A Perspective on Global Salmon Aquaculture: Empowering Ecosystems and Communities

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Tasmania

February 2025

Nuffield Australia project number 2307

Supported by

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In submitting this report, the Scholar has agreed to Nuffield Australia publishing this material in its edited form.

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Executive Summary

This report focuses on the challenges and opportunities posed by climate change and the concept of social license in the salmon farming industry, by providing a comprehensive overview of the global context. The Tasmanian salmon industry is one of Australia's most valuable seafood sectors, providing a healthy and nutritious source of protein to the country.

Tasmania's unique geographical advantages, such as pristine waterways and optimal cold conditions, have facilitated the industry's growth. However, the industry faces regular environmental and social challenges, including the pressure from warming waters caused by climate change and the polarisation of the debate on salmon farms being harmful to the environment. The Tasmanian industry can become an exemplary model for the rest of the world. The streamlined processes, absence of native salmon populations, and geographical isolation are advantageous factors that make this industry unique in the global context.

Global aquaculture is the fastest-growing food sector. In 2022, the Food and Agriculture Organization (FAO) reported that farmed fish production surpassed wild catch for the first time. The salmon aquaculture industry supports global protein demand while reducing pressure on wild fisheries. However, there are environmental and social challenges that need to be addressed before continuing the exponential growth of the industry.

Climate change poses significant threats to salmon aquaculture, impacting water temperatures and fish health. The industry has responded with technological solutions like selective breeding, advanced farming technologies, and Recirculating Aquaculture Systems (RAS). Additionally, adopting ecosystem-based models (EBM) offers a holistic approach by integrating species such as seaweed and mussels into aquaculture systems. These species provide bioremediation services, enhancing marine health and resilience. EBM improves environmental sustainability and offers long-term economic benefits. The future of salmon farming depends on incorporating adaptive ecosystem models to reduce environmental impact and ensure sustainable growth.

Social acceptability requires businesses to gain legitimacy, credibility, and trust from their communities. Transparency, traceability, and collaboration with scientific institutions, indigenous groups, and non-governmental organisations (NGOs) are essential to building a strong social license. Strengthening community relationships through meaningful investment will help shape the industry's intentions and values. Community engagement and addressing the educational gap are crucial for achieving public trust and understanding of aquaculture practices.

In conclusion, the future of salmon aquaculture depends on the willingness and level of collaboration with NGOs, communities, supply chain and other industries. The issues faced are too big to be tackled in isolation; long-term environmental goals are important and should align with the supply chain's strategy. The relationships built over time will shape the culture in and out of the community—a culture that understands the challenges, works tirelessly on improvements and eventually, embraces the industry.

Keywords: salmon farming, climate change, social license, sustainability, community

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Foreword

Arriving in Australia in 2008 with my family from Portugal, I realised how fortunate we were to have the opportunity to live in a country with an incredible variety of ecosystems and pristine nature. From a young age, I wanted to study Marine Biology. Whether my interest in the ocean stems from Portugal's history of discoverers or a personal fascination, I knew I wanted to learn more about the underwater world.

I completed my bachelor's degree in Marine Biology at James Cook University in Townsville. This experience was a significant eye-opener as I learned about the pressures on exploited fish stocks and the bleaching of coral reefs. The confronting reality of an imbalanced ecosystem steered my passion for the ocean to look for pragmatic solutions, leading me to discover aquaculture. After my degree, I spent a couple of years working with prawns and barramundi, gaining practical experience on farms and acquiring new skills. In 2018, I moved to Tasmania with the exciting opportunity to join the salmon industry. Working on the water, where no two days were the same due to changing weather conditions, I enjoyed the challenge of adapting to the environment while pursuing my passion for people and the ocean.

Figure 1 - The author at home in Tasmania. (Source: Author)

Despite the tough weather, there were other challenges associated with the nature of work on a fish farm, including a male-dominated workforce and the remoteness of the operations. These challenges made me feel isolated at times, but I chose to look past these differences and engage with my colleagues as we built a culture of respect and understanding. This experience was a significant learning curve but ultimately rewarding, as I now understand more about people and their connections in small communities.

My career in the salmon industry has been fulfilling, offering many opportunities to develop my skills in various areas: fish health, work health and safety, compliance, and more recently, sustainability and community engagement. The diverse range of work has helped me see different perspectives within the industry, allowing me to develop multiple skills across various business areas. One of the best things about this industry is working with people who inspire me to do more every day.

The challenges faced by the salmon industry in Tasmania were unsettling to me. The negative perceptions from community groups and activists, combined with the environmental pressures from climate change, were topics of interest that drove me to deepen my understanding. In 2022, I stumbled across the Nuffield scholarship, not fully realising the incredible opportunity it would provide. Taking a chance, I applied and found that Nuffield was the perfect segue for my career, allowing me to explore global salmon aquaculture and learn from their challenges and solutions. I am committed to supporting the industry both locally and globally and am eager to continue building connections with people who care and are dedicated to developing a sustainable industry.

Table 1. Travel itinerary

Travel date	Location	Visits/contacts
Oct 26-27, 2022	Australia: Melbourne	**Waste Expo Australia**
Feb 20 Mar 22, 2023	Canada: New Brunswick Nova Scotia British Columbia	**Cooke Canada** Joel Richardson - Vice President Public Relations Jennifer Wiper - Compliance and Certification Wayne Long - MP Liberal Margaret Johnson - Minister of Agriculture, Aquaculture and Fisheries NB **Atlantic Canada Fish Farmers Association (ACFFA)** Susan Farquharson - Executive Director **Dalhousie University** Stephaine Colombo - Associate professor **Sustainable Blue** Dave Roberts - Chief of Sustainability **Contemporary Scholars Conference**
Mar 23 - Apr 1, 2023	New Zealand: South Island	**Nuffield International Triennial Conference** **Mount Cook Alpine salmon**
May 19 – June 20, 2023	Singapore India Qatar Germany USA	**Global Focus Program**
Oct 16 – 27, 2023	Italy: Rome	**Food Agriculture Organisation** **World Food Forum** **Committee on Food Security #51**
April 15 – 30, 2024	Chile: Punta Arenas Puerto Natales Puerto Montt	**Cooke Chile** Eduardo Jara - Technical Manager Rodrigo Perez - Farming Director **Blumar** Estefania Humud - Head of ESG and Climate Change Francisca Lopez Campos - Head of Communities **Cermaq** Nicolas Vial - Manager of Legal Affairs and Regulatory Compliance **Asociacion de Salmonicultores de Magallanes** Francisca Rojas - General Manager **Salmons Aysen** Sonia Stolz - Fish Health Manager **Multi X** Kevin Scherpenisse – Sustainability Manager Francisco Lobos – CHRO ESG & Corporate Affairs

May 16 – 31, 2024	UK: Scotland England	**Aquaculture UK Conference** **Blue Food Innovation Summit** **Cooke Scotland** Calum Jones – Sustainability Manager Michelle Johnson - Technical Manager **Scottish Sea Farms** Amanda Tresise – Environmental Manager **Mowi Scotland** Doughie Hunter – Technical Director Jayne Mackay – Community Engagement Officer **ASC** Aisla Jones – Market Development Manager Roy Van Daatselaar – Global Head of Improver Program **Biomar** Katherine Bryar - Global Marketing Manager **Marine Conservancy Society** Dawn Purchase – Aquaculture Program Manager **W&J Knox Ltd** Ryan Ganfield – Sustainability Manager
June 1 – 13, 2024	Norway: Oslo Bergen Stavanger	**AquaVision 2024** **Cermaq** Lise Bergan – Global Head of Communications **Mowi** Catarina Martins – head of Technology and Sustainability **Greig Seafood** Kristina Furnes – Chief Communications Officer **SeaBOS** Wenche Gronbrekk – Director Strategy and Partnerships **Skretting** Jorge Diaz – Sustainability Director **Norwegian Seafood Federation** Krister Hoaas – Head of Farming Region West Henrik Horjen – Head of Communications

Acknowledgments

Thank you to the Nuffield Australia committee for believing in me even before I did. This scholarship has enriched my life both professionally and personally. It is an absolute privilege to be part of this incredible network of passionate individuals worldwide who strive to improve the food and fibre sectors.

I am forever grateful for the generous support of the Fisheries Research Development Corporation (FRDC), my Nuffield scholarship sponsor. Special thanks to Patrick Horne and Sally Roberts for being such strong advocates for people's development. The continued support from FRDC towards Nuffield scholars in the seafood sector is vital for strengthening connections between industries. I am extremely proud to have represented Australian aquaculture in all 12 countries I visited, and this would not have been possible without their substantial contribution towards my scholarship.

I would like to thank Tassal, my employer, for their understanding and support throughout my time away. I recognise that a lot of work was achieved in my absence thanks to my amazing colleagues who went the extra mile to cover my tasks. I am also grateful to have such a fantastic group of people to rely on for feedback on my presentations and ideas. Tassal's consistent support has given me the confidence to take the steps towards the growth I wanted and needed.

This report would lack soul if it weren't for all the people around the world who took the time to meet me online or in person. I am so grateful for the honest, professional, and transparent opinions that influenced my ideas in this report. A very special thanks to Sophie Ryan from the Global Salmon Initiative for connecting me with key people in salmon aquaculture globally. Her network was invaluable in contributing to my research.

To the Nuffield crew that keeps inspiring me to do more and better, thank you for all the long days and nights spent chatting about things that matter. It has been an incredible journey learning about other food sectors, and everyone has been so enthusiastic about their industry. I have loved learning about different farming practices and getting to know you and your families. I look forward to continuing this lifelong learning journey wherever we meet again.

