



Stakeholder perceptions of the Norwegian salmon farming industry and its future challenges

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ABSTRACT

Aquaculture has emerged as the fastest growing sector in global food production, with salmon farming in the lead. Norway is responsible for over half of the world salmon production, but its industry faces significant challenges which must be addressed to achieve sustainability. One key issue is the lack of a unified understanding among stakeholders of how production affects the environment and intersects with the interests of other users. Given this context, this present study aims to understand the diverse perspectives of different groups of stakeholders regarding the expansion challenges faced by the Norwegian salmon farming industry. We assessed environmental, socio-economic, operational, and regulatory aspects, highlighting areas of agreement and disagreement among stakeholders using Q-methodology. Our results reveal four distinct stakeholder groups, two of which reveal polarized views, while the other two present more balanced opinions. We believe that our findings facilitate enriched dialogues among stakeholders and provide insights into the management of the industry, while addressing the dilemma of ensuring sustainability amid pressures for production growth.

1. Introduction

Aquaculture has emerged as the fastest growing sector in global food production, boasting an annual growth rate of 8 % (Kumar and Engle, 2016). Since the 1970s, salmon and shrimp have led the aquaculture revolution, with salmon emerging as the primary species in marine aquaculture (Asche and Bjørndal, 2011; FAO, 2022). In 2022, Norwegian aquaculture was a global leader, producing about 53 % of the world's salmon (FAO, 2023). By 2023, Norway exported 1.2 million tons of salmon, worth NOK 122.5 billion, out of nearly 1.5 million tons produced (Norwegian Seafood Council, 2024).

In Norway, the salmon industry is crucial for value generation and employment in rural and coastal areas. Four of the world's top aquaculture companies—Cermaq, Lerøy Seafood, Mowi, and Salmar—are headquartered in Norway, highlighting the country's pivotal role in the global seafood market. These corporations have a significant international presence, with operations in Scotland, Ireland, Chile, Canada, and the Faroe Islands (Cermaq, 2024; Lerøy; Mowi; Salmar). But despite this, a notable shift towards greater foreign ownership within the sector has been observed, accounting for over one-third of production capacity in 2018 (Nøstbakken and Selle, 2019).

Nevertheless, the industry faces significant environmental

challenges, including escaped farmed salmon and salmon lice, which threaten wild salmon populations in Norway (Forseth et al., 2017). Escaped salmon risk interbreeding with wild salmon, altering their life-history traits and compromising their genetic integrity (Bolstad et al., 2017). The 2024 risk assessment report by the Norwegian Institute of Marine Research (2024) identified significant genetic assimilation risks, classifying five out of thirteen production areas (3, 4, 7, 8, and 11) as high risk.

Moreover, delousing treatments imposes various expenses for farmers, including direct costs, reduced fish growth, fish escapes, mortality, and welfare issues (Stien et al., 2020). The 2024 risk assessment by the Norwegian Institute of Marine Research (2024) also highlighted welfare concerns in production areas 1–5, noting mortality rates above the 15 % national average between 2019 and 2022.

The farmed salmon industry also impacts the environment through effluents, including nutrients, organic emissions, medications, and pesticides (Olaussen, 2018). However, the 2024 risk assessment by the Norwegian Institute of Marine Research (2024) suggests a low overall risk from organic and nutrient emissions across Norwegian aquaculture. Copper emissions pose a high risk in areas 3 and 4, and moderate in area 2; while medication and pesticide pollution is moderate in areas 4 and 10, and low elsewhere.

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Another challenge for the industry is salmon feed, a significant contributor to energy use and greenhouse gas emissions (Newton and Little, 2018). Its raw materials also contribute to South American deforestation and raise concerns over diverting marine resources from human consumption (Shepherd et al., 2017; Willer et al., 2022). Consequently, stakeholders agree on the need for further research into alternative feed sources within the Norwegian salmon industry (Gillund and Myhr, 2010).

The industry's growth is also hindered by challenges in accessing areas. Hersoug et al. (2021a) emphasize the need for improved social sustainability and equitable benefit distribution to coastal communities to enhance the industry's legitimacy and access to prime locations. Similarly, Misund et al. (2023) underscore the significant role of fair economic benefit distribution in community perceptions. Conflicts with recreational salmon fishers (Liu et al., 2011), marine capture fisheries (Tiller et al., 2012), tourism activities (Buanes et al., 2005), and concerns over visual and noise pollution (Olaussen, 2018) further complicate area access.

Another challenge for the industry is its reputation. In Norway, the media and public debate often focus on its negative environmental impacts (Olsen and Osmundsen, 2017) and perceive it as having a so-called "cowboy behavior" (Fiskeribladet, 2013; Rokkan, 2019). Customer perceptions of farmed salmon also warrant attention. Research indicates a consumer preference for local and sustainable aquaculture products (Risius et al., 2019; Osmond et al., 2023). Moreover, studies argue that the public perception of farmed salmon is more emotional than factual, with mixed preferences for wild fish or no clear distinction (Verbeke et al., 2007; Schlag and Ystgaard, 2013). Nevertheless, a recent study found a preference for imported Norwegian salmon among segments of customers in US, France, and Japan (Onozaka et al., 2023). Yet, the literature also indicates that a portion of consumers continue to perceive salmon as a luxurious product (Wang and Somogyi, 2020).

