Ocean and Coastal Management 165 (2018) 235–243

Contents lists available at ScienceDirect

Ocean and Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

Exploring the building blocks of social capital in the Sechura Bay (Peru): Insights from Peruvian scallop (*Argopecten purpuratus*) aquaculture

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A R T I C L E I N F O

Keywords:
Social capital
Aquaculture
Fishers
Co-management
Peruvian scallop

A B S T R A C T

Social capital has been a key factor for co-management initiatives' success in small-scale fisheries. Nonetheless, this is a complex concept, which can be operationalized in different ways and has no specific standardized measures. This research explores Peruvian scallop aquaculture in the Sechura Bay of Peru as a case study, focusing on the development of social capital among fishers, enterprises and authorities. We evaluated social capital through three of its conceptual building components: (i) trust, (ii) collaboration and reciprocity, and (iii) common norms and sanctions. Specific indicators for each component were developed for analytical purposes. We conducted 66 surveys and 12 interviews with fishers and other key stakeholders. Based on our results, there is weak social capital among aquaculture fishers, enterprises and authorities in the Sechura Bay. This is evident through the low levels of trust and collaboration, as well as the lack of respect for common norms. Weak social capital may explain the two critical problems the system is currently facing for achieving sustainability: reduced availability of seeds and unfair agreements between enterprises and fishermen associations. Strengthening social ties and collaboration can increase aquaculture's resilience at Sechura Bay.

1. Introduction

1.1. Exploring social capital

Social capital is an all-encompassing term for the norms and social networks that facilitate co-operation among individuals and between groups of individuals (Grafton, 2005). Commonly this concept has been built on the components of trust, social networks, reciprocity and co-operation, and common rules and sanctions (Adger and Adger, 2003; Crona et al., 2017; Grafton, 2005; Marín et al., 2015; Pretty, 2003).

Social capital can benefit communities by improving their economic performance and wellbeing (Pretty, 2003; Rosas et al., 2014). General reciprocity characterizes communities with stronger social ties, improving the quality of and access to information, strengthening solidarity, and making community members more prone to assume common risks (Adger and Adger, 2003; Grafton, 2005; Knack and Keefer, 1997; Rosas et al., 2014). Furthermore, social capital is an important factor for increasing resilience in communities for coping with environmental uncertainty as well as sudden natural and technological disasters (Adger and Adger, 2003; Picou et al., 2009).

In the literature, three types of social capital have been defined: *bonding*, *bridging* and *linking*. Bonding social capital refers to social ties within groups of like-minded people (e.g., fishers) (Grafton, 2005; Poortinga, 2006). Bridging social capital pertains to the linkages across similar groups (e.g., angler and skipper fishers). Linking social capital refers to the connections across different groups with asymmetrical relations between actors (e.g., fishers and authorities) (Marín et al., 2015; Rosas et al., 2014). All three types of social capital are necessary for positive societal outcomes, contributing to social support, solidarity and respect for effective mobilization and political institutional will (Poortinga, 2006).

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https://doi.org/10.1016/j.ocecoaman.2018.08.030
Received 22 February 2018; Received in revised form 20 August 2018; Accepted 25 August 2018

1.2. Small-scale fisheries & co-management

In Latin America, small-scale fisheries (SSF) are essential for the livelihoods, food security and economy of millions of coastal citizens (Begossi, 2010; Defeo et al., 2013). Despite SSF importance, fishers' situation has not improved in the past decades mainly due to inadequate top-down management schemes (Salas et al., 2011). Common problems in Latin America around small-scale fisheries management include weak governance structures, poor fisheries knowledge, limited financial support for fishing institutions and the lack of a long-term strategic planning (Defeo et al., 2016; Saavedra-Díaz et al., 2015).

Additionally, fisheries in Latin America are highly vulnerable to environmental changes (particularly the El Niño Southern Oscillation, ENSO) and the fluctuations of globalized markets (Berkes et al., 2006; Defeo et al., 2016). Sudden fluctuations in biomass or market openings can lead to rapid resource exploitation if the necessary management decisions are not implemented and enforced, usually because the ability of local institutions to respond effectively is often overwhelmed (Berkes et al., 2006; Kaplan-Hallam et al., 2017).

Increasingly, co-management is being presented as a solution for failed government management, as it is essential for ensuring fishers' adaptive capacity to unforeseen shocks and environmental uncertainty (Adger and Adger, 2003; Trimble and Berkes, 2013). This concept is defined as the collaborative and participatory process of regulatory decision-making among representatives of user-groups, government agencies and research institutions (Jentoft, 1989). Co-management enhances the ownership and fishing rights of fishers, grants legitimacy to the management scheme, encourages more responsible behaviours, compliances with norms and reliable monitoring by fishers themselves (Defeo et al., 2016; Kosamu, 2015).

Social capital is one of the key factors for successful co-management (Gutiérrez et al., 2011). It facilitates co-operation among and between fishers and authorities, and contributes to fishers' ability to self-organize and overcome collaborative barriers (Basurto et al., 2013; Kosamu, 2015). In addition, social capital helps to reduce the cost of fisheries monitoring, as people are more likely to comply with local and regulatory rules to protect common pool marine resources (Pretty, 2003).

There are few cases of successful co-management in Latin America, as seen in Chile and Mexico (Defeo et al., 2016; Salas et al., 2011).

In Chile, the loco fishery (*Concholepas concholepas*) collapsed in the late 80s due to unsustainable levels of exploitation in pursuit of satisfying newly opened foreign markets (Castilla and Gelcich, 2008). This collapse pushed the Chilean government to allocate Territorial User Rights for Fisheries (TURFS) to artisanal associations exploiting benthic resources (Gelcich et al., 2012). TURFs give back fishers their rights over a resource, and close access to outsiders, generating incentives for sustainable practices and encouraging stewardship behaviour (Crona et al., 2017). These areas tend to have higher reef fish and macroinvertebrate species richness, biomass and density compared to open-access areas (Gelcich et al., 2012). Literature has identified that TURFs with stronger social capital tend to have better economic and productive performance (Crona et al., 2017; Rosas et al., 2014).

