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Sustainable Aquaculture in Norway: Aligning Policy Intentions with Environmental Realities

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Abstract

The aquaculture industry in Norway, with its steady growth, has not only become one of the country's most important industries but also a significant player on the global stage. Its importance is underscored by the fact that it is a major contributor to the country's economy. However, sustainability has emerged as a central concern, especially considering the industry's criticism for increased emissions, diseases, and mortality rates in salmon pollution. Balancing economic growth and environmental concerns is a major challenge in the industry, one that requires careful consideration and strategic planning.

This study, employing a qualitative research method with document analysis, delves into the relationship between the Norwegian government's political intentions as expressed in 'Meld. St. 20 (2019-2020)' and the actual environmental and economic outcomes reported in 'Risikorapport Norsk Fiskeoppdrett 2024'. Through a systematic analysis of these two documents, the study uncovers the trajectory of the aquaculture industry in Norway. The study reveals both alignment and tensions between the political intentions and actual results. The analysis demonstrates a broad correspondence between the sustainability strategies outlined in the whitepaper and the reported environmental challenges. However, the effectiveness of these strategies varies significantly across different production areas. The framework plays a pivotal role in shaping environmental and economic outcomes, but practical implementation poses challenges across all areas. The study also uncovers potential links and trade-offs between the environmental and economic aspects of sustainable aquaculture. These findings significantly contribute to our understanding of the development of the aquaculture industry in Norway and the alignment and tensions between political intentions and actual results.

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Chapter 1: Introduction

1.1 Background Information

Norway's salmon farming industry, known for its significant contributions to the country's economy and as a leading global producer of farmed Atlantic salmon, presents a fascinating case study for environmental and economic analysis. This industry, pivotal for exports and job creation, has evolved remarkably over the decades, driven by technological advancements, a growing global demand, and an increasingly globalized market. Its development, from the use of freshwater hatcheries to sophisticated, controlled sea-based pens, reflects a dynamic interplay between innovation, market forces, international trade, and increasingly, environmental considerations (Jensen, 2023; Sørlie, 2021; Maurseth & Medin, 2020).

The origins of Norway's salmon farming industry date back to the 1960s, when pioneers such as the Vik brothers in Sykkylven gradually acclimated rainbow trout to seawater, and the Grøntvedt brothers from Hitra introduced the first Atlantic salmon smolts into sea cages. These groundbreaking efforts laid the foundation for Norway's modern salmon farming techniques and technologies. Throughout the 1970s and 1980s, the industry experienced significant growth, accompanied by challenges such as disease outbreaks and the use of antibiotics. This led to stricter regulations, including the Aquaculture Act of 1973, which mandated licensing requirements for fish farming operations. The development of vaccines and improved husbandry practices helped address some of these initial hurdles, paving the way for further expansion (Misund, 2021).

During the late 20th century, the Norwegian salmon farming industry witnessed a surge in growth. This was propelled by technological advancements, a rising global demand for salmon, and a regulatory environment conducive to the industry's expansion. However, this period of rapid growth had its share of challenges. Concerns about the industry's environmental impact, fish welfare, and sustainability began to surface. Issues such as nutrient pollution from fish waste, the potential genetic dilution of wild salmon populations due to escapees, and the proliferation of sea lice started to raise alarm bells among stakeholders. This led to ongoing efforts to balance economic growth and environmental stewardship (Misund, 2021).
The Norwegian salmon farming industry has undergone a significant transformation in recent years, becoming increasingly globalized. This shift has been influenced by foreign direct

investments (FDI), which are pivotal in shaping the industry's development and sustainability. As Maurseth and Medin (2020) point out, the EEA agreement, which grants Norway access to the EU's single market, has facilitated FDI in the seafood industry, particularly in the aquaculture and fish processing sectors. However, the agreement also allows for tariffs on processed fish exports from Norway, which has incentivized Norwegian firms to invest in processing facilities within the EU. These dynamics highlight the intricate interplay between international trade, investments, and regulatory factors in the Norwegian aquaculture sector.
Today, the Norwegian salmon farming industry is pivotal in the nation's economy. It significantly contributes to the country's exports and provides employment opportunities across various regions. The industry's economic impact is substantial, as evidenced by the seafood sector's value chain, which amounted to by the sectors generated value of 120 billion NOK, with tax impact of 34 billion NOK in 2021 (Per et al., 2022). This growth is primarily driven by increased activity and prices within the aquaculture industry, highlighting the sectors role as a major economic driver (Per et al., 2022).

Furthermore, Norway's aquaculture industry contributed 30.6 billion NOK to the nation's GDP in 2020 (Nofima et al., 2022). This can be broken down into specific segments: smolt and mature fish production (24.3 billion NOK), slaughtering and processing (4.5 billion NOK), and export activities (1.7 billion NOK). The industry's broader economic impact, including indirect contributions, reached 29.6 billion NOK. This remarkable growth demonstrates the industry's increasing share in Norway's total GDP, driven by strong demand, favorable prices for salmon products, and the industry's ability to navigate international markets and regulatory frameworks.

However, the industry continues to grapple with challenges related to sustainable practices, fish health, and minimizing its environmental footprint. High mortality rates, welfare concerns, and the environmental impacts of intensive farming practices have sparked debates on sustainability. Issues such as space constraints, handling stress, water quality, and the strictest sea lice limits underscore the efforts to balance economic growth with environmental stewardship (Dyrevernalliansen, 2023; Vormedal & Larsen, 2021). Furthermore, the complex sustainability dialogue highlights the repercussions of escaped farmed salmon, disease transmission to wild populations, and nutrient pollution from fish feed and waste. These environmental challenges pose risks to marine ecosystems, exemplified by the potential for genetic dilution and the propagation of parasites and harmful algal blooms (Lundebye et al., 2019; Miljødirektoratet, 2023).

Stringent regulations, technological innovations, and a commitment to responsible aquaculture practices have become paramount in tackling these issues and securing the long-term viability of this vital economic sector. As Norway navigates the challenges and opportunities of an increasingly globalized aquaculture industry, the need for sustainable development that harmonizes economic growth with environmental stewardship and social responsibility has become more pressing than ever (World Commission on Environment and Development, 1987).

Sustainable aquaculture practices refer to operational methods and measures that aim to minimize or reduce the negative environmental consequences of fish farming, such as sea lice infestations, fish escapes, emissions, and high mortality rates. Sustainable practices are designed to preserve the health of marine ecosystems and maintain ecological balance while supporting economic growth. Examples of this include:

- Implementing effective sea lice management strategies,
- Improving containment systems to prevent fish escapes,
- Optimizing feed formulations to reduce nutrient pollution and
- Adopting technologies that enhance fish welfare and survival rates.

In contrast, unsustainable practices lead to environmental overload, pollution, disease transmission, and other negative impacts that undermine sustainability goals. These practices may include inadequate sea lice control measures, poor containment systems that facilitate fish escapes, excessive nutrient discharge from feed and waste, and intensive production methods that compromise fish welfare and survival. Unsustainable practices can contribute to the degradation of marine ecosystems, the spread of diseases to wild populations, and the overall depletion of natural resources. (World Commission on Environment and Development, 1987).

As the Norwegian salmon farming industry adapts to the opportunities and challenges of an increasingly globalized market, the interplay between domestic policies, industry practices, and international economic and regulatory dynamics will remain crucial in shaping its future trajectory. By understanding and addressing these complex dynamics, Norway can work towards developing a more sustainable, resilient, and globally competitive aquaculture sector that balances economic growth with environmental stewardship and social responsibility.

1.2 Problem Statement

This study investigates the impact of the Norwegian government's policies, as outlined in the white paper "Meld. St. 20 (2019-2020)", on promoting sustainable practices in the fish farming industry. Employing a qualitative research approach with document analysis, the research assesses the extent to which the outcomes of the environmental strategies correspond with the aquaculture sector's actual environmental performance, as documented in the "Risikorapport Norsk Fiskeoppdrett 2024".

1.3 Research Questions

1. To what degree do the environmental sustainability strategies and intentions presented in "Meld. St. 20 (2019-2020)" correspond with the actual environmental results and challenges reported in the "Risk Report on Norwegian Aquaculture 2024"?

2. How do the regulatory frameworks and development trends in the aquaculture industry, as identified in the two documents, contribute to shaping the environmental and economic outcomes in the Norwegian fish farming sector?

3. What potential links and trade-offs between the environmental and economic aspects of sustainable aquaculture emerge from the analysis of the two documents?

1.4 Objectives

1. Conduct a qualitative document analysis of "Meld. St. 20 (2019–2020)" to understand the government's intentions and presented strategies for the fish farming industry.
2. Analyze the "Risikorapport Norsk Fiskeoppdrett 2024" to assess actual industry outcomes, focusing on environmental and economic metrics within the salmon and rainbow trout sectors.

3. Compare and contrast the findings from the two documents to determine the alignment or discrepancies between the government's stated goals and strategies and the real-world outcomes and challenges documented in the risk report.

1.5 Significance of the study

This study's findings are significant, not only in theoretical and practical terms but also in their direct relevance to the aquaculture industry. They provide a comprehensive understanding of the interplay between aquaculture policy intentions and industry outcomes, a crucial aspect of the industry's sustainable development.

Theoretically, it contributes to the discourse on aligning policies with real-world realities, highlighting the importance of evidence-based and adaptive policymaking. The study enhances understanding of policy theory application in aquaculture by demonstrating Hoogerwerf's approach of reconstructing and evaluating policy theories based on the assumptions underlying a policy. Hoogerwerf (1990) defines a policy theory as "the total of causal and other assumptions underlying a policy" and proposes criteria such as precision of formulation, differentiation, integration, empirical value, and legitimacy to evaluate the quality of a policy theory. The study applies this approach by reconstructing the prospective policy theory from government documents and statements and comparing it to the retrospective theory based on industry outcomes, thus highlighting any gaps between policy intentions and real-world impacts. This comparison of prospective and retrospective theories is valuable for identifying misalignments and informing adaptive policymaking. It also advances qualitative policy analysis methods through document analysis and causal mapping techniques.

From a practical standpoint, the study's recommendations offer a clear path for policy development and implementation in the Norwegian aquaculture sector. They provide actionable steps to enhance policy precision, differentiation, and empirical grounding, while also addressing economic-environmental trade-offs. This empowers policymakers to make informed decisions and implement effective changes.

Broadly, the study is relevant to other countries facing similar aquaculture challenges. It provides a framework for evaluating policy alignment with industry outcomes and a model for evidence-based, inclusive policymaking in aquaculture. Additionally, it contributes to the

global sustainable development discourse by underscoring the balance between economic growth and environmental sustainability through innovation, research, and collaboration.
This study advances theory informs practice in Norwegian aquaculture governance and offers broader lessons for sustainable aquaculture development globally.

1.6 Structure

This thesis is structured into seven chapters:

Chapter 1: Introduction Provides background, problem statement, research questions, objectives, and significance.

Chapter2: Literature Review Examines existing literature on Norwegian aquaculture's economic, regulatory, environmental, and technological aspects.

Chapter 3: Theoretical Framework Discusses policy theory application, Hoogerwerf's approach, and the plan for comparing policy intentions with industry outcomes.

Chapter 4: Methodology and Data Analysis Outlines the qualitative research design, document analysis methods, data collection, and analysis process.

Chapter 5: Findings This paper presents key findings from analyzing "Meld. St. 20 (2019–2020)" and "Risikorapport Norsk Fiskeoppdrett 2024," including a causal mapping analysis.

Chapter 6: Discussion Provides a comparative analysis of policy intentions and industry outcomes, evaluates the policy framework, and discusses implications.

Chapter 7: Conclusion Summarizes the main insights, offers recommendations, and discusses the broader relevance of the study's findings.

Chapter 2: Literature review

This literature review delves into the multifaceted realm of Norwegian aquaculture, focusing on the economic, environmental, and regulatory aspects that shape its sustainability and innovation. Through an examination of various studies, this review explores the evolution of aquaculture practices in Norway, notably the transition towards more sustainable methods like Recirculating Aquaculture Systems (RAS) and Integrated Multi-Trophic Aquaculture (IMTA), and the industry's response to challenges such as sea lice management, disease control, and environmental regulations. By analyzing the interplay between technological advancements, regulatory frameworks, and market dynamics, this review provides a holistic understanding of the current state and prospects of salmon farming in Norway. It underscores the critical role of collaborative efforts among researchers, government agencies, and industry stakeholders in navigating toward a sustainable and economically viable future for Norwegian aquaculture.

2.1 Economic analysis of land-based vs. sea-based salmon farming

Bjørndal and Tusvik's (2019) study provides an essential economic analysis of land-based salmon farming in Norway. It sheds light on the intricacies of Recirculating Aquaculture Systems (RAS) and their impact on production costs. The study thoroughly evaluates a prototype facility in Norway, highlighting the potential advantages, financial commitments, and structural expenses intrinsic to this nascent sector. It offers critical insight into the inherent challenges and prospects of land-based salmon farming.

The comparison within the study draws attention to the current prevalence of traditional sea-based farming versus the emerging promise of land-based operations. The sustainability issues faced by sea-based farming, particularly concerning sea lice and broader environmental impacts, are contrasted with land-based farming's potential for ecological amelioration. However, the study acknowledges the economic variables, such as the uncertainties introduced by technological and biological factors and the likelihood of higher production costs, which may dictate a cautious and methodical shift toward land-based farming.

Furthermore, the study recognizes that changes in production geography may recalibrate market dynamics, ushering new players into the industry and influencing global market shares. While land-based facilities offer logistical benefits, like proximity to consumer markets that may reduce transportation costs, innovations in sea-based farming continue to advance, potentially enhancing its viability and cost-competitiveness. The successful evolution of land-based salmon farming will significantly impact the industry, potentially reducing salmon prices and altering permit values.

Bjørndal and Tusvik (2019) underscore that the salmon aquaculture industry's future rests on many factors, including technological advancements, regulatory changes, market forces, and environmental mandates. The study calls for concerted efforts from research institutions, government agencies, equipment providers, and other industry stakeholders to navigate an environmentally sustainable and economically viable path for the future of salmon aquaculture in Norway.

2.2 Regulatory responses and company strategies

Vormedal and Skjærseth (2019) investigated how fish-farming companies in Norway responded to environmental regulations aimed at managing sea lice. Their study revealed a strategic divide based on company size. Smaller firms often adopt a reactive stance, opposing stricter regulations due to concerns about higher production costs and doubts about the effectiveness of the regulations in mitigating sea lice (Vormedal & Skjærseth, 2019). The authors cite statements from small company representatives expressing skepticism about the feasibility of complying with stricter sea lice limits, such as "With a 0.2 limit, you start to wonder what kind of measures you're supposed to implement. It's very difficult" (Vormedal & Skjærseth, 2019, p. 522).
In contrast, large firms tended to engage in proactive strategies, not only complying with but also supporting or advocating for more stringent regulations, which they perceived as opportunities to improve biological control, enhance their reputation, and strengthen competitive advantages (Vormedal & Skjærseth, 2019). The study provides evidence from interviews with large company executives highlighting their motivations, such as "We're affected by what our neighbors are doing, and if we lose control over sea-lice levels in one area, that's a big problem for everyone" (Vormedal & Skjærseth, 2019, p. 525).

They suggest that large firms' support for stricter regulations might have been motivated, at least partially, by predatory opportunities to increase their market share at the expense of smaller, disadvantaged competitors (Vormedal & Skjærseth, 2019). They base this argument on evidence from the uneven distribution of new production permits between small and large firms after stricter regulations were introduced and statements from industry representatives acknowledging the competitive advantages of large firms in complying with regulations (Vormedal & Skjærseth, 2019, p. 530).

These regulatory measures and corporate strategies should be considered in the broader framework of the global aquaculture industry's swift expansion and related environmental challenges. Frankic and Hershner (2003) provide an overview of these trends, noting that "landings from worldwide aquaculture have been increasing rapidly in the last decade, approximately 10–15% per year, depending on the reference sources" (Frankic & Hershner, 2003, p. 517). They highlight the dominance of Asian countries, particularly China, in driving this growth.

However, the authors also underscore the significant environmental and social challenges that have accompanied this rapid expansion, stating that "aquaculture development continues to be hindered by a number of constraints. These include limited suitable sites, concerns regarding negative environmental impacts, and multi-use conflicts" (Frankic & Hershner, 2003, p. 518)—emphasizing the need for a more sustainable approach to aquaculture that balances "environmental, social, and economic factors" (Vormedal & Skjærseth, 2019, p. 522).

(Henriksson et al., 2021) delves further into specific interventions to improve global aquaculture's productivity and environmental performance. They discuss the potential of regulations to promote sustainable practices and acknowledge their role as barriers to certain aspects of aquaculture development, such as site selection and new technologies.

The authors state: "Regulations can address more comprehensive sets of farms and farming practices but have also been seen as a barrier for potential grow-out sites, therapeutics, access to fresh water, effluent discharge, and the use of genetically modified organisms (GMOs), non-indigenous species, and novel feed ingredients" (Henriksson et al., 2021, p. 1227).
Henriksson et al. (2021) also highlights the importance of financial tools and socio-economic interventions in enabling small-scale farmers to adopt sustainable practices. They note that "many smallholder farmers cannot benefit from farm improvements, such as quality feed, seed, and disease diagnostics, due to limited access to credit."

However, the authors point out gaps and limitations in the current understanding of proposed interventions' long-term impacts and economic feasibility, particularly in diverse geographical contexts and for small-scale operators. They call for further research to address these knowledge gaps and to develop more targeted, context-specific solutions.

The study by Vormedal and Skjærseth (2019) illuminates how company size, and the pursuit of competitive advantage can shape corporate attitudes toward environmental regulations within an industry, providing evidence from interviews, industry statements, and regulatory outcomes. Frankic and Hershner (2003) contextualize these findings within the broader challenges of balancing economic growth and environmental sustainability in the rapidly expanding global aquaculture sector.

Henriksson et al. (2021) contributes to this discussion by identifying specific regulatory, technological, and socio-economic interventions that could enhance aquaculture practices' sustainability while highlighting the need for further research on the feasibility and impacts of these solutions in different contexts.

Together, these studies underscore the complex interplay between environmental regulations, company strategies, and the aquaculture industry's broader sustainability challenges. They highlight the need for regulatory frameworks that are both effective in protecting the environment and sensitive to aquaculture operators' diverse capacities and constraints, particularly smallholders. Achieving this balance will require close collaboration between policymakers, industry stakeholders, and researchers to develop evidence-based, context-specific solutions that promote the long-term viability and sustainability of the global aquaculture sector.

2.3 Environmental sustainability in Norwegian aquaculture

According to Grefsrud et al. (2021), the research provides a comprehensive overview of environmental sustainability challenges in Norwegian fish farming, focusing on issues such as sea lice management, viral disease transmission, and the impact of escaped farmed salmon on wild populations.

The report highlights a significant reduction in the usage of medicines against sea lice since 2018, with a shift towards feed-based treatments. The environmental impact of these treatments is evaluated, with azamethiphos considered low risk and others posing moderate risks. The use of cleaner fish, such as lumpfish and wrasse, is discussed as an eco-friendly alternative to chemical treatments for managing sea lice in Norwegian aquaculture. These fish species naturally prey on sea lice, potentially reducing the need for chemical delousing agents, which can have broader environmental impacts. However, concerns remain about the sustainability and ecological implications of sourcing these cleaner fish from wild populations, including potential impacts on their natural stocks and the broader marine ecosystem Grefsrud et al.

(2021). The report also assesses animal welfare in fish farming, detailing hatchery challenges and the impact of frequent delousing operations. It introduces a risk assessment methodology for evaluating the potential environmental impacts of fish farming activities.

In evaluating the aquaculture industry's environmental policies and management approaches, it is important to consider general frameworks for policy evaluation and insights specific to environmental impact assessments (EIA) in aquaculture. The study "A Framework for Evaluating Environmental Policy Instruments" by Mickwitz (2003) employs a qualitative methodology to review environmental policy evaluations and introduces a tailored framework. It highlights the unique complexities of environmental problems, such as long timescales, geographical dispersion, and intricate cause-effect relationships, which necessitate tailored evaluation approaches. The proposed framework incorporates these aspects, focusing on assessing side effects, using diverse criteria (economic, democratic), and integrating multiple methods for comprehensive analysis.

Complementing this, the work by Herrick and Sarewitz (2000), "Ex Post Evaluation: A More Effective Role for Scientific Assessments in Environmental Policy," argues for a shift towards ex-post evaluation, where scientific assessments are used after policy implementation to assess impacts rather than relying solely on predictive assessments during policy formulation. They contend that ex-post evaluations can provide more practical guidance for informed policy adjustments, as predictive assessments are often limited by uncertainties inherent to complex environmental issues.

Specific to the aquaculture context, the "Review of Environmental Impact Assessment and Monitoring in Aquaculture in Europe and North America" by Telfer et al. (2009) evaluates the practices and effectiveness of EIA and monitoring in the sector. The study finds significant variability in how EIA is implemented across regions, often facing challenges related to consistency, integration across government levels, and effective public consultation. Notably, the review highlights a need for more empirical evidence on the cost-effectiveness of EIAs in aquaculture and their overall impact on environmental outcomes.

The study indirectly addresses the potential misalignment between the policy intentions behind EIAs and the industry's actual environmental performance. It discusses how EIAs are frequently not applied to the bulk of global small-scale and traditional aquaculture production, and even when conducted, systemic and practical challenges limit their effectiveness in managing environmental impacts as intended.

These works underscore the importance of tailored policy evaluation frameworks that consider the unique complexities of environmental issues. They also highlight the potential discrepancies between policy intentions and real-world outcomes and the need for iterative, evidence-based adjustments informed by rigorous ex-post assessments. As Norway continues to refine its regulatory approach towards environmentally sustainable aquaculture, these insights can inform the evaluation and alignment of policies with desired environmental objectives.

2.4 Frameworks for managing Norwegian Salmon Fjords

Aasetre and Vik (2013) analyze the prevailing discourse on the management of Norwegian salmon fjords, presenting two contrasting frameworks: the conservation frame and the technology frame. These frames represent different approaches to mitigating aquaculture's impacts on wild salmon populations.

The conservation frame emphasizes territorial strategies, advocating for creating designated areas like salmon rivers and fjords with specific management protocols to protect wild salmon habitats. In contrast, backed by the aquaculture industry, the technology frame prioritizes proactive, targeted interventions and technical solutions to address environmental challenges.

The conservation frame conveys a pressing need for immediate and extensive protective actions for wild salmon stocks, while the technology frame advocates for a managed approach through technological solutions, suggesting a less urgent need for action. The two frames agree on the necessity of a rational management process and partially overlap in their support for technical strategies. However, they must diverge their stance on territorial strategies and the urgency of wild salmon threats.

Often associated with governmental and environmental NGO actors, the conservation frame leans towards spatial protection and stricter regulations. The technology frame, supported by the aquaculture industry, favors technical solutions and targeted actions. This divergence reveals conflicting interests and distinct knowledge paradigms, with the conservation frame rooted in "fortress conservation" and the technology frame aligned with industrial discourse emphasizing technological and managerial solutions.

2.5 Scientific knowledge and policy

Amidst the strategic and economic evaluations, the interplay between scientific knowledge and policymaking emerges as a pivotal force shaping the sustainability efforts within Norway's salmon farming industry. Movik and Stokke (2015) explore this interplay in the context of Nordland, a county with a large fish farming industry and significant engagement in the discourse regarding the environmental impact of aquaculture. The region exemplifies the contentious debates on the extent of potential adverse effects on wild salmon stocks, where conflicting views on the knowledge base lead to divergent framing of the problem.

Particularly, the management of salmon lice, naturally occurring parasites, illustrates the complex responsibilities of the farming industry in monitoring and reporting, as well as the implementation of countermeasures when lice densities exceed regulatory thresholds. This operational aspect is embedded in the scientific-policy nexus, where the precision of data and the interpretation of its implications for wild salmon stocks are debated. Moreover, the concern that farmed salmon may replace wild salmon in several rivers adds a layer of urgency to the dialogue, with implications for the region's ecological integrity and the county's self-reproducing salmon stocks.

2.6 Innovation in sustainable aquaculture practices

The study by Joffre et al. (2017) systematically examines how aquaculture innovation is conceptualized and managed, utilizing an analytical framework based on existing innovation theory. Their methodology involves a systematic literature review pulled from databases such as Scopus and ASFA and an analysis through the developed framework. The findings underscore a prevailing dominance of technology-driven approaches, particularly the Transfer of Technology (ToT), which continues to overshadow other innovation strategies. However, there is an emerging trend towards systemic approaches, recognizing the multifaceted nature of aquaculture systems that integrate technical, biophysical, political, and institutional dimensions. Despite these advancements, the study identifies significant gaps, particularly the

limited cross-fertilization between different innovation approaches and relative neglect of institutional and political dimensions in managing aquaculture innovation.
These insights from Joffre et al. (2017) support the rationale for integrating innovation system approaches into aquaculture policy research. This integration can foster a more comprehensive understanding of the complex interactions within aquaculture systems and highlight the importance of inclusive and multidimensional innovation strategies. The study suggests that enhancing engagement with the private sector and emphasizing systemic approaches could improve the management of innovation processes, addressing both technological advancements and broader socio-economic impacts.

The Norwegian salmon industry's exploration of Integrated Multi-trophic Aquaculture (IMTA), as discussed by Ellis and Tiller (2019), exemplifies a sustainable practice with the potential to mitigate environmental impacts significantly. IMTA involves co-cultivation of different marine species at various trophic levels to recycle waste more effectively. Despite its ecological and economic potential, the progression of IMTA in Norway faces challenges due to existing regulatory frameworks that need to be faster to accommodate such innovative methods. The study highlights the necessity for regulatory evolution to support IMTA, balancing ecological benefits against public concerns associated with salmon farming, such as the risk of increased escapes and broader ecosystem impacts.

Furthering the discussion, Ellis and Tiller (2019) propose Regional Multitrophic Aquaculture (RMTA) as an interim solution that could harmonize the industry's expansion demands with the sustainable use of marine spaces. RMTA aims to foster political support through strategic policy development, potentially leading to more sustainable practices, such as producing marine ingredients for fish feed that support coastal employment and environmental enhancement.

The discussion of Joffre et al. (2017) alongside Ellis and Tiller (2019) reveals a critical insight into the dynamic between innovation management and sustainable practices within aquaculture. The alignment of policy, innovation, and regulatory frameworks is crucial for advancing sustainable methodologies like IMTA, illustrating the need for a holistic approach that integrates environmental, technological, and socio-economic factors. This comprehensive approach can position Norway as a leader in developing globally recognized sustainable aquaculture systems that are independent of external mandates and tailored to local ecological needs.

So far, the studies have focused on various aspects of aquaculture sustainability, innovation, and policy responses. However, to systematically analyze and evaluate the effectiveness of aquaculture policies in promoting sustainable practices, it is essential to draw upon relevant theoretical frameworks from the field of policy analysis. Several studies have applied policy theory reconstruction approaches and examined the role of explanatory and normative frameworks in environmental and aquaculture policy analysis.

2.7 Theoretical Approaches to Analyzing Aquaculture Policies

Several studies have applied policy theory reconstruction approaches and examined the role of explanatory and normative frameworks in environmental and aquaculture policy analysis.
Mickwitz (2003) proposes a framework tailored explicitly for evaluating environmental policy instruments. The framework addresses the unique challenges in assessing environmental policies, such as their complexity, long time frames, and geographically dispersed effects. Mickwitz emphasizes the importance of understanding the intervention theories underlying policies - how they are intended to work versus their actual impact. This aligns with Hoogerwerf's approach to reconstructing policy theory by analyzing the assumptions and hypothesized causal mechanisms. Mickwitz stresses, "If the evaluation of environmental policy is undertaken without due consideration of the specifics involved, there is a great risk of identifying only minor impacts and low effectiveness." (Mickwitz, 2003, p. 433). This underscores the value of applying policy theory reconstruction to unpack the complex dynamics of environmental policies.

Herrick and Sarewitz (2000) challenge the traditional reliance on predictive scientific assessments (an explanatory approach) in guiding environmental policy development. They argue that these ex-ante assessments are inherently limited due to uncertainties and the complexity of environmental issues. Instead, they advocate for a shift towards ex-post evaluation, assessing actual policy impacts after implementation. This represents a more normative approach, focused on adjusting policies based on observed outcomes rather than predicted effects. They suggest that "the adaptive management model... offers a more effective

framework for the role of science in environmental policy." While not explicitly using Hoogerwerf's terminology, their argument illustrates the distinction and interplay between explanatory and normative approaches in environmental policy analysis.
Widerberg (2017) applies a "reconstructing intervention theory" method to analyze the effectiveness of the Lima-Paris Action Agenda. By detailing the assumptions and expected causal mechanisms underlying this climate agreement, Widerberg (2017) aims to "uncover the assumptions, mechanisms, and goals behind the LPAA." This approach enables a more nuanced evaluation of complex international environmental agreements, although Widerberg (2017) notes the empirical challenges in verifying all assumed linkages between inputs, outputs, and outcomes.

