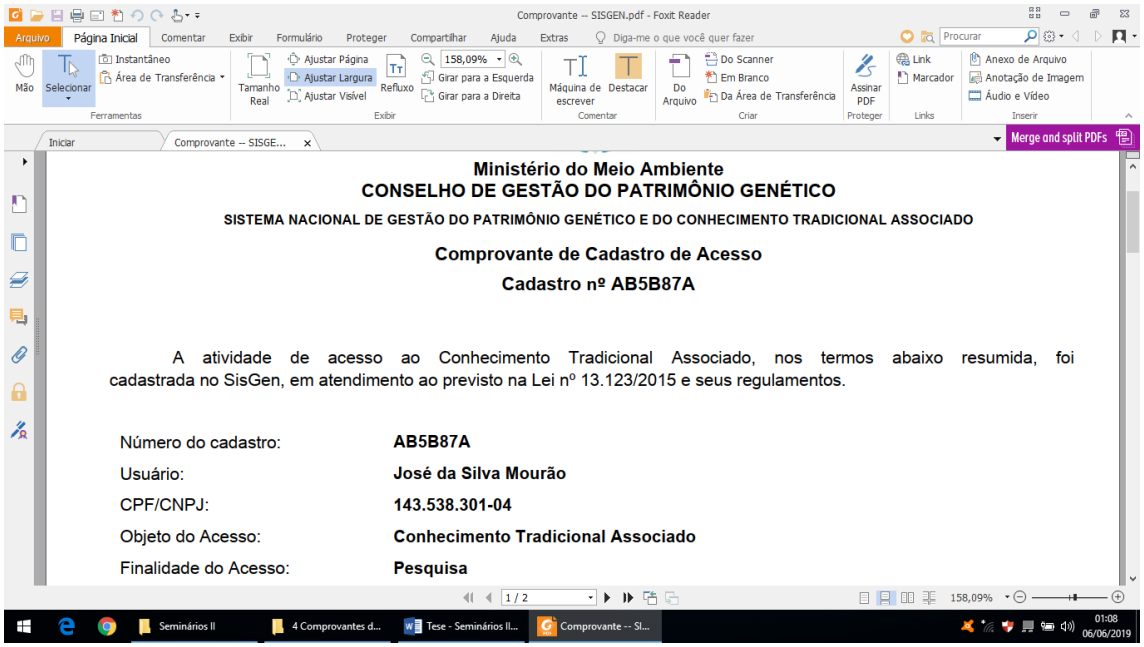
Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

RECIFE, 02 de Maio de 2017

Assinado por:
Marco Aurélio de Valois Correia Junior
(Coordenador)

Anexo 4 – Comprovante do cadastro da pesquisa no Sistema Nacional de Gestão do Patrimônio Genético e do Conhecimento Tradicional Associado (SISGEN).



Ministério do Meio Ambiente
CONSELHO DE GESTÃO DO PATRIMÔNIO GENÉTICO

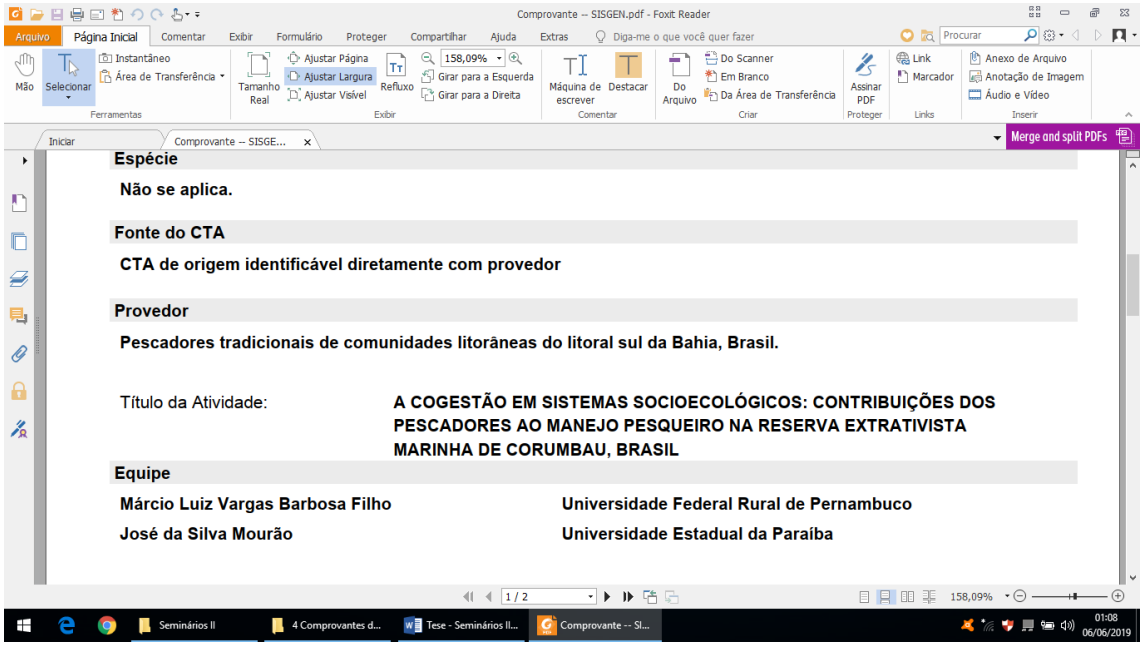
SISTEMA NACIONAL DE GESTÃO DO PATRIMÔNIO GENÉTICO E DO CONHECIMENTO TRADICIONAL ASSOCIADO

