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Short communication

Impacts of COVID-19 on the Chilean salmon: A first approach to the effects of the pandemic in the industry

Romero Lorena a, 1, Yévenes Karina a, 1, Pokrant Ekaterina a, Baumberger Cecilia a, Zavala Sebastián b, Burgos José Miguel c, Wacyk Jurij d, 7, Cornejo Javiera a, 7

a Department of Preventive Medicine, Faculty of Veterinary and Livestock Sciences, Universidad de Chile, Av. Santa Rosa , La Pintana, 11735 Santiago, Chile
b Aquaculture Genomics Lab, Faculty of Veterinary and Livestock Sciences, Universidad de Chile, Av. Santa Rosa, La Pintana, Santiago, 11735, Chile
c Laboratory of Veterinary Pharmacology (FARMAVET), Faculty of Veterinary and Animal Sciences, Universidad de Chile, Av. Santa Rosa, La Pintana, 11735 Santiago, Chile
d Department of Animal Production, Faculty of Agronomic Sciences, Universidad de Chile, Av. Santa Rosa, La Pintana, Santiago 11315, Chile

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ABSTRACT
Chile is the second largest producer of salmon in the world and is an important pillar of the national economy. Any disruption in how the industry functions will have economic and social effects. The objective of this study was to evaluate the impact of the COVID-19 pandemic on the Chilean salmon industry. An online survey was sent to the highest positions in the industry: presidents, managers, and chiefs of salmon companies. Of the 52 respondents, 75% indicated that operations were moderately affected by the pandemic. More than 70% reported a decrease in their company’s production and sales. Work absenteeism was a concern for 88%, and the implementation of sanitary measures was considered effective and relevant to prevent the spread of the virus. However, there were no statistically significant differences (p-value > 0.05) between the degree of impact on operations by company size, or between absenteeism and company size. The information obtained in this study is a first look into understanding the impacts of the pandemic on the Chilean salmon industry in the year 2020.

1. Introduction

Since its identification in December 2019, coronavirus type-2, which causes the coronavirus disease (COVID-19), has infected more than 300 million people around the world [1], forcing governments of all countries to adopt sanitary measures to prevent its spread. Primary measures include border closures, imposition of quarantines, mandatory use of masks and the total closure of non-essential trade [2–4]. These measures had significant impacts, both socially and economically, including effects on the supply chain, which significantly affected different food industries [5]. Data of how COVID-19 and the pandemic have affected the fishing activities in countries, such as the United States, India, Malaysia, Bangladesh, and Australia have been analyzed [6–11]. Chilean aquaculture was also impacted by the pandemic, affecting one of the most important industries in the country, salmon farming [12–14].

Chile is one of the main producers of salmonids worldwide [15] and is mainly based on Atlantic salmon (Salmo salar), representing 50.5% of the total national aquaculture harvest and approximately 74% of salmonid production in the country [16]. Following in relevance are Pacific salmon (Oncorhynchus kisutch) and Rainbow trout (Oncorhynchus mykiss), which account for 17% and 8% of national salmon farming, respectively. This industry developed in the southern-austral part of the country, in Los Lagos and Araucania regions, and expanding production in Aysén and the Magallanes region. The Chilean salmonid industry ranks third in national exports, generating more than 4 billion dollars in 2020 [17]. The arrival of the virus to Chile in March 2020 and the sanitary restrictions implemented impacted over salmon production in the country [13] and reducing exports and prices; mainly due to the closure of foreign markets importing Chilean salmonids, such as China and the United States [18].

To date, there are only three studies investigating different aspect of COVID-19 impacts on Chilean salmon farming [12–14], none of them...
analyze the pandemic effects on operations, production and sales of national salmon farming, nor over the effect on workers and the sanitary measures that the industry had follow. Hence, the objective of this research was to address these issues and evaluate the impact of COVID-19 on the salmon industry from individuals in the highest positions in the Chilean industry.

