Research

Uncovering well-being ecosystem services bundles (WEBs) under conditions of social-ecological change in Brazil

Ana Carolina Esteves Dias [1,2], _Derek Armitage_ [1,2] and _Andrew J. Trant_ [1]

ABSTRACT. This research examines the interplay of a 3-dimensional well-being approach of coastal communities and the ecosystem services upon which they depend, and the implications for marine protected area (MPA) governance. We use the concept of well-being ecosystem services bundles (WEBs) to refer to the links among ecosystem services and social well-being as experienced by fishing communities adjacent to MPAs. This research combines data from surveys with households (n=59) and three participatory workshops (total participation n=48). We supplement results using insights from a photovoice process with community members (n=15) and participant observation (September 2018-April 2019). We identify key WEBs, social-ecological changes, and their trade-offs and synergies in three coastal communities on the southeast coast of Brazil. In doing so, we examine core WEBs relevant to coastal communities, and the drivers of change that influence these WEBs (e.g., increased tourism, deforestation) and show their dynamism and complexity. Further, we develop a typology to reflect how individuals perceive or experience the interplay among components of WEBs, or the "pathways of interaction" that connect their well-being to ecosystem services. Results reveal three key opportunities for improving MPA governance. First, we show that WEBs play a key role in perceptions of physical and public safety experienced in coastal communities, an insight that is especially relevant to the global south and developing countries due to the inequity-related security issues. Second, trade-offs in tourism are a major area for governance interventions to improve fit to the local context, such as enhancing the well-being of locals as it is shaping local livelihoods, culture, and social relations. Third, we develop a typology that highlights overlooked experiential, observational, and visual contributions of WEBs to well-being that have the potential to reinforce conservation values and stewardship actions in communities affected by MPAs.

Key Words: *coastal governance; community; marine protected areas; marine conservation; small-scale fisheries*

INTRODUCTION

In the context of marine protected areas (MPAs), environmental uncertainty and rapid change require flexible, collaborative, and dynamic governance approaches (Villagra 2019), as well as a better understanding of human–nature connections. The ecosystem services scholarship has made relevant theoretical progress in this regard; however, there remains limited empirical analysis on the specific linkages among coastal community well-being and ecosystem services (Blythe et al. 2020). Moreover, existing cases lack geographical diversity, especially in the global south (with a few exceptions, e.g., Chaigne et al. 2019, Daw et al. 2011), and few insights on how a better understanding of ecosystem services-well-being linkages can inform governance of coastal systems under conditions of change and uncertainty (Boyd and Banzhaf 2007, Fisher et al. 2009, Lele et al. 2013, Pascual et al. 2017). Additionally, coastal ecosystem services include both marine and terrestrial components, and nuanced understanding of how coastal ecosystems are relevant to coastal communities in a disaggregated manner is needed for better decision-making outcomes (Lau et al. 2019).

We responded to these gaps by expanding on existing frameworks that link perspectives on social well-being (Gough and McGregor 2007, White 2010) and ecosystem services (Reyers et al. 2013, Bennett et al. 2009). Specifically, we develop and apply a well-being ecosystem services bundles (WEBs) framework to untangle the linkages among coastal ecosystem services and traditional fishing communities in the southeast coast of Brazil, which are located adjacent to an MPA. Three objectives guide this research: (1) to identify key WEBs, social-ecological changes, and their trade-offs and synergies; (2) to examine the core WEBs relevant to three coastal communities on the southeast coast of Brazil, and the specific drivers of change that influence these WEBs (e.g., increased tourism, deforestation); and (3) to develop a typology that reflects how individuals perceive or experience the interplay among components of WEBs, or the "pathways of interaction" that connect their well-being to ecosystem services. In particular, this typology helps to reveal how individuals perceive or experience the interplay of components of WEBs, and the manner in which they are oriented around experiential, extractive, visual, and observational dimensions. Insights from this typology further point to the material and non-material complexity and dynamism of human–nature relationships (Lele et al. 2013, Pascual et al. 2017), contribute to ongoing debates within the ecosystem services discourse (Boyd and Banzhaf 2007, Fisher et al. 2009), and therefore, provide insights into how to improve governance of MPAs in Brazil.

Conceptual framework

The WEBs framework we develop and apply here links the literature of social well-being (Gough and McGregor 2007, White 2010) and ecosystem services bundles (Reyers et al. 2013, Bennett et al. 2009) (Fig. 1). Social well-being is "... a state of being with others, which arises where human needs are met, where one can act meaningfully to pursue one's goals, and where one can enjoy a satisfactory quality of life" (McGregor 2008). It includes material (i.e., practical welfare and standards of living), relational (i.e., personal and social relations), and subjective (i.e., values, perceptions, and experiences) dimensions pursued throughout one's life (Gough and McGregor 2007, White 2010, Coulthard et

[1]School of Environment, Resources and Sustainability, Faculty of Environment, University of Waterloo, [2]Environmental Change and Governance Group, University of Waterloo

al. 2011). Ecosystem services are the benefits, contributions, and occasional detriments that humans experience with nature (MA 2005, Pascual et al. 2017). These gains can be economic such as raw materials (e.g., fish and timber), non-economic, including ecosystem functions (e.g., nutrient cycling), biophysical features (e.g., shelter within coral reefs), and human activities in nature (e.g., fishing, wildlife watching) (Hattam et al. 2015). Detriments include natural diseases and disasters such as floods (Pascual et al. 2017). Our use of the term "bundles" refers to the strong dependency of well-being to a specific set of ecosystem services (Leviston et al. 2018), as well as the dependence of the conservation of ecosystem services based on their contributions to people's values and well-being as an iterative process. We define WEBs as the set of ecosystem services tightly associated with improvements in social well-being of a given community (Daw et al. 2011, Chan et al. 2019).

Fig. 1. Theoretical representation of WEBs as a two-way process, including subset of well-being (e.g., livelihoods) receiving income and food from two ecosystem services: (i) fishing, derived from marine and freshwater fish stocks; and (ii) household agriculture influenced by soil fertility in the Atlantic Forest of Brazil. The arrow below represents opportunities for the ecosystems to gain from the linkages with well-being to foster stewardship actions, motivation for conservation, and improve governance fit of coastal ecosystems.
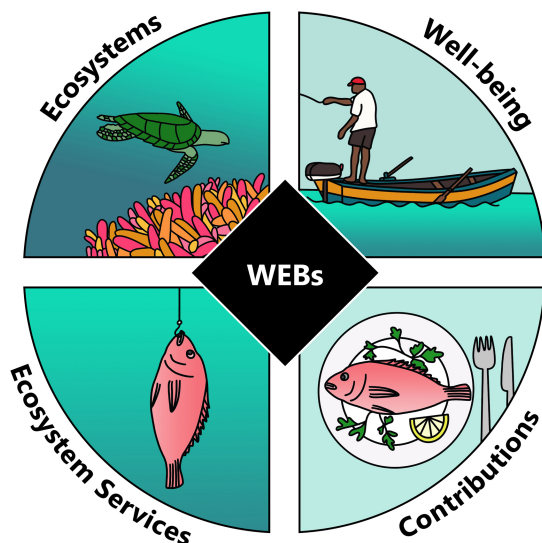
While other ecosystem services and well-being frameworks exist, the WEBs framework provides the identification of the dynamic flows between and among dimensions of ecosystem services and well-being. Masterson et al. (2019) take a similar approach in which ecosystem services provide well-being to people through a well-being basket, mediated by institutions. We expand on the Masterson et al. (2019) conceptual model of feedback between ecosystems services and well-being and provide further insights

