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LETTER

Strong collective action enables valuable and sustainable fisheries for cooperatives

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Abstract

Seafood is one of the most internationally-traded food commodities. International markets can provide higher revenues that benefit small-scale fishing communities but can also drive a decline in fished populations. Collective action in collective organizations such as fishing cooperatives is thought to enhance the sustainability of fished populations. However, our knowledge of how collective action enables fishing cooperatives to achieve positive social-ecological outcomes is dispersed across case studies. Here, we present a quantitative, national-level analysis exploring the relationship between different levels of collective action and social-ecological outcomes. We found that strong collective action in Mexican lobster cooperatives was related to both sustaining their fisheries and benefiting from international trade. In the 15 year study period, lobster cooperatives that demonstrate characteristics associated with strong collective action captured benefits from trade through high catch volumes and revenue. Despite lower (but stable) average prices, the biomass of their lobster populations was not compromised to reap these benefits. Individual case studies previously found that fishing cooperatives can support both positive social and ecological outcomes in small-scale fisheries. Our results confirm these findings at a national level and highlight the importance of strong collective action. Thus, our work contributes to a better understanding of the governance arrangements to promote fishing communities' welfare and benefits from international trade and, therefore, will be invaluable to advancing small-scale fisheries governance.

1. Introduction

Small-scale fisheries are the largest employer in the ocean economy, including major ocean-based industries such as industrial fisheries, oil and gas, shipping, and tourism combined (Kelleher and Mills 2012, OECD 2016, Bevitt *et al* 2021). However, fish populations harvested at sustainable levels decreased from 90% to 64.6% between 1974 and 2019 (FAO 2022), and small-scale fisheries are frequently less sustainable than industrial fisheries (Costello and Ovando 2019). This situation threatens the employment and livelihoods of millions of fishers and their communities. Therefore, understanding the conditions wherein small-scale fisheries can deliver positive social and ecological outcomes is of interest to researchers and policy-makers alike.

International trade offers one promising avenue to improve fishers' welfare (Dollar and Kraay 2004, Wolf 2005) when increasing demand, new sales opportunities, and increased local prices (Bhagwati and Srinivasan 2002, Asche *et al* 2015a, Giron-Nava *et al* 2019). Yet, despite the potential for financial profit, international trade has seldom benefited small-scale fishing communities (Béné *et al* 2010, Drury *et al* 2018, Ferguson 2021). Traders' and exporters' high margins, i.e. the profit from buying and selling not counting transaction and shipping costs, can deprive local communities of the benefits of international trade (Wamukota *et al* 2014, Purcell *et al* 2017, Elsler *et al* 2021). In addition, evidence shows that international trade can drive local depletion of fish populations (Crona *et al* 2016, Eisenbarth 2022), particularly those of high-priced species, by creating financial incentives that lead to overfishing (Elsler *et al* 2019). For example, high prices drove the worldwide collapse of sea cucumber populations and other taxa in the 2000s (Berkes *et al* 2006, Anderson *et al* 2011, Bennett and Basurto 2018). Thus, capturing international trade benefits without compromising their fished populations remains a significant challenge for small-scale fishers.

Collective action can enable sustainable fishing practices when fishing communities design and enforce rules to control access and use of their fishing commons (McCay and Acheson 1987, Ostrom 1990). A common approach within small-scale fisheries to achieve this outcome is to create fishing cooperatives (Pollnac 1981, Ostrom 2011, Basurto *et al* 2013). For example, well-functioning fishing cooperatives offer stable financial benefits and social security to their members (Rivera *et al* 2017, Basurto *et al* 2020, Schlüter *et al* 2021). Cooperatives can enhance revenues through bargaining greater margins and economies of scale (Cook 1995). In addition, they can succeed in making collective decisions to address problems of overfishing (Ovando *et al* 2013) and lead to sustainable harvest even when price increases from international demand (Tekwa *et al* 2019). Evidence from Mexico suggests that experienced fishing cooperatives can restrain fishing effort using precautionary approaches (Méndez-Medina *et al* 2021). In the long-term, sustainable fishing effort can lead to an equilibrium population size providing continuous and possibly high catch (Gordon 1954). Thus, fishing cooperatives have been promoted as a solution to resolve some of the most pressing challenges facing small-scale fisheries management (Deacon 2012, Hilborn and Ovando 2014, Chuenpagdee and Jentoft 2018).

