

Assessing consumer implications of reduced salmon supply in North American markets

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Abstract

This study delves into the ramifications of the Canadian government's decision to reduce the supply of farm-raised salmon in British Columbia (BC) on the North American market. The objectives of this study are to investigate the impacts of farm closures in BC on domestic prices, the level of imports, and the resulting increase in carbon footprint. It also highlights the significance of aquaculture in global food security, considering the projected global population reaching 9.8 billion by 2050. By drawing upon data from diverse sources, this study employs exponential smoothing models to forecast future trends, including those related to salmon prices and production, up to 2026. Due to farm closures, Canada's imports of salmon increased in recent years, and the forecasted results reveal that consumer prices will exhibit greater unpredictability. In addition, an increase in consumption of imported salmon is expected to contribute to heightened carbon emissions and result in job losses within rural and Indigenous communities. Hence, the impending closure of salmon farming in BC carries profound consequences for both the environment and the market dynamics, necessitating a comprehensive analysis of its impact on consumers.

Keywords: Salmon farming, aquaculture, sustainability, salmon global trades

1. Introduction

The government of Canada's decision to close salmon farms in British Columbia (BC) will have a significant and far-reaching impact on the North American marketplace. Farm-raised salmon, the most popular seafood choice of Canadians, has long been BC's top agri-food export and has one of the lowest carbon footprints of animal proteins. Hence, the farm closures have led to less Canadian-grown salmon on the market and are expected to lead to a series of price increases, prompting consumers to shift their preferences toward imported farm-raised salmon alternatives. This development should be seen in the context of a global salmon market characterized by historically high levels of demand. The impending reduction in domestic supply has the potential to exacerbate this already heightened demand, a situation with multifaceted repercussions.

The closure of salmon farms in British Columbia highlights their significant influence on environmental and market dynamics. Therefore, it is imperative to undertake a comprehensive examination and meticulous analysis of the implications of this decision for consumers. Given these considerations, the primary objective of this study is to discern the impact of curtailing the supply of BC farm-raised salmon on consumer pricing dynamics within the North American market. Three fundamental objectives underpin this study: (i) to discern and evaluate the intricate correlation between BC salmon farming and consumer pricing dynamics within the Canadian market; (ii) to scrutinize the multifaceted ramifications that result from the constrained operations of BC salmon farming under prevailing market conditions and investigate the dynamics governing consumer pricing within the broader North American context; and (iii) to investigate the prospective consequences associated with the reduction of the Canadian salmon supply and the concomitant expansion of the carbon footprint within the North American market.

These aspects are considered crucial in elucidating the overarching impact of the federal government's policy decision on the economic and environmental dimensions of the North American salmon market landscape. Canada's imports of salmon have increased rapidly since 2021; Canada imported approximately 20,000 tonnes more salmon in 2022 than in previous years. Price stability or volatility depends on a complex interplay of factors, including domestic production, global supply chains, currency exchange rates, government policies, and market dynamics. An increase in imports has the potential to contribute to greater retail price fluctuations

in Canada, which, in turn, might influence the overall domestic demand for salmon. It was estimated that higher salmon imports in 2022 generated approximately 9.9 million tonnes of CO₂, which was more than in 2020. The average Canadian vehicle releases 4.6 tonnes of CO₂ into the atmosphere every year. The estimated increase in CO₂ emissions released by the increased imports is equal to the emissions released by 2,152,000 vehicles a year in Canada.

This study concludes that the decision to close BC farms reverberates far beyond the boundaries of supply and demand. It has brought about transformative effects on salmon supply, consumer pricing dynamics, and market conditions while exacting a toll on environmental conditions through the upsurge in carbon emissions resulting from increased salmon imports in North America. The convergence of these multifaceted challenges underscores the intricate interplay between economic, environmental, and market forces, prompting a re-valuation of the strategies and policies governing the aquaculture industry.

The remainder of this study is organized as follows. Section 2 presents an overview of aquaculture and its implications for food security. Section 3 delves into the specifics of salmon farming in BC. Section 4 outlines the methodology employed in this research, and Section 5 details the data sources. Section 6 presents the analysis of the results. Section 7 focuses on the forecasting of the main variables, and Section 8 concludes the study.

2. Aquaculture and food security

Food security, a fundamental aspect of human well-being, encompasses not only the quantitative dimension of food availability but also the nuanced aspects of accessibility and the temporal consistency of both availability and access (FAO, 2014). Projections for the year 2050 anticipate a global population increase from 7.6 billion to 9.8 billion individuals, indicating a corresponding rise in food consumption by a substantial margin of 60% to 100% (Grafton et al., 2015; Tilman et al., 2011). In the face of this challenge, aquaculture emerges as a beacon of sustainable promise, poised to contribute significantly to the pursuit of food security.

Currently, aquaculture stands as the leading sector in global food production, constituting a pivotal component of our quest for food security (Ahmed et al., 2020; FAO, 2020). As evidence of its vital role, fish provide nourishment to 3.3 billion people, accounting for a significant 20% of their

animal protein intake. Notably, per capita fish consumption has experienced a remarkable increase, rising from a modest 9 kg in 1961 to a substantial 20.5 kg in 2018, spanning the global culinary landscape (Ahmed et al., 2020; FAO, 2020).

The significance of aquaculture is further underscored by its unique ability to address various aspects of global food security. Seafood products, highly regarded for their role as primary sources of protein, are rich in micronutrients and essential fatty acids notably absent in terrestrial alternatives (Dawood & Koshio, 2020; Filipski & Belton, 2018; Golden et al., 2021; Hua et al., 2019; Sharif et al., 2021; Smith et al., 2010).

In the broader context of sustenance, fisheries and aquaculture remain steadfast pillars, providing sustenance, nutritional strength, economic stimulus, and livelihoods to vast populations worldwide (FAO, 2016; Filipski & Belton, 2018; Golden et al., 2021; Smith et al., 2010). With its growing trajectory, aquaculture distinguishes itself by demonstrating a lower ecological footprint compared to alternative sources of animal-derived food (Froehlich et al., 2018; Garlock et al., 2020; Gephart et al., 2021; Hilborn et al., 2018; MacLeod et al., 2020).

Importantly, seafood plays a prominent role as a primary source of animal protein for many nations, with its significance depending on species diversity and national context. In some regions, domestic aquaculture directly enhances food security through internal consumption, while in others, its contribution takes an indirect path, fostering economic prosperity through export-oriented growth (Anderson et al., 2017; MacLeod et al., 2020). Illustrating this dynamic interplay, Canada's consumption of salmon serves as a testament to the intricate variables involved. Over the past decade, Canada's balance of trade in salmon experienced a notable transformation, with exports remaining steady while imports surged to meet growing domestic demand (Fisheries and Oceans Canada, 2018). Aligned with this trend, Canadian protein consumption from fish and seafood reached 8.5% in 2019, surpassing other meat proteins such as pork (6.2%) and all other meats (6.1%) (Nourish Food Marketing, 2022). The prospect of salmon aquaculture emerges as a resounding call to action, symbolizing a sustainable economic avenue poised to support Canada's journey toward self-sufficiency and the fortification of its food supply (Government of Canada, Pacific Aquaculture Transition—What We Heard Report Phases 1 and 2, Government of Canada, 2023).

3. Salmon farming in British Columbia

The BC aquaculture sector stands out as a global exemplar of conscientious seafood cultivation practices (Government of British Columbia, n.d.). The salmon industry in BC was first introduced in the early 1970s. Salmon farming is mostly done in cool waters that are well flushed by tidal activities. British Columbia has a long coastline with many inlets and bays, which provide ideal conditions for salmon farming. The waters of the Broughton Archipelago on the northeast coast of Vancouver Island as well as several large sounds on the west coast are particularly well suited for aquaculture, and the large majority of salmon farms in BC today are located in these areas (Salmon Aquaculture in British Columbia). British Columbia's prime location on Canada's west coast puts it at the commercial crossroads of the Asia-Pacific region and North America. Companies with operations in British Columbia enjoy duty-free access to the world's largest marketplaces in Asia, North America, and Europe (Government of British Columbia, 2019).

The extensive marine territories of BC provide fertile ground for a thriving salmon aquaculture industry, playing a pivotal role in ensuring Canada's economic stability and food security (Government of Canada, 2023). Significantly, aquaculture accounts for a substantial 60% share of Canada's overall salmon production in quantity and value, firmly establishing its dominance within BC and its significant influence over both the provincial and national economies (Government of Canada, 2017). The salmon industry in BC strengthens the salmon supply here, making Canada the fourth-largest producer behind Norway, Chile, and the UK.

According to a comprehensive report published by the British Columbia Salmon Farmers' Association (BCSFA), in the autumn of 2020, the BC salmon farming sector generated an impressive \$1.9 billion in economic activity. This translated to an infusion of \$721 million into Canada's Gross Domestic Product (GDP) and provided gainful employment to 7,560 Canadian citizens, who collectively earned wages amounting to \$429 million. At the provincial level, these economic benefits translated into over \$1.6 billion in total economic output, \$577 million in GDP contributions, and employment opportunities for 6,370 individuals within BC (RIAS Inc., 2023).

It is essential to emphasize that the realm of aquaculture in Canada operates as a shared responsibility. Fisheries and Oceans Canada maintains a complex collaborative network with federal governmental entities, provincial and territorial authorities, and the aquaculture sector

itself. This collaborative effort aims to prioritize sustainability within Canada's cultivated fish and shellfish sectors (Government of British Columbia, n.d.).

In a significant development on December 17, 2020, the former Minister of Fisheries, Oceans, and the Canadian Guard issued a declaration outlining the federal government's intent to gradually phase out existing salmon farming installations within the Discovery Islands (DI) region (RIAS Inc., 2021). A lack of social license was cited as the reason for the decision.

The implications of this plan are extensive, sparking significant deliberation among various stakeholders, including industry representatives, the local population, and political leaders. The reduction of up to 50% of current licenses will have significant long-term negative socio-economic impacts in BC and Canada. The direct consequence of curtailing the remaining 65,800 tonnes of farmed salmon production is the triggering of substantial economic disruptions and food insecurity. Specifically, the BC salmon farming sector faces an annual economic loss of \$1.2 billion across Canada, a \$447 million decrease in GDP contributions, the elimination of over 4,690 job opportunities, and a resulting reduction in family incomes of \$266 million annually. Notably, the proposed transition plan, as outlined by the Minister of Fisheries, Oceans, and the Canadian Coast Guard, will have economic and financial impacts in BC and Canada (RIAS Inc., 2023).