by developing a WEBs typology. On the other hand, Hamann et al. (2016) take a different approach to combine different well-being indexes and types of ecosystem services in the same location to identify social-ecological dynamics. For instance, the authors identified that higher levels of education and income are associated with lower levels of direct use of ecosystem services. In our research, the WEBs framework helps to identify the dimensions of well-being reported as directly benefiting from a set of coastal ecosystem services. Figure 1 provides a conceptual example of bundles that acknowledges the interdependencies among different types of ecosystem services and dimensions of social well-being.

In Figure 1, a subset of material well-being (e.g., livelihoods), provides two major contributions (a source of income and food) from ecosystem services (e.g., fishing and household agriculture). Ecosystem services are derived from ecosystem functions and biodiversity. Fisheries, for instance, are only possible due to fish stocks sustained by marine and freshwater ecosystems (e.g., riverine systems). Agriculture, in turn, is highly dependent on the properties of the soil in the area. Benefits to well-being - if perceived by locals as such - are an opportunity to foster stewardship actions, conservation strategies, and incentives to enhance governance of both social and ecological dimensions. The WEBs framework can be used to guide the development of disaggregated information on subsets of well-being (material, relational, and subjective), and the way well-being contributions are derived from specific ecosystem services. These insights are crucial for MPA governance because they help to understand how people value, and depend upon, coastal ecosystems, and therefore, can be used to guide more appropriate governance decisions that fit the local social norms and behaviors concerning nature. If well governed (i.e., addressing both socioeconomic and biophysical considerations within a wider context), MPAs are considered a relevant tool for conservation (Kelleher 1999, Wood et al. 2008). As such, greater attention to the governance of MPAs has been identified as a pressing need globally and in Brazil, helping to pursue the post-2020 global biodiversity framework.

Study site context
Three *Caiçara* communities (i.e., traditional fishing communities with mixed heritage) participated in this research initiative: Almada, Picinguaba, and Puruba, which are all located in the southeast coast of Brazil, in Ubatuba municipality in the state of São Paulo. These communities have similar cultural, historic, and economic backgrounds (Begossi 2006) as well as identities. For this reason, they compose a case study, rather than areas to be compared. By exploring three communities in a similar region and with similar cultural and livelihood backgrounds, we were able to provide a broader understanding of WEBs, with a focus on coastal communities adjacent to MPAs. Locals identify themselves as *Caiçaras*, which refers to a traditional group of descendants from Indigenous Peoples and immigrants from Europe and Africa, whose livelihoods are historically based on small-scale fisheries, agriculture, and limited hunting (Diegues et al. 2000). These communities have a strong connection to their terrestrial and marine territories (e.g., fishing grounds) and have developed a detailed knowledge of the local environment and species across generations (Silvano and Begossi 2012). Currently, hunting is prohibited and, in many cases, restrictions to fishing and agriculture are applied, especially within MPAs. These

Table 1. Key features of the selected communities to participate in this study.

Summary	Almada	Picinguaba	Puruba
Population (Census, IBGE[†] 2010)	173 inhabitants 146 households (36.6% permanent)	318 inhabitants 94 households	109 inhabitants 50 households
Population (local health centers 2018)	65 local families	240 families	35 local families
Location in relation to PA	One beach and part of mountain areas inside a state park, marine area inside an MPA[‡]	Two beaches and surrounding islands, part of the village and the surrounding mountain chain inside a state park, marine area inside an MPA	Part of mountain areas inside a state park, marine area inside an MPA
Key livelihoods	Fisheries and tourism	Fisheries and tourism	Fisheries and services

[†]Instituto Brasileiro de Geografia e Estatística , [‡]Marine Protected Area

restrictions require new sources of livelihoods, including tourism, which is playing an increasing relevance locally.

The state of São Paulo has 622 km of coastline, corresponding to 8.5% of the Brazilian coast (Zembruski 1979). This area is characterized by mountain ranges that extend parallel to the sea combined with narrow coastal plains with human occupation. Due to the mountainous terrain, there was limited access to these communities until the construction of a national highway (BR-101) in the 1970s. At the same time as the highway construction, protected areas were established in the territory, with Ubatuba containing the most preserved fragments of the Atlantic rainforest in the country and the highest diversity of coral species in the region (Amaral et al. 2018). Given the several marine and terrestrial biodiversity hotspots, Ubatuba region represents a high conservation priority status.

The Ubatuba region supports a mosaic of no-take and sustainable-use protected areas, with the purpose to preserve land, freshwater, and marine ecosystems. The marine area of the three communities we have studied is part of the Marine Environmentally Protected Area of the North Coast (APA-LN), a sustainable-use (i.e., less restrictive) area. Currently, managers of the APA-LN are in communication with stakeholders to develop a zoning plan of marine uses and regulations. Two other no-take protected areas include portions of the communities, encompassing both terrestrial and marine ecosystems: the Serra do Mar State Park and Serra da Bocaina National Park. All three protected areas were implemented after the settlement of *Caiçara* communities in Ubatuba. Restrictions on fisheries, use of forest resources, and weak communication with resource users are creating conflicts locally (Dias and Seixas 2019).

The southeast coast of Brazil experienced accelerated population growth and tourism activity in the last few decades (EMPLASA 2016). This region is part of the São Paulo macro-metropolis, one of the greatest worldwide, that corresponds to an area of 50,000 km² and a population of approximately 30.5 million (close to the entire Canadian population; EMPLASA 2016). This mix of urbanized and preserved areas is home to many small (300-1500 inhabitants) traditional communities that have inhabited the area for centuries, and that still preserve a diversity of cultural backgrounds and less "globalized" lifestyles, as discussed throughout this paper. Table 1 summarizes the three communities examined.

METHODS

The research combines three different methods to generate individual and collective perceptions of the linkages among ecosystem services and well-being, as well as social-ecological changes affecting them. Data are derived from surveys with households (n=59), supplemented by data from a photovoice process (n=15) and three participatory workshops (total participation n=48). We used a snowball sampling to select participants, accounting for *Caiçara* households who develop daily life activities related to coastal ecosystems (e.g., fishers, boatmen, restaurant owners, other tourism-related businesses, or other fishers' family members). To expand on subjective insights from the surveys, results were supplemented by photovoice (Dias and Armitage 2021) with community members (n=15) and participant observation in the field (Dias 2020). We used a World Café method suitable for qualitative insights (Fouché and Light 2011) to guide the workshops and included a graphic facilitation component (i.e., a visual representation of the discussion). The procedures for each method are described below. The group setting provided insightful information on WEBs, but we acknowledge the challenges in discussing subjective dimensions of well-being. We acknowledge that people may feel inhibited to contribute in a public setting if they consider this a sensitive personal topic. For that reason, individual surveys and photovoice were important methods to generate information on subjective dimensions of well-being.