Fishing cooperatives are diverse and include strong associations and pro forma groups legitimized by government policies (Jentoft 1986, Bennett 2017, Frawley *et al* 2019). Characteristics of fishing cooperatives associated with strong collective action include respect for collective-choice agreements, active monitoring, presence of conflict resolution mechanisms, and engagement in nested hierarchies of organizations (García Lozano and Heinen 2016, Lindkvist *et al* 2017, Nenadovic *et al* 2018, Méndez-Medina *et al* 2021). While these governance characteristics seem to be associated with positive social outcomes (McCay, 2014, Kalikoski *et al* 2019), positive ecological outcomes are also needed for the long-term welfare of fishing communities. Understanding which types of fishing cooperatives can promote positive social and ecological outcomes is required. One main obstacle in a systematic analysis is the lack of cross-sectional data on small-scale fisheries governance, such as cooperatives' characteristics and success. This study draws on a unique Mexican fisheries cooperatives dataset. It was collected and curated by the Coasts and Commons Co-Lab at Duke University in partnership with local collaborators in Mexico. The study measured collective action through a functionality index (Nenadovic *et al* 2018) which we combined with longitudinal landings data for each of the cooperatives included in this study.

Here, we systematically examined whether strong collective action in fishing cooperatives helps them capture the benefits of international trade without compromising their fish populations. We selected lobster-trading cooperatives from the Mexican fisheries cooperatives dataset ($N = 40$) across three coastal areas—the Pacific Ocean, the Caribbean, and the Gulf of Mexico. Spiny lobster (Panulirus sp.) is considered one of the most important small-scale fisheries globally (Defeo *et al* 2016), and in Mexico, it is primarily harvested for export markets. Lobster is a high-value species (avg. price 26 USD), with more than half of the catch destined for international markets (e.g. 59% of the catch in 2000 was exported; Sagarpa 2017). The federal government grants fishing licenses (valid for up to 5 years) or exclusive territorial user rights (TURFs; valid for up to 20 years) to lobster cooperatives. Licenses establish minimum size restrictions for fishing gear and methods (e.g. casitas cubanas, maximum numbers of traps per concession; DOF 2016). Cooperatives with TURFs participate in yearly stock assessments and self-govern the day-to-day management of their territories. Cooperatives diversify their catch composition to mitigate risk during unfavorable environmental conditions and specialize in high-value target species in good conditions (Finkbeiner 2015). This diversity of lobster cooperatives allows us to examine whether there are significant differences in biomass, catch, and revenue under the influence of international market price. Based on the previously discussed evidence, we examined the hypotheses that cooperatives with higher functionality (measured by the functionality index) capture higher revenue due to greater margins (HP1) and have higher biomass levels due to precautionary approaches (HP2). We also hypothesized that for cooperatives with higher functionality, high international price does not lead to higher catch and subsequent lower biomass levels (HP3). In addition, we expect local prices to correspond more strongly to international prices for cooperatives with higher functionality due to greater margins (HP4).

2. Materials and methods

2.1. The National Diagnostics of Fishing Organizations in Mexico dataset

The National Diagnostics of Fishing Organizations in Mexico dataset (herein: Cooperatives dataset) contains information about 199 small-scale fisheries cooperatives. This dataset is a result of a data collection effort that took place during spring and summer of 2017 in six regions across Mexico. It provides information on cooperatives' demographics, infrastructure, governance characteristics, commercialization structure, and a cooperative functionality index (Nenadovic *et al* 2018). The cooperative functionality index is a composite score consisting of five dimensions of collective action: equity, adaptability, accountability, organizational values, and operational and economic capacity. These dimensions are considered principal evaluative outcomes of institutional arrangements of collective action for long-term management of renewable natural resources (e.g. Ostrom 2005). The five dimensions were individually assessed with Likert-scale type questions, using structured surveys from three sources: cooperative members, cooperative leaders, and leaders of federations, formal organizations of cooperatives (supplementary information (SI) table 1). The cooperative functionality index is calculated as an average composite index of five dimensions, on a scale from zero to ten, from these three sources in what is termed a '360-degree' evaluation approach (Nenadovic *et al* 2018). The validity of the functionality index in explaining collective action is supported by its strong statistical correlation with possession of 54 governance characteristics that were both theoretically and empirically associated with strong collective action (Nenadovic *et al* 2018) and was further validated through a series of discussions with fishers. For the present study, we selected cooperatives that reported harvesting lobster ($N = 40$). Given that cooperative functionality is a composite index of five dimensions that mainly cover long-term indicators, we assume that the values of these indicators are relatively stable over short periods. Hence, each cooperative is assigned one fixed functionality index score for the entire timeframe of the analysis.