Figure 2 – The 2023 International Nuffield cohort at the New Zealand triennial. (Source: Author)

It is really important to me to acknowledge the incredible community of friends I have in Tasmania and their never-ending support throughout my scholarship. My travels away from home made me realise how much I enjoy their company, and returning home was always a highlight. Thanks for listening to my stories and challenging my thoughts. A special mention to Manon Simon for the feedback and editing on this report, she is the best at this job and it certainly has helped me reach the end.

Lastly, to my wonderful family and Daniel, who have been there for me from day one. My family may not fully understand what I have been doing, but they are proud, and that's all that matters. As for Daniel, I couldn't be happier with his dedication to our relationship – building a house while I was away, taking care of the animals on the farm, and always having a smile when I returned home.

Abbreviations

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ASC	Aquaculture Stewardship Council
CFS	Committee on Food Security #51
CSR	Corporate Social Responsibility
EBM	Ecosystem-Based Models
EPR	Extended Producer Responsibility
FAO	Food and Agriculture Organisation
FM	Fishmeal
FO	Fish Oil
FRDC	Fisheries Research Development Corporation
GBF	Global Biodiversity Framework
GFP	Global Focus Program
GHG	Greenhouse Gas
GSI	Global Salmon Initiative
MCS	Marine Conservation Society
NGO	Non-Governmental Organisation
RAS	Recirculating Aquaculture Systems
SBTi	Science Based Targets Initiative
SDGs	Sustainable Development Goals
SMEs	Small-Medium Enterprises
SCP	Single Cell Protein
TNFD	Taskforce on Nature-related Financial Disclosures
USS	University San Sebastian
WiCA	Women in Caribbean Aquaculture
WFF	World Food Forum
WHS	Work Health and Safety

Objectives

- Provide an overview of salmon farming in a global and local context.
- Review climate change and social acceptability challenges and opportunities impacting global salmon aquaculture.
- Provide recommendations for the salmon industry to grow sustainably based on a global perspective.

The Tasmanian salmon industry

Tasmania is home to the country's largest aquaculture industry by volume. It is also Australia's smallest state, with a population of approximately 550,000 people. The commercial aquaculture of Atlantic salmon began in the 1980s, with the first stock arriving from Canada. Initially, there were 11-14 start-up companies, but today, only three major salmon producers remain: Petuna, Huon Aquaculture, and Tassal, each owned by international companies Sealord, JBS, and Cooke, respectively. These companies share access to waterways for marine activities in the Huon Estuary and D'Entrecasteaux Channel to the south of Hobart, Macquarie Harbour on the west coast, the Tamar River on Tasmania's north coast, and the Tasman Peninsula areas.

Tasmania possesses unique geographical advantages for aquaculture development. Its access to pristine and remote waterways is characterised by optimal cold conditions that boost salmon growth. The island setting allows for the implementation of stringent biosecurity measures, safeguarding Tasmanian salmon production from diseases and pests (Department of Natural Resources and Environment Tasmania, 2022). Also, the proximity to key Asian markets is a major benefit for exports and the industry's growth.

Over the last four decades, salmon aquaculture has rapidly developed to become Tasmania's largest primary industry and Australia's most valuable seafood sector (Salmon Tasmania, 2023). The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) 2023 reports the production of 85,000 metric tons of salmon in fiscal year 2022-23 with a value of $1.4 billion (Figure 3). However, the gross value of salmon aquaculture production is forecasted to stabilise between 2023 and 2028. Australians consume 83% of Tasmania's farmed salmon, and the domestic consumption per person has remained steady since 2014-15, suggesting that the domestic market has matured (ABARES, 2023). The international export market has supported the remainder of the expected growth for salmonid production in Tasmania.

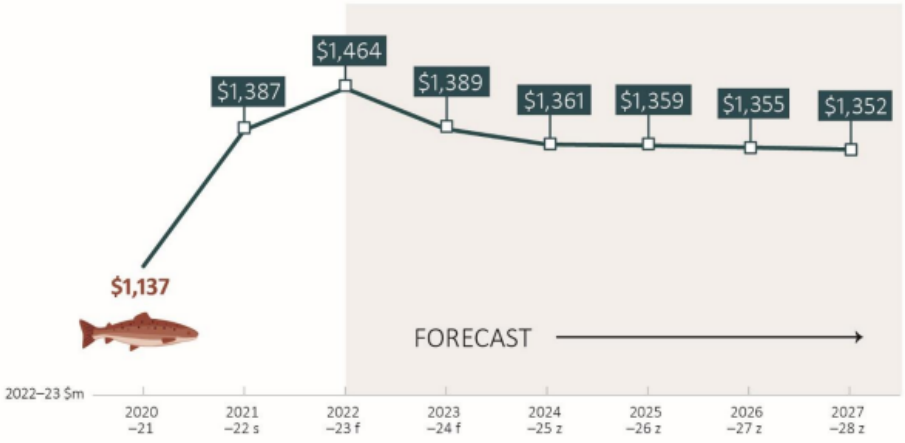


Figure 3 - The gross value of salmon aquaculture production forecast in Australia. All figures are in Australian dollars. (Source: ABARES, 2023).

Aquaculture was initially introduced in Tasmania to increase the state's economy. During its early growth phase, it received overwhelmingly positive media attention, with 95% of the articles being positive (Figure 4), highlighting the potential benefits it could offer to regional communities. However, the industry faced a significant setback between 2014 and 2015, when high-profile environmental incidents precipitated a conflict within the sector. This shift led to a dramatic change in newspaper coverage, with the number of publications tripling and the focus on concerning topics increasing from 2% to 52%, amplifying uncertainties among the Tasmanian community about the industry's sustainability (Condie, et. al., 2022). A senatorial inquiry into regulating the finfish aquaculture industry in Tasmania further challenged the adequacy of environmental regulations (Senate Environment and Communications References Committee, 2015). This inquiry marked a critical juncture, reflecting the community's growing apprehension about the environmental oversight of aquaculture practices.

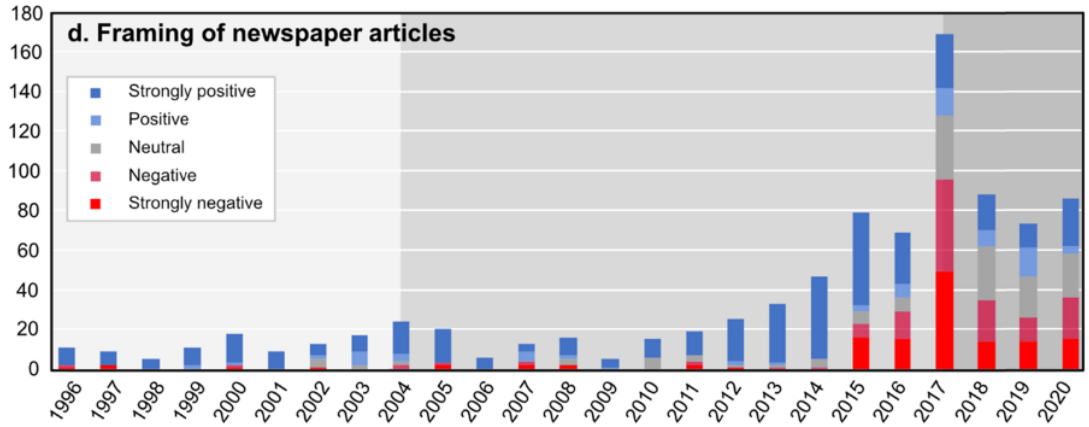


Figure 4 - Number of newspaper articles within each framing category of strongly positive to strongly negative. (Source: Condie, et. al., 2022)

Since then, the industry in Tasmania has been scrutinised by media and activists. Anti-fish farming campaigns through the media have challenged public trust by providing ambiguous information about the industry's environmental credentials and magnifying the negativity surrounding public opinions (Condie, et. al., 2022). Despite the increase in media attention, over the past decade, the salmon industry has more than doubled in Tasmania. The significant growth is accompanied by an increase in community concerns towards key issues including communication, environmental sustainability, and the role of science (Condie, et. al., 2022).

It is against this background that I embarked on a journey to visit the leading salmon-producing countries with the view to determine whether they encounter the same challenges as the salmon industry in Tasmania. My goal was to look beyond the current situation and identify opportunities to advance the future of sustainable salmon farming.

What exactly is sustainability?

The Brundland Commission defines sustainability, as “meeting the needs of the present without compromising the ability of future generations to meet their own needs.” (World Commission on Environment and Development, 1987) This broad and vague description of sustainability makes it difficult to implement. According to the FAO, a truly sustainable food system delivers food security and nutrition for all (2024). Currently, the world’s food system is neither sustainable nor efficient, with about 735 million people (9.2% of the world’s population) facing chronic hunger (FAO, 2024). For a food system to be sustainable, it must balance three key dimensions: economic, social, and environmental (Figure 5). Given the complexity of the ecosystems, declaring any product as “sustainable” is challenging, as it depends on the production processes and business supply chains, which must be traced across all three pillars of sustainable food systems.

When analysing the sustainability pyramid, the economic pillar is the easier one to measure, as businesses are built on growth and profitability, in simple terms we measure the success of a business based on their margins and potential for more economic growth. The social and environmental pillars are indirect parts of the business model and with more complex interwoven relationships, hence more difficult to measure. Nevertheless, the current state of the planet highlights the importance for business to shift from a linear into a circular model, which requires understanding the overarching relationships between the environment, people and profitability.

