UNIVERSIDADE FEDERAL RURAL DE PERNAMBUCO

PRÓ-REITORIA DE PESQUISA E PÓS-GRADUAÇÃO

PROGRAMA DE PÓS-GRADUAÇÃO EM RECURSOS PESQUEIROS E AQUICULTURA

AVALIAÇÃO INTEGRADA DA SUSTENTABILIDADE DE PESCARIAS ARTESANAIS COSTEIRAS NO ESTADO DO AMAPÁ, LITORAL AMAZÔNICO, BRASIL

Érica Antunes Jimenez

Tese apresentada ao Programa de Pós-Graduação em Recursos Pesqueiros e Aquicultura da Universidade Federal Rural de Pernambuco como exigência para obtenção do título de Doutora.

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Tese julgada adequada para obtenção do título de doutora em Recursos Pesqueiros e Aquicultura da Universidade Federal Rural de Pernambuco. Defendida e aprovada em 03/12/2019 pela seguinte Banca Examinadora:

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Dedicatória

Aos pescadores e pescadoras artesanais, por suas trajetórias de luta e resistência.

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Resumo

Este estudo analisou a sustentabilidade de pescarias artesanais costeiras no estado do Amapá, através de três abordagens complementares: uma descrição da dinâmica das pescarias e de sua cadeia de valor, uma caracterização dos conflitos pesqueiros e do estado dos recursos explorados na percepção dos pescadores e uma avaliação das pescarias com base em 32 indicadores multidisciplinares (ecológicos, econômicos, éticos, institucionais, sociais e tecnológicos) pelo método Rapfish. Os dados foram coletados entre 2014 e 2017 através de entrevistas com 395 pescadores, donos de embarcações e líderes comunitários. As entrevistas abrangeram o perfil socioeconômico dos pescadores, a captura e comercialização de pescado, os conflitos pesqueiros, o estado dos recursos explorados, entre outros temas. Entrevistas com funcionários de três empresas de processamento de pescado incluíram informações sobre espécies, produtos, mercado e transporte. Os dados das entrevistas foram complementados com observações de campo, registros fotográficos, interações com membros das comunidades, participação em reuniões das colônias de pescadores e dos conselhos das unidades de conservação e opinião de especialistas em pesca. Os entrevistados eram principalmente homens, com idade média entre 37–43 anos, baixa escolaridade e renda, e experiência de pesca de 20–24 anos em média. As comunidades pesqueiras apresentam alta dependência da pesca como fonte de alimento e renda, escassez de meios de subsistência alternativos, fraca representação política, falta de assistência governamental e dependência de intermediários para escoamento da produção. As pescarias são multiespecíficas, capturando espécies com ciclos de vida longos e vulnerabilidade moderada a alta, com o emprego de barcos de pequeno porte (6–12 metros) e redes de emalhe e espinhéis. A cadeia de valor compreende pescadores, atravessadores e empresas de processamento e exportação, abastecendo os mercados doméstico e internacional. A dinâmica do setor pesqueiro reflete uma variedade de estímulos locais a internacionais. Localmente, destaca-se a vulnerabilidade socioeconômica dos pescadores, a falta de infraestrutura pós-captura, a distância dos mercados consumidores e a ausência de controle efetivo sobre o esforço de pesca. Nacionalmente, o comércio é impulsionado pelo crescente consumo de pescado, enquanto a demanda por bexiga natatória estimula o comércio internacional. O principal conflito citado estava relacionado ao crescente fluxo de pescadores migrantes para a área de estudo, intensificando a competição por territórios de pesca e por recursos pesqueiros limitados, uma vez que 75% dos entrevistados citaram uma diminuição na abundância das espécies exploradas. Há também conflitos relacionados ao acesso aos recursos pesqueiros em unidades de conservação de proteção integral e na região transfronteiriça com a Guiana Francesa. Soma-se a estes fatores a ausência de políticas públicas eficazes, a carência de estruturas sólidas de governança e as grandes lacunas de conhecimento. Os efeitos cumulativos desses fatores resultam em pescarias com desempenho desfavorável em termos de sustentabilidade. A análise do método Rapfish indicou que a maioria das pescarias apresenta desempenho ecológico, econômico e social “menos sustentável”, bem como uma performance institucional e ética “ruim”. Nesse contexto, recomenda-se uma transição para um regime de gestão e governança colaborativa, bem como a implementação de arranjos capazes de lidar com estoques pesqueiros e atividades transfronteiriças. São necessários também esforços para a construção de instituições sociais coesas, capazes de participar efetivamente do processo de tomada de decisão e assumir responsabilidades na gestão da pesca e conservação dos ecossistemas marinhos.

Palavras-chave: Cadeia de valor do pescado; Conflitos pesqueiros; Rapfish; Abordagem Ecossistêmica; Gestão pesqueira.

Abstract

This study analyzed the sustainability of coastal small-scale fisheries in the state of Amapá through three complementary approaches: a description of the dynamics of fisheries and its value chain, a characterization of fisheries conflicts and the status of exploited resources according to fishers' perception and an assessment of fisheries based on 32 multidisciplinary indicators (ecological, economic, ethical, institutional, social and technological) using the Rapfish method. Data were collected between 2014 and 2017 through interviews with 395 fishers, boat owners and community leaders. The interviews covered the socioeconomic profile of fishers, the catching and marketing of fish, the fisheries conflicts, the status of the exploited resources, among other topics. Interviews with officials of three fish processing companies included information on species, products, market and transportation. Interview data were complemented by field observations, photographic records, interactions with community members, participation in meetings of the Fishers' Colonies and the councils of the No-Take Zones, and the opinion of fishery experts. Respondents were mainly men, with an average age of 37–43 years, low education and income, and an average fishing experience of 20–24 years. Fishing communities have high dependence on fishing as source of food and income, scarcity of alternative livelihoods, poor political representation, lack of government assistance and reliance on intermediaries for production flow. Fishing are multispecies, catching fishes with long life cycles and moderate to high vulnerability, using small-sized boats (6–12 meters) and gillnets and longlines. The value chain comprises fishers, middlemen and processing and exporting companies, supplying the domestic and international markets. The dynamics of the fishing sector reflect a variety of local to international drivers. Locally, the main drivers are the socioeconomic vulnerability of fishers, the lack of post-harvest infrastructure, the distance from consumers and the lack of effective control over fishing effort. Nationally, trade is driven by increasing fish consumption, while demand for swim bladder drives international trade. The main conflict cited was the increasing flow of migrant fishers to the study area, intensifying competition for fishing territories and limited fishery resources, as 75% of respondents cited a decrease in the abundance of exploited species. There are also conflicts related to access to fishery resources in No-Take Zones and in the transboundary region with French Guiana. In addition to these factors, there are the absence of effective public policies, the lack of solid governance structures and the large knowledge gaps. The cumulative effects of these factors result in fisheries with unfavorable performance in terms of sustainability. The Rapfish analysis indicated that most fisheries are ecologically, economically, and socially "less sustainable" and institutionally and ethically "bad". In this context, a transition to a collaborative management and governance regime is recommended, as well as the implementation of arrangements capable of dealing with transboundary fish stocks and activities. Efforts are also needed to build cohesive social institutions capable of effectively participate in decision-making process and assume responsibilities in fisheries management and conservation of marine ecosystems.

Keywords: Fish value chain; Fisheries conflicts; Rapfish; Ecosystem Approach; Fisheries Management.

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1. Introdução

1.1. Contextualização da pesquisa

A potencial contribuição do setor pesqueiro no contexto de segurança alimentar e alívio da pobreza é evidente. A produção global de pescado atingiu 171 milhões de toneladas em 2016, dos quais 53% foram provenientes da pesca extrativa e 88% foram utilizadas diretamente para consumo humano (FAO, 2018). Além disso, as cadeias de valor da pesca extrativa abrangem aproximadamente 120 milhões de trabalhadores em tempo integral e parcial, dos quais 97% vivem em países em desenvolvimento e, entre estes, 90% atuam no setor de pequena escala (WORLD BANK, 2012).

Deste modo, a pesca de pequena escala ou artesanal (os termos são utilizados como sinônimos neste estudo) desempenha um papel crucial, fornecendo empregos, renda e alimentos para milhões de pessoas (BÉNÉ, 2006; KAWARAZUKA e BÉNÉ, 2010; BÉNÉ et al., 2015; FAO, 2015, 2016). Essa atividade ocorre em diferentes contextos de desenvolvimento e arranjos políticos, com uma grande diversidade de aspectos geofísicos, bioecológicos e socioeconômicos (BERKES et al., 2001; SALAS et al., 2011; BATISTA et al., 2014). As características comumente atribuídas ao setor de pequena escala incluem alcance limitado de operação, dependência dos recursos locais, trabalho intensivo, baixo investimento de capital, métodos de captura de baixa tecnologia, áreas de desembarque remotas e dispersas nos territórios e diferentes níveis de dependência de intermediários para comercialização e custeio das operações de pesca (SALAS et al., 2007; WORLD BANK, 2012; KOLDING et al., 2014).

Por ser um setor com estreita conexão com os ecossistemas marinhos, os atores envolvidos na pesca de pequena escala têm um importante papel a desempenhar na sustentabilidade e governança dos oceanos e apresentam potencial para contribuir com a implementação de diferentes metas no contexto dos Objetivos de Desenvolvimento Sustentável das Nações Unidas (UNITED NATIONS, 2015), como segurança alimentar, bem-estar das comunidades, igualdade de gênero, redução da pobreza e crescimento econômico (FAO, 2017; SAID e CHUENPAGDEE, 2019).

Entretanto, apesar da reconhecida importância, a pesca de pequena escala enfrenta diferentes tipos de vulnerabilidade e marginalização (ANDREW et al., 2007; ALLISON et al., 2012; CHUENPAGDEE e JENTOFT, 2018), além de ser negligenciada em termos de gestão e oculta ou subestimada nas estatísticas oficiais, o que está relacionado, entre outros fatores, à uma crônica falta de capacidade institucional, que inclui restrições de recursos humanos e financeiros (ANDREW et al., 2007; PURCELL e POMEROY, 2015; POMEROY et al., 2016; SMITH e BASURTO, 2019) e despreparo para lidar com a pluralidade e a natureza difusa e multiespecífica do setor, assim como o grande número de pessoas envolvidas e sua distribuição espacial em áreas extensas e isoladas (BERKES et al., 2001; KOLDING et al., 2014).

À carência de mecanismos adequados de gestão e governança e altos níveis de pobreza e conflitos enfrentados pela pesca de pequena escala (PINHEIRO et al., 2015; PURCELL e POMEROY, 2015; CHUENPAGDEE e JENTOFT, 2018; LOPES et al., 2019), soma-se o aumento da demanda global de pescado e os indícios de esgotamento de diversos estoques pesqueiros (COSTELLO et al., 2012; FAO, 2018), bem como os impactos não dimensionados dos descartes de fauna acompanhante, que representam aproximadamente 10% do total anual das capturas marinhas mundiais (ZELLER et al., 2018). Há ainda os impactos das diferentes pressões antrópicas que afetam todos os oceanos, como destruição de habitat, perda de biodiversidade, poluição e mudanças climáticas (ISLAM e TANAKA, 2004; HALPERN et al., 2008, 2015; BUTCHART et al., 2010), ameaçando os meios de subsistência de milhões de pessoas.

Assim como observado mundialmente, a pesca de pequena escala é historicamente negligenciada pelos órgãos competentes no Brasil, onde a gestão pesqueira é marcada por décadas de acesso aberto, com poucas ações de controle, monitoramento e fiscalização, e com foco em políticas de subsídios para aumento da capacidade da frota e promoção da produção pesqueira (ABDALLAH e SUMAILA, 2007; AZEVEDO e PIERRI, 2014; DI DARIO et al., 2015; PINHEIRO et al., 2015; MATTOS et al., 2017).

O setor pesqueiro brasileiro emprega mais de um milhão de pescadores profissionais formalmente reconhecidos (MPA, 2012a) e gera mais de três milhões de empregos indiretos (MPA, 2012b). Aproximadamente 99% dos pescadores são de pequena escala e 80% vivem no norte e nordeste (MPA, 2012a). Estas duas regiões abrigam 60% dos consumidores regulares de pescado do país (SONODA et al., 2012) e foram responsáveis por 55% (780.345,2 t) da produção nacional de pescado em 2011 e 51% (280.277,30 t) do total proveniente da pesca extrativa marinha (MPA, 2013).

Particularmente no contexto amazônico (norte do Brasil), a pesca é uma fonte primária de proteína animal e renda, bem como um modo de vida para as populações costeiras e ribeirinhas (ALMEIDA et al., 2003; SILVA e BEGOSSI, 2009; CASTELLO et al., 2011; RUFFINO, 2014; ISAAC et al., 2015). A pesca de pequena escala é predominante, mas no litoral também ocorrem capturas de larga escala ou industriais. A produção pesqueira é vendida através de intermediários que abastecem os mercados locais, nacional e internacional (ISAAC-NAHUM, 2006; BATISTA et al., 2012; BENTES et al., 2012; ALMEIDA et al., 2014; RUFFINO, 2014).

Na costa amazônica, que inclui os estados do Amapá, Pará e Maranhão, a pesca de pequena escala emprega diferentes tipos de embarcações, apetrechos, técnicas de captura e locais de desembarque (ISAAC-NAHUM, 2006; LUCENA FRÉDOU e ASANO-FILHO, 2006; ISAAC et al., 2009; ALMEIDA et al., 2011). As capturas são multiespecíficas e as principais espécies desembarcadas pertencem às famílias Sciaenidae e Ariidae, como *Cynoscion acoupa, Macrodon ancylodon, Sciades parkeri, Bagre bagre* e *Sciades proops*, além de coletas manuais de caranguejo (*Ucides cordatus*) e mariscos (ISAAC-NAHUM, 2006; ISAAC et al., 2009; ALMEIDA et al., 2011). Em relação à pesca industrial, a frota de arrasto é direcionada à *Penaeus subtilis, P. brasiliensis* e *Brachyplatystoma vaillantii*, enquanto *Lutjanus purpureus* é alvo das capturas com armadilhas (ISAAC et al., 2009; LUCENA FRÉDOU et al., 2009).

Historicamente, as políticas pesqueiras têm promovido o desenvolvimento da pesca na costa amazônica, incentivando o aumento do esforço e do poder de captura das frotas e reduzindo os custos de operação por meio de subsídios, enquanto a maioria das medidas de regulamentação concentra-se na pesca industrial (ISAAC et al., 2009; BENTES et al., 2012). Entretanto, o desempenho das pescarias indica que essa política não é mais adequada ao contexto local, uma vez que há registros de tendências de capturas decrescentes para vários recursos, como *S. parkeri*, *C. acoupa*, *L. purpureus*, *M. ancylodon* e *Scomberomorus brasiliensis* (LUCENA FRÉDOU e ASANO-FILHO, 2006; ISAAC et al., 2009; ALMEIDA et al., 2014; MOURÃO et al., 2014; CHAO et al., 2015).

Particularmente no Amapá, apesar da importância da pesca para as comunidades locais, e do potencial da atividade em contribuir com o desenvolvimento econômico do estado, não há diretrizes governamentais definidas para a gestão do setor e a condição atual das pescarias e dos recursos explorados é pouco conhecida. Há uma grande lacuna de informações para subsidiar a formulação de políticas públicas que garantam uma exploração sustentável e resiliente de longo prazo. Este cenário é preocupante, pois há mais de 16 mil pescadores no estado (SISRGP, 2016), que dependem da pesca como fonte de renda e alimentos em uma região onde meios de subsistência alternativos são escassos.

Entre 2000 e 2011, o estado do Amapá apresentou uma produção média anual de aproximadamente 15 mil toneladas de pescado[1] proveniente da pesca extrativa. Nesse período, a produção média da pesca marinha e estuarina foi de 5.400 toneladas por ano, sendo que os desembarques ocorrem sobretudo nos municípios de Oiapoque, Calçoene e Amapá, no norte do estado, e as principais espécies capturadas incluem *Cynoscion virescens*, *C. acoupa*, *Sciades couma*, *S. proops* e *S. parkeri* (Figura 1) (PROZEE, 2006). A frota pesqueira atuante no litoral é composta por aproximadamente 500 embarcações motorizadas de madeira, distribuídas em três categorias: canoas e barcos de pequeno e médio porte (Figura 2) (JIMENEZ et al., 2019).

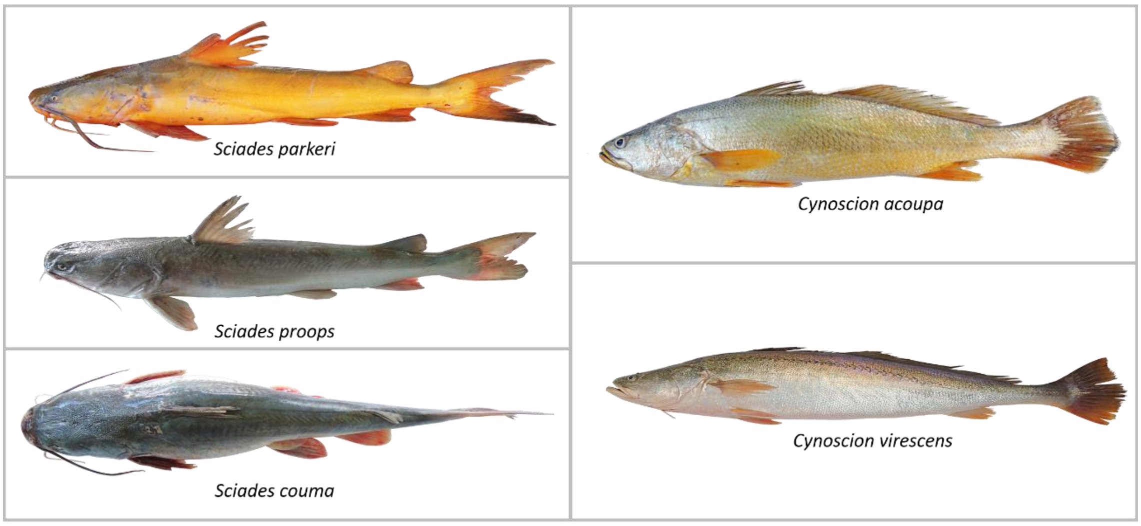

Fig. 1. Principais recursos capturados pela pesca costeira de pequena escala no estado do Amapá, Brasil. Fonte: Jimenez et al. (2017).

Fig. 2. Embarcações utilizadas pela pesca costeira de pequena escala no estado do Amapá, Brasil.

[1] Dados disponíveis no online no website do Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio): www.icmbio.gov.br/cepsul/acervo-digital

Apesar da indisponibilidade de dados precisos, é reconhecido que o esforço de pesca no litoral amapaense aumentou consideravelmente nas últimas décadas, sobretudo com a intensificação da atuação da frota do Pará na região, que tem acirrado a competição por territórios de pesca e recursos pesqueiros (MARINHO, 2009; CAÑETE e CAÑETE; SANTOS, 2015; SILVA et al., 2016; AMANAJÁS, 2018), alguns destes com sinais de esgotamento, como *S. parkeri* e *C. acoupa* (CHAO et al., 2015; ICMBIO, 2018). A localização das áreas de pesca no interior e no entorno de unidades de conservação de proteção integral e na região transfronteiriça com a Guiana Francesa agrava o cenário de conflitos e adiciona maior complexidade e desafios à gestão do setor pesqueiro local.

O cenário exposto reforça a importância de compreender as diferentes dimensões e fatores envolvidos na exploração dos recursos pesqueiros no litoral amapaense e suas interações, bem como os problemas enfrentados pelo setor, para orientar os gestores e formuladores de políticas públicas na tomada de decisões adequadas às condições locais. Neste contexto reside o tema central deste estudo, que busca contribuir para o preenchimento de algumas destas lacunas de informação, através de uma avaliação do estado das pescarias no litoral norte amapaense e da identificação de desafios e diretrizes visando à sustentabilidade a longo prazo. Notavelmente, este é o primeiro estudo que adota uma perspectiva integrada de análise da pesca no estado.

Deste modo, o estudo inclui três componentes complementares. Primeiro, um artigo introdutório fornece uma visão geral da dinâmica das pescarias e da cadeia de valor do pescado, incorporando uma descrição dos principais fatores que impulsionam o setor. Segundo, uma análise dos conflitos e do *status* dos recursos explorados fornece uma visão sobre os problemas e desafios enfrentados pelo setor pesqueiro. Terceiro, uma avaliação multidisciplinar do desempenho das pescarias em termos de sustentabilidade fornece diretrizes sobre onde priorizar os esforços de gestão. Por fim, são apresentadas as considerações finais do estudo, contendo uma síntese das informações abordadas nestes três componentes e recomendações para melhorar o sistema de gestão e governança do setor pesqueiro e avançar em direção a pescarias mais sustentáveis.

1.2. Objetivos

Este estudo teve como objetivo realizar uma análise integrada e multidisciplinar da sustentabilidade de pescarias artesanais costeiras no estado do Amapá, incluindo os municípios de Oiapoque, Calçoene e Amapá, onde concentram-se as capturas e os desembarques da pesca extrativa marinha. Para alcançar este objetivo, a tese foi dividida em três artigos científicos complementares, conforme descrito a seguir.

No artigo 1, intitulado "Value chain dynamics and the socioeconomic drivers of small-scale fisheries on the Amazon coast: A case study in the state of Amapá, Brazil", foram descritas as características da pesca artesanal na área de estudo, incluindo o processo de produção, a estrutura e operação da cadeia de valor e os principais fatores, locais a internacionais, que impulsionam as capturas e o mercado de pescado.

No artigo 2, intitulado "Understanding changes to fish stock abundance and associated conflicts: Perceptions of small-scale fishers from the Amazon coast of Brazil", foram analisados os principais conflitos e o estado dos recursos pesqueiros na área de estudo, de acordo com a percepção e conhecimento dos pescadores locais.

No artigo 3, intitulado "Sustainability indicators for the integrated assessment of coastal small-scale fisheries in the Brazilian Amazon", foi realizada uma avaliação multidisciplinar da sustentabilidade das pescarias na área de estudo, com base em 31 indicadores divididos em seis dimensões (ecológica, econômica, ética, institucional, social e tecnológica), utilizando o método Rapfish. Deste modo, são discutidos os principais problemas e desafios à sustentabilidade das pescarias.

Em seguida, o último tópico da tese contém as considerações finais do estudo, incluindo uma síntese das informações apresentadas nos três artigos e uma consolidação das recomendações de caminhos a seguir rumo à sustentabilidade das pescarias em uma perspectiva de longo prazo.

2. Value chain dynamics and the socioeconomic drivers of small-scale fisheries on the Amazon coast: A case study in the state of Amapá, Brazil

Artigo científico aceito para publicação na revista Marine Policy (ISSN: 0308-597X).

Value chain dynamics and the socioeconomic drivers of small-scale fisheries on the Amazon coast: A case study in the state of Amapá, Brazil

JIMENEZ, E.A. et al.

Abstract

This study examines the characteristics of small-scale fisheries in the state of Amapá (Brazilian Amazon coast), including the production processes, the structure and operation of the value chain, and the drivers of fish trade and resource exploitation. Interviews were held with fishers, boat owners, the presidents of fishers' organizations, and processing companies officials. The interviewees were mostly men, with a mean age between 37–43 years old, low education and income, and an average of 20–24 years of fishing experience. Fishing is the primary source of income and food for most of the respondents. Multispecies fisheries are conducted with small boats (6–12 meters in length), using gillnets and longlines. The value chain comprises fishers, middlemen, and processing and export companies. This chain supplies the domestic market with fish meat, and swim bladder is exported. The dynamics of the fishing sector reflects the interaction between local, national and international drivers. Local drivers are related to the fishers' socioeconomic vulnerability, the lack of post-harvest infrastructure, and the distance between fishers and final consumers. A high reliance on declining fish stocks, poor fishery management, and increasing competition with outside fishers, heightens the vulnerability of local fishers. Nationally, the trade is driven by growing fish consumption, and the demand for swim bladder drives international trade. Overcoming the challenges and limitations facing the fishing sector requires multi-scale interventions; increased governmental, non-governmental, and private-sector support; and joint actions between stakeholders. Sustainable fish trade and food security require effective resource management, and co-management is recommended.

Keywords: Fish value chain; Seafood trade; Middlemen; Vulnerability; Artisanal fishery.

1. Introduction

Human societies faces the challenge of feeding a growing population that could reach approximately 9.8 billion people by 2050 [1], and fish and fish products play a crucial role in global nutrition and food security [2,3]. Estimates from the Food and Agriculture Organization of the United Nations (FAO) indicate that global fish production reached 171 million tons in 2016, of which 53% came from capture fisheries, and 88% was utilized for direct human consumption. Fish provided about 3.2 billion people with almost 20% of their average per capita consumption of animal protein [4].

Fishing is vital for millions of impoverished people with few alternative sources of income, employment, and animal protein, particularly in developing countries [2,5,6], where more than 100 million full-time and part-time workers depend directly on fishing and related activities for their livelihoods [7]. Additionally, 90% of the world's fishers and fish workers are engaged in small-scale fisheries (SSFs), and 97% live in developing countries [7]. SSFs commonly include households with a limited range of operation, a dependence on local resources, labor intensive, low capital investment and low-technology fishing methods [7–9]. The majority of SSFs is multispecies and multigear, with a large diversity of geophysical, bioecological, socioeconomic and political characteristics [10,11].

Fish landed by SSFs circulate within networks of local, regional and international trading systems that connects production to consumers, adding significant value to fish products and rising employment levels [12,13]. Some value chains are solely export-driven, others target only the domestic market, and there are others aimed at both [14,15]. Fish and fish products are among the most traded food items in the world, with approximately 35% of global fish production exported in 2016. This represents an increase of 245% compared to 1976 [4] and reflects the growing integration of the sector into the global economy. The value of global fish exports reached an estimated USD 143 billion in 2016, of which 53% originated in developing countries [4].

However, some studies show that the expansion of the fish trade was not necessarily beneficial to fishers, as they receive the smallest economic benefits compared with other actors in the value chains [16–18]. SSFs often lack basic infrastructure, such as storage facilities, and landing points are widely dispersed across the territory, distant from markets [7,10]. Moreover, formal credit options available are limited and difficult to access due to bureaucracy and the geographical distance between financial institutions and fishing communities, but also because of the difficulty these institutions have in understanding the needs of fishers [19,20]. Consequently, many value chains are dominated by networks of traders that offer fishers informal credit, access to markets, and help them to avoid both the transactional costs of commercialization and exposure to market fluctuations [15,18,21,22]. This can lead to exploitative social relations, whereby traders uses their position to drive down the purchase price of fish products [16,21,23]. These circumstances require management approaches that equalize the distribution of benefits and power between actors in the value chains of fish and fish products.

1.1. The fishing sector in Brazil – A brief overview

Brazil is a vast continental-sized country, marked by greatly differentiated regions. The intrinsic social, political, institutional, economic, and environmental factors of each region influence fisheries [24]. Fishing is a crucial source of food and income for fishing communities that live inland and along the eight thousand kilometers of the Brazilian coast [25]. More than one million fishers are registered, and 99% are small-scale [26]. The latest official statistics available indicate a fish production of 1.4 million tons in 2011, of which 56% originated in capture fisheries (39% in marine fisheries and 17% in inland catches), and 55% in North and Northeast Brazil [27], where 80% of Brazilian fishers live [26].

Despite its importance for local communities, fishing has not been an economic driver for Brazil. From 2006 to 2016, fishing contributed an average of only 0.1% to annual exports, which equates to approximately USD 220 million and 38 thousand tons per year [28]. Additionally, few Brazilian households regularly consume fish, 60% of whom live in the North and Northeast regions [29]. However, per capita fish consumption has increased in recent decades, from 7.62 kg in 1996 to 9.75 kg in 2010 [30]. This growing demand has been met mainly by imports, which has resulted in a consistent trend of deficit in the national fish trade balance since 2006, reaching around USD 991 million in 2011 [27]. Imports are largely driven by consumers with high purchasing power from large metropolitan cities, as well by the demographic expansion of the Brazilian middle-class, with preferences for fish that are not produced domestically (e.g., cod, salmon and hake) [28,31,32].

Along the Amazon coast (North Brazil), which includes the states of Amapá, Pará and Maranhão, fishing is a primary source of food and income, as well as a way of life that integrates the cultural identity of the coastal and rural population [33–35]. The average daily fish consumption reaches 462 grams per person in some communities, one of the highest rates of fish consumption in the world [35]. SSFs in this region use diverse vessels, gears, catch techniques and landing sites, catching multiple species, predominantly Sciaenidae and Ariidae fish [36–38]. Fish and fish products are primarily sold via informal channels with a network of intermediaries that supply local, national and international markets [36,39,40]. Additionally, fishers in Brazil and French Guiana exploit transboundary fish stocks, and catches are made in and around No-Take Zones (NTZs), resulting in many conflicts that have been aggravated by increasing competition for fishery resources that show signs of population decline, such as *Sciades parkeri* and *Cynoscion acoupa* [41,42].

In this context, knowledge about the drivers of trade dynamics and resource exploitation is crucial for the management and governance of fisheries and their value chains, as well as to ensure the welfare of fishers. Many approaches can be used in a value chain analysis, depending on the context and research question. However, a broad analysis considers the range of activities required to bring a product or service to consumers, from conception through the different phases of production [43]. This analysis assist in understanding the inter-linkages dynamics within the productive sector, which may reveal strategies for enhancing the sustainability of value chains, and guide policy interventions that can be supported by stakeholders [13,43].

This study aims to analyze the characteristics of SSFs along the Amazon coast, in the state of Amapá (Brazil). The objectives are to identify the structure and operations of the value chain, how fisheries connect and interact with national and international markets, and the socioeconomic drivers behind the trade of fish and fish products and the resource exploitation. The following questions guide the study: (1) How do fishers operate (e.g., fishing vessels, gears, grounds, and catch seasons)? (2) What is the socioeconomic context of the production process? (3) How are production, processing and marketing structured? (4) Who are the actors in the value chain, and what roles do they play? The answers to these questions will contribute to enhance the knowledge required for sustainable management and governance of the fishing sector in the Amazon.

2. Material and methods

2.1. Case study

The Amazon coast is located in the North Brazil Shelf Large Marine Ecosystem (LME); a highly productive ecosystem [44], and an Ecologically or Biologically Significant Area (EBSA) [45]. The Brazilian state of Amapá (hereinafter, AP, to avoid ambiguities with the municipality of the same name) is located in this region, with a 700 km coastline and roughly 829,000 inhabitants, of which approximately 60% live in the capital, Macapá [46]. Coastal fisheries in AP had an annual average landing of 5,400 tons (2000–2011)[1], with 78% of total production landed in the municipalities of Oiapoque, Calçoene and Amapá [47] [Fig. 1], where this study was conducted. More than 70% of the total catches came from gillnets, and 76% comprise five species (*Cynoscion virescens*, *C. acoupa*, *Sciades couma*, *S. proops* and *S. parkeri*) [47].

[1] Data available on the ICMBio (Chico Mendes Institute for Biodiversity Conservation) website: www.icmbio.gov.br/cepsul/acervo-digital

The three studied municipalities are located between 300 km to 580 km from the capital, with approximately 46,500 residents [46], of which 1,300 are fishers [48]. They constitute 400 km of coastline, with extensive muddy tidal plains and mangroves, which are influenced by the Amazon river discharge and by the North Brazil Current [49,50]. There are three coastal NTZs in this area: the Cabo Orange National Park (CONP), the Maracá-Jipióca Ecological Station (MJEE), and the Lago Piratuba Biological Reserve (LPBR) [Fig. 1], as well as two Ramsar sites (i.e., the CONP and the Amazon Estuary and its Mangroves) established by the Ramsar Convention[2].

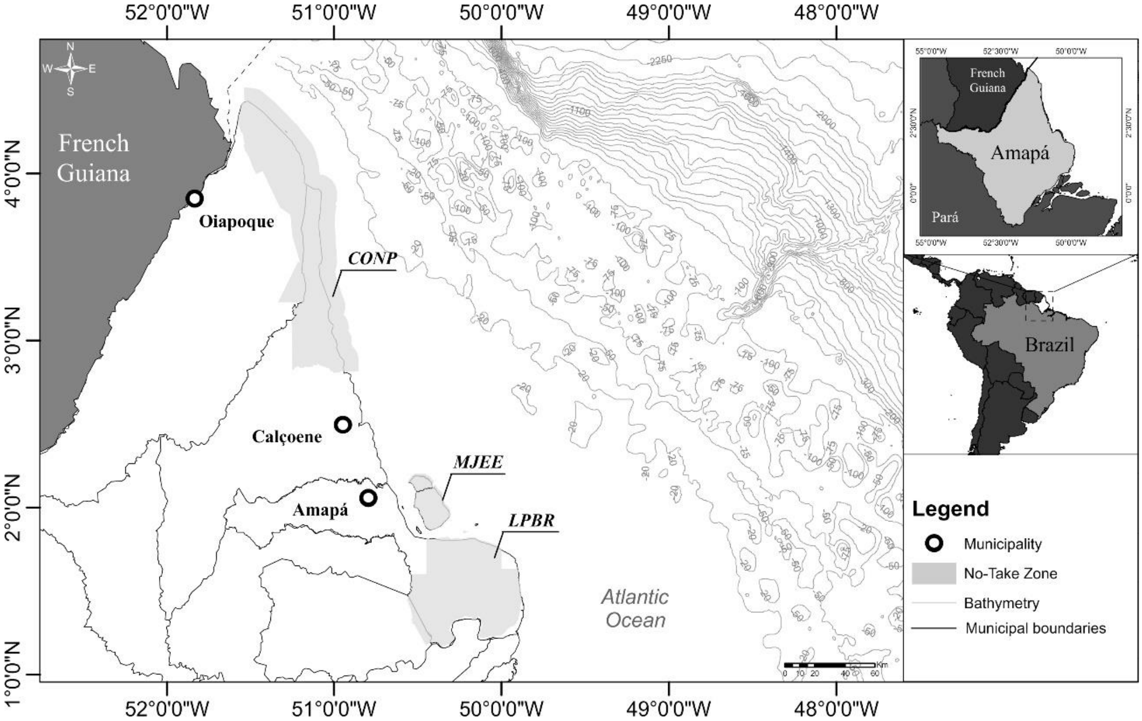

Fig. 1. Location of the studied municipalities (Oiapoque, Calçoene, and Amapá) and the No-Take Zones (Cabo Orange National Park – CONP, Maracá-Jipióca Ecological Station – MJEE, and Lago Piratuba Biological Reserve – LPBR), in the state of Amapá, Brazil.

2.2. Data collection and analysis

Data were collected during 14 field trips between 2014 and 2016, through face-to-face interviews with two stakeholders groups: 1) fishers, boat owners and the presidents of Fishers' Colonies (i.e., formal fishers' organizations), and 2) officials from fish processing companies. A total of 359 stakeholders from the first group were interviewed, distributed as follows: Oiapoque (n = 186), Calçoene (n = 70) and Amapá (n = 103).