2.2. Mexican Landings dataset

The Mexican Landings dataset contains information about official fisheries landings in Mexico from 2000 to 2016. The records are collected and managed by the National Commission of Fisheries and Aquaculture (CONAPESCA) and consist of individual records, each representing a single fishing trip. Each record has self-reported information on the number of days and number of boats used for that trip, the species captured, the total catch and ex-vessel prices for each species, and the landing site and fishing office where the report was made. Given the self-reporting nature of this dataset, it is important to recognize the incentives that fishers have to incorrectly report catches (McCormick *et al* 2013) and its consequences for estimated fisheries reference points. We inflation corrected local prices based on the year 2016.

2.3. UN comtrade

We used the International Trade at the Product-Level dataset (CEPII 2016), a preprocessed version of the UN's Comtrade International Trade Statistics dataset (Gaulier and Zignago 2010, United Nations 2019), to identify the international price of lobster. We retrieved export prices for all transactions of commodity groups containing rock lobster and spiny lobster from 2000 to 2016. We used one average price per year to represent international lobster price and kept price in USD to represent international demand. Seafood prices can be volatile (Asche *et al* 2015b), averaging by year is necessary for comparability of the trade and the Mexican Landings dataset, but reduces the volatility of individual transactions (std. before averaging = 40.74 USD, std. after averaging = 5.62 USD). For comparison, we exchanged USD into MXN using exchange rate information of the Banco de México (2021). We assumed that the catches of Mexican cooperatives do not significantly affect international price (average volume caught by Mexican lobster cooperatives = 1037 mt; average international traded volume = 30 520 mt).

2.4. Construction of B/B_{MSY} time series

B/B_{MSY} is often used as a measure for stock status, where B is the current biomass, and B_{MSY} is the estimated stock biomass at the 'maximum sustainable yield' (MSY). MSY is the theoretical level of maximum extraction that equals the rate of population growth. In other words, the maximum that can be harvested without decreasing the population size, which ensures the long-term sustainability and economic value of the fishery. As such, values of $B/B_{MSY} \geqslant 1$ represent a healthy population, while values of $B/B_{MSY} < 1$ represent an overexploited population. To generate B/B_{MSY} estimates, we used a data-poor stock assessment method known as (CMSY) (Froese *et al* 2017) and which was further adapted for fisheries in the Gulf of California with CONAPESCA data sets (Giron-Nava *et al* 2021). This method estimates reference points using a Bayesian model to fisheries-dependent time series to generate likely distributions of B/B_{MSY} over time. It uses landing data and a qualitative estimate of stock status (B_0) and resilience (r) from published materials (Cisneros-Mata 2016). To better understand the theoretical and mathematical basis for this method, we recommend reviewing the original research by Froese *et al* (2017) as well as the application to small-scale fisheries in the Gulf of California, Mexico (Giron-Nava *et al* 2019).

In catch-only assessment methods as we have applied here, biomass and catch are not fully independent, and there is high uncertainty in estimated fisheries parameters (Ovando *et al* 2021). Since this interdependence and uncertainty cannot be eliminated due to the nature of the methods, it is crucial to interpret the results accordingly. For example, a sustained increase in catch could be identified as an improvement in biomass levels; it may also indicate overfishing that can lead to increasing catch temporarily while depleting biomass (Froese *et al* 2017). In our case, the long-term expertise of the authors in the study area allowed us to contextualize these trends. We adjusted based on expert opinion when necessary while verifying with fishing communities about perceived population health.

