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RESEARCH

Prospects of equitable and sustainable seaweed aquaculture: a case study of changing gender and socio-economic relations in Maullín, Chile

Gloria L. Gallardo Fernández[1] · Marcela Avila[2,3] · Fred Saunders[1] · Ricardo Riquelme[2] · Daniel Rodriguez[2] · Gesica Aroca[2] · Juan Gutierrez[2]

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Abstract
This article examines the development of marine tenure in the Maullín River, Chile. It starts with the emergence of artisanal red algae (*Gracilaria chilensis*) gathering and the changes resulting from the governmental ad hoc allocation of small-scale aquaculture concessions. We aim to track this transition, its drivers, effects on the work organization, gender relations, market relations and the sustainability/equity challenges currently confronting the community. We use a feminist political ecology approach to direct our multi-method data collection strategy and to analyse the empirical material. The State by enabling local tenure for the development of marine aquaculture concessions played an influential role in Maullín community attaining de facto territorial tenure. This led to the establishment of residential aquaculture communities while facilitating the integration of women in aquaculture activities. We see both steps as positive economic and social development opportunities in Maullín. While marine tenure has provided livelihood chances, low prices caused by the producers' disadvantaged market position and the lack of supportive alliance building pose ongoing problems. We conclude that these factors are serious challenges to the sustainability of aquacultural livelihoods at Maullín River. While the case depicts aspects of women's empowerment such as their engagement in developing potential post-production innovation ideas, entrepreneurial abilities to conduct market transactions as well as their better competence in literacy, math and financial expertise, there is still a long way to reach gender equality in the male-dominated aquacultural sector.

Keywords Gender · Small-scale aquaculture · Coastal communities · *Gracilaria chilensis* (pelillo) · Sustainability · Political ecology

Introduction

As the Manifesto for the Marine Social Sciences (Bavinck and Verrips 2020) states, "The rapidly changing political economy of coasts and oceans underscores the need for critical as well as constructive social-science analyses". This includes a need to bring to the fore the manifold realities of small-scale aquaculture fishers, their community and gender dynamics and social justice struggles (Bavinck et al. 2018). Against the stagnation of capture fisheries in the world, since the 1980s, aquaculture has been gaining in strength, growing to such an extent it is now the fastest-growing food-producing industry (FAO 2020). Almost all the growth in global fishery demand in recent decades has been generated by aquaculture (Ritchie 2019; FAO 2017). Notably, seaweeds—the focus of this article—now represent 51.3% of the total production of marine and coastal aquaculture (Chopin and Tacon 2021). While most aquaculture-related challenges and emphasis in academic studies, policies and strategies raise serious questions about its environmental sustainability, far less attention has been paid to critical social sustainability aspects and gender relations, such as concerns over gendered access to resources, uneven distribution of benefits, a disconnection between benefits and local needs and negative

✉ Gloria L. Gallardo Fernández
gloria.l.gallardo.fernandez@sh.se

[1] School of Natural Sciences, Technology and Environmental Studies, Södertörn University, SE-141 89 Huddinge, Sweden

[2] Instituto de Ciencia y Tecnología, Universidad Arturo Prat, Ejercito 443, Puerto Montt, Chile

[3] Cape Horn International Center (CHIC), Universidad de Magallanes, Punta Arenas, Chile

repercussions for ecosystems (undermining resource production conditions and livelihoods) (Krause et al. 2015).

This article responds to the need to better understand the gendered socio-environmental dynamics and implications of small-scale aquaculture by examining the case of *Gracilaria chilensis*[1] cultivation on the North shore of Maullín River in Chile. The article aims to examine the sustainability challenges facing the Maullín River aquaculture communities, with a gender focus. Aquaculture in this place was underpinned by the State in granting an ad hoc distribution of micromarine concessions. While we examine what might be seen as a remote and isolated case, the ambition of this article is to examine how tightly seaweed production (*pelillo*, in this case) and its gendered and socio-environmental effects are connected to the global market and therefore subject to its fluctuations. With this in mind, we aim to contribute to the discussion on the changing political economy/ecology of our coasts. Drawing on a feminist political ecology approach (FPE), we particularly focus on the roles that tenure, market relations and dynamics and gender have in shaping the historical development of aquaculture on the north shore of Maullín River and its present-day situation.

A feminist political ecology approach

Much of the expansion of aquaculture in Chile, and throughout the global South, has been driven by export-oriented development strategies (Naylor et al. 2021; Poblete et al. 2019; Gerhart 2017). Critical scrutiny of aquacultural production is particularly important given the significant role that it is playing as a rural development strategy in the global south (Bank et al. 2021). While the benefits generated from the expansion of aquaculture initiatives may appear promising, they raise sustainability questions concerning the implications for gender relations and intra-community dynamics, governance and market power, distribution of benefits and impacts of production on local environmental conditions. There have been numerous publications that have employed different aspects of what could be regarded as a FPE approach to examine aquaculture/small-scale fisheries.

A FPE approach emphasizes gendered inequalities, justice and struggles that take place within natural resource settings, linked to wider structures of governance which shape the possibilities for resource allocation, adaptation and negotiated solutions (Elmhirst 2015; Nightingale 2017; Rocheleau 1995). Diverse studies on aquaculture/small-scale fisheries and related food systems have critically looked at the different aspects of the role that gender plays. FPE research has variously focused on overlapping topics in aquaculture/fisheries such as gender-specific negative effects of the workings of neoliberal capitalism (Liontakis et al. 2020; Mansfield 2004; Biswas 2011), gender and community governance/management (Frangoudes et al. 2013), enhancing women's empowerment/inclusion (Mengo et al. 2023; Koralagama et al. 2017; Mangubhai and Lawless 2021), access to and control of resources (Gallardo-Fernández and Saunders 2018), division of labour and gendered knowledge (Salmi and Sonck-Rautio 2018; Choo et al. 2008), women's dominant role in social reproduction and community well-being (Porter 2012; Weeratunge et al. 2014), gendered livelihood strategies (Hapke and Ayyankeril 2004), the need to address the invisibility/non-recognition of womens' work in fisheries (Gopal et al. 2020; Pedroza-Gutiérrez and Hapke 2022), women's role in food security (Rabbitt et al. 2019), womens' dominant role in entrepreneurialism/innovation (Bantigue 2018) and gender and environmental justice (Gustavsson et al. 2021) among others. This is by no means an exhaustive account of FPE-related research, but it provides insights into the scope and focus of FPE studies in aquaculture and fisheries.