Despite the challenges, Norway's salmon farming industry is highly regarded as innovative (Bergesen and Tveterås, 2019; Iversen and Hydle, 2023). However, it still struggles with environmental externalities and relies predominantly on open-net sea enclosures (Moe et al., 2007; Greaker et al., 2020). To mitigate environmental impacts, alternative systems are being developed, including land-based facilities, closed and semi-closed sea facilities, and offshore farming (Føre et al., 2022).

In 2015, Norway introduced "development" licenses to encourage innovations addressing the industry's environmental challenges (Norwegian Directorate of Fisheries, n.d.). By September 2021, closed farms and PE-rings for offshore production secured half of these licenses (Føre et al., 2022). Yet, some scholars argue that government incentives remain insufficient to address the growing environmental issues (Greaker et al., 2020; Hersoug et al., 2021b; Watson et al., 2022).

Besides incentives, environmental regulations are crucial for sustainable aquaculture practices. A key Norwegian regulation is the traffic light system, introduced in 2017, which manages salmon lice outbreaks by dividing the coastline into 13 production areas and assessing the impact of salmon farming on wild salmonid mortality. This determines whether companies can expand or must reduce production (Trafikklyssystemet). Moreover, farmers need two permits: one for production volume from the Directorate of Fisheries and another for location from the local municipality. These permits cap the Maximum Allowed Biomass (MAB) to prevent overproduction, generally limiting it to 780 tons per site (Norwegian Directorate of Fisheries, n.d.).¹

Yet, these regulations have faced criticism. Some argue that the traffic light system's reliance on a single indicator (salmon lice level) is insufficient, advocating for additional metrics like mortality rates, medication use, fish escapes, emissions, parasites and viruses, welfare

indicators, and fish growth (Olaussen, 2018; Bailey and Eggereide, 2020; Gismervik et al., 2020; Osmundsen et al., 2020; Larsen and Vormedal, 2021). Similarly, Hersoug (2021) views MAB regulations as a "currency", more valuable for bookkeeping than for regulating total production.

Other regulatory challenges include coordination among governmental agencies and taxation policy. For example, Liu et al. (2011) note that Norway's farmed and wild sectors are managed by the Directorate of Fisheries and the Environment Agency, respectively, with insufficient collaboration between them. Furthermore, in 2023, a 25 % resource rent tax was introduced in the industry, atop the corporate tax, which led to reduced investments by some companies (E24, 2023; White, 2022).

Overall, a key issue in addressing the aforementioned challenges is the lack of consensus among stakeholders on aquaculture's environmental impacts and how they align with broader interests (Pettersen et al., 2015). Also, rapid technological advancements, along with changes in farm scales and locations, demand continuous research updates (Osmundsen et al., 2017). Nevertheless, mapping diverse stakeholder perspectives can increase their awareness of alternative views and promote greater understanding and consensus (Pahl-Wostl and Hare, 2004; Raadgever et al., 2008).

In the salmon industry, studies have explored stakeholder perceptions on topics including regulatory compliance, offshore farming, and spatial conflicts (McGhee et al., 2019; Watson et al., 2022; Bergh et al., 2023). Yet, no study has addressed stakeholder views on the broader challenges for the expansion of the Norwegian salmon farming. Thus, we aim to explore stakeholder perceptions on this topic, arguing that understanding these views can provide valuable insights into the management of the industry and enhance collaboration towards addressing these challenges.

Furthermore, our study seeks to enrich academic discussions by employing Q-methodology, a mixed-methods approach that identifies patterns of subjectivity in human behaviors and opinions. This approach has effectively investigated environmental issues such as ecosystem services, marine plastic waste management, and climate change (Hermelingmeier and Nicholas, 2017; McNicholas and Cotton, 2019; Moser and Baulcomb, 2020). In Norway, it has been successfully employed to investigate the implementation of climate forests on abandoned pastures (Grimsrud et al., 2020). In the aquaculture field, Q-methodology has been used to investigate stakeholder perspectives on a range of topics, including fish farming practices, marine spatial planning, and eco-labels (Bacher et al., 2014; Gustavsson and Morrissey, 2019; Chikudza et al., 2020). Particularly in salmon farming, it has provided insights into topics such as conflicted space in Ireland, as well as transparency and communication in Norway and Canada, revealing nuanced industry views (Carr, 2019; Trueman et al., 2022).

2. Material and methods

Q-methodology combines qualitative and quantitative methods to investigate the subjective and "uniquely human faculty" of forming an opinion by asking participants to rank statements about a specific topic (usually from "agree" to "disagree") according to their point of view (Berns, 1962; Brown, 1993). Weblar et al. (2009) categorize Q-methodology under the umbrella of "discourse analysis techniques", given that it analyzes text to find meaning and patterns. However, the authors emphasize that Q-studies offer a key advantage over other discourse analysis methods by allowing direct comparison of participant responses. Another advantage of this approach is that it does not require large population samples, given that generalizations in such studies are likely to apply to other individuals of the same type (Brown, 1980). Nonetheless, Q-studies are limited in their ability to assess the prevalence of identified perspectives within a broader population, for which surveys are better suited (Weblar et al., 2009). Despite this, results from Q-studies can be expanded upon using surveys to investigate the prevalence of identified perspectives across the general population, as

¹ Note that these stock permits are based on total biomass, rather than on the number of fish.

exemplified by the work of Grimsrud et al. (2020).

