frontiers | Frontiers in Marine Science

TYPE Brief Research Report
PUBLISHED 20 September 2022
DOI 10.3389/fmars.2022.904859

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Ocean Solutions, a section of the journal Frontiers in Marine Science

RECEIVED 26 March 2022
ACCEPTED 29 August 2022
PUBLISHED 20 September 2022

CITATION
Valdez-Rojas C, Beas-Luna R, Lorda J, Zepeda-Domínguez JA, Montáño-Moctezuma G, Medellín-Ortíz A, Torre J and Micheli F (2022) Using a social-ecological systems perspective to identify context specific actions to build resilience in small scale fisheries in Mexico. *Front. Mar. Sci.* 9:904859. doi: 10.3389/fmars.2022.904859

Using a social-ecological systems perspective to identify context specific actions to build resilience in small scale fisheries in Mexico

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To promote the resilience and sustainability of coastal social-ecological systems (SES), it is necessary to implement adaptive and participatory management schemes. Successful examples of adaptation to the rapid change in coastal SES exist, but the question of whether these cases may be scalable to other regions and contexts remains. To this end, the present study aimed to identify how successful management strategies implemented in a fishing cooperative in Baja California, Mexico, can be adapted to other coastal SES. In particular, this study aimed to understand whether adaptive co-management of Isla Natividad (IN) could be replicated in Isla Todos Santos (ITS), a biophysically similar coastal SES to IN but with different results with regard to fisheries management. We found that the resource systems and resources in both SESs were similar. However, there were substantial differences with regard to governance and resource users. In Isla Natividad, the level of organization orchestrated by the resource users has contributed to establishing rules and sanctions that have supported the sustainable use of fishery resources. On the contrary, in ITS, the number of resource users and their socioeconomic attributes have impeded the establishment of effective rules or sanctions. The results of this study suggest that the ITS governance system needs to be improved in order to adapt some of the IN management strategies to increase its adaptive capacity. To promote successful adaptive management, it is necessary to develop context-specific adaptive pathways that contribute to greater resilience in the SESs of this region and in other regions that face similar conditions.

KEYWORDS

adaptive capacity, resilience, resilience-based management, comanagement, benthic fisheries, adaptive management

Introduction

Marine biodiversity and the economic stability of fishing communities are threatened by extreme and complex challenges. As a result of climate change, the intensity and frequency of environmental disturbances in the ocean have increased, affecting the structure and functionality of marine ecosystems and fishery resources and the people who depend on them (Doney et al., 2012). Moreover, illegal, unreported, and unregulated (IUU) fishing has notably and negatively impacted marine ecosystems and their services (Worm and Branch, 2012; Worm, 2016). The combination of extreme environmental events with unsustainable practices has caused ecosystem-level changes, which have decreased the quality, availability, and diversity of resources (Silva et al., 2019), and generated uncertainty in fishing communities (Finkbeiner et al., 2018). However, ecosystem restoration is possible through sustainable fishing practices that integrate ecological, social, economic, and institutional perspectives (Pauly et al., 2002; Stephenson et al., 2018).

Incorporating a social-ecological perspective is key when developing action strategies that seek to promote sustainable fishing practices (Peña-Puch et al., 2020). This perspective addresses problems through an interdisciplinary approach to ensure the resilience of the ecosystems and the communities that depend on them. Small-scale fisheries (SSF) are an example of complex social-ecological systems (SESs) (Berkes, 2003) that have the potential capacity to resist and adapt to environmental changes. Through adaptive management, it is possible to support and improve the resilience of SESs (Folke et al., 2002). Therefore, it is of utmost importance to consider management strategies that take into consideration the vulnerability, complexity, and adaptive capacity of SESs.

Diverse management tools and strategies are available for fisheries. For example, the comanagement model involves resource users in the decision-making process and the implementation of diverse management strategies. This management model is based on participatory processes, such as community-based management, adaptive management, and participatory governance (Berkes, 2003; Gutiérrez et al., 2011; Álvarez et al., 2018; d'Armengol et al., 2018; Peña-Puch et al., 2020). In accordance with the principle of redundancy, comanagement recognizes the importance of complementary and synergistic strategies like the design, implementation, and monitoring of marine reserves and the diversification of fishery products, restocking actions, and fishery certifications (Bell et al., 2008; Elena M Micheli et al., 2012; Finkbeiner and Basurto, 2015; Di Franco et al., 2016). These strategies serve different functions within fisheries that range from promoting the adaptive capacity to coping with negative impacts to establishing collective decision-making systems (Álvarez et al., 2018).

