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Assessing the economic viability of small-scale fisheries: an example from Mexico

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ABSTRACT: Small-scale fisheries (SSF) are generally understudied, their impacts on marine ecosystems not well documented and their vulnerability to large-scale change processes not fully recognized. A better understanding of the dynamics and underlying drivers of SSF is imperative given their important contributions to local economies and community wellbeing. We argue that an assessment of the economic viability of SSF can help improve governance for this sector. Economic viability is defined here as the net benefit to society from fisheries, accounting for subsidies that represent a private benefit to fishing sectors but a cost to society at large, that is above or equal to zero over time. We developed an approach to assess economic viability using data that is often available at national scale, including estimates of total revenue from fishing, total costs of fishing, and fisheries subsidies for SSF and large-scale fisheries (LSF). We applied the methodology to Mexican fisheries and found that LSF receive subsidy amounts disproportionate to their landings and employment numbers relative to the SSF sector; when these subsidies are taken out, SSF are generally more economically viable than their LSF counterparts. To improve the economic viability of SSF, key recommendations include the redirection and redistribution of subsidies, better monitoring, and improved access to data.

KEY WORDS: Economic viability · Financial viability · Fisheries subsidies · Mexican fisheries · Artisanal fisheries · Net benefits to society

1. INTRODUCTION

Despite the fact that ca. 44% of all fishers work in small-scale fisheries (SSF) in the primary production sector and that fisheries provide livelihoods for millions of people (Béné et al. 2010, Teh & Sumaila 2013), SSF worldwide are often politically and economically marginalized (Pauly 1997, Allison & Ellis 2001, Chuenpagdee 2011). This implies that they not only face geographical displacement or barriers to financing and markets, but also that their needs are not represented in management decisions (Pauly 1997, Berkes et al. 2001, Jentoft et al. 2017). Additionally, these coastal community-based fisheries are understudied (Jacquet & Pauly 2008) and face pressures from global market shifts, climate change and large-scale (industrial) fisheries (LSF) development (Kaczynski & Fluharty 2002, Béné et al. 2010, Lam et al. 2012).

LSF are not only more technologically advanced than their small-scale counterparts, but are often given advantages at economic and political levels by governments (Pauly 1997, Chuenpagdee & Bundy

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2006, Schuhbauer et al. 2017). For example, LSF are estimated to receive 84 % of global fisheries subsidies (Schuhbauer et al. 2017), policies and national management strategies are often geared towards LSF and overlook SSF, and most fisheries research focuses on LSF (Pauly 1997, Chuenpagdee & Bundy 2006, Chuenpagdee 2011).

We argue that an economically viable fishery generally has a relatively higher adaptive capacity and thus is better prepared to face various types of stressors. Economic viability (EV) in fisheries, however, has not been clearly defined until recently (Schuhbauer & Sumaila 2016), and its assessment mainly focused on profitability or returns on investment in a similar fashion to financial viability (FV; Lery et al. 1999). Furthermore, EV is an important cornerstone when it comes to developing management and policies towards sustainable fisheries (Eisenack et al. 2006, Cissé et al. 2015, Schuhbauer & Sumaila 2016). Here, we considered a fishery to be economically viable when its net benefits to society from fishing — excluding subsidies paid by the public to private fishing firms — were non-negative over time (Schuhbauer & Sumaila 2016). Looking beyond the FV of the private sector is especially important for SSF, which are often part of local culture and do not only focus on profitability (Kronen 2004, Hospital & Beavers 2012).

A variety of approaches already exist to assess a fishery's viability that are not only limited to financial dimensions, the majority of which are based on viability theory (Doyen et al. 2013, 2017, Hardy et al. 2016, Oubraham & Zaccour 2018). While some have successfully captured the socio-economic and ecological dynamics of SSF, they depend on mathematical modelling and detailed data sets (Hardy et al. 2013, 2016, Cissé et al. 2015), which are not readily available in most SSF (Charles 2011).

This article develops a relatively simple approach to assessing the EV of SSF, looking beyond the financial dimension. Using data available for Mexican fisheries as an example, we compare SSF to LSF and focus the discussion on what policies and management strategies could help increase the SSF's EV.

2. MATERIALS AND METHODS

We use the term EV to refer to the net benefits generated for society by a given fishing sector. Subsidies from the public sector that lower costs or increase revenue for the fishing sector (Sumaila et al. 2010) are excluded from the profit function because they are a cost to society that could potentially have been invested elsewhere (Schuhbauer & Sumaila 2016). On the other hand, a fishery would be financially viable when net benefits from fishing to the private sector, including any subsidies received, are non-negative (Schuhbauer & Sumaila 2016). Therefore, in this study, the key difference between EV and FV are subsidies, which are paid by taxpayers through governments. The key economic attributes, assessment approach and a comparison with FV are described in the following sections.

