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An analysis of the “on/off” Barents Sea capelin fishery

Implications for sustainable management of a fluctuating fish stock

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Master Thesis in International Fisheries Management FSK-3910 (30 ECTS, May 2022)

Acknowledgments

My master's degree is finished after two interesting, challenging and bountiful years.
I learned a lot about the fishing industry, its management and seafood. During my stay I have gained new friends for life, new perspectives of life and now, new life opportunities. Therefore, I would like to especially thank my fellow students and teachers who made the experience as delightful and fun as possible. I hope to see you all again in the future, despite perhaps working in different sectors, and in different countries, as we are after all, connected by one ocean (and degree).

Firstly, I would like to express my gratitude to my supervisor **Jahn Petter Johnsen**. Your positive attitude, insight, guidance and kindness have been a guiding light when creating my paper. Your advice and support throughout the thesis contributed greatly to the process, which I am thankful for.

I would like to thank everyone who participated and contributed to the thesis, and those offering to help. All the input from people in the industry willing to share their knowledge was inspiring, and I will aspire to follow in their footsteps.

Lastly, I would like to thank my family and friends for their continuous support throughout the process. I am grateful for everyone who encouraged and believed in me, thank you.

Abstract

Managing an unstable fishery is a difficult task. After Barents Sea capelin reached its peak harvest volumes, it shortly after collapsed in 1986, negatively impacting the ecosystem. After its recovery due to increased management efforts, the capelin fishery has seen fluctuating quota volumes and extended periods of closed fishing activity. However, this unstable quota has caused some challenges for the fishery's management and sustainability. Previous literature often focuses on the ecological side of the situation, or narrow specific topics, which leads to not viewing the fishing industry as a whole, potentially not covering all the challenges that appear from an on/off fishery. To find the implications of a fluctuating quota, this thesis looks at the entire capelin fishery development, the fishing industry, and stakeholders. Governmental reports from the last ten years the fishery was open (2003-2022), and semi-structured interviews with the various stakeholders present in the capelin industry were conducted to give insight into the entire fishery. The results showed that the main challenges were caused by the requirement to have strict regulations because of the biological attributes of the stock. This unstable nature creates inconsistent quotas and breaks in the fishery, which causes difficulties for the post-harvest sector, and different opinions on how to manage the fishery sustainably.

Keywords: Barents Sea capelin, fisheries management, sustainability, stakeholders, industry, fishery, ecosystem

Abbreviations

NDF – Norwegian Directorate of Fisheries

ICES - International Council for the Exploration of the Sea

IGJM - Iceland, Greenland and Jan Mayen Capelin

IMR - Institute of Marine Research

TAC - Total Allowable Catch

JNRFC - Joint Norwegian-Russian Fisheries Commission

MFCA - Ministry of Fisheries and Costal Affairs

MTIF - Ministry of Trade, Industry and Fisheries

NFM - Norwegian Fisheries Management

MSY - Maximum sustainable yield

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1. Introduction

1.1 The unique situation of the Barents Sea capelin fishery

As a fishing nation with great access to the ocean, Norway has contributed to the world's significant demand of seafood by extracting a wide variety of fish through seasonal fisheries and quotas. Of the many important and long-standing commercial fisheries in Norway, is the herring (*Clupea harengus*) fishery (Nakken, 2008). The herring fishery, and most pelagic fisheries in Norway, typically target small pelagic fish in large schools close to the water column (NOAA, 2021). The story of the herring fishery is both that of a developing open-ocean fishing fleet and various hardships, which eventually resulted in the crash of the herring stock in the 1970s (Bjarnar, et al., 2006). The collapse of the herring stock was the beginning of a slow realization as to the fragility, of the then seemingly endless quantity of fish inhabiting the ocean. Following the crash of the herring stock, regulations began to be implemented to limit fishing activity. The capelin (*Mallotus villosus*) fishery emerged as a substitute for the crashed herring stock, before collapsing in the 1980s because of elevated fishing pressure (Meeren et al., 2009). Following these developments, the Atlantic cod (*Gadus morhua*) stock was heavily reduced. Due to the commercial importance of cod, even stricter regulations for managing the stocks were enforced (Gjøsaeter et al., 2016). Following the crash of the cod stock, and its eventual rebound, regulations covering the entire fishing industry were implemented, which led to the current approach of Norwegian fisheries management. Ensuring a healthy ecosystem and maintaining a sustainable extraction of the various stocks, is the most important aspect of Norwegian fisheries management. Because of the focus on sustainable management, the fishing fleet has become more stable in catch volumes, with a moderate extraction of fish each year, through regulated quotas.

Even with the relatively good stability in Norwegian fisheries, following the development of governance systems, some fisheries stand out. These standout fisheries still experience the possibility of not maintaining a maximum sustainable yield (MSY) over time, causing fishing activity to be closed. As quotas and regulations are in place to limit the impact of fishing activity on nature, management systems exist to regulate the balance between fisheries and natural stock developments. As fishing activity can create an imbalance within natural fluctuations of the stock, the impacts must be compatible with the stock. These instabilities

result in some fish stocks having large fluctuations, which present challenges for the management systems regulating them.