2.5. Generalized fishery model and regression analysis

We employed regression analysis to assess the relationship between cooperative functionality, catches, population status (B/B_{MSY}), revenue, international price, and local lobster prices. First, we interacted with two variables: cooperative functionality and international lobster price, to investigate whether cooperatives with higher functionality respond differently to international price in terms of B/B_{MSY}, catch, and revenue. We log-transformed B/B_{MSY}, catch, and revenue values so data approximated a normal distribution. We standardized predictor variables to have a mean of 0 and a standard deviation of 1

$$Y_{c,t} = \beta_0 + \beta_1 F_{c,t} + \beta_2 I_t + \beta_3 F_{c,t} * I_t + \Theta_t + \varepsilon_{c,t}$$
$$Y_{c,t} = \log(B_{c,t}) ; Y_{c,t} = \log(C_{c,t}) ; Y_{c,t} = \log(R_{c,t}) . \quad (1)$$

F represents cooperative functionality per cooperative *c* and year *t*, and *I* represents the international price for spiny and rock lobster. Year fixed effects (θ_t) control for time-varying factors that could influence stock status, catch, and revenue. We used the Newey–West estimator to calculate standard errors, which is robust in the presence of temporal autocorrelation with lags up to three years and in the presence of heteroskedasticity (Newey and West 1986). The dependent variable *Y* is the logarithm of three variables: *B*, represents B/B_{MSY}; *R*, represents revenue; *C*, represents catch. We also regressed local prices against international price:

$$L_{c,t} = \beta_0 + \beta_1 I_t + \Theta_t + \varepsilon_{c,t} \quad (2)$$

where *L* is the local price, and *I* is the international price for spiny and rock lobster (corresponding to the species caught in Mexico).

Finally, we regressed local prices against cooperative functionality and their interaction with international price (international price times cooperative functionality). We also used the Newey–West estimator for equations (2) and (3) to estimate standard errors

$$L_{c,t} = \beta_0 + \beta_1 F_{c,t} + \beta_2 I_{c,t} + \beta_3 F_{c,t} * I_{c,t} + \Theta_t + \varepsilon_{c,t} \quad (3)$$

where *L* is the local price, *F* is cooperative functionality, and *I* is the international price for spiny and rock lobster. The regressions were implemented in RStudio version 1.1.463 (RStudio Team 2020) and R version R 4.0.3 (R Core Team 2020), using the package 'Sandwich' (Zeileis *et al* 2020) for the calculation of the Newey–West standard errors. We did not use the pre-whiting setting (i.e. the removal of an autocorrelated trend in a time series) which is a default setting for the Newey–West algorithm in the Sandwich package, as advised for large sample sizes ($N > 100$; Bayazit and Önöz 2007). We fitted all distributions separately for each year to a log-normal distribution (Brynjarsdóttir and Stefánsson 2004). We found no *p*-value smaller than 0.05, indicating that the assumption of a log-normal distribution was appropriate. Residual plots were studied for deviations, and no apparent deviations were found.

3. Results

We found evidence of strong collective action in Mexican lobster cooperatives (figure 1). The cooperative functionality index is meant to capture the level of collective action of a fishing cooperative. The average functionality of lobster cooperatives was higher than cooperatives targeting other species (lobster cooperatives averaged 7.15; average across all species was 6.53). Functionality ranged across the higher half of the spectrum; the lowest-functioning lobster cooperative had a functionality level of 4.71 and the highest-functioning cooperative of 9.61 (SI table 2).

3.1. Higher cooperative functionality was associated with higher biomass, catch, and revenue

Based on data from fishing cooperatives across Mexico (Nenadovic *et al* 2018) and international price for spiny and rock lobster from 2000–2016 (United Nations 2019), we found that cooperatives' functionality value had a positive and significant relationship