Examining the aquaculture sector specifically, Krause et al. (2015) highlight the "people-policy gap" - a disconnect between communities' socio-economic realities and aquaculture policies intended to benefit them. They stress the importance of integrating diverse methodologies, including policy analysis and stakeholder analysis, to understand the complex socio-economic implications of aquaculture policies. Krause et al. (2015) argue that aquaculture policies often prioritize ecological or production-oriented explanatory frameworks over normative socio-economic considerations, leading to unintended consequences and a lack of social sustainability.

These studies demonstrate the relevance and value of applying policy theory reconstruction approaches and examining the interplay of explanatory and normative frameworks in environmental and aquaculture policy analysis. These approaches enable more nuanced and effective policy evaluation by unpacking the underlying assumptions, intervention logic, and potential gaps between intended and actual outcomes. However, the studies also highlight the methodological challenges in fully operationalizing these frameworks, given the complexity of socio-ecological systems. Further empirical applications and integrations of these concepts in aquaculture policy analysis could strengthen their practical utility in informing more inclusive and sustainable policies.

2.8 Critiques of Sustainability in Norwegian Aquaculture

Hansen (2019) examines the nuances of this transformation within Norway's salmon farming through his bioeconomic lens. In 'The Weak Sustainability of the Salmon Feed Transition in Norway' Hansen employs a Multi-Level Perspective to assess the industry's shift from traditional wet feed to modern alternatives like soy-based feed, a move driven by economic efficiency yet fraught with environmental and social dilemmas, such as deforestation and the displacement of indigenous communities.

Hansen's analysis challenges the notion of aquaculture as a purely sustainable solution, noting its contribution to increased global protein consumption and potential pressure on ecosystems. She also critically views the industry's response to sustainability, marked by a pivot in the 1990s from rural support to a national economic focus. This change has intensified the struggle to balance economic and environmental goals.

Exploring alternatives, Hansen discusses the potential of insect-based protein and algae to lessen environmental impact. Yet she stresses the complexities of evaluating these options, advocating for standardized life cycle assessments. Her conclusions on 'weak sustainability' in salmon feed transition call for an integrated approach that considers not just economic but also environmental and social factors.

Hersoug (2015) provides a complementary perspective to Hansen's critique of the "weak sustainability" of salmon feed transition by analyzing critical reforms in the Norwegian salmon industry to address environmental sustainability. Hersoug's study, titled "The greening of Norwegian salmon production" examines the industry's efforts to balance economic growth with environmental management, highlighting the challenges faced during the industry's significant growth over the last 45 years, such as sea lice and escapes.

One notable reform discussed is the introduction of green and super-green licenses, which allow farmers to expand production if they adopt new solutions to mitigate environmental issues like sea lice. Another proposal for incremental growth on strict conditions, offering a five percent production increase provided low sea lice levels are maintained, was met with skepticism due to the difficulty in meeting these conditions.

Hersoug also discusses the proposed new allocation regime for regulating growth, which presents three alternatives ranging from continuing current practices to linking growth to environmental indicators. Additionally, the study examines the implementation of a sanction regime that reduces the maximum allowable biomass at farms consistently violating louse limits, emphasizing systematic data collection, and enforcing production capacity reductions for non-compliance.

The study highlights the challenges with sustainability measures, particularly the focus on sea lice frequency as the primary indicator and debates over its connection to wild salmon and trout stocks, the scientific basis for threshold values, and concerns about farmers' under-reporting. Hersoug also touches upon the confusion caused by blending the license system with the locality system, which could hinder achieving sustainable industry goals.

In conclusion, Hersoug's analysis presents a detailed picture of the Norwegian salmon industry's endeavors to achieve sustainability, underscoring the importance of environmental sustainability as a core focus, with reforms like green licenses acting as tools for sustainable expansion. The study illustrates the complex interplay between environmental sustainability, economic growth, and regulatory challenges in the industry, highlighting the uncertainties surrounding the effectiveness of 'green growth' initiatives in resolving primary issues and accommodating industry growth.

2.9 Regulatory reforms and environmental management

The aquaculture industry's rapid growth has raised concerns about its ecological and social sustainability practices, necessitating regulatory reforms and environmental management strategies. Norway, a significant player in global aquaculture, has implemented innovative approaches to address these challenges. Olaussen (2018) traces the evolution of aquaculture regulation in Norway, highlighting a gradual shift towards more sustainable practices. A significant regulatory innovation is the "traffic light system," which manages production levels based on the impact of sea lice on wild salmon mortality. Zones are colored green, yellow, or red, dictating allowed production levels accordingly. While this system addresses the critical issue of sea lice, the study notes potential limitations, such as an excessive focus on this single factor, while overlooking other critical concerns like escapement, genetic mixing, and broader ecological impacts.

Complementing this Olaussen's analysis, Osmundsen et al. provide insights into the operationalization of sustainability within aquaculture certification schemes. Their findings reveal significant discrepancies across different certifications, with an overwhelming emphasis on environmental and governance indicators, while economic and cultural dimensions are largely neglected. This skewed focus may undermine the comprehensiveness and effectiveness of these certifications in fostering genuinely sustainable practices that address sustainability holistically.

These studies underscore the pivotal role of regulatory frameworks and certification schemes in shaping the Norwegian aquaculture industry's environmental, economic, and social outcomes. Norway's efforts towards sustainability are evident in innovations like the traffic light system, which reflects a robust scientific consensus on the potential impacts of farm sea lice on wild salmon populations. However, the studies also highlight potential gaps, such as an excessive emphasis on single issues like sea lice, neglecting broader dimensions of sustainability, and the need for a more holistic approach that considers economic, cultural, and institutional factors alongside environmental concerns.

The Norwegian Food Safety Authority collaborates with research institutes like the Institute for Marine Research to manage emerging problems and uncertainties. This ensures a knowledge-based, precautionary approach to updating sea-lice regulations and protecting wild salmon populations. This collaborative approach is commendable and demonstrates Norway's advanced integration of wild salmonid health into its regulatory practices.

Nonetheless, these works emphasize the need for continuous refinement and adaptation of regulations based on scientific knowledge and collaborative efforts, as well as the importance of addressing potential limitations and considering a more holistic approach that integrates technical, biophysical, economic, social, and institutional dimensions for better management of the innovation process and fostering a genuinely sustainable aquaculture industry.

2.10 Foreign Direct Investments and Norway's relationship with the EU

Maurseth and Medin (2020) provide valuable insights into the patterns and drivers of foreign direct investments (FDI) in the Norwegian seafood industry, focusing on the role of Norway's relationship with the EU. The article highlights the differences in ownership structures and regulations across the fishing, aquaculture, and fish processing sectors, noting that while fishing is primarily domestically owned, the aquaculture industry is characterized by multinational firms.

The authors introduce a theoretical framework for examining FDI decisions, considering trade costs, tariffs, and firm productivity. They find that the EEA agreement, which grants Norway access to the EU's single market, has facilitated FDI in the seafood industry, particularly in the aquaculture- and fish processing sectors. However, the agreement also allows for tariffs on processed fish exports from Norway, which incentivizes Norwegian firms to invest in processing facilities within the EU.

Maurseth and Medin (2020) also examine the potential impact of alternative trade agreements between Norway and the EU on FDI in the fisheries sector. They argue that a reversion to WTO rules or a new free trade agreement could lead to higher tariffs on processed fish, further encouraging Norwegian investments in the EU. Conversely, full EU membership could reduce the need for Norwegian firms to invest in the EU, as they would gain tariff-free access to the single market.

The article's findings underscore the complex interplay between trade policies, FDI patterns, and industry dynamics in the Norwegian seafood sector. They highlight the importance of considering the role of international trade and investment when analyzing the sustainability and governance of the aquaculture industry.

In conclusion, this literature review illuminates Norway's aquaculture policy's dynamic and responsive nature, shaped by a complex interplay of domestic priorities, international trade relationships, and sustainability considerations. The studies revealed a nuanced interaction between economic viability, environmental sustainability, regulatory compliance, and foreign direct investments, navigated by Norway in its dedication to maintaining a responsible and competitive aquaculture sector.

Chapter 3: Theoretical Framework

Correct choice of theoretical framework is crucial, as it provides the lenses for the analysis. Theoretical framework is defined as the structure that supports a theory of a research study and describes the theory which explains why the research problem under study exists (Sacred Heart University, 2022). In this study, the theoretical framework draws on key concepts and analytical approaches from policy theory literature, particularly the works of Hoogerwerf (1990) and Mercer et al. (2021), to reconstruct and assess the policy theory underlying the Norwegian government's strategies for the fish farming industry and the industry's actual performance. The study employs Hoogerwerf's approach to policy theory reconstruction, focusing on identifying causal assumptions and hypotheses and assessing the policy framework's precision, differentiation, empirical justification, and validity.

3.1 Policy Theory and Its Application

As defined by Hoogerwerf (1990), policy theory represents "the total of causal and other assumptions underlying a policy." This theory encompasses a set of propositions, assumptions, and frameworks that seek to explain, predict, and prescribe the mechanisms through which public policies are conceived, implemented, and evaluated. It is a conceptual foundation for understanding the complex and dynamic processes that transform policy ideas into concrete actions and outcomes. The critical components of policy theory include:

Explanatory frameworks: These theoretical approaches describe and explain how policy processes unfold in practice. They aim to identify the key factors, variables, and causal relationships that influence policy agenda-setting, formulation, adoption, implementation, and evaluation. These frameworks often draw upon various social science disciplines, including political science, economics, sociology, and psychology, providing a comprehensive understanding of policy dynamics.

Normative frameworks: These frameworks prescribe how policies should be formulated and the principles that should guide policymaking. They establish value-based criteria and standards for assessing policy options and outcomes' desirability, legitimacy, and effectiveness. Depending on the underlying political and philosophical orientations, these frameworks may emphasize different goals and priorities, such as efficiency, equity, transparency, accountability, and public participation.

Policy theory recognizes the critical role played by various individuals, groups, and organizations in shaping policy processes and outcomes. It examines policy actors' motivations, interests, resources, and strategies—including elected officials, bureaucrats, experts, interest groups, media, and citizens—and considers the institutional contexts that enable and constrain actor behavior and policy choices.

Policy outcomes and impacts: This component of policy theory analyzes the substance of policy proposals and the tools and techniques used to achieve policy objectives. It investigates how policy problems are defined, the solutions considered, and the selection and design of policy instruments like regulations, subsidies, taxes, and information campaigns. Policy theories also explore the assumptions, trade-offs, and implications of various policy approaches and their potential impacts on target populations and society.

3.1.1 Relevance of Policy Theory for analyzing intentions and outcomes

Policy theory is indispensable for analyzing the alignments between policymakers' intentions, as expressed in official statements, plans, and programs, and the actual outcomes and impacts of these policies in practice. By offering a structured and thorough framework for exploring the underlying assumptions, causal reasoning, and normative principles of policies, policy theory helps to unravel the complexities and nuances of policy processes and to identify the factors that shape policy success or failure. This theoretical method is essential for grasping the strengths and weaknesses of policy designs and anticipating potential challenges and unintended consequences, thereby thoroughly examining the efficacy and implications of governmental strategies in the Norwegian fish farming industry.

3.2 Developing a Theory of Change

The central component of the theoretical framework is the development of a Theory of Change, which is presented as a causal map. The Theory of Change represents the assumed causal relationships and mechanisms that link the Norwegian government's aquaculture policies to their intended outcomes, particularly regarding environmental sustainability.

The initial Theory of Change is constructed drawing on findings from the literature review and the theoretical foundations of policy theory. It identifies the key elements and pathways through which the policies outlined in the whitepaper "Meld. St. 20 (2019–2020)" (Klima- og miljødepartementet, 2020) are expected to influence the environmental performance of the Norwegian aquaculture industry.

The causal map visually represents the complex interplay between policy interventions, industry practices, environmental challenges, and sustainability outcomes. It highlights the anticipated causal mechanisms and feedback loops that shape the dynamics of the aquaculture sector.

3.3 Hoogerwerf's Approach to Policy Theory Reconstruction

To further develop and refine the Theory of Change, the study employs Hoogerwerf's (1990) systematic approach to policy theory reconstruction. This approach involves two key dimensions:

1. Identifying causal assumptions and hypotheses: This step involves explicating the underlying assumptions about the causes and consequences of policy problems and the expected effects of policy interventions. Causal mapping techniques visualize these assumptions and hypotheses, focusing on environmental impacts, economic performance, technological innovation, and regulatory frameworks.

1. Evaluating policy theory quality: Hoogerwerf proposes a set of criteria for assessing the quality and robustness of the policy theory, including precision and differentiation, empirical justification, and validity. These criteria guide the evaluation of the policy framework's strengths and weaknesses, informing recommendations for future policy development and implementation.

3.4 Causal Map: Visualizing the Theory of Change

The causal map presented in Figure 1 is a visual representation of the Theory of Change underlying this study. It depicts the assumed causal relationships and pathways through which the Norwegian government's aquaculture policies, as outlined in the white paper "Meld. St. 20 (2019–2020)," are expected to influence the environmental sustainability and economic performance of the Norwegian aquaculture industry.

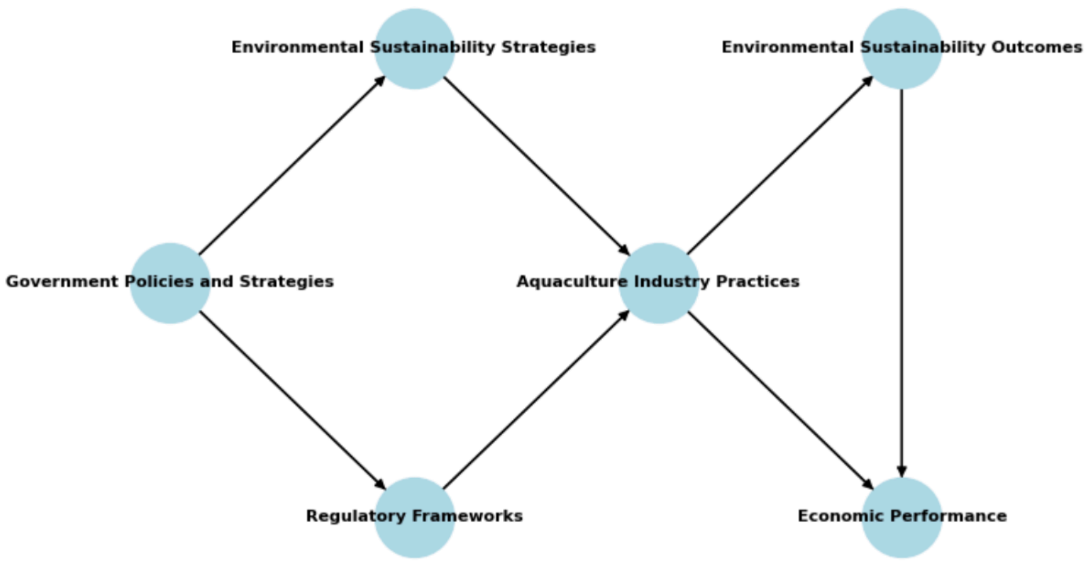

Figure 1: Causal Map

1. **Government Policies and Strategies**: This central element represents the policies, regulations, and strategies outlined in the whitepaper "Meld. St. 20 (2019-2020)," which are hypothesized to influence various aspects of the aquaculture industry.
2. **Environmental Sustainability Strategies**: This element represents the strategies and initiatives aimed at promoting environmental sustainability within the aquaculture industry, which are assumed to be shaped by the government policies and strategies.
3. **Regulatory Frameworks**: This element represents the regulatory frameworks governing the aquaculture industry, which are hypothesized to be influenced by the government policies and strategies, and, in turn, shape the industry practices.
4. **Aquaculture Industry Practices**: This element represents the actual operations and practices of the aquaculture industry, which are expected to be influenced by the regulatory frameworks and environmental sustainability strategies and are assumed to have a direct impact on both environmental sustainability outcomes and economic performance.
5. **Environmental Sustainability Outcomes**: This element represents the intended environmental sustainability outcomes, which are hypothesized to be influenced by the aquaculture industry practices.

6. **Economic Performance**: This element represents the economic performance of the aquaculture industry, which is assumed to be influenced by the aquaculture industry practices and potentially impacted by the environmental sustainability outcomes.

The linkages and causal pathways in the initial causal map are based on theoretical assumptions derived from the existing literature and the study's problem statement, research questions, and objectives outlined in Chapter 1.

The causal map explicates the assumed causal relationships and pathways and serves as a guiding framework for the empirical analysis and policy evaluation conducted in this study. It informs the selection of key variables and indicators to be examined in the analysis of the white paper and the risk assessment report and provides a basis for assessing the coherence, feasibility, and effectiveness of the Norwegian aquaculture policy framework.

Throughout the study, the causal map will be iteratively refined and updated based on the insights gained from the empirical analysis. This adaptive approach ensures that the theoretical framework remains grounded in the real-world dynamics and challenges of the Norwegian aquaculture industry, enhancing the relevance and usefulness of the study's conclusions and recommendations for policy and practice.

3.5 Comparative Analysis of Prospective and Retrospective Policy Theories

The study also emphasizes the value of comparing the prospective policy theory, as articulated in "Meld. St. 20 (2019–2020)," (Klima- og miljødepartementet, 2020) with the retrospective policy theory, as evidenced by the actual outcomes and practices documented in the "Risikorapport Norsk Fiskeoppdrett 2024." (Grefsrud et al., 2024). This comparison allows for an assessment of the alignment or divergence between policy goals and actual results, facilitating policy learning and innovation.

The comparative analysis is guided by a set of evaluative criteria, including coherence, feasibility, effectiveness, legitimacy, and adaptability. These criteria provide a framework for examining the logical consistency, practicality, goal attainment, public acceptance, and flexibility of the policy theories considering the empirical evidence.

Chapter 4: Methodology & Data Analysis

4.1 Research Design

4.1.1 Qualitative Research Approach and Document Analysis

This study adopts a qualitative research approach, with document analysis to examine policy intentions and industry outcomes in the Norwegian aquaculture sector. The depth of the qualitative research approach is particularly suitable for this study as it allows for an in-depth exploration of complex social phenomena, such as the relationship between government policies and real-world industry performance. Creswell, 2009 characterizes qualitative research as a method to grasp the significance individuals or groups allocate to a social or human problem. It involves a research process where questions and procedures may evolve, data is collected in natural settings, analysis builds inductively from specifics to general themes, and the researcher interprets the data's meaning.

The study focuses on document analysis to uncover the underlying themes, patterns, and meanings embedded in the selected policy document and risk assessment report. This comprehensive examination of the content, context, and implications of the two primary data sources, "Meld. St. 20 (2019-2020)" and "Risikorapport Norsk Fiskeoppdrett 2024," offers a detailed and complex insight into the research problem (Bowen, 2009).

The document analysis process employed in this study follows a phenomenological approach, which aims to construe the meaning of the documents, both at the surface level and in their underlying connotations (Armstrong, 2021). This approach involves interpretative analysis, historical research, hermeneutics, narrative analysis, and aesthetic considerations to uncover the deeper meanings and contextual factors shaping the understanding and interpretation of the selected documents.

4.1.2 Systematic and in-depth examination of primary data sources

To conduct a systematic and in-depth examination of the primary data sources, the following steps were taken:

1. "Meld. St. 20 (2019-2020) (Klima- og miljødepartementet, 2020) was carefully analyzed to reconstruct the Norwegian government's policy intentions, strategies, and priorities for the sustainable development of the aquaculture industry.
2. "Risikorapport Norsk Fiskeoppdrett 2024" (Grefsrud et al., 2024) was thoroughly examined to gain insights into the actual environmental, economic, and social outcomes and challenges faced by the Norwegian aquaculture industry.

By employing document analysis to examine both the policy document and the risk assessment report, this study aims to provide a holistic and balanced understanding of the complex dynamics between policy intentions and industry outcomes by employing document analysis to examine both the policy document and the risk assessment report. This approach allows for a critical evaluation of the alignment or discrepancies between the government's stated goals and priorities and the actual experiences and performance of the aquaculture sector.

4.1.3 Justification for document selection

The selection of "Meld. St. 20 (2019–2020)" and "Risikorapport Norsk Fiskeoppdrett 2024" as the primary data sources for this study are justified by their relevance, significance, and complementarity in addressing the research objectives. "Meld. St. 20 (2019–2020)," as a whitepaper issued by the Norwegian government, represents the most recent and authoritative statement of the government's policies, strategies, and priorities for the aquaculture industry. This document provides a comprehensive overview of the government's vision for the sector's sustainable development and economic growth, outlining specific goals, targets, and initiatives to be implemented in the coming years.

As such, "Meld. St. 20 (2019–2020)" is a crucial source for understanding the government's intentions and policy theories underlying its approach to aquaculture governance. By analyzing this document, the study aims to reconstruct the assumptions, values, and evidence base informing the government's decision-making processes and policy choices, providing a foundation for assessing the coherence and feasibility of the proposed strategies.

In contrast, "Risikorapport Norsk Fiskeoppdrett 2024" offers a detailed and evidence-based assessment of the actual outcomes, challenges, and risks the Norwegian aquaculture industry faces. This report, prepared by independent experts and stakeholders, provides a comprehensive overview of the sector's environmental, economic, and social performance, highlighting key trends, data, and case studies. By analyzing this document, the study aims to gain insights into the real-world implications and consequences of the government's policies and strategies, identifying potential gaps, unintended effects, and areas for improvement.

The selection of these two documents is further justified by their complementarity in addressing the research objectives. The study aims to provide a more comprehensive and nuanced understanding of the alignment or discrepancies between policy intentions and industry outcomes by comparing the findings from the policy document and the risk assessment report. This approach allows for a critical evaluation of the effectiveness and appropriateness of the current policy framework, contributing to evidence-based recommendations for future policy development and industry practices.

Moreover, the focus on these two documents is appropriate given the study's scope and limitations. As a qualitative research project based primarily on document analysis, selecting a targeted set of highly relevant and authoritative sources ensures the feasibility and manageability of the research process while still providing a rich and diverse dataset for analysis. While additional documents or data sources could have been beneficial, their inclusion was optional for achieving the objectives of this research.

In summary, the selection of "Meld. St. 20 (2019–2020)" and "Risikorapport Norsk Fiskeoppdrett 2024" as the primary data sources for this study are justified by their relevance, significance, and complementarity in addressing the research objectives. These documents provide a comprehensive and balanced view of the Norwegian aquaculture sector, enabling a critical examination of the relationship between policy intentions and industry outcomes and contributing to evidence-based insights and recommendations for sustainable and effective aquaculture governance.

4.2 Data Collection

The data collection process was meticulously planned to gather relevant documents and statistical data that shed light on the interactions between 'Meldinger til Stortinget,' environmental sustainability measures, and economic performance within the Norwegian salmon farming industry. A targeted search was conducted across relevant governmental departments using specific search terms related to salmon farming and aquaculture. Table 1 outlines the structured approach employed, highlighting the search terms, themes, departments involved, and the resulting documents deemed pertinent for this study. Furthermore, economic and sustainability data were systematically compiled to provide a quantitative foundation for analyzing the impact of 'Meldinger til Stortinget.' This section details the comprehensive search strategy and data collection methodology that underpins the subsequent analysis.

4.2.1 Initial Data Collection Plan

The data collection process was initially designed to gather relevant documents and statistical data that illuminate the interactions between 'Meldinger til Stortinget,' environmental sustainability measures, and economic performance within the Norwegian salmon farming industry. A structured approach was employed, utilizing specific search terms related to salmon farming and aquaculture across relevant governmental departments. The table below outlines the search strategy, including search terms, themes, departments involved, and the resulting documents identified as pertinent to the study.

Search Term	Theme	Department	Hits	Relevant documents	Search Date
Oppdrett	Klima og Miljø	Klima – og miljødepartementet	30	St.meld. nr. 33 (1999-2000), St.meld. nr. 12 (2001-2002), St.meld. nr. 42 (2000-2001), St.meld. nr. 14 (2006-2007)	28.02.2024
None	Fiskeri og Havbruk	Klima – og miljødepartementet	3	Meld. St. 26 (2022–2023), Meld. St. 20 (2019-2020), Meld. St. 35 (2016–2017)	28.02.2024
None	Klima og Miljø	Nærings – og fiskeridepartementet	5	-	28.02.2024
Laks	-	-	207	Meld. St. 22 (2012–2013), Meld. St. 19 (2019–2020)	01.03.2024
Lakseoppdrett	-	-	30	Meld. St. 16 (2014-2015)	01.03.2024
Oppdrettslaks	-	-	40	Meld. St. 10 (2010–2011)	01.03.2024

Table 1: Search strategy plan

In addition to the document search, economic and sustainability data was planned to be compiled to provide a quantitative foundation for analyzing the impact of 'Meldinger til Stortinget.' This approach aimed to establish a comprehensive data set that would support a thorough analysis of the research questions.

4.2.2 Revision of Data Collection Strategy

During the data collection phase for the quantitative analysis, I stumbled upon a significant series of risk reports published by Havforskningsinstituttet (Institute of Marine Research), including the recently released "Risikorapport Norsk Fiskeoppdrett 2024" (Risk Report for Norwegian Fish Farming 2024). Upon closer inspection, it was realized that a substantial portion of the statistical data points that were needed for the analysis were already presented in this report, marking a crucial turning point in the research.

Recognizing the comprehensive nature of the risk report and its relevance to the research objectives, the decision was made to shift the focus of the study to a qualitative analysis approach. This shift aimed to leverage the wealth of information provided in the "Risikorapport 2024", a valuable resource that contains a vast array of data points. By doing so, I avoided duplicating data collection and analysis efforts, a move that underscores the significance of the comprehensive data in our research.

4.2.3 Selection of Primary Data Sources

Following the decision to pursue a qualitative analysis approach, two primary data sources that would form the foundation of the study:

"Meld. St. 20 (2019–2020)" and *"Risikorapport Norsk Fiskeoppdrett 2024"*

"Meld. St. 20 (2019–2020)" (Klima- og miljødepartementet, 2020), a whitepaper published by the Norwegian government, was selected as it represents the most recent and relevant policy document outlining the government's strategies and intentions for the sustainable development of the aquaculture industry, with a specific focus on the salmon and rainbow trout sectors.

"Risikorapport Norsk Fiskeoppdrett 2024" (Grefsrud et al., 2024), the comprehensive risk assessment report published by Havforskningsinstituttet, was chosen as it provides a detailed and up-to-date evaluation of the environmental, economic, and social outcomes and challenges faced by the Norwegian aquaculture industry. This report effectively consolidates the critical statistical data and analysis required for the study.

4.2.4 Accessibility and Scope of Selected Data Sources

No significant limitations or challenges were encountered in the data collection process, as both the whitepaper and the risk assessment report are publicly available documents. The Norwegian government and industry stakeholders maintain high transparency and accessibility in their reporting and communication, ensuring that researchers and the public can easily access these documents through official websites and online repositories.

Moreover, both documents provide extensive information relevant to the study's objectives, covering a wide range of topics and data points related to the sustainability and economic health of the Norwegian aquaculture industry. The whitepaper comprehensively overviews the government's policy intentions and strategies. At the same time, the risk assessment report presents a detailed and evidence-based evaluation of the industry's actual performance and challenges. This breadth and depth of information enable a robust and meaningful analysis of the alignment between policy intentions and industry outcomes.

In summary, the data collection process for this study benefited from the accessibility, credibility, and comprehensiveness of the two primary data sources. The ability to obtain these documents through official channels and the absence of significant limitations or challenges underscore the feasibility and reliability of the research undertaking. The whitepaper and risk assessment report provide a solid foundation for systematically and rigorously analyzing the Norwegian aquaculture sector's policy landscape and industry realities.

4.3 Data Analysis

4.3.1 Theoretical Framework and Analytical Techniques

The data analysis process is guided by the theoretical framework, which draws upon insights from Hoogerwerf's (1990) approach to policy theory reconstruction and Mercer et al. 's (2021) distinctions between explanatory and normative policy frameworks. Hoogerwerf's approach provides a systematic method for reconstructing policy documents' underlying assumptions, objectives, and causal mechanisms. At the same time, Mercer et al.'s distinctions help to differentiate between the explanatory and normative aspects of policy frameworks.

The main analytical techniques used in this study are content analysis and thematic analysis, as outlined in Bowen's (2009) document analysis guide. Content analysis involves organizing information into categories related to the central research questions, while thematic analysis focuses on identifying patterns and themes within the data. These techniques enable a comprehensive examination of the selected policy documents and risk assessment reports, allowing for extracting meaningful insights and identifying key themes relevant to the research objectives.

