
HISTORICAL - GEOGRAPHICAL COLONIZATION OF SALMON FARMING IN PATAGONIA

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SUMMARY

A historical and geographical analysis of the Chilean salmon aquaculture colonization was carried out considering aquaculture licenses. This industry has many environmental and social conflicts in Patagonian seascapes, so a historical view can provide insights for future marine exploitation planning. A total of 1,398 salmon aquaculture licenses have been granted over 40 years, and 367 applications are under evaluation. Most granted license sites are located in the north side of Patagonia (39% and 51.8% in Los Lagos and Aysén regions, respectively) and, the southernmost region (Magallanes) contains 8.5% of granted

licenses, though it has the highest number of pending licenses (47.7%), which are under assessment processes. Over time, the geographical areas of salmon farming operations have changed due to multiples factors such as marine pollution, excess of salmon farms, and disease outbreaks, triggering three pulses of colonization. This process has generated many conflicts linked to indigenous marine stewardship, customary sea tenure, and biodiversity conservation. Considering this scenario, in this work it is considered that new salmon farming expansion could change the social-ecological system in the southern tip of South America.

Introduction

In the last 40 years, aquaculture production has sharply increased worldwide, and most captured fisheries are overexploited globally (Volpe *et al.*, 2013; Belton *et al.*, 2020). In the food industry, fish aquaculture has been an alternative to cover the global demand for seafood. However, the interdependence of coastal and ocean fisheries and terrestrial agriculture has increased as a result of the aquaculture feed production (Naylor *et al.*, 2021). In this global need for incorporating a new actor in the seafood supply chain, fish-aquaculture industries searched for countries achieving high production rates while their production costs (labor, taxes, etc.) have been minimized. Additionally, the environmental production costs are externalized, and for that purpose, aquaculture industries need countries with flexible

regulations and low compliance levels. The salmon farming market represents a glocalization process (see Swyngedouw, 2004) because it can operate at supra-national levels (globalization), but can be established on local spaces, using their global influences with different local actors and national policies (localization).

Salmon farming is the leading aquaculture activity in Chile, although pathogens have been one of the important issues in the aquaculture expansion. Since 1980, this food industry has grown almost continuously, placing the country as the second-largest global producer, just behind Norway (FAO, 2020). In 2007, the industry was hit by the infectious salmon anemia (ISA) virus. This event caused significant mortality on the salmon net pens in the Los Lagos region (Valdés-Donoso *et al.*, 2013), triggering a decline in

production volume and a social crisis with about 20,000 job losses (Quiñones *et al.*, 2019). In April 2013, the ISA virus expanded its presence to southern areas. The salmon industry partially controlled the ISA virus, though the production system is still fragile due to pathogens (Bravo *et al.*, 2013).

In Chile, a substantial number of scientific reports have been published about how salmon farming operations have impacted marine environments from ecological and social aspects. It is known that the increase of nutrient loads, such as phosphorus and nitrogen, can be an important factor in the increase of phytoplankton density and the shift in dominant groups, from diatoms to dinoflagellates (Soto *et al.*, 1997; Buschmann *et al.*, 2006). Salmon farms increase the organic matter sedimentation, triggering lower oxygen levels and reducing species richness (Buschmann *et al.*, 2009;

Miranda *et al.*, 2020). Furthermore, an overuse of antibiotics can have silent consequences on antibiotic resistance in bacteria (see Jara *et al.*, 2021) and, they can affect native fishes as well. For instance, oxytetracycline and quinolone residues have been found in muscle samples of the fishes *Eleginops maclovinus* and *Sebastes capensis* (Fortt *et al.*, 2007). Reports indicate that Chilean salmon farms use up to 20 times more antibiotics than those in Norway (Carranza *et al.*, 2020).