Several SSFs have implemented comanagement with successful outcomes (Gutiérrez et al., 2011; McClenachan et al., 2015; Defeo et al., 2016; d'Armengol et al., 2018). In addition to comanagement, strategies such as territorial use rights for fishing (TURF) that grant exclusive access to fishery resources have contributed to better management outcomes in small scale fisheries in Latin America (Basurto et al., 2012; Defeo et al., 2016). In Mexico, examples of successfully managed small scale fisheries include the Punta Allen (Méndez-Medina et al., 2015) and Isla Natividad (IN; Figure 1A) fishing cooperatives (Ponce-Díaz et al., 2009; Micheli et al., 2012; McCay et al., 2014; McCay, 2017; Álvarez et al., 2018). For example, in Isla Natividad, prolonged hypoxia during 2009–2010 resulted in the massive mortality of several economically important fishing resources in the region (Ponce-Díaz et al., 2009; Micheli et al., 2012; McCay et al., 2014; McCay, 2017; Boch et al., 2018); however, the positive effects of a combination of management actions promoted sustainable fishing and social-ecological resilience. Some benefits of the management strategies implemented in IN include enhancing its social and ecological adaptive capacity, promoting community economic growth, empowering the resource users, improving fishing practices, and obtaining a certification for one of its main fisheries (Micheli et al., 2012; Pérez-Ramírez et al., 2012; McCay et al., 2014; McCay, 2017; Finkbeiner et al., 2018). Thus, Isla Natividad represents an ideal case to describe and explore the possibility of scaling a successful management model for small scale fisheries in the Pacific coast of Baja California, Mexico.

To a great extent, the success of fisheries management in IN is due to the social-ecological context and cooperation among fishers of the Sociedad Cooperativa de Producción Pesquera Buzos y Pescadores de la Baja California, SCCP (hereinafter, Buzos y Pescadores) (McCay et al., 2014; Álvarez et al., 2018). However, the further exploration of IN social-ecological context might contribute to a clear vision on how to scale successful approaches to sustainability and adaptation in coastal SES. IN is an isolated example in the Baja California peninsula, and it is unclear if this approach can be implemented elsewhere in the region, particularly in locations that face similar environmental challenges. For instance, Isla Todos Santos (ITS) in Baja California constitutes a SES that is biophysically similar to the IN SES and may be an ideal place to explore if the successful management practices of IN might be scaled. To ensure the sustainability of small-scale fisheries at ITS, the adaptability of this SES must be increased by understanding the social-ecological interactions among its components. This knowledge will facilitate the generation of appropriate case-specific adaptive responses (Poulain et al., 2018) in other coastal SES.

The goal of this study was to explore the social-ecological context of a successful management model implemented in a coastal SES and how it could be replicated in another SES. Two SES models were compared, and their social-ecological contexts were explored to identify how to scale and implement adaptive comanagement based on their similarities and differences. Our

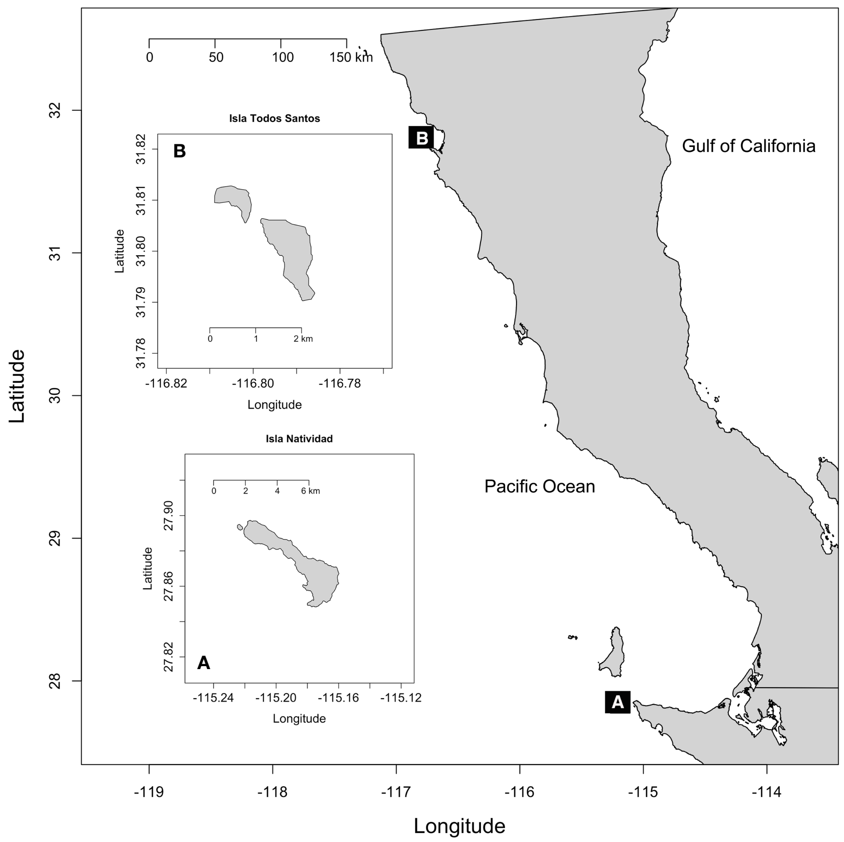

FIGURE 1
Map of the study area including Isla Natividad (inset map **A**) and Isla Todos Santos (inset map **B**).