4. Methodology

4.1. Machine Learning in Salmon Price Prediction

Predicting salmon prices is fundamentally a time-series task. Machine learning approaches for time series forecasting are renowned for their power and flexibility (Tsoumakas, 2019). Machine learning offers the utilization of modern, state-of-the-art supervised learning algorithms, including regression models (Landwehr et al., 2005). Forecasting the future price of salmon holds paramount importance within the salmon market, serving as a core activity for market participants (Bloznelis, 2018). Access to future price information on salmon can significantly influence the original production plan and provide additional value for farmer enterprises (Forsberg and Guttormsen, 2006). The extensive application of machine learning models to predicting salmon prices has provided valuable insights and opportunities to the salmon industry.

However, it's worth noting that there have been relatively few studies focused on predicting salmon prices using machine learning models. Bloznelis (2018) conducted short-term salmon price forecasting using the weekly spot price of Norwegian-farmed Atlantic salmon. The study predicted salmon prices 1 to 5 weeks ahead based on data from 2007 to 2014. The most accurate predictions were achieved using the k-nearest neighbor method for 1 week ahead and the vector error correction model with elastic net regularization for 2 and 3 weeks ahead, as well as future prices for 4 and 5 weeks ahead.

In a recent study (Bjørnstad et al., 2023), four forecasting models were developed to predict future salmon prices: Autoregressive Integrated Moving Average (ARIMA), Seasonal Autoregressive Integrated Moving Average (SARIMA), Seasonal Autoregressive Integrated Moving Average Exogenous (SARIMAX), and Long Short-Term Memory (LSTM). These models were trained on data from the spring of 2013 to the winter of 2021 and tested on data from 2022. The findings demonstrated that considering seasonality significantly improved predictions, with the SARIMAX model performing the best in forecasting salmon prices.

The process of predicting salmon prices using machine learning models involves analyzing historical data in Canada and the U.S. to gain data-driven insights into the salmon market's condition. Subsequently, the study will develop a forecasting model, leveraging the SARIMAX model, to predict future salmon prices and market conditions.

4.2. *Forecasting*

Predicting salmon prices through machine learning models entails the analysis of historical data and the construction of a predictive model. The initial step involves a thorough examination of historical data related to salmon production, supply, and prices. This analysis aims to discern market trends, cycles, and seasonal variations. It also delves into the pricing and consumption patterns of salmon, providing insights into consumer preferences and demand. The resulting historical trends are then highlighted and presented through data visualizations using Tableau software.

Subsequently, forecasting models are developed to predict future salmon pricing and production value, primarily utilizing the SARIMAX model and historical salmon pricing data. SARIMAX

stands out as a robust time-series forecasting model that amalgamates the capabilities of ARIMA with exogenous variables. SARIMAX proves particularly valuable in predicting prices and other time-dependent data, as it characterizes price dynamics by providing a statistical summary of information for each exogenous variable. The transparency of the model simplifies the identification of significant model factors (McHugh et al., 2019).

The accuracy of the SARIMAX model is assessed through appropriate evaluation metrics, such as the Mean Absolute Error (MAE). MAE represents the mean absolute difference between predicted values and actual values in a dataset. A lower MAE indicates a better fit of the model to the dataset. However, it is important to note that MAE is presented on the same scale as the target prediction, and there is no universal rule for an ideal MAE score—it must be evaluated within the context of the specific dataset being analyzed.

5. Data

The present study derives its data from diverse sources, thereby facilitating a comprehensive examination of salmon production and the prevailing market conditions. To obtain an insightful grasp of the statistical intricacies underpinning salmon aquaculture in both Canada and the United States, this investigation leveraged governmental repositories, including but not limited to Statistics Canada, the Government of British Columbia, the U.S. Census Bureau, and the Department of Fisheries and Oceans Canada, all of which are accessible through online platforms. Moreover, supplementary insights into the salmon industry's dynamics were gleaned from non-conventional sources encompassing gray literature and popular media outlets available online. This entailed a thorough examination of documents provided by the British Columbia Farmers Association as well as reports from reputable news outlets such as CBC News. To bolster our understanding of salmon transition strategies in British Columbia, detailed salmon production and sales updates pertinent to North America were garnered from sources such as the Global Salmon Production and Market Update documentation authored by Kontali and the Salmon Retail Sales Report meticulously scrutinized by Nielsen in the United States.

5.1. *Atlantic Salmon Production*

A publicly available dataset for Atlantic salmon production volume and value is accessible through Statistics Canada for the period spanning 1991 to 2021. This dataset serves as the basis for analyzing historical trends in salmon production and projecting future patterns.

5.2. Salmon Prices and Consumer Demand

The retail salmon price dataset was sourced from Statistics Canada, covering the time frame from January 2017 to April 2022. These price data points are instrumental in scrutinizing historical price trends and constructing a forecasting model for predicting future prices. Concurrently, salmon sales data was obtained from the meticulously examined salmon retail sales report scrutinized by Nielsen in the United States. This dataset covers the years 2017 to 2022. To comprehensively understand consumer demand in both Canada and the U.S., a dataset pertaining to Canadian seafood consumption from 2017 to 2022 was compiled, drawing from Nourish Food Marketing.

5.3. Market Distribution

For insights into market distribution, data encompassing Atlantic salmon trade volume and supply was collected from the Government of Canada's online trade records and the U.S. Census Bureau, spanning from 2019 to 2022. Supplementary information sources, such as the Global Salmon Production and Market Update documentation authored by Kontali, were also referenced to gain a comprehensive understanding of salmon market dynamics in North America.

6. Data analysis: Market survey

6.1. Global Atlantic Salmon Production and Canada Share

To gain a comprehensive understanding of the scale and capacity of salmon aquaculture in Canada, particularly within the province of British Columbia (BC), we conducted a meticulous analysis of historical data pertaining to salmon production. Our investigation reveals that Canada's proportion of global salmon production has exhibited a downward trajectory, commencing at 5.3% in 2019 and progressively declining to 4.9% in 2020, a percentage that remained constant in 2021 and 2022 (see Table 1). It is worth emphasizing that British Columbia plays a pivotal role in this context, contributing to the global salmon market on a remarkable scale.

Table 1. Atlantic salmon production, North America, Canada, US, and BC share (in tonnes)

Year	Global Atlantic Salmon Production	North America Harvest Quantity	Canada Share	USA share	BC share
2019	2,577,900	158,300	137,500	20,800	81,500
2020	2,712,600	156,800	136,800	20,000	87,000
2021	2,896,000	161,000	142,000	19,000	79,000
2022	2,865,700	151,000	131,500	19,500	81,500

Data Source: Kontali (2023)

Salmon production and its associated economic value in Canada have demonstrated a generally upward trajectory over the years, notwithstanding marginal declines in 2004, 2014, and 2022. Nonetheless, these brief regressions were swiftly rectified as production levels rebounded in the subsequent year. In the contemporary context, the dynamics of salmon production and its corresponding economic worth have exhibited a degree of volatility. Specifically, from 2017 to 2021, salmon production fluctuated within the range of 120,553 tonnes to 120,186 tonnes. Concurrently, the monetary value of this production exhibited a decline, diminishing from \$1.05 million in 2017 to \$0.99 million in 2021. These trends merit closer examination and analysis within the context of Canada's salmon industry (see Figure 1).

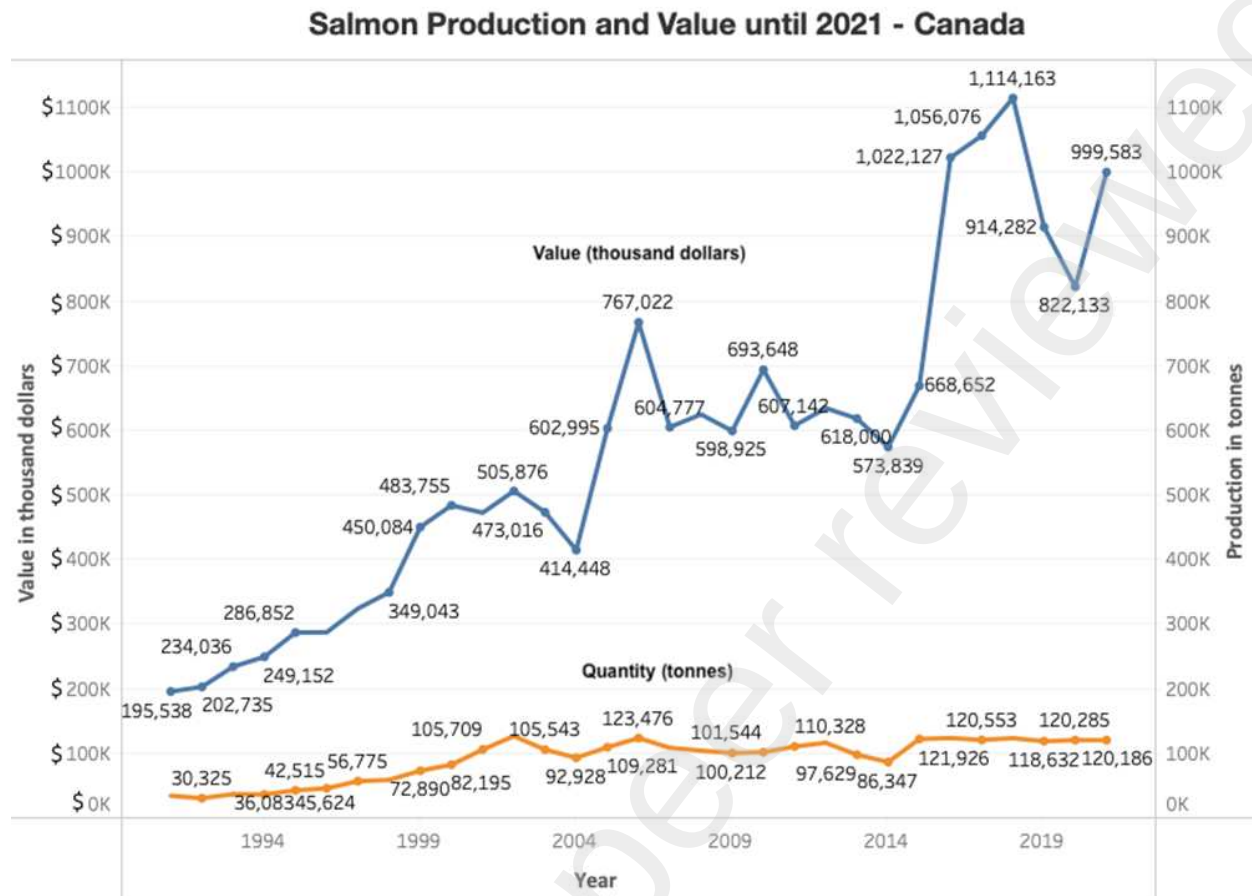


Figure 1. Salmon production and value in Canada

Data Source: Statistics Canada (2023)

6.2. Retail Price of Salmon

In line with global and Canadian production trends, it is crucial to examine the historical affordability dynamics of the product. Figure 2, without accounting for the impact of inflation on food affordability, provides a comprehensive representation of the average monthly retail price per kilogram from January 2017 to June 2023. It is evident that the pricing of salmon exhibits a volatile pattern, characterized by multiple fluctuations throughout the annual cycle.