2.1. Collection and selection of statements

The first phase of a Q-study involves creating a set of statements related to the topic under investigation from a concourse, defined as “the flow of communicability surrounding a topic” (Brown, 1993). This study’s concourse was constructed via face-to-face and video call semi-structured interviews with 23 stakeholders. Participant sampling involved recruiting stakeholders from key interest groups, each likely to have distinct, well-formed opinions. The selected interviewees included experts from diverse academic fields ($n = 6$), representatives from The Norwegian Directorate of Fisheries, The Norwegian Environment Agency and The Norwegian Food Safety Authority ($n = 6$), industry’s executives from producing and supplier companies ($n = 4$), recreational and former commercial salmon fishermen ($n = 4$), and Environmental NGO (ENGO) representatives ($n = 3$). The participants were asked about their opinion on the future challenges for the Norwegian salmon farming industry’s expansion, its current positive and negative aspects and its regulatory framework. Participants were encouraged to guide the conversation, leading to follow-up questions dependent on their input. The interviews were conducted between April and October 2022 in either English or Norwegian.

A total of 1228 statements were initially extracted from the interview transcripts. Following McNicholas and Cotton’s (2019) approach, these statements were categorized into four overarching themes using inductive qualitative analysis: Environmental aspects, Economic/social aspects, Industry operations, and Policy/governance. The statements were coded at the sub-theme and specific issue levels, with duplicates and ambiguous ones removed. After several rounds of review and discussion among the authors, further statement removal was carried out and some sub-themes and issue categories were edited. Efforts were made to maintain a balance between positive/neutral and negative statements, with a few merged for clarity. The final list of 42 statements was then edited for clarity, and statements in English were translated to Norwegian. A pre-test was conducted with a colleague from the field, leading to minor adjustments of two statements. The finalized Q-set (the selection of statements) is detailed in Table 3.

Details about the overarching themes, sub-themes, and specific issues are shown in Appendix A. Statements concerning environmental aspects were further divided into two sub-themes related to environmental sustainability and the impact on farmed and wild salmon, reflecting key environmental concerns highlighted in the literature (Bolstad et al., 2017; Forseth et al., 2017). Economic and social aspects were categorized into three sub-themes concerning the salmon market, economic and social sustainability, as well as attitudes and perceptions towards the industry. Issues highlighted by the literature and media, like conflicts over area (Hersoug et al., 2021a) and industry behavior (Fiskeribladet, 2013; Rokkan, 2019), are included in this theme.

The third overarching theme, focused on industry operations, addresses statements regarding operational dynamics and technology. Some challenges discussed in the literature, such as the industry’s current efforts to enclose production systems to improve sustainability (Føre et al., 2022), are reflected in the Q-set. Finally, statements concerning policy and governance were grouped into sub-themes related to perceptions and critiques of the existing regulatory framework, as well as issues of trust. This theme includes concerns raised in the literature and media, such as the introduction of a resource rent tax (E24, 2023; White, 2022), and other criticisms of regulations (Olaussen, 2018; Bailey and Eggereide, 2020; Gismervik et al., 2020; Osmundsen et al., 2020; Hersoug, 2021; Larsen and Vormedal, 2021).

2.2. Sorting of statements

To ensure a more balanced sample, two additional industry representatives were recruited. A total of 22 participants sorted the 42

statements, 20 of whom had also been interviewed. Participants completed the sorting online using the Q Method Software (Lutfallah and Buchanan, 2019), guided by a one-minute instructional video that clarified the objective: to rank statements from “Most agree (+5)” to “Least agree (-5)”. They were asked to sort the statements (in Norwegian) in a pyramid with a compulsory number per category, creating a forced quasi-normal distribution pattern. Lastly, they were given the opportunity to submit a free-text comment.

2.3. Statistical analysis

In Q-methodology, the variable of interest is the Q-sort, which refers to how each participant sorted the statements in the assigned distribution. The Q-sorts were analyzed using the Q Method Software (Lutfallah and Buchanan, 2019) and principal component analysis (PCA), resulting in eight factors. Following the Kaiser-Guttman criterion, two factors with eigenvalue < 1 were excluded from the varimax rotation, as well as one with only one significant factor loading (SFL), as suggested by Brown (1980).² Also, the Catrell Scree test indicated that a three or four-factor rotation would be most appropriate. A sensitivity analysis between these rotations revealed that the fourth factor added only 5 % to the explained variance, increased the confounded sorts from 2 to 5 and correlated in 60 % with the first factor.³ Its distinctness was also assessed, with small differences between the first and fourth factors leading to the selection of a 3-factor rotation.

2.4. Interpretation

The analysis produced idealized Q-sorts for each factor, which represent individuals who are fully aligned with each of the factors. Analysis focused on these Q-sorts, highlighting significant distinguishing statements (i.e. statements that were ranked significantly different at $p < 0.05$ in comparison to other factors) and those at the scale’s extremes (-5, -4, 4, 5). Supplementary data like free-text comments and interview transcripts aided interpretation. Each factor was then qualitatively interpreted as a distinct social perspective, based on these idealized Q-sorts and discernible patterns.

3. Results

Three distinct factors emerged from analyzing the 22 Q-sorts, explaining approximately 60 % of their variance. The first factor is bipolar, with two negative significant loaders. Bipolar factors arise when participants position identical cards at opposite extremes of the distribution, thus disagreeing with the beliefs that comprise the factor (Webler et al., 2009). We divided this factor for easier interpretation.

Table 1 identifies participants defining a factor. Two stakeholders significantly loaded on multiple factors, thus designated “confounded sorts” and omitted from the perspective formulation as per Q-study norms (Brown, 1993). Table 3 details the factor sort values per statement for each idealized Q-sort, which refers to where in the pyramid each statement is positioned in each idealized Q-sort. Subsequent sections describe the four social perspectives each factor represents, their associated stakeholders, and the corresponding statements and factor sort values from Table 3 (e.g. (S1: -5)). Table 2 summarizes these perspectives and their corresponding value orientations.