SES models were located within two islands of the Baja California Pacific that face climate change-related challenges (Beas-Luna and Ladah, 2014; Woodson et al., 2019; Cheung and Frölicher, 2020): IN and ITS. The social and ecological conditions that appear to promote successful management strategies are discussed, as well as how to achieve resilience through a context specific management approach.

Materials and methods

Study area

Isla Natividad (IN) is located in the Pacific Ocean off the coast of northwestern Mexico in Baja California Sur, 9.3 km from Punta Eugenia (27° 51′ 56.95 ″ N and 115° 10′ 48.08″ W; Figure 1A). Isla Todos Santos (ITS) is located in Baja California, approximately 254 nautical miles northwest of IN and 16.6 km off the coast of Ensenada (31° 47′ 59″ N and 116° 47′ 20″ W; Figure 1B). Both island systems are surrounded by kelp forests dominated by the macroalgae *Macrocystis pyrifera*. There are several commercially valuable benthic species associated with these kelp forests, including the wild abalone (*Haliotis fulgens* & *H. corrugata*), spiny lobster (*Panulirus interruptus*), sea urchin (*Mesocentrotus franciscanus*), sea cucumber (*Parastichopus parvimensis*), and sea snail (*Megastraea undosa*). The livelihood of Buzos y Pescadores from IN fully depends on these resources, while within ITS there are other economic activities besides fisheries.

Characterizing management strategies

We adapted the SESs framework described by Ostrom (2009) to identify the characteristics of the IN SES that have contributed to the successful implementation of management strategies (Table 1). The SES framework contemplates four first-level variables or subsystems: 1) the resource system, 2) the resource units, 3) the resource users, and 4) the governance system. Furthermore, it establishes a series of second-level variables that are relevant for each subsystem. These second-level variables and their interactions determine the outcomes of the SES. With the SES framework, it is possible to evaluate and determine the degree to which resources are being sustainably used in any SES (Binder et al., 2013). For this study, the SES framework was based on the available information and insights from previous studies of SSF (Basurto et al., 2013; Leslie et al., 2015; Villaseñor-Derbez et al., 2019). To better understand the IN SES, information from official documents, scientific publications, and informal consultations were integrated. The consultations were performed to different individuals in the cooperatives, academic and governmental institutions targeting for information gaps when data was not available; these individuals were selected based on their experience on the field, the consultations were performed face to face or by phone call.

Social-ecological system comparison

Once the social-ecological characteristics that contributed to the successful establishment of the management strategies in IN were identified, the ITS SES was described using the modified framework (Table 1) to compare IN and ITS. The rest of the information was integrated from primary and secondary sources, including scientific articles, management plans, official government documents, databases provided by MexCal[1], technical studies, and informal consultations with researchers and staff from nongovernmental organizations (NGOs), and licensed fishers from ITS.

The SES of IN was compared with that of ITS and the similarities among the first-level variables of the two SESs were quantified. All the second-level variables were captured in a quantifiable manner as either quantity, when information was available (with standardized values from 0 to 1), or as presence or absence values, when quantity information was not available. To estimate the similarity between IN and ITS, a modification of the percentage similarity index (PSI) was used (Krebs, 1999) and is shown in Eq. (1):

$$PSI = \sum_i minimum(p_{1i}, p_{2i}) * 100, \qquad \text{Eq. (1)}$$

where PSI is the percentage of similarity between island 1 and island 2, p_{1i} is the relative proportion of variable i on island 1, and p_{2i} is the relative proportion of variable i on island 2. The PSI value is 0 when there is no similarity and 100% when equal.

The resource systems, resource units, resource users, and governance systems were compared. In addition, the management actions that have been implemented in IN, such as investments that resource users have made, were considered and compared between both SESs. Finally, radar charts were used to represent the differences between the two islands with regard to all measured variables.

1 https://mex-cal.org/data/.