Survey

The survey sample is representative of the number of households in the communities and provides information about ecosystem services that support the well-being of local community members. Specifically, the survey collected individual perceptions of key WEBs and social-ecological changes affecting them. We surveyed informants of the coastal communities, identified by snowball sampling (Biernacki and Waldorf 1981). To conduct the snowball sampling, we asked community members to identify the families who most rely on direct use of natural resources to sustain their livelihoods and would be willing to participate in the research. We stopped asking for potential participants when families and individuals started to be repeatedly referenced. This sampling method was appropriate in the context of this research, as communities are quite small, and we prioritized local knowledge from insiders to select relevant participants (Biernacki and Waldorf 1981). We contacted each of the identified families asking for their interest and consent to participate, and aimed for a balance between male and female respondents. We then

conducted a pilot survey with approximately 10% of the potential respondents (n=6/59) to assess whether any adaptations to the survey should be made. After reviewing the pilot interviews, we made minor adaptations to the probing questions and surveyed the remaining participants (18% of households, n=59/330).

Photovoice
Photovoice is a qualitative method based on photographs and a narrative of their components. Photovoice helps to reveal subjective feelings and emotions, and provides more in-depth information about the subjective and relational dimensions of well-being being supported by ecosystem services. As part of a photovoice initiative, we selected participants from the participatory workshops and asked them to select three photographs that represent their daily life in the community and in relation to different types of coastal ecosystems (e.g., sand beaches, Atlantic Forest, mangroves). We subsequently conducted individual semi-structured interviews with each participant, so that participants could further explain the meaning of the images in relation to the links between ecosystem services and their well-being and express their subjective feelings and emotions through a narrative about the photographs. The qualitative insights from these semi-structured interviews were combined with the insights from the surveys and workshops to generate a more comprehensive assessment of WEBs at the individual and community scale (details in Dias and Armitage 2021).
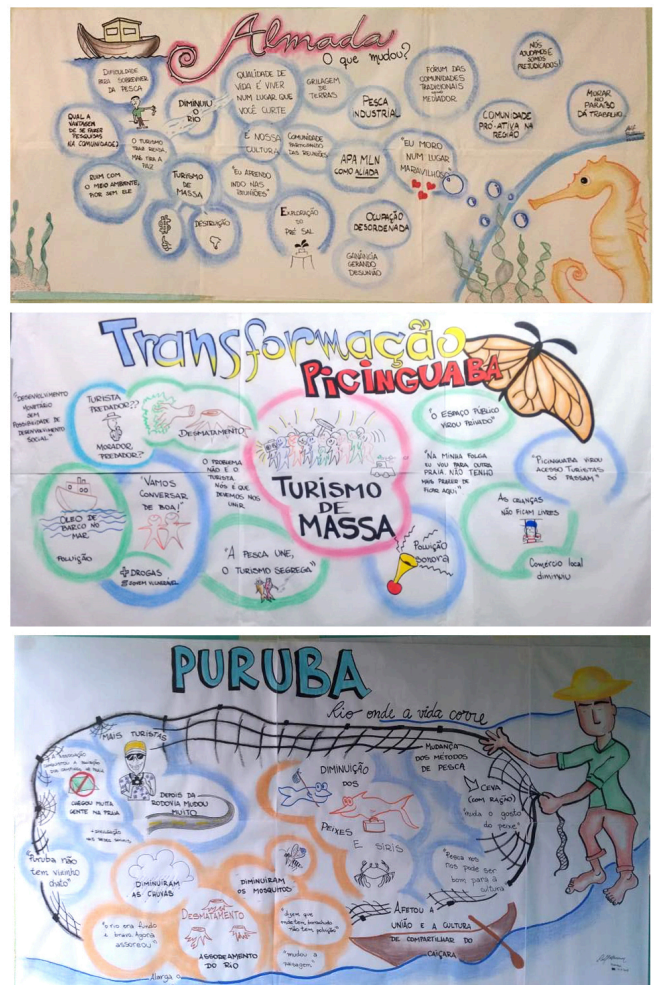
Participatory workshops
Participatory (facilitated) workshops were undertaken to understand how individuals in the communities perceived the ecosystem service and well-being linkages, and how social-ecological changes affect the dynamic between ecosystem services and well-being. The three workshops were guided by the World Café method (Fouché and Light 2011) and aimed to gather data while also giving back to the community. The goals of the workshops were: (i) to understand how social-ecological changes influence social well-being in the community (individual and collective); (ii) to generate systematic and perceptual data to inform MPA decision-making in the face of social-ecological changes; and (iii) to fulfill a local demand specific to each community. These demands were identified during the field activities by discussing with community members ways that this research could support local actions related to coastal governance. At Picinguaba, participants suggested inviting other communities to participate in the workshop and allow for a space to exchange experiences with respect to community-MPA challenges. At Puruba, locals helped to organize an exhibition of Indigenous material found in the local river with the purpose of cultural appreciation. At Almada, no specific request was suggested by participants. All material generated in the workshop was made available to the communities in two different formats: a final report with systematized discussions and a graphic representation of the discussion (Fig. 2).

The World Café process for the workshops was chosen due to its potential to stimulate discussion and co-creation of ideas within a group regarding an established theme, in this case, ecosystem and social changes taking place in each community. World Café is a flexible method that can be tailored to the number, nature, and interest of participants (Fouché and Light 2011). The World

Café method follows seven guiding principles: work within the scope of the meeting; enable discussion; conduct a focused discussion; encourage contributions of all people; welcome the diversity of perspectives and opinions in the co-creation process; exercise active listening; and materialize the knowledge generated (Brown and Isaacs 2005). This was particularly useful for this research because it helped bring together a diversity of perspectives on social-ecological changes.

Fig. 2. Key social-ecological changes and implications to Almada (above), Picinguaba (middle), and Puruba (below). Credits to Rulf Bateman.

To be representative of the community, the invitation to the workshop was open to all community members and focused on four main questions. Overall, the workshops involved 48 participants, with 22 from Puruba (9 female and 13 male), 20 from Picinguaba (9 female and 11 male), and 6 from Almada (2 female and 4 male). Participants ranged from elderly fishers in the communities with relevant knowledge on marine resources and local cycles, to young adults concerned about their future livelihood options. Participants were asked to collectively answer the following questions: 1) What were the main changes you have

Table 2. Ecosystem services provided by coastal areas based on their multiple benefits.

