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Ecosystem services of the Ratones River basin and the role of a conservation unit from the perspective of artisanal fishers

Serviços ecossistêmicos da bacia do Rio Ratones e o papel de uma unidade de conservação na perspectiva dos pescadores artesanais

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Abstract: The ecosystem services (ES) approach is promising for finding solutions in socioecological systems by facilitating interdisciplinary and stakeholder understanding across different sectors of society. Ecosystem-based management is a conservation strategy inherently anthropocentric, which assumes that the understanding of the value and the value criteria are necessary for ecosystem service management. Therefore, it is essential to consider the values of all stakeholders in order to generate empathetic and positive responses to conservation proposals. The objective of this research was to investigate and characterize the perceptions of artisanal fishers about ecosystem services of the Ratones River basin, which is partially protected by the Carijós Ecological Station (ESEC Carijós) in its lower reaches. Specifically, we aimed to identify and characterize the ecosystem services perceived by fishers in this river basin and the role of the protected area in the provision of the perceived ecosystem services. We conducted semi-structured interviews with 52 fishers from 7 localities within or adjacent to the basin. We identified 28 ecosystem services from seven service provider sources. The category of cultural services was the most cited and had the highest number of related services. The presence of ESEC Carijós was perceived positively, primarily as a provider of food and habitat for wildlife, and negatively due to its restriction of traditional ways of life, especially because of the regulatory conditions imposed on the local traditional fishing areas. The current management of ESEC Carijós, based on command and control with a high level of focus on regulation enforcement, compromises its effectiveness in the provision of ecosystem services. Investing in a better relationship between the community and ESEC Carijós, through more inclusive and decentralized management, will bring greater effectiveness to the unit by promoting social and environmental development and the protection of natural heritage beyond the boundaries of the conservation unit.

Keywords: artisanal fishers; ecosystem services; protected areas.

Resumo: A abordagem dos serviços ecossistêmicos (SE) é promissora para encontrar soluções em sistemas socioecológicos, facilitando a compreensão interdisciplinar e das partes interessadas em diferentes setores da sociedade. A gestão de base ecossistêmica é uma estratégia de conservação inerentemente antropocêntrica, que pressupõe que a compreensão do valor e dos critérios de valor são necessários para a gestão dos serviços ecossistêmicos. Portanto, é essencial considerar os valores de todas as partes interessadas para gerar respostas empáticas e positivas às propostas de conservação. O objetivo desta pesquisa foi investigar e caracterizar as percepções dos pescadores artesanais sobre os serviços ecossistêmicos da bacia do rio Ratones, que é parcialmente protegida pela Estação Ecológica Carijós (ESEC Carijós) em seu baixo curso. Especificamente, buscamos identificar e caracterizar os serviços ecossistêmicos percebidos pelos pescadores nesta bacia hidrográfica e o papel da área protegida na prestação dos serviços ecossistêmicos percebidos. Conduzimos entrevistas semiestruturadas com 52 pescadores de 7 localidades dentro ou adjacentes à bacia. Identificamos 28 serviços ecossistêmicos de sete fontes provedoras de serviços. A categoria de serviços culturais foi a mais

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citada e teve o maior número de serviços relacionados. A presença da ESEC Carijós foi percebida positivamente, principalmente como fornecedora de alimentos e habitat para a vida selvagem, e negativamente por restringir o modo de vida tradicional, especialmente devido às condições regulatórias impostas às áreas tradicionais da pesca local. A gestão atual da ESEC Carijós, baseada em comando e controle e alto nível de foco na aplicação da regulamentação, compromete sua eficácia na prestação de serviços ecossistêmicos. Investir em um melhor relacionamento entre a comunidade e a unidade de conservação, por meio de uma gestão mais inclusiva e descentralizada, trará maior eficácia para a unidade ao promover o desenvolvimento social e ambiental e a proteção do patrimônio natural além dos limites da unidade de conservação.

Palavras-chave: pescadores artesanais; serviços ecossistêmicos; áreas protegidas.

1. Introduction

The concept of ecosystem services (ES), coined in 1981 by Ehrlich & Ehrlich, was popularized by the Millennium Ecosystem Assessment (MEA), a global initiative created in 1999 to assess how changes in ecosystems would affect human well-being by understanding the processes linking biodiversity to ecosystem functions (Millennium Ecosystem Assessment [MEA], 2003). Since then, the concept of ecosystem services has gained traction in the scientific research community and in public sector institutions (Mandle et al., 2021) as a tool capable of engaging with different sectors of society, identifying the beneficiaries of ecosystem services and incorporating their values into decision-making processes. More recently, the concept has evolved toward a perspective that considers nature's contributions to people (Díaz et al., 2018), incorporating both positive and negative contributions, or toward discussions in which reciprocal interactions are highlighted (Ojeda et al., 2022). Despite methodological advances, gaps remain in better understanding the inherent link between human well-being and ecosystem services. These gaps are due, in part, to the dominant view of well-being, which is still heavily focused on economic growth (Chan & Satterfield, 2020).

Conservation units (CUs) are a fundamental part of sustainable development strategies, being associated with nature conservation, ecosystem services, and sociocultural values. Social participation in CU management is essential to ensure that the priorities defined at their creation are compatible with the expectations of the local population, actively and meaningfully integrating them into this process (Bezerra et al., 2018). In Brazil, since 2000, the policy for the creation and management of protected areas and CUs has sought to ensure greater and more effective participation by society (MMA 2004), decentralizing the management of natural resources and institutionalizing community management initiatives, with emphasis on the north of the country (Benatti, 2003).

Despite these advances, genuine social participation in the management process of CUs remains a challenge for public managers (Bezerra et al., 2018), since the creation of these units has historically not been integrated with local and regional development processes, undermining

the necessary incorporation of conservation into the way of life of local actors and reducing the effectiveness of these units (Diegues & Viana, 2004; Furlan, 2004). The lack of social participation in defining CUs generally hinders the sense of belonging and the creation of decision-making spaces (Quadros et al., 2015), due to the establishment of norms without legitimacy and non-participatory (top-down) management mechanisms (Ribeiro et al., 2020). As a consequence, many units negatively impact the local population (Oldekop et al., 2016; Chan et al., 2019), especially coastal conservation units in which many people depend on natural resources for their livelihood and the reproduction of their way of life (Blythe et al., 2020; Dias et al., 2022).

The international community has explored ways to reconcile conservation with the way of life of local communities (Berkes et al., 2009; Plieninger & Bieling, 2013) and to allow a conceptual reframing of the place of people in nature (Fisher et al., 2014). In recent decades, there has been a marked increase in studies on the social dimensions of ecosystem services (Chan & Satterfield, 2020), with the development of various methodological models to understand the complexity of socioecological systems (Solé & Ariza, 2019; Uehara et al., 2021). Multiple approaches to ecosystem services using methodologies beyond the monetary one (see Raymond et al., 2009; Oteros-rozas, 2012; Asah et al., 2014; Klain et al., 2014; Fish et al., 2016; Pascual et al., 2017; Barton et al., 2022) have been used in order to capture the diversity of feelings and worldviews inherent to other forms of knowledge, including traditional knowledge (Díaz et al., 2018).