Results

To analyze and compare the SESs of IN and ITS, 27 second-level variables were identified (Table 1). Also, six strategies in which IN users have invested in resource management with successful outcomes for the SES were considered. By gathering information on IN, second-level variables were integrated. According to IN fishers, these variables could play a key role in management success. They include system predictability (RS7), diversity of actors (U1.2), usage history (U3), population (U2.1), user isolation (U2.3), and exclusive access rights to benthic resources (GS4). The comparison between the SESs of IN and ITS showed a greater PSI in the resource system (63%) and the resource units (77%) than in the governance system and resource users (Figure 2). However, the general PSI value between the two SESs when all variables were considered was 51%. Therefore, this analysis suggests that IN and ITS have different social-ecological contexts, and the differences and similarities between the two SESs need to be analyzed independently.

Resource system

Six variables to compare the resource systems between the two SESs were considered, and the PSI value was 63% (Figure 3A). In IN, the size of the system, measured as the total area in which fishing is legally allowed, was 86% larger than that of ITS. The benthic resources fishing area, which represents almost 90% of the total allowed fishing area in IN and 92% in ITS was also considered. The predictability of the system, measured as the coefficient of variation of sea surface temperature, was 12% less predictable in IN than that of ITS. Productivity, determined by estimating kelp biomass using satellite images of the last 30 years, was 57% higher in IN than that of ITS. Although productivity in the IN and ITS SESs was relatively high (Cavanaugh et al., 2019), both systems are vulnerable to the effects of climate change (Micheli et al., 2012; McCay et al., 2014; Boch et al., 2018; Cavanaugh et al., 2019; Beas-Luna et al., 2020). Lastly, both IN and ITS are close to the mainland and located within biosphere reserves. In particular, IN is part of the core zone of the El Vizcaíno Biosphere Reserve (Carabias-Lillo et al., 2000), and ITS covers a large portion of the buffer zone of the Pacific Islands Biosphere Reserve (DOF, 2016).

Resource units

To compare the resource units, the economic value of benthic resources, the economic value relative to the benthic fishing area, the number of resources of high economic value, and the number of species harvested were considered (Table 1). The results suggested a PSI value between IN and ITS resource units of 77% (Figure 3B). The benthic resources harvested in IN include lobsters,

TABLE 1 List of variables used to compare Isla Natividad (IN) and Isla Todos Santos (ITS) adapted from Ostrom (Ostrom, 2009).

Variable	Definition	IN	ITS
Resource System (RS)			
RS3 Size	Total fishing allowed surface area (ha) (Medellin-Ortiz et al., 2020)	81,526 ha	11,597 ha
RS3.1 Benthic fishing area	Authorized fishing area for benthic resources subtracting waters deeper than 300 m and average algal canopy covered area 1982-2018 (Medellin-Ortiz et al., 2020)	72,100 ha	10,681 ha
RS5 Productivity	Average surface biomass estimation of kelp forests using satellite images 1984-2018 (Cavanaugh et al., 2019)	452.04 pixels	196.82 pixels
RS7 Predictability	Coefficient of variation of sea surface temperature 1982-2018.[2]	0.1330	0.1174
RS9.1 Isolation	Distance (km) from the mainland to the island (Leslie et al., 2015)	7.9 km	6.3 km
RS9.2 NPA total area	Total area (ha) that is legally protected	985 ha (Carabias-Lillo et al., 2000)	10492 ha (DOF, 2016)
Resource Units (RU)			
RU4 Economic value	Total landings value of benthic resources from 2000–2018 (USD) (Comisión Nacional de Acuacultura y Pesca, 2017)	US$31,767,431.86	US$3,876,405.96
RU4.1 Economic value per fishing area	Benthic resources economic value relative to the benthic fishing area	US$440.60	US$362.93
RU4.2 Resources of high economic value	Number of benthic resources that generated the highest income from 2000-2018	1	1
RU5.1 Species harvested	Number of benthic species harvested from 2000–2018	5 (DOF, 2018)	8[3]
Users (U)			
U1 Number of users	Average number of benthic fishers 2000-2018	One fishing cooperative with 84 members (DOF, 2018)	Six licensed fishers´ associations
U1.2 Number of active fishing boats	Total number of fishing boats authorized for benthic fisheries 2000-2018 (Medellin-Ortiz pers. comm.)	23	18
U2.1 Population	Number of inhabitants on the island	500 inhabitants (Valle-Padilla, 2008)	0 (INEGI, 2010)
U2.1.1 Main economic activities	Number of economic activities, including fishing	2 (Valle-Padilla, 2008)	3 (Arroyo et al., 2019)
U2.2 Surrounding population	Number of inhabitants in the closest city to the island	2,671 inhabitants (INEGI, 2010)	535,361 inhabitants (COPLADE, 2017)
U2.3 Isolation	Distance (km) to Ensenada (Leslie et al., 2015)	875 km	6.3 km
U3 Usage history	Number of years prior to 2018 that users have extracted the resources in the system	78 (Crespo-Guerrero and Jiménez-Pelcastre, 2018)	48 (Delgado Ramírez and Aguirre, 2018)
U5 Leadership	Users who are capable of promoting collective action as well as conflict solving among the community (Gutiérrez et al., 2011; Basurto et al., 2013)	Present (McCay et al., 2014)	No Data
Governance System (GS)			
GS1 Governmental Organizations	Number of governmental organizations involved in the decision-making process (Zepeda-Domínguez, 2016)	4	4
GS2 NGOs	Number of nongovernmental organizations involved in the decision-making process and in the use of resources	3 (McCay et al., 2014)	0 (Arroyo et al., 2019)
GS3 Stakeholder diversity	Number of stakeholder groups participating in decision-making processes and resource management.	Government, NGOs, academia, fishers (Zetina-Rejón et al., 2020)	Government, fishers (Arroyo et al., 2019)
GS4 TURFs	Property rights or exclusive access (TURFs)	Present (DOF, 2018)	Present (CONANP, 2018)
GS5 Operating rules	The operational rules involved in the day-to-day decisions that determine the actions of the users in the system (Rahman et al., 2017)	Present (McCay et al., 2014)	Absent (Personal communication)
GS6 Collective choice rules	The ability of users to design and implement their own rules	Present (McCay et al., 2014)	Absent (Personal communication)
GS7 Constitutional rules	The ability of users to establish the rules that regulate access and permanence in the system	Present (McCay et al., 2014)	Absent (Personal communication)
GS 7.1. Fishing licenses	Number of actual licenses granted for the use of all fishery resources	4 (DOF, 2018)	52 (Medellin-Ortiz, per. Comm.)