2. Materials and methods

Considering the more integrative role and access to a broader set of information, surveys were distributed to 97 people holding the highest positions in salmon companies, such as presidents, managers, and chiefs, obtaining 52 responses. Individuals were identified through the official salmon producer organizations’ databases. The data was obtained through a questionnaire designed using surveys published by Azra et al., 2021 [6] and van Senten et al., 2020 [10] as a reference, which were adapted to reflect the current national situation. Prior to survey distribution, it was validated through Acuiestudios, a national aquaculture consultancy. The software used to prepare and send the survey was the Google Form platform, and was distributed online from November 2020 to April 2021, using a non-probability sampling strategy by convenience [19].

The survey consisted of 19 multiple-choice or Likert-scale questions and was completely anonymous. For clarity and to hold the attention of industry representatives, the survey was divided into three sections: I: General information, II: Impacts on operations, production, and sales and III: Impacts on workers and sanitary measures. Section I consisted of five questions to classify the respondent and the company where he/she works. Section II had six questions related to effects within the area of operations, production and sales, the challenges faced in their workplace, and their possible causes. In section III eight questions were used to evaluate the current employment situation of the company; determining the absenteeism due to the pandemic and its duration. In addition, the effect of the implementation of sanitary measures, and the perception of the workers about the measures were recorded.

A descriptive analysis of the data was completed. A Kruskal-Wallis statistical test was performed to determine whether there were differences in the degree of impact on operations according to the size of the companies (large, medium, and small/micro companies), which were classified according to the Chilean Ministry of Economy, Development and Tourism [20] related to annual sales. In addition, Pearson’s Chi-square test was performed to associate company size and employee absenteeism. Statistically significant differences were considered when p-value was equal to or lower than 0.05. The analyses were carried out using INFOSTAT software version 2020.

It is important to note the limitations of the present study. First, face-to-face surveys became impossible due to the strong mobility restrictions taken by the Chilean government, so the surveys had to be completed online. Online platforms are useful, but inconveniences range from connection problems and access to the questionnaire link, to the lack of knowledge of those who refuse to participate in the survey. Despite this, data collected from this study coincide with that recorded by the Chilean fishing authorities [18] so the results of our research are useful as a first classification according to the Chilean Ministry of Economy, Development and Tourism. The data was obtained from those regions [18]. The main areas of salmon farming where the respondents reported were processing plants and the grow out phase. Of the respondents, 40% were veterinarians, 31% were engineers and 29% were other professions including marine biologist, agronomist or aquaculturist. Considering the company’s annual sales, 75% reported working in a large company, 15% in a medium-sized company and 10% in a small/micro company [20].

3. Results and discussion

3.1. General information

Fifty-two of 97 individuals responded the survey. Of those interviewed, 52% reported that they held a chief position in the salmon company where they worked, 46% held managerial positions and 2% held presidential positions. The majority of those surveyed (71%) worked in Los Lagos region, followed by the Biobío (13%), Aysén (8%) and Magallanes (4%) regions. This was an expected distribution of the responses considering more than 99% of national salmonid production originates from those regions [18]. The main areas of salmon farming where the respondents reported were processing plants and the grow out phase. Of the respondents, 40% were veterinarians, 31% were engineers and 29% were other professions including marine biologist, agronomist or aquaculturist. Considering the company’s annual sales, 75% reported working in a large company, 15% in a medium-sized company and 10% in a small/micro company [20].

3.2. Impacts on operations, production and sales

On a graded scale of 1–5, with 1 = no effect and 5 = severely affected, 75% indicated that workplace operations were affected by the COVID-19 pandemic at a level of 3 or less. There was no statistically significant difference (p = 0.7165) in terms of impact over operation when compared across company size. These results are consistent with those published by Islam et al., 2021 [21], where 85% of the aquaculture workers in freshwater ponds in Bangladesh indicated being affected by the pandemic at Grade 3 (moderate) or lower. In Chile, Soto et al., 2021 [13] pointed out that improvements in management practices, joint action between the private sector and the government, and the implementation of mitigation measures to prevent the spread of the virus, as well as the classification of the salmon farming industry as an "Essential Service" [22] allowed this sector to continue operating, likely helping to mitigate some of the negative effect over the operation of the companies.