In Mexico some fisheries are managed by fishing cooperatives, which commonly work as harvesters and in processing operations (McCay et al., 2014; Nenadovic and Epstein, 2016). These cooperatives generally target macroinvertebrates, such as spiny lobster (*Panulirus interruptus*), and abalone (*Haliotis* spp.) (McCay et al., 2014). However, it was after the ENSO of 1982/1983 that cooperatives and authorities achieved a co-management scheme, gaining a reputation for productive and sustainable fisheries (Ponce Díaz et al., 2009). Cooperatives have shown strong capacity for reducing illegal fishing and enforcing common rules within the cooperatives (Castilla and Defeo, 2001; Ponce Díaz et al., 2009). Like in Chile, social capital is a key factor behind effective co-management, which can be seen through strong social cohesion within cooperatives and between cooperatives and local communities (McCay et al., 2014; Nenadovic and Epstein, 2016).

Within this context, there are few studies that explore the level of social capital in extractive activities that might threaten resource sustainability, which could also provide relevant information for future management strategies. This research explores the case-study of Peruvian scallop aquaculture in the Sechura Bay of Peru, particularly the level of social capital development among fishers, enterprises and authorities. We evaluated social capital through three components of the concept, having identified and developed specific indicators for each one of them.

This case-study is relevant for other Latin American countries, as they present shared governance problems and are susceptible to 'boom and bust' patterns and environmental uncertainty within their fisheries and aquaculture sectors (Defeo et al., 2016).

2. Description of the case-study

2.1. Peruvian scallop aquaculture in the Sechura Bay

The Peruvian scallop is one of the most economically important and traditionally exploited bivalve in the country, due to its fast growth rates, high productivity and high market value (Kluger et al., 2018; Mendo et al., 2016). In 2016 a total of 4267 tonnes of scallop were exported, worth about US$ 76 million (ADEX, 2017). The Regions of Piura and Ancash are responsible for 80% of all Peruvian scallop exports; in particular, Sechura Bay in Piura accounts for 50% of the national production (Mendo et al., 2016; ADEX, 2017).

The fishery for Peruvian scallop started in 1991, where fishers limited themselves to the collection of wild mature individuals (Badjeck, 2008). However, after the ENSO of 1997/1998 the bay's environmental conditions changed, increasing significantly scallop biomass (Mendo et al., 2016). Additionally, increases in the national and international demand for scallops, as well as access to the European market (after obtaining the sanitary certificate required to export to the European Union - EU), favoured the expansion of the fishery (Badjeck et al., 2009).

In 2001 the Bay became the main production site of Peruvian scallop for export in the country (Burga, 2012). Between 2003 and 2004, the regional government of Sechura granted the first 12 authorizations for fishers' associations to conduct aquaculture in the bay, and since then the number of fishers has increased dramatically (Badjeck et al., 2009). Moreover, Sechura started to receive fishers from other fishing towns, particularly from Pisco (southern Peru), where the scallop stocks had already been depleted (Badjeck, 2008; Burga, 2012) (Fig. 1).

Between 2003 and 2008, national exportation levels stayed below 5000 tonnes per year. Nonetheless, a new change in oceanographic conditions in 2008 triggered a massive increase in production (187% growth in volume and a 140% increase in scallop exports' revenue) by 2009 (Fig. 2) (Mendo et al., 2008; ADEX, 2017). The unexpected "scallop boom" of 2008 basically made aquaculture a *de facto* open-access activity, fostering illegality, overexploitation and poor sanitary conditions in the bay (Badjeck et al., 2009).

Peruvian scallop populations of north Peru are highly sensitive to ENSO. Increase in water temperature and high sediment loading entering the bay as a consequence of heavy rains, produce sharp declines of the natural scallop banks (Mendo et al., 2016). In addition, mass mortalities have been reported without ENSO conditions, potentially associated to hypoxic conditions that result from the decomposition of organic matter in the bay (Mendo et al., 2016). After the mass mortality event in 2012, production recovered and reached new high levels between 2013 and 2014. However, since 2015 the production has remained low (Fig. 2) (El Comercio, 2017; ADEX, 2017).

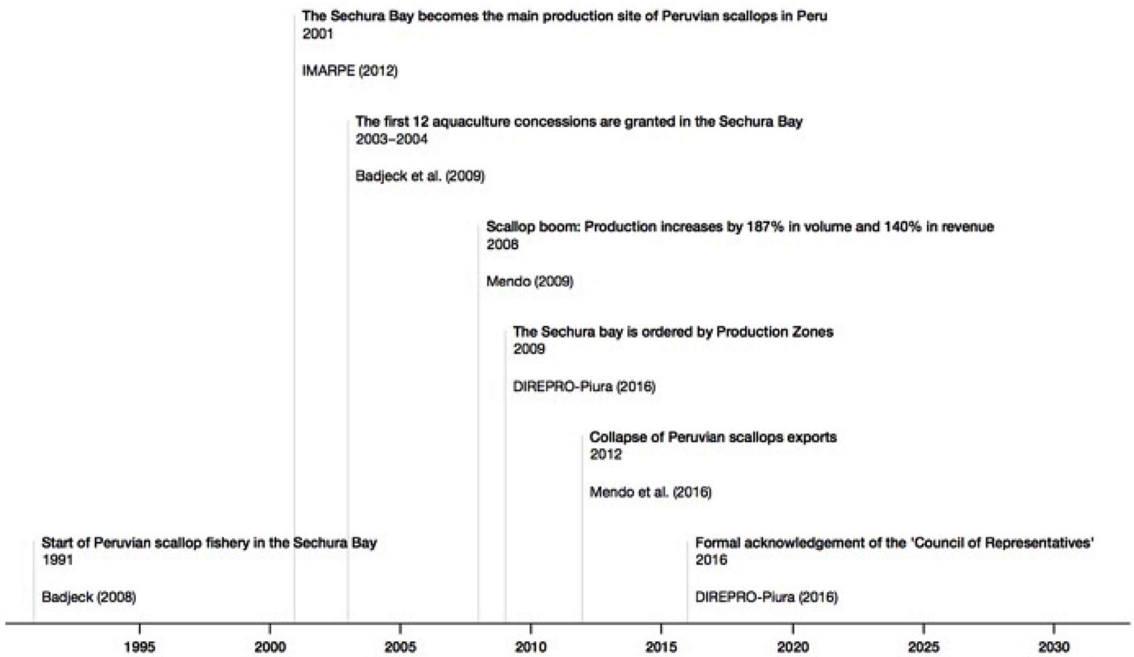

Fig. 1. Key events related to Peruvian scallop aquaculture development in the Sechura Bay.