² Factor loadings indicate the extent to which a Q-sort correlates with a specific factor (Webler et al., 2009). A factor loading in this study is significant at ± 0.40 . An SFL at the 0.01 is given by the equation $SFL = 2.58 \times (1/\sqrt{\text{number of statements}})$.

³ More precisely, with factor 1a.

Table 1

Factor loadings for each Q-sort, ranging from complete disagreement (−1) to complete agreement (+1) with each factor's perspective.

Stakeholder	F1a	F1b	F2	F3
Factor 1a				
Governmental authorities	0.72208	−0.72208	0.18478	0.31101
Governmental authorities	0.87128	−0.87128	−0.15546	0.0435
Scientist (political science)	0.50262	−0.50262	0.33559	0.13691
Fisher	0.60258	−0.60258	0.29601	−0.14571
Fisher	0.67122	−0.67122	0.21729	−0.13318
Fisher	0.78995	−0.78995	0.0858	−0.02973
Fisher (ex-commercial)	0.57669	−0.57669	0.11153	−0.07513
ENGO	0.70881	−0.70881	0.18267	0.09203
ENGO	0.76041	−0.76041	−0.21427	0.23498
ENGO	0.80473	−0.80473	−0.01646	0.14577
Factor 1b				
Industry (producer)	−0.7449	0.7449	0.27563	0.09559
Industry (producer)	−0.75611	0.75611	0.36538	0.22173
Factor 2				
Governmental authorities	0.1815	−0.1815	0.66281	0.48496
Scientist (oceanography)	0.20172	−0.20172	0.71588	−0.11653
Industry (producer)	−0.40112	0.40112	0.56633	0.23931
Industry (supplier)	0.02966	−0.02966	0.71043	−0.24759
Industry (supplier)	−0.16638	0.16638	0.73403	0.30772
Factor 3				
Governmental authorities	0.45783	−0.45783	0.02697	0.56707
Governmental authorities	−0.14382	0.14382	0.03797	0.66624
Scientist (economics)	−0.00842	0.00842	0.03529	0.81203
Confounded sorts				
Scientist (oceanography)	0.54923	−0.54923	0.50616	0.22114
Scientist (veterinary)	0.51102	−0.51102	0.45173	0.43049
Explained variance (%)	34 %		17 %	9 %
Total defining Q-sorts	10	2	5	3
Total Q-sorts	14		7	4

Note: Bolded values represent defining Q-sorts for that factor, considering an SFL with an absolute value of coefficient > 0.4. If the difference between two SFLs for the same Q-sort is substantial, it is not considered confounded.

Table 2

Summary of value orientations for the identified perspectives.

Perspective	Value orientation
Perspective 1a: The Environmental Advocates (F1a)	Strong environmental concern and industry skepticism
Perspective 1b: The Industry Optimists (F1b)	Optimism regarding the industry and its impacts
Perspective 2: The Measured Optimists (F2)	Balanced views on environmental impacts and regulations
Perspective 3: The Eco-Pragmatists (F3)	Strong environmental concern combined with positive and pragmatic views on regulations

3.1. Perspective 1a: the environmental advocates

Perspective 1a consists of 10 significantly loading sorts, involving all Fishers and ENGO participants, alongside two Norwegian governmental representatives, and a scientist. Fundamental to this perspective was a strong environmental concern and industry skepticism. Stakeholders in this group strongly view salmon lice and the escape of farmed salmon as detrimental to wild salmon populations (S5: 5; S26: −4), and question claims regarding the industry being the most sustainable protein producer in the world (S17: −4) and having mortality rates comparable to terrestrial industries (S18: −5). They are also critical of the area allocated for aquaculture (S24: −3), with one ENGO representative commenting, “I do not necessarily disagree with the statement, but I believe that the area available for fish farming is too large.”

This perspective is skeptical of the industry's lobbying efforts (S33: 4) and questionable conduct towards science and researchers (S39: 3), expressing a stronger ethical concern about the allocation of feed raw

Table 3

Factor sort values for statements in the idealized Q-sort, with bold numbers indicating distinguishing statements at $p < 0.05$.