2.1. Analysis of key attributes

We start by defining total revenue (TR) generated from fishing, total cost of fishing, and fisheries subsidies received (Table 1), which are the key elements that together constitute EV. TR is calculated as follows:

$$\mathrm{TR} = P \times \mathrm{TL} \tag{1}$$

where P denotes ex-vessel prices and TL is total fisheries landings. TR is calculated for each year, t, as:

$$\mathrm{TR}_t = \Sigma_{u=1}^{U}(\mathrm{TR}_t)_u \tag{2}$$

where u (unit) represents a fishing vessel or a fishing company that owns more than one vessel and U denotes the total number of units in each year, t. Total costs of fishing (TC) are calculated as follows:

$$\mathrm{TC} = \mathrm{VC} + \mathrm{FC} \tag{3}$$

where VC represents variable costs, consisting of fuel, maintenance, running costs (e.g. docking fees) and labour. In the case of SSF, where vessel owners often operate the vessel and/or crew incomes are directly related to daily catch, labour costs are assumed to be equal to opportunity cost. FC denotes fixed costs, which consist of vessel and gear depreciation and interest paid on capital costs.

Similar to TR, TC is calculated as:

$$\mathrm{TC}_t = \Sigma_{u=1}^{U}(\mathrm{TC}_t)_u \tag{4}$$

It is important to mention that available information on the cost of fishing is mostly at the level of individual fishing vessels. This data was then scaled up to estimate the cost of fishing for a country, region, or fishing sector (e.g. SSF or LSF).

Fisheries subsidies are direct or indirect financial transfers from public entities (i.e. from tax revenues) to private firms (here, the fishing sector) (Milazzo 1998, OECD 2006a). Many different forms such as

Table 1. Elements of economic viability; the geographical scale and time frame of the attributes depend on the study's objectives

Economic attributes (units)	Definition	Sources and measures
Landings (t)	Amount of fish, in weight, landed in all ports by a given fishing sector during the study period (this includes bycatch if it has not been discarded) For case studies, check literature, e.g. government reports, conduct surveys, and monitor the landings	For national numbers, see FAO (http://www.fao.org/fishery/countryprofiles/search/en) and the Sea Around Us Project (SAUP; specifically, catch reconstruction data) database (www.seaaroundus.org)
Ex-vessel price (USD)	Price received by fishers at the dock or landing site per unit weight of fish (Sumaila et al. 2007)	For national numbers, see Fisheries Economic Research Unit (FERU) and SAUP database (Sumaila et al. 2007, Swartz et al. 2013) For case studies, check literature e.g. government reports, conduct surveys, log book, buyer records
Total cost of fishing (USD)	Total cost represents the value of inputs at the next alternative best use. Cost is split up into fixed costs, which do not change with production (e.g. capital investment), and variable costs, which can vary based on inputs and outputs (e.g. fuel, crew, maintenance, refrigeration). Total cost includes opportunity costs, here represented as labour costs, which makes it different from accounting cost (Lam et al. 2011)	For national numbers, see FERU database (Lam et al. 2011) For case studies, check literature, e.g. government reports and/or conduct surveys
Subsidies (USD)	Subsidies are defined here as financial transfers, direct or indirect, from public entities to the fishing sector, which help the sector become more profitable than it would otherwise (Sumaila et al. 2010)	For national numbers, see Sumaila et al. (2016) For case studies, check literature, e.g. government reports and conduct surveys and interview key informants

financial assistance, tax breaks, fisheries management, and research, as well as direct capital infusion are considered fisheries subsidies (see e.g. Abdallah & Sumaila 2007). Subsidies have been categorized, depending on their expected impact on fish stocks over time, into beneficial, capacity-enhancing, and ambiguous (Sumaila et al. 2010). Here, the total amount of subsidies will be used regardless of the category and whether they are cost-reducing or revenue-enhancing types; they all come from taxpayers (society) with the aim of benefiting the fishing sector (private sector).

The amount of total subsidies (TS) received by each fishing sector is calculated as:

$$\mathrm{TS}_t = \Sigma_{u=1}^{U}(\mathrm{TS}_t)_u \quad (5)$$

Note that subsidy amounts can be further divided by number of boats, number of firms, or number of fishers, for comparing across sectors, regions, or countries, depending on data availability.

2.2. EV and FV

To assess EV, we computed net economic benefits from fishing based on Eqs. (1) to (4). A given fleet, f, is economically viable when EV(f) is equal to or above zero:

$$\mathrm{EV}(f)_t^S = \mathrm{TR}_t^S - \mathrm{TC}_t^S \quad (6)$$

where the superscript, S, denotes society. It is important to note that undistorted costs and revenue were used here, i.e. subsidies were not included, and are therefore not subtracted. FV, as in net benefits to the private sector, on the other hand, is calculated as expressed in Eq. (7). FV(f) is achieved when the value is equal to or above zero:

$$\mathrm{FV}(f)_t^\rho = \mathrm{TR}_t^\rho - \mathrm{TC}_t^\rho + \mathrm{TS}_t \quad (7)$$

where the superscript, ρ, denotes the private sector.