MA (2005) category	Ecosystem services	Explanation based on participants' description
Provisioning	Canoe	Service co-produced by humans through wood carving and local knowledge.
Provisioning	Household agriculture	Service co-produced by humans through the manipulation of the land, based on soil fertility and local knowledge.
Provisioning	Hunting	Service co-produced by humans through the extraction of small and medium mammals and local knowledge.
Provisioning	Small-scale fisheries	Service co-produced by humans through the extraction of fishing resources (based on fish stocks) and local knowledge.
Provisioning, cultural	Native vegetation itself and as part of the landscape	Providing of raw material (e.g., medicinal plants) and service co-produced by humans based on individual aspirations and visual and experiential preferences.
Regulating	River basin dynamic	Freshwater resources and ecosystems providing habitat for fishing stocks, water resources and related to erosion and land stability processes.
Supporting	Beach areas	Areas used by locals to perform different type of activities (e.g., relaxing, meeting others, working, etc)
Supporting	Mountain chain protection	Mountainous formation surrounding the community restricting access, providing protection against the wind, as well as susceptible to landslides.
Cultural	Contemplation of nature	Service co-produced by humans based on individual aspirations and visual and experiential preferences.
Cultural	Tourism	Service co-produced by humans by exploring coastal ecosystems through local knowledge and interpersonal skills.

seen happening on the beach and sea of the community?; 2) Among the changes that have taken place over the past five years, which one most affects the life of the community?; 3) How specifically does this change affect the life of the community?; and 4) How does this change affect your life individually? We arranged tables with a large paper sheet and colored pens and invited participants to sit randomly around the tables. All participants were invited to express themselves freely (e.g., including drawings, scribbles, words) on the paper sheet, in addition to verbal communication with others in the same group. For each table, we designated a host responsible for systematically recording the discussion. Hosts were chosen according to the following criteria: a participant who has experience attending events such as this; has experience summarizing oral information in written records; and has a good relationship with other participants. After each question, each table presented a summary of the discussion in plenary. During the discussion, the facilitators collected quotes from participants and sent these to the graphic facilitator, who was concurrently drawing the discussion in a panel.

Data analysis
Our data analysis is based on content analysis of workshop outcomes, surveys, and photovoice, in which we categorize WEBs based on our framework. In the categorization process, we added a new category that emerged from data, or "pathways of interaction." These pathways emerged as a way to explain the benefit flow between ecosystem services and dimensions of well-being, and the mechanisms through which those benefits flow.
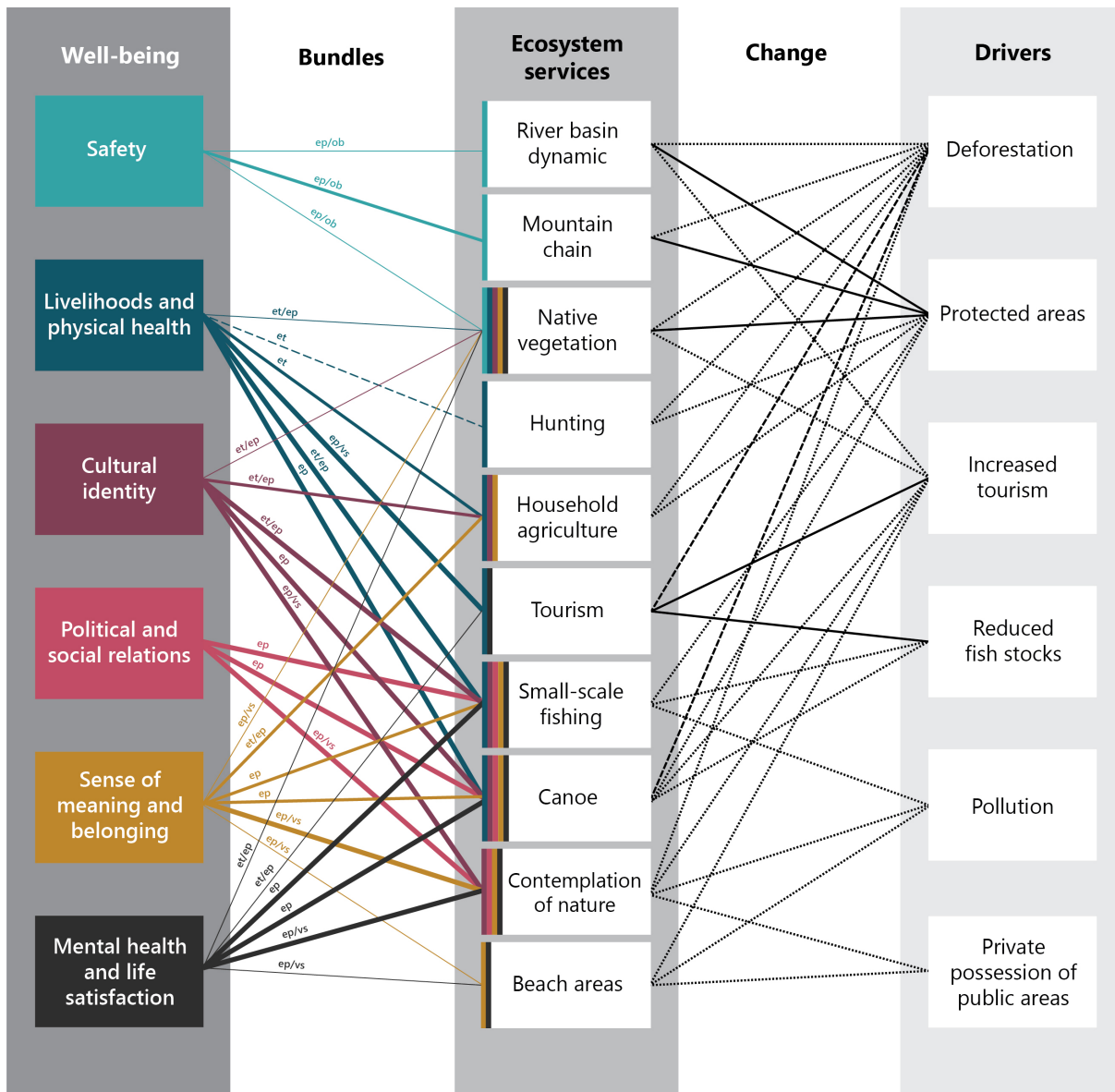
We used N-Vivo software (QSR International, version 12, 2018) to identify the relationship between ecosystem services and well-being using the survey, photovoice, and workshop datasets. First, to identify WEBs, we asked survey respondents about their main and secondary economic activities, activities they perform in relation to nature and with other people in the community, as well as insights and perceptions that emerge during these activities. We coded their answers according to four major themes that emerged

from the surveys based on ecosystem types and formations; specific ecosystem services (Table 2); facets of social well-being in a manner consistent with the conceptual framework (Table 3); and the 'pathways of interaction' that link their well-being with ecosystem services. The same process was undertaken with the photovoice data (photos and narratives). Then, we quantified the strength of the links between ecosystem services and facets of well-being according to the number of mentions or references by participants (Fig. 3).