In this scenario, protected areas take on a broader character by recognizing the central role that culture plays in defining the connections between people and nature (Díaz et al., 2018), as well as in restoring and maintaining these connections (Berkes et al., 2009). To this end, understanding the perceptions, values, attitudes, and beliefs regarding the benefits derived from the ecosystem is an indispensable part of this process (Asah et al., 2014; Cárcamo et al., 2014; Juan et al., 2017; Dias et al., 2022).

The objective of this research was to investigate and characterize fishers' perceptions of the ecosystem services of a river basin partially protected by the Carijós Ecological Station (ESEC Carijós) in its lower reaches. Specifically, we aimed to identify and characterize the ecosystem services perceived by fishers in this river basin, to analyze whether the fishers' place of residence, age, and source of income affect their perception of ecosystem services, and to assess the role of the protected area in the provision of the perceived ecosystem services.

We adopted the MEA classification, which defines ecosystem services as the benefits people obtain from ecosystems. In addition, we discuss the results from the perspective of nature's contributions to people (Díaz et al., 2018). Ecosystem services are divided into at least four categories, based on

the functional characteristics of ecosystems (MEA, 2005): supporting services, such as soil formation; provisioning services, such as food; regulating services, such as climate regulation; and cultural services, such as sense of place and well-being. We expected to find a greater perception of ecosystem services in the provisioning and cultural categories, given the nature of the interviewees' work in artisanal fishing (aimed at obtaining food) and their bond with the environment, characteristic of traditional populations. A positive influence of ESEC Carijós on the provision of ecosystem services was also expected, due to the preservation of a mangrove area and its associated resources, and a negative influence due to the restriction on the use of the traditional fishing area imposed by the conservation unit. Our aim is to generate input for a more participatory management of the ecosystem that is consistent with the interests of the local community. Identifying the local fishing community's perception of nature's contributions to people can constitute a fundamental step in building a participatory planning process.

2. Materials and methods

2.1. Study area

The region of Santa Catarina Island was inhabited by distinct cultural groups over the last 5000 years; however, at the time of contact with Europeans, the Guarani predominated (Salvador, 2017), an Indigenous people who were later nicknamed by the Europeans themselves as Carijó (Brighenti, 2012). From the 17th century onward, the Portuguese crown began occupying these lands, with strong Azorean and Madeiran immigration, which shaped local identity (Diegues et al., 2000). Along the coast of Brazil, as in the coastal communities of Santa Catarina Island, until the early 20th century small population clusters depended on small-scale agriculture and artisanal fishing for their subsistence (Luz, 2014). In Ratones and its surroundings, fishing and agriculture – complementary activities – were fundamental to the formation of the community and its identity, sustained by exchange relations and community work parties (mutirões) (Araújo, 2017).

The Ratones River watershed is located to the northwest of Santa Catarina Island, in southern Brazil (Figure 1). It occupies an area of approximately 61 km^2, making it the most extensive watershed on Santa Catarina Island (Figueirôa & Scherer, 2016). The Ratones River, the main watercourse, is approximately 10 km long and 3 m wide on average (Silva, 2005). At the mouth of this river lies the Carijós Ecological Station (ESEC Carijós) conservation unit.

The artisanal fishers who use the basin reside in neighborhoods with different levels of urbanization and access to the marine environment. Many of them have other sources of income besides artisanal fishing;

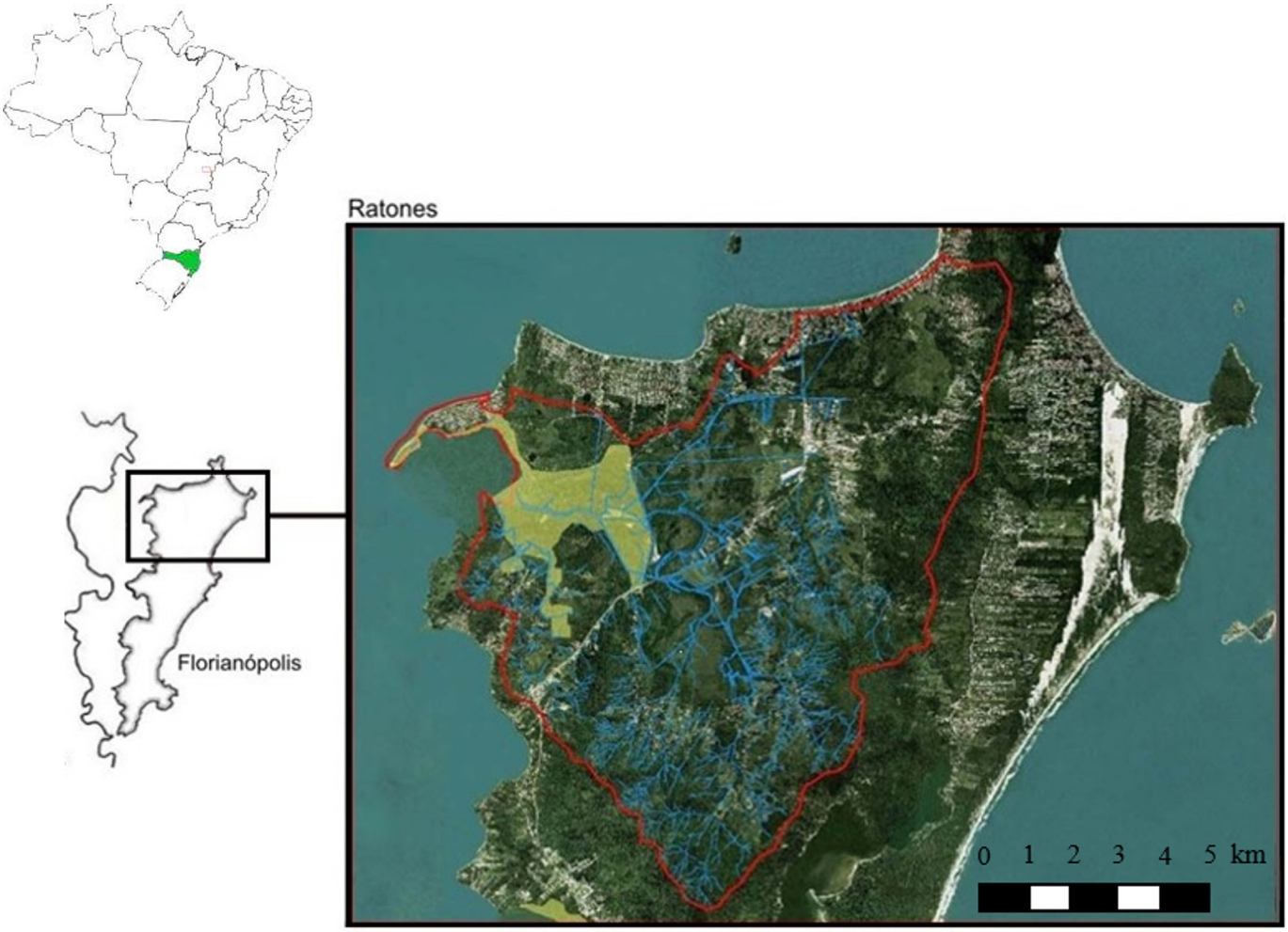


Figure 1

Location of the Ratones River Watershed.