Another significant impact is the escaped salmonids from farms that can alter trophic webs in southern Chile. Salmonids can prey on native species such as *Odonthestes regia* (Niklitschek *et al.*, 2013), and juveniles of the *Macrorhynchus magellanicus* (Soto *et al.*, 1997), that are relevant species for artisanal fisheries. Indeed, 650,000

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COLONIZACIÓN HISTÓRICA - GEOGRÁFICA DE LA SALMONICULTURA EN LA PATAGONIA

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RESUMEN

Se llevó a cabo un análisis histórico y geográfico de la colonización de la piscicultura del salmón chileno en el marco de las licencias de acuicultura. Esta industria tiene muchos conflictos ambientales y sociales en los paisajes marinos de la Patagonia chilena, por lo que una visión histórica puede brindar información para la planificación futura de la explotación marina. Se han otorgado 1398 licencias de acuicultura de salmón durante 40 años y se están evaluando 367 solicitudes. La mayoría de las licencias otorgadas se ubican en el lado norte de la Patagonia (39% y 51,8% en las regiones de Los Lagos y Aysén, respectivamente) y la región más austral (Magallanes) contiene el 8,5% de las licencias otorgadas, pero tiene la ma-

yor cantidad de licencias pendientes (47,7%), que se encuentran en procesos de evaluación. Con el tiempo, las áreas geográficas de las operaciones de cultivo de salmón han cambiado debido a múltiples factores, tales como la contaminación marina, exceso de granjas de salmón y brotes de enfermedades, lo que desencadenó tres pulsos de colonización. Este proceso ha generado muchos conflictos relacionados con la administración marina indígena, la tenencia consuetudinaria de la mar y la conservación de la biodiversidad. Considerando este escenario, pensamos que la nueva expansión de la salmonicultura podría cambiar el sistema socioecológico en el extremo sur de América del Sur.

COLONIZAÇÃO HISTÓRICA - GEOGRÁFICA DA CRIAÇÃO DE SALMÃO NA PATAGÔNIA

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RESUMO

Realizamos uma análise histórica e geográfica da colonização da aquicultura do salmão chileno no âmbito das licenças de aquicultura. Esta indústria tem muitos conflitos ambientais e sociais nas paisagens marinhas da Patagônia, portanto, uma visão histórica pode fornecer informações para um futuro planejamento da exploração marinha. Ao longo de 40 anos foram concedidas 1.398 licenças de aquicultura de salmão e 367 pedidos estão sendo avaliados. A maioria das licenças concedidas está localizada no lado norte da Patagônia (39% e 51,8% nas regiões de Los Lagos e Aysén, respectivamente) e a região mais ao sul (Magallanes) contém 8,5% das licenças concedidas,

mas tem o maior número de licenças pendentes (47,7%), que se encontram em processo de avaliação. Com o tempo, as áreas geográficas das operações de criação de salmão mudaram devido a vários fatores, tais como poluição marinha, crescimento desmesurado de fazendas de salmão e aparição de novas doenças, desencadeando três pulsos de colonização. Este processo gerou muitos conflitos relacionados à administração marinha indígena, posse tradicional do mar e conservação da biodiversidade. Diante desse cenário, pensamos que a nova expansão da criação de salmão pode mudar o sistema socioecológico no extremo sul sul-americano.

salmon escaped in 2018 from a net pen, with an enormous potential impact on native ecosystems (Gomez-Uchida *et al.*, 2018). These ecological effects also embrace social-ecological consequences. For example, the salmon farming industry is responsible for 30%, 46%, and 67% of the conflict-generating projects in the Los Lagos, Aysén, and Magallanes regions, respectively (Carranza *et al.*, 2020). These conflicts have increased the pressure to access marine areas, but many Indigenous communities such as the Yagan people try to defend seascapes, biodiversity and, wellbeing (Mapuexpress, 2019).

In this study, a historical and geographical analysis of the salmon aquaculture devel-

opment in the three regions of Southern Chile (Los Lagos, Aysén and Magallanes) was carried out, regarding granted and pending licenses to understand their spatial and temporal patterns. After that, a discussion about conflicts and future pressures that the salmon farming colonization generate in the still pristine southern tip of South America is presented.