The key difference between Eqs. (6) & (7) is the amount of subsidies (Eq. 5). Given that subsidies paid to fishers are a transfer from taxpayers, the EV calculation does not include them. The FV calculation, on the other hand, includes subsides, as benefits that each fishing unit receives (Eq. 7).

3. CASE STUDY: MEXICO

We applied the approach to Mexico, using available national-level fisheries data. The country's marine SSF fleet is generally understudied and largely unregulated (Cisneros-Montemayor et al. 2013, Teh & Sumaila 2013), despite being among the largest SSF globally, based on catch and employment. Research emphasis has been on LSF, such as those for sardine, tuna and shrimp (e.g. Garcia-Caudillo et al. 2000, Lluch-Cota et al. 2007, Ishimura et al. 2013, Punt et al. 2016). The SSF sector in the country comprises around 70 000 small fiberglass boats, catching around 900 000 t of fish and invertebrates each year (Cisneros-Montemayor et al. 2013). Some regional and local studies, as well as efforts by national government institutions, have illustrated the social, economic, political, and ecological importance of SSF in Mexico (e.g. Smith et al. 2009, Cisneros-Mata 2010, Salas et al. 2011). The Mexican SSF sector is embedded in a wide cultural context providing food and employment for hundreds of thousands of people and contributing to coastal social and economic development (OECD 2006c, Lluch-Cota et al. 2007).

Mexican SSF are very diverse and complex. They are similar to fisheries elsewhere, yet face a wide range of challenges including limited political power and a lack of communication and trust between managers and fishers, leading to mismanagement and marine ecosystem degradation (Young 2001, Cudney-Bueno & Basurto 2009, Espinoza-Tenorio et al. 2011, Zepeda-Domínguez et al. 2017). Additionally, Mexican SSF sometimes encounter extreme climate fluctuations and variability caused by El Niño and climate change (Collins et al. 2002, Pérez-Brunius et al. 2006, Sumaila et al. 2014). Other concerns include limited and unfair access to fishing rights, limited or no funding for monitoring and enforcement, and declining marine resources (Salas et al. 2007, Bueno & Basurto 2009, Cisneros-Mata 2010). It is therefore important to understand the EV of each fishing sector (SSF and LSF) at a national and a wider regional level in Mexico and elsewhere, and the role subsidies play in these sectors.

3.1. Defining Mexican SSF and LSF

Based on the definition of the Mexican National Commission of Fisheries and Aquaculture, the marine small-scale fishing sector includes artisanal commercial fisheries; most sell their catch at local markets and often keep a portion of it for household consumption. The vast majority of SSF use 'pangas', i.e. open-deck fiberglass boats around 7 m in length, usually with 50–115 hp outboard engines. The most common fishing gears used are gillnets, hook-and-line, hookas (a regulator and on-board air-compressor), traps, and a range of small bottom-trawl nets. Large-scale (or industrial) fisheries, on the other hand, include vessels with a covered deck, inboard engine (almost exclusively diesel) and mechanical winches to operate fishing gear like otter trawls, purse-seiners and longlines. A sizable LSF fleet operates in coastal areas, mainly targeting shrimp and small pelagic fishes (e.g. sardines), while some fish offshore targeting tunas and billfishes. Although recreational fisheries in Mexico are important for some regional economies and interact with marine ecosystems and other fisheries (Cisneros-Montemayor et al. 2012), they were not included in the assessment carried out in this study.

Fisheries on the Atlantic and Pacific coasts of Mexico, especially LSF, can be quite different. The LSF on the Pacific coast mainly depends on shrimp, sardine and tuna, whereas most boats on the Atlantic coast target finfish and shrimp (OECD 2006b, Conapesca 2013, Cisneros-Montemayor et al. 2013). To capture these differences, both regional (Pacific and Atlantic) and national assessments were carried out.

3.2. Data sources

Fisheries-specific studies and government reports are the key sources of information used for EV assessment (OECD 2006b, Cisneros-Montemayor et al. 2013, Conapesca 2013, Ramírez-Rodríguez & Almendárez-Hernández 2013). While little is known about the main economic indicators needed for the estimation (i.e. costs, revenues, and subsidies) and their impact on SSF compared to LSF over time, we made use of existing data sources (Table 2). More detailed descriptions can also be found in the Supplement at www.int-res.com/articles/suppl/m617p365_supp.pdf, including a table (Table S1) displaying number of boats per fishing sector and fuel prices over the years studied and used here to estimate the total cost of fishing. The analysis covers the period from 2000 to 2012 at national as well as regional levels.