2.2. Governance system

In Peru, the Ministry of Production (Ministerio de la Producción, PRODUCE) is the main authority in fisheries and aquaculture at the national level, decentralized at the regional level in the Regional Directorates of Production (Dirección Regional de la Producción, DIREPROs). DIREPRO-Piura controls and monitors aquaculture activities in the Sechura Bay, together with two other key governmental entities: the General Directorate of Coast Guards and Captaincies (Dirección General de Capitanías y Guardacostas, DICAPI), and the National Sanitary Fisheries Organization (Organismo Nacional de Sanidad Pesquera, SANIPES). DICAPI's prevue includes granting access and use rights to aquatic areas for aquaculture production, while SANIPES is in charge of assuring the sanitary conditions along fisheries and aquaculture supply chains.

According to current Peruvian regulations (Ministerial Resolution No. 102-2006-PRODUCE), fishers can access aquaculture farms by forming Associations of Artisanal Fishers (*Organizaciones Sociales de Pescadores Artesanales* – OSPAs, in Spanish). Currently there are 158 OSPAs functioning in Sechura, divided in eight productive zones (DIREPRO-Piura, pers. comm.) (Fig. 3). However, it is estimated that at least another 150 OSPAs are working illegally in the bay (Sánchez, 2015). Illegal aquaculture occurs in the buffer zone (Fig. 3), one mile between the coast and formal farms, where high levels of pollution compromise the entire production of the bay (El Comercio, 2015; Quijada, 2016).

In 2016, DIREPRO-Piura legally acknowledged the 'Council of Representatives for the Sechura Bay', which had been functioning informally for seven years (Regional Decree 005-2016/GRP-CR). The aim of this council is to 'achieve co-management through a democratic decision-making process, ensuring adequate sanitary standards and the sustainability of the resource'. Additionally, the council is in charge of guaranteeing that all OSPAs comply with SANIPES sanitary standards in order to secure access to international markets.

2.3. Value chain description

The Peruvian scallop value chain has the following six stages: i) seed acquisition, ii) grow-out, iii) harvest, iv) processing, v) freezing, and vi) export (adapted from Sánchez, 2015).

Seeds for aquaculture can be obtained via three different pathways. Fishers can: i) extract them from natural banks (mainly the Lobos de Tierra Island, a marine protected area located 150 km southwest from Sechura, which is one of the most productive natural banks of Peru (Mendo et al., 2016, 2008)); ii) capture them by installing collectors (floating nets) at their farms (Mendo et al., 2016); and/or iii) purchase

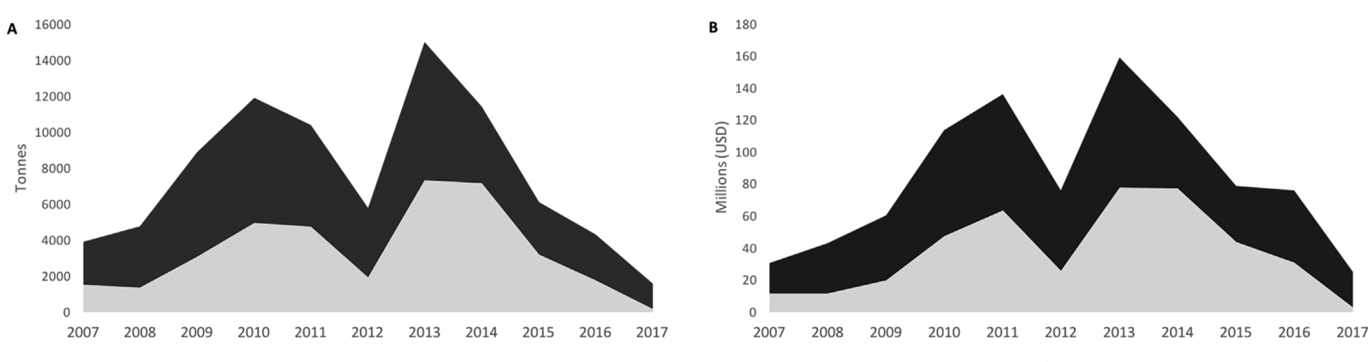

Fig. 2. Evolution of Peruvian scallops' exports between 2007 and 2017. A) Exported volume in tonnes, and B) Exported value in USD (FOB). The Piura region's (Sechura Bay) contribution to the total Peruvian exported value and volume is highlighted within each graph. Data obtained from ADEX Data Trade (2017).