Methods

Search source

The database included in the official website of the Chilean Undersecretary of Fisheries (<http://www.subpesca.cl/portal/619/w3-article-92935.html>) was searched

in order to analyze the temporal dynamics of granted and pending licenses related to salmon operations. The last available update, from December 2019, in the version posted on June 8th, 2020, was accessed). Forty years of the aquaculture industry were considered, divided into three periods, leaving aside the first five years (1980-1985) when the industry was still undergoing a developing process. During the first period (1985-2003) took place the big boom of development in the Inner Sea of Chiloé (Los Lagos region). The second period (2003-2013) was when the industry started to run out of space in Chiloé and had to move to other regions to maintain its growth. The third

period (2013-2020) was when the ISA crisis burst in the Aysén region, and the industry had to plan a new southern expansion. This ISA burst was followed by an outbreak of the rickettsia *Piscirickettsia salmonis* (Gerhart, 2017).

Results

Spatial and temporal aspects of granted and pending licenses

Official statistics from the Chilean Undersecretary of Fisheries report a total of 1,398 salmon aquaculture licenses granted for exploitation in the last 40 years (1980-2020) and, 367 applications are under evaluation. Many of the granted license sites are located in

the most southern regions of Los Lagos (39%) and Aysén (51.8%), whereas a small but increasing number of these licenses (8.5%) are placed in the Magallanes region (Figure 1a). In terms of the pending licenses, the percentages are inverse. While in the Los Lagos region 7.2% of licenses are still pending of concession, the Aysén region has a 17.9% of the licenses pending. The Magallanes region has the highest number of pending licenses (47.7%), waiting to complete the evaluation process (Figure 1b).

On the temporal scale, the granted licenses changed when associated with salmon farming expansion to southern areas (Figure 2). Los Lagos region was the origin of the salmon industry. Between the years 1985 and 2003, the average number (mean \pm SD) was 22.1 \pm 11.9 granted licenses per year; in this period, the Los Lagos region absorbed 71 \pm 26.8% of the granted licenses. Between 2003 and 2013, the Los Lagos

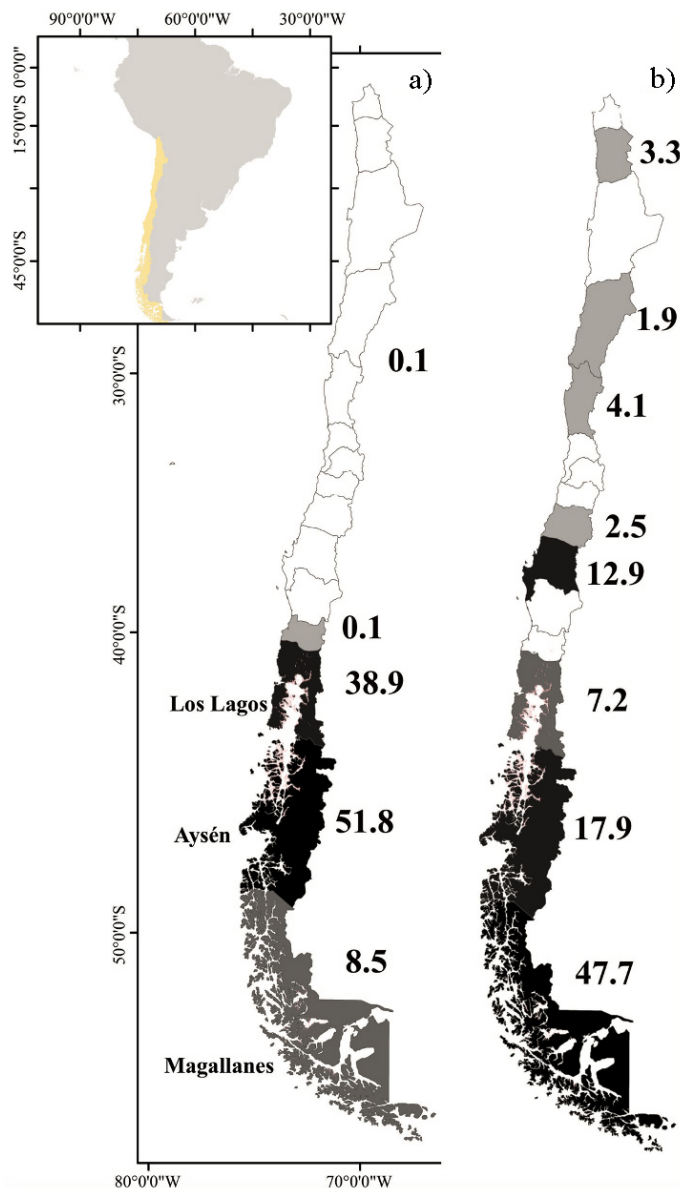


Figure 1. Granted and pending licenses of salmon operations in Chile: a) shows percentages of granted licenses per region, and b) indicates percentages of pending licenses per region.