Significantly, the highest price points for salmon (all types) were notably observed in the vicinity of May 2022, reaching a peak of CAD 29.16 per kilogram, and subsequently, in May 2023, when it reached a comparable peak at CAD 29.09. The price fluctuations underscore the significant volatility in the salmon market, a phenomenon that merits careful examination within the context of economic analysis and consumer behavior. What should be underscored is that importing a food

commodity, including salmon, from abroad can introduce additional variables into the equation and can generate more volatility in retail prices (Gouel, 2016; Valdés, 2012). Price stability or volatility depends on a complex interplay of factors, including domestic production, global supply chains, currency exchange rates, government policies, and market dynamics.

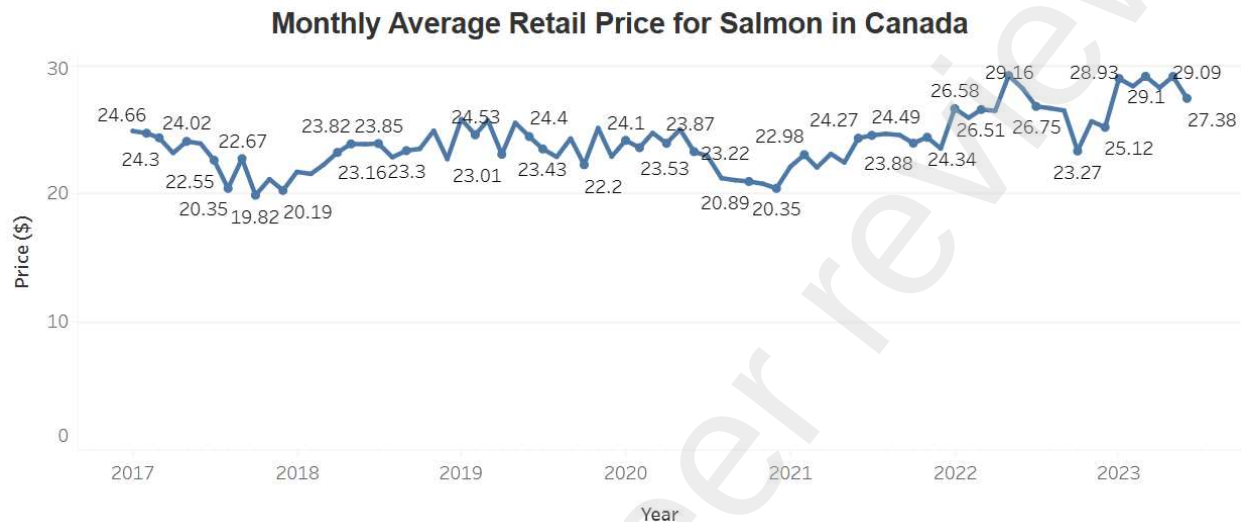


Figure 2. Monthly Average Retail Price for Salmon (per kilogram) from January 2017 to June 2023

Data Source: Statistics Canada (2023)

6.3. Market distribution

In the global Atlantic salmon trade, Canada is the second-largest supplier to the United States, while Chile holds the top spot. A clear trend in this trade landscape is the decrease in salmon exports from Canada. To break it down, from 2019 to 2022, there was a notable drop of 18% in the amount of salmon Canada sent to the United States. By 2022, Canada's share of the U.S. salmon market had shrunk to 14%. This decline in Canadian salmon exports to the United States is significant and has important implications for the dynamics of this industry. It calls for a thorough analysis in the field of international trade studies (see Figure 3).

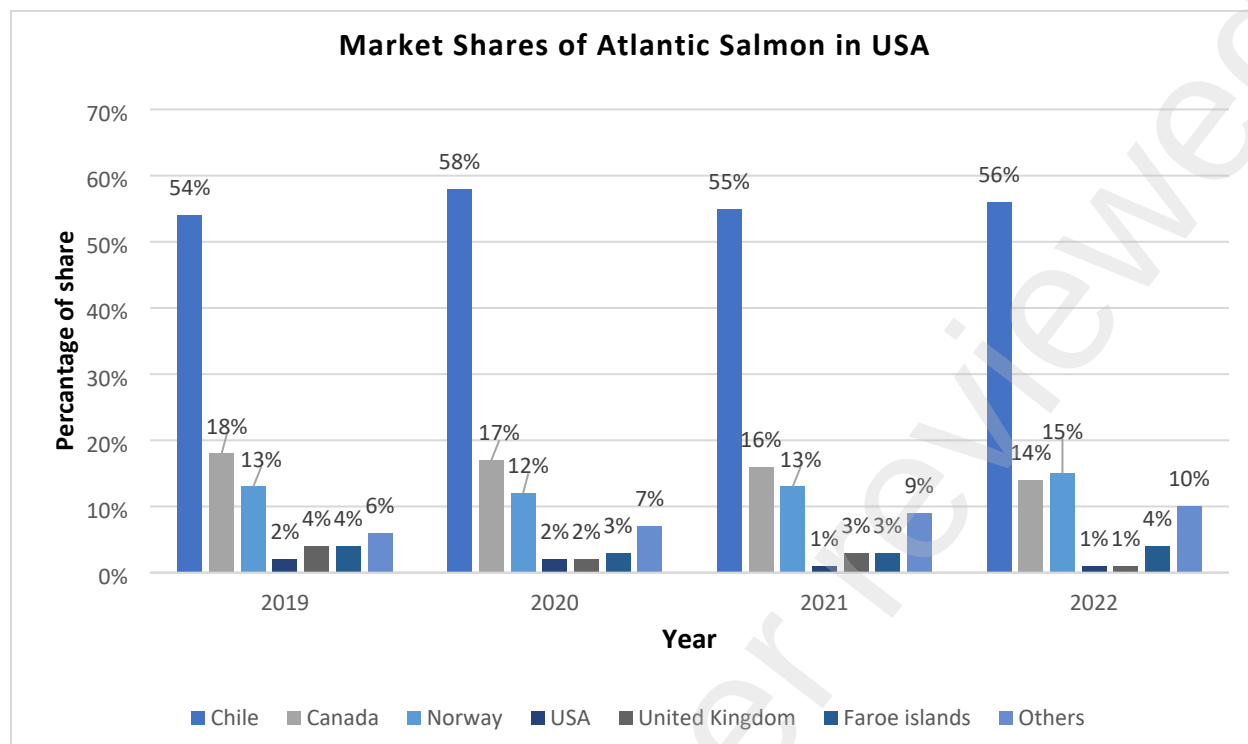


Figure 3. Market Shares of Atlantic Salmon in the USA

Data Source: Kontali (2023)

The United States stands as the primary recipient of Canadian Atlantic salmon exports, with the second-largest portion allocated for domestic consumption. As illustrated in Figure 5, the decline in salmon production has led to a reduction in export volume from 2019 through 2022. Concurrently, there has been a notable capacity to adequately satisfy domestic demand (see Figure 4).

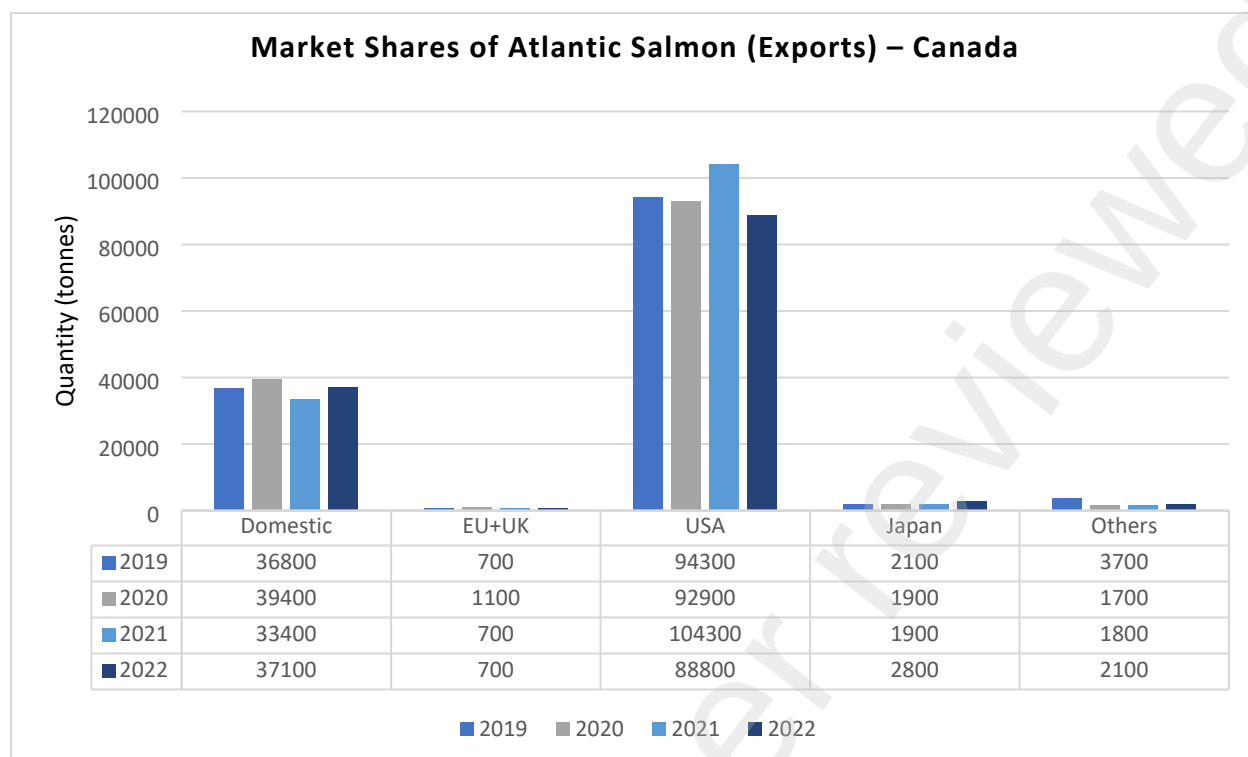


Figure 4. Market Shares of Atlantic Salmon (Exports) – Canada

Data Source: Kontali (2023)