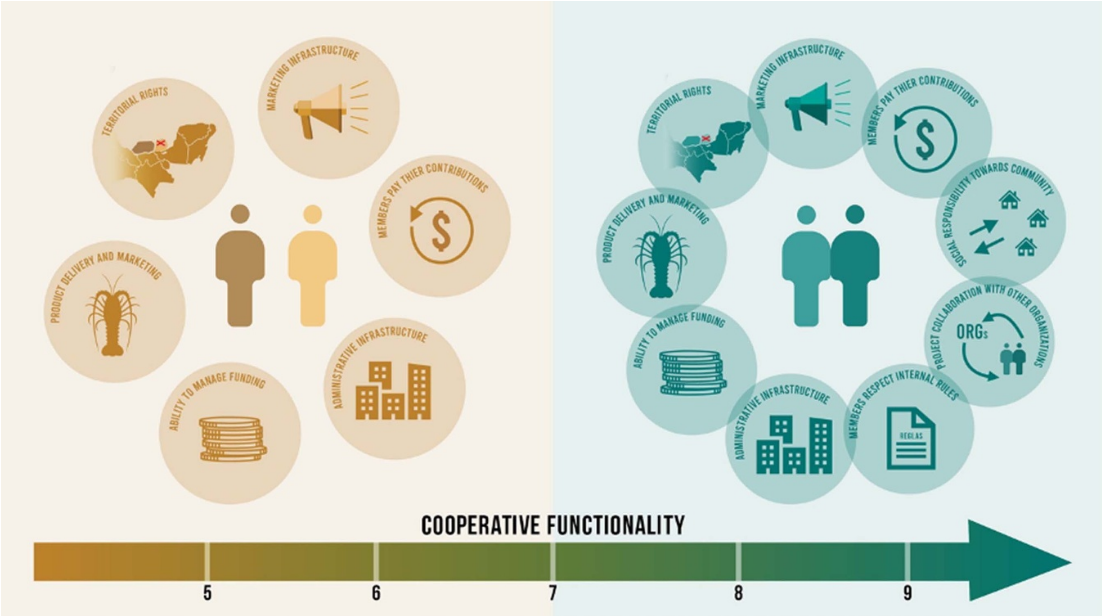

Figure 1. Conceptual figure identifying common governance characteristics associated with cooperatives with low (left) and high (right) scores on the functionality index, a composite index based on five dimensions of collective action. Cooperatives with lower functionality are characterized by exclusive territorial user rights (TURFs), marketing infrastructure, members paying their contributions, administrative infrastructure, an ability to manage funds, and product delivery and marketing (figure 1). In addition to the characteristics of lower functionality, cooperatives with higher functionality are characterized by their social responsibility towards communities, project collaboration with other organizations, and members' respect for internal rules.

Table 1. Regression results for B/B_{MSY}, catch, and revenue using cooperative functionality, international price for lobsters, and their interaction term as regressors.

	B/B_{MSY}	Catch	Revenue
Functionality	0.061**	0.935***	0.587***
	(0.02)	(0.062)	(0.058)
International price	−0.008	0.15	−0.24**
	(0.017)	(0.078)	(0.076)
International price *x* Functionality	−0.009	−0.0065	−0.017
	(0.012)	(0.038)	(0.037)

Significance codes: 0 '***' 0.001 '**' 0.01 '*'. Standard error in parentheses.

to B/B_{MSY}, catch, and revenue (table 1). Our initial hypothesis that cooperatives with higher functionality capture higher revenue (HP1) and have higher biomass levels (HP2) was supported by our analysis. The average B/B_{MSY} of cooperatives was 0.821 (std. 0.192); increasing functionality by one point was associated with a 0.061 increase in B/B_{MSY}. In addition, we found a positive relationship between functionality and catch (figure 2, SI figures 1 and 2). An increase in cooperative functionality by 1 point was associated with an average increase in catch volume of 29 424 kg (R squared = 0.31).

3.2. International trade prices had no effect on biomass and catch, but on revenue

Our third hypothesis that for cooperatives with higher functionality, high international price does not lead to higher catch and lower biomass levels (HP3) was not supported. International price and the interaction term of international price with cooperative functionality did not significantly relate to B/B_{MSY} (table 1). In fact, none of the interaction terms with cooperative functionality was significant (table 1). However, international price was negatively correlated to revenue, which is likely explained by the correlation with the local prices discussed below (section 3.3).

3.3. Cooperatives with lower functionality receive higher prices from international trade

A majority of lobsters caught in Mexico are destined for international markets (SAGARPA 2017). Across the years, the local prices cooperatives received were equivalent to 74.86% of the international trade price. The average price cooperatives received for lobsters was 254.32 MXN kg^{-1}, and the international trade price was 357.15 MXN kg^{-1}. To better understand local and international price dynamics, we examined whether local prices correspond more strongly to international price for cooperatives with higher functionality. In contrast to our hypothesis (HP4), the price data revealed evidence for a small significant and negative relationship between these variables (table 2), indicating that cooperatives with lower functionality might capture greater margins of the international market price. Finally, if cooperative functionality was not controlled for, local prices were also significantly and negatively correlated with the international price (table 2).