The pathways of interaction are a key insight of our paper that emerged from direct participant insights detailing the manner in which people experienced the linkages. For example, data from the survey and photovoice points out benefits from extracting fishing resources as the main source of food and income. This type of benefit was classified as an "extractive pathway" as it comes from the extraction of a resource. Benefits derived from one's experience in being in nature and performing a specific activity (e.g., canoeing) are classified as an "experiential pathway." Benefits coming from observation of cycles of nature, for example, related to local knowledge of fishing stocks and reproductive cycles, is classified as an "observational pathway." Finally, benefits generated visually, for instance, related to the aesthetic value of nature, perceived through one's vision, were categorized as a "visual pathway."

Analysis of workshops happened partially with participants, who identified and prioritized relevant social-ecological changes. This process helped to identify their perception of the key changes affecting the interplay in WEBs. After a brainstorming session on key social-ecological changes, participants prioritized the changes that most affected their lives. A ranking and points system was developed in which participants distributed up to five points toward the most relevant changes identified by the group process. All five points could be attributed to the same change or distributed according to their perception of relevance. During the plenary sessions, we debriefed data together and decided collectively on what were the most relevant influences of these

Fig. 3. Coastal wellbeing-ecosystem services bundles (WEBs). The width of the lines connecting well-being to ecosystem services refers to the number of citations in the surveys, ranging from 1-15 (thin), 16-30 (medium), and 31-45 (thick). The dashed line between livelihoods and hunting refers to ecosystem services relevant in the past, but not present anymore. OB, EP, ET, and VS corresponds to the pathway of contributions of ecosystem services to well-being, observational, experiential, extractive, and visual, respectively. Gray ecosystem services correspond to services co-produced by humans, whereas white ecosystem services are services directly provided by an ecosystem feature, function, or component. Green, red, and blue connections between ecosystem services and changes refers to positive, negative, and trade-offs between positive and negative influence of changes in the ecosystem services.

changes to participants well-being. As an outcome, we had a summary of each discussion group and a graphic representation of the discussion (Fig. 2). As noted above, these two sources of data were also coded using N-Vivo software (QSR International, version 12, 2018) based on the changes being described (e.g., increase of tourism, water pollution, decrease of fish stocks) and the implications for community and individual well-being (e.g., changes in eating habits, increase of local disturbance).

RESULTS
Survey results highlighted core WEBs involving six dimensions of well-being supported by 10 ecosystem services derived from five coastal ecosystems. In this section, we present these core WEBs and how social-ecological changes in coastal areas are shaping them. Figure 3 summarizes the connection among dimensions of well-being and ecosystem services derived from different coastal ecosystems and, in some cases, co-produced by

Table 3. Dimensions and subdimensions of well-being, based on the concept of social well-being by White (2010).

Well-being dimension	Well-being subdimension	Explanation
Material well-being	Safety	Refers to physical safety provided by environmental conditions, such as protection against erosion, and being in place with little violence.
	Livelihoods and physical health	Livelihoods refer to means of living and securing nutrition and income in a household. Physical health refers to the possibility to pursue healthy habits including nutrition, active lifestyle, and means for dealing with disease and physical discomfort derived from nature.
Relational well-being	Political and social relations	Refers to conditions and activities enabling relations of love and care, networks of support and obligation, and arenas for discussion political issues, local and traditional rights, and other relevant topics allowing for *Caiçara* livelihoods, local lifestyles, and cultural reproduction.
	Cultural identity	Activities and conditions allowing for cultural reproduction, knowledge transmission, maintenance and transmission of traditions.
Subjective well-being	Sense of meaning and belonging	Values, perceptions, and experiences that give someone a sense of belonging to a community and sense of meaning beyond oneself. Can in some cases be related to the connection to the sacred and to nature.
	Mental health and life satisfaction	Refers to the enjoyment of life and good mental state derived from interactions with nature.

humans. The number of citations of each connection is represented in Figure 3 by the thickness of the line linking well-being dimensions to each ecosystem service. Notably, many other permutations between ecosystem services and well-being dimensions are possible. However, we highlight these WEBs as they were the most mentioned in the surveys and highlighted by participants as core connections at the time we conducted this research. Moreover, we further identify how the flow between ecosystem services and well-being happens, what we call pathways for interaction. We develop a typology of these pathways, as a relevant way for decision-makers to understand well-being ecosystem services connections when planning management interventions. In the next section, we present relevant WEBs and changes affecting them, followed by a section dedicated to explaining the typology of the pathways of interaction.

Well-being ecosystem services bundles in *Caiçara* communities
Among the WEBs identified, several emerged as particularly novel and relevant for policy-making. The key WEBs identified include (i) safety dimension of well-being supported by mountainous formation of the landscape and vegetation, (ii) relational dimensions of well-being synergically supported by small-scale fisheries, canoes, and beach areas, (iii) subjective dimensions of well-being supported by aesthetic values of the landscape and ecosystem services that also enhance relational and material dimensions of well-being. These critical WEBs for *Caiçara* people are being influenced by core social-ecological changes. The workshops revealed six key drivers of change influencing WEBs, including increased tourism, the implementation of MPAs, deforestation processes resulting in soil erosion, and reduced fish stocks, accounting for their trade-offs, i.e., benefits and detriments to different dimensions of well-being. These results are explained in more detail below and illustrated by quotes from participants.

First, the relationship between safety and landscape was a novel WEB that stood out from our results (Fig. 3). Safety is mostly associated with inland ecosystems and features of the landscape that regulate erosion, and that also restrict human access to the communities (e.g., limited road and trail access). First, we found that safety is defined by participants as environmental features and conditions that (i) prevent degradation of community areas,

such as protection against erosion of mountains and river edges, and (ii) provide an ambience with low levels of violence. Accordingly, community members observe coastal formations as providing safety in two different ways. For instance, respondents consider the maintenance of the physical characteristics of the terrain and the structure of the houses to be linked. As survey respondent #46 from Almada puts it, "*Jundú* [a vegetation type of sandy coastal plains] helps to not let the sea in. The waves, now that most of the *jundú* is gone, invades the beach." Additionally, locals perceive landscape supporting public safety, such as the low incidence of robbery and violence. This results from the difficult access to the communities related to the mountain ranges one must cross in order to reach Picinguaba and Almada (Fig. 3). This point is illustrated by survey respondent #37 from Almada: "Here, there is a low rate of theft, there is no robbery, the door of my house is always open. Here we feel very peaceful."

The safety-landscape WEB is being both positively and negatively affected by MPAs and urbanization processes. MPAs can help preserve the mountain range and the native Atlantic Forest, preserving the safety-landscape WEB. However, MPAs may also be seen as restricting local livelihoods, with negative socioeconomic impacts to *Caiçaras*. Workshop results revealed this positive connection between ecosystem services contributing to safety and the implementation of MPAs (green lines, Fig. 3). During the workshops, participants also reported that they feel restricted in performing traditional livelihoods and that MPAs are governed with little consultation of local communities that depend on coastal resources. Despite this tension in respect to livelihoods, MPAs are perceived as playing an acknowledged role in protecting local safety in the communities and are perceived as a positive outcome of MPAs, which can be explored in participatory MPA processes. This is reflected by one respondent #40 who noted: "We live around the park and we are defended by it. Despite disturbing us, it does not allow for deforestation by outsiders."