6.4. Market Shares of Salmon (Imports) – Canada

The importation of salmon exhibited a substantial upward trajectory during the period spanning from 2019 to 2022. In specific terms, the volume of salmon imports surpassed the 2-million mark in 2019 and surged significantly, exceeding 4 million units by the year 2022. This pronounced increase in salmon imports underscores a notable trend in international trade dynamics, warranting scholarly scrutiny and analysis within the context of this study (see Figure 5). Due to the limited data availability on Atlantic salmon imports, the volume of Pacific, Atlantic, and Danube Salmonidae imports is analyzed.

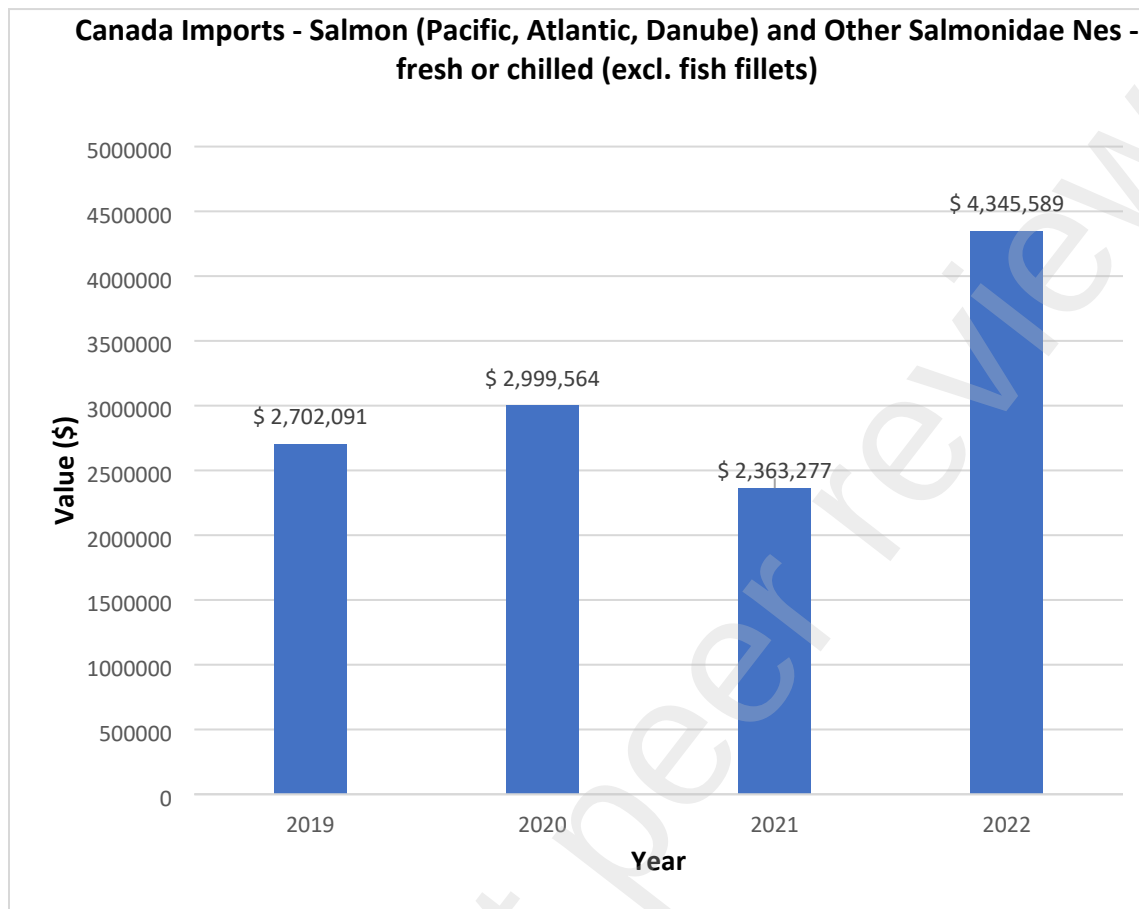


Figure 5. Market shares of Salmon (Imports) – Canada

Data source: Government of Canada Trade Data online

6.5. *Farmed Atlantic Salmon Supply in Canada and BC*

Figure 6 presents the exports of farmed Atlantic salmon from 2012 (January–August) to 2023 (January–August). From 2021 to 2023, exports in Canada dropped from 59,300 tonnes to 42,214 tonnes. The exports in BC are also very similar to the Canadian exports—the quantity dropped from 31,515 tonnes to 21,848 tonnes. The graph clearly conveys that Canadian exports of farmed Atlantic salmon depend on how much BC exports.

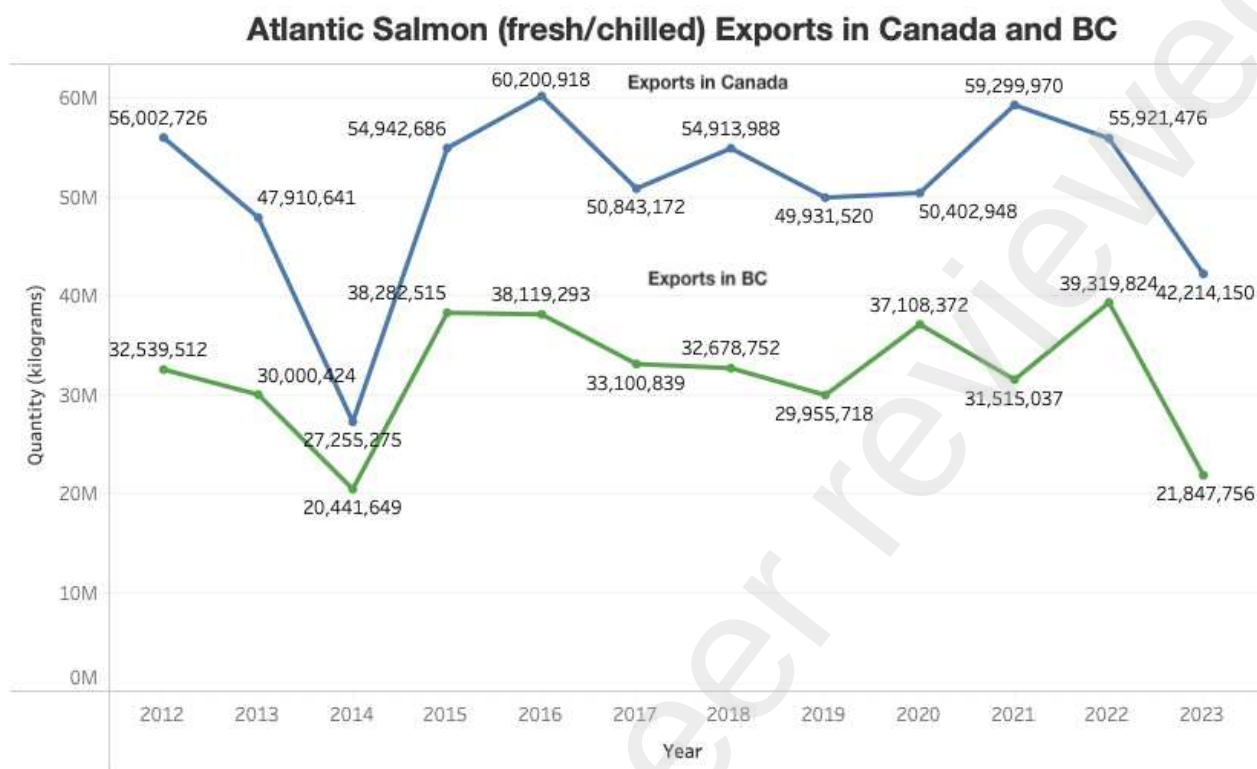


Figure 6. Farmed Atlantic Salmon (fresh/chilled) Exports in Canada and BC (January–Aug 2012 to January–August 2023)

Data source: Government of Canada Trade Data online

6.6. Canadian Farmed Atlantic Salmon Supply, World versus USA

The global supply of farmed Atlantic salmon has exhibited a substantial contraction within the period extending from 2021 to 2023, characterized by a pronounced decline in both quantity and value. Specifically, the total volume of Atlantic salmon supplied to international markets has experienced a substantial reduction, with the supply of salmon dropping from 59,300 tonnes to 42,214 tonnes from August 2021 to August 2023.

Concomitantly, the exports of farmed Atlantic salmon to the United States—a critical market in this context—have dropped from 56,697 tonnes to 40,816 tonnes. This marked reduction in export volume to the United States underscores a substantial shift in the dynamics of the international Atlantic salmon trade landscape (see Figure 7).