(Continued)

TABLE 1 Continued

Variable	Definition	IN	ITS
GS8 Sanctions	Measures formulated by users in the event of non-compliance with the established rules	Present (McCay et al., 2014)	Absent (Personal communication)
Investments (I)			
I1 Marine reserves	Total geographically delimited area (ha) in which fishing is not allowed	200 ha (DOF, 2018)	0
I2 Certified fisheries	Number of sustainable certified fisheries	1 (Alvarez-Flores and Humberstone, 2018)	0
I3 FIPs	Number of FIPs	1 (Fernández-Rivera Melo et al., 2018)	0
I4 Surveillance	An investment by users to monitor fishing activities and enforce the established rules	Present (Valle-Padilla, 2008)	Present (Personal communication)
I5 Ecological Monitoring	Average number of transects done since the implementation of ecological monitoring	102.61 transects 2006-2017 (Comunidad y Biodiversidad, A.C, 2019)	19.4 transects 2011-2019 (Beas-Luna et al., 2020)
I6 Restocking programs	Number of restocking programs	1 abalone restocking program Personal communication	1 abalone restocking program (Personal communication)

NPA, Natural Protected Area; FIPs, Fishery Improvement Projects; TURF, Territorial Use Rights for Fishing.

warty sea cucumbers, red sea urchins, green and pink abalone, and snails (DOF, 2018). At ITS, multiple licensed fishers extract various resources. Licenses are issued for specific benthic taxa, such as red lobsters, warty sea cucumbers, red and purple sea urchins (*Strongylocentrotus purpuratus*), octopuses (*Octopus* spp.), snails, clams (*Panopea* spp.), and crabs (*Cancer* spp.). The total economic value of the benthic fisheries in IN is typically higher than that of ITS. For instance, from 2000–2018, the landings value was around eight times higher in IN than ITS (Table 1, RU4). While the difference between the economic value per fishing area is only about US$77.67, with greater earnings in IN. The fishery with the greatest economic importance in IN is the lobster fishery, this fishery makes up 62.7% of the total benthic resource landings value from 2000–2018. In contrast, the red sea urchin is the resource with the highest economic value in ITS, making up 83% of the total benthic resource landings value from 2000–2018.

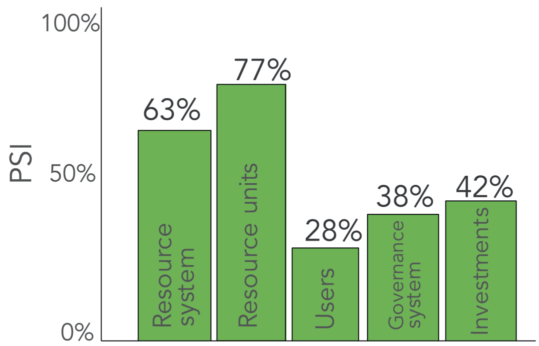

FIGURE 2
Percentage similarity index (PSI) between Isla Todos Santos and Isla Natividad subsystems and investments to management. The PSI value is 0 when there is no similarity and 100% when equal.

2 http://www.marineheatwaves.org/tracker.html.

3 https://www.infomex.org.mx/gobiernofederal/home.action.