[2] The Ramsar Convention is an intergovernmental treaty aimed at international cooperation for the conservation and sustainable use of wetlands and their resources. More information available at www.ramsar.org

Interviews were guided by a survey using closed and open-ended questions regarding the respondents' socioeconomic profile (e.g., age, education, fishing income, fish consumption, alternative livelihoods, and social organization), and their fishing activity (e.g., characteristics of boats and gears, trip length, fishing grounds, exploited species, fish price, processing, and marketing). The average price per kilogram of each species, at first-hand market, was collected in the national currency (Real) and converted into the equivalent in dollars (USD). The interviews took place at the landing sites, at the respondents' homes, and at the Fishers' Colonies. The respondents could speak freely on each topic, and the interviews were often accompanied by local guides to reduce distrust and to avoid associations with surveillance agencies.

A combination of qualitative (snowball sampling) and quantitative (random selection) approaches was used to select respondents. First, the presidents of Fishers' Colonies were interviewed to obtain a general overview of the local context, and to identify potential fishers who they believed to have a considerable fishing experience. The nominated fishers then indicated others, according to the snowball sampling procedure, based on key informants [51]. This method resulted in 5 to 10 interviews with fishers in each municipality. Subsequently, fishers available during fieldwork were randomly selected for interviews. This procedure aimed to minimize possible biases in the interviews, with the sample universe covering approximately 28% of all fishers registered in the study area.

Three interviews were conducted with officials from fish processing companies, distributed as follows: Oiapoque (n = 1) and Calçoene (n = 2). These companies do not operate in Amapá. The interviews covered information on fish species, traded products, market, and transport. Information acquired outside of the context of the interviews were used to support the data. This information was collected by participating in meetings of the Fishers' Colonies and the NTZs advisory councils, by observing fishing-related activities (e.g., landings, boats and gears repairs), from informal conversations with government agents, and through interactions with community members.

Data from the fishers' interviews were tabulated and analyzed, by calculating the percentage of citations in each response category, for each interview question. The characteristics of fishing boats (i.e., length, crew, storage capacity, engine power, and trip duration) and gillnets (i.e., length and height) were analyzed using basic descriptive statistics. Data from the key informants and the randomly selected respondents, were analyzed together, as they exhibited the same response patterns. The taxonomic identification of fishery resources was conducted by observing landings, from photographic records, and through a literature review. The value chain was established by crossing the information from the two groups of stakeholders with the reviewed literature, from field notes, and the opinions of fishery experts.

The fishing fleet was classified into three categories, according to the information from the fishers: (i) Canoes: wooden boats with outboard engine, without a cabin or technological equipment, with fish stored on ice, in old refrigerators or polystyrene boxes; (ii) Small-sized boats: wooden boats with outboard or inboard engine, with or without cabin, fish stored in ice tanks, length of up to 12 m, and mostly equipped with radio and compass; and (iii) Medium-sized boats: wooden boats with inboard engine, cabin, fish stored in ice tanks, greater than 12 m in length, and mostly equipped with radio and GPS.

The fishing grounds were identified through participatory mapping [52] with three groups (one group in each municipality) of four to six experienced fishers. They indicated, on nautical charts, the catch sites and the distances of these sites relative to reference points (e.g., lighthouses, nautical signaling buoys, and rivers). The boundaries of the fishing grounds were inserted into the Geographic Information System, converted into layers, and then into shapefile-type polygons. This enabled the elaboration of thematic maps containing the fishing area of each municipality, using ArcGIS 10.1 software.

3. Results

3.1. Socioeconomic profile of fishers

The majority of the respondents are men (more than 89% across all municipalities), older than 30, with an average age of 37.9±12.1 in Oiapoque, 43.5±11.9 in Calçoene, and 40.6±13.7 in Amapá. Most respondents have little education (i.e., only the early grades of elementary school), are married (formal or informal marriage), with one to four children, and have at least one family member working in fishing. The majority have more than 10 years of fishing experience, with an average time of 20.1±12.7 in Oiapoque, 24.0±10.9 in Calçoene, and 24.9±15.6 in Amapá. Most interviewees in Oiapoque and Calçoene were born in the neighboring state, Pará, and migrated to AP less than ten years ago [Table 1].

Respondents from Oiapoque and Calçoene consume fish from five to seven times a week, whereas in Amapá, the frequency ranges mainly from three to six times a week [Table 1]. Fishing is the only source of income for most respondents (Oiapoque – 77.4%, Calçoene – 58.6%, Amapá – 62.1%), with approximately two to five dependents per household. The national minimum wage (MW) equated to USD 270 in 2016, and many respondents from Oiapoque (79%) and Calçoene (45.7%) earned a monthly income of one to three MWs. In Amapá, the income was mainly lower than the MW (48.5% of respondents) [Table 1]. Some interviewees mentioned activities to complement their income, which are primarily related to the fishing sector (e.g., gears and boats repairs, and naval carpentry). However, agriculture, livestock, minor commerce, and civil construction were also cited. More than 70% of the respondents participate in fishers' organizations, and among them, over 90% are registered with a Fishers' Colony.

Table 1
Socioeconomic profile of small-scale fishers from the state of Amapá, Brazil. N = number of citations. % = relative frequency of citation. NA = Not Answered.

Variable	Category	Oiapoque		Calçoene		Amapá	
		N	%	N	%	N	%
Age (years)	<20	6	3.23	0	0.00	4	3.88
	20−29	47	25.27	8	11.43	25	24.27
	30−39	56	30.11	23	32.86	22	21.36
	40−49	41	22.04	20	28.57	21	20.39
	50−59	25	13.44	13	18.57	22	21.36
	≥60	11	5.91	6	8.57	9	8.74
Marital status	Single	94	50.54	19	27.14	47	45.63
	Married	38	20.43	21	30.00	34	33.01
	Informal union	48	25.81	29	41.43	19	18.45
	Divorced	1	0.54	0	0.00	1	0.97
	NA	5	2.68	1	1.43	2	1.94
Number of children	0	33	17.74	9	12.86	13	12.62
	1−2	75	40.32	26	37.14	34	33.01
	3−4	43	23.12	16	22.86	24	23.31
	5−6	17	9.14	8	11.43	16	15.53
	≥ 7	10	5.38	8	11.43	16	15.53
	NA	8	4.30	3	4.28	0	0.00
Number of fishers in the family	0	53	28.49	37	52.86	35	33.98
	1−2	43	23.12	16	22.86	29	28.16
	3−5	50	26.88	10	14.29	19	18.45
	≥ 6	31	16.67	5	7.14	11	10.68
	NA	9	4.84	2	2.85	9	8.73
Level of formal education	Illiterate	12	6.45	0	0.00	9	8.74
	Elementary School	127	68.28	53	75.71	70	67.96
	Middle School	17	9.14	6	8.57	12	11.65
	High School	22	11.83	7	10.00	10	9.71
	NA	8	4.30	4	5.72	2	1.94

(continued)

Variable	Category	Oiapoque		Calçoene		Amapá	
		N	%	N	%	N	%
Birthplace (state)	Amapá	80	43.01	25	35.71	89	86.41
	Maranhão	10	5.37	4	5.71	1	0.97
	Pará	94	50.54	38	54.29	12	11.65
	Others	1	0.54	1	1.43	0	0.00
	NA	1	0.54	2	2.86	1	0.97
Residence time at the interview site (years)*	≤ 10	84	58.74	22	44.00	11	29.73
	11−20	31	21.68	23	46.00	4	10.81
	21−30	15	10.49	1	2.00	12	32.43
	31−40	7	4.90	2	4.00	3	8.11
	≥ 41	4	2.80	1	2.00	5	13.51
	NA	2	1.39	1	2.00	2	5.41
Fishing experience (years)	≤ 10	54	29.03	5	7.14	22	21.36
	11−20	60	32.26	31	44.29	25	24.27
	21−30	31	16.67	17	24.29	17	16.50
	31−40	26	13.98	10	14.29	18	17.48
	≥ 41	11	5.91	6	8.57	18	17.48
	NA	4	2.15	1	1.42	3	2.91
Weekly frequency of fish consumption	1−2 times	39	20.97	17	24.29	23	22.33
	3−4 times	25	13.44	13	18.57	28	27.18
	5−6 times	66	35.48	6	8.57	24	23.30
	Daily	52	27.96	32	45.71	22	21.36
	NA	4	2.15	2	2.86	6	5.83
Fishing monthly income	<1 minimum wage	29	15.59	23	32.86	50	48.54
	1−3 minimum wages	147	79.03	32	45.71	38	36.89
	>3 minimum wages	8	4.30	9	12.86	1	0.97
	NA	2	1.08	6	8.57	14	13.60
Number of dependents	0	17	9.14	4	5.71	3	2.91
	1	23	12.37	1	1.43	5	4.85
	2−5	125	67.20	47	67.14	88	85.44
	≥ 6	12	6.45	15	21.43	7	6.80
	NA	9	4.84	3	4.29	0	0.00

*Question asked only to those who were not born at the interview site.

3.2. Fishery resources, fishing vessels and gears

The fisheries are multispecies, and 33 fishery resources are traded, including marine, estuarine and freshwater species, of which 16 are common to the three municipalities [Table 2], and five are the most significant in terms of volume and frequency of capture (*C. virescens*, *C. acoupa*, *S. parkeri*, *S. proops* and *S. couma*). The species with the highest average price per kilogram of meat, in the first-hand market, are *Brachyplatystoma filamentosum*, *Hypostomus* spp., *C. acoupa*, *Epinephelus itajara*, *Brachyplatystoma* *rousseauxii* and *Centropomus* spp., respectively [Table 2]. The swim bladder is extracted from the following species: *C. acoupa* (USD 230–276 kg^{-1}), *C. virescens* (USD 92–107 kg^{-1}), *S. parkeri* (USD 25–36 kg^{-1}), *S. couma* and *S. proops* (USD 9–15 kg^{-1}).

Table 2
Fishery resources caught by small-scale fishers from the state of Amapá, Brazil. N = number of citations. %F = relative frequency of citation. P = average price (USD/kg).

Scientific and common names	Oiapoque			Calçoene			Amapá		
	N	%F	P	N	%F	P	N	%F	P
Amphiarius rugispinis (Softhead sea catfish)	-	-	-	-	-	-	2	1.90	0.31
Aspistor quadriscutis (Bressou sea catfish)	2	1.10	0.15	1	1.40	0.25	2	1.90	0.71
Bagre bagre (Coco sea catfish)	44	23.70	0.43	10	14.30	0.43	12	11.70	0.34
Batrachoides sp. (Toadfish)	2	1.10	0.46	-	-	-	-	-	-
Brachyplatystoma filamentosum (Kumakuma)	15	8.10	2.49	-	-	-	1	1.00	3.69
Brachyplatystoma rousseauxii (Gilded catfish)	19	10.20	1.60	21	30.00	2.37	32	31.10	1.88
Brachyplatystoma vaillantii (Laulao catfish)	16	8.60	0.80	12	17.10	1.08	60	58.30	1.23
Caranx spp. (Jacks)	8	4.30	0.58	5	7.10	0.55	-	-	-
Carcharhinus spp. (Sharks)	9	4.80	1.48	8	11.40	0.86	6	5.80	0.92
Centropomus spp. (Snooks)	61	32.80	2.06	19	27.10	2.18	16	15.50	1.63
Cynoscion acoupa (Acoupa weakfish)	118	63.40	1.78	38	54.30	2.98	18	17.50	2.09
Cynoscion steindachneri (Smalltooth weakfish)	-	-	-	-	-	-	1	1.00	1.54
Cynoscion virescens (Green weakfish)	171	91.90	1.14	46	65.70	1.72	4	3.90	1.32
Dasyatis spp. (Stingrays)	1	0.50	1.08	-	-	-	-	-	-
Epinephelus itajara (Atlantic goliath grouper)	2	1.10	2.77	-	-	-	-	-	-
Genyatremus luteus (Torroto Grunt)	29	15.60	0.55	3	4.30	0.68	-	-	-
Hypostomus spp. (Suckermouth catfish)	1	0.50	3.05	1	1.40	0.77	-	-	-
Lobotes surinamensis (Atlantic tripletail)	83	44.60	0.55	12	17.10	0.71	4	3.90	0.43
Macrodon ancylodon (King weakfish)	62	33.30	0.52	7	10.00	0.68	-	-	-
Megalops atlanticus (Tarpon)	3	1.60	0.71	1	1.40	-	2	1.90	0.62
Micropogonias furnieri (Whitemouth croaker)	8	4.30	0.28	1	1.40	0.31	-	-	-
Mugil spp. (Mullets)	19	10.20	0.86	4	5.70	1.32	4	3.90	0.89
Nebris microps (Smalleye croaker)	1	0.50	-	-	-	-	-	-	-
Pellona spp. (Pellona)	91	48.90	0.62	11	15.70	0.58	3	2.90	1.45
Plagioscion spp. (South American Silver Croaker)	84	45.20	1.35	14	20.00	1.32	34	33.00	1.85
Pomatomus saltatrix (Bluefish)	4	2.20	1.23	-	-	-	-	-	-
Pseudoplatystoma spp. (Sorubim)	-	-	-	-	-	-	1	1.00	1.85
Sciades couma (Couma sea catfish)	93	50.00	0.83	43	61.40	0.95	93	90.30	0.83
Sciades parkeri (Gillbacker sea catfish)	28	15.10	2.31	39	55.70	1.72	92	89.30	1.57
Sciades passany (Passany sea catfish)	4	2.20	0.68	-	-	-	-	-	-
Sciades proops (Crucifix sea catfish)	145	78.00	0.95	44	62.90	1.26	77	74.80	0.86
Scomberomorus brasiliensis (Serra Spanish Mackerel)	6	3.20	0.71	1	1.40	0.46	-	-	-
Scomberomorus cavalla (King mackerel)	1	0.50	0.92	-	-	-	-	-	-

Note: Because each interviewee cited multiple species, the percentages do not add up exactly to 100 percent.

The fishing fleet is composed primarily of small-sized boats, which are used by more than 65% of the respondents. The small-sized boats from Amapá have, on average, the smallest crew, storage capacity, engine power and trip length. Medium-sized boats were mentioned only in Oiapoque and Calçoene, and the boats of Oiapoque have, on average, greater length, crew, storage capacity and engine power [Table 3].

Table 3
Characteristics of the fishing fleet used by small-scale fishers from the state of Amapá, Brazil. %= relative frequency of citation. Data presented as minimum, maximum, mean and standard deviation.

Site	%	Length (m)	Crew	Storage (kg)	Engine Power (HP)	Trip length (days)
Canoes						
Oiapoque	7.0	6–12 (8.30±2.20)	2–3 (2.23±0.44)	400–1,500 (736.36±317.09)	15–18 (16.36±1.57)	1–8 (5.19±2.61)
Calçoene	7.1	6.5–10 (7.80±1.35)	2–3 (2.20±0.45)	400–1,000 (740.00±260.70)	6.5–15 (8.50±3.64)	5–12 (9.20±3.03)
Amapá	23.3	5.5–9.5 (6.81±1.26)	2–4 (2.71±0.72)	90–1,500 (666.25±431.37)	3.5–18 (7.88±4.63)	2.5–15 (8.15±3.94)
Small-sized boats						
Oiapoque	79.0	6–12 (9.56±1.52)	2–6 (3.51±0.93)	1,000–7,000 (3,354.42±1,460.1)	10–160 (39.90±30.98)	7–21 (12.10±3.07)
Calçoene	65.7	7–12 (10.10±1.49)	3–6 (3.86±0.76)	1,000–6,000 (3,631.11±1,073.8)	18–69 (29.11±16.37)	7–20 (12.31±2.79)
Amapá	73.8	6.5–12 (10.06±1.58)	2–6 (3.31±1.0)	1,000–5,000 (2,365.2±1,249.36)	10–69 (25.42±18.32)	5-16 (10.34±2.86)
Medium-sized boats						
Oiapoque	8.6	13–18 (15.15±2.17)	4–10 (6.00±2.0)	7,000–14,000 (11,250.0±3,130.5)	33–200 (116.8±46.86)	10–30 (15.38±6.25)
Calçoene	12.9	12.5–16 (13.50±1.15)	3–8 (5.38±1.69)	7,000–12,000 (8,500.00±1,690.3)	45–125 (73.63±30.16)	12–25 (17.63±4.00)

Gillnets are the primary fishing gear used, and the nets are handled manually, with the exception of a few medium-sized boats with equipment that remove nets from the water mechanically. The nets in Oiapoque are longer, on average [Table 4]. The nets can drift, or be fixed to the ground, and most respondents use a mesh size of 60 mm to 70 mm (between adjacent knots). However, gillnets with smaller meshes may be used to catch *Mugil spp.*, *Plagioscion* spp., and other small species in shallow waters. The use of longlines is only common in Amapá, and targets mainly catfishes (e.g., *S. parkeri*, *S. proops* and *B. filamentosum*), with the baits including *Mugil* spp., *Megalops atlanticus*, *Bagre bagre* and *Anableps anableps*.

Table 4
Characteristics of the gillnets used by small-scale fishers from the state of Amapá, Brazil. Length and height data presented as minimum, maximum, mean and standard deviation. Mesh size between adjacent knots.

Site	Length (m)	Height (m)	Mesh (mm)
Canoes			
Oiapoque	100–2,900 (913.64±806.96)	2.0–5.5 (3.75±1.11)	45–70
Calçoene	100–910 (427.50±345.0)	3.0–4.0 (3.57±0.41)	50–70
Amapá	70–600 (291.42±228.50)	2.0–7.3 (4.76±2.65)	30–70
Small-sized boats			
Oiapoque	1,000–9,100 (2,505.65±1,321.51)	1.0–7.6 (4.32±1.29)	30–80
Calçoene	550–5,500 (2,121.36±1,315.35)	2.0–7.0 (4.69±1.37)	40–100
Amapá	100–3,640 (755.38±711.74)	2.5–7.3 (5.19±1.73)	30–70
Medium-sized boats			
Oiapoque	1,000–9,100 (5,275.00±3,027.54)	2.5–9.0 (5.70±1.81)	60–70
Calçoene	2,500–6,400 (4.068,75±1,209.76)	2.5–7.0 (4.62±1.45)	60–100

3.3. Fishing grounds and periods

According to the respondents, catches are made throughout the year, but fisheries are more productive during the dry season, from July to December, which is locally known as “summer”. This is due to the increase in the abundance of fish near the coast, and the better weather conditions. The same fishing grounds are used throughout the year, predominantly in shallow waters (<10 nautical miles from shore), including within the territories of the NTZs [Figure 2]. Fishers live mainly along the rivers, which means that reaching the coastal fishing grounds can take three to six hours, or more.

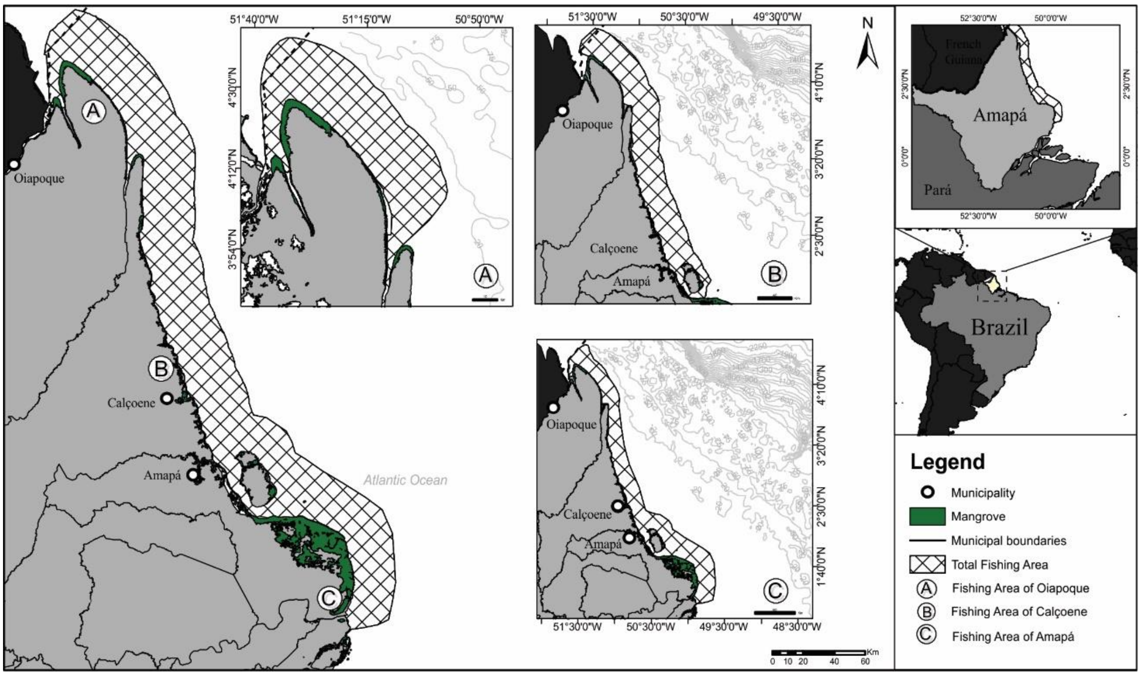

Fig. 2. Fishing area of coastal small-scale fishers from the municipalities of Oiapoque, Calçoene and Amapá, in the state of Amapá, Brazil.

3.4. Fish and fish products value chain

Fish are brought on board the vessel, gutted, washed with seawater and stored on ice; the swim bladder is sun dried. This processing aims to prevent meat spoilage but does not add value to the catches. The production is sold at landings, which occur on small wooden piers in precarious conditions, and without the enforcement of sanitary and hygienic standards. The value chain is relatively simple, with three channels oriented toward domestic market, and one export-oriented channel. The first channel extends from fishers to middlemen and processing companies. It supplies the national markets with fish meat. The second channel is the flow of fish meat from fishers to middlemen, supplying markets in the largest cities of AP (i.e., Macapá and Santana). The third channel represents the flow of fish meat from fishers, to the markets next to landing sites. The fourth channel extends from fishers to middlemen and export companies, supplying foreign countries with swim bladder [Fig. 3].

Middlemen dictate the price of fish, depending on the species and the supply, which fluctuate according to the season. The trade is primarily informal, with no written contracts between chain actors, and fishers have no information regarding price other than that offered by local intermediaries. Due to the lack of data on catches, it was not possible to estimate the volume and value traded per channel. However, according to the respondents, most of the fish meat production is sold in the first channel, with the exception of Amapá, where only the second and third channels operate, as there is no fish processing company to transport the catch to national markets.

Intermediaries, including middlemen and processing companies, control markets access. This is because local market cannot absorb all fish production, and fishers do not have the capital to afford the transaction costs of commercialization. Middlemen may be independent or hired by processing companies. They operate directly with fishers, by buying their catches. In processing companies, fish undergo rapid sensory analysis to assess their quality, based on appearance of the eyes, skin and gills, odor and texture. The fish approved by this analysis are cut into different products (mainly fillets and steaks), packaged, frozen and shipped via refrigerated trucks to the port of Santana. From there, they leave by ferry across the Amazon River to Pará, where products are sold in part, before moving by road to other Brazilian states. The fish not approved by the sensory analysis is returned to the middlemen, who use small trucks to transport the fish in boxes with ice, to supply markets of the largest cities in AP. Only a very small amount of the catch is sold within the towns where landings occurs. The swim bladder is sold to middlemen who send them to export companies in Pará and other Brazilian states [Fig. 3].

At the time of fieldwork of this study, there were three processing companies in Oiapoque, and two in Calçoene. The production of local fishers is not enough to meet demands of these companies, which also buy fish from the fishing fleet of Pará. Waste material from these companies is not used and is improperly disposed. Middlemen in Oiapoque also buy fish from French Guiana's fishers, but there are no data on this transboundary trade. Therefore, the value chain remains largely outside of the control of government, and the state agency responsible for fisheries management and technical support (called PESCAP) has only one office, located in Macapá.

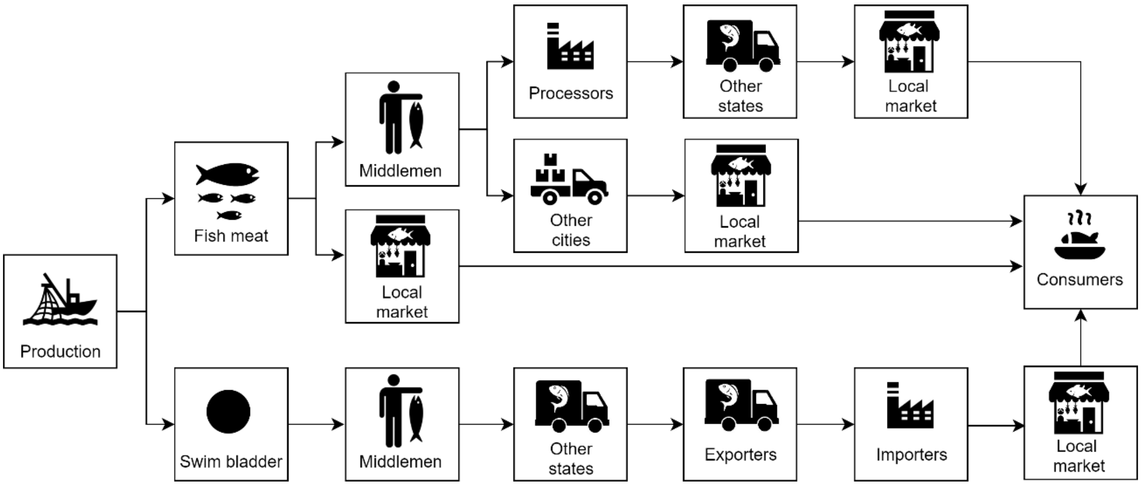

Fig. 3. Value chain of fish and fish products landed by coastal small-scale fishers from the municipalities of Oiapoque, Calçoene and Amapá, in the state of Amapá, Brazil.

Labor relations in fishing are based on informal partnerships or a family regime, and most fishers do not own boats or gears. There are no wages, and income depends on fish production and the revenue generated at the first-hand market. The main profit-sharing system consist of 50% for the owner of the boat and 50% for the crew. The division among the crew may vary according to their roles in the fishery. Each fisher also receives two to four fishes for home consumption. The owners of the boats are the main financers of fisheries in Oiapoque (63%) and Calçoene (53%). In Amapá, middlemen are the main financiers (67%), and fishers agree to sell their catches exclusively to those who provide the financial support. Commonly, processing companies provide fishers with ice, in exchange for a guaranteed supply of fish.

4. Discussion

This case study analyzes small-scale fisheries (SSFs) and their value chain along the Amazon coast and includes important insights on the drivers behind the trade of fish and fish products and the resource exploitation. The value chain comprises four main actors (fishers, middlemen, processors and exporters), who operate in four channels oriented toward either domestic or export markets, depending on the product sold (i.e., fish meat or swim bladder). The primary domestic channel passes fish meat from fishers to middlemen and processors, before being sold at national market. Therefore, fish is consumed at a great distance from its production and landing sites. The only export-oriented channel passes swim bladder from fishers to middlemen and export companies. The dynamics of the fishing sector reflects the interaction of drivers operating from local to international scales. Local drivers are related to the socioeconomic vulnerability of fishers, whereas national and international drivers are related to the growing demand for fish and fish by-products.

Fishers are mostly men, with a mean age between 37 and 43 years old, of low education and income, and who are specialized in fishing, as most respondents do not have alternative livelihoods, and those who participate in complementary activities, indirectly depend on the fishing sector. This may also reflect the lack of opportunities in other sectors. The low education of respondents is a reality for small-scale fishers in developing countries [10,53,54], where children often accompany their parents in fishing activities, and young people leave school to work and contribute to the subsistence of their families. It is also difficult to reconcile “work time” with “study time” [55]. Therefore, fisheries contribute to food security, both directly and indirectly, by providing a primary source of animal protein, and by generating income and employment [2].

Several studies show that fishers’ income, and their power to make decisions about the fishing sector, tend to be lower than that of other chain actors. This is often associated with the inability of fishers to acquire assets and access to markets, thereby reducing their bargaining power [16–18,56,57]. The fishers in this study are impacted by two main factors. First, the main fishers’ organizations (i.e., Fishers’ Colonies) were created as a state intervention to control fishers, in the political context of significant class struggles [58]. Fishers’ Colonies have a history of clientelism, corruption and nepotism, which affects their ability to effectively meet the needs of their members [59]. Second, government agencies are ineffective in the rural municipalities of AP, and investments in post-harvest infrastructure is minimal or nonexistent. Additionally, locals do not traditionally consume seafood. Consumers in the largest cities of AP prefer beef or chicken, due to the high prices of fish in their local markets [60], which are supplied by intermediaries, with freshwater species from the states of Pará and Amazonas [61]. Therefore, the local markets are limited, and most of the fish production is oriented toward national market. The lack of storage facilities, and the distance from final consumers, makes fishers highly dependent on intermediaries who dictate the prices of fish, which they consider low and unfair.

The transport of perishable products from remote regions to distant markets is always a challenge, as the infrastructure for SSFs is often precarious. There are no structures for berthing, landing, storage or marketing [7,10,15,16]. Additionally, production, processing and marketing are mainly conducted through informal channels, outside of the government's regulatory systems [18,23,62]. Commonly, the supply chain is dominated by a network of intermediaries that buy and finance fish production. The supply of capital and inputs is restored by the purchase of fish at low prices [17,23,55,63]. This is aggravated by the lack of transparency in the value chains, as traders and processors often own market information exclusively, preventing fishers from making better decisions for production and trade [57]. Therefore, intermediaries play a paradoxical role, offering security and facilities, absorbing risks and yielding social and economic benefits, yet leaving fishers with minimal bargaining power [16,21] and threatening the potential contribution of SSFs to poverty alleviation.

In many developing countries, the price of fish depends on a wide range of variables, beyond the control of fishers [16]. In this study, the middlemen establish the price of fish, which varies according to the seasonal influence on fish supply. The composition of local fish fauna is influenced by variations in the discharge of the rivers, according to rainy and dry periods. The rainy season is dominated by freshwater species, whereas marine species are more common during the dry period [64]. In Vietnam, the price of fish may be affected by the number of boats simultaneously docked at a given place, with oversupply resulting in a reduction of prices [55]. This also occur in the study area.

Competition with outside fishers, a high reliance on declining fish stocks, and the poor management and governance of fisheries, increases the vulnerability of local fishers. The national conservation status of *S. parkeri* and *C. acoupa* is “Vulnerable” and “Near Threatened” [41,42], respectively. These species were considered fully exploited in North Brazil more than a decade ago [65], with declining catches observed in Pará [41,42,65].

Additionally, studies have registered an increasing number of fishers over the past 10 to 15 years, from Pará and Maranhão, who fish in the coast of AP [38,66,67]. Many respondents migrated to AP less than ten years ago, indicating a migratory flow of fishers to the study area, which is a challenge for both the management of fisheries and the environmental conservation. This also has implications for French Guiana, as its coast is illegally exploited by Brazilian fishers [68]. Globally, the decline of fish populations is often accompanied by the migration of fishing fleets to areas that are still productive, resulting in growing competition between commercial fisheries [69–71].

The management and governance of fisheries in Brazil is marked by decades of open access, and most fisheries still lacks monitoring, control and surveillance [72,73]. Historically, national fishery policy has focused on subsidies to increase the production of industrial fisheries and aquaculture [74]. Despite advances in public policy, the small-scale fishing sector continues to lack adequate institutional and political support at all levels, compounded by the elimination of the Ministry of Fisheries and Aquaculture (MPA) in 2015 [59]. Currently, the Ministry of Agriculture, Livestock and Food Supply (MAPA) is responsible for fishery policy. This is problematic because this responsibility previously resided with this institution, and an unsustainable agribusiness model was adopted, which generated few opportunities for SSFs and social inclusion [59].

Along the Amazon coast, fishery policy has also focused on subsidies [39], and most management measures concentrate on industrial fisheries [37]. *S. parkeri* is the only fishery resource for SSFs that has its catch regulated by law (i.e., a minimum catch size and periodic closure). However, the impacts of these measures remain poorly understood, because of the weak or nonexistent institutional capacity for monitoring and enforcement, which results in poor compliance and inefficient management. Another problem is the different mesh sizes used to catch *C. acoupa*, between the fleets of AP (120–140mm between opposite knots), and Pará and Maranhão (170–200mm) [67,75,76], affecting individuals of various sizes and maturity stages, which can potentially lead to both growth and recruitment overfishing.

Finally, the national and international demand for fish and fish products are significant drivers of resource exploitation. Nationally, fish consumption and demand for fish products has increased in recent decades [30,31]. Internationally, the greatest demand for swim bladder comes from China [77], where it is highly valued for its supposed nutritional and medicinal properties, particularly those of the Sciaenidae family, including *C. acoupa* [78]. No reliable data exist on the quantity of swim bladder exported by Brazil, because much of this trade is illegal and unreported. However, Brazil's Ministry of Development, Industry and Foreign Trade (MDIC) recorded a total export of approximately 500 tons of fish by-products to Asian markets in 2015, primarily swim bladders at an averaging USD 38.76 kg^{-1} [31]. This is significantly lower than the average price the fishers in this study reported for this by-product (USD 98.75 kg^{-1}).

5. Policy recommendations and conclusions

The recommendations of this study assume that a sustainable trade is a people-centered trade, whereby all stakeholders benefit through sustainable production, connected to sustainable consumption [32]. This requires multiscale interventions and joint actions by decision makers, scientists, fishers, intermediaries and other stakeholders. Therefore, the first recommendation is to increase the cooperation between governmental, non-governmental and private sectors.

The second recommendation is to upgrade the position of fishers in the value chain, by implementing cooperatives, associations, single selling desks or other types of organizational models to increase the bargaining power of fishers and improve market conditions, potentially reducing inequalities in income and power [16,18,56,57,63]. A noteworthy strategy is the Fair-Trade certification, which aims to promote small-scale producers in value chains, by supporting the development of their organizational capabilities, and by creating direct markets access [79]. Additionally, campaigns to increase seafood consumption may be useful to develop the state market, including the promotion of institutional consumption (e.g., schools, popular restaurants, prisons and hospitals). This could reduce the transaction costs of commercialization of fish products.

The third recommendation is to increase the exchange of market information along the value chain. Limited knowledge of market pricing is harmful to both the ability of fishers to adapt to market conditions or negotiate fair prices [80] and the capacity of government agencies to assess the veracity of the values reported by exporters [57]. Another suggestion is to provide structural investments in the post-harvest sector (e.g., proper harbors, processing and storage facilities, appropriate electricity and water supply, and good roads). A viable trade-related infrastructure for the domestic market is also the basis for improving a country's ability to trade internationally [32]. The government of AP is making efforts to attract foreign investors to develop the local fishing industry, with recent visits by Russian and Chinese entrepreneurs. The AP is geographically closer to

North America and Europe than other Brazilian states, which could be an advantage in connecting to the international market.

A further recommendation is to improve formal financial support for fishers to overcome the limitations of market access and livelihoods diversification. Currently, formal credit options for fishers are limited and do not meet their needs because most credit lines were originally developed to support agriculture [20]. Additionally, credit access is mediated by PESCAP, which is distant (300−580 km) from the study area. Another suggestion is to provide alternative uses for the waste material from fish processing companies aiming to avoid environmental impacts from improper disposal [81] and to create jobs in the production and marketing of by-products (e.g., bio-jewelry, handicrafts, animal feed and products for human consumption, such as fish burgers, nuggets and sausages).