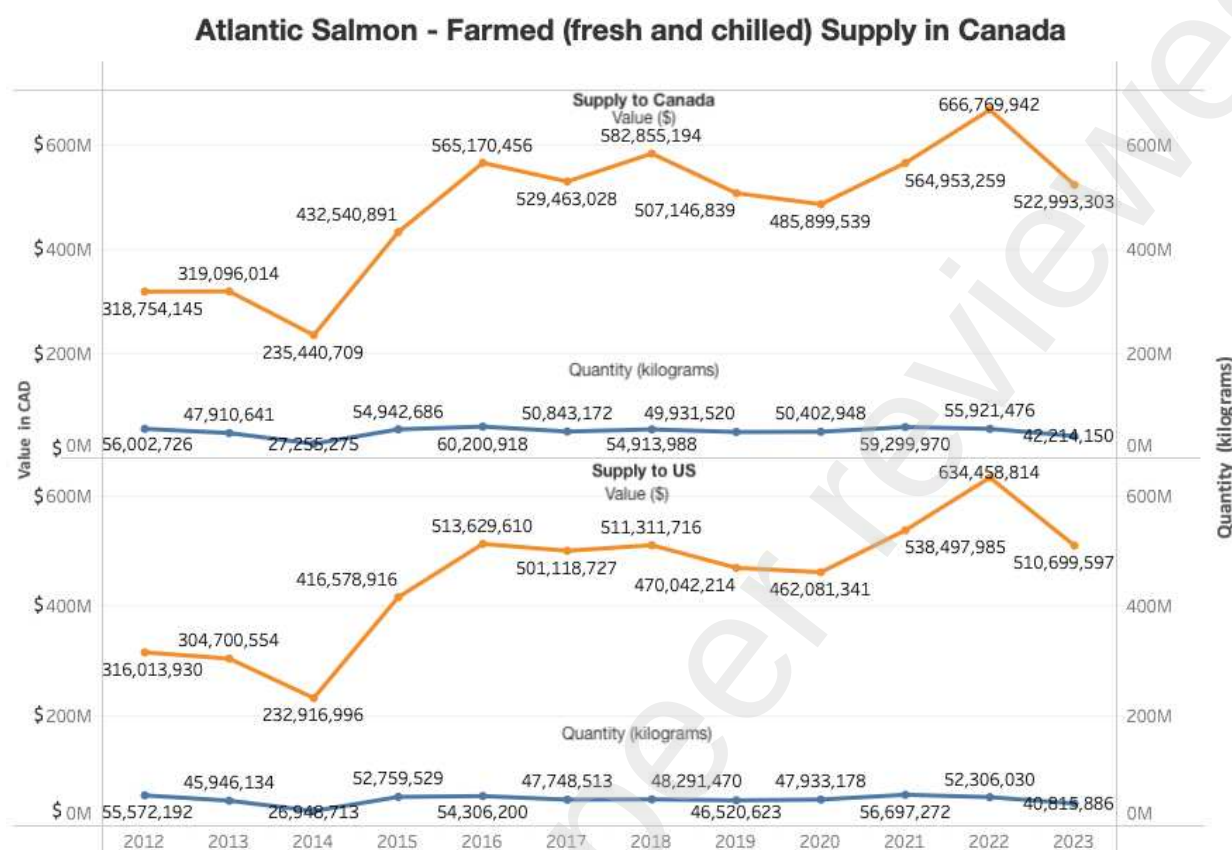


Figure 7. Farmed Atlantic Salmon (fresh/chilled) export quantity and value in Canada to the world and to the USA (January–August 2012 to January–August 2023)

Data source: Government of Canada Trade Data online

6.7. Salmon Sales and Consumer Demand

The trajectory of salmon retail sales exhibited a notable upward trend from 2017 through 2020. Nevertheless, in the subsequent years, there has been a consistent and discernible decline in sales, culminating in the volume of 95,158 metric tonnes recorded in the year 2022 (see Figure 8).

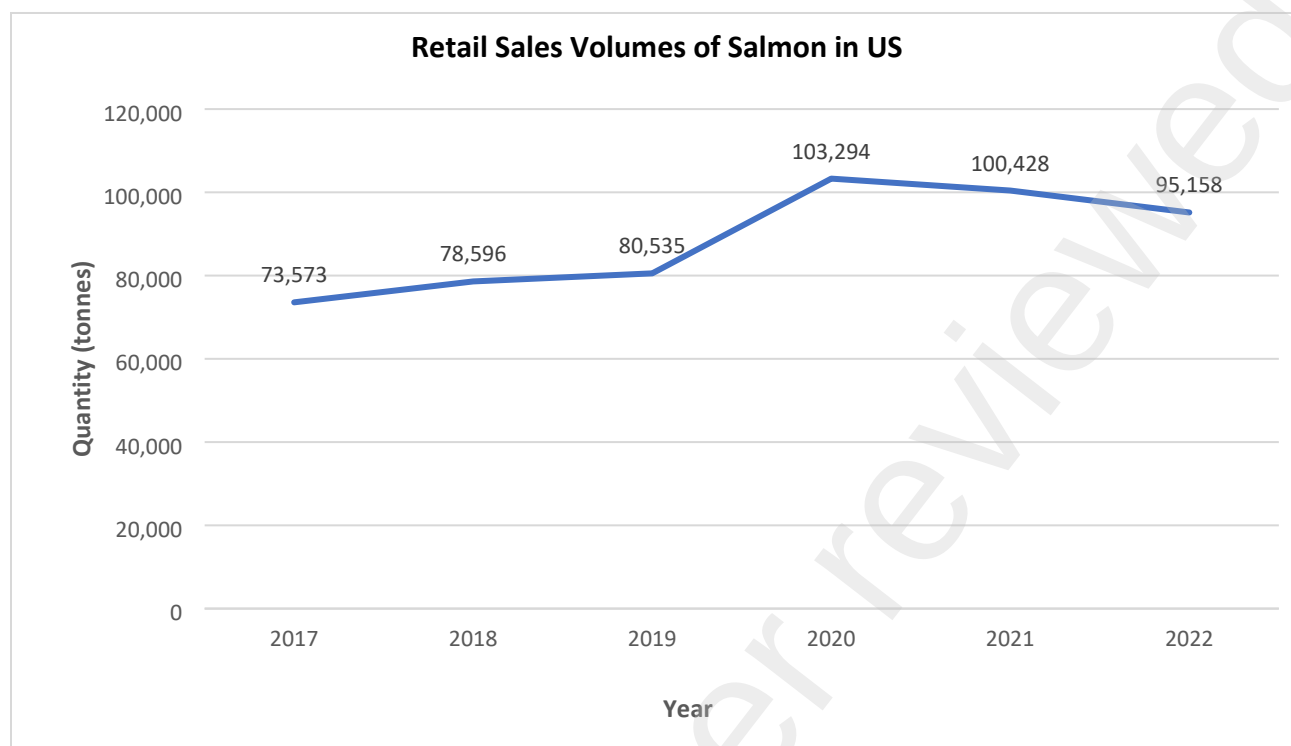


Figure 8: The retail sales volumes of Salmon in the USA from 2017 to 2022

Data Source: Nielsen (2023)

6.8. *Seafood Consumption in Canada*

Studies show that fish and seafood hold a prominent place in the Canadian diet. The survey conducted in 2023 (Colombo and Charlebois (2023), unpublished) revealed that 86.7% of Canadians regularly include fish and seafood in their meals. The primary reason to eat seafood is nutrition (64%), rather than affordability (21%). In terms of regional feeding preferences, British Columbia tops the list as it has a maximum preference for fish and seafood every week (45.8%). Contrary to this, Quebec has the lowest weekly consumption (27.2%) (refer to Figure 9).

Household income plays a very important role in terms of preference for farmed fish. The household with income exceeding \$150,000, showed the highest preference (53.3%) followed by the income with \$35,000–\$74,999 bracket at 50.2% and the \$75,000–\$149,000 bracket at 48.6% (Charlebois & Colombo, 2023).

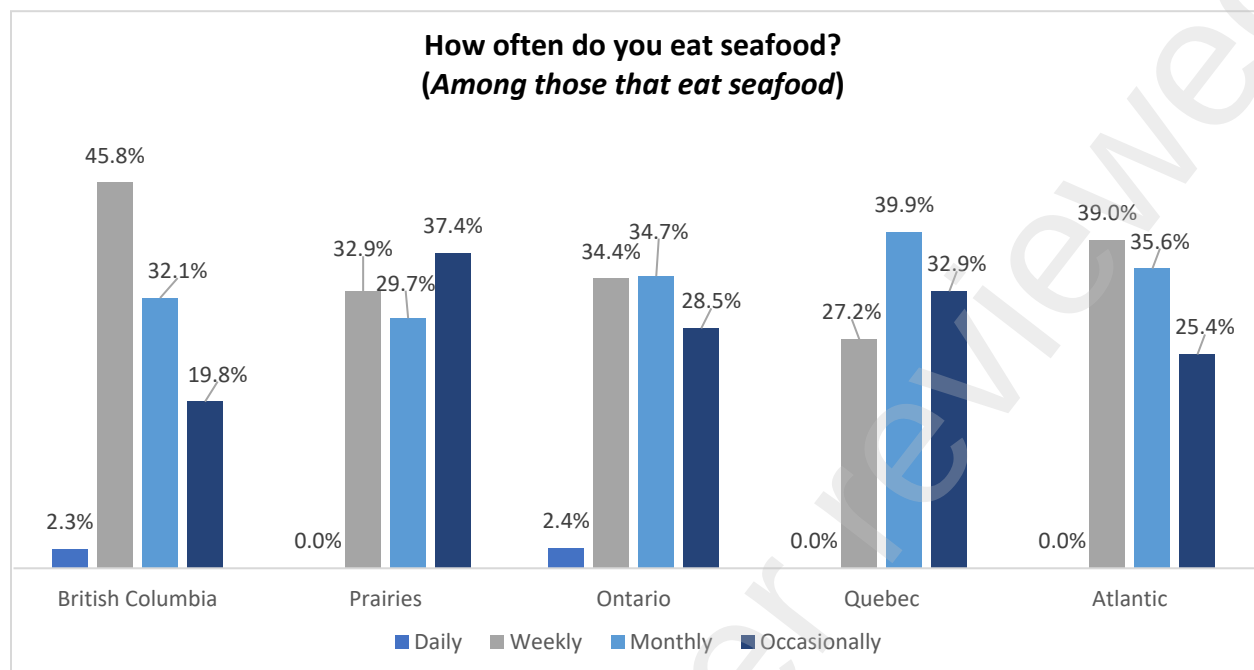


Figure 9: Seafood preference and consumption

Another survey done by Osmond (2023) reported that 55% of Canadians would be more inclined to consume farm-reared salmon if they were fed on an environmentally friendly diet. In the data presented in Table 2, it has been clearly shown that among the different meat protein food sources, chicken consumption demonstrated the most pronounced increase, registering a notable growth of 1.3% during the period spanning from 2019 to 2022, followed by beef and fish or fish dishes. In terms of fish consumption, a marginal decline of 0.6% from the year 2019 was experienced, which was not the case for other food sources. Conversely, other meat protein sources such as poultry (including chicken), pork, and various meats exhibited an upward trajectory in consumption.