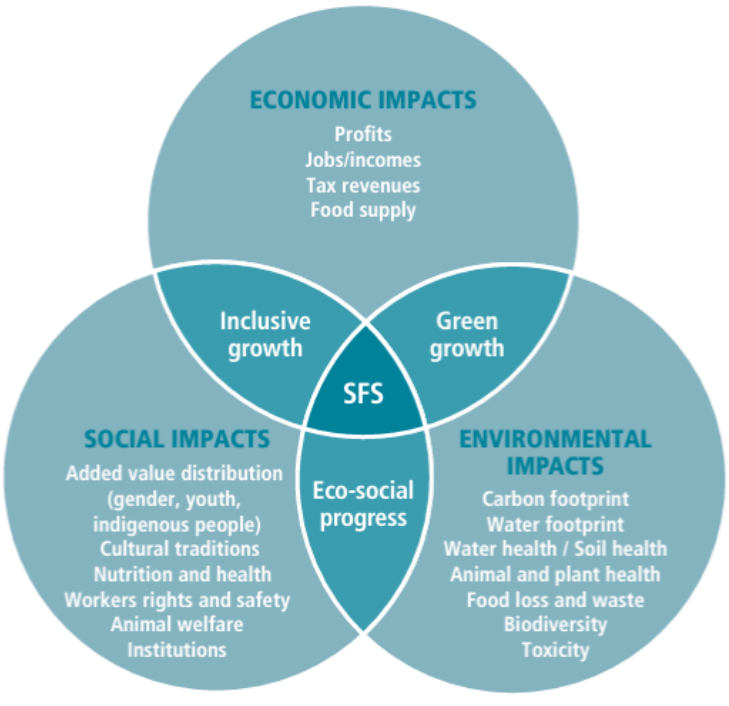


Figure 4 - Sustainability Model (Source: FAO, 2014)

Sustainability & Sustainable Development Goals

The United Nations 2030 Agenda on the 17 Sustainable Development Goals (SDGs) presents humanity with a pathway to a more prosperous, equitable, and sustainable future. It aims not only to eradicate poverty and hunger and improve health and nutrition but also to reduce inequalities and build peaceful and inclusive societies while remaining within planetary boundaries (Troell, et. al., 2023). The FAO calls out for the Blue Transformation, recognising aquatic foods as a powerful solution for dietary improvements and a reliable protein source. With the global population expected to increase to 9.7 billion by 2050, aquatic foods will play an integral role in filling the gap for animal protein demand, expected to rise as much as 88% (Troell, et. al., 2023). However, our current food system is fragile and under significant pressure from climate change. The urgency to act on this transformation is clear; aquaculture has a major role in providing sustainable protein sources.

World Food Forum & Committee on Food Security

In October 2023, the FAO ran the World Food Forum (WFF) and Committee on Food Security #51 (CFS51) events and discussed the current challenges to achieve SDG2 – end hunger. The FAO acts as a facilitator at a high international level for governments, investors, NGOs and the private sector to come together and frame agreements to support SDG2. There are two groups of states at the round table, with different perspectives on sustainable food systems. The Global South, on the one hand, with nations that are threatened with food insecurity. To them, sustainability means feeding their people and having the tools and expertise to do it securely. On the other hand, the Global North debate sustainability as a means to improve food systems and nutrition, to balance and consider eco-social impacts.

The fact that the world is not speaking the same language creates a significant barrier to achieving the SDGs. While it is common to see gender and culturally diverse panels at the FAO, this diversity often highlights a confronting reality. On one hand, young, well-educated advocates from developed countries often speak freely and openly about their aspirations for a better world, emphasising the need for youth involvement in future policy development. These aspirations are in stark contrast with those of developing countries' representatives. For instance, African women call for equality and support to feel heard and empowered in business. They also advocate for better access to education for themselves and their families. Hearing about these challenges, whether it is the frustration of youth not being heard or women not having equal opportunities, can be uncomfortable. Many cultural aspects of society contribute to these disparities, and addressing these issues is a crucial foundation for achieving sustainable food systems.

There is no right or wrong way to look at sustainability, just different perspectives. The literature argues that sustainability has been overused and misused as it has become common jargon suiting businesses in the way they choose, and in many cases, it has lost its real meaning (MacDonald, C., 2011). A truly sustainable food system is the ultimate goal of any sector, and to achieve such status each sector relies on the supply chain's performance to contribute to their outcomes. Now more than ever, the focus on building holistic approaches to growing a business highlights the need for collaboration between sectors as these are interconnected. Every food producer is on a journey to achieve sustainable practices that will demonstrate long-term circular and resilient food systems.

Enhancing global food security through salmon aquaculture

Salmon is one of the most successfully farmed species in the world. It serves as an excellent source of nutrients and contains essential omega-3 fatty acids, necessary for a healthy diet (Gillies. et. al., 2023). It plays a very important role in nutrition security, providing an affordable protein source for Western nations. The success of farmed salmon owes much to technology development, genetic improvements, and a well-integrated supply chain.

While salmon alone won't solve food security challenges in developing nations, it does play an exemplary role in supporting and uplifting other aquaculture species. The challenges faced today in farming underdeveloped low-trophic species such as tilapia and carp were once issues encountered in salmon production. Thus, there is a lot of opportunity for knowledge sharing and indirect improvements in developing countries through salmon aquaculture. A perfect case study to prove this concept is the partnership between Women in the Caribbean Aquaculture (WiCA) and Biomar.

Women in the Caribbean Aquaculture

A dedicated group of female scientists in the Caribbean has come together to support aquaculture growth and unlock the potential of blue foods in the region. Founded by Juli-Anne Russo, a passionate advocate for aquaculture development and women's empowerment, Women in Caribbean Aquaculture aims to address the following critical challenges through collaboration with scientists, farmers and global experts (Caribbean Aquaculture Hub, 2024):

1. Tertiary studies in aquaculture are lacking in the Caribbean. Aspiring professionals must seek qualifications abroad, which poses economic burdens and limits local expertise. The lack of education restricts human and technical resources to general knowledge to advance aquaculture.
2. Most small to medium-sized enterprises (SMEs) are run by men, limiting women's potential contributions. Women's recognition and empowerment are essential for industry development. The support of women in aquaculture can bring social and community benefits as it provides greater gender equality and social inclusion. Furthermore, women can help improve food security and nutrition for their households and communities (World Aquaculture Society, 2017). WiCA is designed to support women and their interests in aquaculture. By creating a network of like-minded people, it is also advocating for gender balance and representation.
3. Globalisation has built competitive global markets that have displaced local businesses, affecting job opportunities. National governments recognise that blue foods are vital in ensuring food security and nutrition in the Caribbean. The Caribbean government provide some funding to support aquaculture by SMEs, but the funding often restricts autonomy and inhibits sector growth.

Juli-Anne's dedication to aquaculture development has been supported by Biomar, a global aquaculture feed company. In collaboration, they have established an education and innovation hub to provide valuable knowledge on best aquaculture practices for the WiCA members. The partnership goals are:

1. WiCA aims to empower women through capacity building so that they become successful business partners in the Caribbean.
2. Develop a curriculum to introduce aquaculture as an option to the next generation of Caribbean students. This integration can promote better practices and informed decision-making.

This case study serves as a model for similar initiatives worldwide. International collaboration is key to addressing education gaps, policy challenges, and market access barriers. Particularly, the sooner we bridge the gaps and develop partnerships between developing nations and the Western World, the quicker we can unlock untapped potential in aquaculture. It not only supports food security and nutrition for all (SDG2) but also revitalises the global partnership for sustainable development (SDG17). The outcomes of tomorrow are dependent on our ability to share our knowledge, support equality, and respect differences, independently of the sector you represent today. Everyone has the right to healthy and nutritious food.

Figure 6 - Juli-Anne Russo (left) and her WiCA representatives.

Global aquaculture

Aquaculture, which dates back over 6,000 years, is an original indigenous technique that has gained significant popularity in the 21st century (Rubis, J., 2020). Aquaculture is the fastest-growing food sector in the world (Winton & Vounaki, 2021), and in 2022, the FAO reported the amount of fish farmed surpassed the wild catch for the first time (Peña, A., 2024) as shown in Figure 7. Aquaculture has undoubtedly been essential in supporting the global demand for protein while reducing the pressure on wild fisheries. Approximately 730 species of animals, plants, and algae are being cultivated worldwide, and 17 of these species represent 60% of the global aquaculture production (FAO, 2024). There is a large number of species underdeveloped and hence an opportunity for investment and upscaling of these species to sustain the global demand and diversify the seafood basket.