The proposed interventions must be coupled with the sustainable management of resources, and a viable alternative is to grant preferential access to fishing territories to local communities. Chile and Mexico, for example, have successfully implemented rights-based management systems [82,83]. In Brazil, the exclusive rights to territories can be guaranteed through Marine Extractive Reserves (MER), which are marine protected areas where natural resources can be sustainably used (IUCN category VI), and jointly managed by users and managers. There are 95 extractive reserves in Brazil[3], of which 24 are marine and 15 are located on the Amazon coast. Additionally, some successful experiences of co-management exist in the continental Amazon, where multiple initiatives, conducted through local self-organization and community-based cooperation, have prevented the collapse of fish populations and contributed to increase the size, abundance and biomass of fish [84–86].

In AP, the Commitment Terms (CT) can be considered as co-management experiences, as the rules and responsibilities are established by participatory processes between users and managers. The CT is a legal tool for the regularization of the use of natural resources by traditional populations whose livelihoods are associated with protected areas where their presence is not permitted (e.g., NTZs) [87]. Currently, two CTs allows fishers from Oiapoque and Amapá to fish in the Cabo Orange National Park and the Lago Piratuba Biological Reserve, respectively. These experiences indicates that

[3] Data from the National Register of Conservation Units (CNUC) available online: https://www.mma.gov.br/areas-protegidas/cadastro-nacional-de-ucs.html

there may be willingness by local fishers to adopt co-management systems [88]. Moreover, since 2005, local fishers have required the government to create a MER to ensure their access to the fishing grounds, which is limited by competition with outsiders [88].

Globally, the sustainable management and governance of fisheries is affected by weak institutional capacity due to the susceptibility of government institutions to political changes and corruption, in addition to the lack of human and financial resources [71,89,90]. Therefore, investments in capacity-building of government institutions are required, and robust and resilient social institutions must be developed to face long-term challenges and to assume responsibilities in co-management and effectively participate in the decision-making process.

Finally, there is a great need to improve the knowledge base to better understand the conditions, opportunities and constraints of the fishing sector. A transnational research cooperation could provide the basis for the implementation of an integrated fishery policy at the regional level, cooperatively managing the resources shared with French Guiana. Furthermore, the effective inclusion of the small-scale fishing sector in the national fishery policy is indispensable.

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3. Understanding changes to fish stock abundance and associated conflicts: Perceptions of small-scale fishers from the Amazon coast of Brazil

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Understanding changes to fish stock abundance and associated conflicts: Perceptions of small-scale fishers from the Amazon coast of Brazil

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Abstract

The perceptions and knowledge of fishers are very important for fisheries management, especially in data-poor regions such as the Amazon coast of Brazil. Here, the perceptions of fishers were used to analyze the main conflicts faced by small-scale fisheries and to identify the status of fishery resources in the state of Amapá (Brazil). Data from interviews with 359 fishers were analyzed. Conflicts involve diverse actors with different and potentially competing interests and accountabilities, including small-scale and large-scale fishers, intermediaries, and government agents. The main conflict was related to access to fishery resources, including issues with the prohibition of fishing in No-Take Zones and competition with fishing fleets from other regions (outsiders). The lack of control over the access of users has culminated in increasing fishing effort. The invasion of traditional fishing territories was a central argument against the outsiders; however, these conflicts are also strongly related to the exhaustion of fishery resources, with about 75% of respondents perceiving a decrease in fish abundance. This scenario reveals a governance crisis and the weak performance and inability of the government to carry out effective enforcement, monitoring, and surveillance. The presence of people heavily reliant on natural resources in a region with very few alternative sources for livelihoods indicates that sustainable fisheries management requires wider cooperation between the government and all stakeholders, with co-management being required.

Keywords: Coastal fisheries; No-Take Zones; Resource use conflicts; Governance.

1. Introduction

Global marine fisheries present a worrying scenario, with 33% of assessed fish stocks being overfished (FAO, 2018), and an average catch decline rate of 1.2 mt per year since 1996 (Pauly and Zeller, 2016). The concern is even greater in developing countries, where fishing plays a crucial role to the livelihoods of millions of people that suffer from high levels of poverty, with few alternative sources of income, employment, and animal protein (Béné, 2006; Béné et al., 2007; Salas et al., 2011). This phenomenon occurs in most countries in Latin America and the Caribbean, where fisheries exhibit high heterogeneity in the gears, boats, and species. These regions also have a great diversity in geophysical, bioecological, and socioeconomic characteristics, as well as multiple political interactions. These various parameters combined, result in diffuse fisheries activity, with temporal and spatial dynamics that are challenging to understand and manage (Fischer et al., 2015; Salas et al., 2011).

In particular, fishing activity in Brazil is extremely heterogeneous, complex, and dynamic, due to the large size of the territory and major regional differences. As a result, the fishing communities in this country have developed adaptations to environmental, socioeconomic, political, and cultural characteristics intrinsic to each place (Silva, 2014). In the Amazon, small-scale fisheries (SSFs) are predominant, and are carried out by fishers operating small and medium-sized wooden boats using a large diversity of gears and catch techniques. Fish are sold through an informal network of intermediaries that supply regional and national markets, and the fishing sector is characterized by very low labor mobility (Almeida et al., 2003, 2011; Isaac-Nahum, 2006; Isaac et al., 2015a, 2009).

In the Amazon, fishers are heavily reliant on SSFs for their livelihoods, with this activity representing the major source of income, animal protein, and culture for coastal and riparian communities (Almeida et al., 2003; Castello et al., 2011; Ruffino, 2014). In some Amazon communities, fish comprise 64–76% of the animal food items intake and 79–87% of the weight ingested, with an average rate of 169 $kg.person^{-1}.year^{-1}$ or 462 $g.person^{-1}.day^{-1}$, representing one of the highest rates of fish consumption globally (Isaac et al., 2015b).

The Amazon coast encompasses the states of Amapá, Pará and Maranhão, where both small-scale and large-scale fishing is carried out from nearshore regions to the continental shelf (Isaac-Nahum, 2006). SSFs capture multiple species, with the Sciaenidae and Ariidae families providing the main fisheries resources; however, crabs and shellfish are also manually collected (Almeida et al., 2011; Isaac-Nahum, 2006; Isaac et al., 2009). In comparison, the industrial fisheries capture single species, including southern brown shrimp (*Penaeus subtilis*), Laulao catfish (*Brachyplatystoma vaillantii*), and southern red snapper (*Lutjanus purpureus*) (Isaac et al., 2009).

In the state of Amapá, fishing has high socioeconomic and food security importance, with 16,700 professional small-scale fishers operating (SISRGP, 2016). The capture and landing of estuarine and marine fish occurs predominantly in the municipalities of Oiapoque, Calçoene, and Amapá (PROZEE, 2006). In this region, the fishing grounds are shared with fishers from other Brazilian states and French Guiana, with catches occurring in and around No-Take Zones (NTZs), culminating in many conflicts (Crespi et al., 2015; Pinha et al., 2015). These conflicts are aggravated by the government having difficulty in controlling the access of users. There is also a lack of time series on biological and socioeconomic data needed for traditional quantitative fishery assessment models.

Consequently, in such ‘data-poor’ regions, the knowledge of fishers is a valuable information source (Saavedra-Díaz et al., 2015; Tesfamichael et al., 2014) and an important instrument for the Ecosystem Approach to Fisheries (EAF). The EAF aims to balance human and ecological well-being under the concept of sustainable development and is based on a holistic view of fisheries (Fischer et al., 2015). Fishers have a great amount of contextual and experiential-based knowledge about the socioecological system of fisheries, including target species and the ecosystem, as well as perspectives on social, economic, technological, behavioral, governance, and market aspects of fisheries (Stead et al., 2006; Stephenson et al., 2016). This knowledge is clearly important for fisheries management and has been highlighted in studies globally (Fischer et al., 2015; Saavedra-Díaz et al., 2015; Stead et al., 2006; Stephenson et al., 2016).

In data-poor situations, the knowledge of fishers is also potentially useful for recording the occurrence of temporal environmental changes, such as increases or decreases in fish abundance (Hallwass et al., 2013). Such information might complement data gaps for assessments (Tesfamichael et al., 2014) or could be used as indicators to prioritize the focus of management systems. The knowledge of fishers is also important to identify possible conflicts regarding the state of natural resources, environmental conservation, fishing regulations, and problems between sectors (Baigún, 2015). It is useful to understand what drives conflicts to identify problems that might lead to the unsustainable extraction of fishery resources (DuBois and Zografos, 2012), in addition to its being essential for cooperation in marine conservation (Majanen, 2007).

Within this context, this study aims to elucidate the main conflicts faced by SSFs and to identify possible changes in the abundance of fishery resources in the state of Amapá (Brazil), as well as to discuss potential causes and solutions to these problems based on the perceptions of fishers. The combined analysis of these two issues is expected to contribute towards identify potential risks for SSFs and assist in establishing key management priorities. This study was motivated by the first author participating as a representative of the Fisheries Agency of Amapá State (a fisheries management agency) on the advisory council of the NTZs in the study area. The councils provide spaces for dialogue, with participants including representatives from government agencies, civil society organizations, scientists, and other stakeholders. The main objective of the councils is to orient the decisions of managers (Almudi and Kalikoski, 2010). Discussions about the conflicts faced by small-scale fishers frequently occur in councils meetings and include complaints by fishers about the decline in fish abundance. Fishers repeatedly state that the Brazilian government does not 'listen to them' or consider their interests and needs when regulating the use of natural resources, often disregarding their traditional knowledge built over many generations. Therefore, the authors decided to investigate the issues that have emerged at the meetings of these councils and identify how the perceptions of fishers could be used to help fisheries management on the Amazon coast of Brazil.

2. Material and methods

2.1. Study area

This study was carried out in the municipalities of Oiapoque, Calçoene, and Amapá, in the state of Amapá (Amazon coast of Brazil) (Fig. 1). The coastal zone of these municipalities is approximately 400 km long, with extensive muddy tidal plains and mangroves (Santos et al., 2016). This area is influenced by the discharge of the Amazon River and by the Brazil North Current (Curtin, 1986). There are three coastal NTZs in the region (Fig. 1): Cabo Orange National Park (CONP), Maracá-Jipióca Ecological Station (MJEE), and Lago Piratuba Biological Reserve (LPBR). These NTZs are managed by Chico Mendes Institute for Biodiversity Conservation (referred as ICMBio), and integrate a network of 17 protected areas, covering 72% (10 million ha) of the territory of the state of Amapá, including flooded and non-flooded forests, savannah, mangroves, and estuaries (CI-Brazil, 2007). This area also encompasses two Ramsar Sites: CONP and the Amazon Estuary and its Mangroves. Wetlands of international importance are designated as Ramsar sites under the Ramsar Convention, which is an intergovernmental treaty that aims to improve the conservation of wetlands and their wise use (Ramsar Convention Secretariat, 2016).

In the study area, there are approximately 1,330 professional fishers (SISRGP, 2016) that mostly live in urban areas, and are organized into four Fishers' Colonies (i.e., formal fisherfolk organizations). Small-scale nearshore and continental fisheries are carried out using passive fishing gears. Nearshore fisheries have an average landing of 5,400 tons.year[1], with gillnets accounting for more than 70% of fish catches. Weakfishes (*Cynoscion virescens* and *C. acoupa*) and marine catfishes (*Sciades couma*, *S. proops*, and *S. parkeri*) represent about 76% of the total catch (PROZEE, 2006).

[1] Data available from the ICMBio (Chico Mendes Institute for Biodiversity Conservation) website: www.icmbio.gov.br/cepsul/acervo-digital

Based on data collected in socioeconomic surveys, it is estimated that the fishing fleet is composed of 500 small and medium-sized wooden boats distributed into three categories: (i) Canoes: boats with outboard engines, no cabin, and 5–12 m in length, with fish being stored in ice in old refrigerators or in polystyrene boxes (90–1,500 kg); (ii) Small-sized boats: boats with outboard or inboard engines, with or without cabins, and 6–12 m in length, with fish being stored in ice tanks (1,000–7,000 kg); and (iii) Medium-sized boats: boats with inboard engines, decks with cabins, and 12.5–18 m in length, with fish being stored in ice tanks (7,000–14,000 kg).

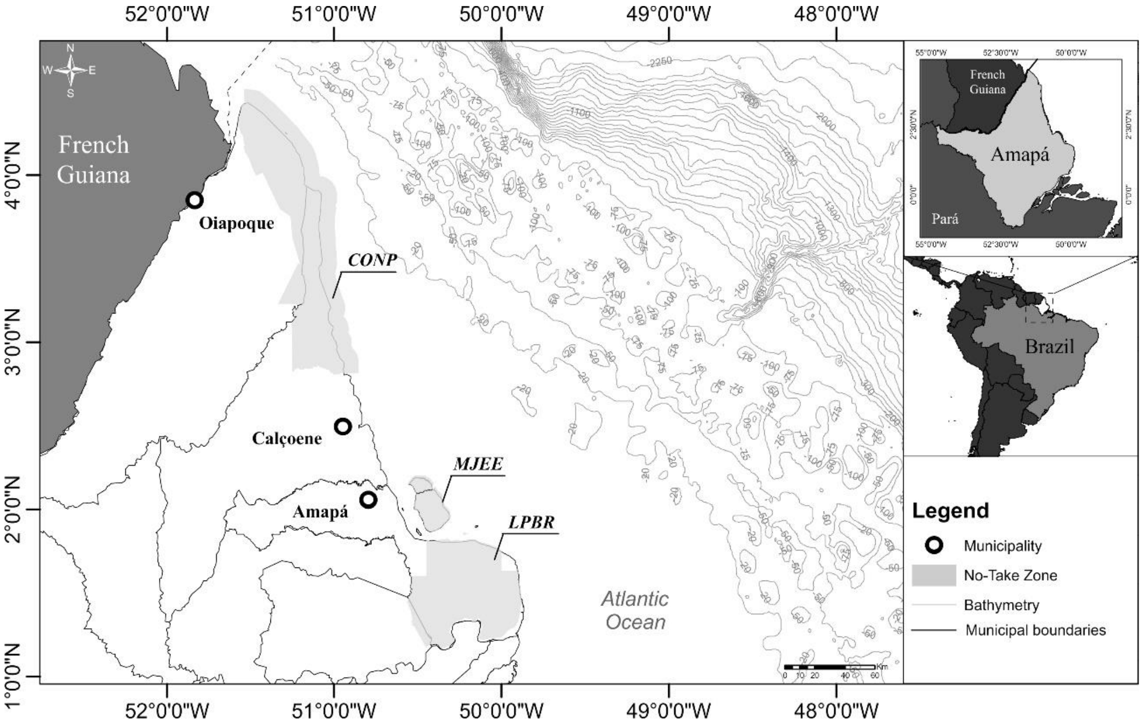

Fig. 1. Location of the studied municipalities (Oiapoque, Calçoene and Amapá) and the No-Take Zones (Cabo Orange National Park – CONP, Maracá-Jipióca Ecological Station – MJEE, and Lago Piratuba Biological Reserve – LPBR), in the state of Amapá (Amazon coast, Brazil).

2.2. Data collection and analysis

Data were collected through face-to-face interviews based on a standardized semi-structured questionnaire on the perceptions of fishers regarding conflicts and changes in fish abundance. The questionnaire consisted of five open-end questions: (1) Is there any conflict related to fishing in your community? (2) What do you think could be done to solve or reduce these conflicts? (3) Do you think that some fish stocks are declining? (4) In your opinion, what is the possible cause for this decline? (5) What do you think could be done to mitigate this decline?

The first and second questions aimed to identify the experiences of conflict by respondents and possible solutions they have considered. This approach allows interviewees to freely list all actions they perceive as conflicting and explain why, as well as the solutions that they believe are possible. The third question aimed to analyze the status of the fishery resources in the study area, and to identify the fish species impacted by anthropic pressure or natural changes. In the last two questions, the respondents were given the opportunity to suggest possible causes and solutions associated with these issues based on their views and experiences.

Fieldwork was carried out with the logistic support of ICMBio during several field trips conducted between January 2014 and September 2016. In total 359 fishers were interviewed, representing 27.6% of all fishers registered in the study area. Respondents were mainly men (92%), aged 18–82 years (39.76 ± 12.69), with low educational level (70% did not complete elementary school). Most had fishing experience of more than 10 years (75%), with fishing being their only source of income (70%).

Interviews were conducted at fish landing sites and at the houses and Colonies of fishers. A combination of random and snowball sampling methods was applied. The first respondents were fishers' leaders (i.e., presidents of the Fishers' Colonies), to obtain a general overview of the local context. Then, the fishers leaders indicated other fishers they believed to have a high fishing experience. The nominated fishers then suggested others. In this way, the snowball sampling procedure was followed, based on key informants (Bailey, 1982). When nominated fishers had already been interviewed, respondents were randomly selected according to the availability of fishers during the field period. This procedure aimed to minimize possible bias in the interviews (Musiello-Fernandes et al., 2018). Information acquired outside the context of interviews was used to support the collected data; such information included observations, experiences, and interactions with community members.

The interviews were carefully translated from Portuguese to English to maintain the original connotations of the narratives. Data from key informants and randomly selected respondents were analyzed together, because the same response patterns were observed. The qualitative responses about conflict experiences and their solutions were organized into categories according to the actors involved and the principal themes that emerged from the data. A response could contain more than one dominant theme. The percentage of respondents that mentioned each theme was calculated, and only themes cited by at least 10% of respondents were considered.

To analyze the status of fish stocks, the relative frequency that each species was mentioned was calculated. The discourses of respondents on the causes and solutions regarding changes to the abundance of fish stocks were analyzed through a quantitative method called 'similarity analysis.' This method extends information beyond the level of individual interviews, providing a deeper analysis of similarities in the structure of arguments used by the interviewees to justify their approach, based on the words used in the narratives, their frequency, and organization (Delattre et al., 2015). The similarity analysis allows the recognition of co-occurrences and connections between words, assisting the identification of the most common and important themes in discourses. This analysis is based on graph theory and is classically used for studying social representations (Flament, 1981).

To evaluate the possible influence of data translation on the results, the similarity analysis was performed in both languages (i.e., Portuguese and English). The two analyses generated very similar results, indicating that the data translation did not bias the results. The similarity analysis were performed using IRAMUTEQ (*Interface de R pour les Analyses Multidimensionnelles de Textes et de Questionnaires*) software (Ratinaud, 2009). To run this analysis, the software replaces all terms in the narratives by their canonical form (e.g., plural forms with singular forms, verbal forms with infinitive forms, elided words with corresponding non-elided words), and only the 'active forms' (e.g., content words like nouns, verbs, and adjectives) are considered (Delattre et al., 2015). The correlation among all active forms taken in pairs was calculated to obtain a similarity matrix, using the similarity index available in the R proxy library. The summary of information contained in the similarity matrix is graphically represented in a maximum tree (i.e., the simplest and most informative tree, containing only the strongest links) (Delattre et al., 2015; Vergès and Bouriche, 2001), in which the words are the vertices and the edges/links represent cooccurrences. The most frequently used words in the narratives appeared proportionately with larger size, with the same occurring for the thickness of the edges/links connecting the words, which reflects the strength of the relations between them. The algorithm of Fruchterman Reingold was used to optimize the display of the graph and to visualize the most 'central' words (Baril and Garnier, 2015).

3. Results

3.1. Conflicts in small-scale fisheries on the Amazon coast of Brazil

The main conflicts experienced by the respondents were grouped into three categories (Table 1): a) Local fishers and outsiders (73.1%); b) Fishers and surveillance agents (20.4%); and c) Fishers and middlemen (11.3%). The conflicts, their causes, actors, and possible solutions were examined.

Table 1
Actors, conflicts, and solutions identified from the discourses of respondents from the state of Amapá (Amazon coast, Brazil).

Actors	Conflicts	Solutions
A) Local fishers and outsiders (73.1%)	(AI) Overlapping of fishing grounds and predatory fishing (44.4%)	(AI) Surveillance (36.4%)
		(AI) To prohibit outsiders from fishing near the coast (26%)
		(AI) To create a protected area for local fishers (13.8%)
	(AII) Reduction of fish stocks (37.5%)	(AII) Surveillance (31.6%)
		(AII) To prohibit outsiders from fishing near the coast (10.5%)
	(AIII) Catches during the closed-season (10.2%)	(AIII) Surveillance (10.2%)
B) Fishers and surveillance agents (20.4%)	(BI) Prohibition of fishing in No-Take Zones (13.1%)	(BI) To create a protected area for local fishers or an agreement to allow fishing in No-Take Zones (13.1%)
	(BII) Aggressive, disrespectful and abusive approach (10.5%)	(BII) To improve approaches and enforcement (10.5%)
	(BIII) Ineffective and unequal surveillance (10.2%)	(BIII) Effective and egalitarian surveillance (10.2%)
C) Fishers and middlemen (11.3%)	(CI) Low price of fish (11.3%)	(CI) Investment in infrastructure and public policies (11.3%)

3.1.1. Conflicts between local fishers and outsiders

Competition with outsiders (i.e., fishers that does not live in the state of Amapá) is clearly the most significant conflict experienced by local fishers. This conflict involved mainly fishers from the state of Pará, with the overlap in fishing grounds and predatory fishing (44.4%) representing the main causes of tension. The fishing practices considered as predatory by the respondents included the use of very extensive gillnets, longlines with many hooks, and technological equipment to support fisheries (e.g., GPS, sonar, and power rollers to pull the nets), as well as the industrial trawl fisheries and their high fish catches and discards. Other conflicts involving outsiders were related to the increasing scarcity of fishery resources (37.5%) and the illegal catches of *S. parkeri* during the closed-season (10.2%), which was facilitated by the fact that surveillance is restricted to landings in the state of Amapá. Consequently, illegal catches landed in other states are not punished. The combination of these issues caused respondents to believe that their fishing activity and rights are negatively impacted by outsiders, whose fishing practices are considered an obstacle to the survival of local SSFs.

The solutions proposed by the respondents to the conflicts with outsiders mostly focused on the surveillance and prohibiting outsiders from fishing in the territories of local fishers (i.e., fishing grounds close to the coast) (Table 1). The fishers believed that these actions would reduce conflicts without any major social impacts, because the fishing fleet of Pará is formed of larger boats with more autonomy and technology to fish far from the coast. Within this context, the creation of a protected area for local small-scale fishers was also cited as solution (13.8%).

3.1.2. Conflicts between fishers and surveillance agents

In Brazil, environmental surveillance is carried out by two institutions: ICMBio (the national protected areas’ manager) and IBAMA (the national environmental agency). The conflicts between fishers and surveillance agents (20.4%) was mainly related to the conservation of natural resources in NTZs, including the prohibition of fishing in these areas (13.1%), the approaches used by surveillance agents (10.5%), and the effectiveness of surveillance (10.2%).

NTZs in traditional fishing territories were created in the 1980s under different contexts in each municipality of the study area. However, in all cases, the government imposed restrictions on the livelihoods of local residents, who heavily depend on natural resources as sources of food and income. In Oiapoque, the president of the Fishers' Colony reported the history of expulsion of the residents of Taperebá Village, which is located inside the CONP. According to this actor, after the NTZ was created, the government deactivated the public services offered to the village and implemented restrictions on access to natural resources. These events forced many residents to migrate to the urban area of Oiapoque, without any compensation. At present, just five families live in the village.

There are two fishers' villages (Araquiçaua and Paratu) inside the LPBR, and one other (Sucuriju) in the nearby area. Their livelihoods are intrinsically linked to the catch of freshwater and estuarine fishes in the protected lakes. The residents were not removed from their homes when the NTZ was created, but many restrictions were imposed by the government on their livelihoods. According to respondents, surveillance agents were aggressive, burning the wooden shelters built by fishers around the lakes. Respondents stated that conflicts with both CONP and LPBR were reduced by establishing Commitment Terms (CT) that regulate SSFs within NTZs by complying with rules that were collectively constructed by fishers and managers.

Respondents stated that there were only a few residents in the MJEE when it was created, but that many fishers used to fish and anchor their boats on the coastal islands that formed the NTZ, leading to many conflicts. In recent years, managers informally authorized fisheries using longlines aimed at reducing conflicts, but many fishers that use gillnets complained that there was no physical demarcation of the NTZ limits. Respondents also cited conflicts regarding the catching of bait for longlines inside the protected islands and the catching of crab by outsiders.

The interviewees also stated that surveillance was unequal and ineffective (10.2%), because it was only applied to local fishers, with outsiders fishing inside NTZs remaining unpunished. According to respondents, outsiders escape satellite surveillance by using small and untracked boats that operate in forbidden areas, supplying larger boats. Interviewees also complained about the approach used by the surveillance agents, which was considered aggressive, disrespectful, and abusive (10.5%).

Respondents cited three solutions to conflicts with surveillance agents: 1) the creation of a protected area for local fishers or an agreement to allow fishing in NTZs (13.1%), 2) improved performance of these agents, with a less aggressive approach (10.5%), and 3) transforming surveillance to be an effective and egalitarian activity, placing outsiders under intensive surveillance (10.2%).

A particular transnational conflict was cited by 22% of the interviewees of Oiapoque, regarding the performance of the surveillance agents. These respondents feel wronged because the fishers from French Guiana frequently fish in the state of Amapá but are not controlled, whereas Brazilian fishers entering French Guiana are aggressively combated by French surveillance agencies. Respondents reported that French fishers fish in the CONP and buy ice and sell fish to companies in Oiapoque. To resolve this conflict, respondents proposed an agreement between Brazilian and French governments to release SSFs in the transboundary region.

3.1.3. Conflicts between fishers and middlemen

The dependence of fishers on middlemen for production flow also constitutes an important source of conflict, cited by 11.3% of the respondents. The absence of structures for preserving fish meat and the lack of financial resources for production flow force fishers to sell their catches to middlemen, usually at low prices. The respondents believe that this conflict could be resolved by the intervention of government agencies, whose presence is perceived to be lacking in this region. The fishers highlighted the need for governmental investments in infrastructure to improve conditions associated with anchoring, landing, lighting, and availability of inputs (e.g., ice and fuel). In addition, fishers identified the need to implement policies and measures that promote fair marketing, as well as strategies that allow a greater diversification and valuation of the fishery products, with the aim of reducing the dependence of fishers on middlemen, which, in turn, would increase their income.

3.2. Status of fish stocks from the Amazon coast of Brazil

In the study area, approximately 75% of the respondents recognized a decrease in the abundance of fishery resources (71.5% in Oiapoque, 87.1% in Calçoene, and 72.8% in Amapá) (Table 2). *S. parkeri* was the main species cited in Amapá (64%) and Calçoene (55.7%), while in Oiapoque, *C. virescens* (32.3%) and *C. acoupa* (24.8%) were the most mentioned. Many respondents (26.8%) also stated that the abundance of all fishery resources have reduced.

Table 2
Fishery resources with reduced abundance according to the number (N) and percentage (%N) of citation by respondents from the studied municipalities in the state of Amapá (Amazon coast, Brazil).

Fishery resource	Oiapoque		Calçoene		Amapá		Total	
	N	%N	N	%N	N	%N	N	%N
Acoupa weakfish (*Cynoscion acoupa*)	33	24.8	19	31.1	7	9.3	59	21.9
Crucifix sea catfish (*Sciades proops*)	15	11.3	5	8.2	11	14.7	31	11.5
Gillbacker sea catfish (*Sciades parkeri*)	23	17.3	34	55.7	48	64.0	105	39.0
Green weakfish (*Cynoscion virescens*)	43	32.3	13	21.3	-	-	56	20.8
Others	48	36.1	12	19.7	8	10.7	68	25.3
All	42	31.6	16	26.2	14	18.7	72	26.8
Number of respondents	133	71.5	61	87.1	75	72.8	269	74.9

The similarity analysis of the discourses of respondents about the causes for declining fish abundance in the study area is shown in Fig. 2. Considering the number of occurrences, 'lot' was the most frequent active form and played a central role in the discourses, followed by 'boat,' 'fishery,' and 'fisherman', which were strongly linked to 'lot.' These words reflected the perception of respondents about intensive fishing activity, high fishing effort, and catching power. Fig. 2 also shows the connection between the words 'lot-gillnets,' 'lot-catch,' 'lot-boat-large,' and 'lot-fish-technology' (which was related to the use of technological equipment to support fish catches).

The presence of outsiders was cited as prejudicial, due to the increased fishing effort and catching power, as well as the predatory fishing, carried by these fishers. The activity of fishers from Pará State in the study area is shown in Fig. 2 through the connection between the words 'lot-Pará' and 'lot-boat-Belém.' Discourses about predatory fishing practices were observed through the words 'small-mesh,' 'industrial,' trawl,' 'closed-season,' and 'predatory,' which were linked to 'fishery' (Fig. 2). Industrial trawl fisheries were considered harmful, due to high fish catches and discards, and the use of small-mesh gillnets was considered predatory, due to the low selectivity of this gear. Outsiders were also accused of disrespecting closed-season of *S. parkeri,* which was demonstrated by the connection between the words 'lot-fishery-closed-season' and 'lot-spawn' (referring to catches during the spawning season).

Another cause cited by respondents was the trade of swim bladders (referred to as 'grude'), which is stimulated by their high value (USD 9–276 kg^{-1}) compared to fish meat (USD 0.15–3.69 kg^{-1}). Interviewees associated the high value of swim bladders with increasing pressure on fishery resources in the study area, because it is necessary to catch many fishes to obtain one kilogram of 'grude.' This discourse is shown in Fig. 2, through the connection between the words 'lot-fishery-grude.' According to respondents, the swim bladder trade includes all the four fishery resources listed in Table 2, and also *Sciades couma*.

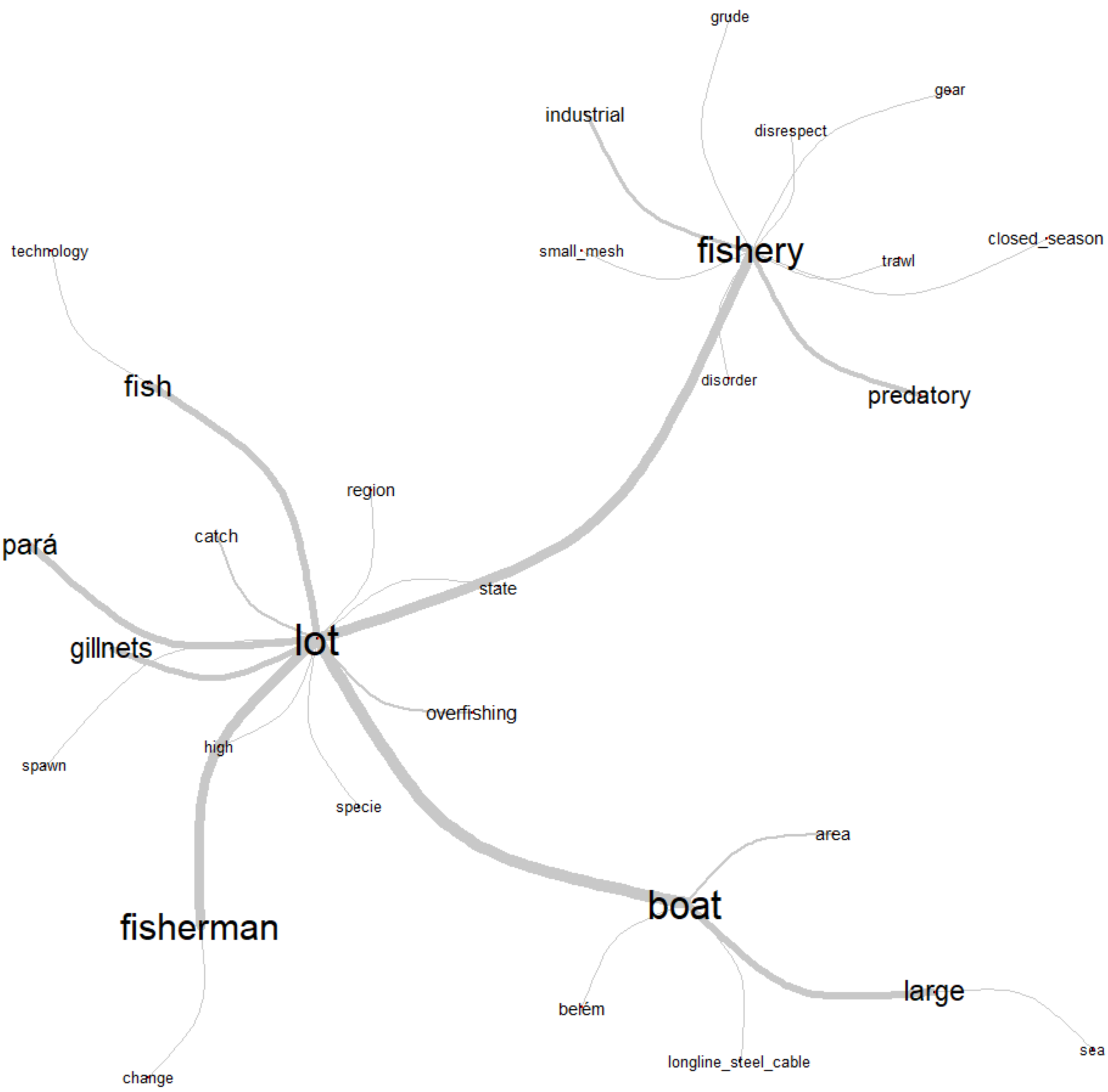

Fig. 2. Similarity analysis of respondent discourses about the causes for the declining fish abundance in the state of Amapá (Amazon coast, Brazil).

The similarity tree (Fig. 3) shows that, according to the perception of respondents, 'surveillance' represents the main solution for recovering fish abundance, because this word was the main active form in discourses, followed by 'boat,' 'fisherman,' and 'fishery.' Interviewees also suggested the need to reduce fishing effort and catching power, as observed by the connection between the words 'stop-freezer-boats' (i.e., boats with freezing systems on board), 'boat-move,' and 'boat-reduce-quantity.'

The similarity analysis (Fig. 3) also showed the perceptions of interviewees about the need to intensify the surveillance of outsiders, as verified by the connection between the words 'surveillance-Pará,' 'surveillance-boat-Belém,' 'surveillance-boat-state-increase,' and 'surveillance-fisherman-industrial.' The same was observed for predatory fishing, because 'surveillance' was also linked to 'trawl,' 'boat-large-discard,' 'fish-death,' and 'fish-mesh-size.'

The need for surveillance during the closed-season of *S. parkeri* also appears in the similarity tree (Fig. 3), through the link between the words 'surveillance-closed-season-respect,' 'surveillance-reproduction,' and 'surveillance-fish-period.' Many interviewees considered that the closed-season (November to March) does not cover the entire breeding season of *S. parkeri*, and that other species should be included in the closed-season, such as those listed in Table 2.