One of these highly fluctuating stocks is the Barents Sea capelin, which is the main topic of this thesis. Over the capelins fishing history, it has seen a steady decline in quotas, even with reduced fishing pressure, in contrast to previous large harvest volumes. Although a reduction in quota and stock occurred for the capelin, the Barents Sea continues to represent the world's most prosperous fishing grounds (Hoel, 2020). What was in the past a fishery contributing with significant volumes of raw materials for the booming fishmeal and fish oil industry, has now become a small portion of the fishing fleets' overall activity. Aside from capelin possessing the role of an active fishery, it plays another big part in the Barents Sea. The current primary role of capelin is as a keystone species, which refers to species that are prey for larger predators and maintain a balance in the ecosystem (Fauchald & Durant, 2019). Among the various predators are larger whitefish species of high commercial value, mainly the Northeast Arctic cod (Hjermann et al., 2007).

For the last 30 years, the capelin fishery has consisted of "interval" periods of fishing activity and fluctuating quota volumes. The harvesting volumes have decreased to a fraction of their peak in 1977, changing from almost two million tons harvested, to below 100 thousand tons currently (2022) (Popov & Zeller, 2018). The interval length between fishing activities varies, and sporadically endures several years of hiatus between each fishing season. These longer breaks between commercial fishing activity are related to diminished capelin stock levels, forcing the government to close down the fishery, due to the possibility of inducing a further collapse. A report by Isaksen et.al. (2008) would define this unique situation as an “on/off” fishery, which means a fishery that can remain closed for an undefined period of time between fishing activity, while having fluctuating quota volumes. These circumstances generate a particularly uncertain fishery and increased complexity in post-fishery activities. In other words, the capelin fishery in the Barents Sea is more unpredictable when compared with the other Norwegian pelagic fisheries. Therefore, to understand the challenges and effects this instability brings to the industry as a whole, a comprehensible analysis of the capelin fishery is required.

Based on previous research and the overall importance of the capelin stock, there are many components to consider when managing such a fluctuating fishery. The intended outcome of the thesis is to highlight the challenges when managing an on/off fishery that appears, not just in the ecological part of the fishery, but throughout the entire industry. Most of the previous and existing research on Barents Sea capelin is dedicated to detailed reports on specific topics, such as biology, economics, or management. Therefore, this thesis aims to combine these important findings and present an overview of the various implications caused when managing a fluctuating fishery.

1.2 Research questions

The theme of this thesis is an overall assessment and analysis of the Barents Sea capelin fishery and its management. This analysis includes evaluating the current and previous history of the capelin fishery, along with the different stakeholders present in the industry. The ecological situation of the fishery, along with the economic and social aspects, will be examined. In summary, the thesis aims to explore the overall sustainability of the fishery to identify the implications and challenges preventing sustainable management. The main research question is as follows:

What are the challenges related to sustainable management when managing a fluctuating "on/off" fishery?

This research question can be divided into two sub-questions in order to accurately assess the fishery.

1. How did the Barents Sea capelin fishery develop into the on/off fishery it is today?
2. What are the current situations and challenges of the Barents Sea capelin fishery?

In order to answer these questions, various pieces of literature about the topic were examined. A document analysis exploring government reports from 2002-to 2022, along with semi-structured interviews with the main stakeholders in the industry, was conducted to answer the research questions. Because of the exploratory and narrative nature of the thesis, data and results follow relevant topics and themes presented in the various chapters.

1.3 Thesis structure

Followed by the introduction, **Chapter 2** consists of the theories utilized, in addition to defining sustainability, fisheries management and regulations in Norway. **Chapter 3** elaborates on the research design, qualitative methods used to analyze the data gathered, along with the limitations of the paper. **Chapter 4** serves as a walkthrough of the capelin fishery, the capelin biology and ecosystem, along with the current situation of the Barents Sea capelin fishery. **Chapter 5** shows the impact of management and the industry. **Chapter 6** is a discussion of the data and findings. Lastly, **chapter 7** consists a conclusion and recommendation for further research.

As there are many similar and translated terms, some phrases can become confusing. This small section is presented to make certain terms clearer:

1. When talking about capelin in the thesis, this refers to the Barents Sea capelin, unless otherwise is specified.
2. When talking about the industry, the thesis refers to the entire caplin fishing industry, including the fishery, not just post-fishing activities. If other industries are the topic (fishmeal and oil industry, consumer industry) this is specified.
3. When talking about cod, this refers to the Northeast Artic cod, as it is the primary cod stock of the Barents Sea.

2. Theoretical framework and key concept definitions

This chapter will cover the theoretical framework used for evaluating the information collected on the topic. Sustainability in a fisheries context and the management process related to Norwegian fisheries and quota regulations, are vital concepts that need to be clarified to accurately answer the research questions and understand the fishery. The three pillars of sustainability: ***ecological, economic, and social***, are further explained as they serve as a theme throughout the thesis.