Despite this growing body of literature about gender aspects of marine resource use, how this affects women and how benefits are distributed still require more empirical scrutiny (Gallardo-Fernández and Saunders 2018; Ramachandran 2012). As Garcia and Tschakert (2022) assert, this needs to include an analytical sensitivity to not only what drivers, dynamics and capacities perpetuate or exacerbate women's vulnerability but also those that empower and enhance women's social positions. In response, we adopt a FPE approach to understand the complexity of local fisheries institutions and practices with a focus on power relations to situate these practices in a broader socio-economic and governance context (Gallardo-Fernández and Saunders 2018; Elmhirst 2011; Rocheleau 1995). A key aspect of this approach is to examine how 'gender boundaries' in fishing that have in the past excluded women, are being negotiated, navigated and crossed (Nightingale 2011). This necessarily means paying close attention to sedimented notions of the role of women in aquaculture/SSF communities. Revealing flows of power among actors' access to and control over and distribution of benefits from resource use (Robbins 2019; Gallardo et al. 2017) can show how changing (global and national) market conditions are deeply implicated in (localized) environmental, political and social processes (Marin 2011; Álvarez et al. 2017; Donoso et al. 2018).

Our FPE approach is inspired and informed by the existing body of critical gender and aquaculture/fishery literature and key FPE work in other areas, like Sundberg (2017) who stresses that "gender is a crucial variable – in relation to class, race and other relevant dimensions of political ecological life – in constituting access to, control over, and

[1] To simplify, we use the popular term *pelillo* to refer to the *Gracilaria chilensis*.

knowledge of natural resources" (p.1). Following Hovorka (2006:209), we draw on FPE to analyse "gendered experiences of and responses to environmental and political-economic change that brings with it changing livelihoods, landscapes, property regimes, and social relations". We employ FPE to examine the gendered division of labour (Nightingale 2011), specifically focusing on (1) the involvement of women in production, marketing and innovation, (2) analysis of access and control of the distribution of aquaculture concessions, (3) the responsibility of women's reproductive labour (childcare, domestic work, community building, etc.) and to some extent (4) gendered knowledge, linked to the activities that women are central in performing (e.g. aspects of production, administration, marketing, innovation, etc.). We also examine the various changes or actions that affect fishers' market position and capacity to influence governance decisions that have implications for well-being, as well as between gendered relations within production and (reproduction) households. Here, we mostly focus on the asymmetrical power relations of the production/market dynamics which shape the possibilities for the distributions of value, with broader social and environmental implications for both men and women fishers.

The study context

Emergence of aquaculture in Chile

Since the 2010s, the demand for macroalgae has intensified worldwide due to the increase and diversification of the industry, and it has become a major new nutritional source for human consumption (Kim et al. 2017). Chile is the largest supplier of farmed algae in South America. Since the 1960s, and up to 1975, Chile produced small volumes of agar—a product derived from *pelillo.* Production intensified in 1975 under the Pinochet dictatorship, which strongly supported a primary export model within a neoliberal framework (Tecklin 2015; Cerda 2016). Through this export drive, the natural *pelillo* beds were intensively exploited between 1979 and 1983, until their ecological collapse in 1985 (Westermeier et al. 1991). At the beginning of the 1980s, demand for dried seaweed increased at the international level, and export prices rose seven to eight times in value over a sustained period of 17 years (Santelices 1989). Currently, one of the most important socio-economic algal resources is *Gracilaria chilensis* or *pelillo* (Calderón and Morales 2016; Adriazola 2017). The greatest number of small concessions for *pelillo* production is in Maullín—our study site.

In Chile, to obtain a marine concession for algae production, the proponent must develop a report describing the technology to be used, the species to be cultivated and the area to be farmed, which must then be approved by the Undersecretary of Fisheries and Aquaculture and the Marine Authority, among other government agencies. If approved, an aquaculture initiative can be authorized for 25 years. In the case of small seaweed farms (< 1 ha), there is no licencing fee.

There has been a gender gap in the Chilean artisanal fishing sector, but this has been changing with the formal entry of women since 2004 onwards, especially as seaweed harvesters (Gallardo-Fernández and Saunders 2018; Gallardo et al. 2018). This recent shift highlights the growing importance of the role of women in a field that until recently was strongly dominated by men (Gallardo et al. 2018; Gallardo and Friman 2010). In 2019, 20,003 women were registered as seaweed harvesters, which represent 28.5% of the total artisanal fishers in the country (SERNAPESCA 2019). Almost half of them, 57.8% (11,567), are from the Los Lagos region, where our study site Maullín is located. Important to highlight is also the increasing role women have been playing in leading fisher organizations in Chile (Gallardo-Fernández and Saunders 2018; Ávila et al. 2021). This expansion of women's participation has been accompanied by the establishment of several national and regional organizations that represent women in fisheries (Álvarez et al. 2017; Ávila et al. 2021).[2] As of 2019 (SUBPESCA/SERNAPESCA 2019), there were 1641 artisanal organizations in the country amounting to 66,880 members of which 55,502 (83%) were men and 11,838 (17%) women. Of the latter, 1190 had leading roles in the organizations as presidents, secretaries and treasurers; although the representation is not huge, it is a quite new scenario within Chilean fisheries.

Historical context of aquaculture on the Maullín River

The boom period of *pelillo* extraction, which led to the ecological collapse of the natural *pelillo* beds in 1985, prompted the Chilean State to grant individual small-scale concessions (favouring heads of families, which could be men or women) to create a more feasible governance system (J. Gutierrez ex-head of undersecretary of Fisheries in Los Lagos Region, Chile. Pers. communication, 2020). Originally, some of the granted concessions were on a commercial scale. During this early period of seaweed exploitation at Maullín, people were living in extremely precarious conditions in informal camps on beach areas (M. Ávila, personal observations during the 90S while working with the project SERCOTEC-PROFO I,

[2] Ávila et al. (2021) mention several of these instances, among which counts: Corporación Nacional de Mujeres en la Pesca Artesanal, created in 2017; Red Nacional de Mujeres en la Pesca Artesanal, created in 2020; and Mesa Tejiendo Redes, created in 2021 and Mesas Regionales de Mujeres, being implemented nationally.