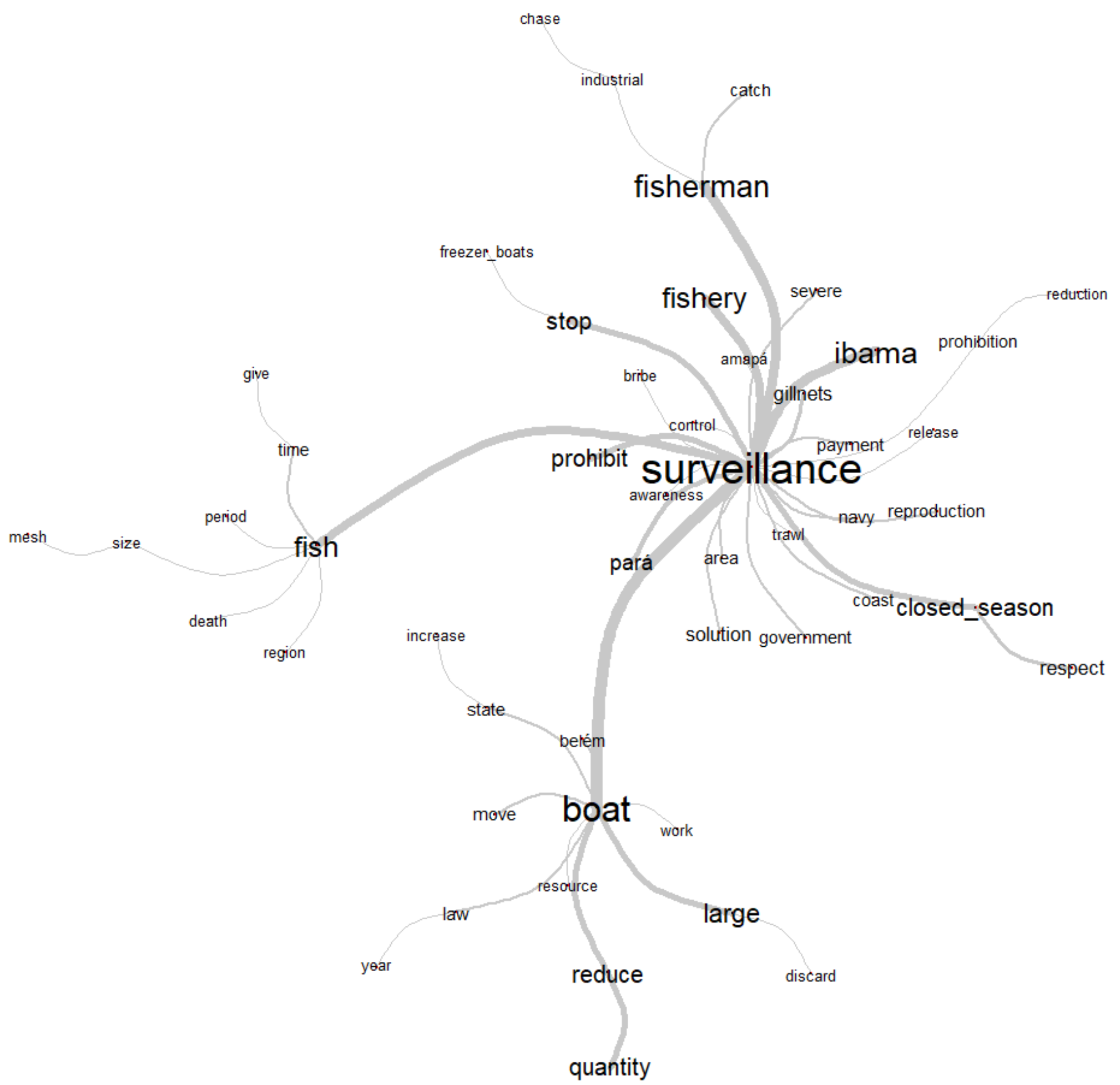

Fig. 3. Similarity analysis of respondents' discourses about the solutions for declining fish abundance in the state of Amapá (Amazon coast, Brazil).

4. Discussion and conclusions

4.1. Conflicts in small-scale fisheries on the Amazon coast of Brazil

On the Amazon coast of Brazil, conflicts exist over access to fishing territories and fisheries resources, which are also conflicts over livelihoods. These conflicts involve small-scale fishers, large-scale fishers, intermediaries, and government agents (e.g., surveillance agents and managers). Among these actors, power relationships are asymmetrical, with small-scale fishers holding the weakest position.

The most evident conflict experienced by local fishers is competition for fishing grounds with outsiders. Anyone involved in fisheries, whether a seaman, fish trader, manager, or scientist, is familiar with this problem. The main conflicts involve large-scale artisanal fisheries and industrial bottom trawlers from the state of Pará, who have the largest fishing fleet on Amazon coast (Bentes et al., 2012). Large-scale artisanal fisheries occupy an intermediate position between industrial and small-scale artisanal systems, as they have larger and more advanced boats than most of the small-scale fleets on the Amazon coast (Isaac et al., 2009).

Growing competition for fishery resources and territories between commercial fisheries is a global trend, especially in developing countries (Camargo et al., 2009; DuBois and Zografos, 2012; Murshed-eJahan et al., 2014; Pomeroy et al., 2007), with the small-scale fishery (SSF) tending to be the loser. For example, in southeast Asia, industrial fleets monopolize coastal fishery resources through high catching power and technology, undermining the productivity of SSFs (Pomeroy et al., 2007). In Sri Lanka, SSFs are threatened by the invasion of fishing grounds by Indian trawl fishers (Scholtens and Bavinck, 2018).

On the north coast of Brazil, the state of Amapá represents the last frontier for fishing, with increasing number of fishers from Pará migrating to this region in the past 10–15 years. The open access conditions and the decrease in fishing productivity in Pará (Betancur et al., 2015; Isaac et al., 2009; Lucena Frédou and Asano-Filho, 2006) have culminated in an increasing migration flow and a disorganized growth of the fishing sector. A similar scenario occurred when fishers from northeastern Brazil migrated to Pará, due to the exhaustion of snapper and lobsters stocks (Isaac et al., 2009).

The migration of fishers to the state of Amapá has intensified the pressure on fishery resources, imposing major challenges on fisheries management and the conservation of natural resources in NTZs, because outsiders illegally fish in these areas using small boats that are not tracked by satellite surveillance. This illegal activity is facilitated by the deficiency in the surveillance system, due to lack of human and financial resources, infrastructure, and equipment. The same strategy is used in Senegal, where industrial vessels transport small boats that fish in forbidden areas (DuBois and Zografos, 2012). Invasion of traditional fishing territories used by local communities and illegal fishing in protected areas also occur in other countries of West Africa, where migrant fishers benefit from the poor enforcement of management measures (Binet et al., 2012).

In this context, the fishery resources are not effectively protected within NTZs in the study area. In practice, restrictions are only imposed on local fishers, which is why they consider surveillance to be unequal and ineffective. This imbalance also results in the unequal distribution of conservation costs and benefits. Another conflict that reinforces this negative perception about surveillance is that the illegal catches of outsiders during the closed-season are not punished, since surveillance is restricted to landings in the state of Amapá. Conflicts involving the unequal application of restrictions between different actors or activities in protected areas are also observed in other regions (Bavinck and Vivekanandan, 2011; Begossi et al., 2011; Camargo et al., 2009; Majanen, 2007).

In different places in Brazil, fishers faces the significant loss of fishing territories due to the creation of NTZs, competition with industrial fishing, and other uses of the marine and coastal space (Begossi et al., 2011; Prestrelo and Vianna, 2016). This phenomenon was also observed in the study area, where local fishers are cornered between NTZs and outsiders working in larger and better equipped boats. In the 1980s, most NTZs were established in Brazil without consulting the local populations. In general, the NTZs were based on the North American preservationist model of that time, which aimed to protect wildlife independent of the human environment (Diegues, 2008). Due to this centralized and top-down approach, the creation of NTZs has culminated in conflicts related to the prohibition of access to natural resources and the expropriation of resident populations. This scenario has been observed in different regions of Brazil (Almudi and Kalikoski, 2010; Begossi et al., 2011; Leal, 2013), as well as other developing countries (Bennett and Dearden, 2014; Camargo et al., 2009; De Pourcq et al., 2015; Majanen, 2007).

In the study area, the creation of NTZs was also marked by a top-down process that did not consider the existence of communities reliant on natural resources, which directly affected local fishers, reducing the territories historically exploited by SSFs (Crespi et al., 2015; Pinha et al., 2015). In the first years after the creation of the NTZs, the relationship between local residents and managers was marked by tensions and highly repressive actions by surveillance agents. In the CONP, the prohibition of commercial fishing, the violent repression actions with military support, and the closure of public services (e.g., education and health services) by the government forced the residents of Taperebá to migrate to the urban area of Oiapoque. These actions led to profound changes to their livelihoods, because traditional activities developed in villages (e.g., agriculture, vegetal extraction, and hunting) could not be carried out in the urban area. As a result, the former residents of Taperebá became full-time fishers, leading to the expansion of fishing activity due to disputes with other fishers and the need to integrate local socioeconomic dynamics. This culminated in increased fishing effort and catching power, along with the replacement of more selective gears (i.e., longlines) in favor of gillnets (Crespi et al., 2015).

Many traditional communities live in and use the natural resources of LPBR, and their livelihoods were impacted by the creation of the NTZ. The repressive actions of surveillance agents included the destruction and burning of fishing gears and wooden shelters used to support fisheries (Pinha et al., 2015). In the MJEE, there were only a few residents on the islands that became protected; however, many fishers used to fish there. Until 2000, conflicts were mitigated by informal agreements. However, the prohibition of boat anchoring in some areas and increased surveillance between 2000 and 2010, culminated in the intensification of conflicts and the disruption of relationships between fishers and managers. These disruptions included retaliatory actions by fishers, such as threats to management teams and the deliberate setting of forest fires on the protected islands (Coutinho and Oliveira, 2016).

In the early 2000s, recognition of the rights of traditional populations, driven by international debates, led to the paradigm changing, including the focus of management agencies. This change facilitated the beginning of a dialogue that culminated years later in the establishment of the Commitment Terms (CT) in CONP and LPBR. CT is a legal instrument that allows the temporary regularization in the use of natural resources by traditional populations whose livelihoods are associated with protected areas where their presence is not permitted (e.g., NTZs) or who disagree with management mechanisms (ICMBio, 2012). In the MJEE, managers adopted an educational and informative approach since 2013, initiating a process of dialogue and conflict resolution, with the planned implementation of a CT (Coutinho and Oliveira, 2016).

The reduction in conflict between fishers and NTZs through CTs is one of the main reasons why this problem appeared as secondary in the narratives of respondents. At present, disputes with outsiders are considered to represent the main threat to SSFs by the interviewees. However, latent conflicts with NTZs are very worrying, because CTs are a transitory instrument that should only be used until a definitive solution is established. Such solutions might include changing or adapting the limits of NTZs or recategorization to a sustainable use area (Pinha et al., 2015). Both solutions should take account of the tradition, knowledge, and skills of local fishers to fish in coastal areas. In particular, the fishing technology (e.g., vessels and gears) used by local fishers does not allow them to fish in deeper water environments.

The respondents perceived that the solution to conflicts with outsiders is centered around surveillance. Despite existing tensions and conflicts, they believe that the presence of surveillance agents should help in reducing the different pressures on NTZs that also threaten their well-being (Melo and Irving, 2012), including fishing by outsiders and illegal mining. Another solution cited by respondents was the creation of a sustainable use protected area, with the aim of ensuring access to fishery resources by local fishers and to compensate them for the loss of fishing territories due to the creation of NTZs. This solution is also an attempt to prohibit outsiders from fishing near the coast. Since 2005, fishers have been attempting to create a Marine Extractive Reserve (MER), which is a protected area with the sustainable use of natural resources (IUCN category VI), where co-management is a prerogative (Gerhardinger et al., 2009). In recent years, the movement to create the MER is gaining strength, mainly due to the efforts of fishers from Oiapoque and the support of Non-Governmental Organizations (NGOs).

The third, most important, conflict experienced by respondents was their dependence on middlemen, which is commonly observed in SSFs worldwide. Globally, SSFs are subject to a lack of basic infrastructure for the fishing sector, and landing points are widely dispersed across the territory, distant from markets (Partelow et al., 2018; Salas et al., 2011; World Bank, 2012). The absence of a local market to absorb the catches and the lack of structures to preserve fish meat might compromise the entire catch, because fish are a highly perishable product. Therefore, the fish supply chain is dominated by a network of intermediaries that link SSF trading networks and the local, national and globalized export markets (Crona et al., 2010; Pedroza, 2013).

Intermediaries finance fisheries, providing credits to fishers in exchange for supplying fish at low prices, which is an obstacle in improving fishers' income (Capellesso and Cazella, 2013; Crona et al., 2010; Pedroza, 2013; Salas et al., 2011), with implications on fisheries management and conservation efforts. Partelow et al. (2018) argued that many fishers are beholden to patron-client systems, which are often exploitative, but are their only market access option. The low prices paid by intermediaries can lead to overharvesting, because increased extraction is the only way for fishers to earn enough income to meet their basic needs and live with dignity. In addition, middlemen often do not comply with the rules of the states (e.g., taxation, labor, and fisheries legislation).

This issue is an incentive for fishers to fish illegally, as their products are bought, even if they do not meet formal regulations, creating a state of ungovernability (Pedroza, 2013). The patron-client relationship also reinforces rent maximization tendencies and hampers the ability of fishers to self-organize. This issue, in turn, hinders their capacity to engage in collective actions for resource stewardship (Johnson, 2010). For instance, Seixas (2004) affirmed that the patron-client relationship is one of the barriers to the participation of resource users in fisheries management in Brazil.

The solutions proposed by the respondents regarding the conflicts with middlemen were focused on governmental investment in infrastructure and policies to facilitate fair marketing and to increase the value of fishery products. Policy makers and managers should also encourage fishers to form cooperatives for pre-sale processing aimed at improving the value added to fishery products, because, at present, only gutted fish are sold. Furthermore, cooperatives might represent an alternative tool to store fish catches, allowing fishers to negotiate better selling prices. This would overcome the issue of the high perishability of the fish and absence of freezing structures, which currently limits the bargaining power of fishers.

4.2. Status of fish stocks exploited by small-scale fisheries on the Amazon coast of Brazil

On the Amazon coast of Brazil, there is no continuous and effective monitoring of fisheries, leading to a deficiency in quantitative data for evaluating the status of fish stocks. However, in the present study, most respondents cited a decline in fish abundance, with the species mentioned by fishers forming the main fishery resources on the Amazon coast (Almeida et al., 2011; Bentes et al., 2012; Isaac-Nahum, 2006). The perception of interviewees was corroborated by landing data from the state of Pará, indicating a 47–54% decrease in the landings of *S. parkeri* between 1997 and 2007, even with increasing fishing effort. It is estimated that the decline of *S. parkeri* populations in Brazil is higher than 30% (ICMBio, 2018). In addition, estimated *C. acoupa* landings have declined by 27% over the last 10 years (Chao et al., 2015). Currently, *S. parkeri* is classified as ‘Vulnerable,’ while *C. acoupa* is classified as ‘Near Threatened’ (Chao et al., 2015; ICMBio, 2018). Both species were considered to be fully exploited in northern Brazil (Lucena Frédou and Asano-Filho, 2006).

The respondents perceived that the main causes for the decline in fish abundance are high fishing effort and catching power. In fact, fishing effort by the large-scale artisanal fleet of Pará has been systematically increasing as a consequence of good economic yields and government subsidies for purchasing fuel and financing fishing vessels (Isaac et al., 2009). The number of boats has increased significantly due to funds from the Constitutional Fund for the Financing of North, which has been operated by the Amazon Bank since 1997 (Lucena Frédou and Asano-Filho, 2006).

There are clear differences in the fishing effort and catching power between the fleets of Amapá and Pará. More than 60% of the fishing fleet from Amapá is composed of small-sized wooden boats of up to 12 m in length, with engine power of up to 160 HP, and storage capacity of one to seven tons, operating gillnets (average of 2,100 m in length) and longlines (average of 1,600 m in length and 1,400 hooks). The large-scale artisanal fishery of Pará is carried out by wooden boats of up to 20 m in length, using gillnets (> 3,000 m in length) and longlines (2,000 m in length and 3,000 hooks). In comparison, the industrial fleet of Pará employs large-sized steel boats (> 18 m in length), with powerful motors (average of 425 HP) and a storage capacity of up to 40 tons (Bentes et al., 2012). The industrial vessels are equipped with communication and navigation devices, and sophisticated catch processing onboard. Furthermore, shrimp trawlers have refrigerated chambers on board to freeze the catches (Bentes et al., 2012; Isaac et al., 2009).

Respondents considered industrial trawl fisheries to be harmful, due to the high fish catches and discards. Studies in the 1990s estimated that about 30 thousand tons of fish were discarded per year by trawl fisheries on the Amazon coast of Brazil (Isaac and Braga, 1999). However, recent studies have suggested that the waste has declined. Klautau et al. (2016) estimated that the trawler fleet catching *B. vaillantii* discarded 30% (311.276 tons) of its total production between 2002 and 2008, with about 44.468 tons being rejected per year during this period. Paiva et al. (2009) estimated that Penaeus subtilis represents only 20% of the total catch, with a ratio of 4.1 kg of bycatch for each 1 kg shrimp, leading to 17 thousand tons of bycatch in 2003.

Another predatory fishing practice cited by respondents was the illegal catches of *S. parkeri* during the closed-season. Moreover, fishers believe that the closed-season (November to March) does not cover the entire breeding season of *S. parkeri*. This demonstrates possible controversies in legislation, and the need for new studies on the life cycle of this species. Fishers also believe that other species should be protected during the closed-season, including *C. virescens*, *C. acoupa*, and *S. proops*.

The trade of swim bladder (‘grude’) was also cited by the interviewees as contributing to increasing fishing pressure because many fish are required to obtain 1 kg ‘grude.’ In the case of *C. acoupa* (the most valued species), 1 kg ‘grude’ is obtained from 10 large individuals weighing at least 7 kg each (Mourão et al., 2009). ‘Grude’ is used in the beverage, food, and cosmetics industries (Isaac et al., 1998). It is also marketed in Pará and Maranhão, from where it is primarily exported to Asian countries, such as Japan and China (Almeida et al., 2014; Mourão et al., 2009).

According to respondents, the main solution to recover fish stocks is surveillance. However, they also recognize the need to reduce fishing effort and catching power to protect fish stocks and SSFs. At present, there is no monitoring or control measures to regulate artisanal fisheries on the Amazon coast. However, the fishery resources cannot be sustained under uncontrolled exploitation for long periods. The imminent risk of overfishing threatens the integrity of ecosystems and the livelihoods of fishing communities in this region.

4.3. Fisheries management on the Amazon coast of Brazil

The two topics addressed in the present study are intrinsically related. The depletion of fish stocks has led to conflicts, which potentially lead to the unsustainable exploitation of fishery resources, with both issues threatening the NTZs. This scenario reveals the weak performance of management agencies and the government's incapacity to carry out effective enforcement, monitoring, and surveillance. It also reveals the lack of cooperation between stakeholders, culminating in a fisheries governance crisis. The major challenge seems to be to align the interests of different stakeholders and the conservation goals.

In this complex context, which includes the existence of diverse actors with different and, potentially, competing interests and accountabilities, new patterns of governance are necessary. Sustainable fisheries management could only be achieved through a wider cooperation between the government and all stakeholders. Co-management systems are characterized by the involvement and participation of resource users, the government, and external agents in decision-making (Jentoft et al., 1998; Pomeroy and Rivera-Guieb, 2005; Sen and Raakjaer Nielsen, 1996). Within these systems, the involvement of local populations and the incorporation of their needs and knowledge into decision-making process is essential (Andrade and Rhodes, 2012; Castello et al., 2009; Castilla et al., 2007; Oldekop et al., 2016). In turn, regulatory regimes are legitimized, with populations contributing to compliance, resulting in more effective conservation strategies (Jentoft et al., 1998).

Co-management arrangements are recognized as satisfactory approaches to achieve sustainable environmental governance. These arrangements are guided by the search for negotiated solutions that allow different interests to be balanced. In South America, Chile's experience in granting Territorial User Rights for Fisheries (TURFs) to small-scale fishers' organizations stands out as a successful co-management strategy (Castilla et al., 2007). One of the positive impacts of this initiative was the prevention of stocks that were being overexploited (Gelcich et al., 2010). Many studies have also demonstrated the role of co-management in reducing fisheries conflicts. For example, in Colombia and southeast Asia, places where co-management arrangements were established had lower levels of conflict, resulting in better fisheries management aimed at long-term sustainability (De Pourcq et al., 2015; Pomeroy et al., 2007). Furthermore, a study in developing countries demonstrated a direct relation between the participation of communities in decision-making process and compliance with conservation strategies within protected areas (Andrade and Rhodes, 2012).

In Brazil, most co-management systems are concentrated in the Amazon, where they contribute towards maintaining fish abundance, sustainable fisheries, and food security (Castello et al., 2009; Silvano et al., 2014). Nevertheless, most of these systems belong to continental areas, and involves territories characterized by well-delimited spatial boundaries, including many lakes (Pezzuti et al., 2018). On the Amazon coast, there are about 15 MERs that are still experimenting with this type of management. Consequently, it is too early to determine whether they are successful. However, they contribute towards protecting mangroves against shrimp farming and towards ensuring the access of traditional people to territories, allowing the maintenance of their culture. A recent study on land use in mangroves has demonstrated the important role MER play in protecting this ecosystem on the Amazon coast of Brazil (Hayashi, 2018). In addition, in the state of Bahia (northeastern Brazil), the implementation of the Cassurubá MER has enhanced social organization, with a gradual increase in social participation in decision making. In particular, this approach has reduced competition for resources with outsiders (Nobre et al., 2017).

The implementation of a MER provides an opportunity to establish a collaborative governance regime because, within this category of protected area, management responsibilities must be shared between managers and the community through deliberative councils, which are important spaces for dialogue, conflict mediation, and a platform for the inclusion of local knowledge in decision-making (Gerhardinger et al., 2009). At the study site, the good performance of the 'Commitment Terms' indicates that there is some willingness by local fishers to adopt co-management.

However, the success of co-management is strongly related to the presence of legitimate community leaders and robust social capital. Gutiérrez et al. (2011) analyzed 130 co-managed fisheries in several countries and identified that the presence of at least one highly motivated individual who was respected as a local leader and guided by collective interests could facilitate resilience to changes in governance, influence users compliance to regulations, and enhance conflict resolution. At present, fishing communities in the state of Amapá are experiencing an emerging leadership crisis, with the president of the Fishers' Colony of Oiapoque being the only leader that is widely respected and who has legitimacy. Therefore, the initial process of implementing a MER should include efforts to identify potential fishers that could be trained for the development of leadership skills and self-organization for collective actions. This process should be supported by scientists, universities, and NGOs.

The issues with local government agencies and the high cost of surveillance and enforcement emphasize the importance of co-management in the study area. In this sense, experiences related to community surveillance have been reported in the Brazilian Amazon as part of fisheries co-management in lake systems (McGrath et al., 2008). In addition, experiences in Mexico show that well-organized local groups can secure viable fisheries and coastal livelihoods (Méndez-medina et al., 2015). Furthermore, examples from Japan and the Philippines show that fishers' organizations contribute towards cost-effective ecosystem monitoring, which is indispensable for adaptive capacities (Makino et al., 2014). Sustainable use protected areas may also contribute to preserve endangered livelihoods, which seems to be the case for fishers from the present study. In Spain, La Restinga and Lira reserves have reinforced local fishing identities, preserving the traditional way of living, and a sense of ownership and responsibility over marine territories. These approaches have increased the control of local fishers in territories that they traditionally use (Pascual-Fernández and Cruz-Modino, 2011).

In the Brazilian Amazon, coastal fisheries management is essential to safeguard the food security of local populations. It is also important for the marine conservation of a region considered to be Ecologically or Biologically Significant Marine Area – EBSA (CBD, 2012), as well as a priority for biodiversity conservation (MMA, 2007). This region also encompasses two Ramsar sites. In this context, the creation of a MER favors the establishment of a network of no-take and sustainable use protected areas, as well as the connectivity between terrestrial and marine environments. This approach would contribute to the progress of Brazil in implementing elements of Aichi Target 11 within the Convention on Biological Diversity, such as connectivity between protected areas, as well as effectiveness and equity in the management of these spaces (CBD, 2010).

Achieving a balance between protecting ecosystems and their sustainable use is a major challenge, especially in the current scenario of the increasing human population, habitat loss, and the depletion of fish stocks. Therefore, NTZs are required, but are not sufficient to guarantee conservation. Effective environmental protection is only possible if local communities support and benefit from the implementation of conservation projects. A study by Oldekop et al. (2016) demonstrated that protected areas with positive conservation outcomes are associated with positive socioeconomic outcomes, which are more likely to occur when protected areas adopted co-management regimes that empower local populations, reduce economic inequalities, and maintain cultural and livelihoods benefits.

Without engagement from all resource users, it is very difficult to achieve fair and effective governance facilitating conflict resolution. Therefore, investment in capacity-building is needed to enable resource users and other stakeholders (e.g., managers, scientists, NGOs) to actively engage in participatory forms of coastal management (Seixas, 2004; Wever et al., 2012). Furthermore, efforts to facilitate interactions between stakeholders are needed, including the creation of a regional fisheries committee. This committee could then objectively discuss fishing rules and responsibilities and incorporate fishers' knowledge in the management process. Another important measure is the establishment of a research agenda that will subsidize a marine spatial planning in the future. The challenges are great, and require mobilization of people, conflict resolution, training, and a regional and multidisciplinary approach. Finally, the methodology used here could be improved by including the perspectives of other stakeholders (e.g., managers, policy makers, surveillance agents, outside fishers) to obtain an in-depth understanding of the identified issues.

Declarations of interest

None.

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4. Sustainability indicators for the integrated assessment of coastal small-scale fisheries in the Brazilian Amazon

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Sustainability indicators for the integrated assessment of coastal small-scale fisheries in the Brazilian Amazon

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Abstract

A multidisciplinary assessment of the sustainability status of 11 coastal small-scale fishery systems (FSs) in the Brazilian Amazon was performed through the Rapfish method, using 32 indicators within six evaluation fields (ecological, economic, ethical, institutional, social and technological). The results indicated that most FSs were ecologically, economically, and socially ‘less sustainable’ and institutionally and ethically ‘bad’. The FSs share similar features: high reliance on fishing, low education and income, scarcity of alternative livelihoods, isolation from large urban centers and markets, weak political representation, and lack of governmental assistance. Fisheries are multispecies, targeting fishes with long life cycles and moderate to high vulnerability. There is a prevalence of open-access systems and lack of decision-making power for fishers. Declining catches, increasing fishing effort and catching power, and competition with outside fleets threatens fisheries sustainability. Recommendations include moving towards participatory management and governance by multi-stakeholder partnerships and empowerment of local communities to assume responsibilities as resource stewards. Efforts to support the building of cohesive social organizations engaged in collective actions and to strength basic human rights to increase adaptive capacity and social-ecological resilience are required. New research and monitoring data are needed, as well as investments in capacity-building in research institutes and management agencies.

Keywords: Rapfish; Multidisciplinary Evaluation; Ecosystem Approach; Fisheries Management

1. Introduction

Fisheries play a crucial role in securing food, nutrition, employment and income for millions of people, especially in developing countries (Béné, 2006; World Bank, 2012). However, overfishing is a worldwide phenomenon as a result of a combination of factors, including subsidies and overcapacity, the rising global demand for fishery products and unsustainable fishing practices (Srinivasan et al., 2010). Global catches have been decreasing sharply at a mean rate of 1.22 mt per year since 1996 (Pauly and Zeller, 2016), and the percentage of assessed marine stocks fished at biologically unsustainable levels has increased from 10% in 1974 to 33.1% in 2015 (FAO, 2018), while 18% of unassessed stocks are possibly collapsed (Costello et al., 2012). Furthermore, discards − a hidden impact of fisheries − account for nearly 10% of total annual marine catches globally (Zeller et al., 2018).

Historically, fisheries sustainability has been evaluated through stock assessment models that requires substantial and reliable data (Alder et al., 2000; Berkes et al., 2001). However, its application in developing countries is limited by unavailability of baseline data and by the multispecies and multigear nature of most fisheries (Batista et al., 2014; Salas et al., 2007). Additionally, conventional stock assessment approaches used to focus on biological and ecological aspects, ignoring the multiple dimensions of fisheries and the broader perspective of sustainability (Garcia and Cochrane, 2005; Garmendia et al., 2010; Salas et al., 2007).

Fishery systems are characterized by a large diversity of geophysical, bioecological and socioeconomic aspects, and multiple political interactions (Berkes et al., 2001; Salas et al., 2011a). The complex relations between humans and natural resources reveals the need for management approaches considering environmental and conservation issues, as well as social and economic well-being. Many of the principles and concepts for responsible fisheries management included in the FAO Code of Conduct for Responsible Fisheries (FAO, 1995) are related to an Ecosystem Approach to Fisheries (EAF), whose main focus is to balance both human and ecological well-being in a fisheries context (Garcia et al., 2003).

One method to analyze the performance of fisheries on an EAF basis is the Rapfish – a multidisciplinary rapid appraisal technique to simultaneous assessment of the sustainability status of fisheries in different evaluation fields expressing a range of ecological and human dimensions (ecological, economic, ethical, institutional, social and technological) (Pitcher et al., 2013; Pitcher and Preikshot, 2001). Rapfish is a cost-effective and flexible technique, as it does not require data that are expensive or difficult to obtain, but instead relies on easily obtained field indicators or on experts' opinion (Tesfamichael and Pitcher, 2006). This technique has been used to assess the sustainability of fisheries worldwide (Baeta et al., 2005; Garmendia et al., 2010; Hernández Aguado et al., 2016; Murillas et al., 2008; Pitcher et al., 2009), including tropical multispecies fisheries (Cissé et al., 2014; Isaac et al., 2009; Suresha Adiga et al., 2016; Tesfamichael and Pitcher, 2006).

In the Brazilian Amazon, fishing is a way of life and the major source of income and food for coastal and inland people, with some communities having one of the highest rates of daily fish consumption in the world (462 g/person) (Isaac et al., 2015). In the Amazon coast, fishing operations range from manual collection of crabs and shellfishes by fishers without boats to large trawlers with freezing facilities. Small-scale fisheries are predominant and consist of typical tropical fisheries, multigear and multispecies (Almeida et al., 2011; Isaac et al., 2009).

In this region, important fish stocks have shown signs of decline, such as *Sciades parkeri* and *Cynoscion acoupa* (Chao et al., 2015; ICMBio, 2018; Lucena Frédou and Asano-Filho, 2006), and both from local and global perspective, fisheries management faces several challenges, such as lack of human and financial resources, weak governance, conflicts, absence of cooperation between the different stakeholders, and poverty (Chuenpagdee and Jentoft, 2018; Lopes et al., 2019; Pinheiro et al., 2015; Purcell and Pomeroy, 2015). Therefore, a transformation towards sustainable fisheries requires a multidisciplinary approach to guide the selection of context-appropriate management strategies, especially in data-limited scenarios.

This study assesses the sustainability status of coastal small-scale fisheries in the state of Amapá (Brazilian Amazon), based on a set of multidisciplinary indicators aiming at highlighting priorities for precautionary management and research to sustain the health of ecosystems and the livelihoods of fishing communities, as well as to establish a reference point to compare the current status of fisheries with a future condition. The application of the Rapfish method to the present case study is also an opportunity to test sustainability indicators to be adapted to other data-poor tropical small-scale fisheries in the context of developing countries.

2. Material and methods

2.1. Defining the fishery systems

The Brazilian Amazon coast is located on the North Brazil Shelf Large Marine Ecosystem (LME), and encompasses the states of Amapá, Pará and Maranhão. This region is also included in the Amazonian-Orinoco Influence Zone – an Ecologically or Biologically Significant Area – EBSA (CBD, 2012). The Amazon coast experiences extremely high energy expended by tides, currents, winds and the great runoff of water, solutes and particulates of the Amazon river, as well as high precipitation and temperature (Nittrouer et al., 1995; Nittrouer and DeMaster, 1996; Oltman, 1968).

The state of Amapá, in the Brazil-French Guiana border, has a coastline of 700 km divided into two sectors: oceanic (north) and estuarine (south) (Amapá, 1996). This case study was carried out in the oceanic sector, where the main landing sites of coastal fisheries are located: the municipalities of Oiapoque, Calçoene and Amapá (in the headquarter and the Sucuriju village) (Fig. 1), with about 1,300 professional fishers (SISRGP, 2016).

The oceanic sector is 462 km long (Amapá, 1996) with extensive muddy tidal plains and mangroves (Santos et al., 2016), encompassing three Full Protection Conservation Units[1] (CU): Cabo Orange National Park (CONP), Maracá-Jipióca Ecological Station (MJEE), and Lago Piratuba Biological Reserve (LPBR) (Fig. 1). They integrate a network of 17 inland and coastal protected areas, covering 72% (10 million ha) of the territory of the state of Amapá, including flooded and non-flooded forests, savannah, mangroves and estuaries (CI-Brazil, 2007). This area also covers two Ramsar Sites[2]: the CONP and the Amazon Estuary and its Mangroves.

Coastal small-scale fisheries are one of the main activities for local communities in the state of Amapá, with an annual average landing of 5,400 tons[3] (2000–2011), of which about 70% are originated from gillnets. Fisheries are multispecies, mostly carried out in shallow waters until 10 nautical miles from shore, with 30–40 fishery resources recorded in landings, however, five species (*Cynoscion virescens*, *C. acoupa*, *Sciades couma*, *S. proops* and *S. parkeri*) account for around 76% of the total catch (PROZEE, 2006). The fishing fleet is composed of approximately 500 wooden boats distributed into three categories: (i) Canoes (CAN): boats with outboard engine, no cabin, and 5–12 m in length, with fish being stored in ice in old refrigerators or polystyrene boxes (90–1,500 kg); (ii) Small-sized boats (SSB): boats with outboard or inboard engines, with or without cabin, and 6–12 m in length, with fish being stored on ice tanks (1,000–7,000 kg); and (iii) Medium-sized boats (MSB): boats with inboard engine, cabin, and 12.5–18 m in length, with fish being stored in ice tanks (7,000–14,000 kg) (Jimenez et al., 2019).

[1] Conservation Units are protected areas defined by Brazilian Law No. 9.985/2000. They are classified into two groups according to their main objective: full protection and sustainable use. Full protection conservation units aims the preservation of nature, and few human uses are allowed, such as scientific research and educational and ecological tourism.

[2] Ramsar Sites are wetlands of international importance designated under the Ramsar Convention – an intergovernmental treaty aiming at international cooperation for conservation and wise use of wetlands and their resources.