The main challenges faced by the respondents in salmon farming operations were increased costs, quarantine and reduced processing capacity (Table 1). These situations were also observed in other countries, such as the fish farming sector in Bangladesh, where productive inputs, such as the rental of ponds, water supply, biosecurity, or even pharmacological supplies, have increased considerably in price [23]. Likewise, lack of inputs (like fish seeds and feed), shortage of labor and declining sales were also operational constraints affecting Indian freshwater aquaculture [24]. The imposition of quarantines due to an increase in confirmed COVID-19 cases, and closure of processing plants, like the Indian shrimp industry [25] and the major meat processing and packaging plants in the US also affected food producing industries [26].

Due to the COVID-19 pandemic, 74% of respondents indicated that there was a decrease in production in their industry. The remaining 26% indicated that they did not see a decrease in salmonid production during

| Challenges                          | Number of responses* | Percent surveyed (%)* |
|-------------------------------------|----------------------|-----------------------|
| Rise in cost of production          | 37                   | 71                    |
| Quarantine                          | 26                   | 50                    |
| Lower process capacity              | 24                   | 46                    |
| Sales decrease                      | 19                   | 37                    |
| Demand variations                   | 18                   | 35                    |
| Shutdown                            | 6                    | 4                     |
| Other*                              | 4                    | 3                     |

Responses were obtained based on a multiple-choice question; *Number of times this option was selected; * *Percentage of respondents (n = 52); * * *Reorganization of shifts and equipment; low availability of inputs; delays and increases in operational costs.
2020. The decrease in production was not a consequence exclusively perceived in our country. The same situation was reported in Galicia where aquaculture production decreased by 10.6% compared to previous years [27]. Similarly, in the Philippine islands there was a decrease in aquaculture productivity due to the increase in the cost of and access to production inputs that were the result of restrictive measures [28]. The main causes of decreased salmon production in Chile were the rotating shift system, quarantines, and absenteeism from work (Table 2). All responses are related to the decrease in personnel available to operate.

A similar situation was described in India, where shrimp farms saw a production decrease by almost 40% compared to the previous year, due to significant labor shortages [8].

Of those surveyed, 79% perceived a decrease in sales at their place of work, while 21% stated that they did not see a decrease in sales in 2020. The same was reported by van Senten et al., 2020 [19], where over 80% of the respondents from the aquaculture sector in the USA indicated having experienced negative impacts on sales. In the same way, the results of the survey conducted by Doerr et al., 2020 [7], in the state of Oregon show a loss of sales, both locally and internationally in all areas, such as harvesters (55% of domestic sales loss), processors (57% of domestic sales loss) and integrated business (90% of domestic’s sales loss), in US aquaculture in the spring of 2020. The main causes of decreased salmon sales in Chile were the decrease in demand and closure of markets (Fig. 1).

The decrease in the demand for marine products globally may have been the result of significant loss of employment and consequent decrease in the income of millions of people around the world [29]. The closure of important seafood purchasers, such as hotels and restaurants, negatively impacted sector sales as well [28,30,31]. In Chile, hotels registered a 79% drop in reservations and, late into the pandemic, 60% of them closed due to the drastic decline in tourism in the country [32]. Restaurants were closed entirely in the final week of March 2020 as a health measure to prevent a rise in cases [33].

3.3. Impacts on workers and the sanitary measures implemented

Absenteeism was listed by 88% of the respondents as impacting the workplace. There was no statistically significant difference (p = 0.4826) in absenteeism and company size. Of survey respondents, 59% indicated that 15 days was the most common number of days missed, while 20% and 11% indicated seven and four days, respectively. The duration of the absenteeism mentioned by the surveyed is in line with the mandatory two-week quarantine for a COVID-19 PCR-positive person [34], and the 24–96 h waiting time for the PCR result reported by the Chilean National Safety Association [35,36].

As expected, 67% of the people surveyed indicated that the company where they were employed adopted health measures due to the COVID-19 pandemic, and the implementation of these measures was based mainly on suggestions from the Chilean Ministry of Health [37]. The sanitary measures implemented in workplaces are shown in Table 3. These responses are echoed in the survey generated by Ceryes et al., 2021 [38], issued to workers in the food retail industry in the United States. The measures most mentioned were social distancing, use of a mask, increase in the frequency of cleaning and issuing of soap and sanitizer by the company. These health measures were of great importance throughout this pandemic, considering that their implementation considerably reduces the spread of COVID-19 [39].