4.3.2 Analysis Process and Tools

The analysis process involves several steps to systematically examine the content of the selected documents and identify significant themes, patterns, and relationships.

Familiarization with the data

The first step in the analysis process involves thoroughly reading both the whitepaper and the risk assessment report to gain a comprehensive understanding of their content and context. This familiarization stage enables the identification of key concepts, topics, and patterns that will inform the subsequent stages of analysis.

Development of a coding scheme

Python was used to identify key characteristics and commonalities between the documents. Python's capability to handle large datasets and perform complex text processing tasks efficiently made it ideal for analyzing extensive policy documents. Its libraries, such as Pandas for data manipulation and NLTK for text processing, provided robust tools that facilitated a thorough and precise analysis. The Python-assisted analysis revealed three main themes: **Environmental Sustainability, Regulatory Frameworks,** and **Aquaculture Industry Development.**

Application of the coding scheme

Based on the main themes identified through the Python analysis, a coding scheme was developed to guide the manual review of the documents. Within each theme, sub-categories were established to capture more specific aspects of the data, such as sustainable development, environmental impact, regulations, aquaculture development, and economic performance. The coding scheme served as a framework for systematically identifying similarities, differences, and relationships between the content of the two documents. The documents were manually examined to identify alignments and discrepancies, allowing for a nuanced and context-sensitive analysis. The coding schemes developed for both documents acted as reference tools during this process.

Identification of key themes and patterns

During the manual review, the study looked for both convergence and divergence in the data, identifying areas of alignment and discrepancy between the policy intentions outlined in the whitepaper and the industry outcomes and challenges documented in risk assessment report. For example, in examining the environmental impact, both documents acknowledged the significant effects of climate change on marine ecosystems. However, the industry report pointed out practical challenges and gaps in implementing the regulations suggested in policy documents, indicating divergent perspectives on regulatory effectiveness. (Klima- og miljødepartementet, 2020; Grefsrud et al., 2024)

4.3.3 Integration of findings through causal mapping

In Chapter 3, the Theory of Change underlying this study was presented as a causal map (Figure 1), visually representing the complex relationships between policy intentions, environmental outcomes, and various influencing factors in Norwegian aquaculture. The causal map serves as a guiding framework for this study's empirical analysis and policy evaluation.

The empirical analysis of the selected documents, "Meld. St. 20 (2019-2020)" and "Risikorapport Norsk Fiskeoppdrett 2024," is used to verify and refine the assumed causal relationships and pathways depicted in the Theory of Change. By systematically examining these documents' content through the coding scheme (See Appendix B and C), the study aims to identify evidence that supports, challenges, or modifies the initial assumptions and hypotheses represented in the causal map.

The integration of findings through causal mapping involves continuously comparing the empirical evidence derived from the document analysis with the theoretical propositions outlined in the Theory of Change. This iterative approach identifies areas of alignment, discrepancies, or gaps between the policy intentions and the actual outcomes and challenges the Norwegian aquaculture industry faces.

The causal map presented in Chapter 3 serves as a foundation for the comparative analysis and discussion of policy intentions and industry outcomes in Chapters 5 and 6. By referring to the Theory of Change and the causal map, the study focuses on the key elements and relationships influencing the environmental sustainability of Norwegian aquaculture, ensuring a coherent and theory-driven analysis throughout the thesis.

4.5 Ethical considerations

The study relies on publicly available documents and does not involve human participants, thus minimizing ethical concerns related to informed consent and confidentiality. However, I acknowledge the importance of maintaining objectivity and fairness in the analysis and interpretation of the data, avoiding any misrepresentation or biased reporting of the findings.

4.6 Potential limitations and delimitations

4.6.1 Limitations of document analysis as the primary method

I acknowledge that this study's reliance on document analysis as the primary method may pose certain restrictions regarding the extent and depth of the understandings produced. The insights generated. While document analysis allows for a comprehensive examination of the selected policy document and risk assessment report, it does not incorporate primary data collection through interviews or surveys with relevant stakeholders in the Norwegian aquaculture industry.

This limitation implies that the research might only encompass part of the spectrum of viewpoints, encounters, and contextual factors that shape the relationship between aquaculture policies and industry outcomes. Interviews with policymakers, industry representatives, and other vital actors could provide valuable insights into the underlying motivations, challenges, and decision-making processes that influence the formulation and implementation of aquaculture policies. Similarly, surveys could offer a broader understanding of insights and perspectives of diverse stakeholders concerning the effectiveness and impact of these policies on the ground.

By relying solely on the analysis of the two selected documents, I may miss out on essential nuances, alternative explanations, and potential gaps in understanding that could be uncovered through direct engagement with relevant stakeholders. The documents provide a specific lens through which to examine the research problem. However, they may need to capture the full complexity and diversity of perspectives within the Norwegian aquaculture sector.

However, I have chosen to focus on document analysis as the primary method due to the richness and relevance of the selected documents, as well as the feasibility and scope of the research project. The whitepaper and risk assessment report offers a comprehensive and authoritative account of the Norwegian government's aquaculture policies and the industry's performance, providing a solid foundation for addressing the research objectives. While the inclusion of primary data collection could have enriched the study's findings, the depth and quality of the selected documents still allow for meaningful insights and conclusions to be drawn.

I have employed a systematic approach to the analysis process to address the constraints of depending exclusively on document analysis, as outlined in the previous sections. Triangulation, reflexivity, and transparent reporting help to enhance the trustworthiness and credibility of the findings, even in the absence of primary data collection. Additionally, I acknowledge these limitations in the interpretation and presentation of the results, ensuring that the conclusions drawn are appropriately qualified and situated within the context of the study's scope and methods.

4.6.2 Delimitations of the study's scope

In defining the scope of this study, I have made deliberate choices to focus on specific aspects of the Norwegian aquaculture industry and its governing policies. The study is limited to the analysis of two key documents: "Meld. St. 20 (2019–2020)", a white paper outlining the government's aquaculture policies, and "Risikorapport Norsk Fiskeoppdrett 2024", a risk assessment report on the industry's performance and challenges. Moreover, the study concentrates specifically on the salmon and rainbow trout sectors within the Norwegian aquaculture industry.

These delimitations have been set to ensure a focused and manageable research project that can provide meaningful insights into the alignment between policy intentions and industry outcomes within a specific context. By concentrating on the most recent and relevant policy document and risk assessment report, I aim to capture the current state of the Norwegian aquaculture industry and its governing frameworks rather than attempting a more historical or longitudinal analysis.

Similarly, the decision to focus on the salmon and rainbow trout sectors reflects their significant economic and environmental importance within the Norwegian aquaculture industry. These sectors are the most well-developed and extensively documented, providing a rich context for examining the interactions between policy and practice.

However, I recognize that these delimitations also limit the potential for the study's results to be applied and transferred to other contexts. The insights and conclusions drawn from the analysis of these specific documents and sectors may not be directly applicable to other aquaculture sectors, such as shellfish or seaweed farming, which may have distinct policy frameworks, production practices, and sustainability challenges.

Furthermore, with its unique institutional arrangements, environmental conditions, and socio-economic factors, the Norwegian context could restrict the breadth to which the outcomes can be extended to other geographical settings. Aquaculture policies and industry dynamics in other countries or regions may differ significantly from those in Norway, requiring caution in applying the insights from this study to other contexts.

Despite these delimitations, the study's focused scope allows for a deep and nuanced understanding of the specific research problem at hand. By offering a thorough and clear description of the study's scope and limitations, I aim to enable readers to assess the transferability and relevance of the findings to their contexts and to identify conceivable areas for future exploration that could enhance and extend the insights generated by this study.

Chapter 5: Findings

“Meld. St. 20 (2019–2020)" and "Risikorapport Norsk Fiskeoppdrett 2024". The analysis process, as outlined in Chapter 4.3.2, involved systematically examining the content of these documents to identify significant themes, patterns, and relationships relevant to the research objectives.

The analysis focused on identifying significant themes, patterns, and relationships relevant to the research objectives, emphasizing the alignment and potential discrepancies between the policy intentions outlined in the white paper and the actual industry outcomes and challenges documented in the risk assessment report.

The findings are organized into two main sections, each focusing on one of the primary data sources. Section 5.1 presents the key findings from "Meld. St. 20 (2019–2020)", highlighting Norway's commitment to sustainable aquaculture, the potential of offshore aquaculture, the importance of integrated ecosystem-based management, and the need for continuous adaptation to climate change. Section 5.2 presents the findings from "Risikorapport Norsk Fiskeoppdrett 2024", comprehensively analyzing the environmental sustainability, economic performance, and regulatory aspects of Norwegian aquaculture across 13 production areas.

The chapter concludes with a causal map analysis in Section 5.3, which integrates the findings from both data sources and visualizes the key elements and relationships influencing the environmental sustainability of Norway's aquaculture industry. This causal map is a foundation for the comparative analysis and discussion later in the thesis.

5.1 Key Findings from the whitepaper

The manual analysis of "Meld. St. 20 (2019–2020)" (see Appendix D) reveals that the document underscores Norway's strong political commitment to developing its aquaculture industry within a framework of sustainable, ecosystem-based management. This involves addressing environmental challenges associated with fish farming, such as sea lice, fish escapes, and waste discharge while ensuring that aquaculture growth's benefits are shared with coastal communities. Norway's approach, which combines a robust regulatory framework, investments in research and innovation, and a focus on environmental sustainability, could serve as a model for other countries seeking to develop their aquaculture sectors responsibly. (Klima- og miljødepartementet, 2020)

The whitepaper identifies offshore aquaculture as a significant opportunity for Norway's aquaculture industry's future growth and transformation. Moving fish farming further offshore enables continued production expansion while mitigating environmental pressures on coastal ecosystems. However, the transition to offshore aquaculture will require significant investments in research, technology development, infrastructure, and careful planning to manage potential conflicts with other ocean users. Norway's experience developing offshore aquaculture could provide valuable lessons for other countries exploring this approach. (Klima- og miljødepartementet, 2020)

Norway's system of integrated ocean management plans, which provides an overarching framework for regulating activities across different marine sectors, is not just a tool but a key tool for ensuring the sustainable use of ocean resources. By considering the cumulative impacts of human activities on marine ecosystems and promoting cross-sectoral coordination, these plans help to create a predictable operating environment for industries like aquaculture while safeguarding the health and productivity of Norway's waters. This underscores the importance of holistic, ecosystem-based approaches to ocean governance in managing the growth of aquaculture and other marine industries. (Klima- og miljødepartementet, 2020)

The whitepaper recognizes the significant challenges climate change poses to the sustainability of Norway's marine ecosystems and the industries that depend on them, including aquaculture. Rising sea temperatures, ocean acidification, and species distribution and productivity changes are expected to have far-reaching impacts on Norway's waters, requiring adaptive and precautionary management approaches. For the aquaculture industry, this may involve developing climate-resilient production systems, adapting to changes in environmental conditions, and contributing to efforts to mitigate greenhouse gas emissions. (Klima- og miljødepartementet, 2020)

In conclusion, the whitepaper "Meld. St. 20 (2019–2020)" provides a comprehensive overview of Norway's approach to sustainable ocean management and the role of the aquaculture industry within this framework. The document highlights the potential for aquaculture to continue to grow and contribute to Norway's economy while emphasizing the need for this growth to occur within ecological limits and in harmony with other ocean uses. Norway's experience developing a sustainable aquaculture industry through integrated, ecosystem-based management, investments in research and innovation, and a robust regulatory framework offers valuable lessons for other countries seeking to balance the benefits and challenges of aquaculture development in their waters. However, the document also underscores the ongoing need for adaptive and precautionary management approaches in a changing climate and the importance of continued research and monitoring to inform sustainable aquaculture practices. (Klima- og miljødepartementet, 2020)

5.2 Key findings from "Risikorapport Norsk Fiskeoppdrett 2024”

"Risikorapport Norsk Fiskeoppdrett 2024" as analyzed in the manual analysis (See Appendix E), comprehensively analyzes the Norwegian salmon and trout aquaculture industry, covering environmental sustainability, economic performance, and regulatory aspects across 13 production areas.

Overview of Norwegian Fish Farming Production Areas

Norway's aquaculture operations are spread across 13 distinct production areas along its extensive coastline, each with unique geographical features:

1. **Production Area 1**: Extends from the Swedish border to Jæren.
2. **Production Area 2**: Ryfylket.
3. **Production Area 3:** Includes the waters surrounding Karmøy up to Sotra.
4. **Production Area 4:** Spans from Nordhordland to Stadt.

5. **Production Area 5:** Covers the coastal area from Stadt to Hustadvika.
6. **Production Area 6:** Encompasses the region from Nordmøre to Sør-Trøndelag.
7. **Production Area 7**: Nord-Trøndelag including Bindal.
8. **Production Area 8**: Helgeland to Bodø.
9. **Production Area 9**: Vestfjorden and Vesterålen.
10. **Production Area 10:** Ranges from Andøya to Senja.
11. **Production Area 11:** Kvaløya to Loppa.
12. **Production Area 12:** Vest-Finnmark.
13. **Production Area 13**: Øst-Finnmark.

5.2.1 Environmental Sustainability

Fish Welfare: Mortality rates (including discards) vary across production areas, with some areas showing higher mortality of 20-27%." (Grefsrud et al., 2024) compared to the national average of 15-16%. (Grefsrud et al., 2024, p. 55). Production Area 2 experienced notably high salmon mortality rates, including discards, ranging from 20% to 26% for the generations of 2020 and 2021, substantially exceeding the national average. (Grefsrud et al., 2024, p. 55). Meanwhile, Production Area 4 grappled with persistently elevated mortality levels between 23% and 27%, showing no signs of improvement over time. (Grefsrud et al., 2024, p. 84). While high mortality rates have been reported in some areas, low production numbers are also a contributing factor. For instance, in Production Area 13, the mortality rate fluctuated between 2-17%. Factors such as algae blooms and jellyfish attacks increase mortality in certain areas. (Grefsrud et al., 2024, p. 187).

Sea Lice: Sea lice emissions and infection pressure vary between production areas, ranging from low to high. For instance, in production area 6, sea lice-induced mortality on out-migrating wild salmon smolts varies widely and is estimated to be between 10% and 30% over several years. In Production Areas 3 and 4, sea lice-induced mortality on out-migrating wild salmon smolts was estimated to be over 30% in all years from 2019-2022. For sea trout, the reduction in productivity due to sea lice was estimated to be over 30% in several production areas like 3, 4, 5, 6, and 7 in 2019-2022. The impact on wild salmonids, particularly sea trout, is a concern in many areas.

Viral Diseases: The occurrence of viral diseases like ILA (Infectious Salmon Anemia) and PD (Pancreas Disease) varies across production areas, with some areas reporting no cases while others have multiple outbreaks. (Grefsrud et al., 2024)

Escapes and Genetic Impact: Escaped farmed salmon are observed in rivers across production areas, with varying levels of genetic introgression into wild salmon populations. The effectiveness of recapture efforts also varies. Production Areas 4 and 7 reported high escape incidents, with thousands of escaped farmed salmon in 2018-2022. (Grefsrud et al., 2024). In Production Areas 3 and 8, a high level of genetic introgression from escaped farmed salmon into wild populations was observed, leading to vulnerable wild stocks. (Grefsrud et al., 2024)

Emissions: The level of emissions (nutrients, organic matter, copper) is generally proportional to the production intensity in each area. Most areas have a low risk of eutrophication, but some have a moderate risk related to particulate organic emissions. In Production Area 3, the feed consumption in 2022 was 252,079 tons, resulting in an estimated discharge of 73,607 tons of fecal matter and 12,604-27,729 tons of uneaten feed. (Grefsrud et al., 2024, p. 77). Copper discharge levels were moderate in areas like 2, 3, 4, and 7, with a moderate proportion of sites showing elevated copper levels in sediments despite reduced usage. (Grefsrud et al., 2024)

5.2.2 Economic Performance

Production: The average monthly standing biomass and total harvest volumes vary significantly between production areas, with some areas having substantially higher production than others. The most production-intensive areas based on tons produced per km2 were production areas 2-4 and 10. (Grefsrud et al., 2024) The most minor production-intensive areas were reported to be production areas 1 and 13. In 2022, production area 1 had only nine fish farming sites reporting salmon production. The average monthly standing biomass was 12,740 tons of salmon, and the total salmon harvested in 2022 was 14,076 tons. (Grefsrud et al., 2024, p. 43). On the other hand, production area 13 had a lower output. In 2022 the average monthly standing biomass was only 5,743 tons of salmon. The total salmon harvested in 2022 was just 5,144 tons, and there were only five fish farm sites in operation in this area. (Grefsrud et al., 2024, p. 196)

Feed Consumption: Feed consumption is directly related to production levels, with higher production areas using more feed. The estimated feces and uneaten feed emissions per fish farm also vary across areas. (See Appendix E)

Wild-Caught Cleaner Fish: Wild-caught cleaner fish, mainly various wrasse species, are commonly used in most production areas. Quotas and catch numbers vary between regions. In 2023, over 10.1 million wrasses were caught and used as cleaner fish in Production Areas 2, 3, and 4 (Grefsrud et al., 2024).

5.2.3 Regulatory Aspects

The traffic light system, which regulates production growth based on environmental indicators, is not explicitly mentioned in all chapters but is discussed in managing aquaculture's environmental impact. Other regulatory measures, such as the quality norm for wild salmon stocks and the aquaculture operations regulation, are mentioned to maintain the industry's sustainability. The report recommends various measures to improve the environmental sustainability of aquaculture, such as reducing sea lice emissions, minimizing escape events, lowering mortality rates, and increasing biosecurity related to the transport of wild-caught cleaner fish. (Grefsrud et al., 2024)

The risk assessment report provides a detailed analysis of the environmental sustainability, economic performance, and regulatory aspects of Norwegian salmon and trout aquaculture across 13 production areas. The findings highlight the variability in environmental impact, production intensity, and regulatory challenges between regions, emphasizing the need for area-specific management strategies to ensure the industry's long-term sustainability.

5.3 Integration of Findings through Causal Mapping

The Causal Map meticulously developed and refined (Figure 2). It is based on the initial assumptions and theoretical foundations, thoroughly discussed in Chapter 3. Each box in the map represents a key element, meticulously identified through the literature review and policy theory analysis. Arrows connect the boxes, indicating the meticulously assumed causal relationships between these elements.

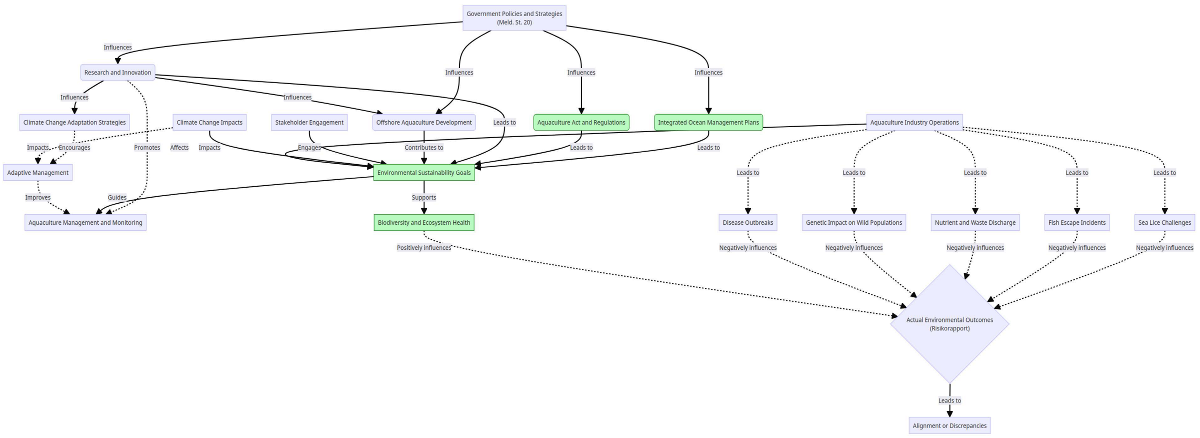

Figure 2: Redefined Causal Map

The problem statement, research questions, and objectives outlined in Chapter 1 guided the identification of the boxes and their linkages. The central box, "Government Policies and Strategies," was derived from the study's focus on examining the policy intentions expressed in the whitepaper. The boxes for "Environmental Sustainability Strategies," "Regulatory Frameworks," and "Aquaculture Industry Practices" were identified as crucial components influenced by government policies based on theoretical assumptions and existing literature.

The arrows connecting the boxes represent the hypothesized causal relationships between the elements. These linkages were initially established based on the policy theory framework and the assumed logic of how government policies and strategies would influence industry practices, regulatory frameworks, and environmental sustainability outcomes.

The empirical findings from the analysis of 'Meld. St. 20 (2019-2020)' and 'Risikorapport Norsk Fiskeoppdrett 2024' played a pivotal role in confirming and enhancing the initial assumptions of the Causal Map. These findings were systematically compared against the map, providing substantial support for several of the assumed causal pathways, such as the influence of government policies on environmental sustainability strategies and regulatory frameworks. This rigorous process not only enhances the credibility and reliability of the research but also reassures the audience about the validity of the findings.

The findings from the risk assessment report necessitated some revisions to the initial Causal Map. The report underscored the importance of regional factors and local environmental conditions in shaping industry practices and sustainability outcomes, which must be fully captured in the original map. To address this, the Causal Map was updated to incorporate regional influences as moderating variables affecting the relationships between industry operations and environmental goals. This acknowledgment of the complexity and context-dependency of the research topic is a significant step forward in the analysis.

The risk assessment report, with its documentation of persistent environmental challenges despite the measures outlined in the whitepaper, played a crucial role in the research. It aligned with the hypothesized links in the map and highlighted potential gaps in the initial causal assumptions. This led to re-evaluating the mechanisms linking policy implementation, industry practices, and environmental outcomes, adding interaction effects and feedback loops in the revised map. This iterative process is a testament to the dynamic nature of the research.

The refinement of the causal map was based on a systematic evaluation of the evidence presented in the two documents, identifying patterns and relationships that suggested causal mechanisms at play. While statistical techniques were not employed to establish causality, the analysis relied on thoroughly examining the data, findings, and contextual information to infer the most plausible causal pathways and update the initial theoretical assumptions.

The empirical evidence from the risk assessment report underscored the interdependence between environmental sustainability and economic performance. While economic impact was not a central focus of the original Causal Map, the findings highlighted the potential trade-offs and synergies between these aspects. To reflect this, the revised map includes bi-directional linkages between environmental sustainability and economic performance, acknowledging their interrelated nature and the influence of regional variations. This comprehensive approach to the research enlightens the audience about the multifaceted nature of the topic.

Chapter 6: Discussion

6.1 Comparative Analysis of Policy Intentions and Industry Outcomes

6.1.1 Alignment of Environmental Sustainability Goals

The comparative analysis reveals several areas of alignment between the policy intentions outlined in the whitepaper and the findings of the risk assessment report. Both documents recognize the importance of sustainable aquaculture development and the need to address key environmental challenges such as sea lice, fish escapes, and nutrient and waste discharge.

The whitepaper's emphasis on maintaining good environmental status and high biodiversity (Klima- og miljødepartementet, 2020, p. 145) aligns with the risk assessment report's findings on the importance of monitoring and managing the environmental impacts of aquaculture activities. The risk assessment highlights the varying levels of environmental risk across the 13 production areas, with some areas showing good environmental status while others face challenges related to sea lice, genetic introgression, and organic waste discharge.

Furthermore, the whitepaper's acknowledgment of the main environmental pressures associated with aquaculture (Klima- og miljødepartementet, 2020, p. 84) is reflected in the risk assessment report's detailed analysis of these pressures across the production areas. The report provides specific data on sea lice levels, escape incidents, and nutrient and organic matter discharge, confirming the ongoing challenges identified in the whitepaper.

The whitepaper also outlines a comprehensive regulatory framework, including the Aquaculture Act and the traffic light system for regulating aquaculture production (Klima- og miljødepartementet, 2020, p. 129). This aligns with the risk assessment report's discussion of the regulatory aspects and their implications for the environmental sustainability of the industry.

The causal map, developed based on the analysis of both documents, further highlights the strong alignment between the white aper and the risk assessment report. The map's emphasis on research and innovation aligns with the whitepaper's focus on strengthening the knowledge base through mapping, research, and monitoring (Klima- og miljødepartementet, 2020, p. 62

and p. 157). Moreover, including climate change adaptation strategies as a factor in the causal map aligns with the whit paper's emphasis on climate-resilient management of marine resources and biodiversity (Klima- og miljødepartementet, 2020, p. 144). The "Aquaculture Management and Monitoring" component of the causal map also aligns with the whitepaper's emphasis on continuous monitoring and data-driven decision-making. Additionally, the causal map's inclusion of "Biodiversity and Ecosystem Health" as a factor aligns with the whitepaper's goals of maintaining ecosystem structure, functioning, and diversity.
(Klima- og miljødepartementet, 2020 p. 18-19).

6.1.2 Discrepancies in Environmental Performance

However, the comparative analysis also reveals some discrepancies and gaps between the policy intentions and the actual environmental outcomes. While the white paper emphasizes the potential of offshore aquaculture to enable sustainable growth.
(Klima- og miljødepartementet, 2020 p.129 and p.157-158), the risk assessment report highlights the uncertainties and challenges associated with this development, such as the need for adapted technologies and the potential for new environmental impacts.

Additionally, the risk assessment report indicates that the environmental sustainability goals outlined in the whitepaper, such as reducing sea lice levels and minimizing genetic impact on wild populations, are not being fully met in practice. Several production areas are reported to have high risks associated with sea lice-induced mortality in wild salmonids and genetic introgression from escaped farmed fish, suggesting that the current policy measures may not be sufficient to address these challenges effectively. Production areas 3, 4, 6, 7, and 8 are reported to have high risks related to sea lice-induced mortality on wild salmonids and genetic introgression from escaped farmed fish. This suggests that the current policy measures may not be adequate to effectively address these challenges. (See Appendix E)

The risk assessment report also identifies high risks related to disease outbreaks in certain production areas, which could be considered a discrepancy given the lack of specific measures to address this issue in the whitepaper. For instance:
Production area 6 is reported to have high risks associated with outbreaks of pancreas disease (PD) and infectious salmon anemia (ISA) (Grefsrud et al., 2024, p. 119). Indicating a potential gap in the whit paper's coverage of disease management strategies.

Furthermore, while the whitepaper discusses the need for climate change adaptation strategies (Klima- og miljødepartementet, 2020, p. 144), the risk assessment report might reveal gaps or limitations in the effectiveness of these strategies in mitigating the impacts of climate change on the aquaculture industry.

The comparative analysis also identifies gaps in the whitepaper's coverage of certain environmental aspects that are highlighted in the risk assessment report. For instance, the risk assessment provides detailed information on the ecological impact of wild wrasse fishing for use in aquaculture, as well as the potential effects of aquaculture activities on vulnerable habitats such as eelgrass beds and cold-water coral reefs. These specific issues are not extensively addressed in the whitepaper, indicating potential areas for further policy consideration. Specifically, the risk assessment report highlights the ecological impact of wild wrasse fishing for use in aquaculture, particularly in production areas 2, 3, and 4. (See Appendix E). This issue is not extensively addressed in the whitepaper, suggesting a potential gap in the policy framework. The report also mentions the potential effects of aquaculture activities on vulnerable habitats like eelgrass beds and cold-water coral reefs. The lack of detailed coverage of these impacts in the whitepaper indicates an area for further policy development. (Grefsrud et al., 2024, p. 16)

Reasons for alignment and discrepancies

Furthermore, while the whitepaper recognizes the importance of research and innovation in supporting sustainable aquaculture development (p. 62 and p. 157-158), the risk assessment report underscores the need for more knowledge and data to reduce uncertainties and inform evidence-based management decisions. (Grefsrud et al., 2024). This suggests that there may be opportunities to strengthen the link between research priorities and the specific knowledge gaps identified in the risk assessment.

The reasons behind the alignments and discrepancies can be attributed to several factors. The alignment between the documents regarding the importance of a knowledge-based approach and continuous monitoring suggests that the policies are grounded in available scientific evidence and data, which aligns with Hoogerwerf's criterion of empirical justification. However, the discrepancies related to disease outbreaks and the effectiveness of climate change adaptation strategies could be attributed to limitations in the policy design, as these issues may not have been adequately addressed or anticipated in the whitepaper.

Additionally, the rapid growth of the aquaculture industry, technological limitations, and the complex ecological interactions between farmed and wild fish populations may contribute to the challenges in achieving the intended environmental sustainability goals outlined in the whitepaper. The need for cautious and adaptive management in the development of offshore aquaculture, as highlighted in the risk assessment, further underscores the importance of addressing uncertainties and potential environmental impacts in the policy framework.