No	Statements	F1a	F1b	F2	F3
1	The regulations are the largest limitation for growth in Norway.	−5	1	−5	−4
2	We should only use fish that cannot reproduce.	0	0	−4	1
3	If the industry continues as it is now, there's a good chance that a major collapse could suddenly occur.	0	−2	−2	2
4	The emission of nutrients and the organic emissions from the farms are not a problem.	−3	1	−2	0
5	Salmon lice and escaped farmed salmon are the two biggest threats to our wild salmon populations.	5	−2	−2	4
6	I'm sure we can increase production.	−4	3	−3	0
7	Compared to the scale of the companies and the revenues, the industry doesn't employ that many people really.	0	−2	−3	2
8	My impression is that the people who work in the industry is generally very decent people.	−1	1	1	5
9	It's a welfare challenge that so many fish die in the cages.	2	2	4	5
10	There should be brought more parameters into the traffic light system model.	3	−1	−1	2
11	There must be a carrot that drives technological change in the system.	0	0	1	3
12	There is indication that some don't follow the regulation and that they cheat the limits and stretch the rules.	1	−2	0	1
13	Customer demands will likely push the industry towards a more sustainable production.	−1	0	0	1
14	It's clear that the aquaculture industry provides many jobs locally.	−3	1	1	−1
15	The industry provides little income to the state if they do not pay any resource rent tax.	1	−4	−3	−3
16	Farmed fish is actually very healthy food.	−1	2	3	3
17	I think that the Norwegian salmon industry is producing probably the most sustainable animal protein in the world.	−4	4	3	−4
18	The mortality rate is too high, but it is not higher than on animal production on land, it's just that people forget to compare.	−5	3	−1	−4
19	Having regulations on the number of fish would provide a stronger incentive to keep the fish alive.	2	−1	1	4
20	There are too many regulatory bodies or hearing instances involved in the regulation of the industry today.	−2	2	1	−2
21	The salmon farming industry gets away with much more compared to land-based industries.	2	−3	0	−5
22	Norway has probably the best regulatory framework for fish farming in the world.	0	3	3	4
23	I think it is important to have locally owned companies.	−1	2	3	−1
24	The area that is used for fish farming is very small compared to the available area.	−3	4	0	2
25	There is room for subjectivity in the interpretation of the Norwegian regulations, which is not necessarily predictable and good.	−2	0	2	0
26	Escapes is not that big of a problem anymore.	−4	5	−4	1
27	I have great faith in the technological development of closed and semi-closed facilities in the sea.	2	3	−1	0
28	We are not close to solving the problem with salmon lice.	3	−1	−2	3
29	The industry must find other feed and raw materials besides soy if it is to grow.	1	−1	2	−1
30	I think that the industry still has a bad reputation.	1	−3	2	1
31	I would say that the industry's impacts on nature is as much the responsibility of the government.	0	1	−1	0
32	I believe there should be inspectors who travel around and conduct the checks, not the aquaculture industry itself.	4	−1	5	−2
33	The industry as a lobbying enterprise is very strong.	4	−4	2	3

(continued on next page)

Table 3 (continued)

No	Statements	F1a	F1b	F2	F3
34	There should simply come a mandate stating that by 2030 it will no longer be permissible to produce in open pens, by then everything must be enclosed.	4	-5	-5	-5
35	I believe that to use closed production systems for salmon aquaculture on this scale is quite challenging.	-3	0	4	-2
36	Salmon is a luxury product.	-1	0	-3	-2
37	It's obviously an enormously important industry for Norway's income.	-2	5	5	-1
38	For the large Norwegian-owned corporations, it doesn't matter much where they produce and where they earn their money.	1	-3	-1	-3
39	The industry is spending enormous amounts of time and resources trying to tell the world that the research and the science is wrong.	3	-4	0	-3
40	Part of the resources used to produce the feed could be used directly as human food, especially for the world's poor.	3	-3	-4	-1
41	Functionality requirements should be set for the farming industry, which are no escapes, no biological emissions, and no lice.	5	-5	0	-3
42	I think the salmon industry, as it is evolved in Norway, is using a lot of cutting-edge science and technology.	-2	4	4	0

materials (S40: 3). They also remain neutral⁴ on the health benefits of farmed salmon (S16: -1) and are less impressed by the industry's innovation and technological advancements compared to other groups (S42: -2). Moreover, they oppose increases in production levels (S6: -4) and are not particularly opposed to the notion that current practices could lead to industry collapse (S3: 0).

Advocating for stricter regulations, they strongly support a zero-tolerance policy for escapes, pollution, and salmon lice (S41: 5), and the setting of a deadline for the industry to transition to closed containment systems within this decade (S34: 4). As an ENGO participant remarked, "The lice problem can be solved quickly if we achieve a technological shift in production methods, reduce the number of farmed salmon in open cages and increase production in closed facilities."

This perspective also advocates for stricter regulations in the sector. The group holds that the industry is treated more leniently than terrestrial industries (S21: 2) and supports the implementation of external inspectors to supervise the industry (S32: 4). They also firmly believe that regulations are not the primary barrier to industry's growth (S1: -5) and do not display strong opinions about the Norwegian regulatory system being the best globally (S22: 0). However, they express weak sentiment regarding the need for the industry to contribute more to the state through a resource rent tax (S15: 1).

3.2. Perspective 1b: the industry optimists

Contrasting sharply with the previous perspective, this group comprises two significant sorts from industry executives. Central to their viewpoint is optimism regarding the industry and its impacts. Unlike the "Environmental Advocates", these executives portray a different assessment about the industry's environmental impacts. They hold a neutral stance on the issue of nutrient release and organic emissions from the farms (S4: 1) and agree that their mortality rates are comparable to land-based industries (S18: 3). Additionally, they firmly believe the industry utilizes only a small fraction of the available area (S24: 4) and consider escapes of farmed salmon as no longer a concern (S26: 5).

⁴ The term "neutral" does not imply literal neutrality but indicates comparatively weaker opinions or sentiments than other statements in the Q-set.

Overall, they view Norway's farmed salmon production as likely the most sustainable protein source globally (S17: 4).

The "Industry Optimists" also hold favorable views about the industry's behavior and public image. They view the industry's role in generating income for Norway positively (S37: 5) and dispute the idea that the industry suffers from a poor reputation (S30: -3) or that some actors fail to comply with regulations (S12: -2). They also strongly disagree that the industry is a powerful lobbying force (S33: -4) and that it invests heavily in discrediting scientific research (S39: -4).

This group also displays a positive opinion about the industry's innovative and technological progress (S42: 4) and uniquely believes that production levels can be increased (S6: -4). Interestingly, they express weaker sentiment on the feasibility of using closed production systems given the industry's scale (S35: 0).