More than half of the respondents indicated that the implementation of the safety measures was moderately difficult (Grade 3) but was highly effective and relevant (Grade 5) in controlling the spread of the virus (Fig. 2).

In the survey conducted by Jubayer et al., 2021 [40], to food industry workers in Bangladesh, it was determined that respondents had a thorough knowledge of the pandemic as well as positive attitudes and practices to prevent the spread of COVID-19 in their workplaces. This is consistent with our study, as the adoption of sanitary practices within the workplace has helped to continue salmon industry operations.

Since this survey was sent out between the months of November 2020 and April 2021, the respondents were sufficiently aware of the impacts generated by the pandemic in their workplaces.

Previously, the Chilean industry has faced other sanitary crisis, like the ISA virus between 2007 and 2010 and various noxious algal blooms during 2016 and 2018. These events pushed for the application of new technologies, field practices and security measures that have contributed for the industry to be more prepared for the COVID-19 impacts [14].

Recent studies regarding the impacts of the COVID-19 in salmon farming [12–14] address the effects of the pandemic from different

![Fig. 1. Causes of decreased sales in the salmon industry due to the COVID-19 pandemic.](image)

Table 3
Sanitary measures implemented in the salmon industry during the COVID-19 pandemic.

| Sanitary measures | Number of responses* | Percent surveyed (%)** |
|-------------------|----------------------|------------------------|
| Mandatory use of a face mask | 51 | 98 |
| Social distancing | 50 | 96 |
| Temperature control | 50 | 96 |
| Hand washing indications | 48 | 92 |
| Instructions to stay at home in case of illness | 48 | 92 |
| Restriction of access to external persons | 46 | 88 |
| Safety announcements | 45 | 87 |
| Physical biosafety measures | 42 | 81 |
| Teleworking | 42 | 81 |
| Decrease in productive shifts | 38 | 73 |
| Others* ** | 5 | 10 |

Responses were obtained from multiple-choice questions; *Number of times this option was selected; **Percent of respondents (n = 52) * *Percent of respondents (n = 52).

Table 2
Causes associated with the decline in the salmon production due to the COVID-19 pandemic.

| Causes | Number of responses* | Percent surveyed (%)* ** |
|--------|----------------------|--------------------------|
| Deferred work shifts | 21 | 40 |
| Quarantine | 20 | 38 |
| Less days worked | 17 | 33 |
| Absenteeism due to illness | 17 | 33 |
| Closure of the workplace | 6 | 12 |
| Lower demand | 4 | 8 |

Responses were obtained from a multiple-choice question; *Number of times this option was selected; **Percent of respondents (n = 52).
angles and not looking at the effects in production, workers and sanitary measures. For this, our results were mainly compared with other aquaculture industries relevant for the economy of their countries, and complement with a different perspective previous reports in Chile.

Among the mitigation actions taken to face these impacts there are improvements in management practices in culture areas; better local working conditions, in terms of a more efficient public-private coordination and the government monetary support to the communities [13]. These strategies increase the industry resilience, not only to the COVID-19 impacts but also for future industry crisis.

Thus, the information presented in this study is the first approach that allows us to understand how the Chilean salmon industry was affected in the first year of the COVID-19 pandemic.

4. Conclusions

This study revealed that the COVID-19 pandemic impacted the Chilean salmon industry. The results showed that the operation area was moderately affected in 2020 and that both salmon production and sales decreased compared to 2019. All the participants in the survey indicated that sanitary measures related to COVID-19 were implemented in their workplace and were considered very effective and relevant to avoid the spread of the virus.

The previously published studies of the effect of the crisis over Chilean salmon farming give information about the first impacts and responses of this industry to the COVID-19 crisis [12] and its vulnerability when facing crisis situations [13]. Our study complement the above mentioned work and contribute with a different approach in terms assessing the effects on a more operational level and considering a comparison with the aquaculture industry of other countries.