The persistent challenges related to sea lice, genetic introgression, and disease outbreaks in multiple production areas may undermine the overall goal of maintaining healthy and viable wild salmonid populations. This highlights the need for more effective and targeted measures to address these issues. Similarly, the lack of specific policies addressing the ecological impacts of wild wrasse fishing and the potential effects on vulnerable habitats could hinder the achievement of the goals related to maintaining biodiversity and ecosystem health. This suggests a need for a more comprehensive approach to managing the environmental impacts of aquaculture activities.

Regarding stakeholder engagement and public participation, the whitepaper mentions the importance of dialogue and cooperation ((Klima- og miljødepartementet, 2020, p. 159). The risk assessment report could provide insights into the level of stakeholder involvement in the monitoring and reporting of environmental impacts. For instance, the report might highlight instances where stakeholder observations or concerns have been incorporated into the assessment process. It would be interesting to explore whether the current level of stakeholder engagement and public participation is sufficient to ensure that the policy framework effectively addresses the challenges identified in the risk assessment report. This could involve considering mechanisms for incorporating stakeholder feedback and local knowledge into the policy development and implementation process.

Overall, the comparative analysis highlights the general alignment between the whitepaper's policy intentions and the risk assessment report's findings, particularly in terms of recognizing the key environmental challenges facing the aquaculture industry. However, it also reveals discrepancies and gaps that may require further attention to ensure that the policy framework effectively supports the achievement of environmental sustainability goals in practice.

6.1.3 Economic Development Intentions vs. Actual Performance

The whitepaper highlights the potential for aquaculture to continue growing and contributing to Norway's economy, while emphasizing the need for this growth to occur within ecological limits and in harmony with other ocean uses. The document identifies offshore aquaculture as a significant opportunity for the future growth and transformation of Norway's aquaculture industry, suggesting that moving fish farming further offshore could enable continued expansion of production while mitigating environmental pressures on coastal ecosystems. (Klima- og miljødepartementet, 2020)

However, the risk assessment report reveals significant variations in economic performance across the 13 production areas. The report indicates that the average monthly standing biomass and total harvest volumes vary substantially between regions, with some areas having significantly higher production than others. For example, production areas 2-4 and 10 are identified as the most production-intensive areas based on tons produced per km2, while production areas 1 and 13 are reported to have the lowest production intensity. (Grefsrud et al., 2024).

These findings suggest that the economic development intentions outlined in the whitepaper, which emphasize the potential for continued growth and expansion of the aquaculture industry, may not be realized uniformly across all production areas. The variability in economic performance highlights the need for area-specific strategies and policies that consider the unique challenges and opportunities of each region.

Furthermore, the variations in economic performance across production areas may have implications for the incentives and resources available for sustainable practices. In areas with higher economic returns, fish farming companies may have more financial capacity to invest in environmental mitigation measures, such as improved sea lice control technologies or waste management systems. Conversely, in areas with lower economic performance, there may be increased pressure to prioritize short-term economic gains over long-term environmental sustainability.

The risk assessment report also highlights how environmental challenges, such as disease outbreaks, can have significant economic consequences for the aquaculture industry. For example, the report notes that the occurrence of pancreas disease (PD) and infectious salmon anemia (ISA) in certain production areas (e.g., Production Area 6) poses a high risk to fish health and can lead to substantial economic losses (Grefsrud et al., 2024, p. 119). This underscores the complex interplay between environmental and economic factors, and the importance of effective disease management strategies for both ecological and financial reasons.

Moreover, the risk assessment report's findings on environmental sustainability issues, such as sea lice infestations, fish escapes, and disease outbreaks, underscore the potential trade-offs between economic growth and environmental protection. The report suggests that the rapid expansion of the aquaculture industry in some areas may be contributing to increased environmental pressures, which could ultimately undermine the long-term sustainability and economic viability of the sector. (Grefsrud et al., 2024)

The findings from the risk assessment report regarding the variations in economic performance across production areas and the potential trade-offs between economic growth and environmental protection can be further contextualized by considering the insights from the literature on FDI, international trade, and regulatory factors in the aquaculture sector (Maurseth & Medin, 2020). The patterns of FDI and the incentives created by trade agreements, such as the EEA agreement, may influence the distribution of economic activities and the prioritization of short-term gains over long-term sustainability in certain regions.

Norway's relationship with the EU and the dynamics of international trade in processed fish products could also shape the economic development trajectory of the aquaculture industry. As Maurseth and Medin (2020) highlight, the tariffs on processed fish exports from Norway under the EEA agreement may encourage Norwegian firms to invest in processing facilities within the EU, potentially impacting the distribution of economic benefits and the industry's overall sustainability.

Considering these international economic and regulatory factors can provide a more comprehensive understanding of the complex interplay between policy intentions, industry performance, and sustainability outcomes in the Norwegian aquaculture sector. Integrating these perspectives into the analysis of the whitepaper and the risk assessment report can help to identify potential challenges and opportunities for balancing economic growth and environmental protection in an increasingly globalized industry.

6.2 Evaluation of policy framework quality

Assessing the overall coherence of Norway's aquaculture policies in promoting environmental sustainability, based on the comparative analysis, reveals a mixed picture. While the policies and strategies outlined in the whitepaper generally align with the key environmental challenges identified in the risk assessment report, there are some notable discrepancies and gaps that may hinder the effectiveness of the policy framework in achieving its sustainability goals.

On a positive note, the whitepaper presents a comprehensive set of policies and strategies that recognize the main environmental pressures associated with aquaculture, such as sea lice, fish escapes, and nutrient and waste discharge. The emphasis on maintaining good environmental status, preserving biodiversity, and strengthening the knowledge base through research and monitoring demonstrates a commitment to addressing these challenges. The regulatory framework, including the Aquaculture Act and the traffic light system, provides a foundation for managing the industry's environmental impacts.

However, the comparative analysis also highlights some areas where the policies may fall short in effectively promoting environmental sustainability. The risk assessment report indicates that several production areas continue to face significant challenges related to sea lice, genetic introgression, and disease outbreaks, despite the measures outlined in the whitepaper. This suggests that the current policies may not be sufficient or effectively implemented to mitigate these pressures adequately.

Furthermore, the whitepaper's emphasis on the potential of offshore aquaculture to enable sustainable growth contrasts with the uncertainties and environmental risks highlighted in the risk assessment report. The lack of specific policies addressing the ecological impacts of wild wrasse fishing and the potential effect on vulnerable habitats also points to gaps in the policy framework's comprehensiveness.

While the whitepaper acknowledges the need for climate change adaptation strategies, the risk assessment report may reveal limitations in the effectiveness of these strategies in mitigating the impacts of climate change on the aquaculture industry. This indicates a need for more robust and proactive measures to build resilience and adapt to the changing environmental conditions.

In terms of balancing the goals of sustainable aquaculture growth and environmental protection, the whitepaper's policies appear to strive for a balance by promoting industry development within a framework of environmental sustainability. However, the discrepancies and gaps identified in the comparative analysis suggest that achieving this balance in practice remains a challenge. The rapid growth of the industry, technological limitations, and complex ecological interactions between farmed and wild fish populations may contribute to the difficulties in fully realizing the intended sustainability outcomes.

To enhance the coherence and effectiveness of the policy framework, there may be opportunities to strengthen the alignment between research priorities and the specific knowledge gaps identified in the risk assessment. Incorporating stakeholder feedback and local knowledge into the policy development and implementation process could also help to ensure that the policies are responsive to the actual challenges experienced by the industry and affected communities.

To summarize, while Norway's aquaculture policies as outlined in the whitepaper demonstrate a commitment to promoting environmental sustainability, the comparative analysis reveals some discrepancies and gaps that may undermine the overall coherence and effectiveness of the policy framework. Addressing these shortcomings, such as the persistent challenges related to sea lice, genetic introgression, and disease outbreaks, and developing more comprehensive strategies for managing the ecological impacts of aquaculture activities, will be crucial for achieving a truly sustainable and resilient aquaculture industry in Norway.

6.2.1 Precision of Policy Goals and Instruments

Strength: The whitepaper sets clear goals for maintaining good environmental status, biodiversity, and ecosystem functioning in Norway's marine environment (Klima- og miljødepartementet, 2020, p.18). It outlines specific targets for reducing sea lice levels, minimizing genetic impact on wild populations, and limiting nutrient and waste discharge.

Weakness: Some of the policy objectives, such as those related to climate change adaptation and the development of offshore aquaculture, lack precise definitions and measurable targets. This ambiguity could hinder the effective implementation and evaluation of these policies. Additionally, regarding the precision of timelines and implementation plans, the whitepaper does not provide detailed deadlines or milestones for achieving the stated goals. While it outlines measures to address challenges like reducing sea lice levels, it does not specify clear timelines for implementation or desired outcome attainment. This lack of precise timelines could hinder monitoring and evaluating progress.

6.2.2 Differentiation across Environmental Aspects

Strength: The whitepaper acknowledges the different environmental pressures associated with aquaculture, such as sea lice, escapes, and waste discharge (Klima- og miljødepartementet, 2020, p. 84-85). It outlines specific measures to address each challenge, differentiated approach to managing the various aspects of environmental sustainability.

Weakness: The risk assessment report reveals the effectiveness of these strategies varies significantly across production areas, with some continuing to face high risks like sea lice and genetic introgression, suggesting insufficient tailoring to local conditions. Furthermore, the whitepaper does not provide detailed differentiation of environmental impacts across different species or production methods, unlike the risk assessment's nuanced analysis covering salmon, trout, cleaner fish farming, and potential offshore aquaculture risks like ecological impacts from new technologies. (Maurseth & Medin, 2020)

6.2.3 Empirical Justification and Grounding in Evidence

Strength: The whitepaper emphasizes a knowledge-based approach, highlighting continuous monitoring, research, and data collection to inform decisions and adapt strategies based on scientific evidence. (Klima- og miljødepartementet, 2020, p. 62-65; p. 157-158).
It acknowledges uncertainties around climate impacts and offshore aquaculture development, stressing precaution (Klima- og miljødepartementet, 2020, p.74-75; p. 151).

Weakness: The whitepaper does not provide explicit details on how the precautionary principle will be applied in practice or how adaptive management strategies will be implemented based on new evidence and monitoring results. Contrasting this, the risk assessment underscores adapting practices to the latest findings and local environmental conditions for each production area. This suggests opportunities to strengthen empirical justification by explicitly incorporating precautionary and adaptive management approaches.

6.2.4 Validity and Likelihood of Achieving Intended Outcomes

Strength: The whitepaper presents a comprehensive aquaculture framework logically structured to balance sustainable growth and environmental protection goals. The integrated management plans' identified causal relationships provide a basis for assessing policy validity.

Weakness: The comparative analysis reveals discrepancies and gaps that raise questions about some policy assumptions' validity and the likelihood of achieving intended outcomes, given the limited effectiveness of measures for mitigating issues like sea lice and genetic introgression in certain areas, suggesting underlying causal relationships are inadequately addressed. Moreover, the white paper lacks detailed analysis of potential economic-environmental objective conflicts and how to reconcile them, contrasting the risk assessment's highlighting of balancing challenges in high-intensity, environmentally pressured areas.

6.2.5 Integration and Coherence of the Policy Framework

Strength: The whitepaper emphasizes an integrated ecosystem-based aquaculture management approach and cross-sector, stakeholder coordination.
(Klima- og miljødepartementet, 2020, p. 14-15). It presents a comprehensive policy framework covering ocean management, planning, pollution control and research.
(Klima- og miljødepartementet, 2020, Chapters 7-9).

Weakness: The comparative analysis reveals inconsistencies between policy intentions and environmental outcomes in the risk assessment, with persistent sea lice, genetic introgression, and disease issues in some production areas suggesting policies are not fully cohesive or effectively integrated in practice. Strengthening consistency across areas and ensuring robust implementation could enhance integration and overall effectiveness.

In summary, the analysis identifies strengths in the white paper's goal setting, differentiating pressures, science-based approach, comprehensive framework, and integration emphasis. However, weaknesses emerge regarding precision of timelines, tailoring strategies to local conditions/species, empirical grounding in precaution and adaptive management, evaluating economic-environment conflicts, addressing persistent environmental issues, and consistent cross-area policy integration. Addressing these gaps through targeted improvements is crucial for effective environmental sustainability policy implementation and outcomes achievement.

Clarity and consistency of concepts and arguments

The whitepaper generally uses clear and consistent terminology when discussing key environmental sustainability concepts such as maintaining good environmental status, biodiversity, and ecosystem functioning. It also consistently addresses the main environmental challenges associated with aquaculture, including sea lice, genetic impact on wild populations, and nutrient and waste discharge.

However, there are some areas where the concepts and arguments could be more clearly defined or elaborated upon. For instance, the whitepaper mentions the need for climate change adaptation strategies and the potential of offshore aquaculture development, but it does not provide precise definitions or detailed explanations of these concepts. Clarifying these terms and their implications for aquaculture sustainability would strengthen the overall clarity and consistency of the policy framework.

Moreover, while the whitepaper presents a comprehensive set of policies and strategies, the comparative analysis reveals some inconsistencies between the stated intentions and the actual environmental outcomes reported in the risk assessment. These discrepancies suggest that the arguments and assumptions underlying certain policies may not be fully aligned with the reality on the ground, undermining the overall consistency of the framework.

Specificity of arguments and policy rationale

The whitepaper demonstrates varying levels of specificity when presenting concepts and arguments related to aquaculture sustainability. In some areas, such as the discussion of sea lice management and the importance of reducing the genetic impact on wild populations, the whitepaper provides specific targets and measures, indicating a high level of specificity.

However, in other areas, the concepts and arguments are presented in more general terms, lacking the necessary specificity to guide effective implementation. For example, the whitepaper acknowledges the need for climate change adaptation strategies but does not provide detailed guidance on how these strategies should be developed or implemented in the context of aquaculture. Similarly, the discussion of offshore aquaculture development focuses on its potential benefits without thoroughly addressing the specific environmental risks and uncertainties associated with this emerging approach.

Grounding in scientific evidence and data

One of the strengths of the whitepaper is its emphasis on a knowledge-based approach to aquaculture management. It highlights the importance of continuous monitoring, research, and data collection to inform decision-making and adapt strategies based on scientific evidence. The whitepaper also acknowledges the uncertainties surrounding climate change impacts and offshore aquaculture development, stressing the need for a precautionary approach.

However, the comparative analysis reveals some gaps in the policy framework's grounding in available evidence and data. The risk assessment report indicates that several production areas continue to face significant environmental challenges, such as sea lice infestations and genetic introgression, despite the measures outlined in the whitepaper. This suggests that the current policies may not be adequately informed by the latest scientific findings or sufficiently adapted to the specific environmental conditions in each production area.

Furthermore, while the whitepaper emphasizes the importance of research and innovation, it does not provide explicit details on how the precautionary principle will be applied in practice or how adaptive management strategies will be implemented based on new evidence and monitoring results. Strengthening the link between research priorities and the specific knowledge gaps identified in the risk assessment could help to enhance the policy framework's grounding in available evidence and data.

Implications for Policy Development and Implementation: The analysis of the clarity, consistency, specificity, and grounding in evidence of Norway's aquaculture policy framework has several implications for its future development and implementation:

1. Clarifying key concepts and arguments: To enhance the overall clarity and consistency of the policy framework, it is important to provide more precise definitions and

explanations of key concepts such as climate change adaptation and offshore aquaculture development. This will help to ensure a common understanding among stakeholders and facilitate effective implementation.

2. Addressing inconsistencies and discrepancies: The discrepancies between the policy intentions and the actual environmental outcomes highlighted in the comparative analysis underscore the need to re-evaluate the assumptions and arguments underlying certain policies. Identifying and addressing these inconsistencies will be crucial for improving the overall coherence and effectiveness of the policy framework.
3. Enhancing specificity and guidance: In areas where the whitepaper lacks specificity, such as climate change adaptation and offshore aquaculture development, there is a need to provide more detailed guidance and specific measures to support the implementation of these strategies. This could involve developing targeted action plans, setting clear milestones, and establishing performance indicators to track progress.
4. Strengthening the link between research and policy: To ensure that the policy framework is effectively grounded in available evidence and data, it is important to strengthen the link between research priorities and the specific knowledge gaps identified in the risk assessment. This could involve establishing mechanisms for regularly updating policies based on the latest scientific findings and incorporating adaptive management strategies to respond to new evidence and changing environmental conditions.
5. Promoting stakeholder engagement and knowledge exchange: Effective policy development and implementation require the active engagement of stakeholders, including industry actors, research institutions, and local communities. Establishing platforms for knowledge exchange and collaborative problem-solving can help to ensure that policies are informed by a wide range of perspectives and expertise and are responsive to the challenges and opportunities identified by stakeholders.

By addressing these implications and continuously refining the policy framework based on new evidence and insights, Norway can work towards a more effective and sustainable approach to aquaculture governance that promotes both environmental sustainability and economic development.

6.3 Implications for Norwegian Aquaculture Governance

Discussing the implications of the findings for the future development and implementation of Norway's aquaculture policies is crucial for ensuring the long-term sustainability and success of the industry. Based on the evaluation of the policy framework's strengths and weaknesses, several key areas emerge as priorities for future policy development and implementation.

6.3.1 Strengths, weaknesses, and opportunities for improvement

Norway's aquaculture policies demonstrate several strengths in promoting environmental sustainability. The whitepaper sets clear goals for maintaining good environmental status, biodiversity, and ecosystem functioning, and it outlines specific targets for addressing key challenges such as sea lice, genetic impact on wild populations, and nutrient and waste discharge. The emphasis on a knowledge-based approach, with continuous monitoring, research, and data collection, provides a solid foundation for informed decision-making and adaptive management.

However, the analysis also reveals areas where Norway's aquaculture policies could be strengthened to better promote environmental sustainability. Some of the key weaknesses and gaps identified include:

1. Lack of precision in certain policy objectives and timelines, particularly regarding climate change adaptation and offshore aquaculture development.
2. Insufficient differentiation of environmental impacts across different species, production methods, and local conditions, as highlighted by the varying effectiveness of strategies across production areas.
3. Limited explicit incorporation of the precautionary principle and adaptive management approaches in response to new evidence and monitoring results.
4. Inadequate consideration of potential conflicts between economic and environmental objectives, particularly in high-intensity, environmentally pressured areas.
5. Persistent environmental challenges, such as sea lice infestations, genetic introgression, and disease outbreaks, in certain production areas despite the measures outlined in the whitepaper.

Implications and strategies for improvement: These weaknesses and gaps in the policy framework have significant implications for the future development and implementation of

Norway's aquaculture policies. If not addressed, they could hinder the effectiveness of efforts to promote environmental sustainability and undermine the long-term viability of the industry.

To address these limitations, several strategies could be considered:

1. Improving policy precision: Developing clearer definitions, measurable targets, and specific timelines for policy objectives related to climate change adaptation and offshore aquaculture development would enhance the clarity and accountability of these policies.
2. Strengthening empirical justification: Explicitly incorporating the precautionary principle and adaptive management approaches into the policy framework and establishing mechanisms for regularly updating policies based on the latest scientific findings, would help to ensure that policies are grounded in the best available evidence.
3. Enhancing policy differentiation: Tailoring strategies and measures to better address the specific environmental challenges and conditions in different production areas, species, and production methods could improve the effectiveness of policies in promoting sustainability across the diverse aquaculture sector.
4. Addressing economic-environmental trade-offs: Incorporating explicit consideration of potential conflicts between economic and environmental objectives, and developing strategies for balancing these priorities, particularly in high-intensity, environmentally pressured areas, would help to ensure a more holistic approach to aquaculture governance.
5. Strengthening implementation and enforcement: Investing in robust monitoring, reporting, and enforcement mechanisms, and promoting stakeholder engagement and collaboration, could help to address persistent environmental challenges and ensure that policies are effectively implemented on the ground.
6. Developing policy tools and incentives that promote both environmental sustainability and economic viability: To effectively balance economic and environmental objectives, there is a need for innovative policy approaches that encourage the adoption of sustainable practices while also supporting the financial health of the aquaculture industry. This could involve exploring market-based mechanisms, such as sustainability certifications or eco-labelling schemes, that create economic incentives for environmentally responsible production. Additionally, targeted financial support or

tax incentives for companies investing in green technologies or practices could help to align economic and environmental goals.

Norway's experience in developing and implementing aquaculture policies offers valuable lessons for other countries seeking to promote sustainable aquaculture growth. These lessons include:

1. The importance of setting clear, measurable goals and targets for environmental sustainability, and establishing a comprehensive policy framework that addresses the diverse challenges and impacts of aquaculture.
2. The value of a knowledge-based approach, with ongoing monitoring, research, and data collection to inform policy development and adaptive management.
3. The need for policy differentiation and flexibility to account for the heterogeneity of environmental conditions, species, and production methods across the aquaculture sector.
4. The importance of stakeholder engagement and collaboration, including industry actors, research institutions, and local communities, in developing and implementing effective and responsive policies.
5. The ongoing nature of the challenge of balancing economic and environmental priorities, and the need for continuous refinement and adaptation of policies based on new evidence and changing conditions.

By learning from Norway's successes and challenges and adapting these lessons to their specific contexts and needs, other countries can work towards developing robust, evidence-based aquaculture policies that promote both environmental sustainability and economic development.

Norway's experiences in navigating the complex trade-offs and synergies between economic growth and environmental sustainability in the aquaculture sector can provide valuable insights for other countries seeking to develop their own industries. The Norwegian case highlights the importance of considering the economic dimensions of sustainable aquaculture development, and the need for policies that can effectively balance and align economic and environmental objectives.

For example, Norway's use of the traffic light system, which links production growth to environmental performance, represents an innovative approach to creating economic incentives for sustainable practices. While the system has faced challenges in implementation, as noted in the risk assessment report, it nonetheless offers a potential model for other countries looking to integrate environmental considerations into their aquaculture governance frameworks.

Furthermore, Norway's emphasis on research and innovation in the aquaculture sector, as outlined in the whitepaper, underscores the potential for technological advancements to create new economic opportunities while also addressing environmental challenges. By investing in the development of sustainable aquaculture technologies and practices, such as closed-containment systems or alternative feed ingredients, other countries can potentially unlock new sources of economic growth while minimizing ecological impacts.

Chapter 7: Conclusion

This study has provided a comprehensive analysis of the alignment between Norway's aquaculture policies, as outlined in the whitepaper "Meld. St. 20 (2019–2020)" and the industry's environmental and economic performance, as documented in the "Risikorapport Norsk Fiskeoppdrett 2024." By systematically examining these two key documents and applying a policy theory framework, the research has generated valuable insights into the strengths, weaknesses, and opportunities for improvement in Norway's approach to sustainable aquaculture governance.

The main conclusions of this study, in response to the research questions, are as follows:

1. There is a general alignment between the environmental sustainability strategies and intentions presented in "Meld. St. 20 (2019-2020)" and the actual environmental results and challenges reported in the "Risikorapport Norsk Fiskeoppdrett 2024." Both documents recognize the key environmental pressures associated with aquaculture, such as sea lice, genetic impact on wild populations, and nutrient and waste discharge. However, the risk assessment report reveals that the effectiveness of these strategies varies significantly across production areas, with some regions continuing to face high environmental risks.
2. The regulatory frameworks and development trends identified in the two documents contribute to shaping the environmental and economic outcomes in the Norwegian fish farming sector. The whitepaper outlines a comprehensive regulatory framework,

including the Aquaculture Act and the traffic light system, which aims to balance sustainable growth and environmental protection. However, the risk assessment report highlights the challenges in effectively implementing these regulations and achieving the intended environmental outcomes across all production areas.

3. The analysis of the two documents reveals potential links and trade-offs between the environmental and economic aspects of sustainable aquaculture. While the whitepaper emphasizes the potential for continued growth and expansion of the industry, particularly through the development of offshore aquaculture, the risk assessment report underscores the need to carefully manage the environmental impacts and risks associated with this growth. The report also highlights the economic consequences of environmental challenges, such as the impact of disease outbreaks on fish health and productivity.

Based on these conclusions, the study offers several recommendations for the further development of Norway's aquaculture policies:

1. Strengthen the precision and specificity of policy goals and instruments, particularly in relation to climate change adaptation and offshore aquaculture development.
2. Enhance the differentiation of environmental strategies and measures across different species, production methods, and local conditions to better address the specific challenges and risks in each production area.
3. Explicitly incorporate the precautionary principle and adaptive management approaches into the policy framework, establishing mechanisms for regularly updating policies based on the latest scientific findings and monitoring results.
4. Address potential conflicts between economic and environmental objectives, particularly in high-intensity, environmentally pressured areas, by developing strategies for balancing these priorities and creating incentives for sustainable practices.
5. Invest in robust monitoring, enforcement, and stakeholder engagement mechanisms to ensure the effective implementation of policies and promote collaboration in addressing persistent environmental challenges.

The findings and recommendations of this study have significant implications for sustainable aquaculture governance in Norway and beyond. By addressing the identified limitations and gaps in its current policy framework, Norway can strengthen its position as a global leader in sustainable aquaculture, demonstrating how economic growth and environmental protection can be effectively balanced and aligned.

The lessons learned from Norway's experience, as documented in this study, can inform the development of sustainable aquaculture policies in other countries and contexts. The study highlights the importance of setting clear, measurable goals for environmental sustainability, adopting a knowledge-based approach with ongoing monitoring and adaptive management, tailoring strategies to local conditions and needs, engaging stakeholders in collaborative problem-solving, and continuously refining policies based on new evidence and changing circumstances. Additionally, as discussed in the literature on FDI and international trade (Maurseth & Medin, 2020), policymakers should consider the international economic and regulatory dynamics that shape the industry's development and sustainability when formulating aquaculture governance strategies.

In conclusion, this study has provided a nuanced and evidence-based assessment of the complex interplay between policy intentions, regulatory frameworks, and industry outcomes in the context of Norwegian aquaculture. By shedding light on the strengths, weaknesses, and opportunities for improvement in Norway's approach to sustainable aquaculture governance, the research contributes to the ongoing global dialogue on how to develop and manage aquaculture industries in an environmentally responsible and economically viable manner. The insights and recommendations generated by this study can serve as a valuable resource for policymakers, industry stakeholders, and researchers working towards the sustainable development of aquaculture in Norway and around the world.

References

Aasetre, J., & Vik, J. (2013). Framing the environment – Disputes and developments in the management of Norwegian salmon fjords. *Ocean & Coastal Management*, *71*, 203–212. https://doi.org/10.1016/j.ocecoaman.2012.09.001

Armstrong, C. (2021). Key Methods Used in Qualitative Document Analysis. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3996213

Bjørndal, T., & Tusvik, A. (2019). Economic analysis of land based farming of salmon. *Aquaculture Economics & Management*, *23*(4), 449–475. https://doi.org/10.1080/13657305.2019.1654558

Bowen, G. A. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal*, *9*(2), 27–40.

Creswell, J. W. (2009). *Research Design : Qualitative, quantitative, and Mixed Methods Approaches* (3rd ed.). SAGE Publications, Inc.