Legend: Red line: boundary of the Ratones River basin. Green area: Carijós Ecological Station, Ratones tract. Blue lines: hydrographic network of the Ratones River basin

nonetheless, they remain the main direct users of the natural resources provided by the basin (Instituto Carijós & IBAMA, 2008). Fishing in the Ratones River is done using cast nets and rowing canoes, mostly for direct consumption, with surpluses directed to the community and sale. The coastal communities of the basin, due to easier access to the sea, also have larger motorized boats, and fish with other larger and heavier gear, such as the nets used in trawling and seine fishing (caceio) (Instituto Carijós & IBAMA 2008).

ESEC Carijós, created in 1987, is a federal full-protection conservation unit whose objective is to preserve important mangrove remnants and associated ecosystems on Santa Catarina Island. It covers two mangrove areas on the eastern shore of Baía Norte, geographically separated, totaling 7.15 km² (IBAMA, 2003). The two areas that gave rise to ESEC Carijós were traditionally used as fishing spots and, above all, as an important access route to the sea for fishers from adjacent communities. After the creation of ESEC Carijós and the implementation of restrictions, fishers in the region suffered deprivations in the use of the river's resources, such as the prohibition of fishing. Since then, various conflicts with enforcement authorities and questions about the effectiveness of the conservation unit have arisen (Instituto Carijós & IBAMA, 2008).

2.2. Data collection and analysis

Data were collected through semi-structured interviews with artisanal fishers between February and May 2017. Based on the literature (Costanza et al., 1997; MEA, 2005; Raymond et al., 2009; Fisher et al., 2009; Fish et al., 2016), we organized an interview protocol to identify ecosystem services based on questions about the ES provider sources (Table 1).

We conducted 52 semi-structured interviews with fishers from seven localities in the Ratones River watershed, classified as inland or coastal according to their geographic position. Fishers were identified using the snowball technique (Albuquerque et al., 2010), based on referrals from local leaders and pre-existing contacts, and according to the following criteria: being an active fisher with at least 20 years of experience in local fishing and agreeing to the informed consent form to participate in the study. In this research, the criterion for sample closure was based on the stability of referrals, understood as the recurrent repetition of the same names throughout the interviews. This stability was considered to have been reached when, by the end of the process, the first five participants indicated had already been mentioned again by other interviewees, signaling network saturation and a reduced probability of including new relevant actors.

We interviewed 51 men and one woman individually. To record fishers' perceptions of ecosystem services, the interview questions were divided into the following topics: neighborhood, fishing, mangrove, Ratones River, hillside forest, native fauna, and ESEC Carijós (Table 1). In this study we refer to these topics as "Source", alluding to the idea of provider sources of ecosystem services and benefits.

The questionnaire prioritized free expression by the interviewees through open-ended questions. We chose not to use terms referring to the names of the services and their categories (according to the MEA 2005 classification or more recent frameworks such as Díaz et al., 2018) and avoided the metaphor of service production by nature. The purpose of this

Table 1 Summary of the questionnaire used in the interviews conducted with fishers of the Ratones River Watershed.

Categories	Questions
Interviewee characterization	Name, place and length of residence, age, years of fishing experience, fishing sites, main source of income
Perception of ecosystem services	Do you like living in your neighborhood? Do you like having your family live here? Why? What does fishing mean / what importance does it have for you and your life? In your opinion, what is the importance / what is the purpose / what are the benefits of: the mangrove, the Ratones River, the hillside forest native fauna What do you fish / collect / use from nature here in the Ratones River basin area? Does ESEC affect the availability of these resources used?
Perceptions of ESEC	In your opinion, what is the importance / what is the purpose of ESEC? Do you think ESEC is fulfilling its purpose? Why? If ESEC did not exist, what do you think this place would be like?

approach was to give voice to actors whose language may not be captured by specific and decontextualized tools (Klain et al., 2014; Asah et al., 2014; Jacobs et al., 2016; Díaz et al., 2018). The same question, when necessary, was reformulated. For example, the question: "What is the importance of the mangrove for you?" could be reformulated as: "what is the function or purpose of the mangrove?" We also asked what would change in the absence of that source: "Without the mangrove, what would change?"

The list of ecosystem services compiled in the literature review served as a guide for the content analysis of the interviews (Bernard & Ryan, 2010), in the identification and characterization of the ecosystem services perceived by the interviewees. If no corresponding service was found in the literature, a new category was created. To identify and characterize the ecosystem services perceived by fishers, we used descriptive analysis and response frequency, following the MEA (2005) classification, disregarding ecosystem services repeated within the same interview. In the analysis of the relationship between "source" and "ecosystem services", we considered repeated citations of the same service by the same interviewee across different sources.

To illustrate the relationships between ecosystem services and their provider sources, we performed an ecological network analysis using the "Alluvial" package. We restricted this analysis to each ecosystem service that was perceived from the same source by at least 6 interviewees ($n = 52$). This analysis was performed in the R programming environment (R Core Team, 2015).

We investigated whether individual characteristics such as place of residence, age, and source of income (strictly from fishing or not) affect fishers' perception of ecosystem services. To test for collinearity among the explanatory variables, we used the "vif" function of the "car" package. For this purpose, we performed two analyses:

(1) a generalized linear model (GLM) with a binomial distribution ("logit" link function) to understand whether individual variables affect fishers' ability to perceive more or fewer ES, within the total number of perceived services (proportion data), and

(2) a multivariate GLM with a binomial distribution ("cloglog" link function) to understand whether individual variables affect the composition of these ES as perceived by fishers.

Model selection was performed using the most parsimonious Akaike Information Criterion (AIC) through the "model.sel" function of the "MuMIn" package. The multivariate model was validated through graphical analysis of the model's residual deviances against predicted values and a Normal Q-Q plot. We restricted these analyses to ES perceived by at least 10 fishers ($n = 52$). After finding the models with the lowest AIC values, we considered additional model simplification steps, using $\Delta AIC < 4$ (Bolker, 2008).

To investigate the role of ESEC in the provision of ecosystem services, we performed a descriptive analysis of the frequency with which ecosystem services were cited as directly and indirectly provided by ESEC. We then performed a descriptive and frequency analysis of the responses regarding the perception of ESEC, divided into positive and negative perceptions, potentially service-providing or service-suppressing, respectively.

Finally, we discuss the results from the perspective of the most recent proposals for understanding nature's contributions to people, classified as material, non-material, and regulating (Díaz et al., 2018).

3. Results

3.1. The fishers

The concept of artisanal fisher varied among localities. In inland neighborhoods, where estuarine fishing predominates, a fisher is someone who fishes, even if only occasionally, as a supplementary source of income. In coastal neighborhoods, on the other hand, a fisher is someone who fishes regularly and, in many cases, depends primarily on this activity as a source of income.