Another key aspect of this perspective is a resistance to additional regulations, evidenced by their strong opposition to zero-tolerance functionality requirements (S41: -5) and to mandating a transition to closed containment systems within the next decade (S34: -5). Consistent with these opinions, they oppose introducing a resource rent tax intended to increase their contribution to the state (S15: -4) and hold neutral views on the idea that shifting biomass regulations to a per-fish count would incentivize keeping the fish alive (S19: -1). They are also ambivalent about the notion that regulations are the primary obstacle to the industry's growth (S1: 1).

3.3. Perspective 2: the measured optimists

This perspective is characterized by five significantly loading sorts, encompassing a diverse group of stakeholders: three industry executives, a government representative, and a scientist. Unlike the previous perspectives, this group offers a more balanced view on the issues at hand.

Like the "Environmental Advocates," the "Measured Optimists" express concerns about the escape of farmed salmon (S26: -4). Uniquely, they oppose the use of sterile fish in farming (S2: -4) and do not hold strong opinions on whether the industry mortality rates surpass those in land-based industries (S18: -1). Echoing the "Industry Optimists," they dismiss ethical concerns regarding the allocation of feed raw materials (S40: -4). Yet, they display neutrality on industry land use (S24: 0).

The "Measured Optimists" share the "Industry Optimists" positives views on the industry's innovative capabilities (S42: 4) and economic contributions to Norway (S37: 5). However, they diverge by being the only group to strongly recognize the challenges of implementing closed production systems at the industry's current scale (S35: 4) and by not portraying strong views regarding the industry's conduct towards science and research (S39: 0).

Participants in this group also offer a nuanced stance on regulation and industry supervision. While they strongly resist setting a deadline for a transition to closed production systems within this decade (S34: -5), they fully support the implementation of external inspections (S32: 5). The "Measured Optimists" also do not hold strong views on implementing zero-tolerance policies for escapes, pollution, and salmon lice (S41: 0), and on the lenient treatment towards the industry compared to land-based industries (S21: 0). However, they disagree that regulations are the primary obstacle to industry's growth (S1: -5) and with increases in production levels (S6: -3).

3.4. Perspective 3: the eco-pragmatists

Perspective 3 consists of three significant sorts from two Norwegian governmental representatives and a scientist. This group distinguishes itself from the others by its positive view on the Norwegian regulatory framework, blending environmental concern with pragmatism.

Stakeholders in this group portray significant worry about environmental issues. Like the "Environmental Advocates," they disagree that the industry's mortality levels are comparable to on-land industries

(S18: -4) and identify salmon lice and farmed salmon escape as major threats to wild salmon populations (S5: 4). Additionally, this group disagrees that the Norwegian farmed salmon production is the world's most sustainable protein source (S17: -4) and is most convinced that the industry's practices could lead to its collapse (S3: 2). However, they do not portray strong concerns about the escapes of farmed salmon (S26: 1).

Moreover, the "Eco-Pragmatists" place strong faith in the integrity of those employed in the industry (S8: 5) but note that the industry employs a relatively small workforce given its size and revenue (S7: 2). They also do not hold strong opinions regarding the industry's level of technological innovation and development (S42: 0) and are the only group to maintain a neutral stance on increasing production levels (S6: 0).

A defining feature of Perspective 3 is its positive outlook on the Norwegian regulatory framework. This group is more convinced that Norway has the world's best regulatory framework for fish farming (S22: 4) and strongly disagree that Norwegian fish farms face more leniency than land-based industries (S21: -5). Moreover, they do not view regulations as the primary limitation to industry growth (S1: -4).

This group's pragmatic approach to policy is also unique. Regarding new regulations, the "Eco-Pragmatists" firmly oppose setting a deadline for a transition to closed production systems within this decade (S34: -5). However, they are unique in strongly recognizing the need for additional incentives to drive technological advancements in the system (S11: 3) and in advocating for regulations based on the number of fish to incentivize farmers to ensure their fish's survival (S19: 4).

4. Discussion

The emergence of four different perspectives highlights the differences in opinions across the participants, also illustrating the plurality of opinions within each stakeholder group. Moreover, main areas of agreement and disagreement were identified in the data, offering valuable insights.

4.1. Main areas of agreement

Stakeholders concur on certain environmental aspects, particularly recognizing farm mortality rates as a welfare concern (S9). Yet, they display less urgency in finding alternative raw materials (S29), aligning partially with [Gillund and Myhr's \(2010\)](#) claim given the absence of clear disagreement to the statement. The consensus extends to nutrient and organic emissions (S4), though the 2024 report by the Institute of Marine Research (2024) highlights copper emissions as a higher risk, suggesting a misplaced focus among stakeholders on organic waste.

The use of sterile fish garnered mostly indifferent reactions, except for strong opposition from the "Measured Optimists" (S2). Their stance is particularly interesting, given their pronounced concern over fish escapes. This illustrates that a segment of stakeholders holds significant concerns about this strategy, underscoring the need for further research into its impacts.

Moreover, the four groups displayed mild opinions on customer demands for sustainability (S13), likely due to widespread recognition in both literature ([Risius et al., 2019](#); [Osmond et al., 2023](#)) and practice, minimizing controversy. Also, the groups do not perceive salmon as a luxury product (S36), suggesting a divergence from some consumers ([Wang and Somogyi, 2020](#)). Except for the surprisingly neutral "Environmental Advocates", all groups regard farmed salmon as healthy (S16), somewhat corroborating [Verbeke et al.'s \(2007\)](#) findings that consumer perceptions in Belgium do not significantly differ between farmed and wild salmon.