Directory of Fisheries. (n.d.). *Fisheries*. English. Retrieved December 3, 2023, from https://www.fiskeridir.no/English/Fisheries

Dyrevernalliansen. (2023). *FAKTA OM FISKEOPPDRETT OG OPPDRETTSFISK*. https://dyrevern.no/content/uploads/2023/02/fisk-faktaark.pdf

Ellis, J., & Tiller, R. (2019). Conceptualizing future scenarios of integrated multi-trophic aquaculture (IMTA) in the Norwegian salmon industry. *Marine Policy*, *104*, 198–209. https://doi.org/10.1016/j.marpol.2019.02.049

Frankic, A., & Hershner, C. (2003). Sustainable aquaculture: developing the promise of aquaculture. *Aquaculture International*, *11*(6), 517–530. https://doi.org/10.1023/b:aqui.0000013264.38692.91

Grefsrud, E., Andersen, L., Grøsvik, B., Hansen, P., Husa, V., Karlsen, Ø., Sami Madhun, A., Samuelsen, O., Sandlund, N., Solberg, M., Stien, L., Svåsand, T., &

Havforskningsinstituttet. (2024). Risikorapport norsk fiskeoppdrett 2024 . In *Havforskningsinstituttet*. Nærings- og fiskeridepartementet. https://www.hi.no/templates/reporteditor/report-pdf?id=79308&84383535

Grefsrud, E., Karlsen, Ø., Kvamme, B., Glover, K., Husa, V., Hansen, P., Grøsvik, B., Samuelsen, O., Sandlund, N., Stien, L., & Svåsand, T. (2021). *RISIKORAPPORT NORSK FISKEOPPDRETT 2021 - RISIKOVURDERING*. Havforskningsinstituttet. https://www.hi.no/templates/reporteditor/report-pdf?id=40200&86977424

Hansen, L. (2019). The weak sustainability of the salmon feed transition in norway – a bioeconomic case study. *Frontiers in Marine Science*, *6*. https://doi.org/10.3389/fmars.2019.00764

Henriksson, P. J. G., Troell, M., Banks, L. K., Belton, B., Beveridge, M. C. M., Klinger, D. H., Pelletier, N., Phillips, M. J., & Tran, N. (2021). Interventions for improving the productivity and environmental performance of global aquaculture for future food security. *One Earth*, *4*(9), 1220–1232. https://doi.org/10.1016/j.oneear.2021.08.009

Herrick, C., & Sarewitz, D. (2000). Ex Post Evaluation: A More Effective Role for Scientific Assessments in Environmental Policy. *Science, Technology, & Human Values*, *25*(3), 309–331. https://doi.org/10.1177/016224390002500303

Hersoug, B. (2015). The greening of Norwegian salmon production. *Maritime Studies*, *14*(1), 16. https://doi.org/10.1186/s40152015000349

Hoogerwerf, A. (1990). Reconstructing policy theory. *Evaluation and Program Planning*, *13*(3), 285–291. https://doi.org/10.1016/0149-7189(90)90059-6

Jensen , B.-A. (2023, May 22). *Norge er fortsatt den største lakseprodusenten i verden – gruser konkurrentene*. IntraFish.no . https://www.intrafish.no/marked/norge-er-fortsatt-den-storste-lakseprodusenten-i-verden-gruser-konkurrentene/2-1-1452383

Joffre, O. M., Klerkx, L., Dickson, M., & Verdegem, M. (2017). How is innovation in aquaculture conceptualized and managed? A systematic literature review and reflection framework to inform analysis and action. *Aquaculture*, *470*, 129–148. https://doi.org/10.1016/j.aquaculture.2016.12.020

Klima- og miljødepartementet. (2020, April 24). *Meld. St. 20 (2019–2020)*. Regjeringen.no. https://www.regjeringen.no/no/dokumenter/meld.-st.-20-20192020/id2699370/?ch=1

Krause, G., Brugere, C., Diedrich, A., Ebeling, M. W., Ferse, S. C. A., Mikkelsen, E., Pérez Agúndez, J. A., Stead, S. M., Stybel, N., & Troell, M. (2015). A revolution without people? Closing the people–policy gap in aquaculture development. *Aquaculture*, *447*, 44–55. https://doi.org/10.1016/j.aquaculture.2015.02.009

Lundebye, A.-K., Bakkejord, A., Nøstbakken, O., Sele, V., & Ørnsrud, R. (2019). *PROGRAM FOR FREMMEDSTOFFER I FÔRMIDLER AV FISK Rapport for innsamlede prøver 2018*.

Maurseth, P. B., & Medin, H. (2020). *8. Utenlandsinvesteringer i sjømatnæringen ognorsk tilknytning til EU*. 232–263. https://doi.org/10.18261/9788215040080-2020-09

Mercer, T., Ayres, R., Head, B., & Wanna, J. (2021). *Public policy theory, practice and teaching: Investigating the interactions* (T. Mercer, R. Ayres, B. Head, & J. Wanna, Eds.). JSTOR; ANU Press. https://www.jstor.org/stable/j.ctv1j9mjmg.9

Mickwitz, P. (2003). *A Framework for Evaluating Environmental Policy Instruments Context and Key Concepts*. SAGE Publications, Inc.

Miljødirektoratet. (2023, October 25). *Utslipp av næringssalter fra fiskeoppdrett*. Miljøstatus. https://miljostatus.miljodirektoratet.no/tema/forurensning/overgjodsling/utslipp-av-naringssalter-fra-fiskeoppdrett/?fbclid=IwAR2hM5LOb-yDJUnoXKuM7j4YI3F7TkfD8Oy7Awe_EmcYogHwBE15bAmQmRs

Misund, B. (2021, February 18). *Fiskeoppdrett*. Store Norske Leksikon. https://snl.no/fiskeoppdrett

Movik, S., & Stokke, K. B. (2015). Contested knowledges, contested responsibilities: The EU Water Framework Directive and salmon farming in Norway. *Norsk Geografisk Tidsskrift - Norwegian Journal of Geography*, *69*(4), 242–255. https://doi.org/10.1080/00291951.2015.1061049

Nofima, SINTEF Ocean, & BarentsWatch. (2022, April 8). *Bærekraft i havbruk* (E. Mikkelsen, Ed.). Www.barentswatch.no. https://www.barentswatch.no/havbruk/verdiskaping-bidrag-til-bnp

Olaussen, J. O. (2018). Environmental problems and regulation in the aquaculture industry. Insights from Norway. *Marine Policy*, *98*, 158–163. https://doi.org/10.1016/j.marpol.2018.08.005

Osmundsen, T. C., Almklov, P., & Tveterås, R. (2017). Fish farmers and regulators coping with the wickedness of aquaculture. *Aquaculture Economics & Management*, *21*(1), 163–183. https://doi.org/10.1080/13657305.2017.1262476

Per, A., Johnsen, F., Rognsås, L., Erraia, J., Grønvik, O., Fjose, S., Blomgren, A., Fjelldal, Ø., Robertsen, R., Iversen, A., & Nyrud, T. (2022). *Ringeirkninger av sjømatnæringen i 2021*. Menon Economics.

Sacred Heart University. (2022, September 7). *Research Guides: Organizing Academic Research Papers: Theoretical Framework*. Sacredheart.edu. https://library.sacredheart.edu/c.php?g=29803&p=185919

Sørlie, M. (2021, August 30). *An introduction to the Government's new aquaculture strategy*. Simonsen Vogt Wiig. https://svw.no/en/insights/an-introduction-to-the-governments-new-aquaculture-strategy

Telfer, T., Atkin, H., & Corner, R. (2009). Review of environmental impact assessment and monitoring in aquaculture in Europe and North America. *FAO. Environmental Impact Assessment and Monitoring in Aquaculture. FAO Fisheries and Aquaculture Technical Paper*, *527*, 285–394.

UN Sustainable Development Group. (2017, June). *THEORY OF CHANGE UNDAF COMPANION GUIDANCE*. Unsdg.un.org. https://unsdg.un.org/resources/theory-change-undaf-companion-guidance

Vormedal, I., & Larsen, M. (2021). *Regulatory Processes for Setting Sensitive-Period Sea-lice Thresholds in Major Salmon Producer Jurisdictions: An Evaluation*. The Fridtjof Nansen Institute (FNI) . https://www.asc-aqua.org/wp-content/uploads/2022/03/Regulatory-Processes-for-Setting-Sensitive-Period-and-Sea-lice-Thresholds-in-Major-Salmon-Producer-Jurisdictions.pdf

Vormedal, I., & Skjærseth, J. B. (2019). The good, the bad, or the ugly? Corporate strategies, size, and environmental regulation in the fish-farming industry. *Business and Politics*, *22*(3), 510–538. https://doi.org/10.1017/bap.2019.30

Widerberg, O. (2017). The "Black Box" problem of orchestration: how to evaluate the performance of the Lima-Paris Action Agenda. *Environmental Politics*, *26*(4), 715–737. https://doi.org/10.1080/09644016.2017.1319660

World Commission on Environment and Development. (1987). *Report of the world commission on environment and development: Our common future*. United Nations. https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

Appendices

Appendix A: Textual analysis

```
#!/usr/bin/env python
# coding: utf-8

# **Textual analysis**
#
# Extracting text from "Meld. St. 20 (2019–2020)" to identify relevant government strategies,
objectives, or policy changes mentioned. Following that, we'll analyze the "Risikorapport
Norsk Fiskeoppdrett 2024" for insights into industry outcomes, challenges, and practices.

# In[4]:


from PyPDF2 import PdfReader


# In[5]:


# File paths
meld_st_file_path =
'/Users/hamidahajimatova/Documents/Masteroppgave/Data/Meld20(2019-2020).pdf'
risikorapport_file_path =
'/Users/hamidahajimatova/Documents/Masteroppgave/Data/risokrapport 2024.pdf'

# Extracting text from "Meld. St. 20 (2019–2020)"
reader_meld_st = PdfReader(meld_st_file_path)
text_meld_st = ''
for page in reader_meld_st.pages:
    text_meld_st += page.extract_text() + ' '  # Adding a space between pages

# Show the beginning of the text to understand its structure and identify relevant sections
text_meld_st[:2000]  # Display the first 2000 characters to make sure data is read.


# Sammendrag (Summary): Provides an overview that might highlight key strategies and
objectives.
#
# Innledning – Helhetlig og økosystembasert hav-forvaltning (Introduction – Comprehensive
and Ecosystem-based Marine Management): Discusses the approach to marine management,
which could contain relevant policies or goals related to the fish farming industry.
#
# Miljøtilstand og utvikling i de norske havområdene (Environmental Condition and
Development in the Norwegian Marine Areas): May offer insights into environmental
sustainability measures or concerns that could impact the fish farming industry.
```

```
#
# To proceed further:
#
# Extract and summarize key points from "Meld. St. 20 (2019–2020)" related to governmental communications about the fish farming industry's environmental sustainability and economic performance.
#
# Follow with an analysis of "Risikorapport Norsk Fiskeoppdrett 2024" to identify actual industry outcomes and challenges.
#
# Draw connections between the findings from both documents to address your research questions
#
#
# Environmental Sustainability and Economic Performance:
#
# "Meld. St. 20 (2019–2020)" emphasizes the importance of preserving the ocean's ecology for long-term value creation and welfare in times of rapid environmental, climate, and activity changes at sea .
# It highlights the interconnectedness of Norwegian marine areas with the global ocean system, underlining the impact of global phenomena like climate change on local marine environments .
# The document outlines Norway's commitment to sustainable and ecosystem-based marine management, aiming for balanced value creation from marine resources while maintaining ecosystem health and biodiversity .

# In[6]:


import re

# Example: Remove headers/footers with regex
text_cleaned = re.sub(r"HeaderPattern|FooterPattern", "", text_meld_st)


# In[7]:


with open('meld_st_2019_2020.txt', 'w', encoding='utf-8') as file:
    file.write(text_meld_st)


# In[8]:


with open('meld_st_2019_2020.txt', 'r', encoding='utf-8') as file:
    text_meld_st = file.read()


# In[9]:
```

```
# Replace multiple spaces with a single space
text_cleaned = re.sub(r'\s+', ' ', text_meld_st)


# In[10]:


# Example: Remove a generic footer that contains "Page X of Y"
text_cleaned = re.sub(r'Page \d+ of \d+', '', text_cleaned)


# In[13]:


keywords = [
    "bærekraftig utvikling",  # Sustainable development
    "Næringssalter",          # Dissolved nutrients
    "miljøpåvirkning",        # Environmental impact
    "fiskevelferd",           # Fish welfare
    "havbruk",                # Aquaculture
    "akvakultur",             # Aquaculture (alternative term)
    "biomangfold",            # Biodiversity
    "rømming",                # Escapes (as in fish escapes from aquaculture facilities)
    "lakselus",               # Sea lice
    "økonomisk ytelse",       # Economic performance
    "næringsutvikling",       # Industry development
    "eksportverdi",           # Export value
    "produksjonsvolum",       # Production volume
    "regnbueørret",           # Rainbowtrout
    "bærekraft",              # Value creation
    "regelverk",              # Regulations
    "forvaltning",            # Management
    "politikk",               # Policy
    "tiltak",                 # Measures
    "lovverk",                # Legislation
    "laks",                   # Salmon
    "ørret",                  # Trout
    "fiskeoppdrett",          # Fish farming
    "akvakulturloven",        # The Aquaculture Act
    "oppdrett",               # Farming
    "lakseoppdrett",          # Salmon farming
    "utslipp",                # emissions
    "økonomisk",              # economy
    "økonomi",
    "samfunnsøkonomi",
    "havøkonomi"
]
```

```
# In[15]:


# Initialize a dictionary to hold contexts for each keyword
keyword_contexts = {keyword: [] for keyword in keywords}

# Define a function to extract context around a keyword
def extract_context(text, keyword, window_size=30):
    pattern = r".{0," + str(window_size) + r"}\b" + re.escape(keyword) + r"\b.{0," +
str(window_size) + r"}"
    found_texts = re.findall(pattern, text, re.IGNORECASE)
    return found_texts

# Search for each keyword in the text and extract context
for keyword in keywords:
    contexts = extract_context(text_cleaned, keyword)
    keyword_contexts[keyword].extend(contexts)

# Print contexts for each keyword to review
for keyword, contexts in keyword_contexts.items():
    print(f"Keyword '{keyword}' found {len(contexts)} times. Example contexts:")
    for context in contexts[:5]:  # Print up to 3 examples per keyword
        print(f" - {context}")
    print("----------\n")



# In[16]:


# Extracting text from "Risikorapport"
reader_risiko = PdfReader(risikorapport_file_path)
text_risiko = ''
for page in reader_risiko.pages:
    text_risiko += page.extract_text() + ' '  # Adding a space between pages

# Show the beginning of the text to understand its structure and identify relevant sections
text_risiko[:2000]  # Display the first 2000 characters to make sure data is read.


# In[17]:


# Example: Remove headers/footers with regex
text_cleaned_risikorapport = re.sub(r"HeaderPattern|FooterPattern", "", text_risiko)


# In[18]:
```

```
with open('risikorapport_2024.txt', 'w', encoding='utf-8') as file:
    file.write(text_risiko)


# In[19]:


with open('risikorapport_2024.txt', 'r', encoding='utf-8') as file:
    text_risiko = file.read()


# In[20]:


# Replace multiple spaces with a single space
text_cleaned_risikorapport = re.sub(r'\s+', ' ', text_risiko)
# Example: Remove a generic footer that contains "Page X of Y"
text_cleaned_risikorapport = re.sub(r'Page \d+ of \d+', '', text_cleaned_risikorapport)


# In[21]:


# Update the keywords list based on the adjustments
keywords = [
    "bærekraftig utvikling", "miljøtiltak", "miljøpåvirkning", "fiskevelferd",
    "havbruk", "akvakultur", "biomangfold", "rømming", "lakselus",
    "økonomisk ytelse", "næringsutvikling", "eksportverdi", "produksjonsvolum",
    "regnbueørret", "bærekraft", "regelverk", "forvaltning", "politikk",
    "tiltak", "lovverk", "laks", "ørret", "fiskeoppdrett", "akvakulturloven",
    "oppdrett", "lakseoppdrett", "utslipp", "sykdommer", "miljørisker",
    "dødelighet", "bærekraftsresultater", "miljøforbedringer", "markedsdynamikk",
    "konkurranseevne", "regulatoriske utfordringer", "politikk respons",
    "teknologisk innovasjon", "tilpasninger", "produksjon", "svinn", "dødlighet",
"næringssalter"
     "økonomisk", "økonomi", "samfunnsøkonomi", "havøkonomi"

]


# In[23]:


# Initialize a dictionary to hold contexts for each keyword
keyword_contexts_risikorapport = {keyword: [] for keyword in keywords}

# Define a function to extract context around a keyword
def extract_context_risikorapport(text, keyword, window_size=100):  # Increased window
size for broader context
```

```
    pattern = r".{0," + str(window_size) + r"}\b" + re.escape(keyword) + r"\b.{0," +
str(window_size) + r"}"
    found_texts = re.findall(pattern, text, re.IGNORECASE)
    return found_texts

# Search for each keyword in the text and extract context
for keyword in keywords:
    contexts = extract_context_risikorapport(text_cleaned_risikorapport, keyword)
    keyword_contexts_risikorapport[keyword].extend(contexts)

# Print contexts for each keyword to review
for keyword, contexts in keyword_contexts_risikorapport.items():
    print(f"Keyword '{keyword}' found {len(contexts)} times. Example contexts:")
    for context in contexts[:5]:  # Adjust the number of examples as necessary
        print(f" - {context.strip()}")
    print("----------\n")




# In[90]:


from sklearn.feature_extraction.text import CountVectorizer


# In[104]:


norwegian_stop_words = [
    'å', 'alle', 'andre', 'at', 'av', 'både', 'båe', 'bare', 'begge', 'ble', 'blei', 'bli', 'blir', 'blitt',
    'bort', 'bra', 'bruke', 'da', 'då', 'de', 'deg', 'dei', 'deim', 'deira', 'deires', 'dem', 'den', 'denne',
    'der', 'dere', 'deres', 'det', 'dette', 'di', 'din', 'disse', 'dit', 'ditt', 'du', 'dykk', 'dykkar', 'eg',
    'ein', 'eit', 'eitt', 'eller', 'elles', 'en', 'ene', 'eneste', 'enhver', 'enn', 'er', 'et', 'ett', 'etter',
    'få', 'for', 'før', 'fordi', 'forsøke', 'først', 'fra', 'fram', 'gå', 'gjorde', 'gjøre', 'god', 'ha', 'hadde',
    'han', 'hans', 'har', 'hennar', 'henne', 'hennes', 'her', 'hit', 'hjå', 'ho', 'hoe', 'honom', 'hoss',
'hossen',
    'hun', 'hva', 'hvem', 'hver', 'hvilke', 'hvilken', 'hvis', 'hvor', 'hvordan', 'hvorfor', 'i', 'ikke',
'ikkje',
    'ingen', 'ingi', 'inkje', 'inn', 'innen', 'inni', 'ja', 'jeg', 'kan', 'kom', 'korleis', 'korso', 'kun',
'kunne',
    'kva', 'kvar', 'kvarhelst', 'kven', 'kvi', 'kvifor', 'lage', 'lang', 'lik', 'like', 'må', 'man', 'mange',
'måte',
    'me', 'med', 'medan', 'meg', 'meget', 'mellom', 'men', 'mens', 'mer', 'mest', 'mi', 'min', 'mine',
'mitt', 'mot',
    'mye', 'mykje', 'nå', 'når', 'ned', 'nei', 'no', 'noe', 'noen', 'noka', 'noko', 'nokon', 'nokor', 'nokre',
'ny',
    'og', 'også', 'om', 'opp', 'oss', 'over', 'på', 'rett', 'riktig', 'så', 'samme', 'sånn', 'seg', 'selv', 'si',
    'sia', 'sidan', 'siden', 'sin', 'sine', 'sist', 'sitt', 'sjøl', 'skal', 'skulle', 'slik', 'slutt', 'so', 'som',
    'somme', 'somt', 'start', 'stille', 'tid', 'til', 'tilbake', 'um', 'under', 'upp', 'ut', 'uten', 'være', 'vært',
```

```
    'var', 'vår', 'vart', 'varte', 'ved', 'verdi', 'vere', 'verte', 'vi', 'vil', 'ville', 'vite', 'vore', 'vors', 'vort',
'hos', 'st', 'figur'
    'særlig','meldes', 'gjennom', 'hensiktsmessig', 'totalt', 'sett'
]


# In[105]:


# Add years to the stop word list
years = [str(year) for year in range(2000, 2025)]
norwegian_stop_words.extend(years)


# In[113]:


def generate_ngrams(text, n=2):
    count_vectorizer = CountVectorizer(ngram_range=(2, 2),
stop_words=norwegian_stop_words)  # Consider adding stop_words='english'
    ngram_array = count_vectorizer.fit_transform([text]).toarray()
    ngram_list = count_vectorizer.get_feature_names_out()
    ngram_freq = ngram_array.flatten()

    # Combine n-grams with their frequencies
    ngram_with_freq = list(zip(ngram_list, ngram_freq))
    ngram_with_freq.sort(key=lambda x: x[1], reverse=True)  # Sort based on frequency

    for ngram, freq in ngram_with_freq[:50]:  # Print top 10
        print(f'{ngram}: {freq}')

# Correct example usage for "Meld. St."
generate_ngrams(text_cleaned, 2)  # For bigrams in Meld. St.

# Correct example usage for "Risikorapport"
generate_ngrams(text_cleaned_risikorapport, 2)  # For bigrams in Risikorapport



# In[110]:


import spacy


# In[111]:


import spacy
# Load the Norwegian model
```

```
nlp = spacy.load("nb_core_news_sm")

# Function to preprocess text using spaCy for NER and POS tagging
def spacy_preprocess(text):
    doc = nlp(text)

    # Filter out named entities
    filtered_entities = [ent.text for ent in doc.ents]
    filtered_text = ' '.join([token.text for token in doc if token.text not in filtered_entities])

    # Further filter based on POS tagging, focusing on nouns and adjectives
    final_text = ' '.join([token.text for token in nlp(filtered_text) if token.pos_ in ['NOUN',
'ADJ']])

    return final_text

# Example usage
text_cleaned = spacy_preprocess(text_cleaned)
text_cleaned_risikorapport = spacy_preprocess(text_cleaned_risikorapport)


# In[114]:


def perform_lda(text_data, n_topics=5, n_words=10):
    # Adjusting ngram_range and removing max_df and min_df for troubleshooting
    count_vectorizer = CountVectorizer(ngram_range=(1, 3),
stop_words=norwegian_stop_words)
    data_vectorized = count_vectorizer.fit_transform(text_data)

    lda_model = LatentDirichletAllocation(n_components=n_topics, random_state=0)
    lda_model.fit(data_vectorized)

    words = count_vectorizer.get_feature_names_out()
    for topic_idx, topic in enumerate(lda_model.components_):
        print(f"Topic #{topic_idx+1}:")
        print(" ".join([words[i] for i in topic.argsort()[:-n_words - 1:-1]]))

# Assuming text_cleaned and text_cleaned_risikorapport are your preprocessed texts
texts = [text_cleaned, text_cleaned_risikorapport]
perform_lda(texts, n_topics=6, n_words=10)


# In[ ]:
```

Appendix B: Coding Scheme Meld.st.20

Meld.st.20			
Section title	**Page range**	**Theme**	**Sub-theme**
Environmental Sustainability	1, 7-8, 22-37, 144-145	Environmental Sustainability	Sustainable Development, Environmental Impact, Biodiversity
Regulatory Frameworks	13-17, 128-135, 146	Regulatory Frameworks	Regulations, The Aquaculture Act
Ocean-based Industries and Value Creation	76-82, 105-110	Aquaculture Industry Development	Aquaculture Trends, Environmental Concerns
Offshore Aquaculture Development	80-81, 129, 146	Aquaculture Industry Development	Aquaculture Trends
Environmental Sustainability in Fish Farming	84,86	Environmental Sustainability	Environmental Impact
Regulatory Frameworks Impacting Fish Farming	129, 146	Regulatory Frameworks	The Aquaculture Act
Aquaculture Industry Development and Economic Health	77-82, 146	Aquaculture Industry Development	Aquaculture Trends
Environmental Status and Trends	22-24	Environmental Sustainability	Environmental Impact, Biodiversity
Integrated Ocean Management Plans	1-8	Regulatory Frameworks	Regulations
Ocean Policy and International Initiatives	16-17	Regulatory Frameworks	Regulations
Climate Change Impacts	22-24	Environmental Sustainability	Environmental Impact
Ocean-Based Industries	1-55	Aquaculture Industry Development	Aquaculture Trends
Integrated and Ecosystem-Based Management	13-18	Environmental Sustainability	Sustainable Development
International Cooperation and Ocean Governance	16-17, 137-159	Regulatory Frameworks	Regulations
Cultivation of Macroalgae and Its Relation to Fish Farming	81	Environmental Sustainability	Environmental Impact
Offshore Aquaculture Development	146	Aquaculture Industry Development	Aquaculture Trends
Environmental Considerations and International Cooperation	137-159	Environmental Sustainability	Sustainable Development
Economic and Administrative Implications	160	Regulatory Frameworks	Regulations

Appendix C: Coding Scheme Risikorapport

Risikorapport			
Section title	**Page range**	**Theme**	**Sub-theme**
Environmental Sustainability		Environmental Sustainability	Impact on Farmed and Wild Salmon
Regulatory Frameworks	13-17, 128-135, 146	Regulatory Frameworks	Regulations, The Aquaculture Act
Ocean-based Industries and Value Creation	76-82, 105-110	Aquaculture Industry Development	Aquaculture Trends, Environmental Concerns
Offshore Aquaculture Development	80-81, 129, 146	Aquaculture Industry Development	Aquaculture Trends
Environmental Sustainability in Fish Farming	84,86	Environmental Sustainability	Environmental Impact
Regulatory Frameworks Impacting Fish Farming	129, 146	Regulatory Frameworks	The Aquaculture Act
Aquaculture Industry Development and Economic Health	77-82, 146	Aquaculture Industry Development	Aquaculture Trends
Environmental Status and Trends	22-24	Environmental Sustainability	Environmental Impact, Biodiversity
Integrated Ocean Management Plans	1-8	Regulatory Frameworks	Regulations
Ocean Policy and International Initiatives	16-17	Regulatory Frameworks	Regulations
Climate Change Impacts	22-24	Environmental Sustainability	Environmental Impact
Ocean-Based Industries	1-55	Aquaculture Industry Development	Aquaculture Trends
Integrated and Ecosystem-Based Management	13-18	Environmental Sustainability	Sustainable Development
International Cooperation and Ocean Governance	16-17, 137-159	Regulatory Frameworks	Regulations
Cultivation of Macroalgae and Its Relation to Fish Farming	81	Environmental Sustainability	Environmental Impact
Offshore Aquaculture Development	146	Aquaculture Industry Development	Aquaculture Trends
Environmental Considerations and International Cooperation	137-159	Environmental Sustainability	Sustainable Development
Economic and Administrative Implications	160	Regulatory Frameworks	Regulations

Appendix D: Manual analysis of Meld. St. 20 (2019–2020)

Environmental Sustainability

Sustainable Development, Environmental Impact, Biodiversity (pp. 1, 7-8, 22-37, 144-145)

The document emphasizes that the basis for value creation from Norway's ocean-based activities depends on *"maintaining good environmental status and high biodiversity in the marine and coastal environment, safeguarding the oceans as a source of food and using ocean resources sustainably*" (Klima- og miljødepartementet, 2020, p.7). This reflects a commitment to balancing economic development with environmental sustainability.

The management plans aim to provide a framework for sustainable use of marine resources and ecosystem services while maintaining ecosystem structure, functioning, productivity, and diversity (p.7-8). This ecosystem-based approach recognizes the interconnectedness of environmental health and economic activities.

However, the document acknowledges that climate change is having growing impacts on marine ecosystems, especially in the Barents Sea (Klima- og miljødepartementet, 2020, p.22-37). Rising sea temperatures and shrinking sea ice cover have resulted in large-scale ecological changes in the northern Barents Sea, such as:

Shifting ecosystem production and biomass, with increased primary production and zooplankton biomass but declines in Arctic zooplankton species (Klima- og miljødepartementet, 2020, p.24-27)
Northward expansion of fish stocks like cod and negative impacts on ice-associated species (Klima- og miljødepartementet, 2020, p.27-30)
Ocean acidification, though effects are not yet documented in the Barents Sea (Klima- og miljødepartementet, 2020, p.31)
These climate change impacts pose challenges for sustainable management of living marine resources and have implications for industries like aquaculture. Warming oceans may affect the suitability of waters for fish farming and increase problems like disease and sea lice (Klima- og miljødepartementet, 2020, p.144-145).

To address this, the document calls for climate-resilient management of marine resources and biodiversity to maintain viable populations and ecosystem services (Klima- og miljødepartementet, 2020, p.144). Efforts to promote green transformation of ocean industries and strengthen marine carbon sinks are also emphasized (Klima- og miljødepartementet, 2020, p.145).

Environmental Impact (pp. 84, 86)

The document identifies several key environmental pressures associated with aquaculture activities. These include:

The spread of sea lice from fish farms to wild fish populations.

Escapes of farmed fish, which can interbreed with wild fish and potentially impact the genetic makeup and fitness of wild populations.

Discharge of waste materials, such as nutrients and organic matter, which can lead to local eutrophication and sediment deposition.

The use of hazardous substances, including chemicals and delousing agents.

These pressures are acknowledged as the main environmental problems currently associated with coastal aquaculture, and the document suggests that similar issues may arise with the development of offshore aquaculture (Klima- og miljødepartementet, 2020, p.84). The scale of these problems is expected to depend on factors such as the technology and production systems used.

Addressing these environmental impacts is critical for the sustainable development of the aquaculture industry. The document notes that knowledge is limited regarding the proportion of nutrients and other pollutants from coastal aquaculture that is transported into offshore areas (Klima- og miljødepartementet, 2020, p.86), highlighting the need for further research to understand the full extent of aquaculture's environmental footprint.

Environmental Impact (p. 81)

Integrated multi-trophic aquaculture (IMTA) is discussed as a potential approach for mitigating the environmental impacts of fish farming. IMTA involves cultivating species from different trophic levels together, such as combining fish production with the cultivation of seaweed or bivalves (Klima- og miljødepartementet, 2020, p.81).