We interviewed 26 fishers in inland neighborhoods and 26 in coastal neighborhoods. Only four fishers live exclusively from fishing in the inland neighborhoods, while 15 do so in the coastal neighborhoods. The mean age of the inland fishers was 57 years (± 8 years) and their mean fishing experience was 44 years (± 12 years). The mean age of the coastal fishers was 52 years (± 14 years) and their mean fishing experience was 42 years (± 14 years).

The mean length of residence in the neighborhood among inland fishers was 48 years, ranging from 10 to 71 years, with 17 of them being native to the community. Among coastal fishers, the mean length of residence was 46 years, ranging from 20 to 73 years, of whom 20 are native to the community.

Regarding fishing locations, among inland residents, five fish exclusively in the rivers, mainly Ratones and Papaquara; fifteen fish both in the Ratones River and in Baía Norte; four fish only in Baía Norte; and two also carry out their activities in open sea. Among coastal fishers, all reported fishing in Baía Norte, with six also fishing in the rivers and six extending their activities to the open sea.

3.2. Perceived ecosystem services

Content analysis identified 28 ecosystem services in 421 citations, divided into four categories according to MEA (2005): ten cultural services; six provisioning; three supporting and nine regulating (Table 2). Each interviewee perceived, on average, 8.10 (± 2.75) ecosystem services.

Table 2 Identification and characterization of 28 ecosystem services provided by the Ratones River Watershed, according to the perception of 52 local fishers and the corresponding type of nature's contribution to people.

Ecosystem services	General characterization according to interviewees, with examples of interview excerpts (in quotes)	Type of nature's contribution to people (Díaz et al., 2018)
Cultural services		
Leisure	Walking; observing; "it's a way to de-stress from today's world" (fishing)	Non-material: Learning and inspiration, Physical and psychological experiences
Aesthetic value	Seeing the beauty of the river; the beauty of the forest	Non-material: Learning and inspiration, physical and psychological experiences
Spiritual and religious value	The forest as a place to meditate; "it's where I connect with God"	Non-material: Learning and inspiration, Physical and psychological experiences
Traditional way of life	Fishing is life; "it's rooted in me"	Material: companionship and work. Non-material: Learning and inspiration, Physical and psychological experiences, Supporting identities
Intrinsic and existence value	"It's important because it's from nature, it's a living being" (fauna);	Non-material: Physical and psychological experiences
Well-being, inspiration	"It's what makes me happy, it's a joy to wake up fishing"	Non-material: Learning and inspiration, Physical and psychological experiences
Sense of place	The neighborhood is my community; the neighborhood is my home"	Non-material: Supporting identities
Knowledge systems	"It tells us what's going to happen during the year" (mangrove)	Non-material: Learning and inspiration
Social relations	"Here I have my friends, peace, and work" (neighborhood)	Material: Materials, companionship and work. Non-material: Physical and psychological experiences and Supporting identities
Cultural heritage	"My community carries on the tradition" (neighborhood)	Non-material: Supporting identities
Provisioning services		
Food	Fishing; farming; livestock raising	Material: Food; Materials, companionship and work
Medicine, pharmaceuticals	Medicinal herbs; tea	Material: Materials, medicinal, biochemical and genetic resources
Fuels	Firewood for the stove	Material: Materials, companionship and work
Fresh water	Waterfall water for drinking	Regulation: Regulation of freshwater quantity, location and timing, and of freshwater and coastal water quality.
Source of income	Fishing is the livelihood; helps with income	Material: Food; Materials, companionship and work
Clean air	"It's fresh, the air is different from the city" (forest)	Regulation: Air quality regulation
Supporting services		
Oxygen production	"The mangrove and the forest produce oxygen"; "the forest makes the air"	Regulation: Air quality regulation; Climate regulation
Habitat provision	"The mangrove and the forests are the animals' home"; "the mangrove is the breeding ground for all fish"	Regulation: Habitat creation and maintenance
Seed dispersal	"They are the ones who plant the forest" (fauna)	Regulation: Pollination and dispersal of seeds and other propagules

Regulating services		
Biological control	"One eats the other and keeps the forest in balance" (fauna)	Regulation of pests and biological processes
Air quality regulation	The forest keeps the air clean; the forest purifies the air	Air quality regulation
Soil quality regulation	The forest protects the soil; "the soil is better with the trees"	Formation, protection and decontamination of soils and sediments
Water regulation	The forest maintains the water on the hillside; the forest maintains the water of the spring	Regulation of freshwater quantity, location and timing; Regulation of freshwater and coastal water quality
Climate regulation	The mangrove and the forest control the heat; without the forest the environment heats up	Climate regulation
Water purification, pollution control	The mangrove is the filter; "it's the filtering sponge that keeps sewage from reaching the river untreated" (mangrove)	Regulation of freshwater and coastal water quality; Formation, protection and decontamination of soils and sediments
Sediment retention and transport	The forest maintains the riverbed (forest); "it holds the ground so it doesn't erode" (forest)	Formation, protection and decontamination of soils and sediments, Regulation of hazards and extreme events
Flood regulation	The river serves to drain the hillside waters	Regulation of hazards and extreme events
Natural hazard mitigation	The trees of the forest hold back the wind; the mangrove lessens the impact of the waves	Regulation of hazards and extreme events

The most cited category was cultural services with 39% of citations, followed by regulating services with 28%, supporting services with 19%, and provisioning services with 14% of citations. More than 60% of interviewees cited habitat provision, food provision, and well-being services. Considering the categories of nature's contributions to people, of the 28 services perceived by fishers, 39% are regulating, 39% are non-material, and 22% are material. Some ecosystem services can be classified into more than one contribution category.

3.3. Provider sources of services

In this analysis we considered 558 citations of the 28 ecosystem services perceived across the different provider sources. The ES perceived in the sources neighborhood of residence and fishing were restricted to the categories of cultural and provisioning ES (Figure 2), including material, non-material, and regulating contributions. The neighborhood was related to seven cultural services and four provisioning services.

The services of sense of place and social relations were the most cited (Figure 3), reflecting non-material contributions of physical and psychological experiences and identity support: *My community still has peace, old customs preserved* (interviewee 3, 55 years old). The idea of the neighborhood as a calm and good place to live was unanimous in the interviews, considered as a temporary condition, which will pass: *It's still good to live here* (interviewee 11, 66 years old).