There is also a general, albeit mild, agreement on the importance of local ownership in Norway (S23) and on the importance of production location for large Norwegian companies (S38). Interestingly, the groups with industry ties value local ownership, despite the global reach and foreign ownership trends in Norwegian companies ([Nøstbakken and](#)

[Selle, 2019](#)). Similarly, the sentiment towards local employment opportunities created by the industry is tepid (S14), contrasting with the more polarized views on its perceived low employment numbers (S7).

One of the few areas of agreement between the two first groups was on their faith in the technological development of closed and semi-closed production systems in the sea (S27), while the other groups showed less enthusiasm. Interestingly, a notable ambivalence was observed across all groups, except the "Eco-Pragmatists" regarding the need for more incentives to drive technological innovation (S11), despite studies advocating for such measures ([Greaker et al., 2020](#); [Hersoug et al., 2021b](#); [Watson et al., 2022](#)). This indifferent response underlines a disconnect, as interview transcripts suggest a widespread belief in the industry's reliance on innovative, enclosed systems for a sustainable future. However, compared to other issues, this topic failed to generate strong sentiment among the stakeholders in our study.

The groups also hold a neutral stance regarding the government's shared responsibility for the industry's environmental impacts (S31) and consider Norway's regulatory framework as the best globally (S22). They also strongly disagree that regulations are the largest limitation for industry's growth, except for the "Industry Optimists" (S1). This suggests that stakeholders with stronger environmental concern perceive the industry's growth potential not merely as a regulatory issue but as a broader sustainability challenge warranting attention. Conversely, the "Industry optimists", with a more favorable view on environmental impacts, display a weaker sentiment to the statement. Notably, even a strong statement about industry actors disregarding regulations elicited a weak reaction (S12), similar to the tepid responses to the claim about their decency (S8).

Regarding more practical propositions for regulatory adjustments, three statements emerged as uncontroversial among the stakeholders. The "Environmental advocates" and "Eco-pragmatists" support the introduction of stock regulations based on fish numbers (S19) and of more parameters in the traffic light system (S10), while the remaining groups remained neutral. This consensus aligns with critiques of the traffic light system and MAB regulations ([Olaussen, 2018](#); [Bailey and Eggereide, 2020](#); [Gismervik et al., 2020](#); [Osmundsen et al., 2020](#); [Hersoug, 2021](#); [Larsen and Vormedal, 2021](#)). Intriguingly, most groups rejected the notion that the industry provides little income to the state without a resource rent tax (S15), suggesting an alignment with the industry's stance against such a tax ([White, 2022](#)).

4.2. Main areas of disagreement

The groups display different opinions about the environmental impacts of the industry, as already highlighted in the literature ([Pettersen et al., 2015](#)). The "Environmental Advocates" exhibit the most pronounced environmental concerns across all groups. In contrast, the "Industry Optimists" stand in the other end of the spectrum. The latter's opinion on escapes (S26) is notably divergent from the scientific community's assessment, as presented in the 2024 risk report by the [Norwegian Institute of Marine Research \(2024\)](#). The remaining groups exhibit more nuanced positions, aligning with either the first group's or the second group's viewpoints.

The socio-economic statements sparked controversy among the groups, particularly regarding production growth (S6), with the "Environmental Advocates" voicing the strongest opposition to increasing production. This resistance, emerging predominantly from the group most concerned with environmental issues, is consistent with the findings of [Aanesen et al. \(2023a, 2023b\)](#), which demonstrate that public support for the expansion of aquaculture in Norway diminishes when its environmental impacts are emphasized. This indicates that the views of both the public and stakeholders on expansion are shaped by their perceptions of the industry's impacts, as also highlighted in other studies on aquaculture ([Whitmarsh and Palmieri, 2009](#); [Chu et al., 2010](#)). We can therefore conclude that stakeholders, like the general public, form their opinions by assessing the industry's positive and negative impacts

based on their knowledge level, while also considering their value orientations, such as environmental concerns.

Our study also unveils notable findings regarding the contentious topic of area usage within the industry (S24). While existing literature underscores a vigorous debate among stakeholders over aquatic resource rights (Buanes et al., 2005; Liu et al., 2011; Tiller et al., 2012), most perspectives in our study reflect a positive outlook on the industry's space utilization. Additionally, our results contrast to Willer et al. (2022) regarding the ethical dilemma of utilizing feed resources potentially suitable for human consumption—a viewpoint not endorsed by the groups apart from the “Environmental Advocates” (S40).

Furthermore, the overall sentiment towards the industry appears somewhat polarized but more favorable than media and public debates in Norway might suggest (Fiskeribladet, 2013; Olsen and Osmundsen, 2017; Rokkan, 2019), based on responses about the industry's reputation (S30), socio-economic contributions (S7, S37), and behavior towards the scientific community (S39). These perceptions are consistent with prior research that highlights positive attitudes towards the salmon or aquaculture industries among the Norwegian public, especially in communities hosting aquaculture operations (Krøvel et al., 2019; Misund et al., 2023; Olsen et al., 2023). This suggests that a segment of stakeholders, like those residing near operations, recognize the industry's value and positive socio-economic impacts. Furthermore, these findings (particularly for S37) suggest that socio-economic concerns are also included in stakeholder priorities, challenging Hersoug et al. (2021a) assertion that the industry's social sustainability is overlooked.