Table 2. Main economic indicators of Mexican fisheries and associated data sources

Economic attributes (units)	Data sources
Landings (t)	Sea Around Us (Cisneros-Montemayor et al. 2013) for 2000–2012 (www.seaaroundus.org)
Ex-vessel price (USD)	Sea Around Us and Fisheries Economic Research Unit databases and the National Commission of Aquaculture and Fishing annual fisheries reports (Conapesca; www.conapesca.sagarpa.gob.mx/wb/) (Conapesca 2013, Swartz et al. 2013)
Total cost of fishing (USD)	Calculation based on data from cost structure (fixed and variable costs) of individual fishing units, scaled up to fishing fleets, and used changes over time of cost of fuel and vessel numbers (Table S1 in the Supplement at www.int-res.com/articles/suppl/m617p365_supp.pdf) to create a timeline (2000–2012) for both SSF and LSF, national and regional levels LSF: data was used from shrimp, sardine, and tuna fisheries and scaled up using number of boats to the whole fishing fleet (Gillet 2008, Agroprospecta 2010, Lam et al. 2011). Fixed costs were estimated based on Lasch (2005) SSF: information was used from OECD (2006b), Lam et al. (2011), Ramírez-Rodríguez & Almendárez-Hernández (2013)
Subsidies (USD)	Data was gathered from fisheries reports, Conapesca annual reports, peer-reviewed articles, OECD reports and gray literature (OECD 2006b, Lara & Guevara-Sangines 2012, Ramírez-Rodríguez & Almendárez-Hernández 2013, Sumaila et al. 2016). Once we gathered information on total subsidies for each year (2000–2012), data from Conapesca annual reports were used to split annual subsidies into SSF and LSF for each year at a national and regional level

3.3. EV and FV

Using data sets from the years 2000 to 2012 for Mexican SSF and LSF, both at a national and regional (Pacific and Atlantic) level, we applied Eqs. (1) to (5) to calculate TR, TC, and TS, and Eqs. (6) & (7) to compute EV and FV over time, respectively.

To make sure that our numbers were comparable over time and comparable to studies from other countries, we expressed monetary values in constant 2015 USD using currency conversion rates from Mexican Peso to USD (Feenstra et al. 2015) and the Consumer Price Index to convert amounts from real to constant USD (World Bank, http://data.worldbank.org/indicator/FP.CPI.TOTL).

4. RESULTS AND DISCUSSION

4.1. TR

Although SSF landed about half of Mexican total fisheries landings (sum of landings 2000–2010) (Cisneros-Montemayor et al. 2013), their TR on average from 2000 to 2012 was ca. 3 times higher than for LSF at the national scale (Table 3). The main reason for this is that a high percentage of LSF landings (especially on the Pacific coast) is not for direct human consumption and therefore fetches lower prices (e.g. sardine fisheries) than most other fish and seafood (Conapesca 2013). We also found that estimated TR from fishing has decreased for LSF and increased for SSF over time (Fig. 1).

When assessing the regional differences in TR by fishing sector, both Atlantic and Pacific SSF as well as Pacific LSF demonstrated increases in TR with peaks around 2004, 2006 and 2007, whereas Atlantic LSF showed a clear decline by over 90% over the 13 yr study period (Fig. 1). Target species varied not only between the 2 fishing sectors but also across the 2 regions. TR trends can therefore be explained by both changes in prices and resource availability (reflected in landings). For example, the decline of LSF TR could be due to the drop in large-scale shrimp catches and landed value (Cisneros-Montemayor et al. 2013), which makes up over 60% of the total landed value of large-scale fishing in both regions combined.

For SSF, both landings and landed values increased over time for the Pacific region (Table 2, Fig. 1), despite (or maybe because of) the fact that the number of vessels in the sector decreased in the same period of time (Table S1 in the Supplement). This indicates that prices for SSF landings did not decline, at least in the Pacific region.

Table 3. Economic viability assessment of small- and large-scale fisheries (SSF and LSF) averaged over the years 2000 to 2012. All values are in constant 2015 million USD. Data are mean ± SD

	Pacific		Atlantic		National	
	LSF	SSF	LSF	SSF	LSF	SSF
Total revenue	583 ± 83	1203 ± 229	128 ± 95	808 ± 109	711 ± 101	2011 ± 288
Total cost of fishing	458 ± 44	1124 ± 108	220 ± 23	845 ± 120	678 ± 67	1969 ± 225
Economic viability	125 ± 103	79 ± 298	−92 ± 105	−37 ± 146	33 ± 152	42 ± 420
Subsidies	122 ± 52	46 ± 25	10 ± 6	4 ± 3	132 ± 56	51 ± 27
Financial viability	246 ± 122	125 ± 307	−82 ± 104	−33 ± 146	165 ± 140	92 ± 429