2.1 Sustainability defined

Sustainability is a versatile term that constantly appears in modern texts and discussions, but is challenging to define, as it can be altered based on context (Vos, 2007). The United Nations Brundtland Commission (1987) first defined sustainability as the following: "*Meeting*

the needs of the present without compromising the ability of future generations to meet their own needs". Since then, sustainability has been utilized as a principle for creating economic prosperity, while also considering the possible ecological impact these actions might have (Rennings & Wiggering, 1997). The context of sustainability is not only related to economic and public resources, but also to social development (Brundtland, 1987). Simply put, sustainability is about finding a healthy balance between the extraction and utilization of resources, to ensure long-lasting prosperity for all.

2.2 Sustainability in a fishery context

The fishing industry has been around for thousands of years and inherently evolved by optimizing its primary objective: improving harvesting (Årland & Bjørndal, 2002). With massive upgrades to catch efficiency, and as the oceans fishing fleets grew, advancements in sustainability were of little concern (Charles, 1994). However, the shift toward sustainable harvesting and technological advances within this field has since grown, but still have room for improvement (Pauly et al., 2002). In the context of most modern fisheries, sustainability can be traced back using historical data, as it is a long-standing industry that is heavily documented (Pauly & Zeller, 2016). Increased and more precise management is of high priority in fisheries, as without regulations, the world's current fishing fleets could quickly drain the ocean of natural resources (van Hoof et al., 2019; Bailey & Jentoft, 1990). The high potential effort of the fishing fleets gives priority to the need to exhibit sustainability. As the fish stocks themselves cannot be regulated, the regulations of a fishery are often made externally, limiting the volumes extracted through proper management (Wilson & McCay, 2001). In addition, fish stocks are becoming increasingly more vulnerable due to rising climate changes (FAO, 2018). Many fisheries are still experiencing a steady decline and a slow collapse of their stocks (Heal & Schlenker, 2008). When discussing the sustainability of a fishery, there is a need to explain precisely the dimensions of the individual fishery, as every fishery is different.

Overall, a typical fishery has undeniable and arguable obstacles to its sustainability. According to the literature by Charles (2001) on sustainable fisheries, these problems can be further grouped into four fundamental categories of sustainability: **Ecological, socioeconomic, community, and institutional.** These points are essential to explore when measuring the overall sustainability of a fishery. In order to present complicated situations in

a structured manner, a framework has to be in place (Macdonald et al., 2011). When analyzing fisheries, there is often a risk of being overly simplistic, or too complicated (Charles, 2001). To avoid overcomplicating aspects of sustainability in a fisheries context, the fishery components presented by Charles (2001, p. 3) has severed as a framework throughout the thesis. These relevant components of a fishery system are used to further discuss the various implications of the sustainability in the capelin fishery. These components can be summarized by the following: Who is the subject, where it resides, who harvests it, who eats/buys it, and who manages it (Charles, 2001).

2.3 Three pillars of sustainability

The "three pillars of sustainability" derived from the Brundtland report (2002), is used to categorize and determine the overall sustainability of a situation. The dimensions of the pillars and what each section contains in a fisheries context, are briefly explained in this section. The pillars can be viewed as a way to achieve an overall balance between the pillars, which increases the sustainability of the management (**Figure 1**).

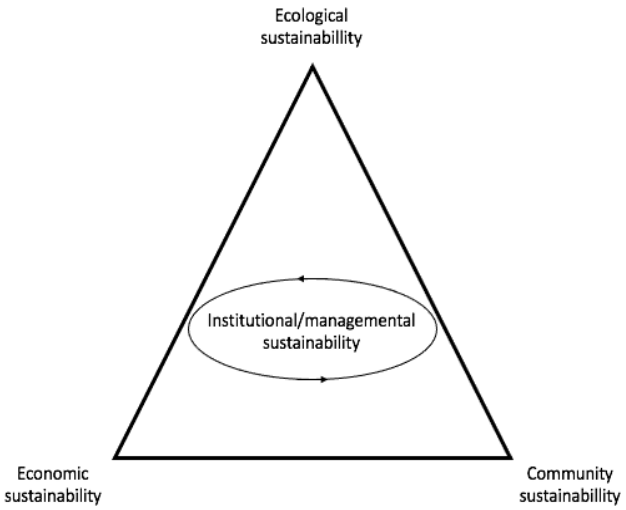


Figure 1. *Sustainability triangle inspired by Charles' model (1994, p. 205). Shows the different sides of the sustainability pillars, and how a balance is needed, in order to reach institutional/managemental sustainability.*

The economic pillar refers to achieving economic growth from extracting fish (Jentoft & Knol, 2014). The ecological pillar refers to sustainable harvesting and ensuring future stock (Charles, 1994), which is essential to maintain a healthy ecosystem for future fisheries. The last pillar refers to the social aspect of sustainability, referring to the community's general well-being and engagement within the fishery (Charles, 1994).

Lastly, it is vital to point out the applicability of a framework. Despite using frameworks, such as Charles model and the three pillars of sustainability, to map out a fishery and stock, a real-world situation is often more dynamic. As fish stocks and the ecosystem change, the other pillars can also follow a similar trajectory. For example, should the market price and demand for the stock decline or the community perspective suddenly change, an imbalance in all three pillars can arise. Therefore, the point of a management system is to consider all the potential changes and create as much balance as possible.