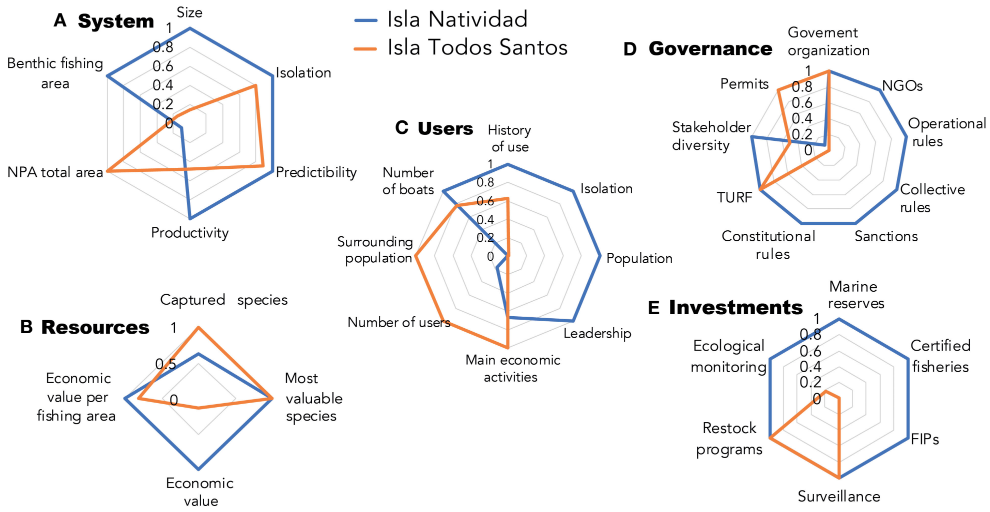

FIGURE 3
Comparison of the social-ecological characteristics of Isla Natividad (IN) and Isla Todos Santos (ITS) SESs (Social Ecological Systems) using standardized values ranging from 0 to 1 (see: Table 1). NPA, Natural Protected Area; FIPs, Fishery Improvement Projects; TURF, Territorial Use Rights for Fishing.

Users

To compare the users at both SES, nine second-level variables that in some way influence the users of the benthic resources of the IN and ITS SES were included (Table 1). The PSI value was 28% (Figure 3C). On average, from 2000–2018 in ITS, there were six licensed benthic resource users, whereas in IN there was just one, Buzos y Pescadores, with exclusive fishing rights to all benthic resources. Buzos y Pescadores was founded in 1942 and have used the fisheries resources since then (Crespo-Guerrero and Jiménez-Pelcastre, 2018). There were 18 registered and active fishing boats for benthic fisheries in ITS and 23 in IN. In ITS, the red sea urchin is officially the oldest benthic fishery in 1972 in Todos Santos Bay (Delgado Ramírez and Aguirre, 2018).

The resource users in IN live on the island, and the community is composed of ~ 500 inhabitants (Valle-Padilla, 2008). On the contrary, there is no established community in ITS, although there are mariculture camps. The community of IN supports itself through two economic activities: fishing and, to a lesser extent, tourism. In ITS, in addition to mariculture and fishing, tourism is a relatively important economic activity due to the natural attractions of the archipelago and various tourism activities, such as diving, marine mammal watching, sport fishing, and surfing, since ITS is part of the Bahía de Todos Santos World Surfing Reserve (Arroyo et al., 2019). The IN community is more isolated from the surrounding populations than that of ITS; IN is 892 km from the capital of Baja California Sur and 875 km from Ensenada, Baja California, where the cooperative's headquarters is located. On the other hand, ITS is located 6.3 km from Ensenada, an important point of sale and distribution site for fisheries in the region.

Governance system

The PSI value for the governance system between the two SESs was 38% (Figure 3D). The governmental sectors within ITS and IN exerted the same degree of influence over their respective SESs. Nonetheless, the SESs differed with regard to the rest of the second-order variables that were considered, such as TURFs, rules, sanctions, the presence of NGOs, and the diversity of stakeholders (Table 1). There is a high diversity of stakeholders in the IN SES, and fishers collaborate with diverse allies, such as NGOs, academics, and governmental organizations. In ITS, the licensed fishers and the NGOs do not collaborate. The only stakeholder groups participating in decision-making are the fishers and governmental organizations. In IN, Buzos y Pescadores, the only user, has exclusive access rights to benthic resources and holds licenses for the exploitation of four fisheries and abalone aquaculture (DOF, 2018). In contrast, the fishing resources of ITS from 2000–2018 have been harvested by 52 licensed fishers, of which six have licenses for benthic resources. In addition, a concession for striped bass (*Morone saxatilis*) mariculture has also been granted for a private company in ITS. Finally, the rules that have been established for resource management and use differ between the two SES. In IN, an entire system of standards, rules, and sanctions to collectively manage resources is in place, which was formulated based on agreements among cooperative members. In ITS, the number of users and the diversity of resources has hindered the establishment of either rules or sanctions; however, users are governed by the rules established by the agencies that regulate fishing activities and the internal agreements of each organization.