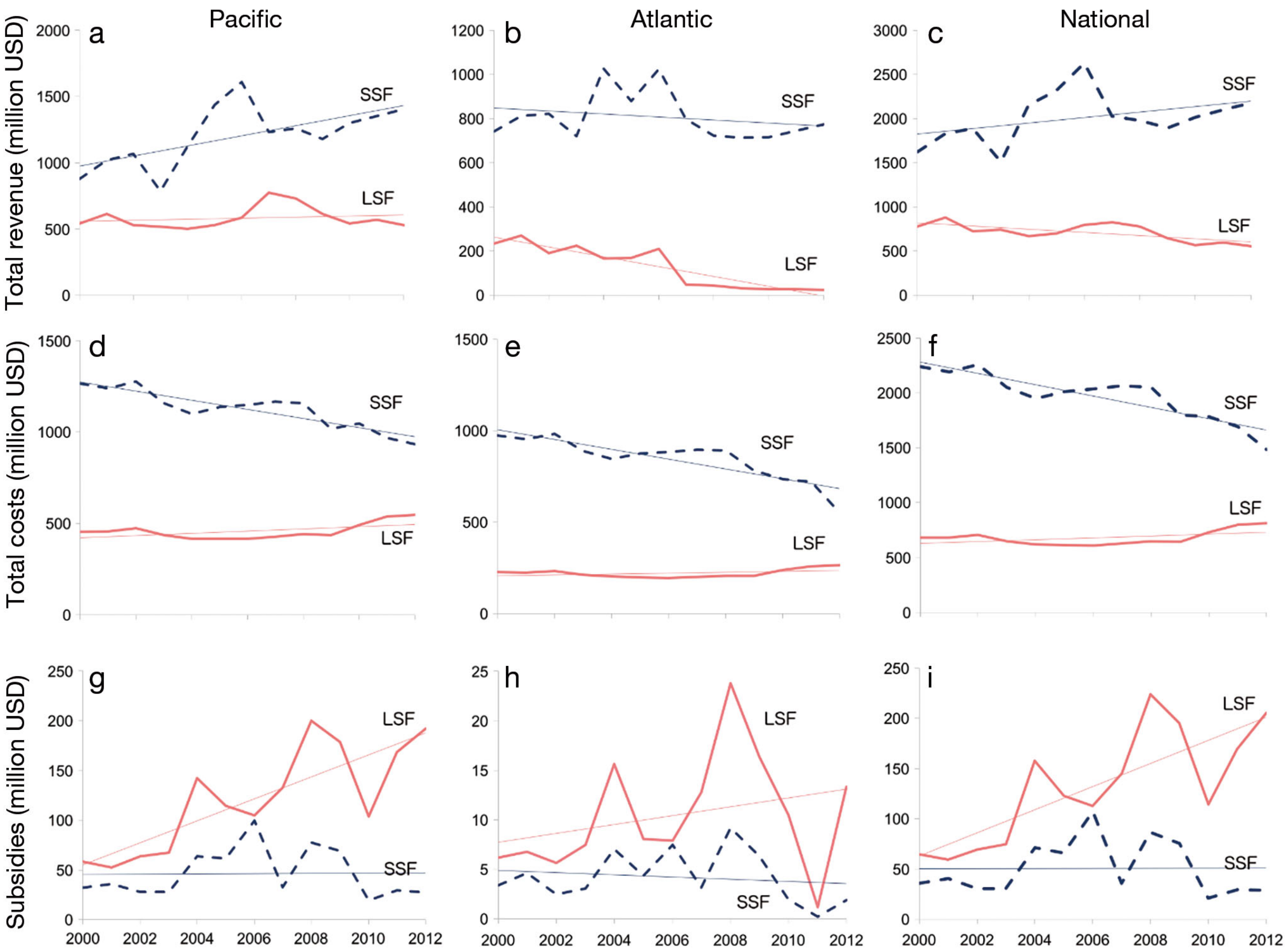

Fig. 1. Total (a–c) revenue from fishing, (d–f) cost of fishing and (g–i) fisheries subsidies presented in constant 2015 million USD for Mexican small- (SSF) and large-scale fisheries (LSF) from 2000 to 2012. Solid straight lines show linear regressions

4.2. TC

There are ca. 20 times more active SSF than LSF vessels in Mexico on average (Table S1), with aggregate costs higher for SSF compared to LSF (Fig. 1). Not surprisingly, however, results show that the annual cost for an individual large-scale fishing vessel, on average, is almost 10 times higher than the cost of a small-scale vessel (ca. 200 000 vs. 20 000 USD, respectively). TC estimated from 2000–2012 for LSF increased by around 20%, whereas it decreased by over 30% for SSF in the same period (Fig. 1) due to a reduction in the fleet.

Trends in national TC over time were very similar when broken down into regions for both SSF and LSF (Fig. 1). The number of fishing vessels in SSF dropped by around 35% whereas the decrease was only around 11% in LSF. This partly explains the decrease in TC for SSF and increase for LSF. Looking into the trends of costs per boat over time by sector and region, results indicate an increase in costs per boat for LSF both on the Atlantic and Pacific coasts, whereas they reveal a decrease for SSF reflected by the price of fuel and number of fishing vessels (Table S1 shows fuel prices and number of boats in each sector over time), because fuel makes up a large percentage of the TC. Prices for diesel fuel increased by almost 30% from 2000 to 2012, which is reflected in the increase in the cost per vessel in LSF. Gasoline prices, on the other hand, did not increase as drastically (Table 2), which helped the cost of fishing per boat for SSF to stay more stable.