2.4 Fishery management in Norway

As the thesis covers a Norwegian fishery, there is a need to understand how they are managed, and what the goal of their management process entails. As for how Norway governs its fisheries and framework, the method itself has been through many adaptations. After shifting from open access fisheries to closed management, following the collapse of the cod stock in the 1990s, Norway further developed and innovated their management (Gullestad et al., 2012). Due to the developments in technology and market policy, the Norwegian governance system can now be better labeled as a cybernetic system with feedback and responses that are more independent of short-term political indecisions (Johnsen, 2014). A cybernetic fishing industry can be described as diverse and complex networks of nature, technology, markets, policy, and society connecting in different manners (Johnsen et al., 2009). Specifically, with increased integration of newly developed technology and increased knowledge of the fisheries and stock parameters, more self-regulation is utilized, as it is easier to incorporate data into the management (Johnsen, 2014). This regulation method is especially relevant to managing the quota size, as it often needs to follow complex biological parameters established to maintain sustainability. As the understanding of the stocks has increased, the fisheries and management follow in the same direction, resulting in them becoming increasingly intricate.

Figure 2 (Johnsen, 2014) shows an overview of the governing approach. The model shows what goes into the governing process and its components. These are the steps and activities when deploying or adopting a new policy in Norway. Therefore, the model cannot simply be defined as a top-down organization. The system depends on the amount of feedback received from the system-to-be-governed and stakeholders (Johnsen, 2014). Fisheries

governance, in short, has developed into a complex matter. What was previously measured as living beings roaming the ocean is now determined through models, data, and precise estimations (Nielsen, 2008). In addition, the more variables and uncertainties a fishery has, the more difficult it becomes to accurately manage. In summary, the fisheries governance model (**Figure 2**) shows the overview of the management system and its components, which is the external political process that affects a fishery. As for the management process used in determining the quotas and regulations, this activity happens occurs on the left side of the model "regulation and control".

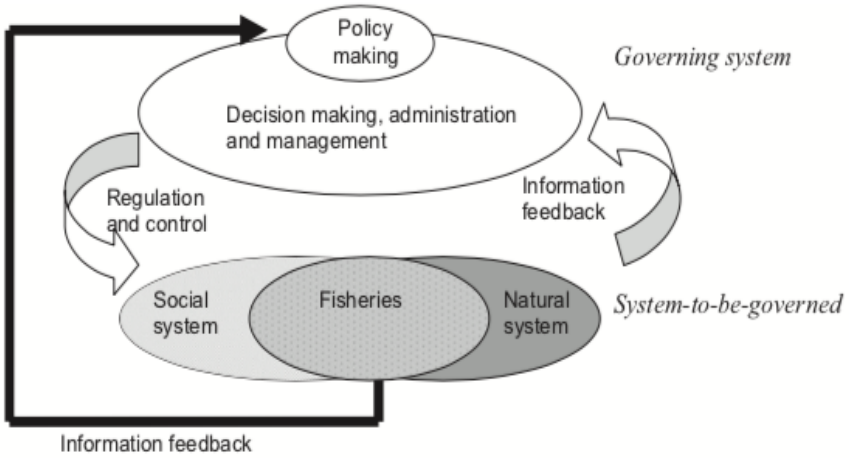


Figure 2. *Fisheries governance model taken from (Johnsen et al., 2014, p.3).*

2.5 Fisheries quota – regulation and control

Based on this general cybernetic model of fisheries governance and systems, we can look further into the specific quota regulation process. Regulating the quota itself requires several steps. The distribution of stocks does not follow politically defined boundaries and are spread throughout the ocean. Therefore, they are not a single country's responsibility to manage, but a joint effort. If a fishery is shared among multiple nations, precise collaborations are needed to maintain a high level of governance (Ministry of Fisheries and Coastal Affairs (MFCA), 2007)). This collaboration means regulations and changes towards management and quotas, are a process that all parties of participatory countries must approve.

All management decisions and quotas in Norway follow the same general regulatory framework. The regulatory chain (**Figure 3**) by the MFCA serves as a model for showing how quotas are decided. This model can be summarized in four main activities: **Research, negotiations, distribution, and fishing** – before repeating the process for the next fishing season.