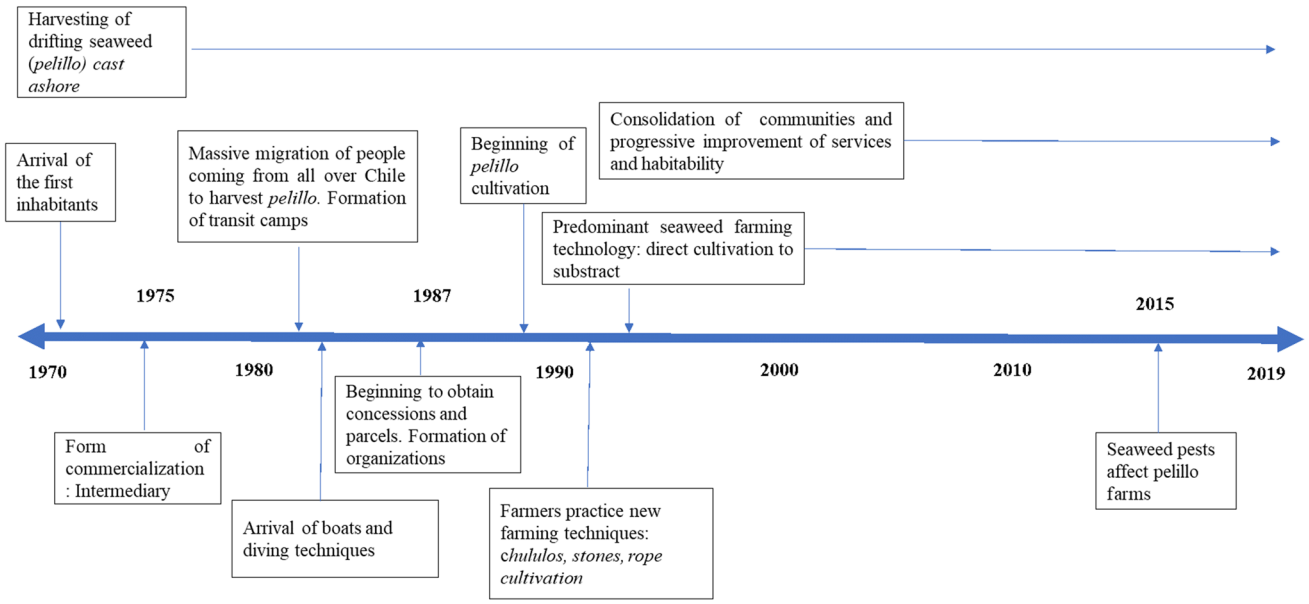


Fig. 1 Timeline from exploitation of natural beds of *pelillo* to initiation of farming

II and III for IFOP).[3] To redress this situation, the State also intervened granting territorial tenure to the harvesters in the form of private small-scale, residential areas adjacent to the beach areas, which resulted in the establishment of various residential, although precarious, communities (Adriazola 2017; interview with F. Ponce M., former Fisheries Director of the Undersecretary of Fisheries (SUBPESCA)-Los Lagos Region June 23, 2022), depending on aquaculture. It was difficult to find registers about this process, but most of the people were from the surrounding areas of Maullín, concentrating specifically in Maullín Norte due to the *pelillo* boom.

With the return of liberal democracy to the country in 1990, artisanal fisher organizations remerged nationally (Gallardo et al. 2011), which included demands for aquaculture concessions for *pelillo* farming. As Marin (2011) specifies, the State intervention strategies are not neutral but directed to a cultural change of the producers that better corresponds to the logic of a competitive market. The local mobilization of artisanal fishers, during 1990–1992, succeeded in persuading the government to withdraw some of the large private concessions on the Maullín River, which were reassigned collectively to organized artisanal fishers (J. Gutierrez ex-head of undersecretary of SUBPESCA-Los Lagos Region, Chile. Pers. communication, 2020). Some of the large-scale concessions lapsed due to the low prices of the *pelillo*.

Figure 1 shows the historical timeline of the different stages of aquaculture development at Maullín. In the empirical part of the article, we mostly focus on the period of aquaculture development from the 1990s onwards (mostly concerned with the current situation) while being mindful of how the historical context has ongoing implications.

Methodology

The empirical part of this study is based on primary and secondary materials, including government reports, statistics, etc. Both quantitative and qualitative methods were used. The fieldwork was carried out in three stages between 2017 and 2019.[4] The first stage of data collection (October 2017 to May 2018) consisted of a survey and semi-structured interviews. The survey was carried out with 94 cultivators corresponding to almost a third of the total of 322 granted concessions to natural persons in the Maullín River.[5] Out of the 94 cultivators surveyed, 69 were men (73.4%), and 27 were women (28.7%). This reflects the gender proportion among concession holders, with almost 30% of the original concessions granted to women as heads of families. The survey data was

[3] Note that the shore or beach area in Chile is a public good.

[4] See Acknowledgments.

[5] The objective of the survey was to perform a socio-productive characterization of aquaculturists, linked to project "FIPA N° 2017–10: Determination of ecosystem factors that favour the increase of *Rhizoclonium* spp., and development of a monitoring and control program of this pest species in the Region de Los Lagos". It aimed to describe the productive processes associated with the cultivation, extraction, harvesting and commercialization of *Gracilaria chilensis* (*pelillo*) and the impact of *Rhizoclonium* on these, specifically in the estuarine sectors of the Pudeto and Maullín Rivers in the Los Lagos Region.

reanalyzed with this study in mind to extract relevant gender-disaggregated data. In addition, semi-structured interviews were performed with 20 leaders (12 men, 8 women) of local fisher organizations on the north shore of the Maullín River to get deeper insights (views, experiences, clarifications, perceptions, ambitions, etc.) into the processes covered in the survey. However, only part of the survey data was used for his paper such as de jure tenure and management disaggregated by gender, as well as the division of labour in the production phase, innovation, aquaculture management, organization and leadership of community and labour level organizations. These data have been used to complement the rest of the information collected for this study. The gender-segregated data that we refer to throughout the articles is derived from the survey and the semi-structured interviews.

The second stage consisted of a reconnaissance visit to the north shore of the Maullín River in July 2018, to meet with a group of ca. 70 women to get their specific perspectives, experiences and insights. During this visit, we went to the villages and surrounding areas as well as the riverbank to observe the concessions. The third stage of the data collection was carried out in December 2018. We held a workshop using participatory tools with aquaculture concession holders. The workshop was attended by 12 women and 4 men, with which we formed 4 groups, finalizing with a plenary.[6] The research team based on an analysis of the earlier reconnaissance visit organized the workshop around four topics: (1) problems, (2) shore collection, (3) innovation and (4) the role of gender in community organization and aquaculture management (seeding, harvest, cleaning, evaluation, etc.). The scope of the workshop spanned the production and marketing of *pelillo*. Production-based activities were divided into three groups: individual cultivators, unions' collective cultivations and extra livelihood activities. The collection and innovation activities were performed exclusively with women based on their expertise and experience in these areas. These groups worked with their respective issues, and data were generated through discussion within the groups. In the plenary, the researchers in discussion with the participants made a synthesis of the main workshop conclusions. The workshop results were then used as the basis for an additional semi-structured interview with two representatives of local unions on the main problems they experience (collectively) as well as possible solutions.[7]

As a result of the analysis of the empirical data collected in the locality, a mental map was developed. The map organizes data into three themes: (1) marine tenure, (2) production (including cultivation and gathering) and (3) marketing, all with a gender perspective. It also includes the description and analysis of problems and possible solutions expressed by the workshop participants (see Fig. 2).