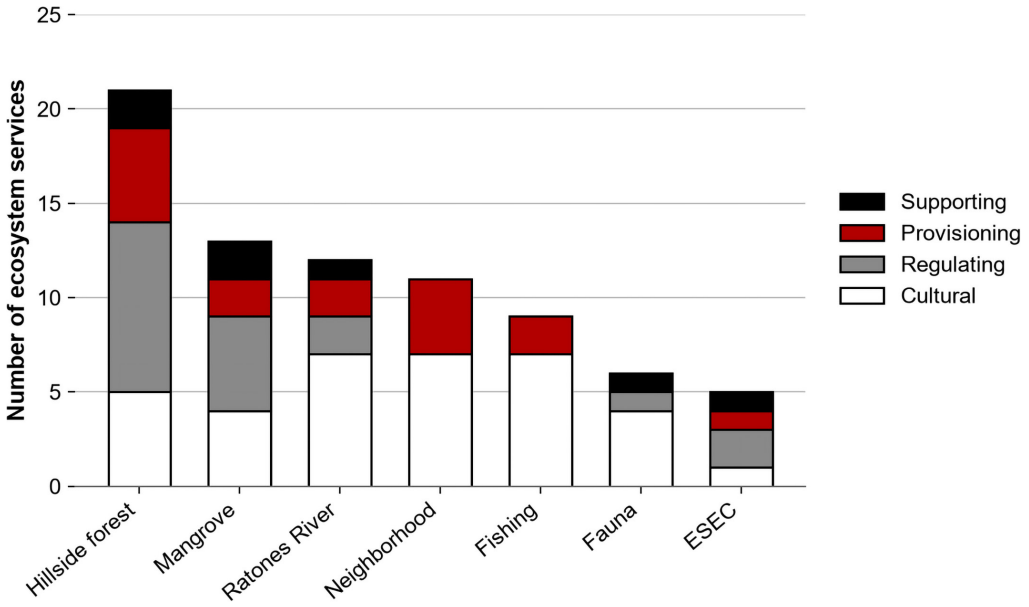


Figure 2

Number of ecosystem services by provider source (*n* = 28 ES, from 52 interviews with fishers).

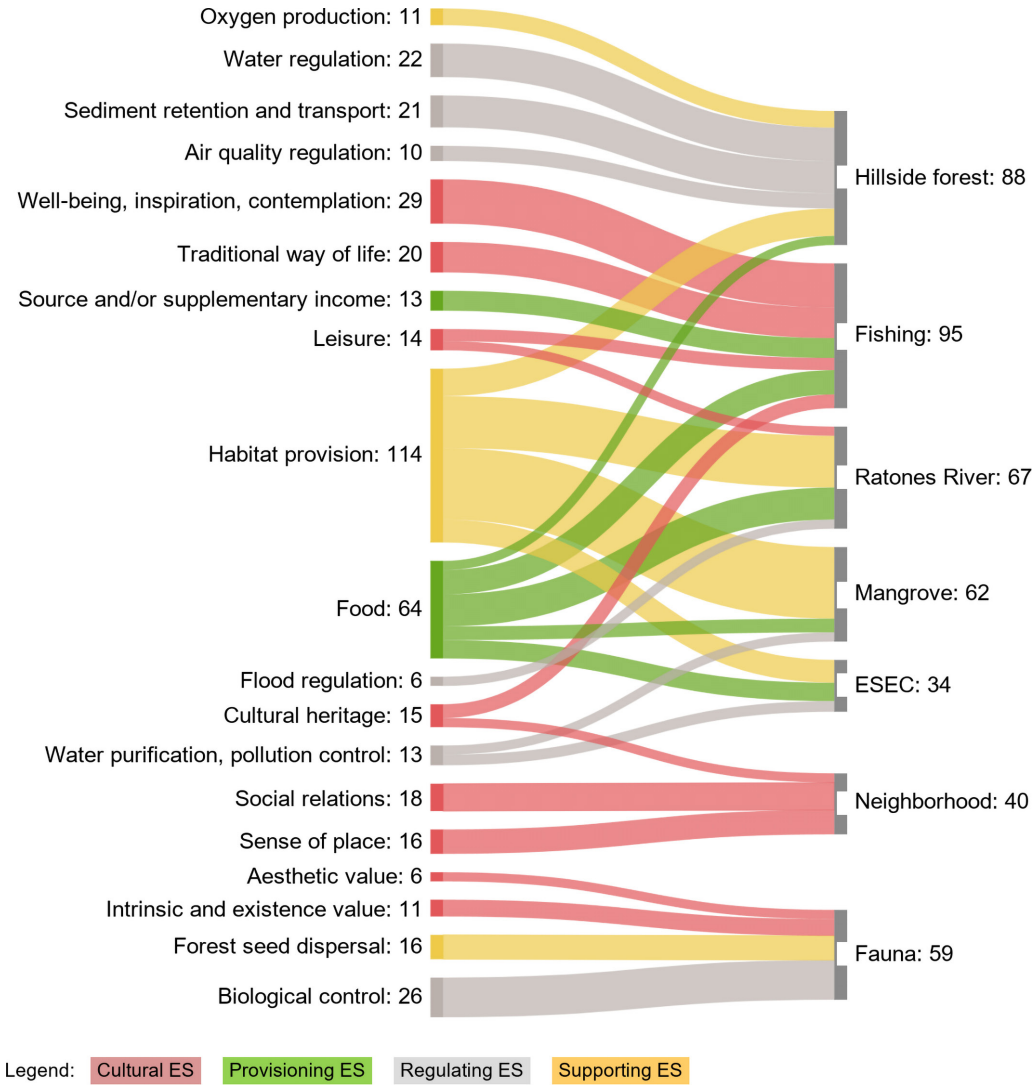


Figure 3

Sankey diagram representing the connections between ecosystem services cited by more than 5 interviewees and their respective provider sources (*n* = 558 citations of 28 ES, from 52 interviews with fishers). ESEC = Carijós Ecological Station.

Fishing was related to seven cultural ES and two provisioning ES, mainly well-being and traditional way of life, and secondarily food provision and source of income, that is, both material and non-material contributions. The traditional way of life service refers mainly to the importance of fishing for happiness and zest for life, described in greater depth than the well-being and inspiration service: *The day I don't go to sea I get sick, I get nervous, I go crazy without it* (interviewee 47, 67 years old).

Native fauna was related to six ES, with biological control, from the regulating category, being the most frequent (Figure 3). It was also considered part of the forest in a relationship of reciprocal dependence: *without animals there is no forest, one needs the other for nature to continue* (interviewee 41, 73 years old). Fauna was the main provider source of the cultural service intrinsic and existence value: *Each animal has its function, planting the trees. Everyone does, we just don't know it* (interviewee 37, 63 years old), also highlighting its regulating contribution.

The hillside forest, the mangrove, the Ratones River, and ESEC Carijós were related to all four ES categories, and to the three groups of nature's contributions to people. The hillside forest was perceived as a provider of 21 ecosystem services, the source with the most associated services, mainly regulating (nine services), such as water regulation and sediment retention and transport. Secondarily, supporting services were mentioned, mainly through habitat provision and oxygen production. The hillside forest was also considered responsible for maintaining other sources, such as the Ratones River, native fauna, and the neighborhood as a good place to live.

The mangrove (13 services), the Ratones River (12 services), and ESEC Carijós (5 services) were perceived mainly as providers of habitats, which is a supporting service. The mangrove was the source most related to this service, representing 41% of the total citations of this service ($n = 114$). *It's the nursery for everything, marine life and other animals* (interviewee 5, 52 years old). The second most significant category for the mangrove was regulating services, while for the Ratones River it was cultural services (non-material contributions), being related to seven ecosystem services in this category, such as leisure and sense of place.