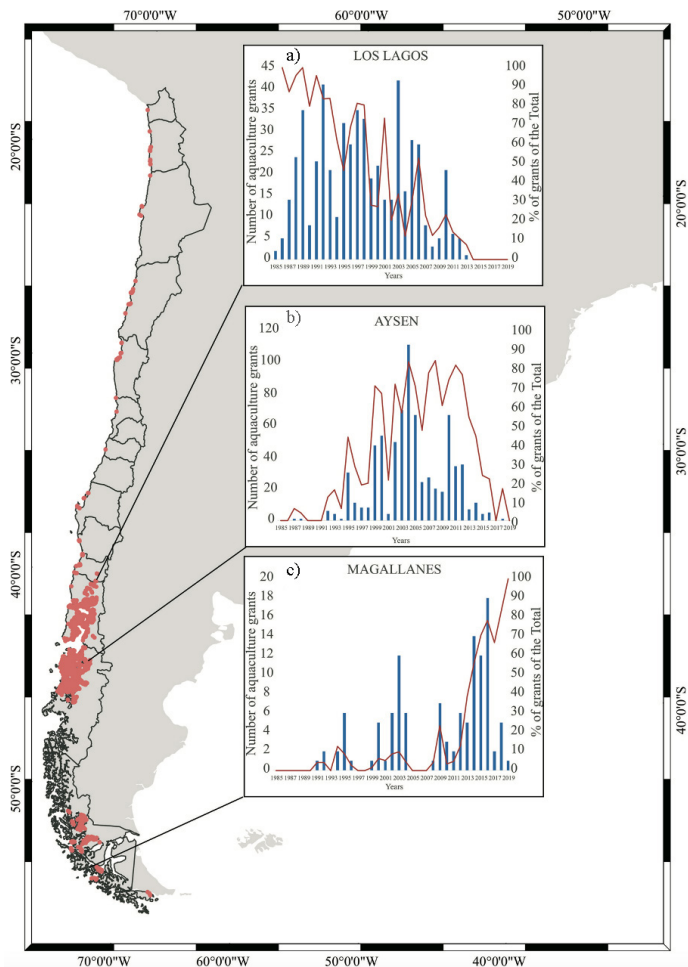


Figure 2. Numbers (blue bars) and percentages (red lines) of granted licenses from 1985 to 2019 in the Chilean southern regions: Los Lagos (a), Aysén (b), and Magallanes (c).

region stopped leading the concession of aquaculture licenses, and the Aysén region experienced a boom of granted licenses, with an average of 40.7 \pm 31.1 per year. In the final period, 2013-2019, the pressure on granted licenses dropped to an average of 5.6 \pm 3.7 per year. At this time, in Chile, this percentage dropped to an average of 23 \pm 20 per year. The Magallanes region experienced the opposite temporary development of salmon granted licenses compared to the Los Lagos region. While in the first period Magallanes represented only 3% of the total with an average of 4 \pm 3 of granted licenses per year, when the Aysén region had its peak, in the intermediate period, the Magallanes region represented

less than 10% of the total licenses. In the 2013-2019 period, the Magallanes region led in the relative number of granted salmon licenses, with 70% of the total.

Discussion

Expansion of the salmon industry to the southern tip

In the 1980s, the salmon industry in Chile began exploitation in the inner sea of Los Lagos region (Figure 2) and in 2008 the aquaculture system was near to collapse due to the ISA virus. The salmon farming industry started its expansion towards southern neighbor areas (Aysén and Magallanes regions). The Aysén region absorbed two roles at the same

time: it absorbed the need for increasing the neglected production in Los Lagos region and for buffering the impact of the Chilean salmon crisis. Both roles caused the Aysén region to become the region with the highest percentage of salmon aquaculture licenses. In 2013, the ISA virus crisis flipped this geographic pattern, and the Magallanes region became the new area of salmon farming colonization.