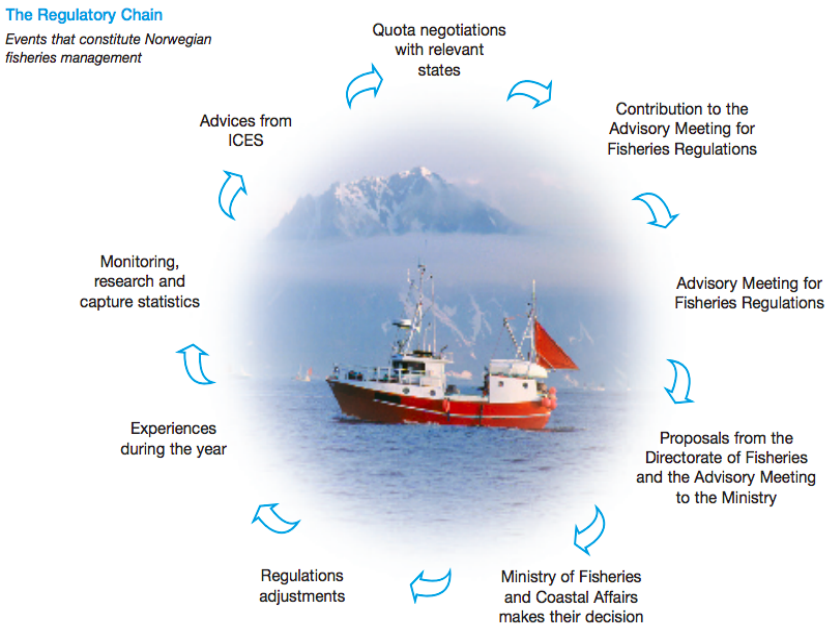


Figure 3. *The regulatory chain (forvaltninghjulet) taken from the (Norwegian Ministry of Fisheries and Coastal Affairs (fisheries.no p.7), 2007). Shows the circular and continuous process of managing quotas in Norway.*

The first step is to gather biological measurements and monitor the condition of the current stock through research cruises and an accumulation of data (IMR, n.d.). Using the collected stock data, the International Council for the Exploration of the Sea (ICES) serves as the primary independent advisor, evaluating the fishery through unbiased calculations and recommendations based on the scientific discoveries. This advice is further used when negotiating the fisheries quotas. When negotiations of the fishing quota are completed, the process moves on to several domestic meetings. At this stage, the stakeholder organizations determine the distributions between the different fisheries and quotas in these joint meetings held by the NDF (MFCA, 2007). In addition, the fisheries rules and regulations are also decided. These gatherings are the last step of the process, before the fishers are allowed to harvest their respective quotas. The biological calculations and scientific

recommendations are collected every year after the fishery is concluded and used to determine the next season's quota. Still, the feedback loop (**Figure 2**), or external parties, could also affect the final quota decisions. This authority means that although a quota is approved in the regulatory chain, the ministry can still affect and choose whether they want to follow the advice. Therefore, politics can contribute to the final decision of how to manage the fishery.

3. Methodology

The main methodology utilized in the paper was a qualitative document analysis using an exploratory research design. In addition, qualitative interviews were conducted with various stakeholders in the industry to supply and provide further context to the findings.

3.1 Exploratory research design

Due to the relatively complex nature of the topic, an explorative design was employed. Exploratory research is a study design suited to investigate a topic and to gain a deeper understanding of the situation (Blanche et al., 2006). The connections between the various elements and implications in the fishery are frequently not examined, as research tends to focus on specific topics. With the thesis question being comprehensive, the exploratory design contributes to evaluating and investigating the different themes present in the study (Blanche et al., 2006). In addition, the situation regarding the reopening of the capelin fishery in 2022 is ongoing as of writing this thesis. Due to these circumstances, current information is, to a degree, also evaluated to depict the fishery's situation accurately. Exploratory research, therefore, provides a new view of complex topics and situations, strengthening the research processes (Casula et al., 2021). Accordingly, the purpose of this design means finding new connections between different factors and explaining their relationship (Mayer, 2015). With some data sources susceptible to errors and being provided by non-scientific articles, like news articles, these materials were further examined to confirm their validity. These articles were not used to make scientific arguments in the paper because of the potential bias.

3.2 Document analysis

The research data and material found were analyzed utilizing a qualitative research method. Qualitative data uses texts and documents to explain the various interconnections of a

situation (Mayer, 2015). The research material was predominantly gathered from utilizing secondary sources. Secondary data can be viewed as data collected from previous materials, utilizing research papers, articles, books, reports and other sources (Tripathy, 2013). A document analysis was applied to analyze the qualitative data. An article by Bowen (2009) describes document analysis as a method to systematically evaluate and categorize qualitative data. As the data on the topic is dispersed across several longer documents with different themes, the document analysis was selected to help synthesizes them and understand their meaning (Corbin & Strauss, 2008).

Nevertheless, using a document analysis versus other research methods has some advantages and limitations. A strength of the document analysis is the ability to use data through public sources (Bowen, 2009). Using existing data makes finding relevant materials more efficient, without using extensive resources and time, which risk overcomplicating the process. In addition, the method allows for broader coverage of a topic over an extended period of time, helping to understand the different settings (Yin, 1994). These two strengths help see the overview of a situation, extract the essential data, and analyze the previously made approaches with a different perspective.

Along with strengths, there are some weaknesses to the document analysis. As articles and papers often describe a distinct situation, they can struggle to give additional information about the general case, hindering accurate answers to later questions (Bowen, 2009). Another potential flaw is the possibility of bias selectivity. The documents are often chosen to be analyzed based off of their availability. This allows for potential prejudice from the researcher, causing certain findings to be prioritized over others (Yin, 1994). These flaws do not necessarily occur in a document analysis, and thus, the method often provides clear and relevant data to the study (Bowen, 2009).