In addition to the number of fishing vessels active in each sector, the number of hours and days fished each year was also a key factor in the cost calculation. However, due to a lack of more detailed information, these are assumed to have stayed constant over the years. This assumption, while simplifying our analysis, creates uncertainty, as fishers likely changed their behaviors over the 13 yr of the study period. Fishers might be traveling further and fishing for more hours to help make up for changes or declines in near-shore availability of marine resources (Sagarin et al. 2008, E. Finkbeiner pers. comm.). Additionally, the number of boats used in this study were based on government reports, and for SSF, had not changed between 2000 and 2009, either in the Atlantic or the Pacific region (Table S1), which might be due to the lack of effective monitoring of the number of active boats. Nonetheless, we believe, despite a possible under- or overestimation of active boats due to lack of monitoring, the bias is consistent throughout the years because the data source is the same.

4.3. TS

As shown in Schuhbauer et al. (2017), LSF globally receive more subsidies than SSF, and the majority of subsidies are capacity-enhancing. The same trend was observed in Mexico. On average, from 2000 to 2012, our analysis showed that LSF in Mexico received over 70% of TS, with yearly subsidies to this sector increasing from 59 million USD to 192 million USD over the study period. This is similar to previous estimates showing that LSF in Mexico received over 83% of total subsidies in 2011 (Lara & Guevara-Sangines 2012). Further, while subsidies provided to Mexican fisheries increased overall, the proportion that SSF received compared to LSF declined drastically between 2000 and 2012 (Fig. 1), despite the fact that the SSF sector employs more people and also takes about half of total fisheries catches.

The regional analysis revealed that the Atlantic region of the country receives much less subsidies than the Pacific region for both SSF and LSF. However, both SSF and LSF in this region are smaller in regard to catch, number of people and number of boats compared to the Pacific, so we calculated the amount of subsidies per fishing vessel for the study period. Results showed that on average, an SSF and an LSF vessel on the Pacific coast receives around 8 and 9 times, respectively, more subsidies than one on the Atlantic coast. While individual vessel capacity was not considered in this calculation and LSF vessels vary greatly depending on their gear and target species (e.g. tuna vessels in the Pacific are much bigger than the ones targeting finfish off the Atlantic coast), this does highlight current questions regarding the distribution of public funds that should be specifically addressed.

4.4. EV and FV

Results demonstrate that SSF have a more positive trend than LSF, for both EV and FV (Fig. 2). Based on this study's EV analysis, which shows a much higher EV for SSF in 2012 than in the earlier years, SSF might be better prepared to tackle some of their struggles such as market shifts. At the same time, EV of SSF shows much higher variance over the years compared to LSF, which could be due to their complexity and dynamics. The decline of the EV of LSF especially between 2008 and 2012 was likely due to an increase in costs (e.g. diesel prices; Table S1) and also a decrease in TR resulting from declines in the price of shrimp, one of the LSF main target species, which could be attributed to competition with aquaculture (E. Finkbeiner pers. comm.). During the times where the SSF could be considered economically viable (see Fig. 2, years 2004, 2005 and 2009–2012), high net benefits to society (much higher than EV of LSF at its peak) were observed, thus demonstrating the importance of SSF to society in Mexico. Due to subsidies provided to SSF, the sector has been able to maintain its FV since 2004 despite a drastic drop of total revenue from 2006 to 2007 by around 700 million USD.

As expected, EV was lower compared to FV for LSF and SSF, even if only slightly lower for the latter. The difference between EV and FV is much higher in LSF (Fig. 2), as it receives a much greater share of subsi-