Results

Marine tenure structure

In the locality, seaweed exploitation began in the 1970s. Twenty-two percent of those surveyed reported having started in the sector working in free-access areas (ALAs in Spanish) with seaweed gathering in that decade, while 41% reported having started between 1985 and 1995 and the rest after that. In the beginning, there were no concessions on the Maullín River; exploitation was done informally, and sales were made directly to a company (interview with a 65-year-old harvester; interview with F. Ponce M., former Fisheries Director of the Undersecretary of Fisheries (SUBPESCA) (June 23, 2022)). After concessions began to be granted, the main wholesale company began to buy algae principally from larger private concessions that, at that time, belonged to non-local people and companies. On this, one interviewee told us that "the local people were of the opinion that the extraction of seaweed should be carried out by the locals" (Fig. 3).[8]

Table 1 shows the complex tenure modalities in the study area. At present, there are aquaculture concessions de jure and de facto use in ALAs. Aquaculture concessions are granted for the use of natural persons and can be granted to (A) a fisher called *parcelero/a* and the concession *parcela* and (B) to any other private person who requests it. There also are aquaculture concessions that are granted to legal persons such as unions, universities and companies. Both categories (1 and 2) are de jure. Most of the aquaculture concessions in the Maullín River belong to type A. There are 322 concessions of 0.30 ha. Concessions held by legal entities (A) are not inheritable, while company concessions (B) are inheritable, alienable, leasable and mortgageable. There is though only one company concession. C concessions such as academic research and governmental entities—both non-profit—are not inheritable. There are two concessions of this type (Ávila et al. 2019).

All gatherers that are registered in the Registro de Pesca Artesanal (RPA; National Fishers Registration) are permitted to collect seaweeds cast ashore (subtidal gathering). Thus, a *parcelero/a* can also formally gather *pelillo* on the shore that comes from the concessions, regardless of which concession

[6] Group 1, 2 and 3 of women did (A) problems and (B) administration and management, likewise group 4 of men. The three groups of women did additionally innovation.

[7] One of the interviewees was the president of a union, and the other was a member of another union. Both unions were created in 1986. The first had 28 members: 17 women and 11 men. The second had 29 members, mostly women.

[8] Male 1 *parcelero* and leader of a Union local organization, 69 years old.

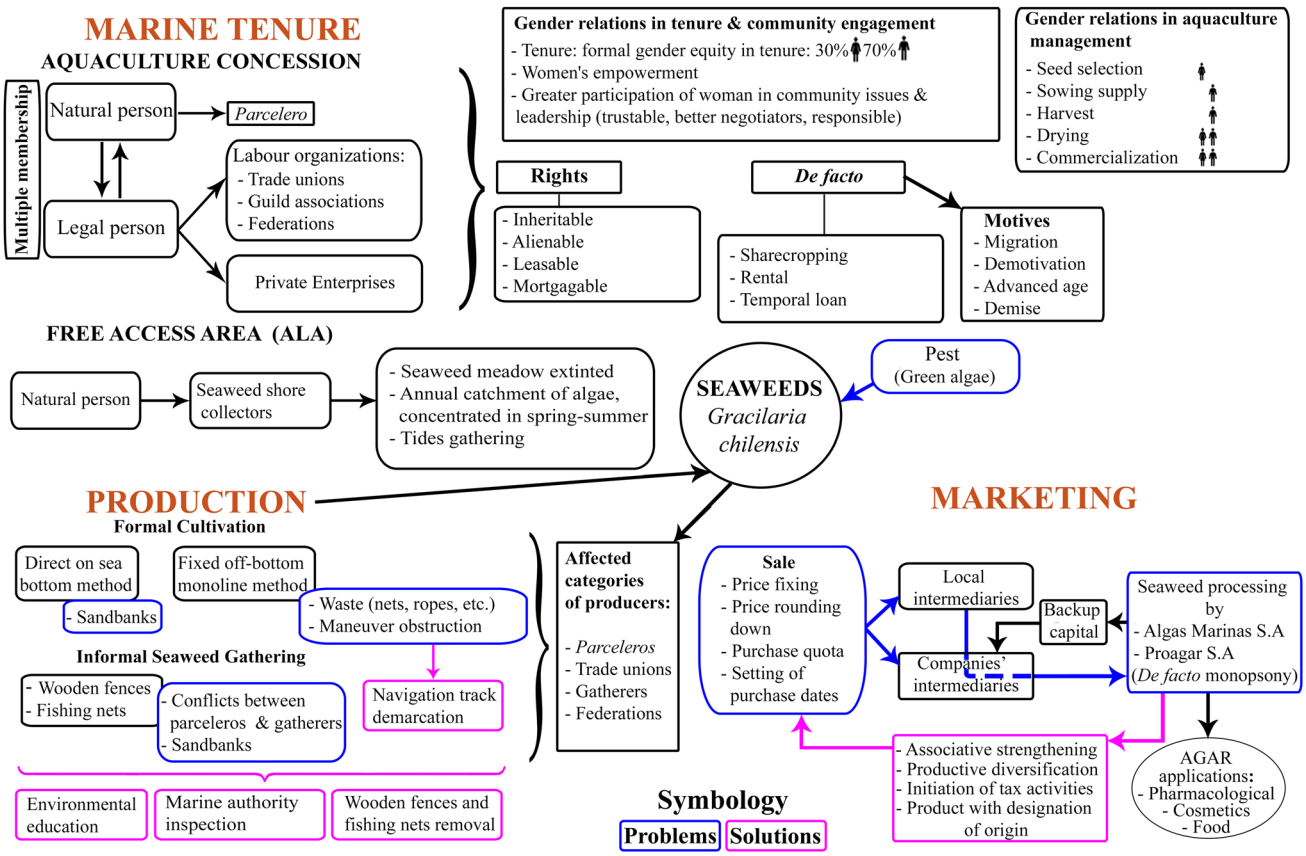


Fig. 2 Mind map based on the analysis of the empirical data collected during the workshop with women and men from the North shore of Maullín River, December 2019

it comes from. There is also an undetermined number of informal gatherers (not registered with SERNAPESCA) who do the same. Subtidal gatherers collect drifted seaweed from the boats also using formal and informal structures/tools. The structures forbidden by law are the wooden fences that are installed without legal authorization. The exploitation period