Table 2. Overall protein consumption by Canadians

	2019	2020	2021	2022
Chicken	29.5%	30.7%	30.3%	30.8%
Beef	12.6%	13.2%	13.0%	12.2%
Fish/Fish Dishes	8.5%	7.9%	8.5%	7.9%
Pork	6.2%	6.5%	6.5%	6.3%
Turkey	1.7%	1.6%	1.4%	1.2%
All other Meat	6.1%	6.7%	6.2%	6.7%
Other Protein (meat alternative)	35.4 %	33.4%	34.1%	34.9%

6.9. Canadian Average Eating Per Capita of Fish/Seafood

The average per capita consumption of meat protein in Canada amounts to 575 instances annually in 2022. Conversely, there has been a reduction in the frequency of fish and seafood consumption, declining from 61 occasions per year to 54. Notably, in the year 2022, the specific consumption of salmon registered a relatively modest figure, with individuals partaking in this particular fish variety only 11 times within the same interval (see Table 3).

Table 3: Average Number of Occasions Per Capita of Fish/Seafood Consumption

	2019	2020	2021	2022
Meat Protein	585	569	586	575
Fish/Seafood	61	56	62	54
Fish/Fish Dishes	44	42	45	40
Salmon Fillet/Steaks	13	12	13	11
Seafood/Seafood Dishes	17	14	17	14

Data source: Nourish Food Marketing (2022)

7. Forecasting

The global seafood industry, driven by evolving consumer preferences, shifting market dynamics, and environmental factors, is experiencing a period of profound transformation. Within this intricate tapestry, salmon, often hailed as the “pink gold” of the sea, occupies a position of paramount significance. The economic and nutritional value of salmon, combined with its

considerable contribution to international trade, underscores its importance as both a commodity and a vital component of global food security.

In recent years, the salmon industry has been marked by fluctuations in pricing, driven by a complex interplay of factors including supply chain disruptions, environmental concerns, regulatory changes, and consumer demand. The inherent volatility of salmon prices necessitates a thorough understanding of the underlying dynamics to inform strategic decisions made by stakeholders, ranging from producers and distributors to policymakers and consumers.

This section embarks on a forward-looking endeavor—an attempt to forecast salmon prices up to the year 2026. This undertaking is motivated by several imperatives. Forecasts serve as an indispensable tool for policymakers grappling with issues of sustainability, trade, and food security, enabling informed decision-making in these areas. Furthermore, for consumers, insights into salmon price projections empower more informed choices regarding their dietary habits and purchasing decisions.

7.1. Forecasting the monthly average retail price of salmon up to 2026

This section introduces the forecasting model employed to predict salmon prices over seven years, spanning from June 2023 to May 2026. The model's foundation rests on historical data, specifically sourced from January 2017 to June 2022. The predictive methodology leveraged herein is based on the SARIMAX model, a recognized and widely applied model in time series forecasting.

The forecasting model projected salmon prices for a period of 7 years, spanning from 2023 to 2026, utilizing data available from January 2017 to May 2023. The forecasting model is illustrated in Figure A.1, Table A.1, and Table A.2 in the appendix. The prediction suggests that salmon prices will experience more frequent fluctuations and a predicted price increase of more than \$30 (per kilogram) by 2026 (nominal; see Figure A.1, Table A.1, and Table A.2 in the appendix), which will experience a more significant increase with the reduction in the volume of salmon production in the future.

An important observation within the forecasting model is the discernible presence of a seasonal pattern. This recurring pattern follows a 12-month cycle, with salmon prices exhibiting consistent fluctuations over time. The existence of seasonality in time series data is a well-documented

phenomenon in the literature, characterized by systematic variations at regular intervals, which can occur on a weekly, monthly, or quarterly basis, and, in some cases, extend to an annual cycle. Various factors can contribute to seasonality, including vacations, climatic conditions, and holidays.

To assess the model's performance, the dataset is split into two segments. Of the total 77 observations, the initial 30 serve as the training dataset, while the remaining 30 constitute the test dataset. The forecasted salmon price values closely align with the actual price values in the training dataset, exhibiting minimal differences. The model's performance is deemed satisfactory, as indicated by a Mean Percentage Error (MPE) metric value of 1.28. MPE is a commonly used evaluation metric to assess the performance of time-series forecasting models. A model closer to zero in terms of MPE signifies superior performance in forecasting future trends.

7.2. *Carbon footprint*

Within the past few years, there has been a discernible shift in the dynamics of the salmon trade, marked by a reduction in exports and a simultaneous surge in imports, particularly from 2019 to 2022. While this transition in trade patterns signifies multifaceted economic dynamics, it is vital to underscore its environmental ramifications, particularly concerning carbon emissions.

Most of the salmon consumed by Canadians came from BC. The reduced production has increased the salmon imports to fulfill domestic consumption. Canada is now importing more salmon from different parts of the world. The quantity of imports has increased rapidly since 2021. Canada imported approximately 86,300 and 86,387 tonnes of salmon in 2021 and 2022, respectively, which is about 20,000 tonnes more than the previous years. The imports are all forms of salmon, including fresh, preserved/prepared, frozen, and canned salmon. Most of the imports were from other dominant salmon suppliers such as Norway, the United Kingdom, Chile, China, Mexico, and Iceland (see Table A.3 in the appendix). It is estimated that the salmon imports from these countries generated approximately 84.56 million tonnes of CO₂ emissions per kilometer in 2021 and 86.3 million tonnes in 2022, which is approximately 9.9 million tonnes more than in 2020.

Table 4. Estimated carbon footprints from imports of salmon from the six dominant countries to Canada from 2021 to 2023(Aug).

Salmon supplier	Distance from border to the border (km)	Kg CO ₂ - eq/tonne-km	Estimated in million tonnes CO ₂ emissions-km (2020)	Estimated in million tonnes CO ₂ emissions-km (2021)	Estimated in million tonnes CO ₂ emissions-km (2022)	Estimated in million tonnes CO ₂ emissions-km (Until August 2023)
Norway	1190	702.5	1.577	2.6956	3.2389	2.0591
UK	2849	1681.8	0.605	1.4836	1.543	0.7285
Chile	6686	3946.8	62.378	64.8652	61.263	53.8973
China	4745	2800.98	10.9577	9.2078	10.4917	5.9561
Mexico	1808	1067.27	0.5933	5.5515	7.9834	6.295
Iceland	1647	972.23	0.2446	0.7559	1.7773	0.7124
Total CO ₂ emissions Produced			76.3556	84.5596	86.2973	69.6484

Note: Distance is calculated using Distance Calculator: <https://distancecalculator.globefeed.com/>. Carbon emissions are calculated using: The Dalhousie seafood carbon emission tool: <http://seafoodco2.dal.ca/>.

The average Canadian vehicle releases 4,600 kg of CO₂ into the atmosphere every year. The estimated increase in CO₂ emissions (from 2020) released by the increased imports is equal to the emissions released by 2,152,000 vehicles a year in Canada. Table 4 provides the estimates of carbon footprints generated by the distance between the countries by airplane transport. Imports from China and Chile produce the highest number of emissions, as the distance is far from Canada compared to other countries.

The production of meat produces carbon emissions. In 2019, the export of 83,180 tonnes of farmed salmon in BC, valued at \$771 million, significantly contributed to the creation of 353 million meals enriched with high-quality protein, all the while minimizing CO₂ emissions (RIAS Inc., 2023). Indeed, salmon emerged as an exemplar of environmentally conscious protein sourcing, generating a mere 0.6 grams of CO₂ emissions in 2019 in BC. In stark contrast, other conventional meat sources such as chicken, pork, and beef accounted for 0.88 grams, 1.3 grams, and 5.92 grams of CO₂ emissions, respectively (as depicted in Figure 10).

Unfortunately, the years following 2019 have seen a decrease in salmon consumption in Canada, paralleled by an upswing in the consumption of other types of meat alternatives. This shift, while indicative of evolving dietary preferences, has environmental implications. Importantly, the increased demand for other protein sources necessitates higher production, which is associated

with higher carbon emissions. Therefore, the heightened demand for alternative protein sources in Canada inadvertently exacerbates the carbon footprint generated by meat production.

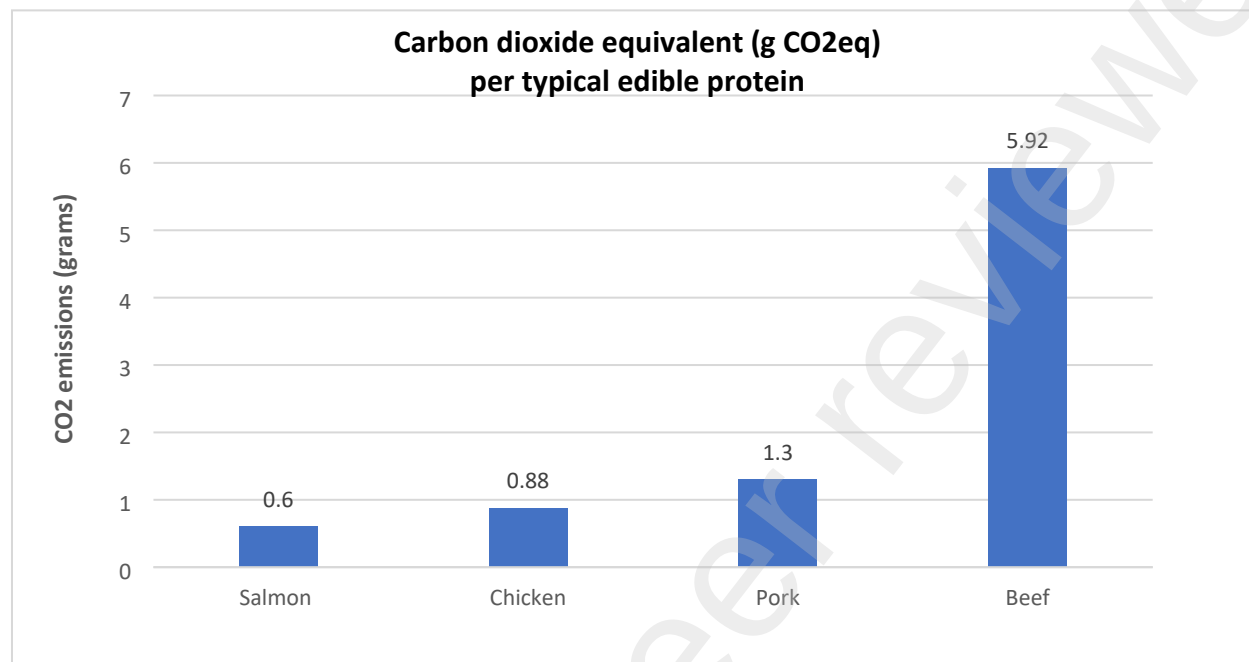


Figure 10. Carbon dioxide equivalent (e.g., CO₂eq - one gram of CO₂) per typical edible protein (2019)

Data source: Kontali (2023)

This nuanced interplay between shifting dietary preferences, trade dynamics, and carbon emissions underscores the importance of comprehending the intricate relationship between global trade and environmental sustainability. As Canada navigates this transition in its dietary landscape, it becomes imperative to consider not only environmental but also socio-economic factors when formulating trade and consumption policies. This recalibration of priorities is essential for mitigating the environmental consequences that accompany changes in protein consumption patterns.