ESEC Carijós was perceived as a provider mainly of habitat and food. Other services included water purification, pollution control, air quality regulation, and aesthetic value. Although ESEC Carijós encompasses a large part of the mangrove of the Ratones River Watershed and the lower course of the Ratones River, it was the source with the fewest related ecosystem services and also with the fewest service citations (36).

3.4. What influences fishers' perception of ecosystem services?

We explored whether individual variables such as age, place of residence, and source of income affect fishers' ability to perceive more ecosystem services provided by the Ratones River Watershed. The proportion binomial

model shows that there is no relationship between individual variables and the number of perceived ecosystem services.

The multivariate binomial model shows that there is a relationship between the individual variable place of residence and the composition of perceived ecosystem services (Table 3; Composition ~ Location). Therefore, there is a difference in the composition of perceived ecosystem services between coastal and inland fishers.

This difference lies in the services aesthetic value ($F = 2.475$; p-value = 0.012), traditional way of life ($F = 2.444$; p-value = 0.02), and habitat provision ($F = 0.063$; p-value < 0.001), which are mainly non-material and regulating contributions. Coastal fishers show a greater perception of these services compared to inland fishers (Supplementary material). Coastal residents perceive more services related to traditional way of life and habitat provision (material and non-material contributions) and fewer cultural services of aesthetic value (non-material contributions) than inland residents. For coastal fishers, these non-material contributions were perceived only in the sources hillside forest, Ratones River, and fauna. Traditional way of life, more strongly perceived by coastal fishers, was strongly related to fishing, but also to the neighborhood and mangrove sources. For inland fishers, in addition to these sources, these services and contributions were also perceived in the hillside forest and the Ratones River.

3.5. The role of the protected area in the provision of ecosystem services

The questions about the services provided by ESEC Carijós generated perceptions that could not be directly translated into ecosystem services, but that can be interpreted as positive and negative contributions to people. We identified 47 citations of positive perceptions, grouped into four items, and 55 citations of negative perceptions, grouped into five items (Figure 4). Responses were grouped by fishers' locality: coastal and inland.

Of the 52 interviewees, 61% saw no usefulness in ESEC Carijós or associated it with something negative. Dissatisfaction is mainly due to the restriction on the use of fishery resources within the conservation unit and the approach taken in enforcement actions, both within and around the unit. These factors were cited as responsible for negatively affecting

Table 3 Results of the multivariate binomial GLM for differences in the composition of ecosystem services perceived by fishers as a function of place of residence, age, and income (ns = not significant; *n* – 1 = degrees of freedom; LR = likelihood ratio test; ∑AIC = sum of AIC; ΔAIC = difference between model AIC values)

Model	Location	Income	Age	n – 1	LR	p-value	∑AIC	ΔAIC
Composition ~ Location + Income + Age	27.81	21.56	20.92	4	75.83	ns	1199.09	15.07
Composition ~ Location + Income	26.94	21.97	-	3	54.9	0.05	1184.02	14.03
Composition ~ Location	*32.92*	-	-	*2*	*32.93*	*0.037*	*1169.99*	*3.07*
Composition ~ 1	-	-	-	1	-	-	1166.92	0

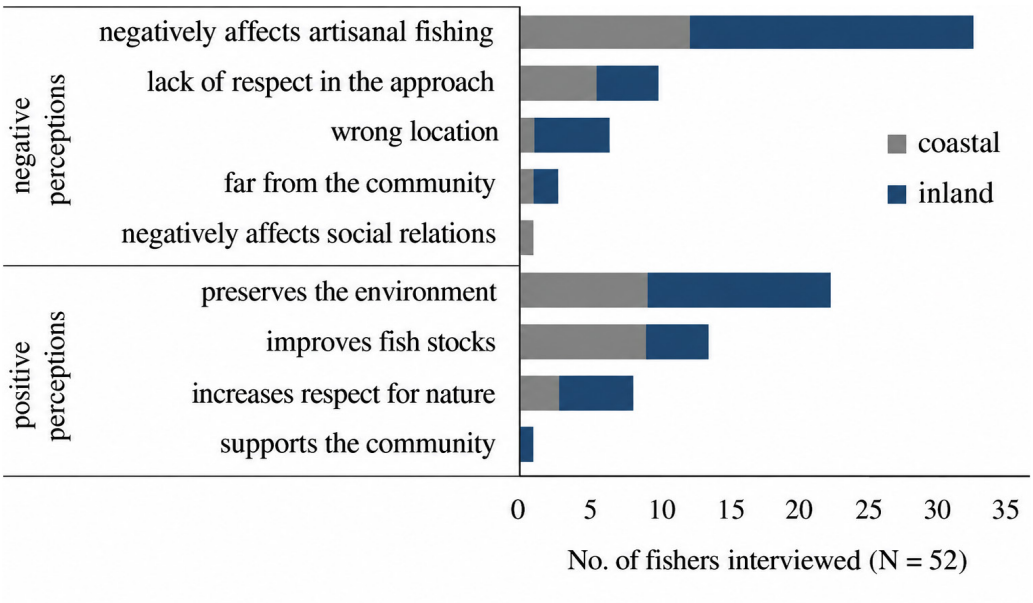


Figure 4

Positive and negative perceptions of the Carijós Ecological Station by inland and coastal fishers of the Ratones River Watershed (N = 52).

fishing by 77% of inland fishers and 50% of coastal fishers. ESEC was also identified as responsible for the decline in well-being: *Yes, (ESEC) changes things because you don't fish happily, something that makes you not feel free* (interviewee 22, 60 years old).

The worsening of pollution and siltation in the basin, which has consequences for fish stocks and the mangrove, was cited as evidence of ESEC's ineffectiveness in fulfilling its objectives. Other negative points mentioned were the design of the unit, considered mistaken for protecting the fishery resource, seen as being upstream of the ESEC area, and the distance between managers and the community: *It can't resolve the conflicts, it's distant from the community* (interviewee 10, 52 years old).

The most cited positive effects of ESEC were the preservation of the environment through the protection of the mangrove and associated fauna, and the regulation of the surrounding area to control encroachment on mangrove areas. Improved fish stocks were cited as a benefit arising from the restriction on fishing in the river, more by coastal fishers (38%) than by inland fishers (19%).

Despite the complaints, in a hypothetical scenario without ESEC, 48% of interviewees preferred the presence of ESEC due to the preservation of the area it occupies: *Despite the setbacks, if they weren't there, everything would already be gone* (interviewee 21, 52 years old). In a scenario without ESEC, the loss of contact with nature, the decrease in quality of life and air quality, the explosion of real estate development, and the loss of water quality were also mentioned. For those who preferred the absence of ESEC (36%), the main reason was the feeling of freedom: *It would be better because everyone would have freedom* (interviewee 41, 73 years old).