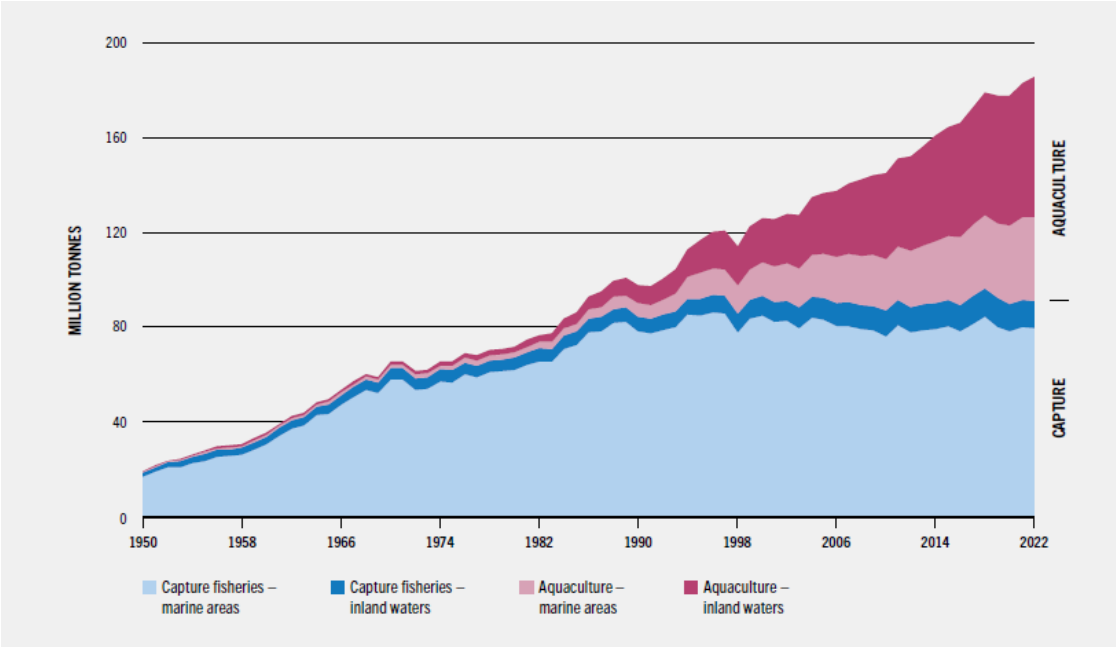


Figure 7 - World Fisheries and Aquaculture production of aquatic animals. (Source: FAO, 2024)

Interestingly, 91% of global aquaculture production comes from Asia (FAO, 2022). The top 5 aquaculture species that account for the mass volume produced include Japanese kelp, whiteleg shrimp, grass and silver carp, and cupped oysters. Atlantic salmon is the 14th largest by weight and accounts for 32% of the global finfish marine and coastal aquaculture (FAO, 2022).

Moreover, aquaculture has become more integrated into the global food system, with rapid production growth. The sector is seen as mature with major advancements in feed ingredients, technology, genetics and value chains (Naylor, et. al., 2021). Despite impressive gains, the seafood sector only accounts for about 17% of the animal proteins consumed worldwide (FAO, 2024). With aquaculture representing 8.7% of the aquatic animal protein produced, the potential for global aquaculture to grow is promising and high on the food agenda.

The global salmon industry

Salmon farming, which originated in the 1960s in Norway and Canada, has experienced remarkable growth. Approximately 70% of the world's salmon is produced through aquaculture, amounting to a staggering 2.7 million metric tonnes (Statista, 2024). Notably, five countries dominate salmon production: Norway, Chile, Canada, the United Kingdom, and the Faroe Islands. These nations have witnessed rapid industry development, often facilitated by mergers and acquisitions that enable multinational companies to operate across borders.

Initially met with positive support due to job security, the global narrative around salmon farming has evolved. As consumers become more environmentally conscious, the industry faces increasing controversy. Consequently, governments worldwide have implemented stringent regulations, requiring companies to obtain licenses for operating in suitable areas. These licenses are subject to rigorous environmental assessments at specific locations (Pandey, et. al., 2023).

The motivation for salmon expansion lies within the economic business model. Growth not only provides better market access and competitive pricing but also encourages large companies to adopt innovative technologies, enhancing efficiency and reducing production costs (Pandey, et. al., 2023). The Norwegian government aims to achieve an astounding 500% increase in production by 2050 (Winton & Vounaki, 2021), while Scotland sets its sights on doubling production by 2030.

Despite the seemingly inevitable expansion of salmon farming, concerns persist. For instance, the influential Coller FAIRR Report highlights the risks associated with continued industry growth (Winton & Vounaki, 2021). The rapidly changing environment exacerbates existing challenges, pushing production levels to their biological limits. While growth remains essential for food security, future investments must carefully consider environmental impacts. Obtaining environmental and social acceptability has become increasingly challenging, even with strict government regulations. Consequently, salmon companies are now more cautious, slowing down the once exponential growth trajectory.

A global perspective on the challenges of salmon farming

Canada, Chile, Scotland, and Norway share three main similarities: cold climates, beautiful landscapes, and status as leading salmon producers. My travels through these countries offered a unique perspective, allowing me to engage directly with key representatives of major salmon companies. Our meetings were set up collaboratively and engagingly: a simple conversation, fact or story was all I was after. I got a lot more than that, I got to experience the culture in each of the locations and how it connects back to the operations and their core values (Figures 8 & 9). The focus of my visits was to discuss the challenges and solutions in salmon aquaculture.

Figure 8 - Visiting salmon farms in Chile with Salmon Aysen and the host Sonia Stolz. (Source: Author)

Figure 9 - Visiting salmon farms in Scotland with Mowi and the host Jayne Mackay. (Source: Author)

Sea lice are the number one headache to salmon farming in countries like Canada, Norway and Chile. Sea lice is a predominant parasite from the wild that affects the health of Atlantic salmon. The levels of sea lice in the salmon are closely monitored and treated. Sea lice treatments are costly and labour-intensive. Overall, the management of sea lice in salmon aquaculture proves to be a serious burden to companies farming salmon in the countries I visited. A lot of investment in technology and research has been dedicated to mitigating sea lice in the salmon industry.

Another challenging health issue that is becoming a top priority for the industry is the complex gill disease, which is a multifactorial condition affecting the gills. The exact pathogens or environmental conditions that directly impact gill health are still unknown because it is a combination of both factors, and treatment options are limited, often leading to significant stock losses. The impacts of jellyfish and algal blooms can contribute to complex gill disease. Jellyfish cause physical damage through their stinging cells on the gills. Some algae bloom species can be harmful when producing toxins that are detrimental to fish health and further deplete oxygen levels in the water.

Fish escapes from aquaculture have been regular enough to be considered as a negative environmental outcome. The farmed salmon escapes have the potential to increase competition and change the genetic diversity of wild salmon populations. Farmed salmon can also be a vector for disease and parasites affecting the natural ecosystem where they escape.

Most of these challenges are intrinsically connected to the social acceptability of salmon farming. As long as environmental events continue to be highlighted in the media which associates with fish mortalities and environmental damage, the salmon industry seems destined for a negative image. Environmental and social acceptability

go hand-in-hand because the acceptance and approval of aquaculture operations by communities are very often related to these environmentally isolated incidents. This becomes the main picture for the industry at a national and international level.

All country representatives mentioned that integrating technology and innovation with salmon farming operations has been important to ensure that accurate data analysis allows for better decision-making and supports transparency. All countries are focused on continuing to use technology as a monitoring and mitigation tool to support environmental challenges.

Despite each company having commendable community initiatives, the issue of social acceptance persists across all regions. Chile and Canada face notable challenges, with the lack of government support, while Scotland and Norway are experiencing growing scrutiny from civil society regarding marine activities. The influence of environmental NGOs and media coverage creates powerful narratives that reach wide audiences.

The salmon industry currently lacks effective communication strategies to counteract misinformation. The prevailing approach is reactive, addressing issues as they arise rather than proactively shaping public perception. Companies are also feeling the increased expectations from stakeholders, investors, consumers and communities. Although social acceptability is a universal challenge, there is a conspicuous absence of collaborative efforts among companies to improve community perceptions and sentiments.

As I sat with the many industry representatives, I realised that the narrative is repeated throughout the different countries. I felt a sense of disappointment for not having the silver-bullet answers I was after. Despite the differences in geographical locations and government support, climate change and social acceptability are two of the major challenges the industry faces at a global and local level.

Environmental challenges & opportunities

This section firstly highlights the impact of climate change on salmon aquaculture through warming water temperatures causing fish health and performance issues, then reviews the multiple options in infrastructure that can help mitigate this impact on the industry. This section further explores the way the industry contributes to climate and environmental impacts through the ingredients used in feed production. At last, it suggests some long-term holistic solutions that can help the industry succeed with the incorporation of ecosystem-based models.

Climate change is a current and future threat to the resilient development of the salmon industry and its supply chain through increased sea surface temperatures, changing precipitation patterns and extreme weather events. Traditional salmon aquaculture involves raising fish in open net pens within ocean environments. The environmental conditions at these sites directly influence the growth and well-being of the fish. Unfortunately, farmers have limited control over these external factors (Lorentzen, T., 2008). Climate change impacts, particularly rising water temperatures, pose a significant threat to salmon farming. For optimal salmon growth, water temperatures ideally range between 13°C and 17°C. Beyond this range, low oxygen conditions diminish production efficiency (Macleod, et. al., 2021). Elevated temperatures also lead to higher bacterial densities in the water and more frequent algal blooms. When conditions become unfavourable for the fish, their physiology becomes stressed, making them susceptible to diseases, resulting in increased mortality rates.

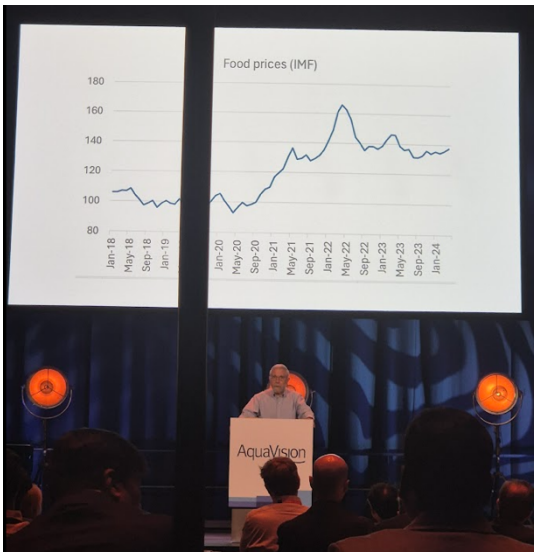


Figure 10 – Paul Krugman at Aquavision 2024, Norway. (Source: Author)

Despite the critical implications of climate change on salmon farming, the economic losses remain inadequately documented (Naylor, et. al., 2021). I attended the AquaVision 2024 conference in Norway and heard from one of the world's leading economists Paul Krugman (Figure 10) who rightly said: “We have vastly underestimated the financial impacts of climate change on our businesses”. He argues for more support for climate science and economic analysis together. The few studies on climate change and aquaculture impacts highlight the initial benefits from improved fish growth. However, the benefits are short-lived and the long-term exposure to warm water will have negative economic consequences that outweigh the initial benefits (Lorentzen, T., 2008).