The document specifically mentions the potential of kelp farming as a component of IMTA systems. By integrating kelp cultivation with fish farming, the nutrients discharged from fish farms can be taken up by the kelp, thereby reducing the overall nutrient loading in the surrounding environment. The document states that "several companies are interested in combining kelp production with salmon farming, since for example sugar kelp can make use of dissolved nutrients from salmon production" (Klima- og miljødepartementet, 2020, p.81).

This suggests that IMTA approaches like kelp farming could play a role in recycling nutrients and minimizing the eutrophication potential of fish farming. However, the document also notes that scaling up production of unfed species like kelp will require more knowledge about issues such as food safety and environmental impacts (Klima- og miljødepartementet, 2020, p.82), indicating a need for further research and development to optimize IMTA systems.

Regulatory Frameworks

Regulations, The Aquaculture Act (pp. 13-17, 128-135, 146)

The document highlights the importance of a comprehensive regulatory framework for managing ocean-based activities, including aquaculture, in Norwegian waters. Norway's system of integrated ocean management plans, first established in the early 2000s, provides an overarching framework for ecosystem-based management of marine areas (Klima- og miljødepartementet, 2020, p.13-14). These plans aim to clarify the overall framework for different sectors and promote coordination and clear priorities for management of Norway's seas (Klima- og miljødepartementet, 2020, p.15).

Within this broader framework, activities in each management plan area are regulated based on existing sector-specific legislation (Klima- og miljødepartementet, 2020, p.15). For aquaculture, the key piece of legislation is the Aquaculture Act, which governs aquaculture operations in coastal waters (Klima- og miljødepartementet, 2020, p.127).

However, with the growing interest in offshore aquaculture development, there is a recognized need to adapt the regulatory framework to accommodate aquaculture activities further from the coast. The document discusses the ongoing development of a legal framework for offshore aquaculture under the Aquaculture Act (Klima- og miljødepartementet, 2020, p.146).

A working group has prepared a report on the regulation of offshore aquaculture, which recommends that in areas outside the geographical scope of the Planning and Building Act (which extends one nautical mile from the coast), the central government should open areas for offshore aquaculture under the Aquaculture Act (Klima- og miljødepartementet, 2020, p.129). This would involve a process of identifying suitable areas (blocks) for aquaculture development and subsequently determining the specific locations for siting facilities within these blocks.

The report also recommends establishing safety zones around offshore aquaculture facilities and adapting marking and lighting requirements to ensure safe navigation in the vicinity of these structures (Klima- og miljødepartementet, 2020, p.129). For mobile aquaculture systems, it is suggested that they should be subject to similar navigational requirements as other vessels to prevent collisions.

Furthermore, the document emphasizes the need for sufficient knowledge about the migration routes, habitats, and feeding grounds of important wild fish stocks to guide the spatial planning of offshore aquaculture and ensure that environmental considerations are properly incorporated into the regulatory process (Klima- og miljødepartementet, 2020, p.129).

To inform this regulatory development process, the Directorate of Fisheries has submitted a proposal recommending a strategic environmental assessment for offshore aquaculture in 11 areas identified as suitable, as well as 12 additional areas for potential future inclusion (Klima- og miljødepartementet, 2020, p.129). The document notes that any formal allocation of areas for aquaculture will be carried out under the Aquaculture Act, which falls under the authority of the Ministry of Trade, Industry, and Fisheries (Klima- og miljødepartementet, 2020, p.130).

Regulations (pp. 1-8)

The document emphasizes the role of Norway's integrated ocean management plans as a framework for regulating marine activities, including aquaculture, while ensuring the sustainable use of ocean resources. The stated purpose of these plans is "*to provide a framework for value creation through the sustainable use of marine natural resources and ecosystem services and at the same time maintain the structure, functioning, productivity and diversity of the ecosystems*" (Klima- og miljødepartementet, 2020, p.7).

The management plans are intended to be a tool for both facilitating value creation and food security, and for maintaining the high environmental value of Norway's marine areas (p.7). They do this by clarifying the overall framework for different marine sectors, promoting coordination between them, and establishing clear priorities for the management of each marine area (Klima- og miljødepartementet, 2020, p.8).

Importantly, the plans are based on an ecosystem approach, which involves considering the cumulative impacts of all human activities on the marine environment and managing ocean use in a way that maintains the natural functioning and productivity of ecosystems (p.8). This holistic perspective is critical for ensuring that the expansion of industries like aquaculture occurs within ecological limits.

The management plans are developed through a collaborative process involving relevant government ministries and agencies, with input from a range of stakeholders including industry, environmental organizations, and local communities (Klima- og miljødepartementet, 2020, p.15-16). This participatory approach helps to balance different interests and ensure that the plans reflect a broad range of perspectives on sustainable ocean management.

By providing a clear and agreed-upon framework for regulating marine activities, the management plans help to create a predictable operating environment for industries like aquaculture while also safeguarding the long-term health and productivity of Norway's marine ecosystems.

Regulations (pp. 16-17)

The document underscores Norway's strong commitment to pursuing an active and sustainable ocean policy, with a focus on promoting responsible commercial activities like aquaculture. Norway's ocean policy is based on the principle of integrated, ecosystem-based management, which aims to balance the needs of different marine sectors while maintaining healthy and productive marine environments (Klima- og miljødepartementet, 2020, p.16).

The Government has identified the ocean industries, including aquaculture, as a key priority area for economic development and value creation. However, this growth is to be pursued within a framework of sustainable management, reflecting Norway's long-term perspective on the use of marine resources for the benefit of both current and future generations (p.16).

Norway's approach to aquaculture development exemplifies this commitment to sustainability. The document notes that "*the Government considers it important for exploitation of natural resources to have positive spin-off effects for communities*" (Klima- og miljødepartementet, 2020, p.76), indicating a focus on ensuring that aquaculture growth benefits coastal populations and supports local economies.

At the same time, the document emphasizes the need for aquaculture to be developed in an environmentally responsible manner, with a focus on addressing challenges such as sea lice, escapes, and waste discharge (Klima- og miljødepartementet, 2020, p.84). Norway's regulatory system for aquaculture, centered around the Aquaculture Act, is designed to promote the sustainable growth of the industry while minimizing its ecological impacts.

Norway is also investing in research and innovation to support the sustainable development of aquaculture, including efforts to develop new production technologies (such as offshore and land-based farming), improve fish health and welfare, and minimize environmental impacts (Klima- og miljødepartementet, 2020, p.82). By prioritizing knowledge-based management and technological advancement, Norway aims to position itself as a global leader in sustainable aquaculture practices.

Aquaculture Industry Development

Aquaculture Trends, Environmental Concerns (pp. 76-82, 105-110)

The document highlights the significant role that fisheries and aquaculture play in Norway's economy and society. The seafood sector is a major contributor to national welfare and value creation, with Norway exporting seafood worth NOK 107.3 billion in 2019 (Klima- og miljødepartementet, 2020, p.77). Fisheries and aquaculture are particularly important for coastal communities, providing employment and economic activity in many regions of the country.

Norway's seafood production has grown substantially over the past few decades, with aquaculture emerging as a key driver of this growth. In 2019, the country's aquaculture sector produced over 1.4 million tons of salmon and trout, representing a significant share of global production (Klima- og miljødepartementet, 2020, p.78). The document notes that there is potential for further growth in aquaculture, particularly through the development of offshore and land-based farming technologies (Klima- og miljødepartementet, 2020, p.79).

However, the expansion of aquaculture has also raised environmental concerns. The document identifies several key environmental pressures associated with fish farming, including the spread of sea lice, escaped farmed fish, waste discharge, and the use of hazardous substances (Klima- og miljødepartementet, 2020, p.84). Managing these impacts is seen as critical for the sustainable development of the industry.

To address these challenges, Norway is investing in research and innovation to develop more sustainable aquaculture practices. This includes efforts to improve fish health and welfare, reduce the environmental footprint of feed production, and develop new production technologies such as closed-containment systems and offshore farming (Klima- og miljødepartementet, 2020, p.80-81).

The document also discusses the potential of emerging ocean-based industries, such as offshore wind power and marine bioprospecting, to contribute to Norway's future economic growth and value creation.

Offshore wind power is identified as a rapidly growing sector globally, with significant potential for development in Norwegian waters (Klima- og miljødepartementet, 2020, p.105). Norway's extensive maritime experience and existing offshore infrastructure (e.g., from the oil and gas industry) are seen as advantages for developing this industry. However, the document also notes that offshore wind development may raise new environmental concerns and spatial conflicts with other ocean users, such as fisheries (Klima- og miljødepartementet, 2020, p.107).

Marine bioprospecting, which involves the search for valuable compounds and genetic material from marine organisms, is another emerging field with potential for value creation (p.108). Norway's marine biodiversity, particularly in the Arctic, is seen as a rich source of potential new products for industries such as pharmaceuticals, biotechnology, and food production. However, the document emphasizes the need to ensure that bioprospecting activities are conducted sustainably and do not harm marine ecosystems (Klima- og miljødepartementet, 2020, p.108).

Aquaculture Trends (pp. 80-81, 129, 146)
The document identifies offshore aquaculture as a significant opportunity for growth in Norway's seafood sector. With increasing demand for seafood products globally and limited scope for expansion in coastal areas, moving fish farming further offshore is seen to enable the continued development of the industry while mitigating environmental impacts on coastal ecosystems.

Norway's extensive experience in offshore industries, such as oil and gas and shipping, is considered an advantage for developing offshore aquaculture. The document notes that "Norwegian ocean industries have considerable maritime and petroleum-related expertise that could play a role in the development of floating wind farms" (Klima- og miljødepartementet, 2020, p.107), suggesting that this expertise could also be applied to the design and operation of offshore fish farming facilities.

The government is actively working to facilitate the growth of offshore aquaculture. In 2017, the Norwegian Ministry of Trade, Industry and Fisheries introduced a new system of development licenses to promote innovation in aquaculture, including the development of technologies for exposed offshore locations (Klima- og miljødepartementet, 2020, p.80). These licenses, which are granted at a reduced fee, are intended to encourage companies to invest in the research and development needed to overcome the technical and environmental challenges of offshore farming.

The document also discusses the ongoing efforts to develop a regulatory framework for offshore aquaculture under the Aquaculture Act (Klima- og miljødepartementet, 2020, p.146). This includes the establishment of a legal definition of offshore aquaculture, as well as provisions for the allocation of suitable areas for offshore farming and the development of technical standards and environmental monitoring requirements.

To support the spatial planning process for offshore aquaculture, the Norwegian Directorate of Fisheries has proposed conducting a strategic environmental assessment of 11 areas identified as suitable for offshore fish farming, with an additional 12 areas identified for potential future development (Klima- og miljødepartementet, 2020, p.129). This assessment will help to identify the environmental risks and potential conflicts with other ocean uses associated with offshore aquaculture development in these areas.

The document emphasizes that while offshore aquaculture presents significant opportunities for growth, it also poses new challenges that will need to be addressed. These include the need for new technologies and production systems adapted to more exposed offshore conditions, as well as the potential for new environmental impacts and spatial conflicts with other ocean industries (Klima- og miljødepartementet, 2020, p.81).

To address these challenges, the government is investing in research and development to support the growth of offshore aquaculture. This includes funding for projects focused on developing new cage designs, feeding systems, and environmental monitoring technologies suitable for offshore conditions (Klima- og miljødepartementet, 2020, p.81). The document also highlights the need for continued research on the environmental impacts of offshore farming, including the potential effects on wild fish populations and benthic ecosystems (Klima- og miljødepartementet, 2020, p.81).

Aquaculture Trends (pp. 77-82, 146)

The document highlights the substantial economic importance of the aquaculture industry for Norway. In 2019, the country's seafood sector generated NOK 64.7 billion in value added and provided employment for approximately 30,700 people, with aquaculture accounting for a significant share of this economic activity (Klima- og miljødepartementet, 2020, p.77).

Aquaculture has been a key driver of growth in Norway's seafood sector over the past few decades. Between 2010 and 2019, value added from aquaculture increased from NOK 13.2 billion to NOK 31.1 billion, while employment in the sector grew from 5,500 to 9,000 people (Klima- og miljødepartementet, 2020, p.83). This growth has been fueled by increasing global demand for seafood products, particularly salmon, as well as Norway's natural advantages for aquaculture production, such as its long coastline and favorable environmental conditions.

Fish processing is another important component of Norway's aquaculture value chain. The document notes that fish processing plants are located along the coast, close to aquaculture production sites, allowing for efficient processing and distribution of seafood products (p.83). In 2019, fish processing accounted for NOK 12.1 billion in value added and employed approximately 11,500 people (Klima- og miljødepartementet, 2020, p.83), highlighting the significant economic impact of this subsector.

Looking to the future, the document identifies offshore aquaculture as a potential catalyst for transforming Norway's aquaculture industry. Offshore farming, which involves moving production further away from the coast to more exposed locations, is seen to enable the continued growth of the industry while reducing environmental pressures on coastal areas (Klima- og miljødepartementet, 2020, p.146).

The development of offshore aquaculture is expected to create new opportunities for value creation and employment in Norway's seafood sector. The document notes that "if aquaculture facilities are sited further out from the coast, new conflicts of interest are likely to arise with the traditional fisheries, shipping and offshore wind farms" (Klima- og miljødepartementet, 2020, p.129), suggesting that the growth of offshore farming may stimulate economic activity and employment in related sectors such as shipbuilding, technology development, and maritime services.

However, the document also recognizes that the transition to offshore aquaculture will require significant investments in research, development, and infrastructure. Offshore farming poses new technical challenges, such as the need for more robust cage designs and feeding systems, as well as logistical challenges related to the remote location of production sites (Klima- og miljødepartementet, 2020, p.81). Addressing these challenges will require continued innovation and collaboration between industry, research institutions, and government agencies.

The document also highlights the potential environmental benefits of offshore aquaculture, such as reducing the impact of fish farming on coastal ecosystems and wild fish populations (p.146). However, it notes that the environmental risks and impacts of offshore farming are not yet fully understood, and that continued research and monitoring will be necessary to ensure the sustainable development of this sector (Klima- og miljødepartementet, 2020, p.129).

Appendix E: Manual analysis of "Risikorapport Norsk Fiskeoppdrett 2024"

Environmental Sustainability

Sustainable Development

- "Bærekraftig utvikling er definert av FN som «en utvikling som tilfredsstiller dagens behov uten å ødelegge fremtidige generasjoners muligheter til å tilfredsstille sine behov»."(Grefsrud et al., 2024, p. 15)
- "Ut fra dette kan det forstås at i et bærekraftperspektiv så skal hensynet til miljøet vektes tyngre enn den økonomiske og samfunnsmessige bærekraften." (Grefsrud et al., 2024, p. 16)

Environmental Impact

- "Med nærmere 500 millioner oppdrettsfisk, inkludert rensefisk, stående hovedsakelig i åpne merder langs kysten til enhver tid, utgjør fiskeoppdrett den største husdyrproduksjonen i Norge. Med en så høy biomasse er det bred enighet om at aktiviteten i større eller mindre grad påvirker miljøet både lokalt og regionalt, og det er knyttet til dels store utfordringer til dyrevelferd." (Grefsrud et al., 2024, p. 16)

- "Lokalisering av oppdrettsanlegg har endret seg over tid og dagens anlegg ligger i større grad i mer strømrike områder. På disse lokalitetene har vi mindre kunnskap om konsekvensene av utslipp på bunnmiljøet i nær- og fjernsonen, og det organiske avfallet spres i større grad og fortynnes ut over et så stort område at påvirkningen kan være vanskelig å måle med dagens overvåkingsmetodikk." (Grefsrud et al., 2024, p. 16)

Fish Welfare

- "Helt siden volumet av oppdrettslaks begynte å øke har parasitten lakselus vært et problem, og smitte til vill laksefisk er i dag den miljøindikatoren som legger begrensninger for videre vekst i norsk lakseoppdrett. Lakselusa påvirker både oppdrettslaksen og vill laksefisk." (Grefsrud et al., 2024, p. 16)

- "Avlusningsoperasjonene er en stor belastning både for oppdrettsfisken og rensefisken, og det er enighet om at det er lakselusbehandlinger i betydelig grad påvirker fiskevelferden gjennom økt dødelighet i perioden etter behandling og skader som følge av behandlingen." (Grefsrud et al., 2024, p. 17)

Regulatory Aspects

Traffic Light System (Trafikklyssystemet)

- "Nærings- og fiskeridepartementet vedtok med bakgrunn i dette i 2017 en forskrift (produksjonsområdeforskriften) som er en handlingsregel for kapasitetsjustering av lakse-, og ørretoppdrett basert på forhåndsdefinerte geografiske områder og miljøindikatorer (trafikklyssystemet)." (Grefsrud et al., 2024, p. 17)
- "Trafikklyssystemet ble etablert med en handlingsregel der miljøstatus, vurdert som lakselusindusert dødelighet hos vill laksefisk (postsmolt), er lagt til grunn for om produksjonen får øke, skal være uendret eller må reduseres i produksjonsområdet." (Grefsrud et al., 2024, p. 17)

Quality Standard for Wild Salmon (Kvalitetsnorm for ville laksebestander)

- "Villaksen forvaltes i dag etter Kvalitetsnorm for ville bestander av atlantisk laks, som hviler på to kvalitetselementer: I) genetisk integritet og II) i hvilken grad bestandene oppnår gytebestandsmål og høstbart overskudd." (Grefsrud et al., 2024, p. 16)

Regulatory Framework

- "Med trafikklyssystem, kvalitetsnorm for ville laksebestander, overvåking av miljø og matvaretrygghet, luseforskrift og et omfattende lovverk både for akvakultur, mat og dyrevelferd ligger Norge i verdenstoppen for kunnskapsbasert forvaltning av havbruksnæringen." (Grefsrud et al., 2024, p. 19)

Economic Performance

Production and Export Value

- "Norge eksporterte i 2022 i overkant av 1,23 millioner tonn oppdrettslaks (Salmo salar) og 56 912 tonn regnbueørret (Oncorhynchus mykiss) til en verdi på henholdsvis 122,5 og 5,5 milliarder norske kroner, og utgjorde 75 % av den samlede eksportverdien av sjømat på totalt 171,7 milliarder kroner (tall fra Norges sjømatråd)." (Grefsrud et al., 2024, p. 15)

Production Volume

- "Atlantisk laks utgjør 1,52 millioner tonn (95%) av den totale produksjonen. Produksjon av regnbueørret var på rundt 81 250 tonn i 2023, som var omtrent det samme som i 2022) (Grefsrud et al., 2024, p. 15)

Production Intensity

- "Produksjonen varierer mellom produksjonsområdene og de mest oppdrettsintensive områdene basert på mengde fisk produsert per areal (tonn produsert fisk/km2) var produksjonsområdene 2-4 Ryfylke til Stadt, samt produksjonsområde 10 Andøya til Senja (tabell 1.1). I andre enden av skalaen ligger produksjonsområde 1 Svenskegrensen-Jæren og produksjonsområde 13 Øst-Finnmark." (Grefsrud et al., 2024, p. 18)

Production area 1:

Environmental Sustainability

Fish Welfare

- "Det vurderes derfor å være høy risiko for at en oppdrettslaks som blir satt ut i produksjonsområde 1 i 2024 opplever så dårlig velferd at den dør eller blir regnet som utkast." (Grefsrud et al., 2024, p. 45)
- "Selv om påvirkningen fra dagens fiskeoppdrett vurderes som lav i produksjonsområde 1, er det mange andre menneskeskapte påvirkninger som gjør at belastningen på det marine miljøet i området er stor." (Grefsrud et al., 2024, p. 45)

Escapes (Rømming) and Sea Lice (Lakselus)

- "Med lav produksjon er det lave utslipp av lakselus, få sykdomsutbrudd, samt lave utslipp av næringssalter, partikulært organisk materiale, kobber og avlusningsmidler til området. Det er rapportert lite rømt oppdrettslaks i elvene som overvåkes og den ville leppefisken som brukes til avlusning er fanget lokalt og transportert over relativt små geografiske avstander." (Grefsrud et al., 2024, p. 45)

-

Emissions (Utslipp)

- "Med lave utslipp av både nitrogen og fosfor samt lav estimert økning i planteplanktonproduksjon, vurderes det å være lav sannsynlighet for overgjødsling som følge av utslipp av løste næringssalter fra fiskeoppdrett." (Grefsrud et al., 2024, p. 49)
- "Estimert utslipp av kobber brukt som antibegroingsmiddel basert på oppdrettsandel (1 %) og areal (3520 km2) i produksjonsområde 1 ble redusert fra 2 kg til 1 kg kobber per km2 i perioden 2021–2022, og vurderes som lavt." (Grefsrud et al., 2024, p. 50)

Regulatory Aspects

Traffic Light System (Trafikklyssystemet)

- "Trafikklyssystemet har nylig blitt vurdert i en større helhetlig gjennomgang av havbruksreguleringen i NOU 2023:23. NOUen vurderer at Trafikklyssystemet har klare styrker som et overordnet konsept for å regulere produksjonskapasitet på regionalt nivå, men har også foreslått en rekke forslag til forbedringer av systemet." (Grefsrud et al., 2024, p. 17)

Economic Performance

Production (Produksjon)

- "I produksjonsområde 1 var det i 2022 og 2023 henholdsvis ni og ti oppdrettslokaliteter som i løpet av året rapporterte inn laks (figur 3.1). Produksjonsområdet hadde i 2022 en gjennomsnittlig månedlig stående biomasse på 12 740 tonn laks med et uttak til slakt på 14 076 tonn laks. Foreløpig statistikk fra Fiskeridirektoratet (23.01.2024) viser 5601 tonn gjennomsnittlig månedlig stående biomasse i 2023 med et uttak til slakt i samme periode på 18 034 tonn." (Grefsrud et al., 2024, p. 43)

Wild-Caught Cleaner Fish (Villfanget Leppefisk)

- "I 2023 ble i underkant av 633 000 leppefisk fangstet i område «Sørlandet». Fisket fordelte seg på de tre artene bergnebb (546 000), grønngylt (30 000) og berggylt (56 600), rundet av til nærmeste 1000." (Grefsrud et al., 2024, p. 52)

Production area 2:

Environmental Sustainability

Fish Welfare

- "I produksjonsområde 2 varierte rapportert produksjonsdødelighet (inkl. utkast) for oppdrettslaksen fra 20-26 % for 2020 og 2021 generasjonene. Dette er høyt sammenlignet med landsgjennomsnittet som ligger på 15-16 %, og tallmaterialet viser ingen tydelige tegn til bedring for 2022 generasjonen." (Grefsrud et al., 2024, p. 55)

Sea Lice (Lakselus)

- "Utslippene av lakselus i dette området viser en økende trend og har vært høye i perioden 2019-2023, mens smittepresset i samme periode var moderat." (Grefsrud et al., 2024, p. 55)
- "For sjøørret vurderes smittepresset som høyere da fisken oppholder seg i sjøen over en lengre periode utover sommeren der det er estimert en reduksjon i produktivitet grunnet lakselus på > 30 %." (Grefsrud et al., 2024, p. 55)

Emissions (Utslipp)

- "Produksjonen av laksefisk er høy i området, noe som medfører høye utslipp både av spillfôr, fekalier og næringssalter. Overvåkingsdata indikerer imidlertid at miljøtilstanden er god og risikoen vurderes som lav for at utslipp av næringssalter og partikulært organisk materiale skal føre til overgjødsling eller endringer i sedimentkjemi og bunndyrsamfunn i produksjonsområde 2." Grefsrud et al., 2024, p. 55)

Copper (Kobber)

- "Selv om kobberforbruket er betydelig redusert de siste årene er det fortsatt en moderat andel lokaliteter med forhøyede kobberkonsentrasjoner i sedimentet. Risikoen vurderes som moderat for redusert artsmangfold som følge av utslipp av kobber fra fiskeoppdrett i produksjonsområde 2." (Grefsrud et al., 2024, p. 55)

Delousing Agents (Avlusningsmidler)

- "Basert på forbruket i 2022, vurderes risikoen som lav for alvorlige effekter hos non-target arter ved bruk av avlusningsmidler i fiskeoppdrett i produksjonsområde 2, men det er betydelig usikkerhet i form av manglende kunnskap knyttet til fremtidig bruk av avlusningsmidler." (Grefsrud et al., 2024, p. 55)

Economic Performance

Production (Produksjon)

- "I produksjonsområde 2 var det i 2022 og 2023 henholdsvis 42 og 40 oppdrettslokaliteter som i løpet av året rapporterte inn laks (figur 4.1). Produksjonsområde 2 hadde i 2022 en gjennomsnittlig månedlig stående biomasse på 43 694 tonn laks med en produksjon på 85 648 tonn laks (uttak til slakt). Foreløpig statistikk fra Fiskeridirektoratet (23.01.2024) viser 44 757 tonn gjennomsnittlig månedlig stående biomasse i 2023 med et uttak i til slakt i samme periode på 85 430 tonn." (Grefsrud et al., 2024, p. 54)

Feed Consumption (Fôrforbruk)

- "Forbruket av fôr i produksjonsområde 2 var på 106 092 tonn. Basert på massebalansebudsjett, utgjør dette et utslipp av 30 979 tonn fekalier og 5 305–11 670 tonn spillfôr i produksjonsområdet." (Grefsrud et al., 2024, p. 63)

Wild-Caught Cleaner Fish (Villfanget Leppefisk)

- "I 2023 ble i overkant av 10,1 millioner leppefisk fangstet i dette området. Fisket fordelte seg på de tre artene bergnebb (1,9 millioner), grønngylt (7,68 millioner) og berggylt (422 000) og gressgylt (138 000) rundet av til nærmeste 1000." (Grefsrud et al., 2024, p. 65)

Regulatory Aspects

Traffic Light System (Trafikklyssystemet)

- The traffic light system is not explicitly mentioned in this chapter, but the production area's environmental status and regulatory implications are discussed in the context of sea lice and other environmental impacts.

Aquaculture Regulations (Akvakulturforskriften)

- "Siden mesteparten av transporten av villfanget leppefisk i området foregår via småbåter og tankbiler, og i tillegg er unntatt akvakulturforskriften er det i praksis liten eller ingen behandling av verken transportmiddel eller transportvannet før det tømmes ut i mottaksområdet." (Grefsrud et al., 2024, p. 65)

Production area 3:

Environmental Sustainability

Fish Welfare

- "Rapportert dødelighet (inkl. utkast) for oppdrettslaksen i produksjonsområde 3 er høy (20–23 %) sammenlignet med landsgjennomsnittet (15–16 %) og tallmaterialet viser ingen forbedring i produksjonsdødelighet over tid." (Grefsrud et al., 2024, p. 68)

- "Dødeligheten hos regnbueørreten for 2020- og 2021-generasjonen ble begge 11 %, mens for 2019-generasjonen var oppe i 19. Dødelighetstallene viser til dels stor variasjon og selv om enkelte generasjoner har vist høy dødelighet tidligere vurderer vi risikoen som moderat for dårlig fiskevelferd for regnbueørret i produksjonsområde 3." (Grefsrud et al., 2024, p. 69)

Sea Lice (Lakselus)

- "Utslippene av lakselus i produksjonsområde 3 har vært høye siden 2014 og smittepresset i området har variert fra moderat til høyt."
- "For sjøørret vurderes også smittepresset som høyt i tillegg til at fisken oppholder seg i sjøen over en lang periode utover sommeren. I alle årene 2019-2022 er det estimert en reduksjon i produktivitet grunnet lakselus på > 30 %." (Grefsrud et al., 2024, p. 69)

Escapes (Rømming) and Genetic Impact

- "For produksjonsområde 3 har det vært rapportert moderate rømmingstall i perioden 2018–2022, høyt innslag av rømt oppdrettslaks i elvene og dårlig effekt av utfisking. Villfiskens bestandsstatus vurderes som dårlig og det er påvist et høyt nivå av genetisk endring i villaksbestandene i området." (Grefsrud et al., 2024, p. 69)

Emissions (Utslipp)

- "Produksjonen av laksefisk er høy i området, noe som medfører høye utslipp både av spillfôr, fekalier og næringssalter. Gode og entydige overvåkingsdata indikerer imidlertid at miljøtilstanden er god i forhold til utslipp av næringssalter og risikoen vurderes som lav for at overgjødsling fra fiskeoppdrett skal gi alvorlige skadelige konsekvenser for biodiversitet og økosystem." (Grefsrud et al., 2024, p. 69)

Copper (Kobber)

- "Selv om kobberforbruket er betydelig redusert de siste årene viser miljøundersøkelsene at det fortsatt er en moderat andel oppdrettsanlegg med dårlig miljøtilstand med hensyn til kobbernivå." Grefsrud et al., 2024, p. 4)

Economic Performance

Production (Produksjon)

- "I produksjonsområde 3 var det både i 2022 og 2023 125 oppdrettslokaliteter som i løpet av året rapporterte inn laks eller ørret (figur 5.1). Området hadde i 2022 en gjennomsnittlig månedlig stående biomasse på 101 378 tonn laksefisk med en produksjon på 194 414 tonn laks og 12 659 tonn regnbueørret (uttak til slakt). Foreløpig statistikk fra Fiskeridirektoratet for 2023 (23.01.2024) er på 82 284 tonn laks og 5434 tonn regnbueørret i gjennomsnittlig månedlig stående biomasse med et uttak i samme periode på 152 150 tonn laks og 1892 tonn regnbueørret til slakt." (Grefsrud et al., 2024, p. 67)

Feed Consumption (Fôrforbruk)

- "Forbruket av fôr i produksjonsområde 3 var på 252 079 tonn i 2022. Basert på massebalansebudsjett utgjør dette et utslipp av 73 607 tonn fekalier og 12 604–27 729 tonn spillfôr i produksjonsområdet, fordelt på 127 matfiskanlegg, som gir et snitt på 580 tonn fekalier og 99–218 tonn spillfôr per matfiskanlegg." (Grefsrud et al., 2024, p. 77)

Wild-Caught Cleaner Fish (Villfanget Leppefisk)

- "I 2023 ble i overkant av 10,1 millioner leppefisk fangstet i dette området. Fisket fordelte seg på de fire artene bergnebb (1,9 millioner), grønngylt (7,68 millioner), berggylt (422 000) og gressgylt (138 000) rundet av til nærmeste 1000." (Grefsrud et al., 2024, p. 80)

Regulatory Aspects

Traffic Light System (Trafikklyssystemet)

- The traffic light system is not explicitly mentioned in this chapter, but the production area's environmental status and regulatory implications are discussed in the context of sea lice and other environmental impacts.