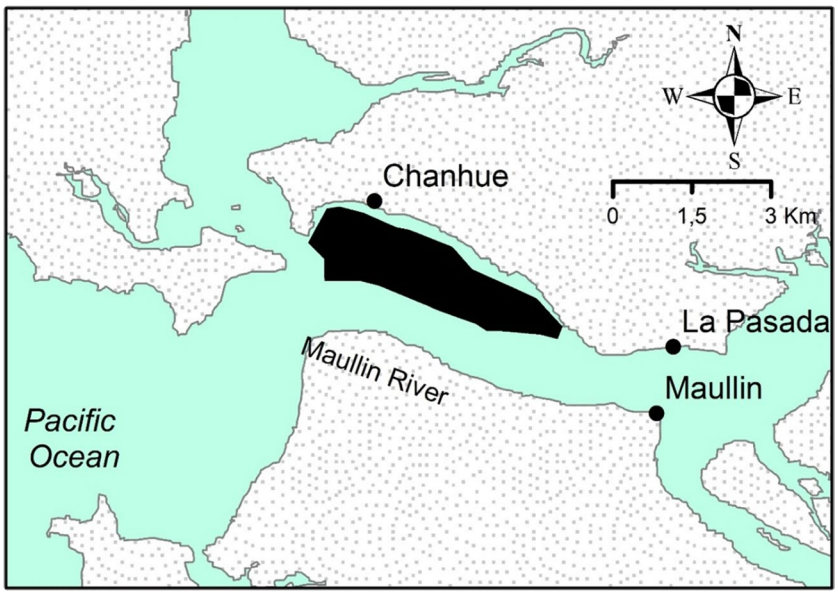


Fig. 3 Distribution of concessions for seaweed culture (in black) in North shore of Maullin River

Table 1 Synthesis of the current (not disaggregated) aquaculture tenure modalities in the study area

Tenure categories		Designation*	Area (ha)	Total area (ha)	Types of tenure/use	Rights
De jure tenure aquaculture farms	1. Natural person	(A) *Parceleros* (men & women) < 1 ha	0.30	96.6	Formal: holder	Inheritable alienable, leasable, mortgageable
					Informal: sharecropping lease, or temporary loans	Non-inheritable
		(B) Cultivator > 1 ha	> 1	7	Formal	Inheritable, alienable, leasable, mortgageable
	2. Legal entity	(A) 25 Artisanal fisher organizations, plus one indigenous community: Unions, guild associations, cooperatives, federations	> 1	237.5	Formal	Non-inheritable, alienable, leasable, mortgageable
		(B) Company	> 1	28.8	Formal	Non-inheritable, alienable, leasable, mortgageable
		(C) University and Municipalities	> 1	7	Formal	Non-inheritable
De facto use in ALAs	1. Natural persons: Subtidal collectors & intertidal shore collectors	Not official registered gatherers; Unknown number			Informal	Don't have any legal tuition

*Denomination only for the Maullín River area

in both areas is seasonal, and the tools used are almost the same in both spaces, except for the rake, which is only used in the intertidal shore during low tide. Informal gatherers collect *pelillo* that gets stuck in the wooden fences that are connected to nets and act as a barrier to retain the algae that is freely floating in the river. Since the informal gatherers do not have permits to carry out this activity and cannot declare what they collect, the volumes of the extracted *pelillo* are unknown. This is a de facto use, occurring during the harvesting season (September to March or April).

Among the *parceleros/as*, even when there is a clear legal assignation to a concession holder, in practice, the concession may be being leased out and operated by a third party, mostly through informal agreements, without being formalized. These informal leaseholders are mainly part of the local male *parceleros*, which explains the figures below in the sense that 23% of men managed two parcels and 9% managed more than two parcels (see below). The functioning of seaweed aquaculture in these cases is not different from the way these parties manage their other tiny parcels. The process to legalize the agreements is an obstacle for several reasons, including the time it takes, the distance from the place where the process must be undertaken or the complexity/uncertainty of the bureaucratic process. Among the reasons that gave rise to third parties using concessions formally held by others are the migration of the holder (mostly men) for economic reasons (temporary or longer term), lack of motivation to cultivate the *parcela* due to the low price of seaweed and the advanced age of the holder or his or her death.

A comparison by gender of the results surveyed between 2017 and 2018 shows that 68% of men managed only one parcel, 23% managed two parcels and 9% managed more than two parcels. Of the total number of 28 surveyed women, the majority stated that they held only one parcel; 8% held two parcels. None of the women surveyed reported holding more than two parcels. Eighty-one percent of the 94 surveyed stated that their income comes mainly from seaweed farming; the remaining 19% obtain their income from various activities (fishing, formal jobs, agriculture or retail trade).

Production

Even when the individual *parceleros/as* have the marine tenure to cultivate seaweed, they commonly lack capital for planting and for the purchase of production-related equipment and/or to support the operational costs of seaweed cultivation. The State supports the cultivation and repopulation of seaweed, according to the size of the area and the technique used (Law No. 20.925). However, the annual budget is limited. Although the *parcelas* are in theory inheritable, alienable, leasable and mortgageable, their value is too low to be used as collateral for bank loans. Although the *parcelas* are

Table 2 Participation of men and women in the whole production process of aquaculture cultivation as of the beginning of the 90 s

Tasks	Men	Women
1. Planning to sow	✓	✓
2. Seed selection		✓
3. Preparation of materials	✓	✓
4. Transportation of seeds & materials to where they will be sown	✓	
5. Diving to sow seeds	✓	
6. Surveillance, monitoring the seaweed (presence of epiphytes, predators) & general care	✓	✓
7. Harvesting	✓	✓
8. Drying	✓	✓
9. Transportation of seaweed to the place of sale	✓	
10. Equipment maintenance & repair	✓	
Total	9	6

in theory inheritable, alienable, leasable and mortgageable, their value is too low to be used as collateral for bank loans. In practice, at least from the beginning, the system worked as a kind of contract farming,[9] involving three social actors: one main company (see below), the middlemen (also called intermediaries in the figures) and the farmers. The company provided the money to the middlemen, many of whom were themselves local farmers, who in their turn provided credit to the *parceleros/as* when required (e.g. for seeding or other operating costs). With time, as the middlemen have improved their situation, they have also been acquiring assets such as trucks and informal storage warehouses to stockpile large volumes of *pelillo* for the company. The system continues to be a kind of contract farming in the sense that neither the company nor the middlemen directly enter the production process. In practice, to be obliged to sell to the middlemen is controversial, increasing fishers' distrust of the criteria for establishing purchase prices for seaweed. A female interviewee noted "Everything here goes through the middleman. Without the middleman there is no delivery. So, what happens? They keep half of the money from us". She also adds "all middlemen are the same; but there is one that has more capital than the rest, but the prices are the same".[10]

Seaweed planting is a seasonal activity, which occurs between autumn and spring. In individual parcels, during summer when children are not at school, this is family work. In some cases, male divers are hired for the planting season. In the fisher organizations, seaweed planting is done collectively by both men and women. The seaweed nurseries are managed by women, who verify the quality of the seaweed for planting. Subsequently, the rest of the work, both transferring the seed and diving, is done by the men from boats. Women's participation in the production process is focused on activities such as planning the planting process, seed selection and other production-related activities. Three tasks are only done by men; these are transportation of seeds, diving to sow seeds and equipment maintenance and repair. Diving and mechanical know-how is traditionally done by men. The rest of the activities except seed selection, which is done by women, are performed together (Table 2).