Regarding the operational and technological aspects, opinions about the industry's innovativeness varied (S42), suggesting that not all stakeholders are aligned with literature characterizing the industry as highly innovative (Sandvold and Tveterås, 2014; Bergesen and Tveterås, 2019; Iversen and Hydle, 2023). Nevertheless, the implementation of closed production systems is perceived as a challenging endeavor only by the “Measured Optimists” (S35), while other groups portrayed mild sentiments towards the statement.

Policy-related statements sparked significant divergence, particularly concerning the proposed ban on open pens by 2030 (S34). The “Environmental Advocates” strongly supported this prohibition, starkly contrasting to the unanimous opposition from the other groups. Opinions also differed on imposing functional requirements on the industry (S41) and its portrayal as a powerful lobbyist (S33), which polarized the first two groups. However, both “Measured Optimists” and “Eco-Pragmatists” showed tempered agreement with the industry's lobbying force, indicating a more critical view compared to its general reputation (S30), as previously mentioned.

Interestingly, the “Eco-Pragmatists” showed vehement disagreement — surpassing even the “Industry Optimists” — with the idea that the industry is treated more leniently than terrestrial sectors (S21), demonstrating this group's positive outlook on the Norwegian regulatory framework. In addition, the “Measured Optimists,” which includes industry insiders, strongly support using external inspectors for oversight of the industry (S32), highlighting the possibility of industry representatives favoring stricter supervision.

Finally, it is noteworthy to discuss the observed variances within the stakeholder groups. ENGOs and fishermen predominantly express environmental concerns and industry skepticism, with all sharing the first perspective. Industry representatives were split between perspectives 1b and 2, with some being optimistic about the industry's reputation and sustainability efforts, while others, especially those from supplier companies, presenting more nuanced views. Government representatives and scientists present the widest opinion range, being represented in almost all perspectives except for the “Industry Optimists”. This diversity also extended to the two confounded sorts belonging to two experts. These findings are consistent with Carr's (2019) Q-study in Scotland, where recreational fishers predominantly fell into the category with the strongest concerns for wild salmonid conservation, whereas industry representatives largely grouped into categories emphasizing

industry development and local implications. Similarly, individuals from the public or educational sectors were evenly distributed across the identified groups in the study.

5. Conclusions

Utilizing Q-methodology, this research explores the diverse viewpoints among stakeholders regarding the expansion challenges of the Norwegian salmon farming industry. Half of the Q-sorts represent the “Environmental Advocates” perspective, characterized by strong environmental concern and industry skepticism, indicating that a significant portion of stakeholders are primarily focused on the industry's negative impacts and view regulations as too lenient. In contrast, the “Industry Optimists”, composed of a segment of industry executives, have polar views, marking the largest friction point in our findings. The other two groups, the “Measured Optimists” and the “Eco-Pragmatists,” offer a more balanced outlook.

Notably, consensus is found on key issues such as the industry's welfare challenges and the perception of Norway having the world's best regulatory framework for fish farming. However, areas of more disagreement that could heighten debate friction include the enforcement of stringent regulations, such as functionality requirements and the compulsory transition to closed production systems by 2030. By delineating these commonalities and divergences along environmental, socio-economic, operational, and regulatory aspects, our study contributes to raising awareness and potentially to fostering consensus. In this way, our findings can facilitate informed dialogues among stakeholders, which are crucial for addressing the industry's sustainability challenges amid pressures for production growth.

It is important to acknowledge that a study involving a limited number of stakeholders always carries a risk of bias and limited generalizability. Although the literature suggests that generalizations from Q-studies “are expected to be valid for other persons of the same type” (Brown, 1980), the results should be interpreted with caution. Hence, future research could benefit from including perspectives from a wider array of stakeholders, such as service providers and tourism businesses. Additionally, testing the Q-set on a representative sample of the general population could help determine whether the polarized views we found are also present in the broader community.

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CRediT authorship contribution statement

Juliana Figueira Haugen: Writing – original draft, Visualization, Methodology, Investigation, Conceptualization. **Jon Olaf Olaussen:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Overview of the concourse themes and selected Q-set statements

Overreaching theme	Sub-theme	Issue (Q-set statement number)
Environmental aspects	Environmental sustainability	Categorization as sustainable (17) Pollution (4) Salmon lice (28)
	Impact on farmed and wild salmon	Farmed salmon welfare (9, 18) Escape of farmed salmon (2, 26) Impact on wild salmon (5) Global and international competition (38)
Economic and social aspects	Salmon market	Price and consumption (36) Potential for growth (1, 6) Resource ethics and consumption (40)
	Economic and social sustainability	Economic benefit and export value (37) Food quality (16) Local value creation (7, 14) Space utilization (24) Industry's reputation (8, 30) Industry's behavior (39) Consumer preferences (13) Innovation (42)
Industry's operations	Operational dynamics	Raw materials supply (29) Structure of the industry (23) Criticism about current practices (3)
	Technology	Optimism in technological development (27) Challenges and limitations of new technology (35) Incentives for technological change (11) Importance of regulations (31) Positive view on regulations (22) Uncertainties (25) Traffic light system (10) Biomass regulations (19) Growth and production systems (34) Regulation on environmental indicators (41) Taxation (15) Fragmentation of agencies (20) Supervision and control (21,32) Compliance with the rules (12) Lobbying (33)
Policy and governance	Perception	
	Criticism and areas for improvement	
	Trust	

Data availability

Data will be made available on request.

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