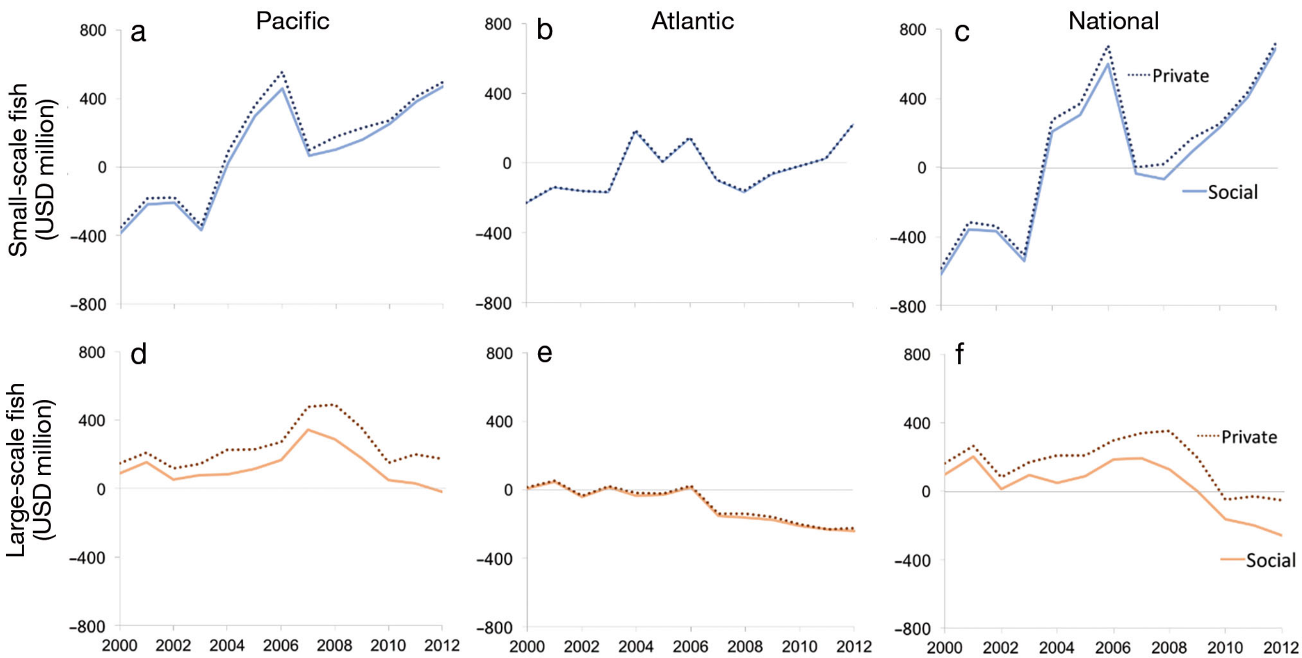

Fig. 2. Economic and financial viability presented by region and fishing sector before subsidies (society) and after subsidies (private) in constant 2015 USD million

dies compared to the small-scale sector. Furthermore, this difference has been increasing over time with the increase in subsidies provided to LSF, especially to Pacific LSF (Fig. 1). At the national level, it seems Mexican policy has enabled SSF to maintain FV (but not EV) from 2006 to 2009 and the LSF to maintain FV (but not EV) in the later years up to 2012 (Fig. 2).

It is important to note that the rather stable price of fuel and the decrease in number of vessels in SSF (Table S1) are most likely the underlying factors that explain the positive trends. This could lead to the assumption that a reduced fishing effort (reduced number of boats) increases EV, even without accounting for stock recovery from decreased fishing effort. Recent research on fisheries in the Mexican Pacific showed that achieving maximum sustainable yield would indeed significantly increase economic benefits to small-scale fishers working in SSF, though further policies and investments would be necessary to support economic stability in coastal communities (Girón-Nava et al. 2015). On the other hand, the decrease in TR plus the increase in diesel costs over time have contributed to the increase in costs of LSF, leading to a decline of EV and FV into negative territory (Fig. 2).

Analyses of EV and FV by region show a much more detailed picture of how net benefits are distributed by sector. Trends in both the Atlantic and the Pacific regions generally increased for SSF but decreased for LSF (Fig. 2). Based on EV assessment, averaged over the 13 yr study period, SSF and LSF on the Atlantic coast are not economically or financially viable, whereas both are viable on the Pacific coast (Table 3). Many coastal communities depend on currently declining living marine resources (Sala et al. 2004, Lluch-Cota et al. 2007, Finkbeiner 2015), and this study only reflects a national and broader regional picture of the sector. An important next step is, therefore, to further look at local levels, as there might be large differences and inequities within SSF, and between SSF and LSF (Cinti 2010, Cinti et al. 2010, Basurto et al. 2012).

5. POLICY AND MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Despite Mexico ranking quite high in the last OECD open government data review (OECD 2016), there is still a lack of transparency concerning fisheries-related information at economic, social, and institutional levels. The scarcity of publicly available data has been a big challenge to gathering sufficient and good quality data for this study. Similar findings have been reported previously, highlighting the importance of access to data, especially concerning information on fisheries subsidies (Cisneros-Montemayor et al. 2013, 2016).

To better understand what the results of this study mean for SSF, it is important to put into perspective what is currently known about this sector, its challenges, vulnerabilities and opportunities. SSF, in general, have been described as flexible and adaptive, where fishers can change their target species based on local abundance of the different commercially valued species, travel to different locations, and use a variety of different fishing gear (Allison & Ellis 2001, Chuenpagdee 2011). Mexican SSF are no exception (Salas et al. 2004, Aburto et al. 2009, Finkbeiner 2015).

In the case of Mexico, net benefits fluctuated greatly over the 13 yr study period. Currently, despite the legal requirement of fishing licenses to fish, not all active small-scale fishers have licenses and fishing effort is only scarcely controlled, thus contributing to overcapacity, overfishing, and ecosystem degradation (Cisneros-Mata 2010, Cisneros-Montemayor et al. 2013). The implementation of regulations has been suggested for both Mexican Pacific and the Atlantic coasts (OECD 2006b, Cisneros-Montemayor et al. 2013, 2016). Furthermore, recommendations for improved policy and management strategies, with a focus on implementing ecosystem-based as well as livelihood-based approaches have been made, not only for the small- but also the large-scale sector (Salas et al. 2007, Cisneros-Mata 2010, Cinti et al. 2010, Erisman et al. 2011).