[3] Data available on the ICMBio (Chico Mendes Institute for Biodiversity Conservation) website: ww.icmbio.gov.br/cepsul/acervo-digital

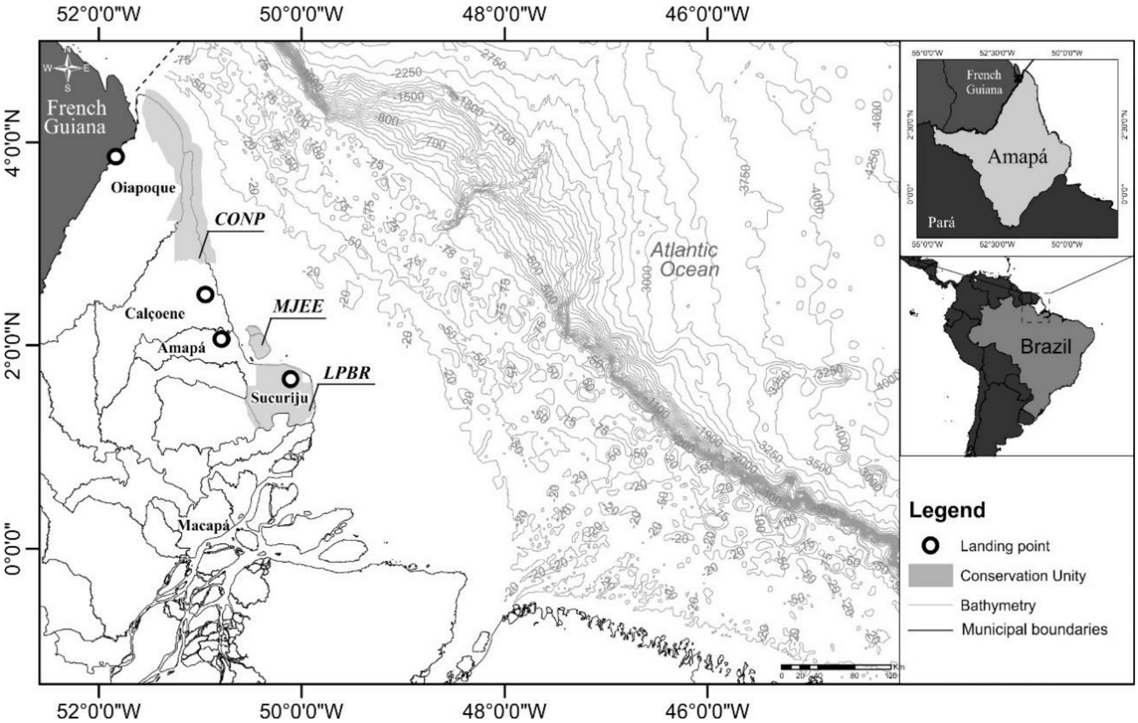

Fig. 1. Location of the state of Amapá (Brazilian Amazon), including the landing points of coastal small-scale fisheries (Oiapoque, Calçoene, Amapá and Sucuriju) and the Full Protection Conservation Units (Cabo Orange National Park – CONP, Maracá-Jipióca Ecological Station – MJEE, and Lago Piratuba Biological Reserve – LPBR).

In the Rapfish analysis, the definition of the fishery systems (FSs) has considerable flexibility, including different criteria, such as spatial, temporal, technological, anthropological and political measures (Alder et al., 2000). Cissé et al. (2014) evaluated the sustainability of small-scale fisheries in French Guiana, which share many similar characteristics with this case study: fisheries are multispecies, with the same dominant species in landings, and predominance of gillnets and small wooden boats. Therefore, in this study, the FSs were classified following Cissé et al. (2014), according to landing site and vessel type (Table 1). The delimitation of the FSs and their characteristics were defined based on fieldwork and literature review.

Table 1
The coastal small-scale fishery systems used for Rapfish analysis in the state of Amapá (Brazilian Amazon).

Landing site	Vessel type	Code	Major gears
Oiapoque	Canoe	O_CAN	Gillnet
Oiapoque	Small-sized boat	O_SSB	Gillnet
Oiapoque	Medium-sized boat	O_MSB	Gillnet
Calçoene	Canoe	C_CAN	Gillnet
Calçoene	Small-sized boat	C_SSB	Gillnet
Calçoene	Medium-sized boat	C_MSB	Gillnet
Amapá	Canoe	A_CAN	Gillnet/Longline
Amapá	Small-sized boat	A_SSB	Gillnet/Longline
Sucuriju	Canoe	S_CAN	Gillnet/Longline
Sucuriju	Small-sized boat	S_SSB	Gillnet/Longline
Sucuriju	Medium-sized boat	S_MSB	Gillnet/Longline

2.2. Defining and scoring attributes

A total of 32 attributes (indicators) that foster or inhibit sustainability were carefully selected according to different sources (Isaac et al., 2009; Pitcher et al., 2013; Pitcher and Preikshot, 2001; Suresha Adiga et al., 2015), and grouped into six evaluation fields (ecological, economic, ethical, institutional, social, and technological). The attributes were chosen based on their ease and objectivity of scoring (Pitcher and Preikshot, 2001), as well as considering the availability of data and their suitability in capturing the dynamics and reality of the FSs to be evaluated. Attributes description, scoring guidelines and data sources are shown in Table 2.

In order to adapt the Rapfish analysis to the present case study, new attributes were added and scoring criteria of some standard attributes[4] were carefully modified. Within each evaluation field (dimensions), five to six attributes were scored on a simple semi-quantitative scale, which was standardized to run from zero (worst) to 10 (best) (Pitcher et al., 2013). Each attribute was scored according to data collected in socioeconomic surveys, literature review, and opinion of fishery experts. These data were also used to assigned upper and lower bounds to individual scores in order to express uncertainty for each attribute. Tables with attributes and their corresponding scores for each evaluation field are available in Appendix A.

Socioeconomic surveys were carried out between 2014–2017 through face-to-face interviews with 395 fishers, owners of boats and community leaders. The interviews accounted for approximately 30% of all fishers registered in the study area, and were

[4] Standard attributes are those proposed by Pitcher et al. (2013) and Pitcher and Preikshot (2001), and those revised by the Rapfish Group of the Fisheries Centre of the University of British Columbia, which are available on the Rapfish official website (www.rapfish.org).

guided by a questionnaire consisting of open and closed questions on socioeconomic indicators (e.g., age, education, fishing income, fish consumption, working relations, alternative livelihoods, and social organization), information about the fishing activity (e.g., fishing gears, species caught, trip length, fish price, and marketing) and the fishing vessels (e.g., length, storage capacity, and power source). The survey also included questions on fishers' perceptions regarding conflicts and the status of fish stocks, as well their knowledge on the environmental legislation. Interviews were conducted at fish landing sites, at respondents' houses and Fishers' Colonies (i.e., formal small-scale fishers' organizations).

Officials of three fish processing companies were also interviewed, with questions on fish species and products traded, products prices, market and transport. Information acquired outside the context of interviews, through participation in meetings of the Fishers' Colonies and the councils of the CUs, photographic records, observations, and experiences with community members, were used to support the collected data. Attribute scoring also incorporated the opinion of fishery experts from the Fisheries Agency of Amapá State (a government fisheries management agency, referred as PESCAP) and the University of the State of Amapá (referred as UEAP). Therefore, data used to score the attributes were quantitative and qualitative.

Table 2
Description, scoring guidelines, and data sources of each attribute of the six Rapfish evaluation fields to be applied for each fishery system. Scoring scale is from zero (worst) to 10 (best), expressing how close the current state of the fishery lies to the worst or best possible status in terms of sustainability.

Attribute	Description and Scoring	Attribute Source	Data source
1. Ecological			
Conservation status	Assesses the national conservation status (CS) of the exploited species. A score was assigned for each extinction risk category (Least Concern = 5; Data Deficient and Near Threatened = 4; Vulnerable = 3; Endangered = 2; Critically Endangered = 1). Then, an average score was estimated for each fishery system according to the species classification in these categories. CS>4–5 (10–8); CS>3–4 (7–5); CS>1–3 (4–2); CS = 1 (1–0)	Attribute included	Conservation status available by species from ICMBio (2018)
Vulnerability	Assesses the susceptibility of the species through the Intrinsic Vulnerability Index (V-Index) by Cheung et al. (2005). Multispecies fisheries require an approximate average score. V=0–9 (10); V=10–14 (9); V=15–19 (8); V=20–24 (7); V=25–29 (6); V=30–39 (5); V=40–49 (4); V=50–59 (3); V=60–69 (2); V=70–79 (1); V≥80 (0)	Standard attribute	V-index available by species from Froese and Pauly (2019)
Migratory range	Assesses the number of jurisdictions encountered during life history of the species. Multispecies fisheries require an approximate average score. 1 jurisdiction only (10); 2–3 (9–7); 4–5 (6–4); 6–7 (3–2); > 7 (1–0)	Standard attribute	Literature review and experts' opinion
Life cycle	Assesses the longevity (in years) of the species. Multispecies fisheries require an approximate average score. <2 years (10); 2–3 (9); >3–4 (8); >4–5 (7); >5–6 (6); >6–7 (5); >7–8 (4); > 8–9 (3); >9–10 (2); > 10 (1–0)	Suresha Adiga et al. (2015)*	Literature review
Catch reduction	Assesses the percentage of interviewees who have cited declining catches. ≤ 20% (10–9); > 20–40% (8–7); > 40–60% (6–5); > 60–80% (4–3); > 80% (2–0)	Attribute included	Socioeconomic surveys
Fishing pressure	Assesses whether there has been an increase in fishing pressure on certain species in the past 10 years. Very little change or decrease (10–9); a small amount (8–7); somewhat (6–4); a lot (3–2); a great amount, rapid increase (1–0)	Attribute included	Socioeconomic surveys
2. Economic			
Subsidies	Assesses the presence of good, bad and ambiguous fishery subsidies. A description of the types of fishery subsidies is available from Sumaila et al. (2010). Good subsidies predominate (10–8); good and ambiguous subsidies predominate (7–6); ambiguous subsidies predominate (5–4); ambiguous and bad subsidies predominate (3–2); bad subsidies predominate (1–0)	Modified standard attribute	Experts' opinion
Autonomy and independence	Assesses the level of autonomy and independence that fishers have to market their products and negotiate prices. None (10); very low (9–8); low (7–6); medium (5–4); high (3–2); very high (1–0)	Attribute included	Socioeconomic surveys
Market	Assesses the extent of the market of fishery products. Local (10–9); state (8–7); regional (6–5); national (4–3); international (2–0)	Standard attribute*	Socioeconomic surveys

(continued)

Attribute	Description and Scoring	Attribute Source	Data source
Catch price	Assesses the average price of fish at the first-hand market (U$/kg). Very high > U$ 3.70 (10–9); high > U$ 2.50–3.70 (8–7); medium > U$ 1.50–2.50 (6–5); low > U$ 0.60–1.50 (4–3); very low ≤ U$ 0.60 (2–0)	Isaac et al. (2009)*	Socioeconomic surveys
Fishers' income	Assesses the average monthly income obtained from fishing based on the national minimum wage – MW (approximately USD 270.00 in 2016). Average > 4 MW (10–9); average > 3–4 MW (8–7); average > 2–3 MW (6–5); average ≥ 1–2 MW (4–3); average < 1 (2–0)	Attribute included	Socioeconomic surveys
3. Ethical			
Alternative livelihoods	Assesses alternative livelihoods to the fishery as sources of support within the community. Many other sources of livelihood (10–9); some (8–6); very limited (5–3); none (2–0)	Modified standard attribute	Socioeconomic surveys
Just Governance	Assesses the inclusion of fishers in management and governance. Full co-management with all parties equal (10–9); co-management and community leading (8–6); co-management and government leading (5–3); consultations (2–1); none (0)	Standard attribute	Experts' opinion and consultation to management instruments
Illegal fishing	Assesses illegal and unreported fish catches (non-compliance with gears, fishing grounds, periods, species and other regulations). None (10–8); some (7–6); a lot (5–3); a great deal (2–0).	Standard attribute	Socioeconomic surveys, consultation to management instruments and experts' opinion
Conflicts	Assesses the existence of conflicts among users, managers or other sectors. None (10–8); some (7–6); a lot (5–3); a great deal (2–0).	Standard attribute*	Socioeconomic surveys and experts' opinion
Food security	Assesses the importance of fish as food source, considering the frequency of weekly consumption. Daily (10–8); 5–6 times (7–5); 3–4 times (4–3); 1–2 times (2–0)	Attribute included	Socioeconomic surveys
4. Institutional			
Inclusiveness	Assesses the participation and influence of all stakeholders in decision-making process, and its results. A great amount (10–9); a lot (8–6); some (5–3); very little (2–0)	Standard attribute	Experts' opinion and consultation to management instruments
Legality	Assesses if the fishery demonstrate compliance to international obligations, national laws and reporting regulations. A great amount (10–9); a lot (8–6); some (5–3); very little (2–0)	Standard attribute	Experts' opinion and consultation to management instruments
Effectiveness	Assesses the effective implementation of management measures (e.g., ecosystem and precautionary approach, monitoring, control, surveillance, protection of species, habitats and areas). A great amount (10–9); a lot (8–6); some (5–3); very little (2–0)	Standard attribute	Experts' opinion and consultation to management instruments
Legislation knowledge	Assesses fishers' knowledge about environmental legislation and fishery management measures. Very high (10–9); high (8–7); medium (6–5); low (4–3); very low (1–2); none (0).	Attribute included	Socioeconomic surveys

(continued)

Attribute	Description and Scoring	Attribute Source	Data source
Professional register	Assesses the percentage of fishers that are formally recognized by the government as professionals. > 80% (10–9); > 60–80% (8–7); > 40–60% (6–5); > 20–40% (4–3); ≤ 20% (2–0)	Attribute included	Socioeconomic surveys
5. Social			
Strength of social network and leadership	Assesses the existence and effectiveness of fishery organizations and community leaders. Effective (10–8); partially effective (7–5); ineffective (4–2); none (1–0)	Modified standard attribute	Socioeconomic surveys and experts' opinion
Education	Assesses the level of formal education of fishers. Higher education (10–9); high school (8–7); middle school (6–4); elementary school (3–1); illiterate (0)	Modified standard attribute	Socioeconomic surveys
Access and road infrastructure	Assesses the access and quality of road infrastructure. Good roads (10–8); roads with medium quality (7–6); precarious roads (5–3); only by water (2–0)	Isaac et al. (2009)*	Socioeconomic surveys
Fishing income	Assesses the importance of fishing for the family income through the percentage of fishers who depend exclusively on fishing. > 80% (10–9); > 60–80% (8–7); > 40–60% (6–5); > 20–40% (4–3); ≤ 20% (2–0)	Modified standard attribute	Socioeconomic surveys
Age profile	Assesses the age profile of the community, where older fishers bring wisdom and perspective. Expresses the positive effects of intergenerational learning on sustainability. Average age ≥ 60 years (10–9); 50–59 years (8–7); 40–49 years (6–5); 30–39 years; (4–3); < 30 years (2–0)	Modified standard attribute	Socioeconomic surveys
6. Technological			
Change in catching power	Assesses whether fishers altered gear and vessel to increase catching power over past 5–10 years. Very little change or decrease (10–9); a small amount (8–7); somewhat (6–4); a lot (3–2); a great amount, rapid increase (1–0)	Standard attribute	Socioeconomic surveys and experts' opinion
Change in fishing effort	Assesses the evolution of fishing effort in the past 5–10 years (gears, fishers, boats, others). Decrease (10–8); stable (7–5); a small increase (4–3); a great increase (2–0)	Isaac et al. (2009)*	Socioeconomic surveys and experts' opinion
Selective gear	Assesses the selectivity based on the main gears used in the fishery system. Longline (10–9); longline mainly (8–7); longline and gillnet (6–5); gillnet mainly (4–3); gillnet (2–0)	Modified standard attribute	Socioeconomic surveys and experts' opinion
Vessel size	Assesses fishing capacity through the average length of vessels (in meters). <8 m (10–8); 8–12 m (7–5); > 12–16 m (4–2); > 16 m (1–0)	Standard attribute*	Socioeconomic surveys
Trip length	Assesses the average days at sea per fishing trip. ≤ 1 day (10); 2–4 (9–8); 5–7 (7–6); 8–10 (5–4); 11–13 (3–2); ≥ 14 (1–0)	Standard attribute	Socioeconomic surveys
Power source	Assesses fishing capacity through the engine power of vessels. < 30 HP (10–8); 30–60 HP (7–6); > 60–100 HP (5–4); > 100–140 HP (3–2); ≥ 150 HP (1–0)	Isaac et al. (2009)*	Socioeconomic surveys

*Categories have been adapted.

2.3. Rapfish analysis

The Rapfish method is based on a constrained Multidimensional Scaling (MDS) ordination technique and includes two types of uncertainty: the errors in estimating individual scores, accessed by a Monte Carlo simulation; and the contribution of each attribute to the results of an evaluation field, accessed by a jackknife-like leverage technique. The Rapfish method is thoroughly described in Alder et al. (2000), Kavanagh and Pitcher (2004), Pitcher et al. (2013, 1998), and Pitcher and Preikshot (2001). Rapfish analysis was performed in R software environment (R Core Team, 2019), with the R code for the Rapfish algorithm downloaded from the Rapfish website (www.rapfish.org).

The MDS output provides a two-dimensional ordination plot for each evaluation field, where the individual fisheries are the objects, and their relative positions are based on the attribute scores (Alder et al., 2000). The distribution of the FSs along the X-axis of the MDS plots express the sustainability status, running from zero (‘bad’) at far left to 100% (‘good’) at the far right (Pitcher and Preikshot, 2001). The Y-axis represent differences among fisheries achieved by obtaining the same sustainability rating from different combinations of attribute scores. Therefore, these differences are not related to sustainability (Baeta et al., 2005; Kavanagh and Pitcher, 2004). Anchor points (i.e., hypothetical fixed fisheries) for the best and worst possible scores, and a set of fixed intermediate scores, are automatically fed into the MDS algorithm (Pitcher et al., 2013), aiming to establish a normative direction to the MDS ordination, and to stabilize mirror image flipping during Monte-Carlo runs (Kavanagh and Pitcher, 2004).

Uncertainty in each attribute score was expressed for each evaluation field through Monte-Carlo runs – a statistical simulation method to evaluate the effects of random errors on a process (Pitcher and Preikshot, 2001). Random choices from triangular distributions (between the upper and lower bounds on each score) were used to select each one of the 500 Monte-Carlo runs performed (Pitcher et al., 2013). The median and 50% interquartile range of the scatter provided upper and lower limits on the performance rating of each FS in each evaluation field (Kavanagh and Pitcher, 2004).

A leverage analysis was carried out to determine how much each attribute influences the overall Rapfish ordination (Tesfamichael and Pitcher, 2006). A series of ordinations successively drops each attribute out of the analysis. Then, for each attribute the sum of squares of the differences of the x and y scores compared to those obtained with the full set of attributes is calculated, providing a standard error expressing the leverage of each attribute (Pitcher and Preikshot, 2001).

The Rapfish analysis provide performance ratings (i.e., sustainability scores) on a percentage scale for each FS, in six evaluation fields (Pitcher et al., 2009). Each FS was categorized based on the sustainability score adapting Pitcher et al. (2009): scores of 70% or more were considered ‘good’ in terms of sustainability, while scores of 60% to < 70% were considered ‘acceptable’ but in need of improvement. Scores of 40% to < 60% were considered ‘less sustainable’, while scores lower than 40% were considered ‘bad’.

In order to compare the overall sustainability status of fisheries, an average score was calculated from the scores of the six evaluation fields for each FS. The sustainability scores were combined in polygonal kite diagrams to provide a simple visual representation and to facilitate comparisons. Each axis of the kites represents one evaluation field, and for each one, a score of zero (0%) lies at the center and a score of 100% lies on the rim of the polygon (Pitcher and Preikshot, 2001).

3. Results

Fig. 2−7 shows the Rapfish analysis in the following order: a) Two-dimensional ordination plots from the MDS analysis. Reference anchor points are fixed at 100% (‘good’) and 0% (‘bad’) on the X-axis, and at -50 (‘down’) and plus 50% (‘up’) on the Y-axis; b) Sustainability performance ratings (vertical bars). Fishery systems are shown in order of performance rating from left to right. Thin lines indicate 50% interquartile (IQ) range from 500 Monte Carlo simulations. Dashed lines indicate performance ratings: ‘good’ (≥ 70%); ‘acceptable’ (60% to < 70%); ‘less sustainable’ (40% to < 60%); ‘bad’ (< 40%), and c) Attribute leverage analysis of the Rapfish ordination, based on the standard error in percent (S.E., %). The results are presented below separately for each evaluation field.

3.1. Ecological dimension

FSs were clumped in the two-dimensional ordination plot of the ecological field (Fig. 2a). Seven FSs lied in the right half of the sustainability axis, higher than 50%. The performance scores ranged from 43.04% for C_MSB to 59.65% for S_SSB. There was no FSs showing 'good' performance rating (≥70%), and 10 FSs had confidence limits that overlap the 'less sustainable' threshold (40% to <60%) (Fig. 2b). The leverage of individual attributes showed great disparities, ranging from 3.48% to 14.71%, and there were two key attributes influencing the ordination position of fisheries: 'Migratory range' and 'Life cycle', with a standard error (S.E.) of 14.71% and 12.49% respectively (Fig. 2c).

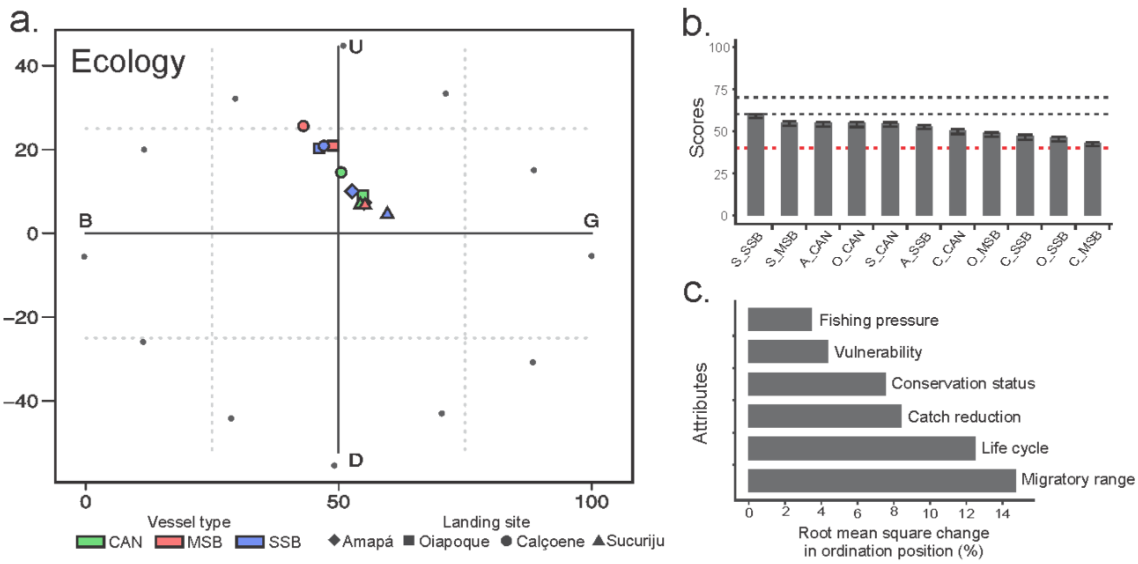

Fig. 2. Ecological Rapfish analysis for coastal small-scale fishery systems in the state of Amapá (Brazilian Amazon). See Table 1 for fisheries codes. a) Two-dimensional ordination plot from the MDS analysis. b) Sustainability performance ratings (vertical bars). c) Attribute leverage analysis of the Rapfish ordination.

3.2. Economic dimension

In the economic field, FSs were relatively clumped in the two-dimensional ordination plot and, except for S_MSB, they all lied in the left half of the sustainability axis, lower than 50% (Fig. 3a). The economic performance scores ranked from 32.69% for C_SSB to 57.35% for S_MSB, and no FS achieved 'good' performance rating. Six FSs (S_MSB, C_CAN, A_CAN, A_SSB, O_CAN and S_CAN) had confidence limits that overlap the 'less sustainable' threshold (40% to < 60%), and four FSs (O_SSB, C_MSB, O_MSB and C_SSB) had confidence limits in the 'bad' threshold (< 40%) (Fig. 3b). The leverage of individual attributes ranged from 2.42% to 10.70%, and there were two key attributes influencing the ordination position of the FSs: 'Market' and 'Autonomy and Independence', with standard error (S.E.) of 10.70% and 8.58% respectively (Fig. 3c).

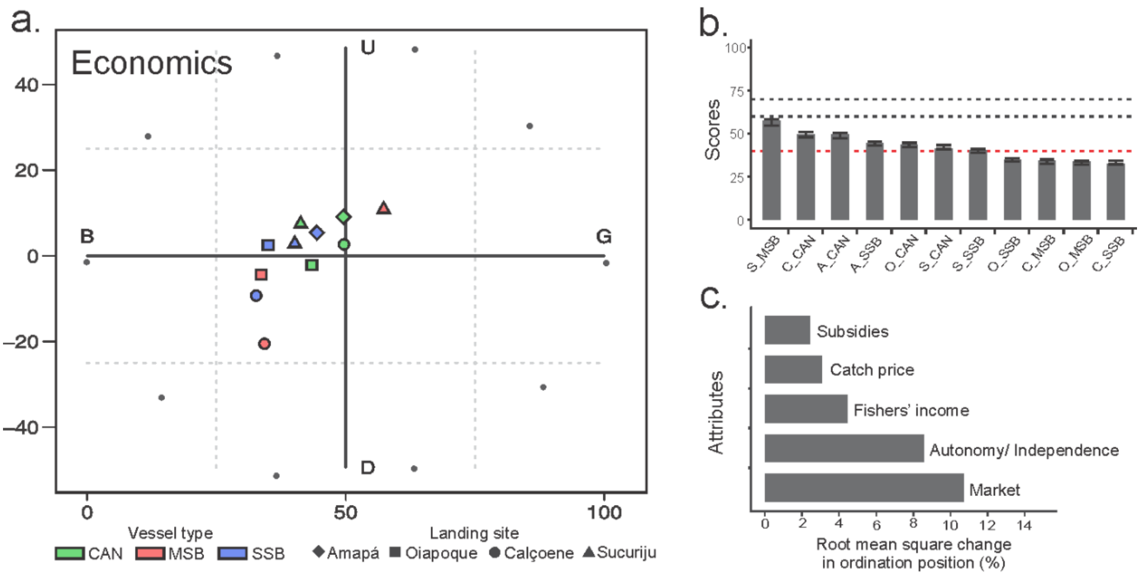

Fig. 3. Economic Rapfish analysis for coastal small-scale fishery systems in the state of Amapá (Brazilian Amazon). See Table 1 for fisheries codes. a) Two-dimensional ordination plot from the MDS analysis. b) Sustainability performance ratings (vertical bars). c) Attribute leverage analysis of the Rapfish ordination.

3.3. Ethical dimension

In the ethical field, FSs were more dispersed in the two-dimensional ordination and, except for O_CAN, they all lied in the left half of the sustainability axis, lower than 50% (Fig. 4a). The ethical performance scores ranged from 32.53% for A_CAN to 55.48% for O_CAN. There were no outstanding ‘good’ performance ratings, and three FSs (O_CAN, O_SSB and C_CAN) had confidence limits that overlap the ‘less sustainable’ threshold (40% to < 60%), while the other eight FSs had confidence limits in the ‘bad’ threshold (< 40%) (Fig. 4b). The leverage of individual attributes showed great disparities, ranging from 2.92% to 9.33% (Fig. 4c). The attributes ‘Just Governance’ (S.E. of 9.33%) and ‘Food security’ (S.E. of 8.93%) had greater influence on the ordination position of fisheries (Fig. 4c).

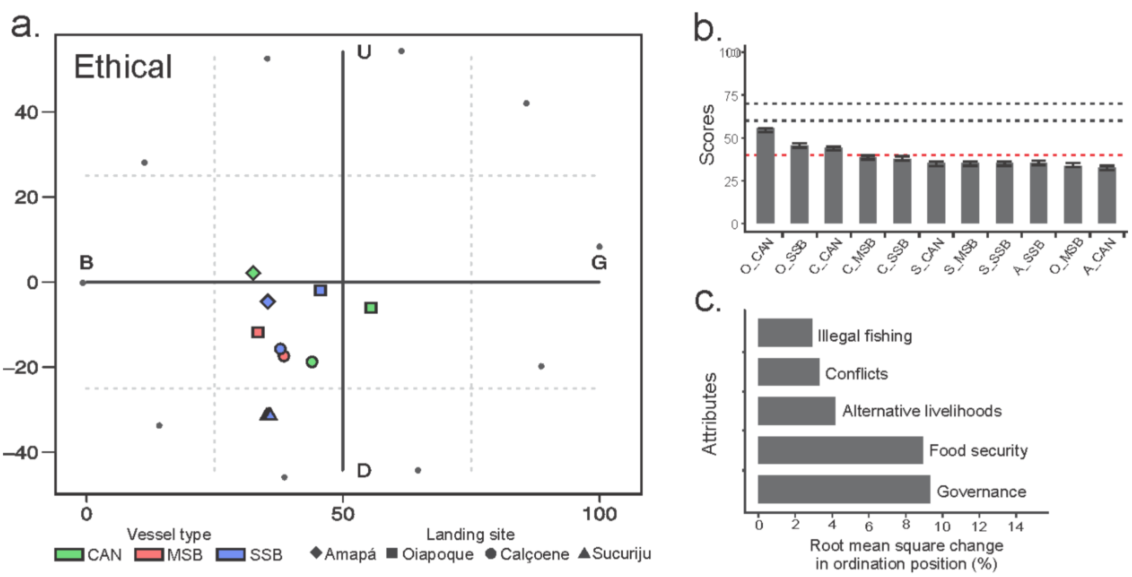

Fig. 4. Ethical Rapfish analysis for coastal small-scale fishery systems in the state of Amapá (Brazilian Amazon). See Table 1 for fisheries codes. a) Two-dimensional ordination plot from the MDS analysis. b) Sustainability performance ratings (vertical bars). c) Attribute leverage analysis of the Rapfish ordination.

3.4. Institutional dimension

In the institutional field, FSs were relatively clumped in the two-dimensional ordination plot (Fig. 5a), with few outliers, and they all lied in the left half of the sustainability axis, lower than 50%. Institutional performance scores ranged from 19.82% for C_CAN to 43.93% for O_SSB. There were no outstanding ‘good’ performance ratings, and except for O_SSB, all FSs had confidence limits that overlap the ‘bad’ threshold (< 40%) (Fig. 5b). The leverage of individual attributes ranged from 3.41% to 7.64% (Fig. 5c). The attributes with greater influence on the ordination position of fisheries were ‘Professional register’ (S.E. of 7.64%) and ‘Legislation knowledge’ (S.E. of 6.69%) (Fig. 5c).

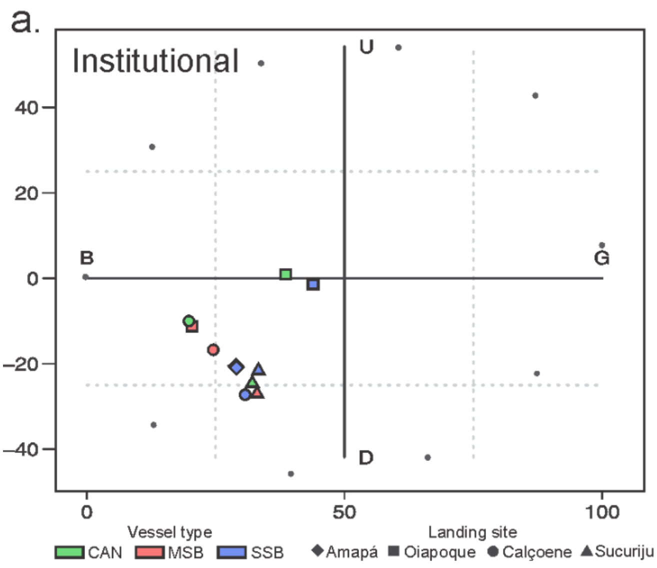

Fig. 5. Institutional Rapfish analysis for coastal small-scale fishery systems in the state of Amapá (Brazilian Amazon). See Table 1 for fisheries codes. a) Two-dimensional ordination plot from the MDS analysis. b) Sustainability performance ratings (vertical bars). c) Attribute leverage analysis of the Rapfish ordination.

3.5. Social dimension

In the social field, FSs were more dispersed in the two-dimensional ordination plot (Fig. 6a). Seven FSs lied in the right half of the sustainability axis, higher than 50%. The social performance scores ranged from 30.22% for S_MSB to 56.80% for C_SSB. There was no FS showing 'good' performance rating (≥70%), and eight FSs (C_SSB, A_CAN, A_SSB, C_MSB, O_SSB, O_MSB, O_CAN and C_CAN) had confidence limits that overlap the "less sustainable" threshold (40% to < 60%) (Fig. 6b), while the other three FSs had confidence limits in the 'bad' threshold (< 40%). The leverage of individual attributes ranged from 4.37% to 10.23% (Fig. 6c). Attributes with the highest influence were 'Income', 'Education', and 'Access and road infrastructure', with standard error (S.E.) of 10.23%, 9.80% and 9.72% respectively (Fig. 6c).

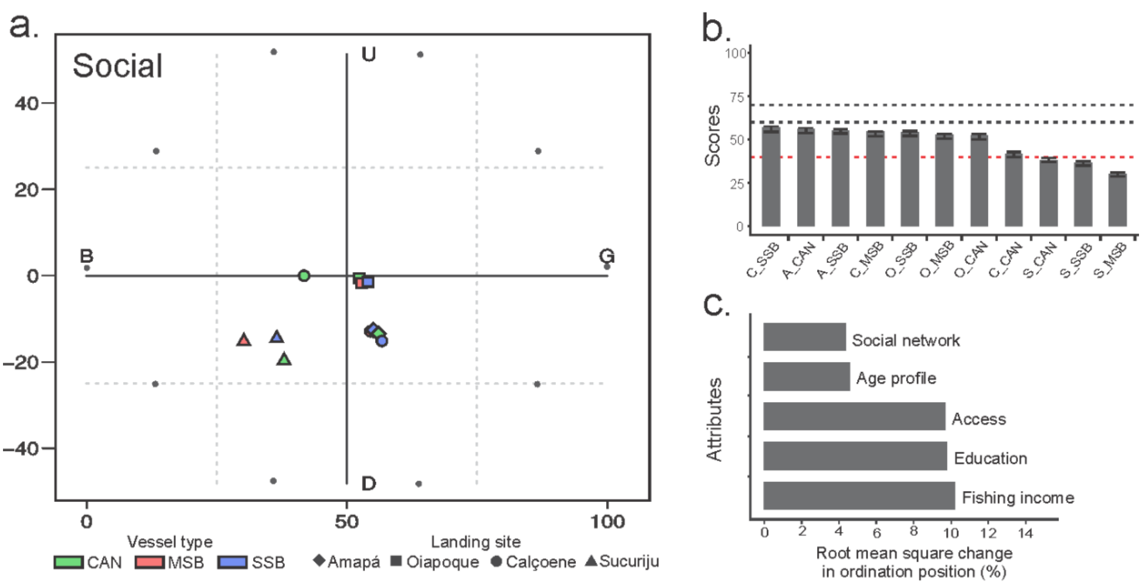

Fig. 6. Social Rapfish analysis for coastal small-scale fishery systems in the state of Amapá (Brazilian Amazon). See Table 1 for fisheries codes. a) Two-dimensional ordination plot from the MDS analysis. b) Sustainability performance ratings (vertical bars). c) Attribute leverage analysis of the Rapfish ordination.