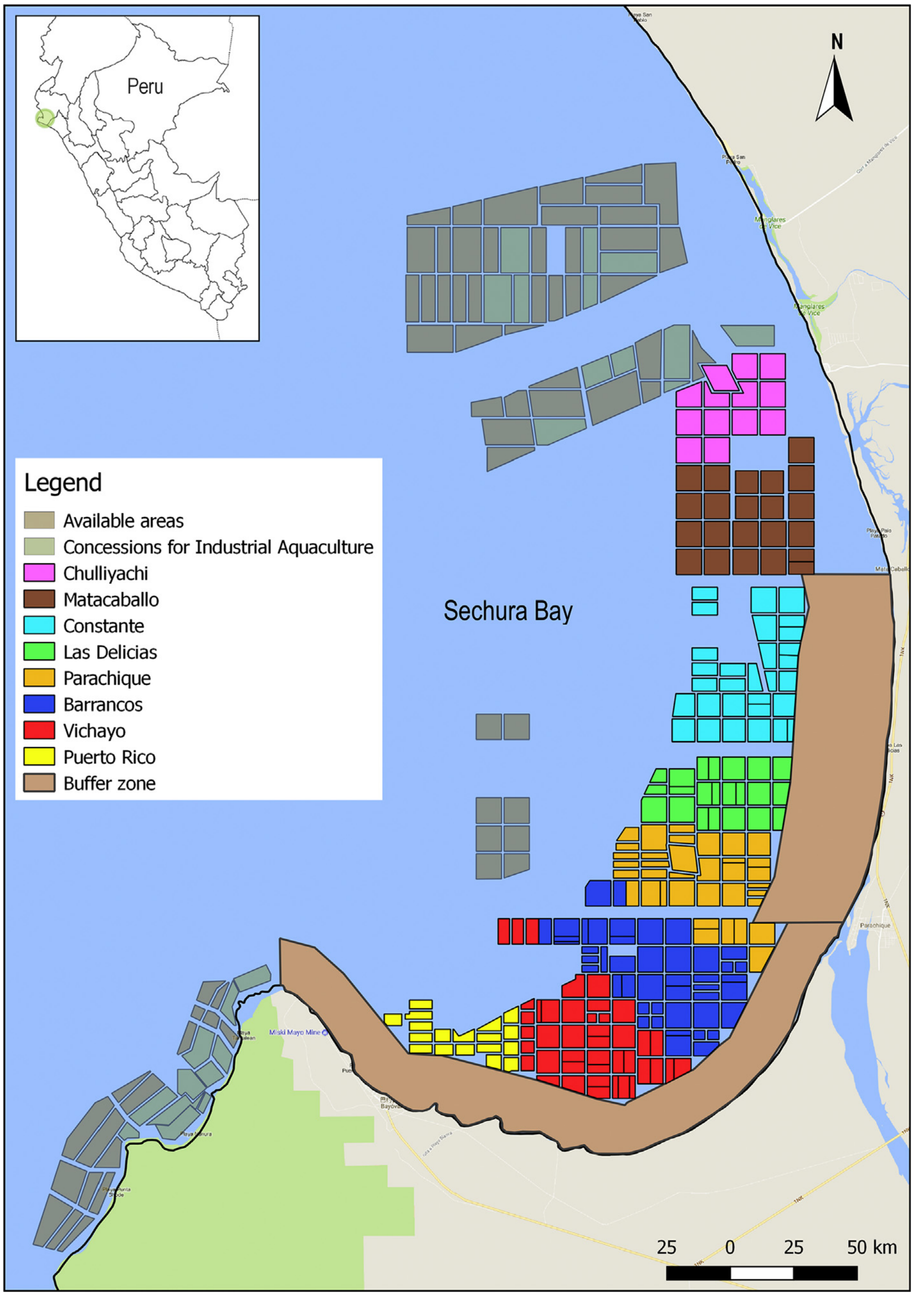

Fig. 3. Farm locations and available areas for aquaculture development in the Sechura Bay. Farms are colour coded to indicate the beaches used to land their scallop production. The bay's buffer zone (i.e., areas close to shore not available for farming), areas available for potential aquaculture development, and concessions for industrial aquaculture are also shown in the map. This information can be downloaded from the National Aquaculture Registry (http://catastroacuicola.produce.gob.pe/web/). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

them from any three hatcheries in Sechura (Sánchez, 2015). Fishers have been transferring seeds from the Island to the Bay since 2003 (Mendo et al., 2011), despite seed extraction being forbidden since 2006 - due to unsustainable levels of extraction and lack of information about the stock (RM 293-2006-PRODUCE).

The next stage is grow-out, which can be done with bottom or suspended culture. The latter allows a faster growth rate and has better protection against predators (Alcazar & Mendo, 2008). However, this method is more expensive, thus most artisanal fishers in Sechura Bay primarily use bottom culture (Alcazar & Mendo, 2008). Once seeds are planted, it will take about 12 months for them to reach the minimum landing size of 65 mm, the size at which they tend to be harvested (Mendo et al., 2016). During this period, members of the OSPAs will visit their farms every week or fifteen days to monitor the status of their crops (Sánchez, 2015).

OSPAs are required to present a "Declaration of Extraction or Recollection" (DER) at the landing sites. This is a legally binding document required by SANIPES that includes information about the product's origin (farm and OSPA code), the license plate of the vessel used for harvesting, and the final destination (name of processing plant) of the production. Thanks to DERs, SANIPES is able to control that only authorized OSPAs are unloading scallops.

Once at land, scallops will undergo primary processing, which consists on cleaning the scallops, removing the shell, and classifying them according to size. Then, scallops will go to industrial processing plants, which entails freezing and packaging. These processes are typified by the Peruvian Law of Aquaculture (Law No.1195). Industrial plants are the stakeholders that export the scallop production to foreign markets, mainly to the EU and USA (Sánchez, 2015). In Sechura, there are twelve operating primary processing plants and four industrial plants (Sánchez, 2015).

3. Methods

3.1. Social capital components and indicators

In order to assess social capital in the Sechura Bay, we selected three of the most important components that build social capital: (i) trust, (ii) collaboration and reciprocity, and (iii) common norms and sanctions (Adger and Adger, 2003; Knack and Keefer, 1997; Marín et al., 2015; Nenadovic and Epstein, 2016). We followed the types of social capital (bonding, bridging and linking) in order to define the types of relationships between stakeholders.

These components guided the design of the applied research tools: a survey, targeting members of OSPAs dedicated to Peruvian scallop aquaculture in the Sechura Bay; and semi-structured interviews, targeting OSPAs' leadership, governmental authorities (SANIPES, DIREPRO-Piura) and other relevant stakeholders (processing plants, local Non-governmental organizations - NGOs). The collected information allowed us to identify key empirical social capital indicators that guided the posterior analysis (Table 1).