Table 2. Regression results for local price using cooperative functionality, international price for lobsters, and their interaction term as regressors.

	Local prices	Local prices
International price (MXN)	−0.126* (0.045)	−0.12* (0.057)
Functionality	−0.313*** (0.045)	
International price *x* Functionality	0.001 (0.028)	

Significance codes: 0 '***' 0.001 '**' 0.01 '*'. Standard error in parentheses.

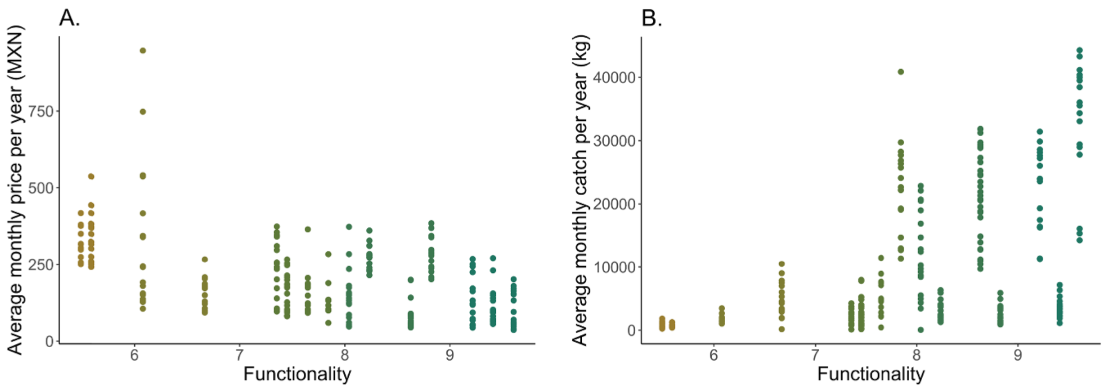

Figure 2. Average monthly local price (left) and catch (right) of lobster per cooperative from 2000 to 2016. Coloring is by cooperative functionality bin, see figure 1.

3.4. Cooperatives with higher functionality got low but stable local prices for their catch; cooperatives with lower functionality got higher but variable prices

Our hypothesis in section 3.3 was rejected by the regression analysis (table 2). Therefore, we further assessed the relationship between local price and cooperative functionality. All cooperatives' yearly average local prices increased between 2000 and 2016, from 224 to 325 MXN. The local prices observed for cooperatives showed that cooperatives with lower functionality generally receive high prices, whereas cooperatives with higher functionality received lower prices (figure 2). This observation is additionally supported by the significant and negative relationship between cooperative functionality and local price when international price was a covariate (table 2). However, cooperatives with high functionality received more stable local prices as measured by the standard deviation (SI figure 3).

4. Discussion

Our findings show that strong collective action in fishing cooperatives is related to sustainable target population biomass and stable benefits from international trade in small-scale fisheries. Higher-functioning cooperatives were associated with significantly higher revenue than lower-functioning cooperatives while securing higher lobster biomass (HP1 & HP2). In addition, they captured stable local prices per unit of lobster. However, our findings show that Mexican lobster cooperatives differ in their ability to capture benefits from trade and can thus help differentiate in which cases improving the sustainability of fisheries may or may not help improve livelihoods (Giron-Nava *et al* 2021). We found that lower-functioning cooperatives captured significantly higher local prices albeit had lower catches and biomass (HP4). Thus, the lower fisheries sustainability may help provide short-term profit but not help improve livelihoods in the long-term. We found no evidence for a relationship between international trade price with catch and biomass (HP3); we only found a negative relationship with revenue and local price. This result indicates that higher-functioning cooperatives benefitted less from high-value than from high-volume trade. In sum, higher-functioning cooperatives can help deliver long-term, positive social and ecological outcomes in small-scale fisheries, yet, the relationship to trade requires further investigation.

Our findings contrast with previous research, which suggested that access to international markets compromises sustainability while not providing better income for fishers (Béné *et al* 2010, Frawley *et al* 2019). We observed enduring high catch volumes in higher-functioning cooperatives, alongside sustainable and locally abundant populations. In particular, members' compliance with internal rules, was only present in higher-functioning cooperatives and is vital for sustainable management (Ostrom 1998). When cooperative members impose, follow, and enforce additional and stricter regulations for their members, they can limit fishing effort or the portion of biomass harvested (Méndez-Medina *et al* 2021). For example, in the Pacific Ocean, higher-functioning cooperatives limit the maximum number of chambers per trap, amount of bait, and conduct random checks on members (McCay *et al* 2014). Thus, fishing effort in these cooperatives can be adjusted to the abundance of target populations. Maintaining sustainable population levels might have enabled higher-functioning cooperatives to preserve high catch volumes, leading to higher long-term revenues.