The Magallanes region has ecological and cultural attributes with both local and global relevance for biocultural conservation (see Rozzi *et al.*, 2010). This region is considered one of the last 12 wilderness areas worldwide, because it preserves 70% of its original vegetation and has a low industrial and urban development (Mittermeier *et al.*, 2003). Many marine taxa increase their diversity in this austral seascape. For instance, macroalgae and mollusks increase their richness and endemism (Santelices and Marquet, 1998; Valdovinos *et al.*, 2003; Linse *et al.*, 2006). In the Magellanic Sub-Antarctic Channels, indigenous coastal communities, such as the *Kawésqar* and the *Yaganés*, have developed during millennia multiple interactions with marine ecosystems that remain nowadays (Emperaire, 1963; Ojeda *et al.*, 2018). Both indigenous communities have historically experienced a terrible European colonization process (e.g., genocide, pandemics, land rights loss; see Emperaire, 1963) and, to some extent, current salmon farming operations would contribute a new marine colonization process. In 2019, the Yagan community and local citizens of Puerto Williams carried out massive demonstrations against salmon farming industries that are planned to be established inside the Cape Horn Biosphere Reserve (Mapuexpress, 2019). This reserve prioritizes customary uses and human activities with low environmental impacts such as ecotourism and artisanal fisheries (Rozzi and Schüttler, 2015).

Conflicts between customary tenure and growing industrial business

In 2009, under the ILO 169 Agreement's legal umbrella, Chile recognized the right of indigenous people to claim territorial rights regarding the management of natural resources and environmental defense. The development of the new law by the Chilean government has had many difficulties and conflicts among indigenous-local communities, policy makers, and business leaders. As a result, indigenous people mainly represented by *Lafkenche* communities developed with the government the Act No.20.249 (also known as 'Lafkenche Law') to promote the legal tool to recognize the association between indigenous people and coastal seascapes. The Lafkenche Law provides a national policy in which indigenous communities can apply for the customary management on coastal areas known as 'ECMPO' (*Espacio Costero Marino de Pueblos Originarios*; Hiriart-Bertrand *et al.* 2020). *Williche*, *Kawésqar* and *Yagan* communities have claimed to preserve marine areas, but salmon farming intents are overlapped with them, causing conflicts in the sea tenure (Outeiro *et al.*, 2015a, b). Today, it is known that administration from the indigenous perspective might contribute to rebuilding traditional practices and biodiversity conservation (IPBES, 2019). Thus, the future effectiveness of customary areas could be weak if the Chilean government is not capable to comply with their national and international commitments with indigenous and local communities.

The overlapping among salmon farming applications, Chilean national parks, natural reserves and natural monuments creates unclear priorities in the Magallanes region. Over 50% of the territory has a category linked to biological and cultural conservation (Sielfeld 1997; Rozzi and Schüttler, 2015) although, paradoxically, most national parks include

only regulations on terrestrial ecosystems and there is no clear jurisdiction on marine ecosystems (Rozzi *et al.*, 2015). The salmon farming industry could take advantage to operate on the marine side of national parks, increasing the risk of ineffectiveness and generating the so-called 'paper parks'. Thus, in the same vein as Navedo and Vargas-Chacoff (2021) it is posed that protected areas in the Magallanes region could align targets of biodiversity conservation, indigenous practices and activities with low environmental impacts.

Concluding remarks

The southern expansion of salmon farming in Chile is presented using the number of concessions granted from north to south in the Chilean Patagonia. For four decades, salmon aquaculture has had the same colonization pattern; when the environmental and sanitary problems exploded on seascapes where the industry was settled, it moved southwards. First, the Los Lagos region was exploited; once the 'collapse' took place, the industry moved to the Aysén region, where granted licenses proliferated. Consequently, the next area is the pristine seascape of the Magallanes region, the last fringe of South America. As exposed in this study, cultural and biological diversity in the southern tip of South America has a fragile situation to confront and stop a new aquaculture collapse. In this pandemic crisis, the industries' globalization in developing countries has been proved once more to be a social-ecological conflict, costly for the environment and customary practices.

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