To mitigate the impact of climate change on salmon farming, several initiatives have been proposed and implemented. The industry has been proactive worldwide in identifying salmon families and genetics best suited to warming waters due to their capacity to adapt to hypoxia tolerance. Significant investments have been made in developing new farming technology to enhance water quality by increasing oxygen saturation levels.

Post-smolt facilities, which rear salmon under controlled conditions to a larger size before transferring them to the ocean, are becoming more common. This approach

results in more robust fish and reduces their exposure to climate impacts by minimising the time spent in the uncontrolled marine environment. Moreover, semi-closed containment systems act as partial barriers to the open ocean, allowing farms to have some control over the environment, thereby reducing environmental stressors like sea lice.

The most debated containment for salmon farming is the inland facilities which houses the full life cycle of salmon on land through Recirculating Aquaculture Systems (RAS). This option provides full control over the farming environment, leading to healthier fish and reducing the risk of disease. By removing the fish from their natural environment, these systems also eliminate the direct impacts of climate change. Although this approach is the most effective in tackling the impacts of climate change on the industry, multiple constraints should be considered before moving salmon farming onto land.

Establishing a RAS facility requires significant upfront investment for infrastructure, technology, and land purchase. Terrestrial habitat conversion for aquatic species is already a challenge for shrimp aquaculture, where the availability of suitable land is limited and has put pressure on mangrove habitats and ecosystems. Furthermore, in some countries, food security is threatened by the lack of land available for agricultural production. Moving current salmon production from open nets to land would be a monumental task. Growing salmon to market size would require massive amounts of energy, water, and well-developed systems to sustain production, exacerbating the current pressure on land availability by competing with other food sectors.

Land-based systems tend to consume more energy due to the need for water treatment, heating, and cooling. Depending on the availability of renewable energy, land farming can increase greenhouse gas emissions in aquaculture. In a RAS system, all waste is collected and filtered through the water, requiring efficient and circular solutions for disposal to ensure no environmental impacts on adjacent waterways. The shift to land-based aquaculture could also lead to changes in employment patterns, with jobs moving to areas where land-based aquaculture is more viable, potentially affecting the socioeconomic balance of coastal and regional areas (Niogu, et. al., 2024).

Overall, it is crucial to assess and quantify the impacts of climate change on the industry, the warming of the water is unlikely to decrease. It is important to include the impact of climate on the balance sheet for better-informed decisions towards new infrastructure that can support the resilient development of salmon farming.

Feed & greenhouse gas emissions

Salmon aquaculture contributes to climate change through its operations and supply chain. To support the Paris Agreement, which aims to significantly reduce greenhouse gas (GHG) emissions, all sectors are expected to quantify and implement better practices. Aquaculture contributes approximately 0.49% of global anthropogenic GHG emissions (USDA, 2024).

Salmon farming, in particular, produces the majority (60-90%) of GHG emissions through the production of feed. Most feeds are carefully formulated with a blend of fats, oils, carbohydrates and essential nutrients. The raw materials are sourced globally, with wild-caught fish and soy concentrate being the primary ingredients. Soy is mostly produced in Brazil, the United States and Argentina. The soy from Latin America has

a long history of high carbon footprint due to farming practices associated with deforestation.

Northern Europe deforestation-free soy in salmon feed

The Global Salmon Initiative (GSI) network identified the need to overcome the deforestation issues associated with Brazilian soy used in salmon feed. This initiative, driven by GSI members and major feed producers (Skretting, Cargill, Biomar, and Mowi), aimed to leverage Brazilian agricultural practices to meet their requirements. The “Aquaculture Dialogue on Sustainable Soy Sourcing from Brazil” was established to implement 100% deforestation-free soy aquafeed in Northern Europe starting in 2020.

ProTerra was engaged as a third-party certifying organisation to ensure the legitimacy of these processes. Traceability information was crucial to track soy back to its origin, using technology to quickly identify and address any non-compliant activities. This process ensures complete transparency throughout the supply chain.

Achieving this voluntary benchmark required the cooperation of the entire supply chain, serving as an example not only for the aquaculture sector but also for other animal protein producers. It highlights the industry’s commitment to environmental responsibility. This success story is rooted in strong collaboration, with competitor companies joining forces to enhance their environmental performance. Together, they have a greater presence and the ability to drive systemic change.

Figure 11 - Kristina Furnes, Chief Communications Officer at Greig Seafood, Oslo (Source: Author)

I interviewed Kristina Furnes, a GSI member and key facilitator of the deforestation-free soy project (Figure 11). Kristina, with her extensive knowledge of business dynamics, explained the synergies needed to align different parts of the supply chain. Achieving such goals requires persistence and patience. Despite the challenges, the collaborators found co-benefits in working together, which ignited more support and representation. Consequently, soy farmers had no choice but to align with this vision.

Feed & wild fish stocks

Global aquaculture has become the largest consumer of fishmeal and fish oil. As the demand for aquafeeds rises, the need for more cost-effective and sustainable alternatives is expected to grow (Colombo, et. al., 2023). The reliance on fishmeal and fish oil is straining wild fish stocks and indirectly contributing to climate change by disrupting ecosystem functionality (Colombo, et. al., 2023). The ongoing commitment from the salmon industry over the past 20 years has seen a significant reduction of fishmeal and fish oil dependency in salmon diets, the reduction of fishmeal dependency from 65% to 18% and fish oil from 24% to 11% (Global Salmon Initiative, 2020). Despite such progress, the demand for fishmeal and oil remains high due to

the rapid growth of the industry. Additionally, low fish oil yields continue to drive market prices and create uncertainty about future harvests.

Alternative feeds are an important topic for salmon aquaculture as the industry develops feed producers and salmon companies understand the limitations of reliance on wild fish stocks. I attended the UK Aquaculture 2024 conference in Aviemore, where a panel discussed the progression and adoption of alternative ingredients in Scotland. The speakers stressed the importance of alternative feeds, in the past two years, the raw material sourcing suffered from economic, climate and geopolitical challenges, and the diversification of the raw material basket is necessary to mitigate these risks. Three organisations presented their alternative ingredients and highlighted their benefits as follows:

1. Dsm-firmenich - Single Cell Protein (SCP) is considered a sustainable alternative to traditional fishmeal. It heavily relies on fermentation technology to cultivate microorganisms such as bacteria, yeast, algae or fungi which have high protein content and nutritional value.
2. Protix - Insect Protein has a lower footprint than many other traditional raw ingredients. Black soldier fly larvae can be particularly beneficial for salmon diets as it is rich in omega-3 and omega-6 fatty acids. Insects can be raised from organic waste, reducing environmental footprint and contributing to circularity.
3. Veramatis - Algal oil is rich in omega-3 fatty acids and a good alternative to fish oil. It seems to improve fillet texture and taste. This product has been successfully developed to commercial scale.

Scalability, production costs, and fish performance are key challenges in integrating alternative ingredients into salmon feed. Despite the introduction of novel ingredients in feed formulations, the transition has been slow due to the industry's caution regarding potential adverse effects on fish performance. Given that feed represents one of the highest costs in salmon farming, it is in the industry's best interest to optimise raw ingredients and reduce costs effectively. Suppliers of novel feeds have urged the industry to set long-term commitments to support the use of more sustainable ingredients. Such commitments will, in turn, ensure the scalability of these products and potentially reduce costs once mass production is achieved

Figure 12 – Aisla Jones (2021 Nuffield Scholar), Market Development Manager from Aquaculture Stewardship Council UK. (Source: Author)

We heard from Aisla Jones (Figure 12), Aquaculture Stewardship Council (ASC) Market Development Manager, and her work was focused on developing the new ASC feed standard, which looks at legal, social and environmental factors; this is an important accreditation for feed mills to attain and demonstrate to the supply chain that they follow best practices. Aisla's best advice to the industry was that, ultimately, transparency and traceability become the global shared knowledge.

Future adaptation to climate change

The industry needs to accelerate its efforts to mitigate and adapt to the changing climate. Mitigation focuses on reducing GHG emissions to decrease the impact of global warming. The industry has been very proactive in measuring, assessing and reporting on their mitigation performance. The incorporation of renewable energy, sustainable feeding practices and good water management are just some practices that have been well integrated into salmon aquaculture.

Adaptation involves building resilience to the consequences of climate change by relying on human and natural systems. Adaptation requires long-term vision with short-term changes in decision-making. Salmon aquaculture relies on the ocean's ecosystem services for the fish to grow. While aquaculture claims to be the most regulated industry in the primary sector, even strict compliance with existing regulations has not prevented the decline of the ocean's health (UN Global Compact & World Wildlife Fund, 2022). The industry cannot adapt effectively to the impacts of climate change in isolation from other sectors that indirectly impact marine ecosystems. Mitigating aggregated impacts on the ocean requires collective efforts and responsibility.