Integrated approaches to ecosystem-based management (human dimension included) in comparison to single-species management have been promoted for many years as a means to achieve sustainability at the ecosystem, economic and social levels e.g. (Arreguín-Sánchez & Arcos-Huitrón 2011, Cisneros-Montemayor et al. 2012, Link et al. 2017). Policies to foster ecosystem-based approaches need to focus on whole areas rather than on individual fisheries; therefore, understanding the EV of Mexican SSF (instead of only a single fishery at a time) seems important for policy recommendations. Additionally, our results highlight the need for fisheries policies to be tailored specifically to each fishing sector since SSF and LSF can be very different from each other and should not be lumped together when policy and management strategies are made.

Our results suggest that a reduced number of fishing vessels (Table S1, years 2009–2012) could lead to an increase in EV (Fig. 2, years 2009–2012. Increased EV is linked to improving the livelihoods of people who depend on marine resources. It is not an easy step to implement regulations, such as reducing fishing effort (as in number of fishing vessels), in a place where hundreds of thousands of people depend on SSF and many fishers are marginalized from policy processes. Such restriction may not necessarily lead to desirable outcomes or may create other unintended consequences. Thus, Cinti et al. (2010) suggested looking into a possible redistribution of fishing effort within SSF, where access rights are only granted to those who actively fish, which would lead to more sustainable practices (Sumaila 2010). Currently, only a few individuals hold the majority of fishing permits and the number of fishing permits is not always equal to the number of fishing vessels registered (Cinti et al. 2010, Basurto et al. 2012). A redistribution of fishing rights instead of reducing their availability across the board could therefore lead to increased EV.

A lack of communication with the federal fisheries agency has been observed. Often, not enough funding is available from federal agencies to enable them to contribute at the local scale (Cudney-Bueno & Basurto 2009, Zepeda-Domínguez et al. 2017), which directly impacts SSF. This downfall makes it challenging to see recommended regulations being adequately implemented for the maintenance of positive EV. Furthermore, inconsistent and sometimes contradictory policy directions have inhibited sustainable fisheries management, especially for SSF (Espinoza-Tenorio et al. 2011). To tackle this challenge, we recommend decreasing harmful subsidies for both SSF and LSF and instead investing taxpayers' money into improved communication, data transparency and monitoring of fishing effort. Further, policy should be designed and implemented to fit the local SSF contexts, with maintaining peoples' livelihoods as one of the main objectives.

As shown in many other studies at global and national levels (e.g. Schorr 2005, Charles 2011, Cisneros-Montemayor et al. 2016), subsidy policies are in need of reform, and capacity-enhancing subsidies that lead to overfishing urgently need to be reduced (to zero if possible for both SSF and LSF). Financial support should focus on beneficial subsidies such as monitoring and enforcement, especially at a local scale where funds are currently scarce. This would not only fight illegal and unreported fishing (Sumaila et al. 2010), but would also improve the quality of EV assessments. More detailed monitoring of fisheries catches and their social and economic contributions is crucial information for designing management plans that could improve EV, such as redistributing access rights (Saavedra-Díaz et al. 2016).

Effective subsidies should address the core issues a fishing industry is facing and not just the symptoms by increasing profits artificially through the provisions of subsidies. Additionally, policy makers should focus on establishing clear, feasible, long-term goals (Cisneros-Montemayor et al. 2016). Another example is to bring education and skill development to coastal communities to increase employment opportunities for coastal fishers (Sumaila et al. 2016). This is especially important in a developing country such as Mexico, where coastal SSF are essential for the economic stability of hundreds of thousands of people and where over 20 million people suffer from undernourishment (Olaiz-Fernandez et al. 2006). These suggestions, directed at fisheries subsidies in general, would bring more equity to the distribution of subsidies, and with it, improved EV for SSF.

Management of fisheries based on their spatial distributions along the coastlines as well as emphasizing equitable fishing access rights and involving fishers in the decision-making processes have also been recommended (Salas et al. 2007, Erisman et al. 2011). Another important example is to establish policies that give incentives toward fishing practices that are oriented to increasing the added value and reducing impacts on the environment (Cisneros-Mata 2010). If implemented, these suggestions could address issues related to overcapacity, open-access regimes, and the unequal distribution of subsidies, which would lead to an improvement of EV of SSF in the long term and the sustainability of fisheries at the ecosystem, social, economic and institutional levels.

The situation in Mexican SSF is typical of SSF globally (Pauly 2006, FAO 2008, Johnson et al. 2012). Therefore, results and conclusions drawn from this article can point out important areas of knowledge for sustainable and equitable fisheries management in general.

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