The second critical WEB highlighted in our analysis was the connection between social and political relations with canoes, fisheries, and the beach. Generally, beach ecosystems provide an arena for social and political discussions (e.g., festivals, canoe races) and contemplation of nature. These physical spaces are

integral to canoeing and fishing activities - these activities reinforce *Caiçaras* relational and subjective well-being (e.g., social identity, perception of self). For example, respondent #37 from Almada noted: "I always participate in the canoe races, I am well known here, a leader, people invite me to go and plan. We have fun, we rejoin with other communities, dance, have fun, and talk about what matters to us." Moreover, we identified that fishing and the manipulation of canoes require collective work to preserve and foster the sharing aspect of *Caiçara* culture, and therefore, they are key components of relational well-being. This also positively influences key dimensions of subjective well-being (e.g., perception of self, sense of belonging). As respondent #53 from Puruba noted, "Everyone who helps fishing has their share, it's always been a habit to share. It's in our blood." Fisheries and canoes are also a means of cultural reproduction, transmission of knowledge, and activities that mediate relations among family and community members. As suggested by interviewees, small-scale fisheries, canoes, and the beach are part of local lifestyle, mediating family, friendship, and political relations. They are also the context from which local leaders emerge (usually well recognized elderly fishers, canoe carvers, and their descendants), and the contextual setting for the emergence of local traditions, cultural expressions, and beliefs.

Despite its relevance for relational dimensions of well-being and interconnections with subjective well-being of *Caiçara* people, this WEB is strongly affected by social-ecological and governance changes. Notably, it is being both positively and negatively influenced by an increase in tourism and restrictions in livelihoods imposed by MPAs and fishing regulations, as shown in Figure 3. Research respondents highlighted the importance of the shift from fisheries to tourism as a main source of livelihoods, given the influence of imposed restrictions by MPAs. On the one hand, this shift is enhancing material well-being locally because it provides a new source of income. On the other hand, it is also changing the identity of the community and cultural transmission, as represented in this quote: "fisheries unite, tourism segregates" (workshop participant from Puruba). Participants discussed that fisheries carry core values of *Caiçara* culture, such as the culture of sharing and collectiveness, mostly transmitted by helping in fisheries activities and sharing catches among those who helped in the process. This livelihood shift is also supported by restrictions imposed by MPAs, as reported by survey respondent #59: "The Environment [referring to MPAs] represents the pursuit of *Caiçara*. We cannot hunt, farm, and fish... only with a document. Otherwise, they won't let you." Moreover, a workshop participant from Picinguaba noted that: "public spaces are used as private." Thus, tourism and MPAs are shaping social relations in the communities, with both positive (e.g., new source of income and contingence of deforestation, respectively) and negative (e.g., enhancing conflicts and cultural loss) outcomes.

Third, fishing, canoeing, and contemplation of nature improve the mental health of respondents by providing peace of mind, relaxation, and reveal a two-way interaction, in which ecosystems also benefit from the provisioning of well-being. Survey respondent #30 from Almada argues: "Go out fishing and go around in a canoe is like therapy, it relaxes, de-stresses, and relieves oneself." This view was echoed by survey respondent #32 who said that: "In addition to nutrition, fishing means peace, everyone leaves anything to go fishing, it is a pleasure." These quotes show the holistic nature of WEBs, especially those related to subjective

dimensions of well-being, and how the same ecosystem service provides different contributions to well-being in different ways. The contemplative aspect of both land and seascapes during the sunrise and the aesthetic value of the beaches, for instance, foster one's enjoyment of life and sense of meaning and belonging, as demonstrated in Figure 3. Subjective well-being is then dependent on other WEBs - and is enhanced by a broad range of ecosystem services (Fig. 3).

However, human-driven changes affect both relational and subjective dimensions of well-being, which are correlated. Examples of key anthropogenic changes include deforestation, urbanization processes, declining fish stocks, and increases in unregulated tourism (Fig. 3). For instance, deforestation negatively affects relational and subjective well-being because it is a source of conflict and disturbance. Survey respondent #7 mentioned: "Deforestation by the river makes us nervous, takes away peace. An outsider appropriates the place to degrade, does not respect people or nature." In respect to MPAs, participants also feel they are being restricted from fishing, with implications for local culture. Consequently, authorities should consider the impacts of industrial fisheries as more damaging to the environment and prioritize the management of such activities first. The following quotes illustrate cultural losses: "All this began to make us gradually lose our culture, but our culture still remains among us," (survey respondent #58), and "All [this] results in changes in the *Caiçara* culture and losses in our fishing tradition," (workshop participant from Puruba).

Finally, despite the economic benefits of tourism, we found it does affect both relational and subjective well-being. For instance, respondent #8 noted: "The beauty of the beach attracts tourism and enhances competition and market speculation. I work in the tourism sector; this is where my income comes from. At the same time, it is sad because the community is becoming too competitive, people do not live well with one another anymore." In addition, almost 45% of the survey respondents (26 out of 59) argue that tourism is causing depression, resulting in greater mistrust among families and friends. As mentioned by one respondent, these issues include, "intrigue, lack of social cohesion, selfishness, psychological issues, stress" (survey respondent #35 from Almada). This is echoed by respondent #44 from Almada "All these symptoms and feelings are present in our daily lives due to the increase of tourism. But we cannot say that tourism is so negative and only brings us bad feelings because it is now part of our livelihoods. What would be better for us is to make tourism organized and sustainable."

Interestingly, there is a two-way interaction among WEBs. For instance, subjective dimensions of WEBs (e.g., sense of meaning and belonging) play a key role in ecosystem stewardship, and this is a core area to be further explored in collaboration and coastal governance processes. This perspective is supported by survey respondent #7: "I take care of this beach like the apple of my eye! I can't live without the sea. We were born and raised in front of the beach. If we take care of nature, it only brings good things back to us. The more love you give to the more love she will give you." This perspective is echoed by survey respondent #58: "I look at this nature and feel part of it. Nature represents everything to us, the sea, the forest, the river. The human being is interconnected to it, such as a baby is connected to a mom's umbilical cord. If we

harm nature, we will feel the harm in ourselves." Finally, survey respondent #7 raised the issue of stewardship and connected it to issues in the tourism industry: "If someone take me out of here, I will die of sadness. They can't take it from me to give to the rich [referring to tourism businesses]. I take care of the nature here." Overall, WEBs that reflect subjective dimensions of well-being are often closely connected to a local sense of protecting nature and reveal an entrée for improving coastal governance and negotiating with MPA authorities.