Adapting to the future is not an easy task for salmon aquaculture or any other food sector. Adaptation measures will evolve, as new data and new tools are developed around environmental solutions. It is important for the industry to look forward and anticipate what is coming; environmental sustainability does not stop at GHG emissions reduction. Biodiversity protection policy is certainly also taking traction. The adoption of the Kunming-Montreal Global Biodiversity Framework (GBF), for instance, serves as a global tool to halt and reverse biodiversity loss. Whilst countries review their National Biodiversity Action Plans and governments set guidelines that eventually will become mandatory requirements and disclosures, the industry has an opportunity to get ahead by setting strategies that encompass ecosystem-based models (EBM).

Much of the scientific literature suggests that EBM are the best way to respond to the current climate challenge as EBM incorporates broader long-term systems thinking. This implies not only considering the species in culture but also what other species can be used to bioremediate the environment (Naylor, et. al., 2021). Seaweed, mussels, abalone and any other species that provide the ecosystem with balance will have an indirect positive impact on salmon farming. Integrated Multitrophic Aquaculture systems are seen as a more environmentally friendly, economically rewarding, and resilient system in the face of climate change compared to monocultures.

it is important to recognise that the diversification of species with the multitrophic approach is not a one-size-fits-all solution: it may not be viable for all species, particularly for salmon farming. The investment required to commercialise another aquaculture species in common ground may outweigh the profitability of the business. However, it is important to understand that successful diversification does not mean all species are harvested: other species can support the marine systems and benefit the production of salmon. As an example, seaweed is an efficient species at storing carbon, it provides habitat for marine diversity, and it is food for many marine species. Seaweed forests can act as a biocontrol through nutrient absorption (nitrogen and phosphorus). By doing so, it inhibits the growth of harmful algae. Seaweed can also provide a physical barrier as it grows vertically, and it can restrict the movement of jellyfish from reaching the salmon farms.

The future of salmon farming and its capacity to withstand climate challenges depends on the industry's ability to incorporate adaptive ecosystem models that contribute positively to the health of the marine habitat and, in turn, reduce the economic risk associated with aquaculture.

Purina Pet Foods – positive solutions

Purina, the pet food company, presented their ocean restoration project at the 2024 Blue Food Innovation Summit in London. If successfully scaled, it can regenerate parts of the ocean in this decade.

Purina started by assessing their supply chain's impact on climate change noting biodiversity loss, fertiliser and run-off all impact on ocean acidification. They identified biodiversity loss as a major concern and assessed what impact it will have on the fish species that supply their business. Globally, there has been significant habitat loss, including 30% seagrass, 85% oyster reefs, and 60% seaweed forest in decline. Recognising that if, by 2048, no significant change occurs and businesses continue to operate as usual, there will be no fish left in the ocean, Purina decided to act in this space. Ultimately, it is also in their best interest to have a healthy marine ecosystem.

To ensure long-term supply chain resilience, Purina set an ambition – to restore 1500 hectares of marine habitats in the North Sea by 2030. There are four main objectives established to achieve their goal:

- Planting seagrass meadows to enhance biodiversity and capture carbon;
- Restoration of oyster reefs by using biodegradable bricks that will give oysters time to mature and improve the water quality by absorbing pollutants;
- Seaweed forest using mobile seaweed nurseries to restore forests, which act as a natural water purifier and carbon capture systems; and
- Urchin removal to remove excess sea urchins to help balance species populations.

Overall, the combination of these projects will have interwoven benefits. Oyster reefs will clean the water, and seagrass revegetation will bring back biodiversity. Removing sea urchins allows seaweed to set and grow, providing a habitat for sea urchin predators. The ultimate goal is to achieve ecological balance. The project scale will extend from the coast of Norway through France and all the way to the south of Portugal.

Unfortunately, restorative projects in the marine space are not common. Kristen Schneidutch, Director of Corporate Communications and Sustainability at Purina, highlighted that accounting frameworks are essential to demonstrate investment in the ocean space and recognise industries' efforts to restore ecosystems. The development of biodiversity frameworks can be incorporated within business balance sheets to drive systemic change. Other challenges include the lack of scientific research underwater, as it is relatively more difficult to assess changes and impacts on the marine environment.

Given the challenges ahead and the vulnerability within the supply chain for most aquaculture sectors, it is important that policy frameworks support these initiatives and incentivise businesses to contribute to nature-positive solutions. It is speculated that ocean restoration can happen at a much faster rate than terrestrial ecosystems.

Future policy adaptation

The salmon industry operates in a global market, where trade agreements are established to ensure economic growth. As part of these agreements, it is important to incorporate global frameworks to ensure salmon farming practices are sustainable. The FAO sets guidelines, standards and targets that countries can then adopt and implement in domestic legislation. Even though there is not a single unified policy specifically for salmon farming at the global level, the Global Salmon Initiative (GSI) acts as a leading organisation with initiatives and frameworks that guide international companies to more sustainable and standardised practices. The opportunity for the global movement would be to have all salmon and supply chain major producers involved with GSI as a united front, not only for alignment with standards but also to have a stronger influence on the food sector though international collaboration.

The Taskforce on Nature-related Financial Disclosures (TNFD) and the Science Based Targets Initiative (SBTi) are closely related in their efforts to integrate nature and climate considerations into business and financial decision-making. Both provide frameworks that help companies assess and disclose environmental impacts. The collaborative effort from TNFD and SBTi facilitates the integration of nature-related considerations into decision-making processes for a more comprehensive and impactful outcome. Having tools that can capture all companies, commitments and standard verification allows governments to make informed decisions on national policy. Furthermore, national policies should support the responsible sustainable development of the industry and identify gaps in the sector that policy can improve.

With better data collection and a better understanding of environmental factors affecting salmon farming, it is imperative that governments assess their current allowed areas for farming. When initial licenses to farm were granted, there was a lack of understanding about these areas and the ecosystems they support. As time has passed, we have developed technology that can find the best suitable sites not only to grow the fish in a sustainable environment but also to take into account neighbouring communities that may be affected by the operations. In Chile, there are about 1300 licenses for salmon farming, although only approximately 300 are operational. The non-operational licenses are unused because the sites are not suitable or too close to a marine protected area (USDA, 2022). Future assessments and the development of new aquaculture policies should include a wider range of factors, including indirect impacts from other water and land users on the industry and, most importantly, cumulative impacts in the ocean.

Social acceptability

A common description of social acceptability also known as social license suggests that businesses must obtain essential elements of legitimacy, credibility, and trust from their communities to commence or continue operations (Gottschalk & Hamerton, 2023). These three abstract concepts are not easily measured. While metrics are important in business, the current model for sustainability is more complex. Measuring and managing it requires a deeper understanding of what matters to communities based on their values, perceptions, and experiences.

Peter Drucker famously said, “What gets measured gets managed, but not everything that matters can be measured.” Each community is unique, and within any local community, there are different groups with varying values. Industries like salmon aquaculture often present themselves to local coastal communities with the promise of significant economic benefits, which can be enough to gain acceptance from many. Economic benefits are easily measured. However, in today’s world, with the pressures of climate change and the consequences of significant environmental events, the way people accept large organisations operating in their backyard has changed.

Beyond local communities, that do not directly benefit economically from the industry, tend to be more critical as they suffer from the perceived adverse impacts. Without the direct connection to the industry, often distant communities have formed opinions based on media campaigns. Unfortunately, these are the main voices creating a negative narrative that is prevalent in wider society.

The industry faces a challenge ahead, with social acceptability becoming increasingly important. Focusing on the three main concepts of legitimacy, credibility, and trust is a good initial model to follow.

Legitimacy improved with traceability & transparency

A crucial component of increasing credibility is traceability throughout the supply chain. Globalisation has enabled millions of products to move around the world efficiently, but it has also extended supply chains to the point where visibility into all the parts that make up a product is difficult but essential for legitimacy to ensure transparency around traceability. For salmon aquaculture, traceability in feed ingredients is vital for sustainability, as these can come from various parts of the world with different farming practices. In the coming years, technology will play a crucial role in traceability, allowing us to demonstrate on a single page all parts of a product and their origins, providing a digital DNA of the product.

Parallel to traceability is transparency. Once we have the information, it is important to share it with a wider audience. Clear and simplified information that is accessible to all can help reduce misinformation. Transparency can often be perceived as selective regarding what information is shared by the industry. Therefore, the food sector must innovate in sharing their information and practices.

Hof Teepker poultry & pig farm, Germany

Other protein producers, like those in the poultry and pig industries, face similar public scrutiny as salmon aquaculture, particularly concerning animal welfare issues such as adequate space, nutrition, and antibiotic use.

In Germany, I visited Stephan Teepker, a farmer participating in an initiative called “Insights into Animal Husbandry.” This initiative has 150 farms registered across various regions, allowing the public to visit these farms and learn where their food comes from. It was amazing to see the level of transparency at the poultry and pig farm I visited and how creative and interactive their display was. The farms have windows cut out in housing barnscalled “Kiek in box” – meaning peek through the box, and it is open twenty-four hours to the public. Strategically placed educational materials explain not only nutrition but also important topics related to animal welfare.

Stephan commented that the initiative was well received by the community, with frequent visits from people bringing their children to see the animals. Given the success of this idea, there is even a vending machine selling animal products to visitors. It was very impressive to see how transparency and educational materials can effectively support the farming of chickens and pigs. There are lessons to be learned from the innovative ideas of other protein producers to possibly transfer and adapt to salmon aquaculture. There is always a risk associated with such visibility and transparency, yet this example demonstrates the positive outcomes outlay the negative pre-existing prejudice.