3.2. Survey characteristics

Surveys were implemented between February and March of 2016 by local trained pollsters. Surveys were voluntarily completed over approximately 30 min, and consisted of 80 close-ended questions. The survey had six sections: (1) Respondent's personal information, (2) OSPA profile, (3) aquaculture activity characteristics, (4) scallop commerce, (5) associativity, and (6) main challenges faced by local scallop farmers.

3.3. Semi-structured interviews characteristics

Interviews were conducted applying a semi-structured protocol. Interviews lasted between 30 and 90 min. Participants were selected through convenience and purposive sampling, prioritizing OSPA leaders and representatives of local institutions and authorities. Interviews started by asking participants about their role in the Bay, followed by questions on the history of aquaculture development in the area, as well as requesting a description of the current situation, and ending with questions regarding what they considered to be the main challenges that they currently faced. Interview transcriptions and notes were coded and analysed using ATLAS. ti (v1.0.43), a qualitative data analysis software.

3.4. Ethics approval

This research was approved by the Ethics Committee of Cayetano Heredia University, Lima, Peru. Participants gave their informed written consent.

4. Results

There are 158 OSPAs dedicated to scallop aquaculture in the Sechura Bay (Kluger et al., 2018). However, only 105 were active during our study (SANIPES, pers. comm.). Surveys were implemented on the representatives of 66 OSPAs. Additionally, 12 relevant stakeholders were interviewed.

This section is divided into four sub-sections: 4.1) OSPAs profile, 4.2) characteristics of Peruvian scallop aquaculture in the Sechura Bay, 4.3) level of social capital and, 4.4) critical challenges. Quantitative and qualitative results are combined in order to provide a comprehensive picture of the current scenario in Sechura. Quotes are presented throughout the results, to help illustrate the views and perspectives of the majority of participants. Average values, when presented, are followed by their corresponding standard deviation ($\bar{x} \pm \sigma$).

4.1. OSPAs' profile

The OSPAs' representatives that completed the survey were mostly men (89.4%), with an average age of 43.2 ± 9.8 years (Table S1). On average, each OSPA had 16.2 ± 9.0 members [range: 4 to 50 members], giving an estimate of 1069 active small-scale fishers dedicated to scallop aquaculture at the time of the study. The average operation time of OSPAs is 8.4 ± 4.0 years [range: 1–26 years]. Finally, on average each OSPA manages a farm of 62.2 ± 24.4 ha [range: 20–100 ha].

4.2. Peruvian scallop aquaculture at Sechura Bay

All but one surveyed OSPAs acquired seeds from all three sources: 84.8% have seed collectors, 83.3% buy seeds from the MPA Lobos de Tierra Island and 19.7% buy seeds from hatcheries. Only one OSPA exclusively sources from hatcheries. According to fishers, seeds from hatcheries tend to be more expensive and fragile to grow (i.e. higher mortality rates than collected seeds).

Harvest usually occurs after 11.7 ± 4.4 months of sowing the seeds. Most OSPAs (69.7%) wait until scallops are bigger than 65 mm to harvest, 15.2% harvest them at 65 mm, and 10.6% replied they harvest them below the minimum landing size.

The majority of OSPAs harvest and sell scallops to primary plants (71.2%), while some (24.2%) sell their harvest directly to industrial plants. The OSPAs that sell directly to industrial plants tend to cover the fees of the primary processing plants. However, when OSPAs sell their production directly to the industrial freezing plants, it is highly likely that at least one of the OSPA members is also the owner of a primary plant.

"*Someone offered my husband to be part of an OSPA so we could work the farm. We started producing, selling, and we managed to arrange the economic capital to implement a primary plant … Now I am the OSPA president, we have twelve members and manage 75 ha, and I am the owner of the plant. The plant is still new; it has two years of operation.*"

(Owner of industrial plant, 45 years old, female)

Table 1
Selected conceptual building components of social capital and their respective indicators for each type of relationship between OSPAs, authorities and enterprises.

Building Component	Relationships	Indicators
Trust	Within OSPAs	• Percentage of OSPAs integrated by families. • Prevalence of conflicts within OSPAs.
	Between OSPAs	• Number of OSPAs with guardians at the farms.
	Between OSPAs and processing plants	• Perception of satisfactory agreements.
Collaboration and reciprocity	Between OSPAs	• Occurrence of corruption in community-based organizations.
	Between OSPAs and authorities	• Positive relationship between fishers and authorities.
Common norms and sanctions	Between OSPAs	• Percentage of OSPAs that use seeds from marine protected areas (MPA) • Percentage of OSPAs that harvest scallops below minimum landing size • Percentage of OSPAs operating at the buffer zone

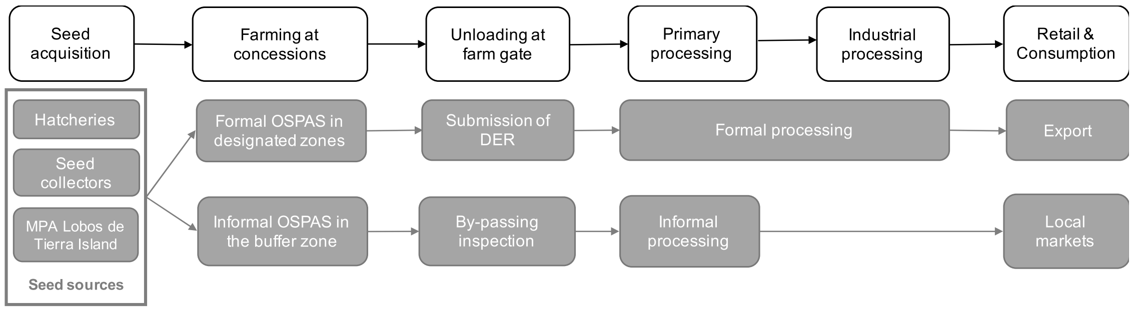

Fig. 4. Value chain of the Peruvian scallop aquaculture in the Sechura Bay. Upper level is the general value chain, lower level is divided into formal and informal OSPAs.