3.6. Technological dimension

In the technological dimension, FSs had a wide distribution in the two-dimensional ordination plot. However, among the 11 FSs analyzed, seven lied in the right half of the sustainability axis, higher than 50% (Fig. 7a). The technological performance scores ranked from 22.77% for O_MSB to 70.72% for S_CAN. Overall, there was a tendency for the scores to decrease with the increase in boat size and catching capacity. The two FSs with the lowest scores comprised medium-sized boats (O_MSB and C_MSB), while the two FSs with the best performance comprised canoes (S_CAN and A_CAN). The S_CAN was the only FS showing 'good' performance rating (≥70%). Four FSs (A_CAN, S_SSB, C_CAN and O_CAN) had confidence limits over the 'acceptable' threshold (60% to <70%). Other four FSs (A_SSB, C_SSB, S_MSB and O_SSB) had confidence limits in the 'less sustainable' threshold (40% to < 60%), and two FSs (O_MSB and C_MSB) in the 'bad' threshold (< 40%) (Fig. 7b). The six attributes had similar values in the leverage analysis, ranging from 2.30% to 4.40%, and the attribute with the highest influence was 'Trip length' (S.E. of 4.40%) (Fig. 7c).

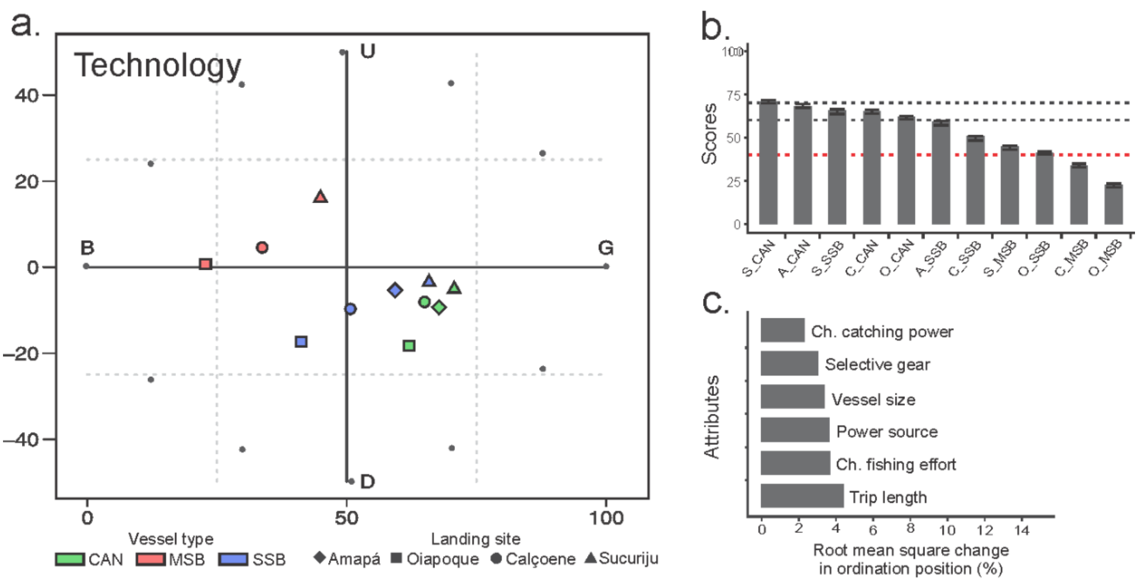

Fig. 7. Technological Rapfish analysis for coastal small-scale fishery systems in the state of Amapá (Brazilian Amazon). See Table 1 for fisheries codes. a) Two-dimensional ordination plot from the MDS analysis. b) Sustainability performance ratings (vertical bars). c) Attribute leverage analysis of the Rapfish ordination.

3.7. Comparison between fishery systems

The performance rating of each FS in the six evaluation fields and the mean sustainability scores are shown in Table 3. The mean sustainability scores ranged from 35.35% to 51.13% (Table 3). Nine FSs had 'less sustainable' overall performance, and two had a 'bad' performance. FSs comprising canoes (O_CAN and A_CAN) held the highest mean sustainability score. Conversely, FSs comprising medium-sized boats (O_MSB and C_MSB) appears to be the least sustainable. In general, most FSs showed better performance ratings in the technological, ecological and social dimensions, and a worse performance in the institutional field (Table 3), which is also demonstrated by the kite diagrams (Fig. 8).

Table 3
Sustainability performance scores according to Rapfish ordination for coastal small-scale fishy systems in the state of Amapá (Brazilian Amazon), in six evaluation fields. See Table 1 for fisheries codes.

Fishery System	Ecology	Economics	Ethical	Institutional	Social	Technology	Mean	Rank
O_CAN	54.85	43.46	55.48	38.60	52.35	62.05	51.13	1
A_CAN	55.03	49.59	32.53	28.93	56.10	67.76	48.32	2
A_SSB	52.67	44.44	35.37	29.05	55.10	59.34	46.00	3
S_CAN	54.50	41.32	35.51	32.12	37.94	70.72	45.35	4
S_SSB	59.65	40.17	35.51	33.23	36.55	65.88	45.17	5
C_CAN	50.53	49.67	43.91	19.82	41.79	65.01	45.12	6
O_SSB	46.16	35.01	45.63	43.93	54.05	41.20	44.33	7
S_MSB	55.21	57.35	35.51	33.03	30.22	44.94	42.71	8
C_SSB	47.09	32.69	37.81	30.73	56.80	50.66	42.63	9
C_MSB	43.04	34.30	38.52	24.56	54.53	33.71	38.11	10
O_MSB	48.98	33.65	33.44	20.38	52.88	22.77	35.35	11

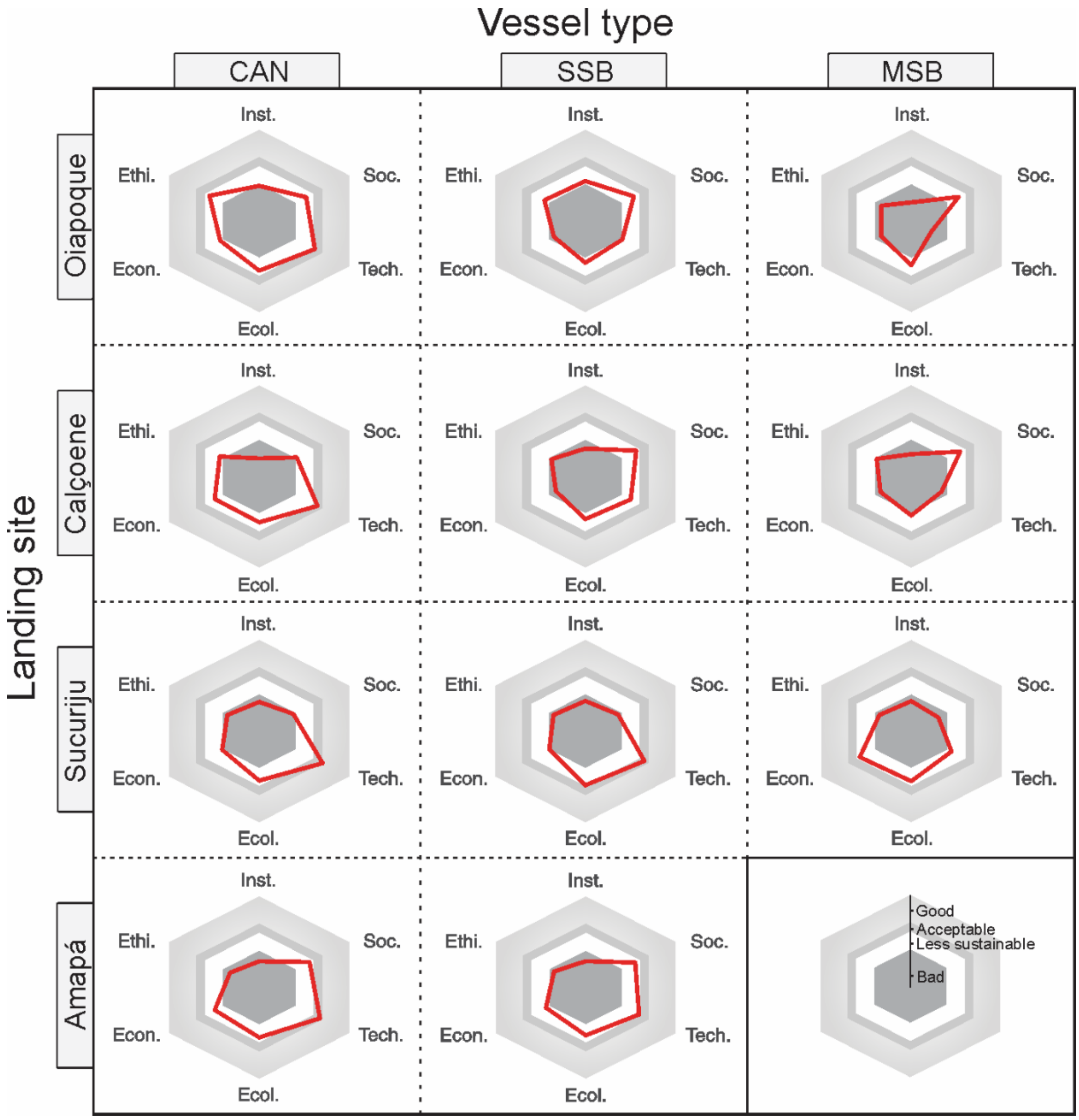

Fig. 8. Multidisciplinary kite diagrams expressing the sustainability scores in six evaluation fields for each coastal small-scale fishery system in the state of Amapá (Brazilian Amazon). ‘CAN’ stands for Canoes, ‘SSB’ for Small-sized boats and ‘MSB’ for Medium-sized boats.

4. Discussion

4.1. The sustainability status of coastal small-scale fisheries in the Brazilian Amazon

This paper provides a multidisciplinary assessment of the sustainability status of coastal small-scale fisheries (SSF) in the state of Amapá (Brazilian Amazon), using the Rapfish technique. The results showed that most fishery systems (FSs) had a ‘less sustainable’ overall performance, and they are better ranked in the technological and ecological dimensions, while the opposite occurred in the institutional and ethical fields. In Pará (Brazil) and French Guiana, the FSs also had a better sustainability performance in the ecological dimension (Cissé et al., 2014; Isaac et al., 2009).

The ecological sustainability scores of FSs were close due to the similar characteristics of these fisheries: multispecies, operating in adjacent fishing grounds, catching fishes with long life cycles (most have longevity > 10 years) and moderate to high vulnerability (V-index 51–90). The FSs with the worst performance (C_MSB, O_SSB, C_SSB and O_MSB) had poor scores for the attribute ‘fishing pressure’, which is related to an increasing market demand for fish and fish by-products. Particularly, the average price (USD 98.75 kg^{-1}) of swim bladders is much higher than fish meat, leading to a greater fishing pressure on certain stocks, such as *Sciades parkeri* and *Cynoscion acoupa*. Similarly, in Mexico, a high demand for fish swim bladders has increased pressure on the critically endangered *Totoaba macdonaldi*, since fishers earn more in one night catching few totoabas than they may otherwise earn in a year (Crosta et al., 2018).

Additionally, local fishers perceive a decrease in the abundance of the main fishery resources (Jimenez et al., 2019), and tendencies of declining catches were observed in Pará and Maranhão for important fish stocks, such as *S. parkeri*, *C. acoupa*, *Lutjanus purpureus*, *Scomberomorus brasiliensis* and *Macrodon ancylodon* (Almeida et al., 2014; Chao et al., 2015; ICMBio, 2018; Isaac et al., 2009; Lucena Frédou and Asano-Filho, 2006; Mourão et al., 2014), accompanied by a decreasing trend for threatened species commonly caught as bycatch in gillnet fisheries (e.g., *Epinephelus itajara*, *Megalops atlanticus*, *Isogomphodon oxyrhynchus*, *Sphyrna tudes* and *Carcharhinus porosus*) (ICMBio, 2018; Lessa et al., 2016, 2005).

Economically, most FSs were ‘less sustainable’ and four were ‘bad’. The FSs with the worse economic performance (C_SSB, O_MSB, C_MSB and O_SSB) supply national and international markets through intermediaries, since fishers do not have financial resources to afford transaction costs of commercialization. This high dependence on intermediaries results in the absence of autonomy and independence for fishers to sell their products and negotiate fair prices. Globally, fish value chains are dominated by intermediaries that buy and finance fish production, linking SSFs with local, national and global markets (Bjorndal et al., 2014; De Silva, 2011; Salas et al., 2011a; World Bank, 2012). Therefore, intermediaries play a paradoxical role, providing fishers with informal credits, access to markets, and helping them to avoid both transaction costs of commercialization and exposure to market fluctuations, but also leaving them with weak bargaining power (Basurto et al., 2013; Bjorndal et al., 2014; De Silva, 2011).

The FS economically better is composed of medium-sized boats landing in Sucuriju (S_MSB), whose owners act as middlemen, providing fuel and ice and buying catches of smaller boats. They sell fish in the capitals of Amapá (Macapá) and Pará (Belém) direct to consumers or to local fairs traders, allowing the negotiation of better prices. Similarly, in French Guiana, the FSs with better economic performance, sells fish direct to consumers, while the FS economically worse, sells fish to Brazilian middlemen (Cissé et al., 2014).

In the ethical and institutional fields, most FSs were sustainably 'bad'. Fisheries are crucial for food security as fish is the main protein for most fishers, especially in remote areas such as Sucuriju, where other sources of animal protein are limited. Furthermore, alternatives livelihoods are rare and fishing regulation measures, catches monitoring and mechanisms to ensure fishers’ participation in decision-making process are scarce. There are successful co-management experiences in Brazil, particularly in the Amazon (Castello et al., 2009; Lopes et al., 2019; Silvano et al., 2014), but effective participatory systems are generally unusual (Silva, 2014). Fisheries management is marked by decades of open-access (Di Dario et al., 2015; Pinheiro et al., 2015), with national policies focusing on capacity-enhancing subsidies (Abdallah and Sumaila, 2007; Azevedo and Pierri, 2014).

In the Amazon coast, most management measures are oriented to industrial fisheries (Isaac et al., 2009), and *S. parkeri* is the only fish caught by SSFs that has catch regulations (e.g., minimum catch size and periodic closure). However, monitoring, enforcement and surveillance are weak due to staff and financial constraints of government institutions, which is common in SSFs worldwide (Andrew et al., 2007; Pomeroy et al., 2016; Purcell and Pomeroy, 2015). Additionally, government institutions are frequently unprepared to deal with the diffuse and multispecies nature of SSFs, as well as the large number of people involved and their spatial distribution over large and often isolated areas (Berkes et al., 2001; Kolding et al., 2014).

In the study site, the councils of the Conservation Units (CUs) are important spaces of fisheries management and governance, dialogue and conflict mediation, since most fishing grounds are located in full protection areas (Jimenez et al., 2019). The councils aims to orient the decisions of the CUs' managers, with participants including representatives from government, civil society organizations, scientists, and other stakeholders (Almudi and Kalikoski, 2010). Fishers have an active voice in the councils, and although they have no decision-making power, their needs have been considered by managers, who have made efforts to implement 'Commitment Terms' (CT) – a legal instrument to regularize the use of natural resources by traditional populations whose livelihoods are associated with CUs where human uses are restricted (ICMBio, 2012). In summary, CTs are co-management systems with government leading, and the rules and responsibilities are establish in participatory processes including users and managers.

The FSs with the best ethical and institutional performances (O_CAN and O_SSB) have a CT that regulate fisheries within Cabo Orange National Park. This is the only formal experience of co-management in coastal areas in the state of Amapá, while in inland environments, a CT authorizes residents of Sucuriju to fish in the lakes of the Lago Piratuba Biological Reserve. There is also an informal agreement between local fishers and managers to authorize longline fisheries around the islands of the Maracá-Jipióca Ecological Station. Nonetheless, although there are formal and informal agreements regulating fishing in Full Protection CUs and reducing conflicts, monitoring compliance with the rules and effective surveillance to curb catches by outside fishers are hampered by limited capacity of management agencies (Jimenez et al., 2019).

There has been an increasing number of fishers from Pará and Maranhão fishing in coastal waters of Amapá (Almeida et al., 2011; Mourão et al., 2014, 2009), intensifying conflicts over fishing grounds (Jimenez et al., 2019). Possibly this migration is consequence of declining catches in those states. Globally, fish population decline is often accompanied by the migration of the fleet to places that are still productive, resulting in a growing competition between commercial fisheries (Pauly, 2006; Pomeroy et al., 2016, 2007). This is also the case of snapper and lobster fishers from Northeast Brazil who have migrated to Pará and Maranhão (Almeida et al., 2011; Isaac et al., 2009).

Socially, fisheries are full-time activities for most fishers, which are individuals with average age of 40–44 years, low education, and weak social organization. They are vulnerable and marginalized people with limited resources and poor political representation. Many Fishers' Colonies are ineffective to represent the collective interests of their members, since leaders often serves their personal interests and the politicians with whom they are associated. However, it must be recognized that communities' representativeness has increased since the creation of the CUs' councils. The weak organization and lack of social cohesion contribute to increase vulnerability and reduce resilience (Salas et al., 2011b). In contrast, well-organized groups can secure viable fisheries and livelihoods, improve the living conditions of fishers and help them to face times of crisis (e.g., low catch seasons) (Méndez-medina et al., 2015; Salas et al., 2011a).

In the FSs with the best social performance (C_SSB, A_CAN, A_SSB and C_MSB) fishers live in towns with some infrastructure (e.g., paved roads, public services of electricity, health, education, water and other amenities). The FSs socially worse are composed by boats landing in Sucuriju, with one of the poorest living conditions in the state of Amapá. Sucuriju is remote and accessible exclusively by water, electricity is available only at night from diesel power generators, and residents store rainwater as there is no piped water service.

In the technological field, there were FSs with sustainability from 'good' to 'bad'. The FS with the worst performance (O_MSB) uses most sophisticated technology (e.g., GPS and equipment for mechanically removing nets from water), with boats having the greatest average size, storage capacity and engine power, and showing increasing fishing effort and catching power. In Pará and Maranhão, a trend of increasing the number and size of vessels and nets and decreasing mesh size with support from subsidies has been observed (Almeida et al., 2011; Isaac et al., 2009; Mourão et al., 2009).

Globally, capacity-enhancing subsidies predominate over beneficial and ambiguous (Sumaila et al., 2016, 2010). Consequently, global fleets have increased their power an average of 10-fold since the 1950s and expanded their reach over all oceans, while the catch per unit of effort decreased (Watson et al., 2013). In Pará, the length of some gillnets more than doubled in 10 years (Mourão et al., 2014), and many medium-sized vessels were funded for *C. acoupa* fisheries (Mourão et al., 2009), which is now classified as 'large-scale artisanal' as they have more advanced attributes (e.g., engine power, autonomy, boat size) than most of the small-scale fleets in the Amazon (Isaac et al., 2009). Moreover, different mesh sizes are used to catch *C. acoupa* (Almeida et al., 2011; Mourão et al., 2009), and individuals of various sizes and maturity stages are caught, which may lead to growth and recruitment overfishing. Additional issue is the lack of discards data for SSFs. In French Guiana, discards reach 50% of the gillnets catches (Cisse et al., 2014).

4.2. Recommendations and conclusions

The Rapfish analysis showed that most FSs are ecologically, economically, and socially 'less sustainable', and institutionally and ethically 'bad'. Therefore, improvements in all fields are needed. The FSs share similar features: relative socioeconomic homogeneity, high reliance on fishing for food and income, scarcity of alternative livelihoods, isolation from large urban centers, and lack of governmental assistance. Hence, fisheries management and governance should be linked to a human rights perspective to achieve both human development and resource sustainability (Allison et al., 2012; Jentoft and Chuenpagdee, 2018).

International instruments and frameworks on good governance rooted on the humans rights approach to support of sustainable fisheries-based livelihood include the 'Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication' (FAO, 2015) and the United Nations Sustainable Development Goals (SDGs) (United Nations, 2015). They were built on the premise that eradicating poverty in all its forms and dimensions, bringing people out from marginalization and impoverishment, is an indispensable requirement for sustainable development. The effective implementation of their principles require multi-stakeholder partnerships and collaborative actions at all levels, bringing together governments, private sector, civil society, and scientists (FAO, 2015; United Nations, 2015).

In this context, transition to a collaborative governance regime with the involvement of all stakeholders is highly recommended. The experiences of the CTs indicates that there is willingness by local fishers for adoption of co-management (Jimenez et al., 2019), but efforts are required to build cohesive social institutions, training potential fishers in leadership skills and empowering them to participate in decision-making process and assume responsibilities in fisheries management and marine conservation. Some meta-analysis have shown that fisheries management success is related to the presence of strong leadership and robust social capital (Gutiérrez et al., 2011; Kosamu, 2015).

Additionally, investments in post-harvest infrastructure, in mechanisms to ensure fair trade and in diversification of livelihoods, are important measures to reduce fishers' vulnerability. Cooperatives, associations, and other types of organizational models have been recommended to reduce transaction costs, to increase fishers' bargaining power and to create better market conditions (Bjorndal et al., 2014; Garcia Rodrigues and Villasante, 2016; Purcell et al., 2017), but also to generate jobs in the post-harvest processing and marketing, contributing to poverty-averting potentials among fisheries households (Chuenpagdee and Juntarashote, 2011).

The open-access conditions of many SSFs and the presence of fish stocks shared between different states within a country or even between different countries, poses greats challenges to fisheries management (Salas et al., 2007). Similarly, in the study site, stocks are shared between different Brazilian states and French Guiana. Therefore, arrangements able to deal with transboundary stocks and to increase control over fishing pressure are required to minimize the risks of crossing undesirable thresholds. The creation of international collaborative working groups would be useful to synthesize available information and to establish standardized methods for data collection and analysis, enabling for subsequent comparisons.

The Rapfish method was employed here with some revised and new attributes, and the results provides important insights on the current trends of fisheries sustainability, creating a reference point for future assessments, but it must be stressed that this is not a definitive interpretation. Although extensive effort was made to make the scoring system and the definition of reference thresholds as objective as possible, due to the large gap of baseline data, much of this process was based on the subjective judgment of the people involved in this research, which may have led to a potential imprecision.

Particularly in the ecological field, the results may be not reasonable. Limitations in this dimension include difficulties in the estimation of biological information species-by-species, since in multispecies fisheries, fish specimens are commonly identified in large groups (e.g., sharks and rays). Additionally, there is no information on catches and population trends for most resources and their current state has not been appropriately evaluated. Therefore, a more detailed evaluation is required to support strategic management decisions. Over time, it is expected data to improve and assessment to become more reliable and accurate. This requires investments in the institutional capacity of research and management agencies. Finally, the process of identifying, defining and scoring attributes would be enriched through the participation of all relevant stakeholders, as done by Suresha Adiga et al. (2015) and Hernández Aguado et al. (2016).

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Appendix A. Supplementary material

Declarations of interest: None

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Appendix A. Scores for each attribute in six evaluation fields.

Ecology

Fishery system	Conservation status	Vulnerability	Migratory range	Life cycle	Catch reduction	Fishing pressure
A_CAN	8.7	3.8	9.3	0.8	4.0	8.5
A_SSB	8.5	3.6	9.3	1.2	3.5	7.0
C_CAN	8.9	3.9	9.5	1.6	0	8.5
C_MSB	8.7	3.8	9.5	1.2	0	3.0
C_SSB	8.5	3.9	9.6	0.8	2.7	3.0
O_CAN	8.9	3.4	9.0	1.9	4.9	6.0
O_MSB	8.7	3.9	9.5	1.6	3.5	2.0
O_SSB	8.5	3.3	9.5	0.6	3.8	2.0
S_CAN	8.5	3.7	9.3	1.0	3.7	8.5
S_MSB	8.2	3.9	9.0	1.9	4.4	7.0
S_SSB	8.9	3.7	9.2	1.6	6.8	7.0

Economics

Fishery system	Subsidies	Autonomy and independence	Market	Catch price	Fishers' income
A_CAN	6.0	2.4	9.0	4.7	1.5
A_SSB	6.0	1.8	7.5	4.2	2.5
C_CAN	3.0	4.0	9.0	4.2	2.0
C_MSB	3.0	1.1	2.5	5.4	6.5
C_SSB	2.5	2.6	2.5	5.2	3.5
O_CAN	5.0	0.0	9.0	4.2	3.0
O_MSB	7.0	0.6	2.5	4.2	5.5
O_SSB	8.5	0.9	2.5	4.0	5.0
S_CAN	6.0	0.0	9.0	4.0	1.0
S_MSB	7.0	6.6	6.0	4.9	4.0
S_SSB	6.0	1.4	6.0	4.2	3.0

Ethical

Fishery system	Alternatives	Governance	Illegal fishing	Conflicts	Food security
A_CAN	5.0	1.0	4.0	4.0	3.0
A_SSB	5.0	1.0	4.0	4.0	5.0
C_CAN	5.5	0.0	4.0	6.5	8.0
C_MSB	5.5	0.0	4.0	4.0	8.5
C_SSB	5.5	0.0	4.0	4.0	8.0
O_CAN	4.0	4.0	6.5	6.5	6.0
O_MSB	4.0	0.0	5.0	3.0	6.0
O_SSB	4.0	4.0	6.0	3.0	6.0
S_CAN	1.0	1.0	4.0	3.0	10.0
S_MSB	1.0	1.0	4.0	3.0	10.0
S_SSB	1.0	1.0	4.0	3.0	10.0

Institutional

Fishery system	Inclusiveness	Legality	Effectiveness	Legislation	Professionals
A_CAN	2.0	2.0	3.0	1.0	8.9
A_SSB	2.0	2.0	3.0	1.0	9.0
C_CAN	1.0	2.0	2.0	1.0	4.9
C_MSB	1.0	2.0	2.0	2.0	6.5
C_SSB	1.0	2.0	2.0	3.0	9.2
O_CAN	5.0	4.0	5.5	0.0	7.1
O_MSB	2.0	1.0	3.0	0.0	6.0
O_SSB	5.0	4.0	5.5	2.0	7.1
S_CAN	2.0	2.0	2.0	3.0	9.3
S_MSB	2.0	2.0	2.0	3.0	10.0
S_SSB	2.0	2.0	2.0	4.0	8.1

Social

Fishery system	Social network	Education	Access	Income	Age profile
A_CAN	4.0	2.0	8.0	7.6	4.9
A_SSB	4.0	2.0	8.0	7.1	5.0
C_CAN	4.0	2.0	8.0	1.0	5.4
C_MSB	4.0	2.0	8.0	6.5	5.6
C_SSB	4.0	2.0	8.0	7.5	5.6
O_CAN	9.0	2.0	4.0	7.9	5.0
O_MSB	9.0	2.0	4.0	7.9	5.4
O_SSB	9.0	2.0	4.0	9.0	4.4
S_CAN	4.0	1.0	1.0	9.1	5.2
S_MSB	4.0	1.0	1.0	4.3	7.6
S_SSB	4.0	1.0	1.0	10.0	2.6

Technological

Fishery system	Change catching power	Change fishing effort	Selective gear	Vessel size	Trip length	Power source
A_CAN	7.5	5.0	5.5	8.2	5.8	9.6
A_SSB	6.5	5.0	5.5	6.5	4.5	8.5
C_CAN	7.5	5.0	5.0	8.0	5.1	9.5
C_MSB	4.0	5.0	3.0	3.7	0.0	5.3
C_SSB	4.0	5.0	4.0	6.5	3.1	8.3
O_CAN	6.0	3.5	4.0	7.6	7.8	9.1
O_MSB	2.5	2.0	3.0	2.5	0.7	3.2
O_SSB	2.5	2.0	3.0	6.8	3.2	7.3
S_CAN	7.5	7.0	5.5	8.3	5.3	9.7
S_MSB	6.5	7.0	5.5	3.0	1.0	4.9
S_SSB	6.5	7.0	5.5	6.5	6.7	7.8

5. Considerações finais

Este estudo analisou a sustentabilidade de pescarias artesanais costeiras do estado do Amapá (litoral amazônico), através de três abordagens complementares que incluíram uma descrição da dinâmica da pesca de pequena escala e de sua cadeia de valor, uma caracterização dos conflitos no setor pesqueiro e do status dos recursos explorados na percepção dos pescadores locais e uma avaliação do estado das pescarias em relação a indicadores multidisciplinares de sustentabilidade através do método Rapfish.

Na área de estudo, a dinâmica da cadeia de valor dos produtos da pesca marinha responde a uma variedade de estímulos com efeitos sinérgicos. O aumento do consumo nacional de pescado e da demanda por subprodutos no mercado externo, aliado à ausência de controle efetivo sobre o esforço de pesca, tem impulsionado o setor pesqueiro local. A carência de meios de subsistência alternativos à pesca também age como fator de incentivo, ao mesmo tempo em que a alta dependência desta atividade como fonte de renda e segurança alimentar torna as comunidades locais muito vulneráveis à degradação dos ecossistemas marinhos e declínios nas capturas, o que já tem sido constatado pelos pescadores, conforme demonstrado neste estudo.

A vulnerabilidade destas comunidades é agravada pelo baixo nível de escolaridade dos pescadores, pela fraca atuação das organizações sociais existentes, pela distância dos mercados consumidores e dos órgãos governamentais, e pelo crescente fluxo de pescadores migrantes para a região, intensificando a competição por recursos limitados. Soma-se a estes fatores a ineficácia do governo, incluindo a ausência de políticas públicas adequadas às condições locais, a carência de estruturas sólidas de governança, as grandes lacunas de conhecimento e o apoio insuficiente às instituições de pesquisa.

Os efeitos cumulativos dos fatores citados, resultam em pescarias com desempenho desfavorável em termos de sustentabilidade considerando todas as dimensões analisadas. Deste modo, promover o equilíbrio entre a conservação e o uso sustentável dos recursos é complexo, sobretudo considerando que a dinâmica do setor pesqueiro local inclui elementos que ultrapassam as fronteiras jurisdicionais do país. Diante do exposto, ao menos dois desafios principais precisam ser superados para melhorar a sustentabilidade das pescarias: i) aprimorar o sistema de gestão e governança e ii) reduzir a vulnerabilidade das comunidades pesqueiras. Em muitos aspectos estes desafios estão interrelacionados.

Considerando a incapacidade do governo de assumir todas as responsabilidades inerentes ao gerenciamento do setor pesqueiro, é evidente a necessidade de uma reforma no sistema de gestão e governança vigente em direção a abordagens que permitam às comunidades locais uma maior participação no processo de tomada de decisão. Nesse sentido, os resultados apresentados neste estudo sugerem a concessão de direitos de acesso preferencial às comunidades locais, a fim de promover a co-gestão como um dos caminhos possíveis para uma boa governança.

Assim, recomenda-se a criação da reserva extrativista marinha ou a realização de um zoneamento das áreas de pesca, delimitando os espaços onde as diferentes frotas podem operar e destinando os locais próximos à costa às comunidades locais. Igualmente importante é a mobilização e capacitação dos pescadores para compartilharem a responsabilidade pelo monitoramento da região, uma vez que a dificuldade de acesso e as condições ambientais extremas impõem grandes desafios logísticos e operacionais aos órgãos competentes, que possuem capacidade institucional limitada.

É imprescindível também o controle do esforço e do poder de captura das frotas. Adicionalmente, o monitoramento das capturas deve ser adotado como uma política permanente de estado, uma vez que este tipo de informação é essencial para o planejamento das ações governamentais, seja no âmbito socioeconômico ou de conservação dos ecossistemas locais. Nesse sentido, destaca-se também a necessidade de um maior controle sobre o mercado de bexiga natatória, uma vez que grande parte da comercialização ocorre de forma informal, o que é preocupante tanto do ponto de vista da arrecadação de impostos quanto do aumento da pressão pesqueira, conforme reportado pelos pescadores neste estudo.

Reduzir a vulnerabilidade das comunidades perpassa pela formação de instituições socais coesas, capazes de participar efetivamente da gestão, e pelo fortalecimento do papel dos pescadores na cadeia de valor do pescado. Em ambos os casos, são necessárias ações de extensão para desenvolver a capacidade de auto-organização das comunidades e formar novas lideranças. Há também a necessidade de investimentos estruturais no setor pós-captura e da criação de políticas que possibilitem o acesso direto ao mercado, incluindo a ampliação do mercado local para produtos da pesca marinha e a promoção do consumo institucional. Por outro lado, é importante a construção de uma política que viabilize a diversificação das atividades geradoras de renda para melhorar as condições de vida dos pescadores e suas famílias e reduzir a pressão sobre os recursos pesqueiros.

Do ponto de vista da governança, é preciso criar estruturas ou fortalecer aquelas que estão em funcionamento, como é o caso dos conselhos das unidades de conservação, uma vez que estes espaços têm sido o palco principal das discussões sobre as problemáticas da pesca de pequena escala. Outra questão importante é a inclusão do conhecimento ecológico local no manejo das pescarias. O período de defeso da gurijuba (*S. parkeri*) é questionado pelos pescadores, os quais também apontam a importância de proteger os períodos reprodutivos de outras espécies intensamente exploradas, como a corvina (*C. virescens*) e a pescada amarela (*C. acoupa*).

Conforme observado neste estudo, alcançar a sustentabilidade requer transformações e cooperações em múltiplas escalas, bem como assistência técnica e financeira em todos os níveis. Apesar das limitações de dados, o estudo fornece uma análise importante sobre as tendências atuais da sustentabilidade das pescarias, e os resultados podem ser utilizados para orientar o planejamento de ações para melhorar o desempenho do setor. O estudo também pode servir como uma linha de base para uma análise posterior mais precisa, com a incorporação de informações que atualmente não estavam disponíveis. De todo modo, o desempenho das pescarias nas diferentes dimensões precisa ser monitorado ao longo do tempo para orientar a priorização dos esforços de gestão.

Para finalizar, são apresentadas algumas recomendações visando assegurar a sustentabilidade das pescarias em uma perspectiva mais geral e de longo prazo:

- Elaboração participativa de uma política integrada de gestão da pesca na plataforma norte do Brasil e Guiana Francesa, baseada nas “Diretrizes Voluntárias para Garantir a Pesca de Pequena Escala Sustentável no Contexto da Segurança Alimentar e da Erradicação da Pobreza” (FAO, 2015) e nos “Objetivos de Desenvolvimento Sustentável” das Nações Unidas (UNITED NATIONS, 2015), que são instrumentos complementares e sinérgicos;
- Criação de um grupo de trabalho regional para sintetizar as informações disponíveis e estabelecer métodos padronizados para coleta, processamento e análise de dados, bem como estabelecer uma rede de cooperação em pesquisa visando a produção de uma base comum de conhecimentos que viabilize uma colaboração futura mais ampla em termos de regulamentação e ordenamento das pescarias, bem como de avaliação dos estoques compartilhados.
- Fortalecimento da cooperação entre o governo, a sociedade civil, o setor privado, a comunidade científica e outras partes interessadas, através da criação de espaços de diálogo e construção coletiva de estratégias de gestão e mediação de conflitos;

- Aprimoramento da capacidade institucional de órgãos de pesquisa, monitoramento, controle, fiscalização, assistência técnica e extensão rural;
- Elaboração de um plano regional de ação de combate à pesca ilegal, não reportada e não regulamentada e aprimoramento do monitoramento, fiscalização, comunicação e cooperação no compartilhamento de informações;
- Implementação de um sistema de monitoramento para avaliação regular da performance das medidas de gestão aplicadas e do desempenho das pescarias.
- Estabelecimento de uma agenda de pesquisa que subsidie a gestão dos recursos pesqueiros e dos ecossistemas aquáticos da região, incluindo temas como: a) a estrutura e o funcionamento dos ecossistemas aquáticos; b) os impactos da pesca e do mercado de pescado na saúde dos ecossistemas e na segurança alimentar das comunidades pesqueiras; dentre outros;
- Incluir efetivamente a pesca de pequena escala nas políticas nacionais direcionadas ao setor pesqueiro.