Figures 13 & 14 - Poultry Farm Kiek in Box with display of components and informative material, Germany, June 2023. (Source: Author)

Credibility through collaboration

Credibility can be obtained through association and collaboration with other organisations such as scientific institutions, indigenous groups, and NGOs. Industry actors are required to comply with regulatory requirements. Yet, those are often considered to be minimum standard in line with societal norms.

The salmon industry has gone above these minimum requirements by applying for third-party certifications such as Aquaculture Stewardship Council, Best Aquaculture Practices, Global Gap and many others, providing an independent and higher standard for environmental and social responsibility. Consumers love to see a “green label” on their food, and certifications can help reduce greenwashing with the independent third-party validation of the company’s credentials. It plays an important role in ensuring the industry continues to improve and stay up-to-date with the latest sustainability trends.

Yet, third-party certifications are only a part of how the industry can demonstrate its commitment to responsible aquaculture.

Scientific institutions (such as universities and research organisations) can provide the public with reputable, reliable and credible scientific information based on transparent, strict ethical guidelines and peer-reviewed processes. The successful engagement of independent experts is critical to re-frame the debate around salmon aquaculture as it allows for collective learning about coastal environments and aquaculture impacts (Condie, et. al., 2022).

Partnerships with indigenous groups can also be very beneficial for the industry. Indigenous communities have a unique cultural and environmental connection to the land and water, which is rooted in centuries of traditional knowledge and practices. Indigenous groups often emphasise holistic and sustainable approaches to resource management, which can enhance the environmental stewardship of aquaculture operations. These partnerships can lead to the co-creation of innovative solutions that respect both traditional knowledge and modern science, fostering mutual learning and respect. By incorporating their values and management strategies into modern salmon farming, the industry not only creates a more resilient and sustainable industry but can gain greater respect from the public.

NGOs have a significant presence between science and government. They often partner with certification bodies to develop standards for sustainable aquaculture. NGOs play a crucial role in advocacy and awareness, and the more collaborative the relationship with the industry, the clearer the message can be. NGOs also help with transparency and accountability ensuring that the industry adheres to its commitments and continuously improves its practices. By working closely with NGOs, the salmon industry can better align its operations with societal expectations and environmental goals.

The Marine Conservation Society, UK

The Marine Conservation Society (MCS) is a leading NGO in the UK dedicated to protecting the marine environment and promoting sustainable practices. One of their key initiatives is the Good Fish Guide, which provides sustainability ratings for various seafood, including farmed salmon. The MCS evaluates farmed salmon based on several criteria, including fish feed, fish welfare, and environmental practices. Their decision-making is based on extensive consultation with scientists, fishermen, and businesses. Collaboration with aquaculture companies is fundamental for the credibility of their decisions, which are based on transparent communication and rigorous assessments.

The classification of farmed salmon in the Good Fish Guide varies, with the best choices being farmed organic or ASC certified. The guide warns consumers against wild-caught Atlantic salmon as the numbers are dangerously low.

Figure 15 - Dawn Purchase at the UK Aquaculture Conference. (Source: Author)

I met with Dawn Purchase (Figure 15), the Aquaculture Programme Manager for the MCS, to discuss her work associated with salmon aquaculture in Scotland. Dawn has worked for the MCS for over 20 years, and significantly influenced the industry's move towards better practices. Much of her work has focused on providing advice for certification standards and policy with an emphasis on environmental improvement.

Dawn highlighted the value of collaboration between NGOs and industry to achieve better outcomes. The engagement of both parties is necessary to increase public trust and confidence, ensuring mutual benefits in tackling the challenges faced by the industry and the environment. This collaborative approach is essential for maintaining the social license to operate as it demonstrates the industry's commitment to responsible and sustainable practices and contributes to gaining public trust and support.

Trust is all about people

A community that trusts the industry is the ultimate achievement. Trust is built when the industry behaves in a way that meets expectations, allowing the broader community to have confidence in their practices. Fundamentally, trust is about relationships between people: it can be strengthened by sharing consistent and reliable information and encouraging the exchange of ideas and values through positive interactions.

The benefits of having close social ties between the farmer and the consumer are reciprocal for the common reasons; a sense of connection to where the food is coming from and a sense of care and direct connection to the product. For example, most people would prefer to buy vegetables from a local farmer at the market rather than from a retailer. The local farmer is preferred for many reasons including locally sourced produce, low food miles, minimal inputs, and overall sustainability. Even if the same product is available at the retailer, the consumer may not feel the same connection or confidence in their purchase. This is because the direct link to the farmer is missing. People connect over food, and when there is a direct relationship with the person who has grown that food, it creates a sense of trust through the consistency and care the farmer shows by regularly advocating for their produce.

In global organisations, building trust is more challenging because there isn't a single farmer representing the product; instead, there are many brands and many farmers. Large corporations often focus on corporate social responsibility (CSR) by delivering sophisticated reports highlighting their performance in sustainability, ESG (Environmental, Social, and Governance), compliance, and impact metrics. These reports are publicly available and provide valuable evidence of the industry's commitment to sustainability. However, while producing reliable information is necessary to inform people, the industry often overlooks the need to invest in the farmers who represent the brand and can create positive relationships with consumers.

Creating a common language

The salmon industry has an incredible story to tell. Over 40 years of development, it has advanced significantly, thanks to the confidence and determination of those who led the way. With rapid development and growth, new corporate languages, systems, and technology were also developed. However, this fast-paced growth may not have allowed for a common language in the industry—a language that translates corporate reports into a story of pride and confidence in the product.

A common language speaks to people in a way they understand, resonates with them, and is easily remembered. Concise and clear communication is key to propagating the salmon industry narrative. This starts with internal awareness and education, helping farmers understand the importance of their role at work and in their community. Providing them with the "why" behind the industry's spotlight and clearly outlining the facts that can better support their dialogues. This support gives people the option to engage or not in the debate that has been so heavily polarised. But without the option, the industry lacks a significant pillar in fundamental communication not only to the local community but also to the wider society.

Creating a common language is not a simple task, it requires time and effort dissecting what matters. It is important that in the attempt to communicate we don't get lost in the bureaucracy of what is acceptable or not, the authenticity of the people who work for the salmon industry is what will make the story real, as with no doubt they are the ones with the connection to the environment and the fish.

From a common language of understanding, the industry can expect a culture change, where more engagement and support develop naturally as people feel comfortable discussing relevant issues, more opinions are formed, and values are shared at a ground level. The industry that empowers farmers with the confidence to share their stories and knowledge with others will benefit ultimately from the positive relationships fostered among their community.

Community engagement

Community engagement through sponsorships, donations, volunteering, and forums builds trust and fosters meaningful connections. Establishing an engaged workforce is just the first step to ensuring positive community engagement; strengthening the connection between the corporate world and the community is also essential. Numerous initiatives worldwide target this level of engagement, and the positive impact of industry presence in coastal communities is evident in sports clubs, community centres, schools, and events. These efforts support the well-being of communities, demonstrating that even small contributions can make a significant difference.

Salmon farms often operate in regional coastal communities where they are typically the main industry. These towns frequently have low socioeconomic backgrounds, and the isolation and lack of resources can be significant burdens for residents. In such communities, sports clubs play a crucial role in engaging both young and older people, contributing to their physical and social skills development. The industry's presence fosters long-term support for families, helping to establish confidence and stability for future generations.

Success stories from industry support showcase how meaningful investments can build resilient, long-term communities. Many companies strategically engage with their communities, aligning their support with core values to ensure meaningful

development. This targeted approach ensures that investments are not only beneficial but also sustainable, fostering a sense of shared growth and prosperity.

Meaningful investment - Blumar

Blumar, a prominent company in the fishing and aquaculture industry in Chile, has demonstrated the significant impact of community engagement and meaningful investment (Figure 16). In 2022, it launched its initiative, the “Escuela de Agua Potable Rural” (Rural Potable Water School) in partnership with University San Sebastian (USS). The project aimed at improving the management and sustainability of rural potable water systems in Chucahua, Huar Island.

Figure 16 – Estefania Humud (left) ESG and Climate Change Manager and Francisca Lopez (right), Head of Communities at Blumar’s headquarters in Puerto Montt, Chile. (Source: Author)

The project involved extensive community participation, with local residents actively contributing to the initiative. Workshops and training sessions were conducted to educate the community on water management and sustainability practices. This hands-on approach not only empowered the community but also fostered a sense of ownership and responsibility towards the project.

Blumar’s investment extended beyond financial support. The company provided technical expertise and resources, working closely with USS to implement the project. This collaboration ensured that the community received high-quality training and support, addressing the specific challenges faced by rural water systems. A better understanding of sustainable water management ensures long-term benefits for the community and the environment.

Blumar’s intentions on this project exemplify how community engagement and meaningful investment can lead to positive outcomes. By empowering the community and investing in sustainable practices, Blumar has not only improved the quality of life of Chucahua residents, but also set a benchmark for corporate social responsibility in the industry. The initiative received significant recognition, winning the first category award at the Salmon Sustainability Awards 2023.

The educational gap

The aquaculture industry faces a significant challenge in terms of community engagement and understanding due to a widespread educational gap. This gap contributes to polarised opinions about salmon farming and other aquaculture practices, often stemming from a lack of knowledge and awareness (Condie, et. al., 2022). One of the primary issues is the general lack of awareness about aquaculture. Many people are unaware of what aquaculture entails and its importance in today’s world. Current generations often believe that all fish come from the wild, not realising the extent to which modern society depends on aquaculture. This misconception is rooted in the historical context where fishing was the primary method of obtaining fish.