Typology for understanding pathways of interactions in WEBs
Survey results showed that the way in which ecosystem services are perceived to provide benefits to people emerges in four different "pathways." Specifically, participants reported four pathways of interaction among well-being and ecosystem services that can be characterized as primarily observational, experiential, extractive, and visual (Table 4). These four pathways are not mutually exclusive but reflect the predominant manner in which people perceive the WEBs of most importance to them. This is shown in Figure 3, in which a well-being component can be benefited by different pathways and ecosystem services. We highlight these results below that emerged from our analysis of WEBs. These four pathways emerged from the quotes from participants when explaining how ecosystem services supported their well-being and explained in Table 4. Throughout this section, we illustrate these pathways using direct quotes from survey respondents.

Table 4. Pathway of WEBs interaction.

Pathway	Explanation
Observati-onal	Benefits perceived by observation of a phenomena or ecosystem functioning, associated to local knowledge about ecosystem processes.
Experiential	Benefits from the performance of the activity
Extractive	Benefits from a resource obtained from nature
Visual	Benefits from looking to a natural phenomenon or land/seascape

First, observational pathways are related to local knowledge on ecosystem processes benefiting the community. For instance, by observing over the years that the native vegetation helps to contain erosion processes in the mountain chain surrounding the communities, participants report feeling safer in areas with no deforestation. This pathway in which safety benefits are perceived by observation of ecosystem dynamics is classified as "observational pathway" and is represented in Figure 3. The observational pathway is also illustrated by respondent #59 who reports coastal protection by sand vegetation: "The vegetation protects the river. If you remove the vegetation, the sea comes and enters the river. What sustains the sand is the *jundú* [sandy coastal plains] and the roots of the trees. If you clear it, the sand strip decreases." This quote highlights how an observation shapes the way in which the role of vegetation preventing erosion can provide a sense of safety, thereby supporting the material well-being of the observer.

Second, material well-being is typically supported by extractive activities, such as from agricultural products, fish, and seafood, as shown in Figure 3. Harvesting these resources clearly provides

material resources for food security, income to local communities, and contributes to their material well-being. This extractive pathway also relates to the "provisioning" category of ecosystem services established (MA 2005). However, the extractive pathway points to other important interactions, including those that are non-material. For example, fisheries and household agriculture are strong cultural components, supporting local cultural identity. This is expressed by participant #22: "I enjoy fixing a fishing net and I fish because I am used to it. I cannot go very often because of my health condition, but I feel happy to see my son going out to fish." Participant #08 adds: "Fisheries is a tradition; we teach our own children about our culture. Fishermen like their work so much that it is not even because of the money."

Third, our results show that benefits obtained through experiential pathways, such as surfing, fishing, or canoeing, can contribute to subjective as well as relational aspects of well-being, as expressed in Figure 3. The experiential pathway is key to the maintenance of certain social relations in the community and among family members, as expressed by respondent #48: "I started fishing when I was 12 and what I like the most about it is the interaction with people, with my passed father, and the gentlemen here." Another participant (#23) mentions fisheries as a time to spend time with parents: "I used to go fishing for squid and fish with my father and gather shellfish with my mother." The experiential pathway of WEBs also supports mental health and life satisfaction, as illustrated by survey respondent #7: "Diving, canoeing, walking in the rocks brings me peace of mind." Experiential pathways of WEBs also help to clarify non-material benefits of ecosystem services to the well-being of coastal communities. For example, respondent #49 mentions: "Go around in a canoe is like a therapy, it relaxes, de-stresses, relieves me."

Finally, results of this research also show the benefits from ecosystem services gained through a visual pathway and particularly in terms of how visual experiences with ecosystems are aligned with the subjective dimension of well-being. Figure 3 shows the visual pathway in the WEBs related to relational and subjective dimensions of well-being. For instance, visual interactions with ecosystems and contemplation of nature can lead to feelings of "peace of mind." As respondent #7 noted while referring to a beach at Picinguaba: "Just the pride of looking at the seascape here makes me happy." Visual contributions to enjoyment of life are also supported by survey respondent #35: "I enjoy seeing the beach, this beauty, open my door and look at the sea. This is my home!" Elucidation of these non-material contributions of WEBs is crucial for understanding the multi-dimensional ways people experience one "single" ecosystem service.

DISCUSSION
This research was undertaken to untangle the linkages among coastal well-being and ecosystem services in three fishing communities in Brazil. Using the lens of WEBs, we identified six well-being components that interact directly with 10 ecosystem services, including natural services (e.g., native vegetation, beach areas, river basin) and services co-produced by humans (e.g., fisheries, canoes, tourism). Similarly, Dias and Armitage (2021) identified the canoe as an example of a service co-produced by humans that supports cultural identity and provides an arena for

collective action toward relevant cultural and livelihood goals in coastal communities. Moreover, we show here the pathways of interaction among ecosystem services and well-being: observational, experiential, extractive, and visual pathways were identified. Several insights are drawn from the results of this research; highlighting relevant points of interplay between WEBs elements that, if well addressed in MPA strategies, can improve governance outcomes. However, we acknowledge that other connections exist and that they evolve and change over time.

First, our WEBs framework brings relevant insights for coastal governance. Safety, for instance, is a well-being dimension strongly supported by the features of the landscape being changed by development processes. We empirically demonstrate that local sense of safety is directly connected to biophysical conditions and landscapes, although this interaction of well-being and ecosystem services is being modified by deforestation and increases in tourism. This finding reveals a crucial point with which to foster collaboration and enhance communication to deal with conflicts emerging from different perspectives about tourism, for instance. Moreover, mountainous formations are perceived to hinder access to the communities, helping to build cohesion as norms of cooperation are established according to cultural aspects (e.g., sharing culture in fishing), patterns of mutual aid and information exchange, and trust among known people. Public safety is a major challenge in many contexts globally, and there are opportunities to further extend this insight which has not been captured explicitly in previous research efforts on well-being and ecosystem services interactions. This finding reinforces the need to explore the linkages between WEBs accounting for geographic diversity, as pointed out by Blythe et al. (2020).

Our findings also reveal WEBs as opportunities for fostering ecosystem stewardship, emphasizing the iterative interplay between well-being dimensions and ecosystem services. The recognition of an ecotone (Ray and Hayden 1992) between terrestrial and marine ecosystems and their links to local safety, as well as ecosystems' contributions to subjective well-being, reveal an opportunity for synergic action with MPAs. Serra do Mar State Park, for example, is perceived as an ally in protecting terrestrial ecosystems, thereby, protecting the safety of coastal communities, despite the detrimental impacts to local livelihoods and culture. This is further supported by results that reveal relational well-being connections with fisheries, canoes, and beach ecosystems (Fig. 3). This finding is supported by Masterson et al. (2019) who point out a feedback loop between the benefit flow and ecosystem services and well-being. This is a key finding to be further explored in coastal governance, and particularly relevant to boost collaborations between MPAs and coastal communities being affected by them.