All the data explored in the document analysis came from the various regulation meeting reports from The Norwegian Directorate of Fisheries (NDF) public site (**Table 1**). Certain elements in these reports are excluded, and only the sections related to the Barents Sea capelin have been analyzed in detail. The yearly NDF reports primary purpose is to discuss, the previous and new fishing season regulations for all Norwegian fisheries. Some reports do not provide detailed quota and fishery information because of its closure. Therefore, these

short reports provided little details to further explain the situation and were not examined. Several documents on the Barents Sea capelin on the NDF site were explored and can be categorized as the following reports:

- NDFs finalized report of the yearly fishery (Saksdokument)
- Stakeholder input (Innspill)
- Meeting report (Referat)

The detailed list of the specific reports used can be found in Appendix A. The finalized reports written by NDF, described the regulations and decisions on how to manage the yearly fishery. As for the stakeholder input reports, they consist of the various stakeholder organizations, sharing their belief on what to do with the capelin. Lastly, the meeting reports elaborate on the actual discussion of the joint gathering between NDF and the stakeholders, where they decide on the final report. As the NDF report provides little information on the individual stakeholders' opinions, the stakeholder inputs and meeting reports, were added to the document analysis. Some organizations have an advisory purpose, while other organizations only represent interest groups, which means they have different levels of authority. As many organizations lack a direct English translation, the Norwegian name is instead stated, and whom the organization represents. **Table 1** shows all organizations who gave their opinions on how to manage the Barents Sea capelin fishery.

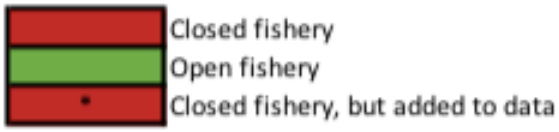
Table 1. *All organizations mentioned in the NDF reports analyzed (2002-2022). Some organizations have changed name since the original meetings (2008), and not all organizations present statements each year.*

Organization name	**Who the organization represents**
Norges Fiskarlag	Norwegian fisher's association
Pelagisk forening	Pelagic and purse seiners organization
Norges Kystfiskarlag	Costal fishermen trade union
Sjømat Norge	Norwegian seafood (seafood processing industry)
Nordland Fylkes Fiskerlag	Regional branch of Norwegian fishermen association
Sametinget	The Sámi Parliament of Norway
Bivdu	Small scale Sámi fisheries organization
WWF	World Wide Fund for Nature

All these organizations had an opinion on how the fishery should be managed. The list of the organizations above is structured roughly according to their influence for the final decisions of the fishery. Not all stakeholders participated with input each year. The ten most recent years when the fishery was open were selected, as they would provide a sample of sufficient and reliable information. The following years were used: 2003, 2009-2015, 2018 and 2022 (**Table 2**). An additional year when the fisheries were closed (2017) was added to the data, to get insight into the statements from a closed period. 2017 was chosen to get data from before COVID-19, as the pandemic could cause unrelated implications to the fishery. It is important to note that although the fishery occurs in the year stated in the report, the meeting is held in November, the year before the fishery starts. To avoid confusion, when a report and fishery are mentioned, it will be referred to based on the year the fishery took place, and not the meeting.

Table 2. *Showing the years analyzed in the document analysis when the fishery was open using data from NDF (2002-2021).*

	Was the fishery open?	
Year	YES	NO
2003		
2004		
2005		
2006		
2007		
2008		
2009		
2010		
2011		
2012		
2013		
2014		
2015		
2016		
2017		*
2018		
2019		
2020		
2021		
2022		
Total	10	1



As for the document's contribution to the economic side of the situation, the stated reports from NDF cover the average historical prices and amount sold to fish meal/oil and capelin consumption. The market for capelin is dynamic, and variables affecting the value with each catch and year due to the auction system of Sildeslaget, where all pelagic fish caught by Norway are sold after capture. These variables in the value, mean that detailed calculations are needed to make statements of economic sustainability. Therefore, the thesis avoids direct assumptions about the fisheries' profitability and instead, uses the presented numerical data in the NDF report, combined with the interview statements.

3.3 Qualitative interview

Several semi-structured qualitative interviews were conducted over the 6-month research period. These interviews confirmed some of the data found in the document analysis and provided further details of essential themes. The interviews were conducted using a general interview guide approach design (see Appendix B). The general interview guide approach is close to an informal conversation interview, but specific topics and questions are conveyed to maintain relevant answers, while having flexible questions (Turner, 2010). The choice of this method is due to the diversity of participants surveyed and their specializations in the industry. Therefore, the questions were adapted to match their respective field. Four stakeholders from different sides of the capelin fishery were asked to share their thoughts on the industry and fishery. The following participants were interviewed:

- Fishmeal and oil industry representative (**Informant A**)
- Capelin fisheries and management representative (**Informant B**)
- Capelin consumption industry representative (**Informant C**)
- Capelin purse seiner representative (**Informant D**)

These four interviews were around 30-40 minutes in length. The number of interviews deemed sufficient for the research, depends on the necessity of the information and the question at hand (Baker & Edwards, 2012). As the document analysis provides the main results, this thesis is not entirely dependent on these interviews to answer the research question. The interviews were utilized to understand the different contexts and see different perspectives within the capelin fishing industry. A second criteria was their willingness to share their knowledge and field of expertise. Therefore, the number of interviews can be deemed sufficient in this research as the interview fulfilled their intended purpose. Although the questions were adapted to respondents because of their different backgrounds in the capelin fishing industry, a notion of their general thoughts and impressions were maintained throughout the interviews. The participants were interviewed over teams, in person, and over the phone to accommodate their schedule, availability, and preferences. Despite the different settings, the interviews were all conducted in a casual setting, allowing all participants to freely share their knowledge.