There is a traditional gender division of labour when harvesting: men (in groups of two or three) harvest the seaweed directly on the water from a boat with the help of a hooka diver with a tool called a 'spider'. Women recollect detached seaweed on the shore partially submerged in the water. A key problem highlighted by women in the workshop and interviews was the *macho* behaviour of the men concerning the aquaculture work and household tasks. That is, although both work in the *pelillo* production, women do all the reproductive work (i.e. caring and housework).

Systematic poaching of seaweed was highlighted as a problem to the extent that each holder must invest their own time in surveillance or pay others to prevent theft. Production problems highlighted included among others, siltation (accumulation of sand on the bottom) and the presence of waste (abandoned nets, ropes and rest of wooden fences). Since 2013, there has also been a periodic occurrence of pest-related algal blooms (*Rhizoclonium*-type green algae). This resulted in almost 90% of annual production losses between 2013 and 2015. We were told by fishers that it reduces the quality of *pelillo* and constitutes an ongoing production threat up to our days. This problem was also highlighted by Ávila et al. (2021, p. 27).

Marketing

An interviewee pointed out that since 1978, the marketing of *pelillo* has been uninterrupted except during three separate

[9] "Contract farming, in its various forms, allows a degree of control over the production process and the product without the firm directly entering into production." (Prowse 2012: 9).

[10] Female cultivator (1) local leader of fisher organization, 52 years old.

periods: (a) overexploitation in the period 1985–1990, (b) a decrease in international demand when China began producing and exporting *agarophyte algae* during 2009–2010 and (c) occurrence of the massive proliferation of the algae pest *Rhizoclonium* spp. since 2013.

While artisanal fishers' organizations sell their *pelillo* to companies or middlemen, individual *parceleros/as* and informal gatherers sell only to middlemen. Both women and men are paid directly by the middleman in the process of selling the seaweed. The price paid per kilo of seaweed does not vary among the middlemen. The *pelillo* production ends up in two processing companies. Of these, the Algas Marinas S.A. company purchases almost all the sold seaweed (> 95%) and another company, Proagar S.A., the remainder. This is what the fishers interviewed referred to all the time as a 'monopoly', thus having direct implications on the price due to the concentrations of market power.

Pelillo marketing includes several tasks in which men and women participate. Of the total of six activities involved in the *pelillo* marketing, women participate in four. The two activities that women are not involved in (3 and 6) require more physical effort. The only task that is done mainly by women is recording the weight of seaweed sold at the beach. Men and women collaborate on all the other tasks. For the sale of the gathered or cultivated seaweed, either fresh from the beach or dried from their precarious warehouse, a workgroup is organized consisting of three people: a woman who keeps the weighing records as the fishers' counterpart, the men who clean the seaweed of impurities and fill sacks or baskets for weighing and the intermediary, who record the weight. These records are used to verify fair payment for the raw material sold. Transportation to the processing plant is done in trucks that carry from 30 to 60 t of seaweed, driven mostly by men; drivers can be middlemen or contracted by the processing company.

Income generation has been stagnant since 2010, which *pelillo* producers attribute to various reasons, including the local market relations or monopoly conditions referred to above. The wholesale purchasing companies also have significant influence over production processes, the sale or delivery of seeds, how definition purchase volumes are determined and prices. All these aspects are vital parts of the *pelillo* production and sale process and can have significant effects on the distribution of benefits to the *parceleros*, the fisher organizations and the coastal collectors.

Producers' income is also affected by poor *pelillo* cultivation practices, such as installing fences (wooden stakes) to capture the floating and untouched seaweed (see Fig. 2), which affects the environmental conditions for crop production and generates recurring conflicts between producers and shore collectors. Since the 1980s, conflicts have arisen due to the installation and use of forbidden fences in the *parcelas*. A *pelillo* without regular pest infestations would also render better prices.

Table 3 Participation of men and women in the marketing phase of *pelillo*

Gender participation in the marketing of *pelillo*		
Marketing tasks	Men	Women
1. Contact with buyers	✓	✓
2. Cleaning of harvested seaweed	✓	✓
3. Weighing	✓	
4. Recording		✓
5. Payment	✓	✓
6. Transportation to the factories	✓	
Total	5	4

Surveyed interviewees indicated that there are abuses by middlemen in the price paid for wet and dry seaweed, which is reflected in the lack of clarity in pricing parameters, uncertainty about purchase dates and the practice of rounding down (to a lower amount) by middlemen during seaweed weighing, for example, if the weight is 6.6 kg payment is rounded down to 6 kg. Since the beginning of commercial fishing activity in 1975, conflicts over pricing have been a persistent problem (see Fig. 1). Refusing to sell seems not to be an alternative for individual producers. For example, the two women representatives of local unions expressed that "The lack of financial solvency makes them sell the seaweed day by day".[11]

Fishers also state that during periods when international demand decreases, a system of purchase quotas per family is generated, independent of the number of parcels managed by the family. Middlemen then decide who to buy from, privileging certain groups over others. One interviewee captured the uncertainty associated with this situation "today they bought 1,000 kilos from the parcels; we don't know when they will buy again".[12] The uncertainty of demand and low prices generate disincentives for producers. They do however have ideas to address these problems. For example, it was suggested that formalizing the production activity with the Internal Revenue Service would allow producers to sell directly to companies. Under the current arrangements, wholesale seaweed buyers (i.e. companies) cannot buy seaweed from producers without being registered, so producers must sell to middlemen. Another proposal to add value (for local producer benefit) by cultivators and gatherers was to construct free-access storage warehouses with modern infrastructure. This was considered by some of our interviewees to be an important initial step to be able to have more control in the face of fluctuating international demand and intermediary power. A female interviewee summarizes these aspirations in the following way, adding other reasons

[11] Please, see footnote 6.

[12] Male cultivator, 69 years old.

Table 4 Gender participation in innovation, aquaculture management, organization and leadership at community and labour level organizations

Innovation	Men	Women
1. Organization of local committees to solve community problems	✓	✓
2. Application of projects		✓
3. Proposing innovation alternatives beyond, aquaculture production		✓
Unionization & leadership		
4. Acting in leading positions at local unions & regional federations & local committees	✓	✓
5. Membership in unions	✓	✓

for discontent: "We need an administrative structure, warehouses where we can dry and export; we no longer must go through those middlemen that are there. They should not come and set the prices; we should set the prices".[13] Table 3 summarizes the participation of men and women in the marketing phase of *pelillo.*