Considering the great relevance of the salmon industry in Chile and the fact that the present research is a first approach of the impacts suffered by this industry, we strongly recommend that this type of research be repeated, focusing on the continued effect of the pandemic on the salmon industry.

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Declaration of Competing Interest

The authors of this study declare that they have no conflicts of interest that have influenced the work carried out and its results.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.marpol.2022.105185.

References

[1] WHO (World Health Organization), 2022. Coronavirus Disease (COVID-19) Dashboard. https://covid19.who.int/ (Accessed 05 January 2022).

[2] E. Goddard, The impact of COVID-19 on food retail and food service in Canada: preliminary assessment, Can. J. Agric. Econ. 68 (2020) 157–161, https://doi.org/10.1111/cjag.12243.

[3] H. Lau, V. Khorawipour, P. Kocharch, A. Mokalajczyk, J. Schubert, J. Bania, T. Khorawipour, The positive impact of lockdown in Wuhan on containing the COVID-19 outbreak in China, J. Travel Med. 27 (3) (2020), https://doi.org/10.1093/jtm/taaa037.

[4] A.M. Fakir, T. Bharati, Pandemic catch-22: The role of mobility restrictions and institutional inequalities in halting the spread of COVID-19, PloS One 16 (6) (2021), e0253348, https://doi.org/10.1371/journal.pone.0253348.

[5] S. Aday, M.S. Aday, Impact of COVID-19 on the food supply chain, Food Qual. Saf. 4 (2020) 167–180, https://doi.org/10.1016/j.fqsaf.2020.02.004.

[6] M.N. Azra, N.A. Kasan, R. Othman, G.A. Noor, S. Mazelan, Z.B. Jamari, M. Ikwunwdu, Impact of COVID-19 on aquaculture sector in Malaysia: Findings from the first national survey, Aquac. Rep. 19 (2021), 100568, https://doi.org/10.1016/j.aqrep.2020.100568.

[7] Doerr, A., Doyle, J., Glidics, A. Impacts of COVID-19 on the Oregon seafood industry 2020, (2020) 1–4. https://library.oregonstate.edu/concern/technical_reports/9p290h627.

[8] M. Kumaran, R. Geetha, J. Antony, K.K. Vasagam, P.R. Anand, T. Ravisankar, K. K. Vijiyan, Prospective impact of Corona virus disease (COVID-19) related lockdown on shrimp aquaculture sector in India—a sectoral assessment, Aquac. 531 (2021), 735922, https://doi.org/10.1016/j.aquatrends.2020.735922.

[9] J. Stewart, J.R. Craig, C. Cline, A.M. Hegarty, N.M. Meadows, A. Gould, C. Young, Using their heads-A novel, collaborative approach between industry and scientists to monitor a commercial mullet fishery as a result of COVID-19 restrictions, Fish. Res. 250 (2022), 106272, https://doi.org/10.1016/j.fishres.2022.106272.

[10] J. Van Senten, M.A. Smith, C.R. Engle, Impacts of COVID-19 on US aquaculture, aquaponics, and allied businesses, J. World Aquac. Soc. 51 (3) (2020) 574–589, https://doi.org/10.1111/jwao.12715.

[11] K. Waino, H. Fazhan, S.D. Ishak, N.A. Kasan, H.J. Liew, M.H. Norainy, M. Ikhwanuddin, Impact of COVID-19 on aquaculture sector in Malaysia and its coping strategies, Aquac. Rep. 18 (2020), 100450, https://doi.org/10.1016/j.aqrep.2020.100450.

[12] Chávez, C., Salazar, S., Simon, J., 2020. Efectos socioeconómicos y responsables públicos-privados de corto plazo ante la crisis del Covid-19 en el sector salmonicultor: una fotografía de la experiencia internacional. https://www.incar.cl/wp-content/uploads/2020/06/PF6.pdf.

[13] D. Soto, C. Chávez, J. León-Muñoz, C. Luengo, Y. Soria-Galvarro, Chilean salmon farming vulnerability to external stressors: The COVID 19 as a case to test and build