As stated, the interviews were used mainly as supplementary material to the results from the document analysis. Subsequently, direct statements from the interviews are not used in the text. Instead, the data from the document analysis and interviews are combined with the respective themes. As for the compliance with research ethics, the conversation transcript was only written down to prevent recording of the audio data. No personal information was needed from the subjects. All participants were asked for consent before the interview and informed of the purpose of the conversation. To maintain anonymity, details that could identify the interviewees were withheld. Therefore, the interviews were compliant with general ethical guidelines. However, collecting data only by writing down the conversation, causes a possibility for the information to not precisely replicate the statements of the participants. Because of this data collection method, the thesis refrains from directly quoting participants.

3.4 Thematic analysis

Based on Braun and Clarke's (2006) literature, a thematic analysis was utilized to analyze the data selected. Thematic analysis means coding the data by selecting and categorizing the relevant text, and creating themes (Braun & Clarke, 2006). The reason for choosing a thematic analysis to organize the documents and findings, was due to the similar format between all governmental documents, thus avoiding the repetition of similar findings. The analysis themes were based on the previously stated pillars of sustainability and categorized depending on the various content. After dividing data, the content was further divided and compressed into subgroups based on Charles' (2001) framework.

3.5 Limitations

As the thesis was written as a 30-credit master's thesis, there were some limitation towards of time constraints. The capelin fishery contains many different elements and research papers dedicated to niche parts of the whole industry. When talking to the interview subjects it felt possible to write a thesis about each of the participants sides of the capelin fishery. Therefore, some of the information gathered did not make it into the thesis, as it was not as relevant to answer the research question. In addition, the large scope of the thesis could cause flaws due to the writers' lack of expertise in the field, and broadness of the research topic.

For the qualitative interviews there it would have been preferable interviewing more people. As the industry is vast, there might have different views even in the same side of the industry. In addition, with limited contacts and knowledge of the industry, some of the interviews might have been susceptible to bias when selecting the informants. As for the interview subjects themselves, in working with this thesis, it is clear the perspective of the coastal fishers should have been explored, as they likely have different views and opinions from the purse seiners.

4. Norwegian capelin fishing history and management

This chapter serves as a walkthrough of significant events and outcomes in the capelin fishery. In order to gather an understanding and contextualize how the capelin fishery developed into what it is today, knowledge of its history is required. The biology and ecosystem of the capelin, followed by the fishery's current situation and management, are explored to provide context to the various implications later discussed.

4.1 Barents Sea capelin biology and ecosystem

The Barents Sea can be described as an ocean area in the northernmost shelf of the Arctic sea (Smedsrud et al., 2013) situated at the northern border of Norway and Russia (**Figure 4**). The area possesses hot streams from the Gulf, paired with the rich, cold water from the Arctic, providing a suitable habitat for diverse aquatic life (Sakshaug et al., 2009).

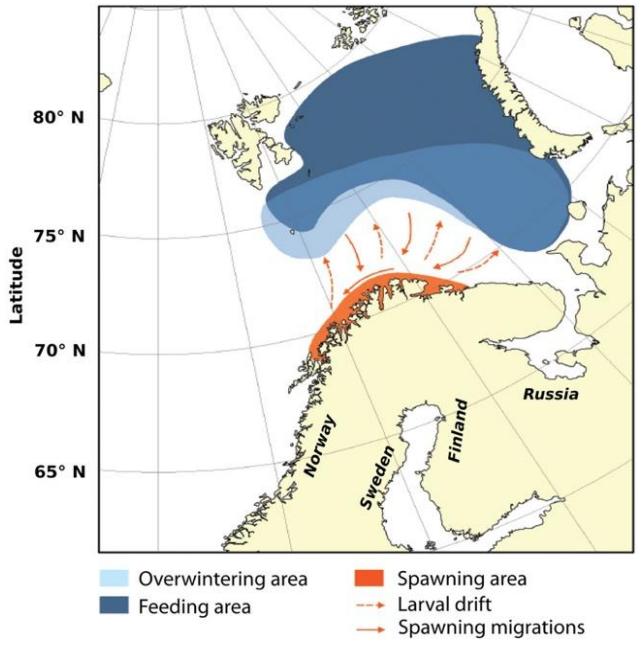


Figure 4. *Map over the capelin distribution area in the Barents Sea taken from: (Baulier et al., 2012). Shows both the area capelin usually is located (dark blue), and the area it travels to when spawning (orange).*

The environmental conditions in the Barents Sea provide a high production of plankton, which is the main diet of the Barents Sea capelin (Gjøsæter et al., 2002). Capelin is a small pelagic forage fish (**Figure 5**), living in arctic oceans (Smedsrud et al., 2013). As for migration, the Barents Sea capelin spends most of its life grazing in the sea before travels to the northern coast of Norway to spawn around March (**Figure 4)** (Meeren et al., 2009). During the spawning period, visible stripes of scales appear along the mid-section on both sides of the male capelin (Gjøsæter et al., 2007). These prickly scales are how the capelin got its Norwegian name "lodde", referring to its “hairy” appearance. Several capelin stocks of varying sizes exist across the world's oceans, but The Barents Sea capelin stock is considered to be the world's largest stock when at its peak (Gjøsæter, 1998).