On the other hand, OSPAs that harvest scallops at their farms when these are still below the minimum landing size, will sell their production to illegal processing plants that don't require any documentation. These undersized scallops are typically sold at local markets (Fig. 4).

4.3. Level of social capital

4.3.1. Trust

4.3.1.1. Characterizing trust within OSPAs. Percentage of OSPAs integrated by families: According to the Peruvian law (General Law of Fisheries, No. 25997), OSPAs need to be integrated by small-scale fishers with valid fishing permits that are registered in DIREPROs and/or PRODUCE. In Sechura, OSPAs are largely integrated by family members: 21.2% of surveyed OSPAs are completely familiar, 42.4% of OSPAs have between 50% and 90% family members, while 27.3% have between 20% and 40% family members. Only 6 OSPAs (9.1%) reported no family members.

However, throughout the interviews, it was mentioned that not all family members are fishers. This practice serves two purposes: having enough members to create an OSPA (at least two registered fishers), and reducing the possibility that some fisher may betray the association (i.e. selling their products under the table, harvesting alone).

Prevalence of conflicts within OSPAs: Struggle within OSPAs is also common, no matter if there are family members involved or not. High levels of conflict have led to the subdivision of farms, where members will only work smaller parcels within the farms they own. This undermines the purpose of OSPAs, which is to foster collaboration and entrepreneurship among fishers (General Law of Fisheries, No. 25997).

> *"Wherever you go you can see conflict … members within an OSPA fight among themselves, and then subdivide the farms, then each fisher has to work its own part, being in charge of sowing and everything … However, it still appears as one whole farm in the registers."*
>
> (Port manager, 39 years old, male)

4.3.1.2. Characterizing trust between OSPAs. Number of OSPAs with guardians at farms: In Sechura, scallop stealing at the farms is quite common, which can be done by farm neighbours or external fishers. Thus, OSPAs need to hire a guardian to take care of their farms: 98.5% of surveyed OSPAs have a guardian, which implies a monthly cost of USD 710 ± 355.

> *"When there is good scallop production there are several scallop thefts, they have even killed a guardian from a farm in order to steal. Another guardian was tied up and the thieves cut the line of the suspended cultures, so they could take them."*
>
> (NGO assistant, 29 years old, male).

4.3.1.3. Characterizing trust between OSPAs and processing plants. Perception of satisfactory agreements: Trust is the key component for successful agreements, as there are no legally binding documents that ensure that both parties will comply with their mutually agreed obligations. Thus, along the interviews, processing plant representatives mentioned that know who to trust was a 'learning process'. Nonetheless, some of the interviewees stated that these agreements were fake, as processing plants in reality are using OSPAs for accessing farms and doing aquaculture on their own. For instance, six of the participants replied that currently their farms are rented to enterprises, which is an illegal practice (Ministerial Resolution No. 102-2006-PRODUCE). Furthermore, when fishers are in urgent need of money and compelled to look for work outside their own farms, companies will get them to work on the farms they sublet - but at lower rates.

> *"These agreements are based on good faith, I would like to make them legal, but then no fisher would actually sign them, because they don't have any guarantees to give you. It is a learning process, there are some people that will take the money but then don't sell the product to you … we have managed to consolidate a group of people that is willing to work with us and that take responsibility for their farms."*
>
> (Industrial plant manager, 36 years old, male)

4.3.2. Collaboration and reciprocity

4.3.2.1. Between OSPAs. Occurrence of corruption in community-based organizations: In 2008 the poor sanitary conditions of Sechura Bay led to an export moratorium imposed by the European Union, the primary export market for scallops. This moratorium lasted for approximately six months. After this, fishers organized themselves in the "Sechura Aquaculture Group" (FREMARSEC in Spanish), in order to comply with EU sanitary standards. FREMARSEC was in charge of collecting the funds for conducting the required sanitary monitoring for the EU. However, FREMARSEC leaders started mismanaging and stealing funds, soon running out of any funds for the sanitary monitoring. This led to a corruption scandal, which ended with FREMARSEC dissolution. The failure of FREMARSEC, due primarily to its leaders having no consideration for Sechura fishers, reflects weak collaboration and reciprocity among fishers to secure their main source of income.

4.3.2.2. Between OSPAs and authorities. Positive relationship between fishers and authorities: After the FREMARSEC fiasco, there was still the need to monitor the bay in order to comply with EU standards. Thus, SANIPES started working with fishers in Sechura and created a system of 'Health Managers'. Two leaders from each productive zone were selected, assuming the responsibility for the monitoring and sanitary management of their bay zone.

> *"Thanks to our work [SANIPES] each productive zone nominated two representatives that now have turned into local leaders. This happened when FREMARSEC had corruption problems and did not have money to keep paying for the sanitary monitoring of the bay … however SANIPES does not have the authority to forbid illegal activities … our responsibility is to ensure optimal sanitary conditions …"*
>
> (SANIPES coordinator, 42 years old, male)

Although SANIPES has no legal authority to control and sanction illegal practices in aquaculture, the institution stepped in to foster farmers' compliance of international sanitary requirements. SANIPES started doing surveillance activities in the buffer zone to identify which OSPAs were cultivating or extracting scallops, and conducting diving activities in the farms to ensure OSPAs' landings were proportional to their production. According to the interviewees, SANIPES efforts have helped Sechura fishers improve their quality standards. The concern that SANIPES showed to the fishers fostered a close collaboration between OSPAs and the institution.

"SANIPES has had to learn a lot in order to discourage illegal practices in the bay … now it has managed to get along with fishers that before would have been doing illegal activities. These fishers started telling SANIPES who was doing something illegal, allowing them to identify the most illegal and corrupt fishers … now I can say the bay is safer and cleaner than before."