These themes and sub-themes provide an overview of the key aspects discussed in Chapter 5 of the Risikorapport, focusing on environmental sustainability, economic performance, and regulatory aspects specific to Production Area 3. The direct quotes in the original language support the identification of these themes and provide context for further analysis and comparison with the findings from Meld. St. 20 (2019-2020).

Production area 4:

Environmental Sustainability

Fish Welfare

- "Rapportert dødelighet (inkl. utkast) for oppdrettslaksen i produksjonsområde 4 er høy (23–27 %) sammenlignet med landsgjennomsnittet på 15–16 %, og tallmaterialet viser ingen forbedring i produksjonsdødelighet over tid." (Grefsrud et al., 2024, p. 84)
- "Dødeligheten på regnbueørreten er moderat og ligger på rundt 13–14 %, med en liten reduksjon til 11 % for 2021-generasjonen og det har vært en svært positiv nedgang av PD-smitte i produksjonsområde hos to siste generasjonene." (Grefsrud et al., 2024, p. 84)

Sea Lice (Lakselus)

- "Utslippene av lakselus i produksjonsområde 4 har vært høye siden 2016 og smittepresset i området har variert fra moderat til høyt. Dødelighet hos utvandrende postsmolt laks som følge av lakselussmitte fra oppdrett er estimert til å være høy (> 30 %) i alle år fra 2019." (Grefsrud et al., 2024, p. 84)

- "For sjøørret vurderes også smittepresset som høyt i tillegg til at fisken oppholder seg i sjøen over en lang periode utover sommeren. I alle årene 2019–2022 er det estimert en reduksjon i produktivitet grunnet lakselus på > 30 %." (Grefsrud et al., 2024, p. 84)

Escapes (Rømming) and Genetic Impact

- "For produksjonsområde 4 har det vært rapportert høye rømmingstall i perioden 2018-2022, moderat andel rømt oppdrettslaks i elvene de tre siste årene og dårlig effekt av utfisking. Villfiskens bestandsstatus vurderes som dårlig og det er påvist et høyt nivå av genetisk endring i villaksbestandene i området." (Grefsrud et al., 2024, p. 84)

Emissions (Utslipp)

- "Produksjonen av laksefisk er høy i området, noe som medfører høye utslipp både av spillfôr, fekalier og næringssalter." (Grefsrud et al., 2024, p. 84)
- "Beregningen av økning i planteproduksjon er likevel langt fra referanseverdien for denne parameteren, som støttes av de miljødata som finnes i området. Risikoen for at overgjødsling fra fiskeoppdrett skal gi alvorlige skadelige konsekvenser for biodiversitet og økosystem vurderes derfor totalt sett å være lav i produksjonsområde 4." (Grefsrud et al., 2024, p. 84)

Copper (Kobber)

- "Selv om kobberforbruket er betydelig redusert de siste årene viser miljøundersøkelsene at det fortsatt er en moderat andel oppdrettsanlegg med dårlig miljøtilstand med hensyn til kobbernivå." (Grefsrud et al., 2024, p. 85)

Economic Performance

Production (Produksjon)

- "I produksjonsområde 4 var det i 2022 og 2023 henholdsvis 120 og 118 oppdrettslokaliteter som i løpet av året rapporterte inn fisk (figur 6.1). Området hadde i 2022 en gjennomsnittlig månedlig stående biomasse på 83 535 tonn laksefisk med et totalt uttak til slakt på 123 891 tonn laks og 48 765 tonn regnbueørret." (Grefsrud et al., 2024, p. 82)

Feed Consumption (Fôrforbruk)

- "Forbruket av fôr i produksjonsområde 4 var på 222 654 tonn i 2022. Basert på massebalansebudsjett utgjør dette et utslipp av 65 015 tonn fekalier og 11 133–24 492 tonn spillfôr i produksjonsområdet, fordelt på 120 matfiskanlegg, som gir et snitt på

542 tonn fekalier og 93–204 tonn spillfôr per matfiskanlegg." (Grefsrud et al., 2024, p. 93)

Wild-Caught Cleaner Fish (Villfanget Leppefisk)

- "Produksjonsområde 4 inngår i fiskerisone «Vestlandet» der kvoten for fangst av leppefisk er satt til 10 millioner fisk. I 2023 ble i overkant av 10,1 millioner leppefisk fangstet i dette området. Fisket fordelte seg på de fire artene bergnebb (1,9 millioner), grønngylt (7,68 millioner), berggylt (422 000) og gressgylt (138 000) rundet av til nærmeste 1000." (Grefsrud et al., 2024, p. 96)

Regulatory Aspects

- The traffic light system is not explicitly mentioned, but the report discusses measures to improve the environmental sustainability of fish farming in the area, such as reducing sea lice emissions, escape incidents, and mortality rates.

Production area 5

Environmental Sustainability

Fish Welfare

- "Rapportert dødelighet (inkl. utkast) for oppdrettslaksen i produksjonsområde 5 er moderat (13–19 %) og ligger rundt landsgjennomsnittet på 15-16 %. Dødeligheten ser ut til å være noe på veg ned fra 2020- og 2021-generasjonene, men usikkerhet i form av at nedgangen i dødelighet kan være midlertidig, gjør at risikoen vurderes som høy for dårlig fiskevelferd hos oppdrettslaks i produksjonsområde 5." (Grefsrud et al., 2024, p. 99)
- For regnbueørret: "Dødeligheten i området vurderes å være moderat, og selv om dødelighetstallene viser til dels stor variasjon kan dette knyttes til enkelthendelser og vi konkluderer derfor med moderat risiko for dårlig velferd hos regnbueørret i sjø i produksjonsområde 5." (Grefsrud et al., 2024, p. 100)

Sea Lice (Lakselus)

- "Da det er stor mellomårlig variasjon i utslipp knyttes det noe usikkerhet til hvorvidt luseindusert dødelighet vil bli høy eller moderat neste år. Det er stor mellomårlig variabilitet i smittepresset. Hva som gir denne variabiliteten, er vanskelig å forutsi fra år til år." (Grefsrud et al., 2024, p. 100)

- "For sjøørret vurderes smittepresset som høyt da fisken oppholder seg i sjøen over en lang periode utover sommeren. Det er estimert en reduksjon i produktivitet grunnet lakselus på > 30 %. Det er godt samsvar mellom modellresultater og observasjoner, og vi konkluderer med høy risiko for at reduksjonen i produktivitet grunnet lakselus vil ha en bestandsreduserende effekt hos beitende sjøørret i produksjonsområde 5." (Grefsrud et al., 2024, p. 100)

Escapes (Rømming) and Genetic Impact

- "På tross av lave rømmingstall i perioden 2018–2022 er det registrert moderate mengder rømt oppdrettslaks i elvene. Disse kan ha vandret inn fra andre områder med rømminger, i tillegg til at det på generelt grunnlag er knyttet usikkerhet til rømmingstallene for produksjonsområdet. Andelen elver som overvåkes for innslag av rømt oppdrettslaks er også noe lav." (Grefsrud et al., 2024, p. 100)

- "Risikoen vurderes derfor totalt sett å være moderat for at ytterligere genetiske endringer som følge av innkryssing fra oppdrettslaks skal føre til mer sårbare villaksbestander i produksjonsområde 5." (Grefsrud et al., 2024, p. 100)

Emissions (Utslipp)

- "Produksjonen av laksefisk er moderat høyt sammenlignet med andre produksjonsområder, noe som medfører moderat høye utslipp både av spillfôr, fekalier og næringssalter. Til tross for økt usikkerhet i deler av produksjonsområdet grunnet manglende overvåkning i oppdrettsintensive områder, er beregnet økning i planteproduksjon fra utslipp av næringssalter langt fra referanseverdien for denne parameteren." (Grefsrud et al., 2024, p. 100)
- "Vi konkluderer derfor med at risikoen totalt sett er lav for at overgjødsling fra fiskeoppdrett skal gi alvorlige skadelige konsekvenser for biodiversitet og økosystem i produksjonsområde 5." (Grefsrud et al., 2024, p. 100)

Copper (Kobber)

- "Med vekt på dette reduseres risikoen fra moderat til lav for at det vil forekomme en reduksjon i artsmangfold som følge av utslipp av kobber fra fiskeoppdrett i produksjonsområde 5." (Grefsrud et al., 2024, p. 101)

Economic Performance

Production (Produksjon)

- "Området hadde i 2022 en gjennomsnittlig månedlig stående biomasse på 42 078 tonn laksefisk med totalt uttak til slakt på 61 808 tonn laks og 11 886 tonn regnbueørret." (Grefsrud et al., 2024, p. 89)

Feed Consumption (Fôrforbruk)

- "Forbruket av fôr i produksjonsområde 5 var på 107 302 tonn i 2022. Basert på massebalansebudsjett utgjør dette et utslipp av 31 332 tonn fekalier og 5 365–11 803 tonn spillfôr i produksjonsområde 5, fordelt på 38 matfiskanlegg, som gir et snitt på 825 tonn fekalier og 141–311 tonn spillfôr per matfiskanlegg." (Grefsrud et al., 2024, p. 108)

Wild-Caught Cleaner Fish (Villfanget Leppefisk)

- "Produksjonsområde 5 inngår i fiskerisone «Nord for 62 grader nord» der kvoten for fangst av leppefisk er satt til 4 millioner fisk. I 2023 ble det fangstet drøyt to millioner leppefisk i dette området." (Grefsrud et al., 2024, p. 110)

Regulatory Aspects

- The traffic light system is not explicitly mentioned, but the report discusses measures to improve the environmental sustainability of fish farming in the area, such as reducing sea lice emissions, escape incidents, and mortality rates.

Production area 6:

Environmental Sustainability

Fish Welfare

- "Rapportert dødelighet (inkl. utkast) for oppdrettslaksen i produksjonsområde 6 var13_17 % for 2019 til 2021-generasjonene, og ligger dermed rundt landsgjennomsnittet på 15_16%. Det ble rapportert om noe angrep av perlesnormanet i området høsten 2023. Til tross for at dødelighetsmønsteret ser ut til å endre seg mot noe høyere dødelighet, vurderes risikoen å være moderat for dårlig fiskevelferd hos oppdrettslaks i sjø i produksjonsområde 6." (Grefsrud et al., 2024, p. 113)

Sea Lice (Lakselus)

- "Utslippene av lakselus og smittepresset i produksjonsområde 6 varierer fra moderat til høyt og viser stor variasjon både mellom år og innen området. Dødelighet hos utvandrende postsmolt laks som følge av lakselussmitte fra oppdrett er estimert til å være moderat de fleste år (10-30% dødelighet)." (Grefsrud et al., 2024, p. 114)
- "Basert på alvorlighetsgraden av konsekvensene og usikkerhet om hvorvidt fremtidig smittepress vil bli høyt, vurderes risikoen som høy for at den lakselusindusert reduksjon i produktiviteten vil ha en bestandsreduserende effekt hos beitende sjøørret i produksjonsområde 6." (Grefsrud et al., 2024, p. 117)

Viral Diseases (Virussykdommer)

- "Med få utbrudd av ILA i 2022–2023, få rapporterte rømt oppdrettslaks og få rømte oppdrettslaks i elvene, vurderes sannsynligheten for endring i forekomst av ILA hos vill laksefisk som følge av smitte fra oppdrett som lav i produksjonsområde 6." (Grefsrud et al., 2024, p. 119)
- "Selv om antall PD-tilfeller ble mer enn halvert fra 2022 til 2023, vurderes det å ha vært et høyt antall tilfeller i begge år. Det var relativ lite rømt oppdrettslaks og få rømte oppdrettslaks i elvene. På tross av lite rømt oppdrettsfisk vurderes sannsynligheten for endring i forekomst av SAV hos vill laksefisk som følge av smitte fra oppdrett vurderes totalt sett som høy i produksjonsområdet." (Grefsrud et al., 2024, p. 119)

Escapes (Rømming) and Genetic Impact

- "For produksjonsområde 6 har det vært rapportert høye rømmingstall i perioden 2018-2022, moderat innslag av rømt oppdrettslaks i elvene og dårlig effekt av utfisking." (Grefsrud et al., 2024, p. 114)
- "Risikoen vurderes derfor å være moderat for at ytterligere genetiske endringer som følge av innkryssing fra oppdrettslaks skal føre til mer sårbare villaksbestander i produksjonsområde 6." (Grefsrud et al., 2024, p. 114)

Emissions (Utslipp)

- "Produksjonen av laksefisk i produksjonsområde 6 er det høyeste av samtlige produksjonsområder, noe som medfører høye utslipp både av spillfôr, fekalier og næringssalter." (Grefsrud et al., 2024, p. 114)

- "Vi konkluderer derfor med at risikoen er lav for at overgjødsling fra fiskeoppdrett skal gi alvorlige skadelige konsekvenser for biodiversitet og økosystem i produksjonsområde 6. "(Grefsrud et al., 2024, p. 114)

- "Totalt sett vurderes derfor risikoen som lav knyttet til partikulære organiske utslipp fra fiskeoppdrett i produksjonsområde 6." (Grefsrud et al., 2024, p. 114)

Copper (Kobber)

" Estimert utslipp av kobber ble mer enn halvert fra 2021 til 2022. Miljødata viser at en del av lokalitetene i området har forhøyede kobberverdier i sedimentet, men produksjonsområdet er stort og påvirkningen utgjør en liten del totalt sett. Med vekt på dette vurderes risikoen som lav for redusert artsmangfold som følge av utslipp av kobber fra fiskeoppdrett i produksjonsområde 6." (Grefsrud et al., 2024, p. 115)

Economic Performance

Production (Produksjon)

- "Området hadde i 2022 en gjennomsnittlig månedlig stående biomasse på 140 612 tonn laks med et totalt uttak til slakt på 258 966 tonn laks. Det var ingen produksjon av regnbueørret i området i 2022. Foreløpige tall fra Fiskeridirektoratet (23.01.2024) for 2023 er på 135 829 tonn laks og 28 tonn regnbueørret i gjennomsnittlig månedlig stående biomasse med et uttak til slakt i samme periode på 242 284 tonn laks. Totalt sjøareal er 12 371 km2 og sjøareal innenfor grunnlinjen er på 9950 km" (Grefsrud et al., 2024, p. 113)

Feed Consumption (Fôrforbruk)

- "Forbruket av fôr i produksjonsområde 6 var på 311 195 tonn i 2022. Basert på massebalansebudsjett 2 utgjør dette et utslipp av 90 869 tonn fekalier og 15 560–34 231 tonn spillfôr i produksjonsområdet, fordelt på 108 matfiskanlegg, som gir et snitt på 841 tonn fekalier og 144–317 tonn spillfôr per matfiskanlegg." (Grefsrud et al., 2024, p. 122)

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Wild-Caught Cleaner Fish (Villfanget Leppefisk)

- "Produksjonsområde 6 inngår i fiskerisone "Nord for 62 grader nord» der kvoten for fangst av leppefisk er satt til 4 millioner fisk. I 2023 ble det fangstet drøyt 2 millioner leppefisk i dette området. Fisket fordelte seg på de to artene bergnebb (1,83 millioner) og berggylt (229 000) rundet av til nærmeste 1000." (Grefsrud et al., 2024, p. 124)

Regulatory Aspects

- The traffic light system is not explicitly mentioned, but the report discusses measures to improve environmental sustainability, such as reducing sea lice emissions, outbreaks of pancreas disease, escape incidents, and mortality rates.
- Specifically, the report states: "For å sikre bærekraften i området bør det være et mål å redusere utbrudd av pankreassykdom, redusere utslippene av lakselus, holde rømmingstallene nede og redusere produksjonsdødeligheten på oppdrettsfisken. Også økt biosikkerhet i tilknytning til flytting av villfanget leppefisk vil bidra til å redusere risiko for smitteoverføring." (Grefsrud et al., 2024, p. 115)

Production area 7

Environmental Sustainability

Fish Welfare

- "Rapportert dødelighet (inkl. utkast) for oppdrettslaksen i produksjonsområde 7 var 12 % 2021-generasjonen, og ligger under landsgjennomsnittet på 15-16 %. Tidligere generasjoner har også hatt relativt lav dødelighet. Dødeligheten for 2022-generasjonen var allerede 12 % ved årsskiftet 2023/24, med 31 % av fisken igjen i sjøen." (Grefsrud et al., 2024, p. 129)

- "Til tross for at det kan bli moderat dødelighet (nær 15 %) for 2022-generasjonen, har dødeligheten for de siste generasjonene generelt ligget rundt 10-12 %. Vi vurderer derfor sannsynligheten som lav (vesentlig under 15 %) for at en oppdrettslaks laks som blir satt ut i produksjonsområde 7 i 2024 skal oppleve så dårlig velferd at den dør eller blir regnet som utkast. 2022-generasjonen skaper imidlertid usikkerhet og kunnskapsstyrken bak sannsynlighetsvurderingen må betraktes som moderat. Usikkerheten knyttet til hvor høy dødeligheten vil bli for 2022-generasjonen vektlegges og risikoen vurderes som moderat for dårlig fiskevelferd hos oppdrettslaks i sjø i produksjonsområde 7." (Grefsrud et al., 2024, p. 130)

Sea Lice (Lakselus)

- "Utslippene av lakselus i produksjonsområde 7 var moderate og smittepresset i området vurderes også å være moderat. Det er knyttet høy usikkerhet til vurderingen i form av manglende samsvar mellom modell og observasjoner, samt usikkerhet knyttet til utvandringstid og ruter for postsmolten i området." (Grefsrud et al., 2024, p. 131)

- "Basert på alvorlighetsgraden av konsekvensene og usikkerhet knyttet til fremtidig smittepress, vurderes risikoen som høy for at lakselusindusert reduksjon i produktiviteten vil ha en bestandsreduserende effekt hos beitende sjøørret i produksjonsområde 7."

Viral Diseases (Virussykdommer)

- "Med få utbrudd av ILA i 2022-2023, ingen rapporterte rømte oppdrettslaks, men til dels mye rømt oppdrettsfisk i elvene, vurderes sannsynligheten for endring i forekomst av ILA hos vill laksefisk som følge av smitte fra oppdrett likevel som lav i produksjonsområde 7." (Grefsrud et al., 2024, p. 128)
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- "Det var ingen rapporterte tilfeller av PD i 2022 eller 2023. Sannsynligheten for endring i forekomst av SAV hos vill laksefisk som følge av smitte fra oppdrett vurderes som lav i produksjonsområdet." (Grefsrud et al., 2024, p. 132)

Escapes (Rømming) and Genetic Impact

- "For produksjonsområde 7 har det vært rapportert høye rømmingstall i perioden 2018-2022, høyt innslag av rømt oppdrettslaks i elvene og moderat effekt av utfisking. Det er knyttet noe usikkerhet til rømmingstallene og andelen elver som overvåkes for innslag av rømt oppdrettslaks er lav." (Grefsrud et al., 2024, p. 128)

- "De høye rømmingstallene, mye rømt oppdrettslaks observert i elvene og en forverring av genetisk status bidrar til at risikoen vurderes som høy for at ytterligere genetiske endringer som følge av innkryssing fra oppdrettslaks skal føre til mer sårbare villaksbestander i produksjonsområde 7." (Grefsrud et al., 2024, p. 128)

Emissions (Utslipp)

- "Produksjonen av laksefisk i produksjonsområde 7 er høy, noe som medfører høye utslipp både av spillfôr, fekalier og næringssalter." (Grefsrud et al., 2024, p. 129)
- "Vi konkluderer derfor med at risikoen totalt sett er lav for at overgjødsling fra fiskeoppdrett skal gi alvorlige skadelige konsekvenser for biodiversitet og økosystem i produksjonsområde 7." (Grefsrud et al., 2024, p. 129)
- "Totalt sett vurderes derfor risikoen som lav knyttet til partikulære organiske utslipp fra fiskeoppdrett i produksjonsområde 7." (Grefsrud et al., 2024, p. 135)
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Copper (Kobber)

- "I tillegg viser miljødata at en del av lokalitetene i området har forhøyede kobberverdier i sedimentet og på tross av at estimerte utslipp er lave, vurderes risikoen som moderat for redusert artsmangfold som følge av utslipp av kobber fra fiskeoppdrett i produksjonsområde 7." (Grefsrud et al., 2024, p. 136)

Economic Performance

Production (Produksjon)

- "Området hadde i 2022 en gjennomsnittlig månedlig stående biomasse på 55 629 tonn laks med et totalt uttak til slakt på 115 791 tonn laks. Foreløpige tall fra Fiskeridirektoratet (23.01.2024) for 2023 er på 71 525 tonn gjennomsnittlig månedlig stående biomasse med et uttak til slakt i samme periode på 122 486 tonn." (Grefsrud et al., 2024, p. 126)

Feed Consumption (Fôrforbruk)

- "Forbruket av fôr i produksjonsområde 7 var på 136 742 tonn i 2022. Basert på massebalansebudsjett utgjør dette et utslipp av 39 929 tonn fekalier og 6 837-15 042 tonn spillfôr i produksjonsområdet, fordelt på 53 matfiskanlegg, som gir et snitt på 753 tonn fekalier og 129-284 tonn spillfôr per matfiskanlegg." (Grefsrud et al., 2024, p. 135)

Wild-Caught Cleaner Fish (Villfanget Leppefisk)

- "Produksjonsområde 7 inngår i fiskerisone "Nord for 62 grader nord» der kvoten for fangst av leppefisk er satt til 4 millioner fisk. I 2023 ble det fangstet drøyt 2 millioner leppefisk i dette området. Fisket fordelte seg på de to artene bergnebb (1,83 millioner) og berggylt (229 000) rundet av til nærmeste 1000." (Grefsrud et al., 2024, p. 137

Regulatory Aspects

- The traffic light system is not explicitly mentioned, but the report discusses measures to improve environmental sustainability, such as reducing sea lice emissions and escape incidents: "For å sikre bærekraften i området bør det være et mål å redusere utslippene av lakselus og holde rømmingstallene nede. Også økt biosikkerhet i tilknytning til flytting av villfanget leppefisk vil bidra til å redusere risiko for smitteoverføring." (Grefsrud et al., 2024, p. 129)

Production area 8:

Environmental Sustainability

Fish Welfare

- "Rapportert dødelighet (inkl. utkast) for oppdrettslaksen i produksjonsområde 8 var 11 % for 2021-generasjonene og ligger under landsgjennomsnittet på 15–16% og vurderes å være lav. 2022- og 2023-generasjonene hadde en dødelighet på respektive 11 % og 8% ved utgangen av 2023. Med fortsatt mye laks igjen i sjøen forventes dødeligheten for disse generasjonene å øke ytterligere." (Grefsrud et al., 2024, p. 141)

- "Likevel vurderes dødelighetstallene å ligge godt under landsgjennomsnittet og risikoen vurderes å være lav for dårlig fiskevelferd hos oppdrettslaks i sjø i produksjonsområde 8." (Grefsrud et al., 2024, p. 141)

Sea Lice (Lakselus)

- "Både utslipp av lakselus og påslag på postsmolt i produksjonsområde 8 har stort sett vært lave, men på grensen til moderate de senere år. Selv om flere av de lange fjordene i området som er nasjonale laksefjorder med lite lus som vil redusere tiden i eksponeringsområdet, er det usikkerhet i form av stor variabilitet i datagrunnlaget og manglende kunnskap om utvandringsruter." (Grefsrud et al., 2024, p. 141)

- "Basert på usikkerhet om fremtidig smittepress og svært alvorlige konsekvenser vurderes risikoen som moderat for bestandsreduserende effekter hos sjøørreten og sjørøye som følge av lakselussmitte fra oppdrett i produksjonsområdet 8." (Grefsrud et al., 2024, p. 141)

Viral Diseases (Virussykdommer)

- "Det var ingen rapporterte tilfeller av ILA, men fire rapporterte tilfeller av PD i 2023. På tross av usikkerhet i form av manglende overvåking legger vi vekt på få påvisninger av både ILA og PD. Få påvisninger og lite rømt fisk i området bidrar til å redusere usikkerheten, selv om det er noe rømt oppdrettsfisk i elvene i området." ." (Grefsrud et al., 2024, p. 141)

- "Med bakgrunn i dette vurderes risikoen å være lav for alvorlige konsekvenser på ville laksefiskbestander som følge av ILAV- og SAV-smitte fra oppdrett i produksjonsområde 8." (Grefsrud et al., 2024, p. 141)

Escapes (Rømming) and Genetic Impact

- "For produksjonsområde 8 har det vært rapportert moderate rømmingstall i perioden 2018-2022, høyt innslag av rømt oppdrettslaks i elvene og dårlig effekt av utfisking. Villfiskens bestandsstatus vurderes som dårlig og det er påvist et høyt nivå av genetisk endring i villaksbestandene i området." (Grefsrud et al., 2024, p. 141)
- "Mye rømt oppdrettslaks observert i elvene, dårlig bestandsstatus og et høyt nivå av genetisk innkryssing fra oppdrettslaks bidrar til at risikoen vurderes som høy for at ytterligere genetiske endringer som følge av innkryssing fra oppdrettslaks skal føre til mer sårbare villaksbestander i produksjonsområde 8." (Grefsrud et al., 2024, p. 141)

Emissions (Utslipp)

- "Produksjonen av laksefisk i produksjonsområde 8 er høy, noe som medfører høye utslipp både av spillfôr, fekalier og næringssalter. Til tross for økt usikkerhet i deler av produksjonsområdet som mangler overvåking, er beregnet økning i planteproduksjon fra utslipp av næringssalter langt fra referanseverdien for denne parameteren. Dette støttes av de miljødata som finnes." Grefsrud et al., 2024, p. 141)

- "Vi konkluderer derfor med at risikoen totalt sett er lav for at overgjødsling fra fiskeoppdrett skal gi alvorlige skadelige konsekvenser for biodiversitet og økosystem i produksjonsområde 8." (Grefsrud et al., 2024, p. 141)
- "Resultatene fra B- og C-undersøkelsene i området viser høy andel av tilstandsklasse «meget/svært god» og «god». De fleste av undersøkelsene ble gjort på bløtbunn der undersøkelsene fungerer bra. Usikkerheten fremstår som liten og vi konkluderer med lav risiko knyttet til partikulære organiske utslipp fra fiskeoppdrett i produksjonsområde 8." (Grefsrud et al., 2024, p. 141)

Copper (Kobber)

- "Estimert utslipp av kobber er mer enn halvert fra 2021 til 2022 og vurderes å være lavt. Miljødata viser at få av C-undersøkelsene i området har forhøyede kobberverdier i sedimentet. Med vekt på dette vurderes risikoen som lav for redusert artsmangfold som følge av utslipp av kobber fra fiskeoppdrett i produksjonsområde 8." (Grefsrud et al., 2024, p. 142)

Economic Performance

Production (Produksjon)

- "Området hadde i 2022 en gjennomsnittlig månedlig stående biomasse på 83 384 tonn laks med et totalt uttak til slakt på 183 881 tonn laks. Foreløpige tall fra Fiskeridirektoratet (23.01.2024) for 2023 er på 84 448 tonn gjennomsnittlig månedlig stående biomasse med et uttak til slakt i samme periode på 159 727 tonn. Det var ingen produksjon av regnbueørret i området." (Grefsrud et al., 2024, p. 139)