Women's participation in innovation, management and leadership

It was emphasized that women play a significant role in innovation and aquaculture management. It was stressed that especially younger women are very active in aquaculture production innovations. Generally, women were seen by men to have more competencies in these areas and a bit higher educational level than men; competencies considered to help build connections with public agencies, NGOs and research centres. For example, applications for outside support, engagement or to comply with administrative requirements are mostly made by women. These skills, along with other soft skills attributed to women, have also emerged in various other studies (Gallardo-Fernández and Saunders 2018; Ávila et al. 2021).[14] A problem highlighted by women was that during the winter months, income decreases due to the production cycle of *pelillo.* Proposed innovations focussed on new local consumption niches by adding value to the production of *pelillo* including producing seaweed flour with a designation of origin brand, fertilizer for local agricultural activities, cosmetics and seaweed gastronomy products (local pastries and traditional fairs). Although not directly related to seaweed-based livelihoods, women also highlighted the potential to develop tourism activities in the area, including local handicrafts, camping, fishing, boating and competitive sports. According to semi-structured interviews with 20 leaders of local fisher organizations, since the 1990s, women also have been key to obtaining fundamental infrastructure and services such as drinking water, primary school and medical posts. This was after fishers had been granted tenure rights for housing. Women are as well unionized and play leadership roles with fisher organizations, unions and other community-based organizations. In this regard, participants in group 4 of the workshop mentioned that over the past few years, there has been a noticeable rise in women's involvement not only in unions but also in neighbourhood juntas, housing committees and sports clubs. Referring to the distinctions in responsibilities between men and women, men stated that when women take on leadership roles, they do so with a greater sense of responsibility, and they tend to receive more respect, being seen as more serious and trustworthy. We were told, at that time, eight women were presidents of local unions out of a total of 20. Table 4 summarizes gender participation in the mentioned spheres.

Women suggested, both in the workshop and in the additional semi-structured interview we did with two representatives of local unions, ways to improve current conditions and orient seaweed cultivation and gathering on a more sustainable footing. As indicated in the "Methodology" section, we were told women were most active in innovation activities. Therefore, we followed this issue in two groups of women in the workshop, while in the plenary part of the workshop, women also discussed adding value and certification of origin. Men also suggested here the formalization of tenure of informal concessions. Of the six improvement factors (see Table 5), four were proposed by women, while one factor was mentioned by both men and women.

Analysis

The co-emergence of community and aquaculture

The development of the marine tenure to support algae cultivation has had an important gender and socio-ecological effect

[13] Female cultivator (2), local union leader of a Union, 40 years old.

[14] Gladys Alvarado, member of the Women's Weaving Network, leader of CONAPACH, first woman present on the board of the Hualaihué Fishermen's Federation, councillor for 8 years in the Municipality of the same commune as well as president of the Union of Neighbourhood Councils of the Hualaihué Commune, said "leading has always been a matter for men, but since women are more organized, we have been gaining spaces for participation and decision power, breaking down obstacles" (Avila et al. 2021, p. 32).

Table 5 Summary of critical improvement factors divided by gender

Critical improvement factors	Current problems	Suggestions to overcome problems		
		Men	Women	Both
Tenure	There is a degree of informality due to excessive bureaucracy	Formalization of tenure of informal concessions		
Farming technologies	No innovation in farming technologies		Training for innovation in cultivation techniques to improve production and ensure sustainability (seeds) and preventive pest monitoring	
Fair price	Weak marketing system. Cultivators/gatherers negotiate individually or through unions. Variable price, existence of middlemen with abusive practices that 'control' the purchase of seaweed			Create a producer's association and establish fair price criteria in a transparent way
Quality criteria	There are no established criteria for producers, they are subject to the intermediary (purchaser)		Establish quality criteria in a transparent manner and make them known to producers to implement a price band	
Good practices in *pelillo* farming	Low yield in cultures and low quality of seaweed		Training in improving yield in production, primary processing, development in cultivation and harvesting technology, seedling production and dissemination of the existing good practices for *pelillo* cultivation. Interact with science researchers in genetics, impact of the seaweed culture in ecosystems, epiphytes and diseases, threats for climate change, apport of seaweed cultures in carbon sequestration	
Diversification in the use of *pelillo* with an emphasis on adding value to products	There are no products with market projection that allow other uses of *pelillo*; only pilot initiatives. (e.g. flour, fertilizers, organic agar, gastronomy)		Encourage the development of projects on the use of *pelillo* with the participation of growers in the search for products with market projection	

on the north shore of the Maullín River, which generated a geographically delimited coastal settlement in the form of six small villages, which spatially connected aquacultural activities ('the work area') with the fishers' living area. While both the seaweed-based livelihood and living area remained relatively precarious, the adjacent land tenure enabled a synergy between domestic and work life, which as we have seen played an important role in aquacultural practice. During the early 1990s, with the transition of the country to a liberal democracy, fishers were effective in mobilizing to exert pressure on the State to withdraw concessions assigned to private companies during the military government. The role of the State was also crucial. Through its various agencies, it enabled tenure security of marine spaces for the implementation of algae cultivation but also land tenure for housing. The distribution of marine parcels—individual and collective—not only provided access to develop *pelillo* aquaculture but was also important in integrating women in aquaculture contributing to family income, encouraging a family work culture as well as community social organization, in which women played a key role. It supported both the creation and maintenance of social organizations that helped to improve living conditions and strengthened the connections of producers to their main livelihood activity and to each other, thus helping to generate community coherence and indeed connections to place.

Market power dynamics—a common problem for fishers

The positive advances described above were important at the community level, empowering women's roles in aquacultural production and generating productive community dynamics in similar ways that have happened elsewhere (Ahmed et al. 2012; Luomba 2013). However, these positive aspects were adversely affected when the price of the resource fell drastically in the 2010s. This price drop was further exacerbated by the connection to market constraints (discussed at length above), low demand and purchase quotas. In sum, it meant that the production of a concession of 0.3 hectares did not generate sufficient income to support a family.[15]

The seaweed wholesale company, via individual agreements with its (male) middlemen, sets the price and the local demand for the seaweed (as raw material), and it has been argued by the company that both have been declining in recent years due to factors associated with the global market. The argument is that since 2003, a*garophyte* algae, which is produced in China, has largely replaced Chile's *pelillo* production thereby lowering both demand and price on the global market. However, export statistics (FAO 2012) do not fully support the price argument. While it can be observed that there has been a decrease in the volume of *pelillo* exported from 2004 to 2018, both for dried seaweed (around 80%) and agar–agar (around 40%), international prices have been rising. The value paid to cultivators and gatherers during 2019–2020 for raw seaweed was approximately 27% of the export value. To counteract the low prices, it is not possible to increase the number of parcels or the size of parcels per family, because almost the entire area suitable for *pelillo* cultivation is already occupied. This has resulted in men emigrating elsewhere for work, commonly during wintertime, but also for longer periods. This is a phenomenon that has been observed elsewhere, which as Islam and Herbeck (2013) note may help poorer fishers cope with shocks (such as price drops in this case) but may also have adverse implications for family connections and well-being, as well limiting the capacity of communities to effectively represent their needs and interests to public agencies and other relevant actors.