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ANEXOS

Anexo I: Formulário de entrevista com pescadores

Nome do coletor:	Data da coleta / /
Município:	Comunidade:

PERFIL DOS ENTREVISTADOS

Nome do entrevistado:		Apelido:
Idade:	Sexo ( ) F ( ) M	Estado civil: ( ) Solteiro ( ) Casado ( ) Amigado ( ) Divorciado ( ) Viúvo
Escolaridade (especificar série):		Tem filhos? ( ) Não ( ) Sim. Quantos?
N° de filhos que estudam:	Naturalidade (especificar município e estado):	
Tempo de moradia no local da entrevista (somente para os que são de outros municípios/estados):		
Tempo de atuação na pesca:	Ainda atua na pesca? ( ) Sim ( ) Não. Por quê?	
Realiza outras atividades geradoras de renda? ( ) Não ( ) Sim. Quais? Frequência de realização da atividade: ( ) Permanente ( ) Sazonal (especificar período):		
Renda mensal com a pesca (especificar valor médio): R$		
Renda mensal com outras atividades (especificar valor médio): R$		
N° de dependentes da renda mensal:		
N° de pessoas da família que trabalham com a pesca:		
Participa de organização social? ( ) Não ( ) Sim. Tipo de organização: ( ) colônia ( ) associação ( ) cooperativa ( ) outra:___________________________ Nome da organização social:		
Tem RGP? ( ) Sim ( ) Não	Recebe seguro-defeso? ( ) Sim ( ) Não	
Qual o período de defeso na sua comunidade?		
O Sr. acha que o período de defeso está correto?		

CARACTERIZAÇÃO DA ATIVIDADE PESQUEIRA

Os mesmos pesqueiros são utilizados o ano inteiro? ( ) Sim ( ) Não Nome dos pesqueiros:	
Tempo de deslocamento ao primeiro pesqueiro:	N° de dias de pesca:
Nº de viagens que realiza por mês:	
Qual o melhor período para a pesca e por quê?	
Captura total por viagem (safra):	
Captura total por viagem (entressafra):	

Apetrechos

Apetrechos principal: ( ) rede de emalhar ( ) rede de arrasto ( ) tarrafa ( ) espinhel ( ) Outros:___________					
Apetrechos secundários:					
Tempo de exposição do apetrecho principal:		N° de lançamentos por dia:			
Descrição dos apetrechos:					
Rede	Tipo: ( ) fundo ( ) superfície	Comprimento:		Altura:	Malha:
Tarrafa	Altura:	Malha:			
Espinhel	Tipo: ( ) fundo ( ) superfície	Comprimento:	Tamanho do anzol:	N° de anzóis:	Isca:
Outros					
Métodos de pesca					
Rede: ( ) escorada ( ) estacada ( ) bubuia ( ) outro:					
Espinhel: ( ) escorado ( ) deriva - bubuia ( ) outro:					
Outras informações					
Nome comum da rede: ( ) serreia ( ) tainheira ( ) douradeira ( ) pescadeira ( ) outra (especificar qual):					
Espécies-alvo da rede:					
Espécies-alvo do espinhel					

Embarcações

Proprietário de embarcação: ( ) Sim ( ) Não		Função na embarcação:	
Nome da embarcação:			
Descrição do tipo de embarcação:			
Comprimento:	Material:	N° tripulantes:	Capacidade (kg):
Tipo de armazenamento: ( ) urna ( ) caixa de isopor ( ) geladeira/freezer ( ) outro (especificar):			
Propulsão: ( ) motor ( ) remo ( ) motor e vela ( ) remo e vela ( ) outro. Especificar:			
Potência do motor:	Tipo de motor: ( ) centro ( ) popa comum ( ) popa rabeta		
Tipo de combustível: ( ) gasolina ( ) diesel ( ) outro (especificar qual):			
Porto de origem:		Local de desembarque:	
Equipamentos de navegação: ( ) Não possui ( ) Rádio ( ) Bússola ( ) GPS ou navegador ( ) Sonda ( ) Outros (especificar):			
Equipamentos de apoio às capturas: ( ) Não possui ( ) Guincho ( ) Outros (especificar):			

Custos por viagem

Combustível (l):	Combustível (R$):	Rancho (R$):
Gelo (kg):	Gelo (R$):	
Quem financia as pescarias? ( ) atravessador ( ) dono do barco ( ) encarregado ( ) pescadores ( ) outro (especificar quem):		
Como é feita a divisão dos lucros (descrever detalhadamente)?		

Principais recursos explorados

Peixes	Captura (kg) / viagem	Preço (R$) / kg	Destino da produção

Fauna acompanhante

Quais peixes não são aproveitados para consumo ou não apresentam valor comercial?	
Espécie	Kg / viagem

Conservação do pescado

Conservação a bordo da embarcação: ( ) *in natura* ( ) gelo ( ) sal ( ) outro (especificar):
Conservação em terra firme: ( ) *in natura* ( ) gelo ( ) sal ( ) congelador ( ) outro (especificar):
Tem fábrica de gelo no município? ( ) Não ( ) Sim. Quantas?
Como é feita a compra do gelo (dinheiro, vale, peixe, etc.)?
O que acha da qualidade do gelo que utiliza? ( ) Ótimo ( ) Bom ( ) Razoável ( ) Ruim ( ) Péssimo

Beneficiamento de pescado

Os peixes são tratados antes da comercialização? ( ) Não ( ) Sim Percentual de peixes tratados: ( ) menos de 50% ( ) 50% ( ) mais de 50% ( ) 100%
Tipo de tratamento: ( ) evisceração ( ) descabeçamento ( ) salga ( ) filetagem ( ) outro (especificar):
Onde realiza o tratamento? ( ) durante a pesca ( ) no porto ( ) em casa ( ) outro (especificar):
Como manuseia o pescado a bordo da embarcação?
Como transporta o pescado da embarcação para a terra firme? ( ) basqueta ( ) carrinho de mão ( ) saco ( ) manualmente ( ) outro (especificar):

Comercialização

Local de comercialização: ( ) porto ( ) mercado ou feira ( ) atravessador ( ) indústrias ( ) em casa ( ) na rua ( ) barco geleiro ( ) outro (especificar):
Origem do principal comprador: ( ) local ( ) Macapá ( ) outro município (qual?):______________________ ( ) Outro estado (qual?): ( ) Outro país (qual?): ( ) Outro (qual?):
Quantidade de peixe estragado (peixe fraco):
Destino do peixe estragado (peixe fraco):
O que pensa fazer para agregar valor ao pescado?
Vende grude? ( ) Não ( ) Sim. Caso sim, especificar as principais espécies utilizadas para este fim e o preço do kg por espécie.

Impactos ambientais

O Sr. (a) acha que algum tipo de pescado está reduzindo em quantidade? ( ) Não ( ) Sim. Quais?
Na sua opinião, qual é a possível causa dessa redução?
O que o Sr. (a) acha que deveria ser feito para solucionar ou amenizar esta situação?

Conflitos

Existe algum conflito relacionado à pesca na sua comunidade? ( ) Não ( ) Sim. Qual?
O que o Sr. acha que pode ser feito para solucionar ou reduzir estes conflitos?
O Sr. conhece as leis que controlam a pesca na sua comunidade? ( ) Não ( ) Sim. Quais são?

Frequência semanal de consumo de proteína animal

Pescado	( ) Todo dia ( ) 1 a 2 vezes ( ) 3 a 4 vezes ( ) 5 a 6 vezes
Gado	( ) Todo dia ( ) 1 a 2 vezes ( ) 3 a 4 vezes ( ) 5 a 6 vezes
Frango	( ) Todo dia ( ) 1 a 2 vezes ( ) 3 a 4 vezes ( ) 5 a 6 vezes
Porco	( ) Todo dia ( ) 1 a 2 vezes ( ) 3 a 4 vezes ( ) 5 a 6 vezes
Caça	( ) Todo dia ( ) 1 a 2 vezes ( ) 3 a 4 vezes ( ) 5 a 6 vezes
Outra. Especificar:	( ) Todo dia ( ) 1 a 2 vezes ( ) 3 a 4 vezes ( ) 5 a 6 vezes

Anexo II: Formulário de entrevista com empresas de processamento de pescado

Nome do coletor:______________________________________ Data: ___ / ___ / ______
Nome da empresa:____
Local:____
Nome do entrevistado:____
Função:____

1. Quantas espécies são processadas na empresa?
2. Quais as principais espécies processadas em volume?
3. Quais as principais espécies processadas em valor comercial?
4. Houve introdução de novas espécies nos últimos anos? Se sim, quais?
5. Quais as razões para a introdução de novas espécies?
6. Quais os principais produtos comercializados? (Ex: eviscerado, filé, postas, lombos).
7. Houve introdução de novos produtos nos últimos anos? Se sim, quais?
8. Quais as razões para a introdução de novos produtos?
9. Há comercialização de barbatanas e bexiga natatória? Se sim, qual o mercado consumidor?
10. O que é feito com os resíduos do processamento?
11. Quais as etapas do processamento? (Ex: 1- Decapitação; 2-Despelamento; 3-Evisceração; 4-Lavagem; 5-Congelamento; 6-Filetamento ou corte em postas; 7-Embalagem; 8-Armazenamento)
12. Qual o maquinário utilizado para o processamento?
13. Quando os equipamentos foram adquiridos?
14. Quais as principais espécies e produtos, por mercado?

Mercado	**Principais espécies**	**Principais produtos**	**Valor (R$/kg)**
Local			
Estadual			
Nacional			

15. Quais os mercados abrangidos pela empresa? (Estadual, nacional e internacional)

16. Como o pescado é transportado até a comercialização? (Ex: terrestre, aérea, etc.)

17. Há problemas no transporte do pescado para a comercialização? (Ex: condições das estradas, preço do frete, poucos voos e falta de estrutura adequada de armazenamento nos portos e aeroportos).

18. A empresa tem frota própria?

19. A empresa vende gelo ou produz somente para consumo? Qual o preço da tonelada?

20. Qual a produção média diária de gelo (t)?

21. Qual a capacidade de produção de gelo por dia (t)?

22. Fornecem auxílio às frotas? Ex: abastecimento de gelo, apetrechos de pesca, combustível, dinheiro, isca, etc.

23. Qual a capacidade de armazenamento de pescado (t)?

24. Qual a capacidade média diária de absorção de matéria-prima (t)?

25. Qual a produção média diária de pescado (t)?

26. Quem são os fornecedores do pescado?

27. Há problemas relacionados com a oferta dos recursos pesqueiros?

28. Qual o período de safra da empresa?

29. Quais as principais espécies processadas durante a safra?

30. Quais as principais espécies processadas durante a entressafra?

31. Há perspectivas de ampliação a curto e longo prazo?

32. Quais os fatores limitantes à expansão dos mercados?

33. Quais os principais problemas enfrentados pelo setor? (Ex: custos de manutenção, energia, mão-de-obra qualificada, água potável, etc.).

34. Há quanto tempo a empresa está em funcionamento?

35. Desde quando tem SIF? Pode repassar os dados que são enviados ao MAPA?

Anexo III: Artigo científico publicado na revista Ocean and Coastal Management

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Understanding changes to fish stock abundance and associated conflicts: Perceptions of small-scale fishers from the Amazon coast of Brazil

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ABSTRACT

The perceptions and knowledge of fishers are very important for fisheries management, especially in data-poor regions such as the Amazon coast of Brazil. Here, the perceptions of fishers were used to analyze the main conflicts faced by small-scale fisheries and to identify the status of fishery resources in the state of Amapá (Brazil). Data from interviews with 359 fishers were analyzed. Conflicts involve diverse actors with different and potentially competing interests and accountabilities, including small-scale and large-scale fishers, intermediaries, and government agents. The main conflict was related to access to fishery resources, including issues with the prohibition of fishing in No-Take Zones and competition with fishing fleets from other regions (outsiders). The lack of control over the access of users has culminated in increasing fishing effort. The invasion of traditional fishing territories was a central argument against the outsiders; however, these conflicts are also strongly related to the exhaustion of fishery resources, with about 75% of respondents perceiving a decrease in fish abundance. This scenario reveals a governance crisis and the weak performance and inability of the government to carry out effective enforcement, monitoring, and surveillance. The presence of people heavily reliant on natural resources in a region with very few alternative sources for livelihoods indicates that sustainable fisheries management requires wider cooperation between the government and all stakeholders, with co-management being required.

1. Introduction

Global marine fisheries present a worrying scenario, with 33% of assessed fish stocks being overfished (FAO, 2018), and an average catch decline rate of 1.2 mt per year since 1996 (Pauly and Zeller, 2016). The concern is even greater in developing countries, where fishing plays a crucial role to the livelihoods of millions of people that suffer from high levels of poverty, with few alternative sources of income, employment, and animal protein (Béné, 2006; Béné et al., 2007; Salas et al., 2011). This phenomenon occurs in most countries in Latin America and the Caribbean, where fisheries exhibit high heterogeneity in the gear, boats, and species. These regions also have a great diversity in geophysical, bioecological, and socioeconomic characteristics, as well as multiple political interactions. These various parameters combined, result in diffuse fisheries activity, with temporal and spatial dynamics that are challenging to understand and manage (Fischer et al., 2015; Salas et al., 2011).

In particular, fishing activity in Brazil is extremely heterogeneous, complex, and dynamic, due to the large size of the territory and major regional differences. As a result, the fishing communities in this country have developed adaptations to environmental, socioeconomic, political, and cultural characteristics intrinsic to each place (Silva, 2014). In the Amazon, small-scale fisheries (SSFs) are predominant, and are carried out by fishers operating small and medium-sized wooden boats using a large diversity of gears and catch techniques. Fish are sold through an informal network of intermediaries that supply regional and national markets, and the fishing sector is characterized by very low labor mobility (Almeida et al., 2003, 2011; Isaac-Nahum, 2006; Isaac et al., 2015a, 2009).

In the Amazon, fishers are heavily reliant on SSFs for their livelihoods, with this activity representing the major source of income, animal protein, and culture for coastal and riparian communities

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(Almeida et al., 2003; Castello et al., 2011; Ruffino, 2014). In some Amazon communities, fish comprise 64–76% of the animal food items intake and 79–87% of the weight ingested, with an average rate of 169 kg.person-1.year-1 or 462 g.person-1.day-1, representing one of the highest rates of fish consumption globally (Isaac et al., 2015b).

The Amazon coast encompasses the states of Amapá, Pará and Maranhão, where both small-scale and large-scale fishing is carried out from nearshore regions to the continental shelf (Isaac-Nahum, 2006). SSFs capture multiple species, with the Sciaenidae and Ariidae families providing the main fisheries resources; however, crabs and shellfish are also manually collected (Almeida et al., 2011; Isaac-Nahum, 2006; Isaac et al., 2009). In comparison, the industrial fisheries capture single species, including southern brown shrimp (*Penaeus subtilis*), Laulao catfish (*Brachyplatystoma vaillantii*), and southern red snapper (*Lutjanus purpureus*) (Isaac et al., 2009).

In the state of Amapá, fishing has high socioeconomic and food security importance, with 16,700 professional small-scale fishers operating (SISRGP, 2016). The capture and landing of estuarine and marine fish occurs predominantly in the municipalities of Oiapoque, Calçoene, and Amapá (PROZEE, 2006). In this region, the fishing grounds are shared with fishers from other Brazilian states and French Guiana, with catches occurring in and around No-Take Zones (NTZs), culminating in many conflicts (Crespi et al., 2015; Pinha et al., 2015). These conflicts are aggravated by the government having difficulty in controlling the access of users. There is also a lack of time series on biological and socioeconomic data needed for traditional quantitative fishery assessment models.

Consequently, in such 'data-poor' regions, the knowledge of fishers is a valuable information source (Saavedra-Díaz et al., 2015; Tesfamichael et al., 2014) and an important instrument for the Ecosystem Approach to Fisheries (EAF). The EAF aims to balance human and ecological well-being under the concept of sustainable development and is based on a holistic view of fisheries (Fischer et al., 2015). Fishers have a great amount of contextual and experiential-based knowledge about the socioecological system of fisheries, including target species and the ecosystem, as well as perspectives on social, economic, technological, behavioral, governance, and market aspects of fisheries (Stead et al., 2006; Stephenson et al., 2016). This knowledge is clearly important for fisheries management and has been highlighted in studies globally (Fischer et al., 2015; Saavedra-Díaz et al., 2015; Stead et al., 2006; Stephenson et al., 2016).

In data-poor situations, the knowledge of fishers is also potentially useful for recording the occurrence of temporal environmental changes, such as increases or decreases in fish abundance (Hallwass et al., 2013). Such information might complement data gaps for assessments (Tesfamichael et al., 2014) or could be used as indicators to prioritize the focus of management systems. The knowledge of fishers is also important to identify possible conflicts regarding the state of natural resources, environmental conservation, fishing regulations, and problems between sectors (Baigún, 2015). It is useful to understand what drives conflicts to identify problems that might lead to the unsustainable extraction of fishery resources (DuBois and Zografos, 2012), in addition to its being essential for cooperation in marine conservation (Majanen, 2007).

Within this context, this study aims to elucidate the main conflicts faced by SSFs and to identify possible changes in the abundance of fishery resources in the state of Amapá (Brazil), as well as to discuss potential causes and solutions to these problems based on the perceptions of fishers. The combined analysis of these two issues is expected to contribute towards identify potential risks for SSFs and assist in establishing key management priorities. This study was motivated by the first author participating as a representative of the Fisheries Agency of Amapá State (a fisheries management agency) on the advisory council of the NTZs in the study area. The councils provide spaces for dialogue, with participants including representatives from government agencies, civil society organizations, scientists, and other stakeholders. The main objective of the councils is to orient the decisions of managers (Almudi and Kalikoski, 2010). Discussions about the conflicts faced by small-scale fishers frequently occur in council meetings and include complaints by fishers about the decline in fish abundance. Fishers repeatedly state that the Brazilian government does not 'listen to them' or consider their interests and needs when regulating the use of natural resources, often disregarding their traditional knowledge built over many generations. Therefore, the authors decided to investigate the issues that have emerged at the meetings of these councils and identify how the perceptions of fishers could be used to help fisheries management on the Amazon coast of Brazil.

2. Material and methods

2.1. Study area

This study was carried out in the municipalities of Oiapoque, Calçoene, and Amapá, in the state of Amapá (Amazon coast of Brazil) (Fig. 1). The coastal zone of these municipalities is approximately 400 km long, with extensive muddy tidal plains and mangroves (Santos et al., 2016). This area is influenced by the discharge of the Amazon River and by the Brazil North Current (Curtin, 1986). There are three coastal NTZs in the region (Fig. 1): Cabo Orange National Park (CONP), Maracá-Jipióca Ecological Station (MJEE), and Lago Piratuba Biological Reserve (LPBR). These NTZs are managed by Chico Mendes Institute for Biodiversity Conservation (referred as ICMBio), and integrate a network of 17 protected areas, covering 72% (10 million ha) of the territory of the state of Amapá, including flooded and non-flooded forests, savannah, mangroves, and estuaries (CI-Brazil, 2007). This area also encompasses two Ramsar Sites: CONP and the Amazon Estuary and its Mangroves. Wetlands of international importance are designated as Ramsar sites under the Ramsar Convention, which is an intergovernmental treaty that aims to improve the conservation of wetlands and their wise use (Ramsar Convention Secretariat, 2016).

In the study area, there are approximately 1,330 professional fishers (SISRGP, 2016) that mostly live in urban areas, and are organized into four Fishers' Colonies (i.e., formal fisherfolk organizations). Small-scale nearshore and continental fisheries are carried out using passive fishing gears. Nearshore fisheries have an average landing of 5.400 tons.year[1], with gillnets accounting for more than 70% of fish catches. Weakfishes (*Cynoscion virescens* and *C. acoupa*) and marine catfishes (*Sciades couma*, *S. proops*, and *S. parkeri*) represent about 76% of the total catch (PROZEE, 2006).

Based on data collected in socioeconomic surveys, it is estimated that the fishing fleet is composed of 500 small and medium-sized wooden boats distributed into three categories: (i) Canoes: boats with outboard engines, no cabin, and 5–12 m in length, with fish being stored in ice in old refrigerators or in polystyrene boxes (90–1,500 kg); (ii) Small-sized boats: boats with outboard or inboard engines, with or without cabins, and 6–12 m in length, with fish being stored in ice tanks (1,000–7,000 kg); and (iii) Medium-sized boats: boats with inboard engines, decks with cabins, and 12.5–18 m in length, with fish being stored in ice tanks (7,000–14,000 kg).

2.2. Data collection and analysis

Data were collected through face-to-face interviews based on a standardized semi-structured questionnaire on the perceptions of fishers regarding conflicts and changes in fish abundance. The questionnaire consisted of five open-end questions: (1) Is there any conflict related to fishing in your community? (2) What do you think could be done to solve or reduce these conflicts? (3) Do you think that some fish

[1] Data available from the ICMBio (Chico Mendes Institute for Biodiversity Conservation) website: www.icmbio.gov.br/cepsul/acervo-digital.

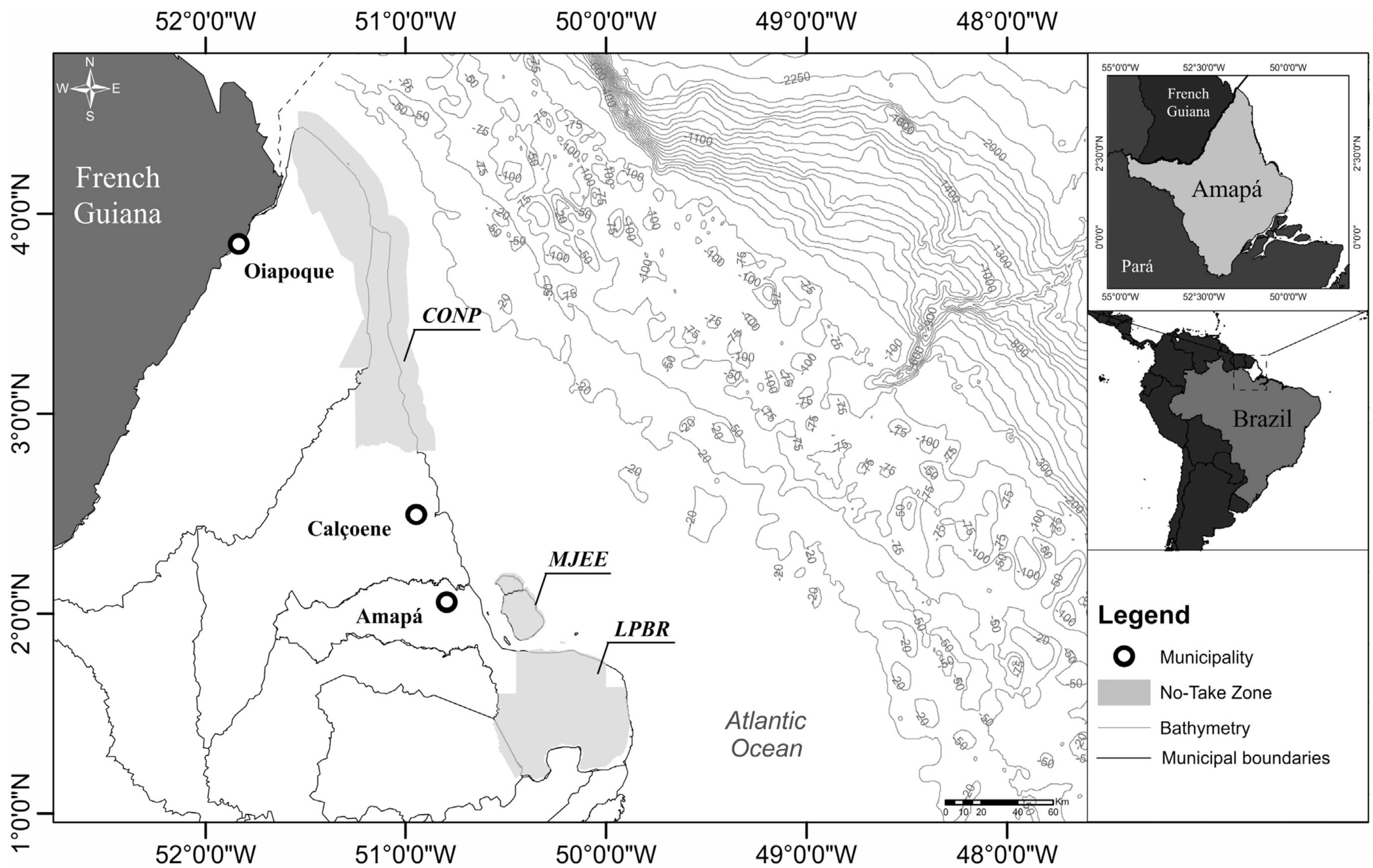

Fig. 1. Location of the studied municipalities (Oiapoque, Calçoene, and Amapá) and the No-Take Zones (Cabo Orange National Park - CONP, Maracá-Jipióca Ecological Station - MJEE, and Lago Piratuba Biological Reserve - LPBR), in the tate of Amapá (Amazon coast, Brazil).

stocks are declining? (4) In your opinion, what is the possible cause for this decline? (5) What do you think could be done to mitigate this decline?

The first and second questions aimed to identify the experiences of conflict by respondents and possible solutions they have considered. This approach allows interviewees to freely list all actions they perceive as conflicting and explain why, as well as the solutions that they believe are possible. The third question aimed to analyze the status of the fishery resources in the study area, and to identify the fish species impacted by anthropic pressure or natural changes. In the last two questions, the respondents were given the opportunity to suggest possible causes and solutions associated with these issues based on their views and experiences.

Fieldwork was carried out with the logistic support of ICMBio during several field trips conducted between January 2014 and September 2016. In total 359 fishers were interviewed, representing 27.6% of all fishers registered in the study area. Respondents were mainly men (92%), aged 18–82 years (39.76 ± 12.69), with low educational level (70% did not complete elementary school). Most had fishing experience of more than 10 years (75%), with fishing being their only source of income (70%).

Interviews were conducted at fish landing sites and at the houses and Colonies of fishers. A combination of random and snowball sampling methods was applied. The first respondents were fishers' leaders (i.e., presidents of the Fishers' Colonies), to obtain a general overview of the local context. Then, the fishers leaders indicated other fishers they believed to have a high fishing experience. The nominated fishers then suggested others. In this way, the snowball sampling procedure was followed, based on key informants (Bailey, 1982). When nominated fishers had already been interviewed, respondents were randomly selected according to the availability of fishers during the field period. This procedure aimed to minimize possible bias in the interviews (Musiello-Fernandes et al., 2018). Information acquired outside the context of interviews was used to support the collected data; such information included observations, experiences, and interactions with community members.

The interviews were carefully translated from Portuguese to English to maintain the original connotations of the narratives. Data from key informants and randomly selected respondents were analyzed together, because the same response patterns were observed. The qualitative responses about conflict experiences and their solutions were organized into categories according to the actors involved and the principal themes that emerged from the data. A response could contain more than one dominant theme. The percentage of respondents that mentioned each theme was calculated, and only themes cited by at least 10% of respondents were considered.

To analyze the status of fish stocks, the relative frequency that each species was mentioned was calculated. The discourses of respondents on the causes and solutions regarding changes to the abundance of fish stocks were analyzed through a quantitative method called 'similarity analysis.' This method extends information beyond the level of individual interviews, providing a deeper analysis of similarities in the structure of arguments used by the interviewees to justify their approach, based on the words used in the narratives, their frequency, and organization (Delattre et al., 2015). The similarity analysis allows the recognition of co-occurrences and connections between words, assisting the identification of the most common and important themes in discourses. This analysis is based on graph theory and is classically used for studying social representations (Flament, 1981).

To evaluate the possible influence of data translation on the results, the similarity analysis was performed in both languages (i.e., Portuguese and English). The two analyses generated very similar results, indicating that the data translation did not bias the results. The similarity analysis were performed using IRAMUTEQ (*Interface de R pour les Analyses Multidimensionnelles de Textes et de Questionnaires*) software (Ratinaud, 2009). To run this analysis, the software replaces all terms in the narratives by their canonical form (e.g., plural forms with singular forms, verbal forms with infinitive forms, elided words with corresponding non-elided words), and only the 'active forms' (e.g., content words like nouns, verbs, and adjectives) are considered (Delattre et al., 2015). The correlation among all active forms taken in pairs was calculated to obtain a similarity matrix, using the similarity index available in the R proxy library. The summary of information contained in the similarity matrix is graphically represented in a maximum tree (i.e., the simplest and most informative tree, containing only the strongest links) (Delattre et al., 2015; Vergès and Bouriche, 2001), in which the words are the vertices and the edges/links represent co-occurrences. The most frequently used words in the narratives appeared proportionately with larger size, with the same occurring for the thickness of the edges/links connecting the words, which reflects the strength of the relations between them. The algorithm of Fruchterman Reingold was used to optimize the display of the graph and to visualize the most 'central' words (Baril and Garnier, 2015).

3. Results

3.1. Conflicts in small-scale fisheries on the Amazon coast of Brazil

The main conflicts experienced by the respondents were grouped into three categories (Table 1): a) Local fishers and outsiders (73.1%); b) Fishers and surveillance agents (20.4%); and c) Fishers and middlemen (11.3%). The conflicts, their causes, actors, and possible solutions were examined.

3.1.1. Conflicts between local fishers and outsiders

Competition with outsiders (i.e., fishers that does not live in the state of Amapá) is clearly the most significant conflict experienced by local fishers. This conflict involved mainly fishers from the state of Pará, with the overlap in fishing grounds and predatory fishing (44.4%) representing the main causes of tension. The fishing practices considered as predatory by the respondents included the use of very extensive gillnets, longlines with many hooks, and technological equipment to support fisheries (e.g., GPS, sonar, and power rollers to pull the nets), as well as the industrial trawl fisheries and their high fish catches and discards. Other conflicts involving outsiders were related to the increasing scarcity of fishery resources (37.5%) and the illegal catches of *S. parkeri* during the closed-season (10.2%), which was facilitated by the fact that surveillance is restricted to landings in the state of Amapá. Consequently, illegal catches landed in other states are not punished. The combination of these issues caused respondents to believe that their fishing activity and rights are negatively impacted by outsiders, whose fishing practices are considered an obstacle to the survival of local SSFs.

The solutions proposed by the respondents to the conflicts with outsiders mostly focused on the surveillance and prohibiting outsiders from fishing in the territories of local fishers (i.e., fishing grounds close to the coast) (Table 1). The fishers believed that these actions would reduce conflicts without any major social impacts, because the fishing fleet of Pará is formed of larger boats with more autonomy and technology to fish far from the coast. Within this context, the creation of a protected area for local small-scale fishers was also cited as solution (13.8%).

3.1.2. Conflicts between fishers and surveillance agents

In Brazil, environmental surveillance is carried out by two institutions: ICMBio (the national protected areas' manager) and IBAMA (the national environmental agency). The conflicts between fishers and surveillance agents (20.4%) was mainly related to the conservation of natural resources in NTZs, including the prohibition of fishing in these areas (13.1%), the approaches used by surveillance agents (10.5%), and the effectiveness of surveillance (10.2%).

NTZs in traditional fishing territories were created in the 1980s under different contexts in each municipality of the study area. However, in all cases, the government imposed restrictions on the livelihoods of local residents, who heavily depend on natural resources as sources of food and income. In Oiapoque, the president of the Fishers' Colony reported the history of expulsion of the residents of Taperebá Village, which is located inside the CONP. According to this actor, after the NTZ was created, the government deactivated the public services offered to the village and implemented restrictions on access to natural resources. These events forced many residents to migrate to the urban area of Oiapoque, without any compensation. At present, just five families live in the village.

There are two fishers' villages (Araquiçaua and Paratu) inside the LPBR, and one other (Sucuriju) in the nearby area. Their livelihoods are intrinsically linked to the catch of freshwater and estuarine fishes in the protected lakes. The residents were not removed from their homes when the NTZ was created, but many restrictions were imposed by the government on their livelihoods. According to respondents, surveillance agents were aggressive, burning the wooden shelters built by fishers around the lakes. Respondents stated that conflicts with both CONP and LPBR were reduced by establishing Commitment Terms (CT) that regulate SSFs within NTZs by complying with rules that were collectively constructed by fishers and managers.

Respondents stated that there were only a few residents in the MJEE when it was created, but that many fishers used to fish and anchor their boats on the coastal islands that formed the NTZ, leading to many conflicts. In recent years, managers informally authorized fisheries using longlines aimed at reducing conflicts, but many fishers that use gillnets complained that there was no physical demarcation of the NTZ limits. Respondents also cited conflicts regarding the catching of bait

Table 1
Actors, conflicts, and solutions identified from the discourses of respondents from the state of Amapá (Amazon coast, Brazil).

Actors	Conflicts	Solutions
A) Local fishers and outsiders (73.1%)	(AI) Overlapping of fishing grounds and predatory fishing (44.4%)	(AI) Surveillance (36.4%) (AI) To prohibit outsiders from fishing near the coast (26%) (AI) To create a protected area for local fishers (13.8%)
	(AII) Reduction of fish stocks (37.5%)	(AII) Surveillance (31.6%) (AII) To prohibit outsiders from fishing near the coast (10.5%)
	(AIII) Catches during the closed-season (10.2%)	(AIII) Surveillance (10.2%)
B) Fishers and surveillance agents (20.4%)	(BI) Prohibition of fishing in No-Take Zones (13.1%)	(BI) To create a protected area for local fishers or an agreement to allow fishing in No-Take Zones (13.1%)
	(BII) Aggressive, disrespectful and abusive approach (10.5%)	(BII) To improve approaches and enforcement (10.5%)
	(BIII) Ineffective and unequal surveillance (10.2%)	(BIII) Effective and egalitarian surveillance (10.2%)
C) Fishers and middlemen (11.3%)	(CI) Low price of fish (11.3%)	(CI) Investment in infrastructure and public policies (11.3%)

for longlines inside the protected islands and the catching of crab by outsiders.

The interviewees also stated that surveillance was unequal and ineffective (10.2%), because it was only applied to local fishers, with outsiders fishing inside NTZs remaining unpunished. According to respondents, outsiders escape satellite surveillance by using small and untracked boats that operate in forbidden areas, supplying larger boats. Interviewees also complained about the approach used by the surveillance agents, which was considered aggressive, disrespectful, and abusive (10.5%).

Respondents cited three solutions to conflicts with surveillance agents: 1) the creation of a protected area for local fishers or an agreement to allow fishing in NTZs (13.1%), 2) improved performance of these agents, with a less aggressive approach (10.5%), and 3) transforming surveillance to be an effective and egalitarian activity, placing outsiders under intensive surveillance (10.2%).

A particular transnational conflict was cited by 22% of the interviewees of Oiapoque, regarding the performance of the surveillance agents. These respondents feel wronged because the fishers from French Guiana frequently fish in the state of Amapá but are not controlled, whereas Brazilian fishers entering French Guiana are aggressively combated by French surveillance agencies. Respondents reported that French fishers fish in the CONP and buy ice and sell fish to companies in Oiapoque. To resolve this conflict, respondents proposed an agreement between Brazilian and French governments to release SSFs in the transboundary region.