4. Discussion

4.1. Perception in the fishers' own voice

The fishers of the Ratones River basin recognize, through local ecological knowledge, a wide range of ecosystem services and contributions of nature, provided by different sources, linked to the broader functioning of the ecosystem, a characteristic found in communities with a history of coastal/rural subsistence in multifunctional landscapes (Sagoe et al., 2021). As in the work of Klain et al. (2014), the fishers interviewed specified the importance of the environment using metaphors distinct from those conceived by the ecosystem services concept (production of ecosystem services by nature). The methodology applied made it possible to elicit a high number of services (28), including those in the regulating and habitat categories, which may be obscured in closed, prompted, or multiple-choice formats due to the influence of the language used.

It is possible to comprehensively understand stakeholders' opinions on ecosystem services and nature's contributions to people, without this implying obscuring other ways of understanding the relationships between humans and nature (Klain et al., 2014; Jacobs et al., 2016; Díaz et al., 2018).

Cultural ecosystem services are non-material benefits obtained from ecosystems through spiritual, recreational, and aesthetic experiences (Guo et al., 2010). They are interpretive and pluralistic, specific to the geographic and environmental context and to the cultural practices that construct and enable them (Fish et al., 2016). The predominance of cultural services, or non-material contributions, is related in the literature to both urban and rural conditions. However, in urban areas, there is a predominance of cultural services and non-material contributions of nature related to aesthetic and recreational value, whereas in rural areas ecosystem services are related to an affirmative understanding of place and ways of life (Martín-López et al., 2012; Maestre-Andrés et al., 2016). In this study, we identified cultural ecosystem services related both to aesthetic and recreational value and to place and ways of life, representing the rural-urban transition experienced by these fishers.

Fishing was more related to the cultural ecosystem services of traditional way of life and well-being/inspiration than to leisure, source of income, and food services. This result expresses the identity bond between fishing and the fisher, very different from a leisure or work activity, as would be expected in a merely economic relationship with the resource. According to Klain et al. (2014), this connection is fundamental for the fisher, for their sense of self and being in the world, extrapolating a simple material benefit of food or source of income. As in the case of fishing, other authors have shown that activities valued by managers for their economic importance are often valued by users for their cultural importance (Asah et al., 2014; Outeiro et al., 2019), emphasizing the multidimensional nature

of well-being, which goes beyond financial benefit (Narayan et al., 2000; Dias et al., 2022), especially for traditional activities.

Pascual et al. (2023) highlight that the dominant ecosystem services approach is imbued with the worldview of "living from" nature, which is complementary to, but does not encompass, the approaches of living in nature and living as nature. The latter, according to the author, prioritizes incorporating and perceiving nature as a physical, mental, and spiritual part of oneself, emphasizing broad values of unity, kinship, and interdependence. Schaafsma et al. (2023) point out that such values, particularly rooted in the values and knowledge of traditional populations, are rarely recognized as legitimate and are not adequately represented by assessment methods that do not engage with traditional knowledge.

Despite the advance of urbanization, districts such as Ratones still preserve the culture of origin of fisher and farmer settlers (Fusverk, 2002). The services of social relations and sense of place, provided by the neighborhood, are closely related to the origin of the community, mostly descendants of Azorean and Madeiran immigrants (Diegues et al., 2000), and to their relationship with the environment. These characteristics are valued today by the community (Saldanha, 2013) and bring attachment and a sense of belonging to the place.

According to Ainsworth et al. (2019), some cultural benefits, such as sense of place, aesthetic pleasure, and cultural identity, are bidirectional and directly contribute to a "fulfilled human life". Strengthening the activities that sustain these cultural bonds can be seen as an action in favor of the environment, by improving positive civic behavior and significantly influencing human behavior toward ecosystems (Stedman 2002; Daniel et al., 2012).

Regulating services, resulting from ecological processes, generally have no market value, although they are highly relevant to society (Carpenter et al., 2006). These services and contributions generally go unnoticed until they are lost or disturbed (Groot et al., 2002). In this study, however, this category was the second most cited by interviewees, mainly represented by the hillside forest.

The hillside forest was related to 21 ecosystem services, the source with the highest number of services identified in this study. It was also cited as responsible for maintaining other sources, highlighting its importance to the other contributions of nature to people. Recognition of this source may relate to the community's rural past, dependent on forest resources, which results in a greater understanding of ecosystem functioning. According to Martín-López et al. (2012), local ecological knowledge is combined with regulating and cultural services related to traditional practices, mainly perceived in multifunctional land-use areas, typical of rural environments. This author emphasizes the importance of maintaining traditional practices, reconciling them with nature conservation proposals, to ensure the

continuity of the provision of various ecosystem services linked to local ecological knowledge.

Supporting services, or regulating contributions, are fundamental to natural ecosystems and the basis for the other types of services (MEA, 2005). This category, the third most cited, was led by the habitat provision service, which corresponded to 64% of the total citations in this category. This service, recognized by almost all fishers, was mainly characterized by its function as a nursery habitat for ichthyofauna in the estuarine environment, perceived in the sources mangrove, Ratones River, and ESEC Carijós. Although fundamental, supporting services generally go unnoticed (Raymond et al., 2009); however, in fishing communities, the habitat function for ichthyofauna is frequently observed (Martins et al., 2014; Cárcamo et al., 2014; Juan et al., 2017), as it is related to the resource of interest to fishers. According to Fisher et al. (2009), benefits of interest influence the perception of ecosystem services. The presence of ESEC Carijós may also influence this result, since the habitat function for ichthyofauna is one of the objectives of its creation, a recurring theme of environmental education programs previously carried out in the neighborhood (Instituto Chico Mendes de Conservação da Biodiversidade [ICMBio], 2010). According to Maestre-Andrés et al. (2016), residents near protected areas tend to value ecosystem services linked to biodiversity, demonstrating the importance of these areas for the perception of ecosystem benefits. According to Ghorbanzadeh and Björkqvist (2019), ecosystem functions are transformed into services when people perceive their values and benefits.

Contrary to what we expected, the category of provisioning ecosystem services, or material contributions, was the least cited. This category was mainly represented by the food ecosystem service, the second most cited service overall, related to fishing activity. Despite its low frequency, this category is no less important to the community, as the provision of these services contributed to the formation and sustenance of the community, of agricultural/fishing origin. The urbanization process certainly influenced this result, through the reduced dependence on the neighborhood's provisioning services, and increased environmental restrictions.

It is important to note that the study did not aim to establish weights that would reflect the hierarchy of importance of the perceived services or contributions of nature. The results on perceptions of ecosystem services cannot be generalized or extrapolated beyond the scope of the research. The benefits and values of each interviewee may be subjective, as may the categorization of these perceptions (Klain et al., 2014; Oliveira & Berkes, 2014). Social preferences for ecosystem services are context-dependent and vary among interviewees due to individual needs, cultural traditions, access to services, sources of income, among others (Martín-López et al., 2012; Díaz et al., 2018).