8. Conclusions

The reduction in salmon production, triggered by the closure of 19 farms in British Columbia, has significantly impacted the sustainable supply of salmon to consumers in both Canada and the United States. An examination of historical trends in salmon production reveals a concerning

trajectory characterized by declining production volumes and a simultaneous reduction in the market value of salmon, a trend that commenced in 2019.

Interestingly, within the North American market, Canada has historically held a dominant position in the salmon sector, supplying a substantial portion to the United States. However, this market dominance has steadily eroded since the beginning of 2019. The decline in Canadian market share is mirrored by noticeable shifts in consumer behavior, with retail prices for salmon rising alongside a palpable decrease in demand for this seafood staple across North America.

The repercussions of reduced salmon production and disruptions in the supply chain extend beyond economic considerations and encroach into the realm of environmental sustainability. The decrease in salmon production has led to a corresponding drop in exports and a simultaneous surge in salmon imports, significantly contributing to the carbon footprint associated with North American consumption patterns.

In addition, as previously discussed, an increase in imports has the potential to contribute to greater retail price fluctuations in Canada, which, in turn, might influence the overall domestic demand for salmon. Policymakers and market participants must take these factors into account when evaluating the potential consequences of food imports on retail prices within a particular country or region. It is noteworthy that North Americans have gradually shifted away from seafood in favor of alternative sources of meat protein. This transition not only impacts dietary preferences but also exerts a tangible influence on carbon emissions within the Canadian context.

Conversely, as a result of the diminished availability of Canadian salmon in the United States market, the U.S. has progressively sought out alternative suppliers, such as Norway and Chile. Meeting the demand for Canadian salmon in the U.S. market has proven to be a formidable challenge. Although diversifying sources is important, this approach unintentionally contributes to an increase in carbon emissions linked to salmon imports.

Projections for the future indicate a further decline in salmon production within Canada, a trend poised to have cascading effects on global and domestic markets, Gross Domestic Product (GDP), and salmon consumption patterns in North America. Canada, once a pillar in the aquaculture industry, now faces the daunting challenge of being unable to fulfill the growing market demand,

both on a global and domestic scale. Moreover, forecasting the future of retail salmon prices in Canada presents a formidable challenge. However, predictive models indicate that price fluctuations may intensify with a decrease in domestic production.

The decision to close BC farming facilities reverberates far beyond the boundaries of supply and demand. It has brought about transformative effects on salmon supply, consumer pricing dynamics, and market conditions while exacting a toll on environmental conditions through the upsurge in carbon emissions resulting from increased salmon imports in North America. The convergence of these multifaceted challenges underscores the intricate interplay between economic, environmental, and market forces, prompting a re-valuation of the strategies and policies governing the aquaculture industry.

References

- Ahmed, N., Thompson, S., & Turchini, G. M. (2020). Organic aquaculture productivity, environmental sustainability, and food security: insights from organic agriculture. *Food Security*, 12(6), 1253–1267. <https://doi.org/10.1007/s12571-020-01090-3>
- Anderson, J. L., Asche, F., Garlock, T., & Chu, J. (2017). *Aquaculture: Its Role in the Future of Food* (pp. 159–173). <https://doi.org/10.1108/S1574-871520170000017011>
- Bjørnstad, H., Halvorsen, Ø. L., & Rognås, V. C. J. (2023). Forecasting the price of salmon using machine learning algorithms [Norwegian University of Science and Technology]. In *NTNU Open*. file:///C:/Users/Bibh/Desktop/no.ntnu_inspira_140915232_146857240.pdf
- Bloznelis, D. (2018). Short-term salmon price forecasting. *Journal of Forecasting*, 37(2), 151–169. <https://doi.org/10.1002/for.2482>
- Charlebois, S., & Colombo, S. (2023). Canadians Cast Their Nets of Preference: New Study Reveals Insights into Seafood Choices and Sustainability. *Unpublished, Agri-Food*.
- Dawood, M. A. O., & Koshio, S. (2020). Application of fermentation strategy in aquafeed for sustainable aquaculture. *Reviews in Aquaculture*, 12(2), 987–1002. <https://doi.org/10.1111/raq.12368>
- FAO. (2016). *The State of World Fisheries and Aquaculture: Contributing to Food Security and Nutrition for All*. <https://www.fao.org/3/i5555e/i5555e.pdf>
- FAO. (2020). *The State of World Fisheries and Aquaculture 2020*. FAO. <https://doi.org/10.4060/ca9229en>
- FAO, I. and W. (2014). *The State of Food Insecurity in the World 2014: Strengthening the Enabling Environment for Food Security and Nutrition*. <https://www.fao.org/3/i4030e/i4030e.pdf>
- Filipski, M., & Belton, B. (2018). Give a Man a Fishpond: Modeling the Impacts of Aquaculture

- in the Rural Economy. *World Development*, 110, 205–223.
<https://doi.org/10.1016/j.worlddev.2018.05.023>
- Fisheries and Oceans Canada. (2018). *Outlook to 2027 for Canadian Fish and Seafood*.
<https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/40732836.pdf>
- Froehlich, H. E., Runge, C. A., Gentry, R. R., Gaines, S. D., & Halpern, B. S. (2018). Comparative terrestrial feed and land use of an aquaculture-dominant world. *Proceedings of the National Academy of Sciences*, 115(20), 5295–5300.
<https://doi.org/10.1073/pnas.1801692115>
- Garlock, T., Asche, F., Anderson, J., Bjørndal, T., Kumar, G., Lorenzen, K., Ropicki, A., Smith, M. D., & Tveterås, R. (2020). A Global Blue Revolution: Aquaculture Growth Across Regions, Species, and Countries. *Reviews in Fisheries Science & Aquaculture*, 28(1), 107–116. <https://doi.org/10.1080/23308249.2019.1678111>
- Gephart, J. A., Henriksson, P. J. G., Parker, R. W. R., Shepon, A., Gorospe, K. D., Bergman, K., Eshel, G., Golden, C. D., Halpern, B. S., Hornborg, S., Jonell, M., Metian, M., Mifflin, K., Newton, R., Tyedmers, P., Zhang, W., Ziegler, F., & Troell, M. (2021). Environmental performance of blue foods. *Nature*, 597(7876), 360–365. <https://doi.org/10.1038/s41586-021-03889-2>
- Golden, C. D., Koehn, J. Z., Shepon, A., Passarelli, S., Free, C. M., Viana, D. F., Matthey, H., Eurich, J. G., Gephart, J. A., Fluet-Chouinard, E., Nyboer, E. A., Lynch, A. J., Kjellekvold, M., Bromage, S., Charlebois, P., Barange, M., Vannuccini, S., Cao, L., Kleisner, K. M., ... Thilsted, S. H. (2021). Aquatic foods to nourish nations. *Nature*, 598(7880), 315–320.
<https://doi.org/10.1038/s41586-021-03917-1>
- Gouel, C. (2016). Trade Policy Coordination and Food Price Volatility. *American Journal of Agricultural Economics*, 98(4), 1018–1037. <https://doi.org/10.1093/ajae/aaw020>
- Government of British Columbia. (n.d.). *Salmon aquaculture in British Columbia*.
<https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/environmental-assessments/eao-project-reviews/salmon-aquaculture-summary-report.pdf>
- Government of British Columbia. (2019). *Business advantage: Grow your business in British Columbia, Canada*. <https://www.britishcolumbia.ca/wp-content/uploads/bc-businessadvantages-1.pdf?lang=fr#:~:text=Organizations benefit from our prime,climate and skilled%2C educated workforce.&text=More than 98%25 of the,from clean or renewable resources>.
- Government of Canada. (2017). *Farmed Salmon*. Species Farmed in Canada. <https://www.dfo-mpo.gc.ca/aquaculture/sector-secteur/species-especes/salmon-saumon-eng.htm>
- Government of Canada. (2023). *Pacific aquaculture transition - What we heard report phases 1 and 2*.
- Grafton, R. Q., Williams, J., & Jiang, Q. (2015). Food and water gaps to 2050: preliminary results from the global food and water system (GFWS) platform. *Food Security*, 7(2), 209–220. <https://doi.org/10.1007/s12571-015-0439-8>
- Hilborn, R., Banobi, J., Hall, S. J., Pucylowski, T., & Walsworth, T. E. (2018). The