3.1.3. Conflicts between fishers and middlemen

The dependence of fishers on middlemen for production flow also constitutes an important source of conflict, cited by 11.3% of the respondents. The absence of structures for preserving fish meat and the lack of financial resources for production flow force fishers to sell their catches to middlemen, usually at low prices. The respondents believe that this conflict could be resolved by the intervention of government agencies, whose presence is perceived to be lacking in this region. The fishers highlighted the need for governmental investments in infrastructure to improve conditions associated with anchoring, landing, lighting, and availability of inputs (e.g., ice and fuel). In addition, fishers identified the need to implement policies and measures that promote fair marketing, as well as strategies that allow a greater diversification and valuation of the fishery products, with the aim of reducing the dependence of fishers on middlemen, which, in turn, would increase their income.

3.2. Status of fish stocks from the Amazon coast of Brazil

In the study area, approximately 75% of the respondents recognized a decrease in the abundance of fishery resources (71.5% in Oiapoque, 87.1% in Calçoene, and 72.8% in Amapá) (Table 2). *S. parkeri* was the main species cited in Amapá (64%) and Calçoene (55.7%), while in Oiapoque, *C. virescens* (32.3%) and *C. acoupa* (24.8%) were the most mentioned. Many respondents (26.8%) also stated that the abundance of all fishery resources have reduced.

The similarity analysis of the discourses of respondents about the causes for declining fish abundance in the study area is shown in Fig. 2. Considering the number of occurrences, 'lot' was the most frequent active form and played a central role in the discourses, followed by 'boat,' 'fishery,' and 'fisherman', which were strongly linked to 'lot.' These words reflected the perception of respondents about intensive fishing activity, high fishing effort, and catching power. Fig. 2 also shows the connection between the words 'lot-gillnets,' 'lot-catch,' 'lot-boat-large,' and 'lot-fish-technology' (which was related to the use of technological equipment to support fish catches).

The presence of outsiders was cited as prejudicial, due to the increased fishing effort and catching power, as well as the predatory fishing, carried by these fishers. The activity of fishers from Pará State in the study area is shown in Fig. 2 through the connection between the words 'lot-Pará' and 'lot-boat-Belém.' Discourses about predatory fishing practices were observed through the words 'small-mesh,' 'industrial,' trawl,' 'closed-season,' and 'predatory,' which were linked to 'fishery' (Fig. 2). Industrial trawl fisheries were considered harmful, due to high fish catches and discards, and the use of small-mesh gillnets was considered predatory, due to the low selectivity of this gear. Outsiders were also accused of disrespecting closed-season of *S. parkeri*, which was demonstrated by the connection between the words 'lot-fishery-closed-season' and 'lot-spawn' (referring to catches during the spawning season).

Table 2
Fishery resources with reduced abundance according to the number (N) and percentage (%N) of citation by respondents from the studied municipalities in the state of Amapá (Amazon coast, Brazil).

Fishery resource	Oiapoque		Calçoene		Amapá		Total	
	N	%N	N	%N	N	%N	N	%N
Acoupa weakfish (*Cynoscion acoupa*)	33	24.8	19	31.1	7	9.3	59	21.9
Crucifix sea catfish (*Sciades proops*)	15	11.3	5	8.2	11	14.7	31	11.5
Gillbacker sea catfish (*Sciades parkeri*)	23	17.3	34	55.7	48	64.0	105	39.0
Green weakfish (*Cynoscion virescens*)	43	32.3	13	21.3	–	–	56	20.8
Others	48	36.1	12	19.7	8	10.7	68	25.3
All	42	31.6	16	26.2	14	18.7	72	26.8
Number of respondents	133	71.5	61	87.1	75	72.8	269	74.9

Another cause cited by respondents was the trade of swim bladders (referred to as 'grude'), which is stimulated by their high value (USD 9–276 kg^{-1}) compared to fish meat (USD 0.15–3.69 kg^{-1}). Interviewees associated the high value of swim bladders with increasing pressure on fishery resources in the study area, because it is necessary to catch many fishes to obtain one kilogram of 'grude.' This discourse is shown in Fig. 2, through the connection between the words 'lot-fishery-grude.' According to respondents, the swim bladder trade includes all the four fishery resources listed in Table 2, and also *Sciades couma*.

The similarity tree (Fig. 3) shows that, according to the perception of respondents, 'surveillance' represents the main solution for recovering fish abundance, because this word was the main active form in discourses, followed by 'boat,' 'fisherman,' and 'fishery.' Interviewees also suggested the need to reduce fishing effort and catching power, as observed by the connection between the words 'stop-freezer-boats' (i.e., boats with freezing systems on board), 'boat-move,' and 'boat-reduce-quantity.'

The similarity analysis (Fig. 3) also showed the perceptions of interviewees about the need to intensify the surveillance of outsiders, as verified by the connection between the words 'surveillance-Pará,' 'surveillance-boat-Belém,' 'surveillance-boat-state-increase,' and 'surveillance-fisherman-industrial.' The same was observed for predatory fishing, because 'surveillance' was also linked to 'trawl,' 'boat-large-discard,' 'fish-death,' and 'fish-mesh-size.'

The need for surveillance during the closed-season of *S. parkeri* also appears in the similarity tree (Fig. 3), through the link between the words 'surveillance-closed-season-respect,' 'surveillance-reproduction,' and 'surveillance-fish-period.' Many interviewees considered that the closed-season (November to March) does not cover the entire breeding season of *S. parkeri*, and that other species should be included in the closed-season, such as those listed in Table 2.

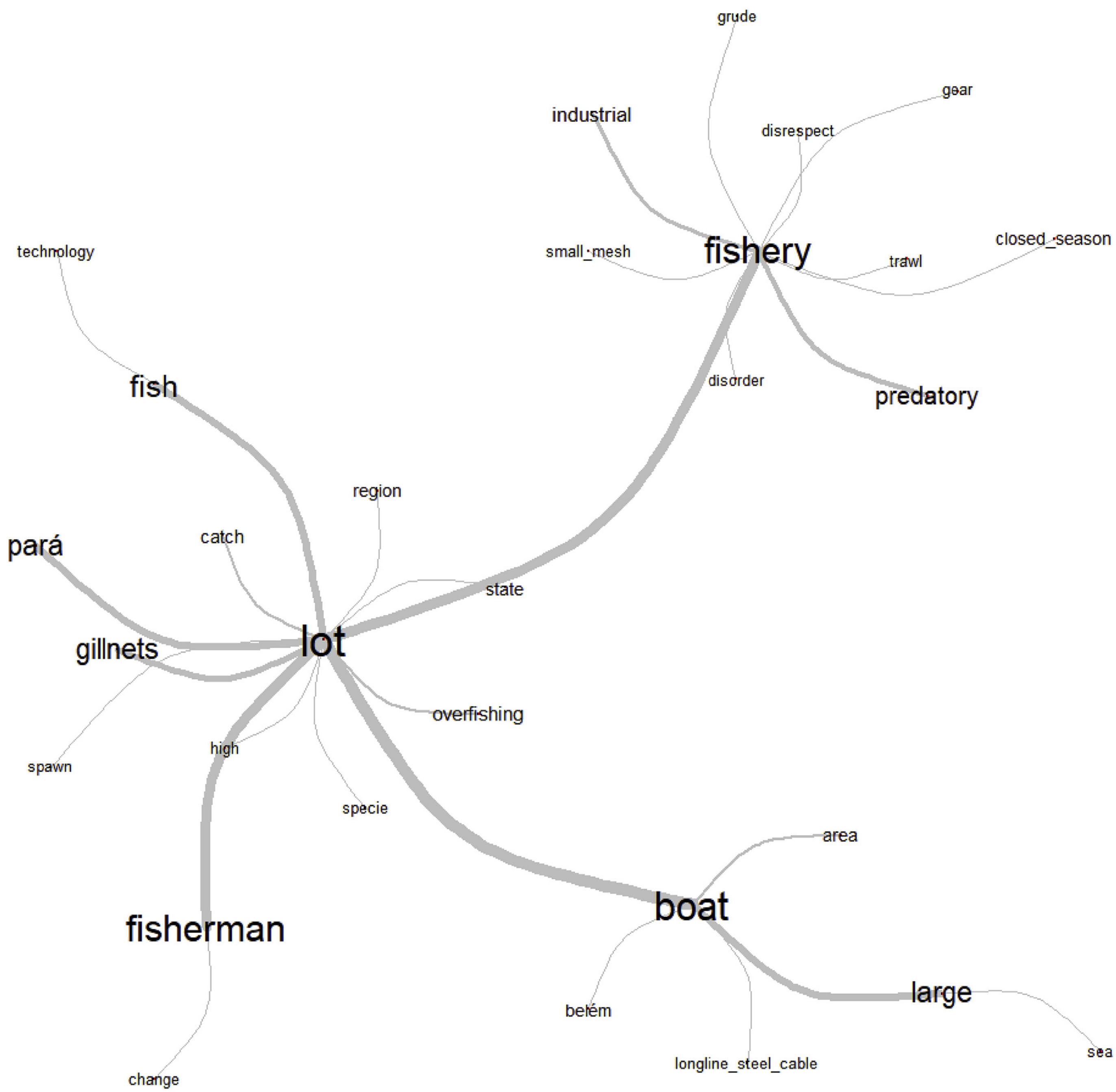

Fig. 2. Similarity analysis of respondents' discourses about the causes for the declining fish abundance in the state of Amapá (Amazon coast, Brazil).

4. Discussion and conclusions

4.1. Conflicts in small-scale fisheries on the Amazon coast of Brazil

On the Amazon coast of Brazil, conflicts exist over access to fishing territories and fisheries resources, which are also conflicts over livelihoods. These conflicts involve small-scale fishers, large-scale fishers, intermediaries, and government agents (e.g., surveillance agents and managers). Among these actors, power relationships are asymmetrical, with small-scale fishers holding the weakest position.

The most evident conflict experienced by local fishers is competition for fishing grounds with outsiders. Anyone involved in fisheries, whether a seaman, fish trader, manager, or scientist, is familiar with this problem. The main conflicts involve large-scale artisanal fisheries and industrial bottom trawlers from the state of Pará, who have the largest fishing fleet on Amazon coast (Bentes et al., 2012). Large-scale artisanal fisheries occupy an intermediate position between industrial and small-scale artisanal systems, as they have larger and more advanced boats than most of the small-scale fleets on the Amazon coast (Isaac et al., 2009).

Growing competition for fishery resources and territories between commercial fisheries is a global trend, especially in developing countries (Camargo et al., 2009; DuBois and Zografos, 2012; Murshed-e-Jahan et al., 2014; Pomeroy et al., 2007), with the small-scale fishery (SSF) tending to be the loser. For example, in southeast Asia, industrial fleets monopolize coastal fishery resources through high catching power and technology, undermining the productivity of SSFs (Pomeroy et al., 2007). In Sri Lanka, SSFs are threatened by the invasion of fishing grounds by Indian trawl fishers (Scholtens and Bavinck, 2018).

On the north coast of Brazil, the state of Amapá represents the last

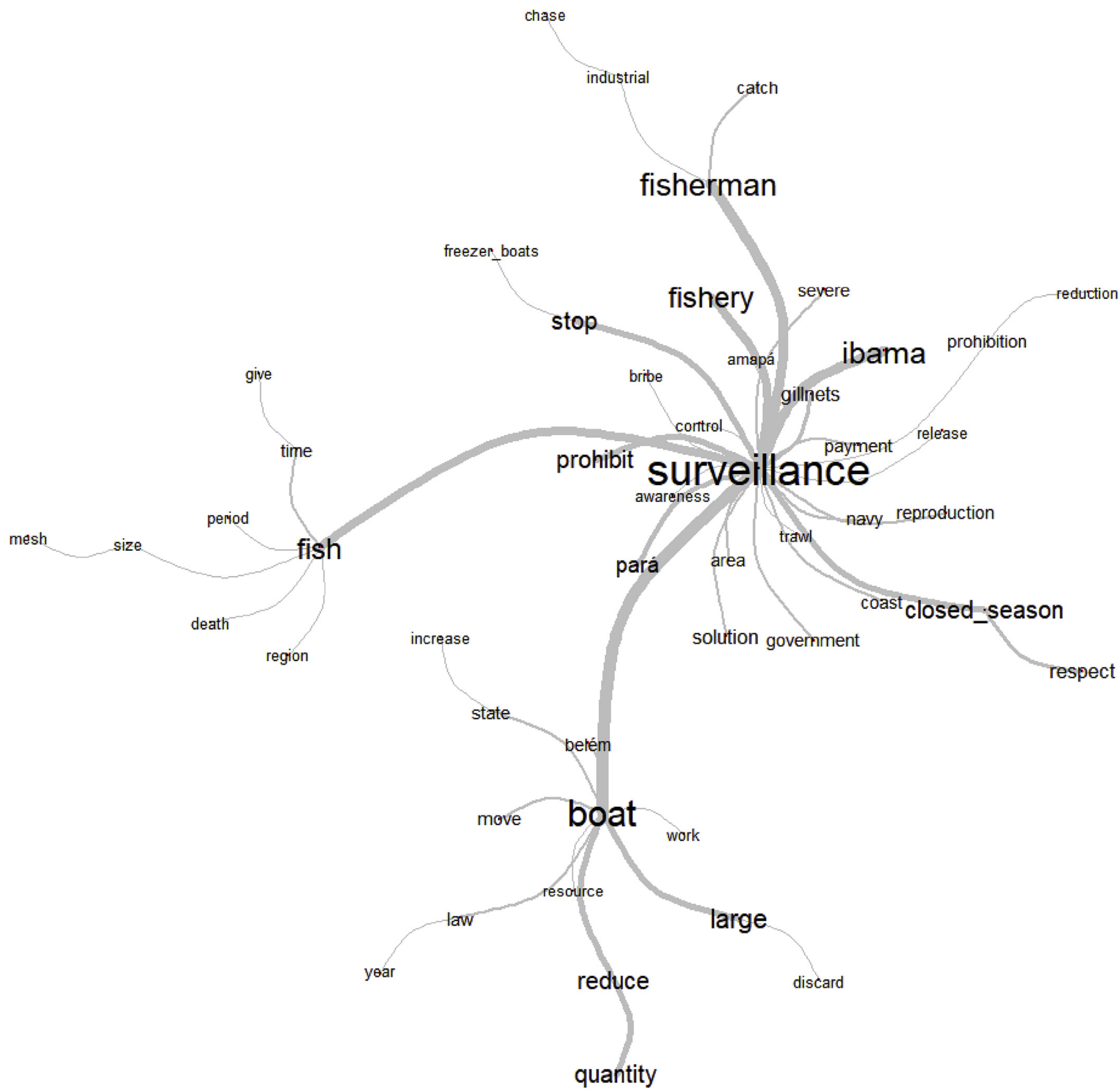

Fig. 3. Similarity analysis of respondents' discourses about the solutions for declining fish abundance in the state of Amapá (Amazon coast, Brazil).

frontier for fishing, with increasing number of fishers from Pará migrating to this region in the past 10–15 years. The open access conditions and the decrease in fishing productivity in Pará (Betancur et al., 2015; Isaac et al., 2009; Lucena Frédou and Asano-Filho, 2006) have culminated in an increasing migration flow and a disorganized growth of the fishing sector. A similar scenario occurred when fishers from northeastern Brazil migrated to Pará, due to the exhaustion of snapper and lobsters stocks (Isaac et al., 2009).

The migration of fishers to the state of Amapá has intensified the pressure on fishery resources, imposing major challenges on fisheries management and the conservation of natural resources in NTZs, because outsiders illegally fish in these areas using small boats that are not tracked by satellite surveillance. This illegal activity is facilitated by the deficiency in the surveillance system, due to lack of human and financial resources, infrastructure, and equipment. The same strategy is used in Senegal, where industrial vessels transport small boats that fish in forbidden areas (DuBois and Zografos, 2012). Invasion of traditional fishing territories used by local communities and illegal fishing in protected areas also occur in other countries of West Africa, where migrant fishers benefit from the poor enforcement of management measures (Binet et al., 2012).

In this context, the fishery resources are not effectively protected within NTZs in the study area. In practice, restrictions are only imposed on local fishers, which is why they consider surveillance to be unequal and ineffective. This imbalance also results in the unequal distribution of conservation costs and benefits. Another conflict that reinforces this negative perception about surveillance is that the illegal catches of outsiders during the closed-season are not punished, since surveillance is restricted to landings in the state of Amapá. Conflicts involving the unequal application of restrictions between different actors or activities in protected areas are also observed in other regions (Bavinck and Vivekanandan, 2011; Begossi et al., 2011; Camargo et al., 2009; Majanen, 2007).

In different places in Brazil, fishers faces the significant loss of fishing territories due to the creation of NTZs, competition with industrial fishing, and other uses of the marine and coastal space (Begossi et al., 2011; Prestrelo and Vianna, 2016). This phenomenon was also observed in the study area, where local fishers are cornered between NTZs and outsiders working in larger and better equipped boats. In the 1980s, most NTZs were established in Brazil without consulting the local populations. In general, the NTZs were based on the North American preservationist model of that time, which aimed to protect wildlife independent of the human environment (Diegues, 2008). Due to this centralized and top-down approach, the creation of NTZs has culminated in conflicts related to the prohibition of access to natural resources and the expropriation of resident populations. This scenario has been observed in different regions of Brazil (Almudi and Kalikoski, 2010; Begossi et al., 2011; Leal, 2013), as well as other developing countries (Bennett and Dearden, 2014; Camargo et al., 2009; De Pourcq et al., 2015; Majanen, 2007).

In the study area, the creation of NTZs was also marked by a top-down process that did not consider the existence of communities reliant on natural resources, which directly affected local fishers, reducing the territories historically exploited by SSFs (Crespi et al., 2015; Pinha et al., 2015). In the first years after the creation of the NTZs, the relationship between local residents and managers was marked by tensions and highly repressive actions by surveillance agents. In the CONP, the prohibition of commercial fishing, the violent repression actions with military support, and the closure of public services (e.g., education and health services) by the government forced the residents of Taperebá to migrate to the uran area of Oiapoque. These actions led to profound changes to their livelihoods, because traditional activities developed in villages (e.g., agriculture, vegetal extraction, and hunting) could not be carried out in the urban area. As a result, the former residents of Taperebá became full-time fishers, leading to the expansion of fishing activity due to disputes with other fishers and the need to integrate local socioeconomic dynamics. This culminated in increased fishing effort and catching power, along with the replacement of more selective gears (i.e., longlines) in favor of gillnets (Crespi et al., 2015).

Many traditional communities live in and use the natural resources of LPBR, and their livelihoods were impacted by the creation of the NTZ. The repressive actions of surveillance agents included the destruction and burning of fishing gears and wooden shelters used to support fisheries (Pinha et al., 2015). In the MJEE, there were only a few residents on the islands that became protected; however, many fishers used to fish there. Until 2000, conflicts were mitigated by informal agreements. However, the prohibition of boat anchoring in some areas and increased surveillance between 2000 and 2010, culminated in the intensification of conflicts and the disruption of relationships between fishers and managers. These disruptions included retaliatory actions by fishers, such as threats to management teams and the deliberate setting of forest fires on the protected islands (Coutinho and Oliveira, 2016).

In the early 2000s, recognition of the rights of traditional populations, driven by international debates, led to the paradigm changing, including the focus of management agencies. This change facilitated the beginning of a dialogue that culminated years later in the establishment of the Commitment Terms (CT) in CONP and LPBR. CT is a legal instrument that allows the temporary regularization in the use of natural resources by traditional populations whose livelihoods are associated with protected areas where their presence is not permitted (e.g., NTZs) or who disagree with management mechanisms (ICMBio, 2012). In the MJEE, managers adopted an educational and informative approach since 2013, initiating a process of dialogue and conflict resolution, with the planned implementation of a CT (Coutinho and Oliveira, 2016).

The reduction in conflict between fishers and NTZs through CTs is one of the main reasons why this problem appeared as secondary in the narratives of respondents. At present, disputes with outsiders are considered to represent the main threat to SSFs by the interviewees. However, latent conflicts with NTZs are very worrying, because CTs are a transitory instrument that should only be used until a definitive solution is established. Such solutions might include changing or adapting the limits of NTZs or recategorization to a sustainable use area (Pinha et al., 2015). Both solutions should take account of the tradition, knowledge, and skills of local fishers to fish in coastal areas. In particular, the fishing technology (e.g., vessels and gears) used by local fishers does not allow them to fish in deeper water environments.

The respondents perceived that the solution to conflicts with outsiders is centered around surveillance. Despite existing tensions and conflicts, they believe that the presence of surveillance agents should help in reducing the different pressures on NTZs that also threaten their well-being (Melo and Irving, 2012), including fishing by outsiders and illegal mining. Another solution cited by respondents was the creation of a sustainable use protected area, with the aim of ensuring access to fishery resources by local fishers and to compensate them for the loss of fishing territories due to the creation of NTZs. This solution is also an attempt to prohibit outsiders from fishing near the coast. Since 2005, fishers have been attempting to create a Marine Extractive Reserve (MER), which is a protected area with the sustainable use of natural resources (IUCN category VI), where co-management is a prerogative (Gerhardinger et al., 2009). In recent years, the movement to create the MER is gaining strength, mainly due to the efforts of fishers from Oiapoque and the support of Non-Governmental Organizations (NGOs).

The third, most important, conflict experienced by respondents was their dependence on middlemen, which is commonly observed in SSFs worldwide. Globally, SSFs are subject to a lack of basic infrastructure for the fishing sector, and landing points are widely dispersed across the territory, distant from markets (Partelow et al., 2018; Salas et al., 2011; World Bank, 2012). The absence of a local market to absorb the catches and the lack of structures to preserve fish meat might compromise the entire catch, because fish are a highly perishable product. Therefore, the fish supply chain is dominated by a network of intermediaries that link SSF trading networks and the local, national and globalized export markets (Crona et al., 2010; Pedroza, 2013).

Intermediaries finance fisheries, providing credits to fishers in exchange for supplying fish at low prices, which is an obstacle in improving fishers' income (Capellesso and Cazella, 2013; Crona et al., 2010; Pedroza, 2013; Salas et al., 2011), with implications on fisheries management and conservation efforts. Partelow et al. (2018) argued that many fishers are beholden to patron-client systems, which are often exploitative, but are their only market access option. The low prices paid by intermediaries can lead to overharvesting, because increased extraction is the only way for fishers to earn enough income to meet their basic needs and live with dignity. In addition, middlemen often do not comply with the rules of the states (e.g., taxation, labor, and fisheries legislation). This issue is an incentive for fishers to fish illegally, as their products are bought, even if they do not meet formal regulations, creating a state of ungovernability (Pedroza, 2013). The patron-client relationship also reinforces rent maximization tendencies and hampers the ability of fishers to self-organize. This issue, in turn, hinders their capacity to engage in collective actions for resource stewardship (Johnson, 2010). For instance, Seixas (2004) affirmed that the patron-client relationship is one of the barriers to the participation of resource users in fisheries management in Brazil.

The solutions proposed by the respondents regarding the conflicts with middlemen were focused on governmental investment in infrastructure and policies to facilitate fair marketing and to increase the value of fishery products. Policy makers and managers should also encourage fishers to form cooperatives for pre-sale processing aimed at improving the value added to fishery products, because, at present, only gutted fish are sold. Furthermore, cooperatives might represent an alternative tool to store fish catches, allowing fishers to negotiate better selling prices. This would overcome the issue of the high perishability of the fish and absence of freezing structures, which currently limits the bargaining power of fishers.

4.2. Status of fish stocks exploited by small-scale fisheries on the Amazon coast of Brazil

On the Amazon coast of Brazil, there is no continuous and effective monitoring of fisheries, leading to a deficiency in quantitative data for evaluating the status of fish stocks. However, in the present study, most respondents cited a decline in fish abundance, with the species mentioned by fishers forming the main fishery resources on the Amazon coast (Almeida et al., 2011; Bentes et al., 2012; Isaac-Nahum, 2006). The perception of interviewees was corroborated by landing data from the state of Pará, indicating a 47–54% decrease in the landings of *S. parkeri* between 1997 and 2007, even with increasing fishing effort. It is estimated that the decline of *S. parkeri* populations in Brazil is higher than 30% (ICMBio, 2018). In addition, estimated *C. acoupa* landings have declined by 27% over the last 10 years (Chao et al., 2015). Currently, *S. parkeri* is classified as 'Vulnerable,' while *C. acoupa* is classified as 'Near Threatened' (Chao et al., 2015; ICMBio, 2018). Both species were considered to be fully exploited in northern Brazil (Lucena Frédou and Asano-Filho, 2006).

The respondents perceived that the main causes for the decline in fish abundance are high fishing effort and catching power. In fact, fishing effort by the large-scale artisanal fleet of Pará has been systematically increasing as a consequence of good economic yields and government subsidies for purchasing fuel and financing fishing vessels (Isaac et al., 2009). The number of boats has increased significantly due to funds from the Constitutional Fund for the Financing of North, which has been operated by the Amazon Bank since 1997 (Lucena Frédou and Asano-Filho, 2006).

There are clear differences in the fishing effort and catching power between the fleets of Amapá and Pará. More than 60% of the fishing fleet from Amapá is composed of small-sized wooden boats of up to 12 m in length, with engine power of up to 160 HP, and storage capacity of one to seven tons, operating gillnets (average of 2,100 m in length) and longlines (average of 1,600 m in length and 1,400 hooks). The large-scale artisanal fishery of Pará is carried out by wooden boats of up to 20 m in length, using gillnets (> 3,000 m in length) and longlines (2,000 m in length and 3,000 hooks). In comparison, the industrial fleet of Pará employs large-sized steel boats (> 18 m in length), with powerful motors (average of 425 HP) and a storage capacity of up to 40 tons (Bentes et al., 2012). The industrial vessels are equipped with communication and navigation devices, and sophisticated catch processing onboard. Furthermore, shrimp trawlers have refrigerated chambers on board to freeze the catches (Bentes et al., 2012; Isaac et al., 2009).

Respondents considered industrial trawl fisheries to be harmful, due to the high fish catches and discards. Studies in the 1990s estimated that about 30 thousand tons of fish were discarded per year by trawl fisheries on the Amazon coast of Brazil (Isaac and Braga, 1999). However, recent studies have suggested that the waste has declined. Klautau et al. (2016) estimated that the trawler fleet catching *B. vaillantii* discarded 30% (311.276 tons) of its total production between 2002 and 2008, with about 44.468 tons being rejected per year during this period. Paiva et al. (2009) estimated that *Penaeus subtilis* represents only 20% of the total catch, with a ratio of 4.1 kg of bycatch for each 1 kg shrimp, leading to 17 thousand tons of bycatch in 2003.

Another predatory fishing practice cited by respondents was the illegal catches of *S. parkeri* during the closed-season. Moreover, fishers believe that the closed-season (November to March) does not cover the entire breeding season of *S. parkeri*. This demonstrates possible controversies in legislation, and the need for new studies on the life cycle of this species. Fishers also believe that other species should be protected during the closed-season, including *C. virescens*, *C. acoupa,* and *S. proops*.

The trade of swim bladder ('grude') was also cited by the interviewees as contributing to increasing fishing pressure because many fish are required to obtain 1 kg 'grude.' In the case of *C. acoupa* (the most valued species), 1 kg 'grude' is obtained from 10 large individuals weighing at least 7 kg each (Mourão et al., 2009). 'Grude' is used in the beverage, food, and cosmetics industries (Isaac et al., 1998). It is also marketed in Pará and Maranhão, from where it is primarily exported to Asian countries, such as Japan and China (Almeida et al., 2014; Mourão et al., 2009).

According to respondents, the main solution to recover fish stocks is surveillance. However, they also recognize the need to reduce fishing effort and catching power to protect fish stocks and SSFs. At present, there is no monitoring or control measures to regulate artisanal fisheries on the Amazon coast. However, the fishery resources cannot be sustained under uncontrolled exploitation for long periods. The imminent risk of overfishing threatens the integrity of ecosystems and the livelihoods of fishing communities in this region.

4.3. Fisheries management on the Amazon coast of Brazil

The two topics addressed in the present study are intrinsically related. The depletion of fish stocks has led to conflicts, which potentially lead to the unsustainable exploitation of fishery resources, with both issues threatening the NTZs. This scenario reveals the weak performance of management agencies and the government's incapacity to carry out effective enforcement, monitoring, and surveillance. It also reveals the lack of cooperation between stakeholders, culminating in a fisheries governance crisis. The major challenge seems to be to align the interests of different stakeholders and the conservation goals.

In this complex context, which includes the existence of diverse actors with different and, potentially, competing interests and accountabilities, new patterns of governance are necessary. Sustainable fisheries management could only be achieved through a wider cooperation between the government and all stakeholders. Co-management systems are characterized by the involvement and participation of resource users, the government, and external agents in decision-making (Jentoft et al., 1998; Pomeroy and Rivera-Guieb, 2005; Sen and Raakjaer Nielsen, 1996). Within these systems, the involvement of local populations and the incorporation of their needs and knowledge into decision-making process is essential (Andrade and Rhodes, 2012; Castello et al., 2009; Castilla et al., 2007; Oldekop et al., 2016). In turn, regulatory regimes are legitimized, with populations contributing to compliance, resulting in more effective conservation strategies (Jentoft et al., 1998).

Co-management arrangements are recognized as satisfactory approaches to achieve sustainable environmental governance. These arrangements are guided by the search for negotiated solutions that allow different interests to be balanced. In South America, Chile's experience in granting Territorial User Rights for Fisheries (TURFs) to small-scale fishers' organizations stands out as a successful co-management strategy (Castilla et al., 2007). One of the positive impacts of this initiative was the prevention of stocks that were being overexploited (Gelcich et al., 2010). Many studies have also demonstrated the role of co-management in reducing fisheries conflicts. For example, in Colombia and southeast Asia, places where co-management arrangements were established had lower levels of conflict, resulting in better fisheries management aimed at long-term sustainability (De Pourcq et al., 2015; Pomeroy et al., 2007). Furthermore, a study in developing countries demonstrated a direct relation between the participation of communities in decision-making process and compliance with conservation strategies within protected areas (Andrade and Rhodes, 2012).

In Brazil, most co-management systems are concentrated in the Amazon, where they contribute towards maintaining fish abundance, sustainable fisheries, and food security (Castello et al., 2009; Silvano et al., 2014). Nevertheless, most of these systems belong to continental areas, and involves territories characterized by well-delimited spatial boundaries, including many lakes (Pezzuti et al., 2018). On the Amazon coast, there are about 15 MERs that are still experimenting with this type of management. Consequently, it is too early to determine whether they are successful. However, they contribute towards protecting mangroves against shrimp farming and towards ensuring the access of traditional people to territories, allowing the maintenance of their culture. A recent study on land use in mangroves has demonstrated the important role MER play in protecting this ecosystem on the Amazon coast of Brazil (Hayashi, 2018). In addition, in the state of Bahia (northeastern Brazil), the implementation of the Cassurubá MER has enhanced social organization, with a gradual increase in social participation in decision making. In particular, this approach has reduced competition for resources with outsiders (Nobre et al., 2017).

The implementation of a MER provides an opportunity to establish a collaborative governance regime because, within this category of protected area, management responsibilities must be shared between managers and the community through deliberative councils, which are important spaces for dialogue, conflict mediation, and a platform for the inclusion of local knowledge in decision-making (Gerhardinger et al., 2009). At the study site, the good performance of the 'Commitment Terms' indicates that there is some willingness by local fishers to adopt co-management.

However, the success of co-management is strongly related to the presence of legitimate community leaders and robust social capital. Gutiérrez et al. (2011) analyzed 130 co-managed fisheries in several countries and identified that the presence of at least one highly motivated individual who was respected as a local leader and guided by collective interests could facilitate resilience to changes in governance, influence users compliance to regulations, and enhance conflict resolution. At present, fishing communities in the state of Amapá are experiencing an emerging leadership crisis, with the president of the Fishers' Colony of Oiapoque being the only leader that is widely respected and who has legitimacy. Therefore, the initial process of implementing a MER should include efforts to identify potential fishers that could be trained for the development of leadership skills and self-organization for collective actions. This process should be supported by scientists, universities, and NGOs.

The issues with local government agencies and the high cost of surveillance and enforcement emphasize the importance of co-management in the study area. In this sense, experiences related to community surveillance have been reported in the Brazilian Amazon as part of fisheries co-management in lake systems (McGrath et al., 2008). In addition, experiences in Mexico show that well-organized local groups can secure viable fisheries and coastal livelihoods (Méndez-medina et al., 2015). Furthermore, examples from Japan and the Philippines show that fishers' organizations contribute towards cost-effective ecosystem monitoring, which is indispensable for adaptive capacities (Makino et al., 2014). Sustainable use protected areas may also contribute to preserve endangered livelihoods, which seems to be the case for fishers from the present study. In Spain, La Restinga and Lira reserves have reinforced local fishing identities, preserving the traditional way of living, and a sense of ownership and responsibility over marine territories. These approaches have increased the control of local fishers in territories that they traditionally use (Pascual-Fernández and Cruz-Modino, 2011).

In the Brazilian Amazon, coastal fisheries management is essential to safeguard the food security of local populations. It is also important for the marine conservation of a region considered to be Ecologically or Biologically Significant Marine Area – EBSA (CBD, 2012), as well as a priority for biodiversity conservation (MMA, 2007). This region also encompasses two Ramsar sites. In this context, the creation of a MER favors the establishment of a network of no-take and sustainable use protected areas, as well as the connectivity between terrestrial and marine environments. This approach would contribute to the progress of Brazil in implementing elements of Aichi Target 11 within the Convention on Biological Diversity, such as connectivity between protected areas, as well as effectiveness and equity in the management of these spaces (CBD, 2010).

Achieving a balance between protecting ecosystems and their sustainable use is a major challenge, especially in the current scenario of the increasing human population, habitat loss, and the depletion of fish stocks. Therefore, NTZs are required, but are not sufficient to guarantee conservation. Effective environmental protection is only possible if local communities support and benefit from the implementation of conservation projects. A study by Oldekop et al. (2016) demonstrated that protected areas with positive conservation outcomes are associated with positive socioeconomic outcomes, which are more likely to occur when protected areas adopted co-management regimes that empower local populations, reduce economic inequalities, and maintain cultural and livelihoods benefits.

Without engagement from all resource users, it is very difficult to achieve fair and effective governance facilitating conflict resolution. Therefore, investment in capacity-building is needed to enable resource users and other stakeholders (e.g., managers, scientists, NGOs) to actively engage in participatory forms of coastal management (Seixas, 2004; Wever et al., 2012). Furthermore, efforts to facilitate interactions between stakeholders are needed, including the creation of a regional fisheries committee. This committee could then objectively discuss fishing rules and responsibilities and incorporate fishers' knowledge in the management process. Another important measure is the establishment of a research agenda that will subsidize a marine spatial planning in the future. The challenges are great, and require mobilization of people, conflict resolution, training, and a regional and multidisciplinary approach. Finally, the methodology used here could be improved by including the perspectives of other stakeholders (e.g., managers, policy makers, surveillance agents, outside fishers) to obtain an in-depth understanding of the identified issues.

Declarations of interest

None.

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