Feed Consumption (Fôrforbruk)

- "Forbruket av fôr i produksjonsområde 8 var på 204 073 tonn i 2022. Basert på massebalansebudsjett utgjør dette et utslipp av 59 589 tonn fekalier og 10 204–22 448 tonn spillfôr i produksjonsområdet fordelt på 81 matfiskanlegg, som gir et snitt på 736 tonn fekalier og 126–277 tonn spillfôr per matfiskanlegg." (Grefsrud et al., 2024, p. 148)

Regulatory Aspects

- The traffic light system is not explicitly mentioned, but the report discusses measures to improve environmental sustainability, such as keeping sea lice emissions low and reducing escapes: "For å sikre bærekraften i området bør det være et mål å holde utslippene av lakselus på et lavt nivå og redusere utslippene i perioden sjøørret og sjørøye beiter i området samt holde rømmingstallene på et lavt nivå for å redusere risiko for ytterligere genetisk innkryssing av rømt oppdrettslaks." (Grefsrud et al., 2024, p. 142)

Production area 9:

Environmental Sustainability

Fish Welfare

- "Rapportert dødelighet (inkl. utkast) for oppdrettslaksen i produksjonsområde 9 var 11 % for 2021-generasjonene og ligger under landsgjennomsnittet på 15–16 %. For 2018-generasjonen ga imidlertid oppblomstring av algen Chrysochromulina leadbeateri en dødelighet på 23%. Lignende algeoppblomstring inntraff i denne landsdelen i 1991, og en mindre oppblomstring i 2008." (Grefsrud et al., 2024, p. 153)
- "På tross av noe usikkerhet knyttet til algeoppblomstring vurderes risikoen å være lav for dårlig fiskevelferd hos oppdrettslaks i sjø i produksjonsområde 9." (Grefsrud et al., 2024, p. 153)

Sea Lice (Lakselus)

- "Utslippene av lakselus i produksjonsområde 9 var totalt sett lave og smittepresset i området vurderes å være lavt. Dødelighet hos utvandrende postsmolt laks som følge av lakselussmitte fra oppdrett er estimert til å være lavt de fleste år Det er noe usikkerhet knyttet til utvandringsrutene til postsmolten, men det er godt samsvar mellom modeller og observasjoner og risikoen vurderes derfor som lav forbestandsreduserende effekt av lakselussmitte på laksebestandene i produksjonsområde 9." (Grefsrud et al., 2024, p. 153)

- "Sjøørret oppholder seg i sjøen over en lang periode utover sommeren, men smittepresset mesteparten av området er lavt gjennom beitesesongen. Det er godt samsvar mellom modeller og observasjoner og usikkerheten kan betraktes som liten og det konkluderes med lav risiko for bestandsreduserende effekter hos sjøørret og sjørøye som følge av smitte med lakselus fra oppdrett i produksjonsområde 9." (Grefsrud et al., 2024, p. 153)

Viral Diseases (Virussykdommer)

- "Det var ingen rapporterte tilfeller av verken ILA eller PD for produksjonsområde 9 i 2023. På tross av usikkerhet i form av manglende overvåking legger vi vekt på at det ikke har vært noen påvisninger av ILA eller PD og lite rapportert rømt oppdrettslaks." (Grefsrud et al., 2024, p. 153)

- "Med bakgrunn i dette vurderes risikoen å være lav for alvorlige konsekvenser på ville laksefiskbestander som følge av ILAV- og SAV-smitte fra oppdrett i produksjonsområde 9." (Grefsrud et al., 2024, p. 153)

Escapes (Rømming) and Genetic Impact

- "For produksjonsområde 9 har det vært rapportert moderate rømmingstall i perioden 2018–2022, moderat innslag av rømt oppdrettslaks i elvene og dårlig effekt av utfisking. Villfiskens bestandsstatus vurderes som moderat og det er påvist et moderat nivå av genetisk endring i villaksbestandene i området." (Grefsrud et al., 2024, p. 153)
- "Selv om det er knyttet noe usikkerhet til rømmingstallene og andelen elver som overvåkes for innslag av rømt oppdrettslaks er lav, har rømmingstallene vært lave de to siste årene og det har vært en nedgang i andel elver med moderat og høyt innslag. Risikoen justeres derfor ned fra høy til moderat for at ytterligere genetiske endringer som følge av innkryssing fra oppdrettslaks skal føre til mer sårbare villaksbestander i produksjonsområde 9." (Grefsrud et al., 2024, p. 153)

Emissions (Utslipp)

- "Produksjonen av laksefisk i produksjonsområde 9 er høy, noe som medfører høye utslipp både av spillfôr, fekalier og næringssalter." (Grefsrud et al., 2024, p. 153)

- "Risikoen vurderes som lav for at overgjødsling skal gi alvorlige skadelige konsekvenser for biodiversitet og økosystemets motstandskraft som følge av utslipp av løste næringssalter fra fiskeoppdrett." (Grefsrud et al., 2024, p. 153)

- "Basert på resultatene fra B- og C-undersøkelsene som viser at det er en moderat andel anlegg med «dårlig» eller «meget dårlig» miljøtilstand i forhold til gjennomsnittet for alle produksjonsområder, samt at det er flere anlegg plassert i områder som vurderes å være mer sårbare for organisk belastning konkluderes det med moderat risiko knyttet til partikulære organiske utslipp fra fiskeoppdrett i produksjonsområde 9."

Copper (Kobber)

- "Estimert utslipp av kobber er halvert fra 2021 til 2022. Miljødata viser at svært få av lokalitetene i området har forhøyede kobberverdier i sedimentet, og med vekt på dette og lave estimerte utslipp vurderes risikoen som lav for redusert artsmangfold som følge av utslipp av kobber fra fiskeoppdrett i produksjonsområde 9." (Grefsrud et al., 2024, p. 153)

Economic Performance

Production (Produksjon)

- "Området hadde i 2022 en gjennomsnittlig månedlig stående biomasse på 83 116 tonn laksefisk med et totalt uttak til slakt på 144 385 tonn laks Foreløpige tall fra Fiskeridirektoratet (23.01.2024) for 2023 er på 83 174 tonn gjennomsnittlig månedlig stående biomasse med et uttak til slakt i samme periode på 161 259 tonn. Det ble ikke produsert regnbueørret i området." (Grefsrud et al., 2024, p. 151)

Feed Consumption (Fôrforbruk)

- "Forbruket av fôr i produksjonsområde 9 var på 190 523 tonn i 2022. Basert på massebalansebudsjett utgjør dette et utslipp av 55 633 tonn fekalier og 9 526 – 20 957 tonn spillfôr i produksjonsområdet fordelt på 84 matfiskanlegg, som gir et snitt på 662 tonn fekalier og 113 249 tonn spillfôr per matfiskanlegg." (Grefsrud et al., 2024, p. 158)

Regulatory Aspects

- The traffic light system is not explicitly mentioned, but the report discusses measures to improve environmental sustainability, such as keeping escape numbers low to reduce genetic introgression risk: "For å sikre bærekraften i området bør det være et mål å holde rømmingstallene på et lavt nivå for å redusere risiko for ytterligere genetisk innkryssing av rømt oppdrettslaks." (Grefsrud et al., 2024, p. 154)

Production area 10:

Environmental Sustainability

Fish Welfare

- "Rapportert dødelighet (inkl. utkast) for oppdrettslaksen i produksjonsområde 10 var 12 % for 2021-generasjonen, under landsgjennomsnittet på 15% for denne generasjonen. For 2018-generasjonen, og delvis også 2019-generasjonen, ga oppblomstring av algen Chrysochromulina leadbeateri forhøyet dødelighet. Lignende algeoppblomstringer har også hendt i 1991 og en mindre oppblomstring i 2008 i denne landsdelen." (Grefsrud et al., 2024, p. 164-165)
- "Dødeligheten vurderes å være moderat, men siden dette området på den ene siden har vist seg sårbart i forhold til algeoppblomstring og manetangrep, samtidig som dødelighetstallene for 2020- og 2021-generasjonene var relativt lave det er stor usikkerhet knyttet til vurderingen. Vi konkluderer likevel med moderat risiko for dårlig fiskevelferd hos oppdrettslaks i sjø i produksjonsområde 10." (Grefsrud et al., 2024, p. 164)

Sea Lice (Lakselus)

- "Utslippene av lakselus i produksjonsområde 10 var totalt sett lave i perioden 2012-2023, men påslaget vurderes å være moderat siden tiden postsmolten befinner seg i eksponeringsområdet vurderes er relativt lang. Det knyttes noe usikkerhet til vurderingen grunnet manglende kunnskap om utvandringsrutene og moderat samsvar mellom modeller og observasjoner." (Grefsrud et al., 2024, p. 165)
- "Basert på alvorlighetsgraden av konsekvensene og usikkerhet om fiskens tålegrenser, vurderes risikoen som moderat for at den lakselusindusert reduksjon i produktiviteten vil ha en bestandsreduserende effekt hos beitende sjøørret i produksjonsområde 10." (Grefsrud et al., 2024, p. 165)

Viral Diseases (Virussykdommer)

- "Det var kun ett reportert tilfelle av ILA i 2022, og ingen rapporterte tilfeller av ILA eller PD i produksjonsområde 10 i 2023. Rapporter om kun enkelte tilfeller av rømt fisk i området bidrar til å redusere usikkerhet grunnet manglende overvåking." (Grefsrud et al., 2024, p. 165)

- "Med bakgrunn i dette vurderes risikoen å være lav for alvorlige konsekvenser på ville laksefiskbestander som følge av ILAV- og SAV-smitte fra oppdrett i produksjonsområde 10." (Grefsrud et al., 2024, p. 165)

Escapes (Rømming) and Genetic Impact

- "På tross av svært høye rømmingstall og dårlig effekt av utfisking for området i perioden 2018-2022, har det vært en nedgang i innslag av rømt oppdrettslaks i elvene i produksjonsområdet gjennom perioden." (Grefsrud et al., 2024, p. 165)
- "Med vekt på andel rømt oppdrettslaks i elv, vurderes risikoen derfor totalt sett å være moderat for at ytterligere genetiske endringer som følge av innkryssing fra oppdrettslaks skal føre til mer sårbare villaksbestander i produksjonsområde 10." (Grefsrud et al., 2024, p. 165)

Emissions (Utslipp)

- "Produksjonen av laksefisk i produksjonsområde 10 er høy, noe som medfører høye utslipp både av spillfôr, fekalier og næringssalter. Til tross for økt usikkerhet på grunn av manglende overvåking i deler av produksjonsområdet, er beregnet økning i planteproduksjon fra utslipp av næringssalter langt fra referanseverdien for denne parameteren. Dette støttes av de få miljødata som finnes." (Grefsrud et al., 2024, p. 165-165)
- "Vurderingen hviler på sterk kunnskapsstyrke, usikkerheten fremstår som liten og vi konkluderer med lav risiko knyttet til partikulære organiske utslipp fra fiskeoppdrett i produksjonsområde 10." (Grefsrud et al., 2024, p. 165-165)

Copper (Kobber)

- "Estimert utslipp av kobber er halvert fra 2021 til 2022. Miljødata viser at svært få av lokalitetene i området har forhøyede kobberverdier i sedimentet, og med vekt på dette og lave estimerte utslipp vurderes risikoen som lav for redusert artsmangfold som følge av utslipp av kobber fra fiskeoppdrett i produksjonsområde 10." ." (Grefsrud et al., 2024, p. 166)

Economic Performance

Production (Produksjon)

- "Området hadde i 2022 en gjennomsnittlig månedlig stående biomasse på 69 861 tonn laks med et totalt uttak til slakt på 130 654 tonn laks. Foreløpige tall fra Fiskeridirektoratet (23.01.2024) for 2023 er på 78 017 tonn gjennomsnittlig månedlig stående biomasse med et uttak i samme periode på 145 572 tonn til slakt. Det ble ikke produsert regnbueørret i området." (Grefsrud et al., 2024, p. 163)

Feed Consumption (Fôrforbruk)

- "Forbruket av fôr i produksjonsområde 10 var på 156 060 tonn i 2022. Basert på massebalansebudsjett utgjør dette et utslipp av 45 570 tonn fekalier og 7 803 – 17 167 tonn spillfôr i produksjonsområdet fordelt på 60 matfiskanlegg, som gir et snitt på 759 tonn fekalier og 130 – 286 tonn spillfôr per matfiskanlegg." (Grefsrud et al., 2024, p. 171)

Regulatory Aspects

- The traffic light system is not explicitly mentioned, but the report discusses measures to improve environmental sustainability, such as reducing sea lice emissions and keeping escape numbers low:
  "For å sikre bærekraften i området bør det være et mål å redusere utslipp av lakselus og holde rømmingstallene på et lavt nivå, samt redusere dødelighetstallene på oppdrettslaksen. En redusering i antall behandlinger med deltametrin om sommeren og redusert totalt forbruk av emamektin vil bidra til redusert risiko." (Grefsrud et al., 2024, p. 166)

Production area 11:

Environmental Sustainability

Fish Welfare

- "Rapportert dødelighet (inkl. utkast) for oppdrettslaksen i produksjonsområde 11 var 13 % for 2021- generasjonene og ligger dermed rundt landsgjennomsnittet på 15–16 % og dødeligheten vurderes som moderat." (Grefsrud et al., 2024, p. 177)
-
- "På tross av noe usikkerhet knyttet til hvorvidt dødeligheten for 2022-generasjonen vil bli lav, vektlegges den stabilt moderate dødeligheten og risikoen vurderes som

moderat for dårlig fiskevelferd hos oppdrettslaks i sjø i produksjonsområde 11." (Grefsrud et al., 2024, p. 177)

Sea Lice (Lakselus)

- "Den virtuelle smoltmodellen indikerer lavt påslag i alle årene i produksjonsområdet 11 sett under ett, men estimatene viser høyere påslag de siste fem årene (men fortsatt lave) og den luseindusert dødeligheten vurderes å være lav. Det er noe usikkerhet knyttet til vurderingen da det mangler tråldata fra området og utvandringsrutene ikke er kartlagt. Likevel viser modellen at det er lavt smittepress og det er lite variabilitet i estimatene over tid og flere av de lange fjordene er nasjonale laksefjorder med lite lus som vil redusere tiden i eksponeringsområdet." (Grefsrud et al., 2024, p. 177)
- "For beitende sjøørret og sjørørret indikerer modellresultatene at det er lite eller ingen reduksjon i marint leveområde grunnet høy tetthet av lakselus. Det er godt samsvar mellom modellresultater og observasjoner og det konkluderes det med lav risiko for bestandsreduserende effekter hos sjøørret og sjørøye som følge av smitte med lakselus fra oppdrett i produksjonsområde 11." (Grefsrud et al., 2024, p. 177)

Viral Diseases (Virussykdommer)

- "Det var ingen rapporterte tilfeller av ILA eller PD i produksjonsområde 11 i 2023. På tross av manglende overvåking og mye rømt oppdrettslaks i elvene, vektlegges det at det ikke har vært sykdomsutbrudd i området de to siste årene."
- "Med bakgrunn i dette vurderes risikoen å være lav for alvorlige konsekvenser på ville laksefiskbestander som følge av ILAV- og SAV-smitte fra oppdrett i produksjonsområde 11." (Grefsrud et al., 2024, p. 177)

Escapes (Rømming) and Genetic Impact

- "På tross av lave rømmingstall er det både høyt innslag av rømt oppdrettslaks i noen av elvene og moderat effekt av utfisking for området, ettersom det er elver med middels innslag hvor det ikke har vært utfisking. Det vurderes totalt sett å være høy sannsynlighet for forekomst av rømt oppdrettslaks på gyteplassene i produksjonsområde 11." (Grefsrud et al., 2024, p. 181)

- "Andelen elver som overvåkes for innslag av rømt oppdrettslaks er noe lav, det er observert mye rømt oppdrettslaks i området, den genetiske innkryssingen fra oppdrettslaks er høy og bestandsstatus er dårlig. Risikoen vurderes derfor som høy for at ytterligere genetiske endringer som følge av innkryssing fra oppdrettslaks skal føre til mer sårbare villaksbestander i produksjonsområde 11." (Grefsrud et al., 2024, p. 177)

Emissions (Utslipp)

- "Produksjonen av laksefisk er moderat høyt sammenlignet med andre produksjonsområder, noe som medfører moderat høye utslipp både av spillfôr, fekalier og næringssalter. Til tross for økt usikkerhet på grunn av manglende overvåking i deler av produksjonsområdet, er beregnet økning i planteproduksjon fra utslipp av næringssalter langt fra referanseverdien for denne parameteren." (Grefsrud et al., 2024, p. 177)

- "Vi konkluderer derfor med at risikoen totalt sett er lav for at overgjødsling fra fiskeoppdrett skal gi alvorlige skadelige konsekvenser for biodiversitet og økosystem i produksjonsområde 11." (Grefsrud et al., 2024, p. 177)
- "Vurderingen hviler på sterk kunnskapsstyrke, usikkerheten fremstår som liten og vi konkluderer med lav risiko knyttet til partikulære organiske utslipp fra fiskeoppdrett i produksjonsområde 11." (Grefsrud et al., 2024, p. 183)
-

Copper (Kobber)

- "Estimert utslipp av kobber er halvert fra 2021 til 2022. Miljødata viser at svært få av lokalitetene i området har forhøyede kobberverdier i sedimentet, og med vekt på dette og lave estimerte utslipp vurderes risikoen som lav for redusert artsmangfold som følge av utslipp av kobber fra fiskeoppdrett i produksjonsområde 11." (Grefsrud et al., 2024, p. 178)
-

Economic Performance

Production (Produksjon)

- "Området hadde i 2022 en gjennomsnittlig månedlig stående biomasse på 43 729 tonn laks med en produksjon (totalt uttak til slakt) på 81 532 tonn laks. Foreløpige tall fra Fiskeridirektoratet (23.01.2024) for 2023 er på 48 647 tonn gjennomsnittlig månedlig stående biomasse med et uttak i samme periode på 92 155 tonn til slakt. Det ble ikke produsert regnbueørret i området." (Grefsrud et al., 2024, p. 175)

Feed Consumption (Fôrforbruk)

- "Forbruket av fôr i produksjonsområde 11 var på 98 487 tonn i 2022. Basert på massebalansebudsjett utgjør dette et utslipp av 28 758 tonn fekalier og 4 924–10 834 tonn spillfôr i produksjonsområdet, fordelt på 38 matfiskanlegg, som gir et snitt på 757 tonn fekalier og 130–285 tonn spillfôr per matfiskanlegg." (Grefsrud et al., 2024, p. 183)

Regulatory Aspects

- The traffic light system is not explicitly mentioned, but the report discusses measures to improve environmental sustainability, such as keeping escape numbers low and reducing mortality rates: "For å sikre bærekraften i området bør det være et mål å holde rømmingstallene nede, samt redusere dødelighetstallene på oppdrettslaksen." (Grefsrud et al., 2024, p. 178)

Production area 12:

Environmental Sustainability

Fish Welfare

- In 2021, the mortality rate (including discards) for farmed salmon in Production Area 12 was 17%, slightly higher than the national average of 15-16%. The mortality for the 2022 generation has been preliminarily set at 15%, relatively high given over 47% of this generation was still at sea by the end of 2023 due to lower sea temperatures .

(Grefsrud et al., 2024, p. 187)

- «Vi ser at særlig fiskegrupper som har blitt satt ut senhøstes eller tidlig vinter har hatt høy dødelighet første vinter i sjø. En del av økningen i dødelighet kan forklares med utbrudd av parasittsykdommen systemisk spironukleose høsten 2022. I tillegg rapporterte fem lokaliteter om manetangrep til Mattilsynet høsten 2023.» The risk of poor fish welfare is considered high, particularly for fish groups set out in late autumn or early winter, which have shown higher winter mortality. This has been partly attributed to outbreaks of systemic spironucleosis and jellyfish attacks in 2022 and 2023. (Grefsrud et al., 2024, p. 187)

Sea Lice (Lakselus)

- The incidence of sea lice-induced mortality on outgoing post-smolt salmon and reduced productivity in sea trout and Arctic char is considered low. Despite small areas with moderate infection pressure during smolt migration, the overall infection risk in the area remains low . "akselusindusert dødelighet hos utvandrende postsmolt laks er estimert til å være lavt de fleste år. Risiko knyttet til dødelighet av post-smolt laks grunnet lakselus i produksjonsområde 12 vurderes som lav. På tross av en økende trend i antall oppdrettsfisk og at påslaget de senere år har økt og nærmer seg grensen til moderat, er det lite usikkerhet knyttet til vurderingen. Vi konkluderer med at det er lav risiko for bestandsreduserende effekt på laksebestandene i produksjonsområde 12" (Grefsrud et al., 2024, p. 187)
- «For beitende sjøørret og sjørøye indikerer modellresultatene at det er lite eller ingen reduksjon i marint leveområde grunnet høy tetthet av lakselus. Det er godt samsvar mellom modellresultater og observasjoner og det konkluderes det med lav risiko for bestandsreduserende effekter hos sjøørret og sjørøye som følge av smitte med lakselus fra oppdrett i produksjonsområde 12.» (Grefsrud et al., 2024, p. 187)

Viral Diseases (Virussykdommer)

- There were few reported cases of Infectious Salmon Anemia (ILA) and no reported cases of Pancreatic Disease (PD) in 2023. Despite the lack of monitoring and the presence of some escaped farmed salmon in the rivers, the risk of significant impact on wild salmonid populations due to ILAV and SAV infections is considered low. «et var få rapporterte tilfeller av ILA og ingen av PD i produksjonsområde 12 i 2023. På tross av manglende overvåking og noe rømt oppdrettslaks i elvene, vektlegges det at det ikke har vært få sykdomsutbrudd i området de to siste årene. Med bakgrunn i dette vurderes risikoen å være lav for redusert overlevelse hos ville laksefiskbestander som følge av ILAV- og SAV-smitte fra oppdrett i produksjonsområde 12.» (Grefsrud et al., 2024, p. 187).

Escapes (Rømming) and Genetic Impact

- Moderate escape numbers and moderate occurrences of escaped farmed salmon in rivers were reported, with a high level of genetic changes observed in wild salmon stocks. However, the overall stock status of wild salmon is considered good, thus the risk of further genetic introgression leading to more vulnerable wild salmon stocks is seen as moderate.

Emissions (Utslipp)

- Total emissions from fish farming, including feed spillage and fecal matter, are significant due to high production volumes. However, the risk of eutrophication and serious damage to biodiversity and ecosystems is considered low, supported by limited environmental monitoring data showing low nutrient levels in most of the production area.

Copper (Kobber)

- The estimated discharge of copper has halved from 2021 to 2022, and with few sites showing elevated copper values in sediments, the risk to biodiversity is considered low. The usage of delousing agents is moderate, with uncertainties around the potential effects on non-target species. (Grefsrud et al., 2024, p. 187-188)

Economic Performance

Production (Produksjon)

- In 2022, the area recorded an average monthly standing biomass of 70,461 tons of salmon, with a total extraction for slaughter at 116,291 tons. Preliminary figures for 2023 show an average biomass of 72,482 tons with a harvest of 99,311 tons . (Grefsrud et al., 2024, p. 185)

Feed Consumption (Fôrforbruk)

- The feed consumption in 2022 was 138,361 tons, resulting in emissions of 40,402 tons of feces and between 6,918 to 15,220 tons of feed spillage . (Grefsrud et al., 2024, p. 193)

Regulatory Aspects

- The regulatory framework emphasizes maintaining low escape numbers and reducing mortality rates to sustain environmental health in the area .

Production area 13:

Environmental Sustainability

Fish Welfare

- "Det er stor variasjon i produksjonsdødelighet (inkl. utkast), fra 2–18% for de siste generasjonene oppdrettsfisk, og dødeligheten vurderes derfor å være moderat." (Grefsrud et al., 2024, p. 198)
- "Selv om det er mye usikkerhet knyttet til hvorvidt dødelighetstallene blir lave eller over gjennomsnittet, konkluderer vi med moderat risiko for dårlig fiskevelferd i produksjonsområde 13." (Grefsrud et al., 2024, p. 198)

Sea Lice (Lakselus), Viral Diseases (Virussykdommer), Escapes (Rømming) and Genetic Impact, Emissions (Utslipp), and Copper (Kobber)

- "Med lav produksjon er det lave utslipp av lakselus, få sykdomsutbrudd, det er rapportert om lite rømt oppdrettslaks i elvene som overvåkes, samt lave utslipp av næringssalter, partikulært organisk materiale, kobber og avlusningsmidler til området, vurderes det å være lav risiko for redusert bærekraft som følge av fiskeoppdrett i produksjonsområde 13." (Grefsrud et al., 2024, p. 198)

Economic Performance

Production (Produksjon)

- "Området hadde i 2022 en gjennomsnittlig månedlig stående biomasse på 5743 tonn laks med et totalt uttak til slakt på 5114 tonn laks. Foreløpige tall fra Fiskeridirektoratet (23.01.2024) for 2023 er på 4821 tonn gjennomsnittlig månedlig stående biomasse med et uttak til slakt i samme periode på 13 449 tonn. Det ble ikke produsert regnbueørret i området." (Grefsrud et al., 2024, p. 196)

Feed Consumption (Fôrforbruk)

- "Forbruket av fôr i produksjonsområde 13 var på 12 171 tonn i 2022. Basert på massebalansebudsjett utgjør dette et utslipp av 3 554 tonn fekalier og 609–1 339 tonn spillfôr i produksjonsområdet, fordelt på fem matfiskanlegg, som gir et snitt på 711 tonn fekalier og 122 268 tonn spillfôr per matfiskanlegg." (Grefsrud et al., 2024, p. 202)

Regulatory Aspects

- An increase in aquaculture production in the area could trigger a need for more monitoring: "En eventuell økt akvakulturproduksjon i området vil kunne utløse behov for mer overvåking, blant annet av miljøtilstanden i oppdrettsintensive områder og mulig smitte av lakselus og andre patogener fra oppdrettsfisk til villfisk." (Grefsrud et al., 2024, p. 198

Appendix F: Causal Map coding sheet

```
flowchart TB
    classDef positive stroke:#228B22, fill:#b9fbc0, color:#004d00; // Positive
impacts in green
    classDef negative stroke:#FF0000, fill:#ffcccc, color:#8B0000; // Negative
impacts marked prominently in red
    classDef neutral fill:#f4f4f4, color:#333; // Neutral actions in a grayish tone

    A["Government Policies and Strategies \n (Meld. St. 20)"]:::neutral
    B("Integrated Ocean Management Plans"):::positive
    C("Aquaculture Act and Regulations"):::positive
    D("Research and Innovation"):::neutral
    E("Offshore Aquaculture Development"):::neutral
    F["Environmental Sustainability Goals"]:::positive
    I["Climate Change Adaptation Strategies"]:::neutral
    H["Aquaculture Management and Monitoring"]:::neutral
    J["Sea Lice Challenges"]:::negative
    K["Fish Escape Incidents"]:::negative
    L["Nutrient and Waste Discharge"]:::negative
    M["Genetic Impact on Wild Populations"]:::negative
    N["Disease Outbreaks"]:::negative
    O["Biodiversity and Ecosystem Health"]:::positive
    U{"Actual Environmental Outcomes \n (Risikorapport)"}:::negative
    W["Alignment or Discrepancies"]:::neutral
    X["Stakeholder Engagement"]:::neutral
    Y["Adaptive Management"]:::neutral
    Z["Climate Change Impacts"]:::neutral
    G["Aquaculture Industry Operations"]:::neutral

    A -->|Influences| B
    A -->|Influences| C
    A -->|Influences| D
    A -->|Influences| E
    B -->|Leads to| F
    C -->|Leads to| F
    D -->|Leads to| F
    D -. "Promotes" .-> H
    D -->|Influences| E
    D -->|Influences| I
```

```
E -->|Contributes to| F
F -->|Supports| O
F -->|Guides| H
G -. "Leads to" .-> J
G -. "Leads to" .-> K
G -. "Leads to" .-> L
G -. "Leads to" .-> M
G -. "Leads to" .-> N
J -. "Negatively influences" .-> U
K -. "Negatively influences" .-> U
L -. "Negatively influences" .-> U
M -. "Negatively influences" .-> U
N -. "Negatively influences" .-> U
O -. "Positively influences" .-> U
U -->|Leads to| W
X -->|Engages| F
Y -. "Improves" .-> H
I -. "Encourages" .-> Y
Z -->|Impacts| F
Z -. "Impacts" .-> Y
G -->|Affects| F

class B,C,F,O positive
class H,J,K,L,M,N,U,G negative
class A,D,E,I,W,X,Y,Z neutral
```

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