(NGO assistant, 29 years old, male)

On the other hand, DIREPRO-Piura, which is the authority responsible for local regulation and enforcement, does not have a good relationship with fishers. DIREPRO-Piura's involvement in the activity came later in the developing process, and has maintained a hierarchical relation with fishers. This has forced them to piggy-back on SANIPES efforts in order to create the 'Council of Representatives' in 2016, which is based on the 'Health Managers' system. Nonetheless, this initiative is a first step towards co-management in the bay.

"This business was developed by us, and we have managed to take our product to foreign markets. Now the government [DIREPRO-Piura] is trying to organize us, and support us. But when we really needed them, they were not there for us."

(Plant owner, 42 years, female)

4.3.3. Common rules and sanctions

There are three essential rules for conducting responsible aquaculture at Sechura Bay that all OSPAs need to comply: (i) to use seeds from legal sources, (ii) not to operate in the buffer zone of the bay, and (iii) respect the minimum landing size for scallops. However, these rules are not followed by an important segment of OSPAs.

- *Percentage of OSPAs that use seeds from the MPA Lobos de Tierra*: 83.3% of OSPAs continue to acquire seeds from this natural bank.
- *Percentage of OSPAs that harvest scallops below minimum landing size*: 10.6% of surveyed OSPAs.
- *Percentage of OSPAs operating at the buffer zone:* We managed to identified this problem through our interviews, but we didn't obtain the total number of operating OSPAs.

4.4. Critical challenges

Participants of this study highlighted critical challenges that compromise the sustainability of scallop aquaculture in the Sechura Bay, which are 1) reduced seed availability and 2) unfair agreements between OSPAs and industrial processors.

4.4.1. Reduced seed availability

Seeds are vital to scallop aquaculture, but their availability has started to decrease. For instance, 89% of OSPAs replied there has been a reduction in production in the past couple of years. Multiple unsustainable practices can explain this trend in productivity: harvesting scallops during spawning, extracting scallops below their minimum landing size (i.e. age of maturity), and a continuous extraction of seeds from the natural bank of Lobos de Tierra Island.

"Fishers don't want to understand sustainability, for which you need two things: respect minimum landing sizes and spawning seasons. The activity has been growing, in 2013 there was a lot, but in 2014 it started to decrease … the natural bank from the island has been depleted … The main problem in Sechura is that the scallops are harvested before they spawn and we have over-exploited the resource."

(OSPA President, 46 years old, male)

Currently, hatcheries are not satisfying the demand for seeds in Sechura, and their prices are still much higher than those for seeds collected in the island or through natural collectors at the farms. Nonetheless, 78.8% of fishers are highly attracted to the idea of investing in hatcheries, and 87.9% of them are interested in receiving training that would allow them to set up their own hatcheries.

4.4.2. Unfair agreements between enterprises and OSPAs

OSPAs not always have the economic capital required to drive aquaculture production (i.e. buying seeds). More than 20% of survey participants replied that processing plants are the ones that finance them. This modality is informally known as 'agreements' (*convenios* in Spanish). The processing plants agree to give OSPAs the required money to acquire seeds and any additional equipment needed, under the premise that the plant will have exclusive access to their production, discounting what they initially gave to the OSPA.

"Currently we have agreements with two OSPAs, we provide them seeds from hatcheries … There are different types of agreements, one is that the company provides the seeds and then we discount the costs and divide the utilities of the harvest. Sometimes it can be 40%-60% profits, it depends on how much the OSPA puts into the enterprise. However, I always put a guardian and a team that will go and supervise the farm once in a while … all of these costs are then subtracted from the OSPA gains."

(Industrial plant manager, 36 years old, male)

However, due to the asymmetrical relation between OSPAs and processing plants, fishers are more vulnerable to earn less than expected by the end of the season as companies will discount several additional 'associated costs' of the activity or pay lower prices for their production.

"Sometimes fishers get into bad arrangements because they are just desperate for money."

(Port manager, 39 years old, male)

5. Discussion

Social capital is a multidimensional concept that refers to the social ties and relationships within a society (Crona et al., 2017; Grafton, 2005). Therefore, different authors use different components as building blocks (Adger and Adger, 2003; Bodin and Crona, 2009; Marín et al., 2015). Here we define social capital as a concept based on trust, collaboration and reciprocity, and common rules and sanctions. By narrowing the building components, we have managed to identify pertinent and relevant indicators for each component that may help operationalize the concept. These indicators are measurable and can be monitored through time.

Exploring social capital in the aquaculture system of Sechura is highly relevant for the co-management initiatives that authorities have started to implement (i.e. Council of Representatives for the Sechura Bay). Without changes in social norms and a general sense of collaboration and reciprocity within the fishers' community, fishers will not respect legal norms or regulations in the long run (Crona et al., 2017; Pretty, 2003). This is particularly important in the context of the Sechura Bay, as it is vulnerable to environmental uncertainty (Mendo et al., 2016) and to sudden changes in markets (Badjeck et al., 2009; Kluger et al., 2018). Thus, by fostering social capital a more resilient socio-ecological system can be built (Adger and Adger, 2003; Marín et al., 2015).

Based on our results, there is weak social capital among small-scale fishers participating in scallop aquaculture, enterprises and government authorities in the Sechura Bay. This is evident through the low levels of trust and collaboration, as well as the lack of respect for common rules. First, there is a high level of mistrust among fishers, as OSPAs tend to be more family-oriented than collaborative between fishers, with high prevalence of conflicts. Then, OSPAs are obligated to hire guardians to protect their farm production from other OSPAs, and agreements between enterprises and fishers tend to end in unfair settlements for fishers. On the other hand, the FREMARSEC fiasco demonstrated that when fishers tried to organize themselves, it failed due to lack of reciprocity and good leadership. Nonetheless, SANIPES started working with fishers shortly after this failure, managing to strengthen their relationship with fishers and building capacity among fisher representatives. However, DIREPRO-Piura, the main aquaculture authority, still needs to improve its relationship with fishers in order to assure legitimacy of their management schemes. Finally, the three general common rules for responsible scallop aquaculture are not respected by all fishers.