- environmental cost of animal source foods. *Frontiers in Ecology and the Environment*, 16(6), 329–335. <https://doi.org/10.1002/fee.1822>
- Hua, K., Cobcroft, J. M., Cole, A., Condon, K., Jerry, D. R., Mangott, A., Praeger, C., Vucko, M. J., Zeng, C., Zenger, K., & Strugnelli, J. M. (2019). The Future of Aquatic Protein: Implications for Protein Sources in Aquaculture Diets. *One Earth*, 1(3), 316–329. <https://doi.org/10.1016/j.oneear.2019.10.018>
- Kontali. (2023). *Global Salmon Production and Market Update: Systemizing the World of Aquaculture and Fisheries*. <https://edge.kontali.com/>
- Landwehr, N., Hall, M., & Frank, E. (2005). Logistic Model Trees. *Machine Learning*, 59(1–2), 161–205. <https://doi.org/10.1007/s10994-005-0466-3>
- MacLeod, M. J., Hasan, M. R., Robb, D. H. F., & Mamun-Ur-Rashid, M. (2020). Quantifying greenhouse gas emissions from global aquaculture. *Scientific Reports*, 10(1), 11679. <https://doi.org/10.1038/s41598-020-68231-8>
- McHugh, C., Coleman, S., Kerr, D., & McGlynn, D. (2019). Forecasting Day-ahead Electricity Prices with A SARIMAX Model. *2019 IEEE Symposium Series on Computational Intelligence (SSCI)*, 1523–1529. <https://doi.org/10.1109/SSCI44817.2019.9002930>
- Nielsen. (2023). *Retail Trend of Atlantic Salmon: Retail scan numbers for seafood in the US*.
- Nourish Food Marketing. (2022). *Canadian Consumption of Seafood*.
- Osmond, A. T. Y., Charlebois, S., & Colombo, S. M. (2023). Exploratory analysis on Canadian consumer perceptions, habits, and opinions on salmon consumption and production in Canada. *Aquaculture International*, 31(1), 179–193. <https://doi.org/10.1007/s10499-022-00972-x>
- RIAS Inc. (2021). *Consequences of the Decision to Shut down Salmon Farming in the Discovery Islands*.
- RIAS Inc. (2023). *Economic And Financial Impacts of Minister Murray's Transition Plan for BC Salmon Farms*.
- Sharif, M., Zafar, M. H., Aqib, A. I., Saeed, M., Farag, M. R., & Alagawany, M. (2021). Single cell protein: Sources, mechanism of production, nutritional value and its uses in aquaculture nutrition. *Aquaculture*, 531, 735885. <https://doi.org/10.1016/j.aquaculture.2020.735885>
- Smith, M. D., Roheim, C. A., Crowder, L. B., Halpern, B. S., Turnipseed, M., Anderson, J. L., Asche, F., Bourillón, L., Guttormsen, A. G., Khan, A., Liguori, L. A., McNevin, A., O'Connor, M. I., Squires, D., Tyedmers, P., Brownstein, C., Carden, K., Klinger, D. H., Sagarin, R., & Selkoe, K. A. (2010). Sustainability and Global Seafood. *Science*, 327(5967), 784–786. <https://doi.org/10.1126/science.1185345>
- Statistics Canada. (2023). *Aquaculture, production and value*. <https://doi.org/10.25318/3210010701-eng>
- Tilman, D., Balzer, C., Hill, J., & Befort, B. L. (2011). Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences*, 108(50), 20260–20264. <https://doi.org/10.1073/pnas.1116437108>
- Tsoumakas, G. (2019). A survey of machine learning techniques for food sales prediction.

Artificial Intelligence Review, 52(1), 441–447. <https://doi.org/10.1007/s10462-018-9637-z>
Valdés, A. (2012). *Net food-importing developing countries: who they are, and policy options for global price volatility*. file:///C:/Users/Bibh/Desktop/Valdes and Foster NFIDCs 2012.pdf

Authors Contribution

Contributions of the authors are: Conceptualization: Sylvain Charlebois and Stefanie Colombo, Methodology: Keshava Pallavi Gone; Software: Keshava Pallavi Gone; Validation: Keshava Pallavi Gone; Formal Analysis and Investigation: Keshava Pallavi Gone; Resources, Data Curation, and Writing – Original Draft Preparation: Keshava Pallavi Gone; Writing, Review & Editing: Swati Saxena, Keshava Pallavi Gone, Bibhuti Sarker

Data Availability Statement:

Data will be available upon request.

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Appendix

Table A.1: Forecasting salmon prices per kilogram from January 2024 to December 2026

Date	Forecasted Price	Date	Forecasted Price	Date	Forecasted Price
Jan-24	29.06	Jan-25	29.65	Jan-26	30.23
Feb-24	28.67	Feb-25	29.25	Feb-26	29.84
Mar-24	29.12	Mar-25	29.71	Mar-26	30.29
Apr-24	28.6	Apr-25	29.18	Apr-26	29.77
May-24	29.76	May-25	30.34	May-26	30.92
Jun-24	29.43	Jun-25	30.01	Jun-26	30.59
Jul-24	28.79	Jul-25	29.37	Jul-26	29.96
Aug-24	27.86	Aug-25	28.44	Aug-26	29.02
Sep-24	28.5	Sep-25	29.08	Sep-26	29.66
Oct-24	27.05	Oct-25	27.64	Oct-26	28.22
Nov-24	28.41	Nov-25	28.99	Nov-26	29.58
Dec-24	27.23	Dec-25	27.82	Dec-26	28.4

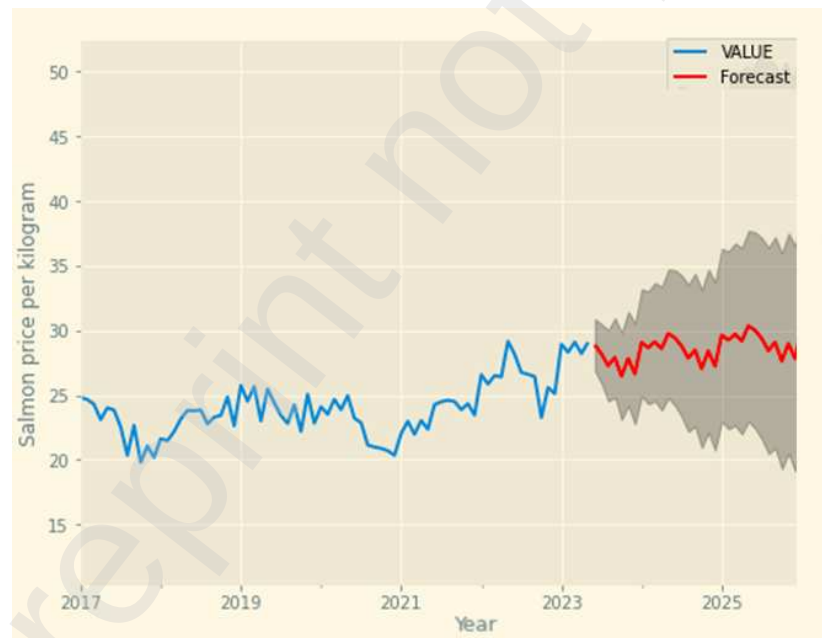


Figure A.1: Forecasting salmon prices per kilogram from January 2024 to December 2026

Table A.2: Statistical Summary of Salmon Pricing Forecasting Model (SARIMAX results)

Variable	Coefficient	z-statistics
AR(1)	-0.445*** (0.136)	-3.264
MA.S(12)	-1.000 (1166.307)	-0.001
σ^2	0.897 (1046.328)	0.001
AIC	158.842	
BIC	164.637	
Jarque-Bera	1.180	

Note: *** denotes significance at the 1% level.

Table A.3: Imports of Salmon (all types) to Canada from Jan 2020 to August 2023

Country	2020	2021	2022	2023 (until August)
USA	38,302,333	49,327,231	47,256,253	25,944,836
Chile	15,804,696	16,434,882	15,522,162	13,655,955
Norway	2,244,782	3,837,213	4,610,537	2,931,071
China	3,912,098	3,287,334	3,745,725	2,126,420
Mexico	555,861	5,201,595	7,480,236	5,898,253
Iceland	251,567	777,498	1,828,093	732,743
United Kingdom	359,778	882,171	917,462	433,171
Lithuania	450,538	614,487	689,109	249,751
Thailand	1,369,993	1,649,477	1,018,263	495,149
Poland	615,508	806,309	385,082	144,016
New Zealand	151,218	469,326	108,543	87,521
Netherlands	172,603	98,559	91,274	65,690
Sweden	31,557	36,661	58,255	62,695
Italy	859	52,967	67,904	31,685
Türkiye	0	776	18,038	89,910
Denmark	67,101	108,581	261,189	113,595
Canada	213,181	161,847	230,967	62,330
Ireland	172,542	35,571	5,938	14,181
France	74,746	1,983	177	94,369
Faroe Islands	19,123	28,843	61,351	11,915
Panama	332,051	490,781	740,358	51,325

Country	2020	2021	2022	2023 (until August)
Colombia	3,374	13,858	56,392	4,064
Japan	108,280	19,151	8,166	4,492
Brazil	0	0	6,357	4,240
Trinidad and Tobago	0	8,848	83,188	3,026
Viet Nam	19	12,415	18,419	1,145
Sri Lanka	0	0	284	4,417
Iran	45	134	89	1,655
Germany	9,527	3,681	38,338	1,170
Guyana	0	0	944	1,350
Portugal	1,053	5,030	1,229	844
Morocco	0	200,016	0	16
Australia	0	2	125	5
Benin	0	0	0	2
Korea, South	0	112	0	0
Argentina	237,345	481,388	468,932	0
Bangladesh	0	0	0	0
Belarus	112	428	0	0
Cameroon	0	47	0	0
Costa Rica	0	0	191	0
Ecuador	4,082	1,067	727	0
Egypt	0	1	0	0
Finland	0	2	0	0
Ghana	0	902	0	0
Greenland	0	453	0	0
Honduras	0	11,610	1,315	0
Hong Kong	0	2	0	0
India	0	0	0	0
Indonesia	44,089	20,583	226	0
Israel	349	10	0	0
Kenya	0	0	0	0
Latvia	3,656	13,676	27,287	0
Mauritania	435	100,000	35	0
Mozambique	0	0	0	0
Nigeria	20	37	1	0
Peru	1,588	111,903	30,566	0
Philippines	0	0	1,688	0
Russian Federation	874,604	969,688	539,149	0
Saudi Arabia	0	0	0	0
Senegal	1	0	18	0
Singapore	3	0	0	0

Country	2020	2021	2022	2023 (until August)
Spain	40,848	19,455	542	0
Switzerland	1,334	0	4,839	0
Taiwan	44	0	60	0
United Republic of Tanzania	0	635	0	0
Togo	12,318	0	9	0
Tunisia	0	0	210	0
Ukraine	0	1,155	648	0
Total imports Quantity	66,445,261	86,300,381	86,386,890	53,323,007

Source: Statistics Canada data retrieved from CATSNET Analytics, AAFC