Comprovante de Cadastro de Acesso

Cadastro nº AB5B87A

A atividade de acesso ao Conhecimento Tradicional Associado, nos termos abaixo resumida, foi cadastrada no SisGen, em atendimento ao previsto na Lei nº 13.123/2015 e seus regulamentos.

Número do cadastro:	**AB5B87A**
Usuário:	**José da Silva Mourão**
CPF/CNPJ:	**143.538.301-04**
Objeto do Acesso:	**Conhecimento Tradicional Associado**
Finalidade do Acesso:	**Pesquisa**



Espécie

Não se aplica.

Fonte do CTA

CTA de origem identificável diretamente com provedor

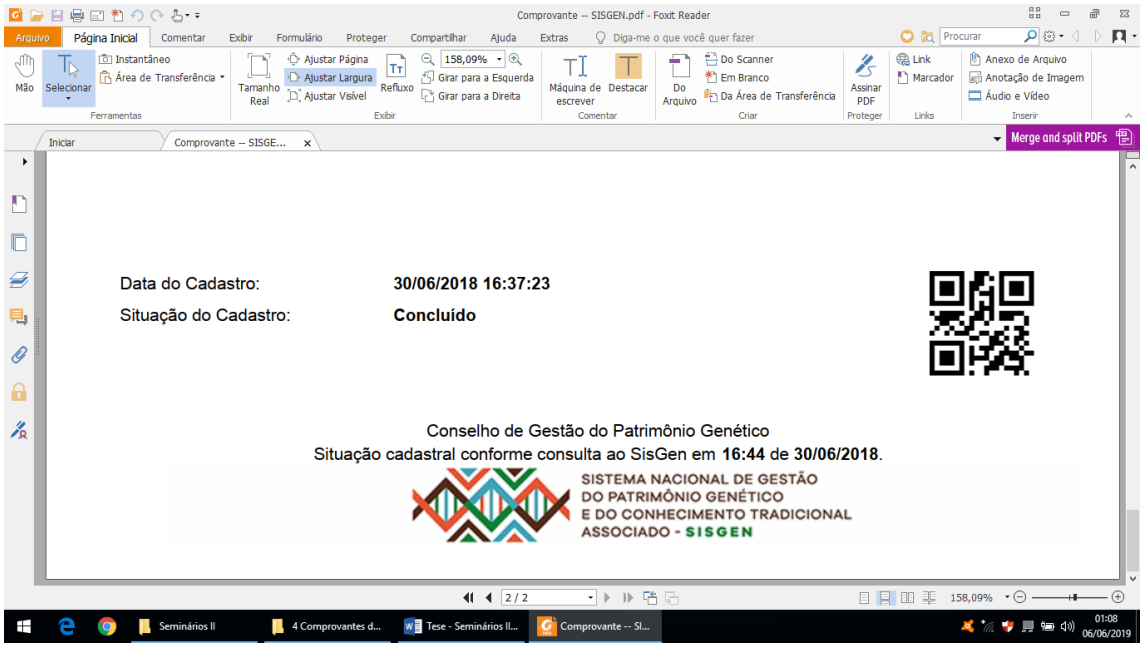
Provedor

Pescadores tradicionais de comunidades litorâneas do litoral sul da Bahia, Brasil.

Título da Atividade:	**A COGESTÃO EM SISTEMAS SOCIOECOLÓGICOS: CONTRIBUIÇÕES DOS PESCADORES AO MANEJO PESQUEIRO NA RESERVA EXTRATIVISTA MARINHA DE CORUMBAU, BRASIL**

Equipe

Márcio Luiz Vargas Barbosa Filho	**Universidade Federal Rural de Pernambuco**
José da Silva Mourão	**Universidade Estadual da Paraíba**


Comprovante -- SISGEN.pdf - Foxit Reader
Data do Cadastro: 30/06/2018 16:37:23
Situação do Cadastro: Concluído
Conselho de Gestão do Patrimônio Genético
Situação cadastral conforme consulta ao SisGen em 16:44 de 30/06/2018.
SISTEMA NACIONAL DE GESTÃO DO PATRIMÔNIO GENÉTICO E DO CONHECIMENTO TRADICIONAL ASSOCIADO - SISGEN