Investments

The PSI value for the investments between the two SESs was 42% (Figure 3E). The successful strategies that IN users have invested for resource management include the implementation of marine reserves (fish refuges since 2016) that collectively span 200 ha (10% of the total area of its concession) (DOF, 2018); the certification of their main fishery (lobster) by the Marine Stewardship Council (Alvarez-Flores and Humberstone, 2018); an ocean whitefish (*Caulolatilus princeps*) fishing improvement project (Fernández-Rivera Melo et al., 2018); surveillance of their fishing grounds; ecological monitoring, carried out by the community; and an abalone restocking program. In ITS, some investments have been made for resource management, although to a lesser degree than those present in IN. For example, academic institutions have implemented ecological monitoring programs since 2011 (Fernández-Rivera Melo et al., 2018), and some licensed fishers have invested in the surveillance of their fishing grounds. In addition, an abalone restocking initiative has been put forth by licensed fishers in collaboration with the academic sector (Bauer et al., 2020).

Discussion

To our knowledge, this is the first time that the SES framework has been used as a tool to quantify similarities and analyze the viability of scaling a successful management example of a small-scale fishery in coastal SES. This work describes how seemingly closely related SESs are in fact very different. The general implication that was highlighted from the results was that the main differences were revealed within the users and governance subsystems. The comparison between ITS and IN SESs suggested a 51% difference in the general similarity index. Interestingly, some of the differences between governance structures and stakeholder composition have been documented for fisheries in this region (Zetina-Rejón et al., 2020), indicating that the involvement of diverse stakeholders in governance networks promotes effective governance in the case of IN. On the other hand, similarities were found in that both SESs are characterized by highly valuable fishing resources. Both are located in highly productive coastal ecosystems that are vulnerable to climate change (Vilalta-Navas et al., 2018; Arafeh-Dalmau et al., 2019). Additionally, the characterization of both SESs allowed us to understand the social-ecological context of IN as a successful management model and to point out which variables in ITS can be improved and which are inherent to the system.

By quantifying the similarities between both SESs subsystems, we identified a context-specific set of actions to promote sustainability and social-ecological resilience in ITS. For example, strengthening the ITS governance system is probably one of the most relevant outcomes of this exercise. We found that there is a need to establish a set of rules by the resource users themselves to ensure compliance. However, the process will not be straight forward, as the dynamics among users are different between the two SESs (PSI 28%) and most of these variables are inherent to the system. For instance, IN fishers live in the SES, and thus they have a higher ability to identify events or circumstances that could affect or threaten their fishing resources, such as poaching or any other non-compliance with laws and regulations (McCay et al., 2014). In contrast, ITS is uninhabited, not isolated, and easily accessible to possible users without proper fishing permissions. This represents a potential threat for the resources and users of ITS, since the probabilities of illegal fishing increase. Hence, promoting enhanced governance at ITS is needed, however, this needs to be coupled with an enforcement program in which all stakeholders are held accountable for illegal activity.

In response to this, instead of trying to replicate the governance system of IN, an adaptation of the system according to the context must occur in ITS. We identified it is essential to involve users and diverse stakeholders in a participatory committee since participatory processes and the creation of cross-sectional consortia composed of NGOs, government agencies, academic entities, and resource users are essential for the management of small-scale fisheries (Karr et al., 2017; d'Armengol et al., 2018; Zetina-Rejón et al., 2020). In addition to the resource users, the SES framework facilitated the identification of several other entities that should be involved in a cross-sectoral consortium [e.g., fishers, mariculturists, local surfers, members of the National Commission of Natural Protected Areas (CONANP), and local researchers]. This will allow for an opportunity to implement an enforcement program combined with adaptive management strategies, considering all parties involved in the use, management and conservation of natural resources of ITS.

On the other hand, the similarities found on the resource systems and resource units indicate that like in IN, implementing enhanced management practices in the ITS SES could result in significant benefits for an already productive system with resources of high economic value. The participation of a cross-sectoral consortium in management decisions will also contribute to smart decision making to cope with climate variability in the region. Red sea urchin populations in ITS have presented high historical variability; however, ITS has been identified as one of the sites with the highest population density of this species in Baja California (Medellín-Ortiz et al., 2020). On the contrary, a notable decrease in sea cucumber abundance in the region has been observed (Chávez et al., 2011) despite similar management strategies being implemented as those for the urchin fishery. Therefore, it is essential to implement strategies like TURFs and comanagement focused on recovering benthic resources and the fisheries in ITS (Ovitz and Johnson, 2019). In addition, CONANP, the World Surfing Reserve, and local researchers have proposed initiatives to implement a community monitoring program (Montaño-Moctezuma et al., 2013; CONANP, 2018; Arroyo et al., 2019). Along with restocking programs and marine reserves for benthic resources, these context-specific actions can provide a greater adaptive capacity and direct benefits for the resource users of ITS.