However, with the decline of wild fish stocks and the increasing demand for seafood, aquaculture has become essential to provide a reliable protein to the world.

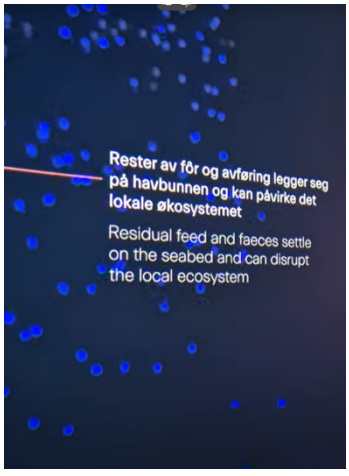
Aquaculture is a relatively new and emerging industry that has not yet been fully integrated into school curriculums. Unlike agriculture, which has been around for millennia and is well-understood, aquaculture is not as intuitive. People are familiar with the concept of domesticated animals on farms, but the idea of farming fish is less ingrained in public consciousness. Community engagement plays a crucial role in bridging this educational gap. This can be achieved through various means, such as educational programs, participation in school activities, educational centres, and tours, which can expose students to the industry and remove any misconceptions. Social media platforms and other public outreach methods can also be used to educate the public and promote the benefits of aquaculture widely and effectively.

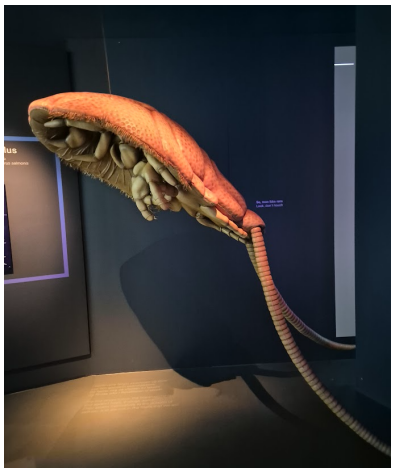
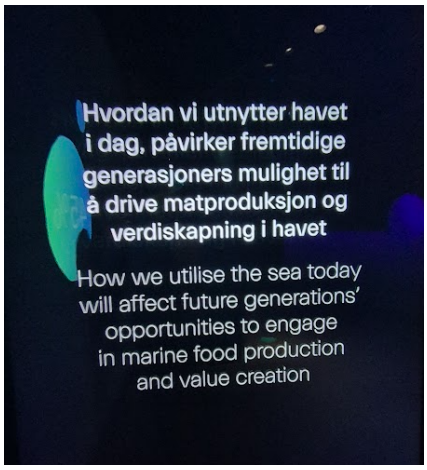
By addressing the educational gap, the aquaculture industry can improve community engagement and understanding, ultimately leading to more informed and balanced opinions about salmon farming and other aquaculture practices.

The Storeblå Aquaculture Visitor Centre, Bergen, Norway

Nestled in the picturesque coastal city of Bergen, Norway, the Storeblå Aquaculture Visitor Centre stands as an example of knowledge and innovation in the aquaculture industry. This centre offers visitors an immersive experience of salmon farming, one of Norway's most significant industries.

The Storeblå Aquaculture Visitor Centre is renowned for its state-of-the-art displays and interactive exhibits (Figures 17 to 19). Visitors are greeted with a digital experience that brings the underwater world to life. The centre features a living exhibition that showcases the entire process of salmon farming, from hatching to harvesting. High-definition screens and interactive touch panels allow visitors to explore the various stages of aquaculture, providing a hands-on learning experience. Educational activities are tailored for all ages, making it an ideal destination for families and school groups. One of the highlights of the centre is the opportunity to see salmon up close. Through a combination of virtual reality and real-life tours, visitors can embark on a boat trip to a nearby fish farm.



Figures 17, 18 & 19 - Examples of the interactive display at the Storeblå Aquaculture Visitor Centre in Bergen, Norway. (Source: Author)

The centre also addresses critical questions about the future of aquaculture. Through engaging audio-visual presentations, visitors learn about the challenges and opportunities facing the industry. Topics such as sustainability, environmental impact and technological advancements are explored in depth encouraging visitors to think critically about the role of aquaculture in global food security.

In a country that is one of the world's leading producers of salmon, having dedicated aquaculture visitor centres like Storeblå is invaluable. The centre is more than just a museum, it is an educational hub that bridges the gap between the public and the aquaculture industry. A visit to Storeblå is not only informative but also inspiring, offering a glimpse into the future of sustainable aquaculture.

Tasmania's salmon industry as a global model

I come back to Australia after visiting the main salmon producers globally and I can confidently say that the Tasmanian salmon industry is an exemplary model to the rest of the world. My original journey was to explore the issues the industry is facing overseas, and I come to conclude that those are perhaps more contentious than the Tasmanian narrative. I found that the combination of some unique characteristics makes the Tasmanian industry a great global model. Even though Tasmanian salmon is not as well known in other parts of the world it is certainly a hidden gem with a lot of potential to be more recognised worldwide.

The unique characteristics making Tasmanian salmon a global model include:

Geographical Isolation and Biosecurity

Tasmania's geographical isolation provides a unique advantage for the salmon industry. Being an island, Tasmania benefits from excellent biosecurity measures, significantly reducing the risk of disease outbreaks. Unlike countries such as Canada, where companies must navigate varying provincial regulations, Tasmania's salmon industry deals with a single set of state legislation. This uniformity simplifies compliance and enhances operational efficiency. Additionally, the proximity of leases around the island facilitates easy implementation of new processes, streamlining logistics and ensuring fast responses to industry needs.

Small Production and Streamlined Processes

The relatively small size of the Tasmanian salmon industry compared to Norway, Chile, and Scotland has driven innovation and standardisation across farms. While marine farming licenses are difficult to obtain, the industry has focused on optimising existing operations. The last license for onshore farming was granted in 2017 (Fløysand, et. al., 2021). Years of optimisation projects have led to streamlined processes and better outcomes, demonstrating that small-scale production can foster efficiency and innovation.

Native Populations, Escapes, and Sea Lice

Tasmania's salmon industry enjoys a significant advantage due to the absence of native salmon populations, eliminating interactions between farmed and wild salmon. Fish escapes, a major challenge for overseas producers, are less problematic in Tasmania due to the lack of sea lice. The industry has invested heavily in infrastructure and methods to prevent fish escapes, despite pressure from Australian fur seals. The last known escape in 2020 had minimal ecological impact (Lyle, J., 2021). This lack of native salmon populations and sea lice reduces public scrutiny and enhances the industry's reputation.

Leveraging Regionality and Provenance

The Tasmanian salmon industry is fortunate to farm salmon in the provenance of an iconic place known for its exceptional attributes as a food-growing region. Despite the competitive nature of the three main companies operating in Tasmania, the end product is universally recognised as Tasmanian salmon. This product is ultimately sold to Australian consumers as the main market.

Jane Bennett's Nuffield Report "The Role of Regionality in the Marketing and Branding of Food" emphasises that producers and distributors should highlight the specific attributes that provenance represents rather than the term itself. National markets are more likely to support regional products if they align with environmental and animal

welfare standards. To meet consumer expectations, the provenance message must be backed by the regional community's true values and aspirations (Bennett, J., 2008). This approach fosters trust in the product's source. Reinforcing the Tasmanian brand could thus focus on the values of living in a pristine island environment and in harmony with the industry's commitment to sustainability and quality.

Commitment of the Tasmanian Workforce

The Tasmanian salmon industry employs over 5,000 people, with most workers living in regional areas. This local workforce is deeply committed to sustainable farming practices, both in the ocean and on land. Their respect for the environment and dedication to the industry make them true champions and advocates. The knowledge and expertise of these farmers are invaluable and should be harnessed and protected, as Tasmania offers a unique and special place to live and work.

Best of Both Worlds

From visits to Norway, Scotland, Chile, New Zealand, and Canada, it is clear that the Tasmanian salmon industry is well-positioned and advanced in its farming practices. However, Tasmania faces similar challenges with climate and social acceptability as international companies. The opportunity for the Tasmanian industry lies in leveraging these advantages and demonstrating its capacity to adapt to global challenges.

The solutions are already evident in the examples provided in this report, ranging from holistic approaches and ecosystem-based models to empowering the workforce and investing in educational centres. For the Tasmanian salmon industry to stand out as a global model, it must lead the change by incorporating essential environmental and social practices into its strategic development.

Conclusion/Recommendations

Aquaculture is set to play a crucial role in ensuring future food security. Specifically, salmon aquaculture will continue to offer a nutritious and affordable protein source for the Western world. As a leading species in the aquaculture sector, salmon not only provides significant nutritional benefits but also contributes to the advancement of other aquaculture species by sharing knowledge and existing technologies.

Global aquaculture companies, regardless of their location (Canada, Chile, Norway, Scotland, and Australia), face similar challenges related to climate change and social license to operate. They must recognise the benefits of collaboration over competition at both international and local levels to achieve long-term goals that protect the environment and build strong communities.

- Future growth and investment should seriously consider the ecosystem-based model to ensure that positive outcomes are measured and help address climate change adaptation.
- The industry needs to engage with the supply chain beyond a transactional relationship. The success of suppliers is also the industry's success.
- Strengthen partnerships with organisations outside salmon farming to open up pathways to greater credibility and support for the sector.
- Enhance community engagement by addressing the educational gap and empowering the workforce to foster a culture of sustainability.

The biggest learning throughout this journey is that people are at the centre of our food system, and through experiences, we formulate our values. We can make a real difference when our values align, and we embrace sustainability as a shared goal.

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