To address the integration of the *pelillo* value chain in all its phases (i.e. seed supply, planting, harvesting, processing and connections to markets) requires investment by cultivators, who do not have the funds to invest since seaweed cultivation gives marginal levels of income, thereby inhibiting (re)investment. It is also evident that there is a lack of collaboration among cultivators and between cultivators and other institutions that support sustainable *pelillo* production, including university research centres and public institutions such as ministries and municipalities. The lack of technological innovations in cultivation and other problems associated with the activity, such as theft, installation of wooden fences and nets to trap algae and the lack of oversight by state agencies, are problems that the Maullín River cultivators have not been able to solve either independently or with the current levels and types of support available from public agencies involved in seaweed cultivation. The fishers, both male and female, argue that the lack of supportive collaboration and innovation, lack of selling contracts with middlemen, holding of parcels without formal concessions, etc. are problematic. The exploitative role of the middlemen in fisheries is not uncommon and has been noted elsewhere, for instance, see Thủy et al. 2019) in a Vietnamese fisheries context writing about the skewed distribution of benefits to middlemen and Surtida (2000) discussing the oligopolistic market structure in the Philippines, where middlemen have significant control over the market distribution of fish. Maullín River cultivators also stress that the current institutionalized market arrangements, the lack of cooperation between unions and individual producers in the selling process and the recurrent occurrence of pests force them into

[15] This analysis does not include a comparison of the production results of the concessions of the fisher organizations, whose earnings also go to the individual concession cultivators (as members of these organizations). While our study did not address a comparison of the production results of the concessions of the fisher organizations, the market practices (and wider price trends mentioned above) equally affect fisher organization incomes. According to a fishing organization leader interviewed, one local wholesaler company buys 95% of the seaweed production.

unfair arrangements with firms, a situation where middlemen exert market power resulting in low prices for seaweed. This gives the fishers little to no leverage when negotiating over seaweed prices.

Gendered concession holdings

The tenure dynamics discussed above have resulted in a system of 'first-hand' formalized tenure of concessions, with time and changing conditions, also influencing the emergence of an informal system of 'second-hand' tenure concessions, running in parallel. This is due to the absenteeism of individual holders, mostly men. This was because of a decreased incentive to cultivate (because of low prices, as discussed above) with the effect that formal tenure holders seek work elsewhere. These shifts are problematic because the informal/formal tenure arrangements that have emerged work to undermine the access and distributional aspects embedded within the formal institutional constraints, i.e. against holding multiple concessions and furthermore work to disadvantage women, although low prices affect men and women fishers alike. That is, it is mostly men who hold multiple concessions.

Production synergies and reproduction roles

Both men and women consider that they work in complementary ways to produce *pelillo*. This gives the work activity a family character, which is most explicitly expressed in the way families manage their individual concessions. The family character of aquaculture work, as well as the proximity between residential and production spaces, further underscores the complementary roles that men and women play (Andrada 2015). The lack of viability of income solely from seaweed production production-related activities generates a range of negative impacts. Including the need for men to travel elsewhere for work which divides families, threatens the gender synergies evident in aquacultural practice and undermines the capacity for collective action by the local community (as members may be absent for extended periods). Complementary gender relations in seaweed production do not seem to translate into a more equally shared workload inside the home, where the greater weight of domestic work continues to fall on women and even more so when men migrate to work. While men migrate, women are those who stay.

Gendered innovation and knowledge

The low market power of the cultivators has a substantial impact on Maullín River cultivators' capacity to support innovative projects to draw national competitive innovation funding, as promoted by women. Innovation support would potentially open seaweed processing options (beyond only selling seaweed as raw material) and enable diversification of post-harvest activities to produce seaweed-related products with greater added value. Women were more knowledgeable about and engaged in developing potential post-production innovation ideas than men—a finding that Freeman and Svels (2022) and others such as Frangoudes et al. (2013) also note in other contexts. Men were aware of and spoke positively of women's entrepreneurial abilities to organize linkages to and conduct market transactions. Men also acknowledged the variety and extent of seaweed-related administrative activities that women undertake. These tasks demand a diverse range of knowledge competencies, including literacy, math and financial expertise as has been demonstrated by other empirical studies (Álvarez et al. 2017; Gallardo-Fernández and Saunders 2018; Ávila et al. 2021). In addition to increasingly holding leadership positions in fishing organizations, women also have continued to play leadership roles in securing community services and infrastructure (see Bantigue 2018, who also notes this in a Philippines context). More specifically women were key actors involved in gaining marine family concessions and land tenure security. Shirajee et al. (2010) and Choudhury et al. (2017) in Bangladeshi contexts also observe the significant leadership roles women play across a broad range of aquaculture production and post-production activities.

Conclusions

This article has described several positive aspects of the Maullín aquaculture development, such as the government granting small-scale community marine concessions and support for adjacent community settlement, as well as widespread cooperation (sharing of work) between men and women in aquaculture production. However, we have also examined several interlocking processes implicated in the marginalization of the fishers and threats to the sustainability of aquaculture at Maullín. These processes are associated with different aspects of current aquaculture practice and the institutional context in which it is embedded. They are (1) drops in seaweed prices through both localized processes of collusion by middlemen employed by wholesalers and/or through world market fluctuations with severe implications for the viability of seaweed-related livelihoods which, apart from being inequitable, damages community coherence; (2) the ongoing vulnerability and loss of production related to worsening environmental conditions largely induced by the aquaculture activity itself, which include ongoing pest infestations and regular eutrophication events; (3) men's labour migration, which has the effect of reducing gender synergies

in aquaculture work, dividing families and undermining potential for effective collective community action, besides overloading women with household responsibility and care of both children, disabled and elderly; (4) the asymmetrical gender access of informal de facto maritime concessions, which exacerbates the inequity of gender relations, favouring men; and (5) the more general lack of alliance building and government political, scientific, technological and infrastructural support. All these factors interact to generate worsening conditions, livelihood conditions and prospects from seaweed cultivation at Maullín—degraded environmental conditions, poor economic prospects and inequitable social and gender relations that continue to be reproduced among offspring.

The results underline that the exploitation of natural resources is crossed by inequities between actors at the local levels which is shaped by relations to broader socio-economic, institutional (governance and market) context. While Maullín is but one case of aquaculture development, arguably, it can be seen as a part of a broader shift, where the rapidly changing political economy of coasts and oceans are reconstituting gender relations and social identities through the emergence of new economic activities linked to the global market in the interface with nature—for the better or worse. Nonetheless, women's empowerment in fisheries may have arrived given their increasing profile and roles. We must remain critical of the fact that women may fall easily into the double-duty trap, still without remuneration for reproduction.

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Data availability The data underpinning this article is available on demand.Requests for access to the data can be made by contacting Gloria.l.gallardo.fernandez.@sh.se

Declarations

Conflict of interest The authors declare no competing interests.

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