In addition, our results highlight that subjective well-being dimensions are enhanced when material and relational dimensions are well supported, the connections to the sea and landscapes are visually appealing and allow for personal experiences individually and collectively, and that subjective well-being has a key role in fostering ecosystem stewardship in the communities. Valuing local small-scale fisheries, knowledge transmission related to canoe carving, and use of beach areas with healthy and aesthetic values are opportunities for stewardship and collaboration between preserving local well-being as well as

healthy ecosystems. Thus, despite the conflicts and trade-offs associated with MPA imposed restrictions, we identify opportunities for collaboration in coastal conservation based on underlying values of local people, and stewardship actions toward coastal ecosystem services. These opportunities are revealed by the iterative interplay between components of WEBs, understanding the benefits ecosystems provide to coastal communities and the values associated with these connections that foster stewardship actions from community members in synergy with conservation goals. Similarly, fostering the sense of protecting nature that emerges from WEBs is a promising mechanism for collaboration with MPA authorities. This sense of protecting nature emerges from subjective and relational values of ecosystems (Milcu et al. 2013, Chapin et al. 2009).

Second, adaptation in current MPA governance approaches is needed in order to reduce risks related to cultural loss and marginalization of *Caiçara* people, and potential shifts to unsustainable livelihoods. Understanding ecosystem–well-being trade-offs for *Caiçara* communities adjacent to MPAs, such as with regards to tourism, can help MPA authorities and community members make informed decisions in recognition of consequences. This research highlights emerging opportunities in the context of uncertainty, such as alternative tourism that foster an appreciation for local culture and traditions, as well as for nature conservation. Results show that tourism is relevant for sustaining local livelihoods, however, due to lack of regulation and enforcement, it is detrimental to coastal ecosystems (e.g., driver of deforestation). Efforts to address trade-offs in tourism, such as creating guidelines to support sustainable tourism practices and providing appropriate enforcement of guidelines and legal regulations can improve conservation measures and outcomes.

Adaptations toward enhancing capacity building to understand the implication of community actions and consequences to their material, social, and subjective well-being are also necessary, and WEBs provide a useful lens in this regard. Results suggest that people value healthy ecosystems and recognize contributions to their well-being. However, they usually do not recognize themselves as key drivers of change in local ecosystems. Understanding their impact and potential to perform stewardship actions can help MPA authorities, as well as the communities themselves to evaluate their own behaviors toward coastal ecosystems. This is a long-term process given the need to build trust and address conflicts, especially in negotiations with government and other environmental regulatory agencies and public sectors. The findings of this research can help to address mainstreaming social values into MPA governance by improving our understanding of human–nature interactions toward better conservation measures and outcomes, as suggested by Bennett et al. (2017).

Third, our typology of pathways of interaction within WEBs provides theoretical contributions to the ecosystem services scholarship and knowledge to inform MPA governance. A major gap in the ecosystem services scholarship relies on disaggregating the benefits coastal ecosystems provided to people (Blythe et al. 2020) beyond economic and aesthetic values related to tourism (Milcu et al. 2013). Doing so will help to reduce oversimplifications of human–nature relationships. A key

challenge to fill this niche relates to the lack of clarity regarding the different types of ecosystem services and their contributions to well-being (Daniel et al. 2012, Milcu et al. 2013, Daw et al. 2016). Fishing, for instance, is considered under the "provisioning" category; still, it is a core service fostering local culture related to both relational and subjective well-being. Similar findings were proposed by Poe et al. (2016) in demonstrating how shellfish provide a sense of place and identity to coastal communities in Puget Sound (Washington). Yet, as illustrated here, we can examine WEBs that extend the categories of ecosystem services and explore how different ecosystem services bundle together to enhance specific dimensions of the well-being of *Caiçara* people. Thus, the WEBS framework offers an integrative understanding of these links, or pathways of interaction.

Experiential, observational, and visual linkages between coastal services and well-being are seldom included in the context of coastal governance, despite being particularly relevant in the context of tourism and recreation services (Milcu et al. 2013). Prior studies have noted the importance of life satisfaction involved in fishing (e.g., Pollnac and Poggie 2008, Weeratunge et al. 2013), yet these contributions are rarely considered in management strategies and as a criterion in decision-making processes (Song et al. 2013, Bavinck et al. 2017, Chan et al. 2019). In contrast, experiential and visual WEBs reveal opportunities to improve governance processes in MPAs as they strongly relate to cultural identity, life satisfaction, and sense of belonging.

In the Serra da Bocaina State Park fishers recognize the positive outcome of the park in protecting the landscape for visual WEBs but highlight detriments in experiential and extractive pathways that may limit fishing, hunting, and household agriculture with little consultation. In the APA-Ln, a key opportunity to explore experiential and visual connections of *Caiçara* is linked to ongoing zoning processes in the MPA (Muhl et al. 2020). This process involves several rounds of consultation with the communities and has the potential to establish zones according to the visual, experiential, and extractive linkages with *Caiçara* communities, aligned with local conservation needs. Reyes et al. (2013) suggest a social-ecological systems approach to measure ecosystem services and their contribution to well-being. Accordingly, here we highlight the trade-offs and relational and subjective values in ecosystem services that are hard to measure through the typology of pathways of interaction.

The four pathways for WEBs (observational, experiential, extractive, and visual) suggest that well-being of coastal communities is shaped by MPAs beyond access and resource use issues. Rather, MPAs may interfere in the sense of belonging and connection to the sacred, subjective feelings of safety and collectiveness in coastal communities. Thus, MPA implementation would benefit from integrating overlooked WEBs as a priority in sustaining local livelihoods and stimulating local support in conservation efforts. This includes decisions to create an MPA, establish its goals, select its specific ecosystems and geographic boundaries, define monitoring and enforcing protocols, and enable an adaptive scheme according to social and ecological outcomes. As a result, stewardship and responsibility over coastal areas are more likely to be fostered and enhanced, as they are related to sense of attachment and can shape better compliance for conservation strategies (Lau et al. 2020).

CONCLUSION

The application of a WEBs perspective provides an innovative way to understand how coastal ecosystems are valued and benefit stakeholder groups, such as coastal communities. The pathways of interaction among WEBs reveal linkages between people and nature that are perhaps less obvious, but that are important opportunities to address inequity (e.g., in the tourism sector) and reduce environmental degradation by fostering stewardship actions that take into account what is valued by people. Communities and decision-makers can improve governance outcomes, and in this case in the context of MPAs, by understanding dynamic WEBs, and critical pathways of interaction. Still, an understanding of the diverse perspectives on WEBs, and especially conflicting perspectives among coastal communities and decision-makers, provides an opportunity for further investigation. Moreover, we have argued that identifying the particular pathways through which people perceive WEBs (e.g., experientially, or through extractive activities) is particularly important. Ultimately, how people perceive the pathways of interaction among well-being and the ecosystems upon which they depend will influence MPA outcomes.

Responses to this article can be read online at:
https://www.ecologyandsociety.org/issues/responses.php/13070

Data Availability:

The data that supports the findings of this study are openly available in uwspace at https://uwspace.uwaterloo.ca/bitstream/handle/10012/16381/Dias_AnaCarolinaEsteves.pdf?sequence=1&isAllowed=y. Ethical approval for this research study was granted by the Office of Research Ethics, University of Waterloo (ORE#22119).

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