We found that lower-functioning cooperatives captured significantly higher local prices. Our conversations with cooperative leaders indicate that higher-functioning cooperatives often secure predetermined sales quotas at the beginning of the season (Basurto 2020). Accepting lower prices might be economically feasible for these cooperatives because they ensure the purchase of their high catch volumes, reducing the sales risk of their highly perishable product (Wilson 1980). Cooperatives may cover foregone costs associated with the economies of scale of marketing higher catch and processing volumes (Mankiw and Taylor 2020). In contrast, lower-functioning cooperatives' might be more constrained by costs due to smaller catch volumes, entering the industry only when spot prices are high (Smith 1968, Tekwa *et al* 2019). Hence, our analysis reinforces the idea that higher-functioning cooperatives capture a greater catch volume and a higher revenue even if the average price per unit of catch is lower.

While it is critical to quantify outcomes of small-scale fisheries governance, our results need to be interpreted with care and open up new possibilities for future research. First, biomass and catch are not fully independent in catch-only biomass estimates (Ovando *et al* 2021). Thus, future work must provide independent stock assessments to increase the reliability of the results presented here. Second, different approaches to lobster management (licensing, concessions, TURFs) can alter incentives for local governance, which would require data not available here. Third, we did not account for the distribution of revenues within the cooperatives. Inequality in benefit distribution differs with different fishing rights allocations (Villanueva-Poot *et al* 2019) and is increasingly recognized as important to determining social success in small-scale fisheries (Österblom *et al* 2020, Elsler *et al* 2021). Thus, future work could investigate how benefits are distributed within cooperatives. Fourth, the relationships—or lack therein—between international trade price with biomass, catch, revenue, and local price opposed previous findings (Clark 1976, Lenzen *et al* 2012), creating the need for studying the underlying causal mechanisms of these relationships. While we can interpret our findings in the context of other studies, a better causal understanding is a necessary next step to inform initiatives aiming to promote successful small-scale fisheries and international trade opportunities and threats.

Our findings have important implications for small-scale fisheries policies. At the national level, lobster is among Mexico's most strictly managed small-scale fisheries populations (Pérez-Ramírez *et al* 2012). Combining exclusive TURFs with compliance allows cooperatives to internalize the benefits of long-term sustainable harvest (Schlager and Ostrom 1992). In this way, small-scale fisheries policies can lay the foundation for successful fishing cooperatives. In addition, our research highlighted the differences between cooperatives' functionality. Investment in social capacity, such as building trust to strengthen fishing cooperatives as a form of governance (Schlüter *et al* 2021, Ouréns *et al* 2022) and leadership training (Andersson *et al* 2020), are relevant ways to strengthen collective action.

Reversing the trend of unsustainable fishing is vital to continue supporting small-scale fisheries as the largest employer in the ocean sector (FAO 2022). In support of previous case studies, we found across Mexico that fishing cooperatives can support positive social and ecological outcomes in small-scale fisheries (Hilborn *et al* 2005, Martin *et al* 2007). Importantly, our analysis highlights that these benefits were primarily associated with strong collective action. Yet, the relationship with international trade warrants further investigation. Higher-functioning cooperatives in our study were able to sustainably govern small-scale fisheries. Promoting fishing cooperative formation for positive social and ecological outcomes must be based on understanding how to strengthen collective action. Thus, small-scale fisheries policies aimed at enhancing collective action in fishing cooperatives can make a real difference. The assessment of fishing cooperatives with different governance characteristics against social-ecological outcomes is a first necessary step provided by this study to consider appropriate policies.

Data availability statement

The data generated and analysed during the current study are not publicly available for legal/ethical reasons but are available from the corresponding author on reasonable request.

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Conflict of interest

The authors of this work declare no conflicts of interest.

Ethics statement

The collection of the Mexican Fisheries Cooperatives dataset was approved by the Duke University ethics council.

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