4.2. Perception and individual characteristics

Among the individual characteristics, only place of residence (inland and coastal) had a significant influence on the perception of three ecosystem services: traditional way of life, habitat provision, and aesthetic value. In addition to the difference in access to the sea between these localities, the influence of ESEC and the landscape also differ. More than half of coastal fishers still depend exclusively on fishing to survive. These fishers perceive more of the traditional way of life and habitat provision services, both related to fishing activity. In contrast, inland fishers have faced various difficulties over time in carrying out fishing, such as interventions in the Ratones River Basin (Instituto Carijós & IBAMA, 2008) and the restrictions arising from the creation of the Carijós Ecological Station (ESEC). In the first years after its establishment, access to the area was severely limited. Currently, although physical access is now permitted, the prohibition on fishing within the unit's boundaries persists. According to Araújo (2017), the prohibitions imposed by ESEC cause the fisher to lose their connection and awareness, no longer seeing themselves as involved with the activity and as part of that environment, altering their way of living in that space and deconstructing their former culture.

Access to the sea for the inland neighborhoods occurs mainly through the Ratones and Veríssimo rivers, both of which are silted up and too shallow for navigation. The few fishers who still have fishing as their main activity keep their boats outside the neighborhood where they live, on nearby beaches. These factors have contributed to the decline of fishing as the main source of income in these localities. The lower perception of the traditional way of life and habitat provision services, combined with the greater perception of the aesthetic value service by these fishers, may reflect a distancing from traditional activities and a trend toward a more urban perception, without dependence on the fishery resource. Also, the greater perception of the aesthetic value service by inland fishers may be related to the still-preserved area of the interior of this basin, which retains important remnants of native forest and mangrove areas. A large part of this mangrove is preserved by ESEC Carijós. Only inland fishers related the sources mangrove, ESEC Carijós, and neighborhood to this service. This means that ESEC Carijós influences the greater perception of this service through the preservation of the area. Similarly, ESEC Carijós appears to exert an antagonistic influence on the provision of the traditional way of life ecosystem service: it is perceived negatively due to the restriction on resource use for inland fishers, and positively due to the improvement in fish provisioning for coastal fishers.

4.3. Effect of ESEC Carijós

The small number of citations of ESEC Carijós as a source of ecosystem services contrasts with the importance interviewees attributed to the man-

grove, which is almost entirely within the unit (IBAMA, 2003). ESEC Carijós protects a large part of the mangrove, a provider of services and contributions of nature perceived by interviewees. This highlights the weak connection, for interviewees, between the mangrove's contributions and ESEC Carijós's role in maintaining these services and contributions. A similar result was found in a study on the perception of environmental quality of Florianópolis's mangroves, including ESEC Carijós. In that study, interviewees did not distinguish differences between mangroves protected or not by conservation units (Brasil, 2017). This does not mean that conservation units do not contribute to the conservation of these areas, but that this improvement in conservation is not perceived by users.

ESEC Carijós concentrates its activities on enforcement, with little investment in environmental education programs and communication with the community, which negatively affects its effectiveness (ICMBio, 2010). The focus on use restriction increases resistance to accepting the benefits of protected areas (Stoll-Kleemann, 2001; Outeiro et al., 2019) and has contributed to the feeling of loss of territory and freedom, frequently reported in the interviews. The negative perception of ESEC Carijós as a vector for worsening fishing, reported by most interviewees, impacts several ecosystem services associated with this source, especially the cultural ecosystem services inherent to the condition of artisanal fisher. Similarly, Outeiro et al. (2019) identified cultural impacts associated with the impossibility of accessing some parts of the Fernando de Noronha MPA, resulting in loss of sense of place, cultural heritage, and identity. These authors point out that the erosion of cultural services can also contribute to the loss of social cohesion (Outeiro et al., 2019).

The inland community, more affected by the restriction on resource use in the estuary, perceives more of the negative effects of ESEC Carijós on artisanal fishing and on the location of the unit. The coastal community perceives the improvement in fish stocks more than the inland community, as it is directly benefited by the protection of this resource, caught in the adjacent bay. Both recognize the environmental preservation effect of ESEC Carijós's presence.

Historically, the creation of protected areas in Brazil did not consider the traditional forms of natural resource use by local populations, nor the social and economic impacts resulting from the creation of these areas (Furlan, 2004). The same occurred with ESEC Carijós (Saldanha, 2013; Abrahão & Asmus, 2018), especially in relation to the local community of artisanal fishers, direct users of the basin's resources. Figueirôa (2017) points out the lack of valid methodology and justification for choosing the restrictive category of this conservation unit, as with many others in Brazil. As a result, different types and classes of ecosystem services are prioritized, but do not always meet the demands of the local community, which negatively affects empathy for conservation proposals (Jacobs et

al., 2016; Blythe et al., 2020) and contributes to the low effectiveness of Brazilian protected areas (Figueirôa, 2017).

This historical legacy is reflected in the management of protected areas, which still marginalizes local communities and intensifies conflicts in marine-coastal areas. Dias et al. (2022) highlight that improving governance and better understanding the interconnections between people and nature is essential to reduce the risks of cultural loss and increase the effectiveness of conservation strategies.

Conservation policies that focus on biodiversity alone capture only a fraction of ecosystem service values and minimize other values, in addition to excluding local populations (Barton et al., 2022). Despite the recognition by interviewees of the benefits provided by ESEC Carijós, excessive enforcement, the lack of dialogue with the community (Abrahão & Asmus, 2018), and the approach taken in enforcement actions with fishers undermine acceptance of the unit and its effectiveness beyond its boundaries.

5. Conclusion

Our results confirm the hypothesis of a greater perception of cultural services or non-material contributions of nature, linked to the locality's rural past, mainly through the neighborhood and fishing sources. ESEC Carijós was the source with the lowest number and frequency of related services or contributions, despite harboring and protecting a large part of the mangrove and the Ratones River, which are fundamental to the well-being and maintenance of the community's way of life. For most interviewees, ESEC Carijós is not seen as a provider of the ecosystem services of the sources it encompasses. This invisibility is due, in part, to inefficient communication between ESEC Carijós management and the local community and to the lack of spaces and incentives for these actors to participate in and take ownership of management spaces.

Considering the studied basin as a socioecological system, due to the evident influence of human use on the site, ecosystem-based management could bring more benefits if incorporated into ESEC Carijós's Management Plan. This type of management takes human beings into account in its analysis, provides for the participation of multiple stakeholders in defining objectives, and is inherently adaptable to deal with change. There is no single formula, as the local context defines the management approach. Incorporating cultural values into management is a good way to bring the unit's management closer to the local community and expand the scale of conservation beyond its boundaries. It is worth discussing how this full-protection conservation unit, with a highly productive ecosystem, can enhance the conservation of the entire basin. Changing the unit's category to allow more flexible use may be an alternative (Figueirôa, 2017), from the perspective that biodiversity produces benefits, contributions, and returns

that can be leveraged for social benefit, reducing pressure on the resources themselves.

Sociocultural values directly influence well-being and, consequently, decisions and actions related to resources. By maintaining and strengthening people's connection with the environment, we can motivate the conservation of natural resources through a sense of responsibility and care for nature. In this sense, local ecological knowledge, linked to artisanal fishing, is a potential ally for conservation, but it needs to move beyond its current marginal condition. We hope that this study contributes to this change.

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