This study has compiled and integrated relevant information of the ITS SES resource system and resource units to document its productivity, sustainability, and adaptive capacity. For example, subtidal community structure, Landsat biomass estimations, physical and chemical oceanographic parameters, and fishing data were integrated (Palleiro-Nayar, 2013; Beas-Luna and Ladah, 2014; Beas-Luna et al., 2020; Medellín-Ortiz et al., 2020). The integration of this information must be accessible to users to facilitate the design and implementation of adaptive management strategies. Adaptive management has proven to be successful when resource users create collaborative networks and generate knowledge of their SES (Plummer et al., 2012). Therefore, the collective participation of users and those interested in conserving ITS is essential for adaptive management actions to be successful. This first effort is expected to help jump start additional data integration, the identification of information gaps, and the design of data visualization tools to keep all users informed and explore adaptive alternatives.

Isla Natividad represents a particularly successful case study because the SES has been shaped by specific conditions that allowed effective management strategies to be established (Álvarez et al., 2018). The results of this study suggest that the social-ecological context of IN shows structural differences from that of ITS, and to effectively replicate success at ITS, strategies need to be adapted to the circumstances of this SES. The case of IN is an example of how comprehensive, participatory, and collaborative management schemes can increase the adaptive capacity of a SES given a context of climate change and overfishing. This analysis highlighted the importance of an effective governance system, which was identified as crucial for achieving a resilient SES in ITS.

Finally, this approach to understanding if successful management examples in coastal SES may be scalable to other contexts helped identify the similarities and differences from a social-ecological perspective and how the success or failure of a management scheme may be determined by understanding this variability between SESs. The analysis of specific cases and particular contexts is therefore essential to scale successful management models instead of adopting universal approaches and so-called infallible remedies that inevitably fail due to a lack of contextual sensitivity (Ostrom, 2007; Partelow and Boda, 2015). In the absence of controlled experiments, sustainability sciences depend on comparative studies documenting small yet important differences consistently present in different cases.

Conclusions

This study identified how successful management models may be scaled to other SES. Two fishing SES of great ecological and socioeconomic importance were contrasted with regard to their organization and management levels. By using a social-ecological perspective, the characteristics that promote the successful implementation of strategies were identified in the context of climate change. It was found that IN is an example of this successful implementation and may provide lessons for establishing future management schemes in other SESs. To replicate the success of IN in ITS it is necessary to: 1) promote comanagement and the implementation of a cross-sectoral consortium, 2) identify any current information gaps, 3) obtain the missing data while keeping users informed and up-to-date on any progress, and 4) explore adaptive management alternatives based on the available information. These actions will enhance the adaptive capacity of ITS if they are incorporated into an adaptive management program that maintains open communication channels among all of the entities involved while promoting a transparent decision-making process. The design and implementation of management actions for ITS may constitute a preventive measure against climatic stress or potential overexploitation. The adaptation capacity of the SES may contribute to both social and ecosystem resilience.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding authors.

Author contributions

Conceptualization, CV-R, JL, and RB-L. Data curation, CV-R, JL, RB-L, AM-O, JT, and FM. Formal analysis, CV-R. Funding acquisition, JL, RB-L, JT, and FM. Investigation, JZ-D, GM-M, AM-O, JT, and FM. Methodology, CV-R, JL, RB-L, and JZ-D. Project administration, CV-R, JL, and RB-L. Resources, JL, RB-L, JT, and FM. Supervision, JL and RB-L. Validation, JZ-D,

GM-M, AM-O, and JT. Visualization, CV-R and RB-L. Writing – original draft, CV-R, JL, and RB-L. Writing – review and editing, JZ-D, GM-M, AM-O, JT, and FM. All authors contributed to the article and approved the submitted version.

Funding

This study was supported by the Environmental Defense Fund of Mexico to CV-R, RB-L, GM-M,and JL, the Walton Family, the Marisla Foundation, the Sandler Family Foundation Publisher's note to JT, the National Science Foundation DEB-1212124 and OCE1736830 to FM, and UABC internal Funds from UABC Funds to JL and RBL

Acknowledgments

We are grateful to the members of the fishing cooperative Buzos y Pescadores, the Isla Natividad community, and fishing cooperative Litoral for their participation and support of this research. We also thank S. J. Teck for the helpful suggestions that improved the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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