Weak social capital may explain the two critical challenges faced by aquaculture stakeholders in Sechura: reduced availability of seeds and unfair agreements between enterprises and OSPAs.

Seed abundance keeps decreasing as it faces three types of overfishing at the same time: growth (i.e. extraction of juveniles), recruitment (i.e. extraction below 65 mm) and Malthusian overfishing (i.e. too many fishers). The latter, Malthusian overfishing, occurs when there are equity problems, and the governance and management schemes are not considered legitimate by fishers (Finkbeiner et al., 2017). Thus, social capital can be linked directly to overfishing practices in the Sechura Bay. In addition, low collaboration between OSPAs may explain why hatchery-sourced seeds remain too expensive for fishers and that enterprises tend to take advantage of OSPAs. Weak social ties among fishers leave individual OSPAs isolated when negotiating with enterprises (Nenadovic and Epstein, 2016). With stronger social capital, OSPAs could decide to boycott an enterprise that is acting unfairly (e.g., refusing to pay a fair price for the product) and could be more open to share information about prices and agreements. Hence, fostering a more transparent scenario for scallop commerce in Sechura (Adler and Kwon, 2002).

Additionally, common risks are generally not undertaken when social capital is weak, as fishers don't trust each other (Rosas et al., 2014). For example, no community-level self-imposed restrictions for recovering the natural bank at the MPA have been implemented, and unsustainable practices (i.e. extracting scallops below minimum landing size) regularly occur. Thus, the scallop bank at the Lobos de Tierra Island MPA is facing the “tragedy of the commons” (Ostrom et al., 1999), where fishers are extracting as many seeds as they can before the stock disappears. Although most fishers have shown interest in investing on hatcheries, this hasn't translated yet into a plan for developing communal hatcheries that could help them secure seeds for the entire bay.

Poor social capital might also explain the presence of illegal processing plants and farms operating within the buffer zone. These two practices denote a generalized lack of reciprocity and consideration in the fishing community. Due to EU export standards, if scallops are identified as unhealthy, the EU can forbid scallop exports from the entire bay (Kluger et al., 2018). Thus, the irresponsible practice of one OSPA has the potential to jeopardize the entire aquaculture activity in the bay (including fishers and people that rely indirectly on aquaculture, approximately 20,000 citizens) (Kluger et al., 2018; Loaiza et al., 2018). Unfortunately, as a consequence of OSPAs operating within the buffer zone, the EU imposed a ban on scallop exports from Sechura in 2017, after identifying a shipment that did not meet their sanitary requirements (Comunicado No. 027-2017 SANIPES/DSFPA/SDSA).

Finally, this paper provides a baseline to assess changes in social capital through time, with pertinent indicators that can be easily monitored. By monitoring these indicators, stakeholders (including the Government) will be better informed, and may be even able to identify when to tackle the challenges of implementing a co-management scheme. This has the potential to grant more legitimacy to the process and to increase their success chances. These indicators are not site-specific, thus have the potential to be used for other marine aquaculture scenarios in Peru and Latin America, which face similar challenges (Defeo et al., 2016; Espinoza et al., 2010).

6. Conclusion

This is the first research conducted in Peru that explores the level of social capital in the context of small-scale fisheries and aquaculture. As discussed, social capital is critical for successful co-management schemes, which are gaining popularity in Latin America (Defeo et al., 2016). Therefore, the main contribution of this paper lays on the operationalization of the social capital concept. By identifying empirical indicators for each of the building components of this concept, other parties will be able to monitor and assess changes in them over time.

According to the Peruvian Ministry of Production, aquaculture is an attractive alternative to small-scale fisheries (PRODUCE, 2010). However, without proper fishers' participation, enforcement and control systems, marine aquaculture will face the same problems as small-scale fisheries. The governance problems identified at the Sechura Bay jeopardize the sustainability of the aquaculture activity and compromise the communities’ well-being. These problems can be solved by fostering trust, collaboration, reciprocity, and respect for common rules and sanctions amongst stakeholders. Through the strengthening of social ties and collaboration, aquaculture at Sechura Bay has a chance to become a resilient and sustainable activity (Adger and Adger, 2003).

Funding

This work was supported by the Instituto Tecnológico de la Producción, Ministerio de la Producción (Perú) and Universidad Peruana Cayetano Heredia, both of which provided the financial support to the Centro de Innovación Productiva y Transferencia Tecnológica Acuícola Privado from Universidad Peruana Cayetano Heredia (CITEacuícola UPCH). The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the scientific article.

Contributors

Rocío López de la Lama participated substantially in the conception and design of the study, acquisition, analysis and interpretation of data, writing the manuscript and incorporating further comments of the other authors, participating in the final approval of the version submitted. Armando Valdés-Velásquez participated substantially in the conception and design of the study, helped throughout the analysis and interpretation of data, and participated in the process of writing the article and final approval of the version to be submitted. Luis Huicho contributed substantially to the conception and design of the study, analysis and interpretation of data, revised the article critically for important intellectual content and participated in the final approval of the version to be submitted. María Rivera contributed substantially to the conception and design of the study, analysis and interpretation of data, revised the article critically for important intellectual content, and participated in the final approval of the version to be submitted. Estefanía Morales contributed in the conception and design of the study, helped with data acquisition, and provided helpful comments to the final draft of the article.

Declaration of interest

There are no conflicts of interests between the researchers and the conducted study.

Acknowledgements

Special thanks to Daniel Pauly and Santiago de la Puente for their insights and comments on the manuscript. Acknowledgements are given to María Pía Carrasco and María Fuertes, both who actively assisted during fieldwork. Finally, we are grateful to the many volunteers from Sechura whose assistance during data collection was fundamental for the project.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ocecoaman.2018.08.030.

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