Figure 5. *Pictures of Barents Sea capelin from the 2022 season (private photo)*

Although the potential total stock is substantial, informant B stated that the Barents Sea capelin stock is highly inconsistent in expected volume. The total amount has dropped to almost zero in some years throughout the capelin stocks history, but still managed to recover. The reasons for its instability in stock size and large fluctuations are linked to several reasons:

1. Capelin easily perish after spawning, and usually only <5% survive post-spawning.
2. Capelin's life expectancy is 3-4 years before its first spawning.
3. It is a keystone species in the middle of the food web.

The first two points are related to capelin's biology, which causes large fluctuations in the stock. If the recruitment is suddenly staggered for 1-2 years because of the high recruitment of predators or other external factors, capelin's biological characteristics cause a drastic reduction in the total stock. The fragile nature, paired with only spawning once in their lifetime (Berg et.al., 2021), cause large natural fluctuations in the stock.
To further elaborate on the capelin's important role in the ecosystem, capelin is in the middle of the marine food web and is susceptible to considerable predation from multiple aquatic species before fully maturing. This prey-predator relationship causes recruitment to be challenging if the predators are too abundant before the capelin manage to spawn. Capelin in the Barents Sea is targeted throughout its whole lifecycle. Juvenile herring (*Clupea harengus*) target the capelin larvae, while Northeast Arctic cod and other larger whitefish species, including marine mammals and seabirds, consume juvenile capelin and adults (Meeren et al., 2009). According to informant C, some of the customers consuming exported capelin are not just people, but also marine animals in zoos. This high demand from marine inhabitants and humans alike shows that capelin is a sought-after delicacy.

4.2 Capelin fisheries agreements and management

The previously mentioned regulatory chain (**Figure 3)** shows the main steps in the management, which also applies for the capelin. The annual cycle is implemented in order to maintain a sustainable fishery each year, following the same process as the regulatory chain. An important topic to highlight is the capelin fishery is a joint collaboration of Norway and Russia, through the Joint Norwegian-Russian Fisheries Commission (JNRFC) (MTIF, 2021). As the two nations have rights to the fishery, they share quotas, access to fishing zones, quota exchange and research efforts. The research efforts, through combined research cruises and management efforts, is the starting process of the regulatory chain. In these cruises, biological stock measurements are taken and used to ask of quota advice from ICES. From this data ICES sets a total allowable catch (TAC), which is usually followed and then divided between the two nations. As for the details of how the Norwegian quota is divided this will be further explained in chapter 5. After the fishing season is finished, the process is repeated.

4.3 The early development of the Norwegian pelagic fishery - 1960-1970

Pelagic fish have always been used as fertilizer and to feed farm animals, but the extensive commercial efforts began after the fishery started targeting the herring stocks (Harbitz, 1993). With a high amount of fishing effort on the coastal fisheries, the fishers eventually looked towards the open sea to target new and larger quantities of fish species (Bjarnar et al., 2006). Around the 1960s, new technologies improving the ability to find and harvest fish were implemented in the fisheries (Bjørndal & Ekerhovd, 2014). The echo sounder and giant hydraulic power blocks made it possible to locate the fish and haul large volumes onboard (Bjarnar et al., 2006). The introduction of the power block also made it possible to fish deeper in the ocean and construct specialized fishing nets adapted to catch pelagic fish, referred to as purse seines. In the early period of the fleet, mainly North Sea herring was targeted in both summer, autumn and spring (Jenssen, 1982). An essential part of the herring fishery was the recently mature part of the stock called “fat-herring”, because of their high oil content (NDF, 1974). The fishers realized the value potential of these herring and other fish not suitable for consumption early on, and the first herring fish oil factory was already established in 1884 (Harbitz, 1993).

As the total harvest volumes grew, the fishmeal and oil industry grew along with it to utilize the large quantities of raw fish material. The fleet quickly expanded, from 20 vessels in 1963 to around 450 vessels in 1967 (Bjarnar et al., 2006). With the fleet fishing more than was possible to consume, the fishmeal and oil industry played a crucial role in utilizing the large amounts of fish caught, and factories became present along the entire coast of Norway. The fleet also shifted from a homogenous fleet, to a more specialized fleet according to the species the vessels targeted. The fleet also became highly mobile with their larger vessels, making it possible for one vessel to target multiple seasonal fisheries.

4.4 The collapse of the herring stock and growing importance of capelin - 1970-1986

With purse seiners expanding in vessel size, they could now carry bigger catches and harvest fish more efficiently. This expansion, paired with the considerable growth of total vessels and technological advances, caused fishing efforts to increase rapidly (Bjørndal & Ekerhovd,

2014). At the time, there were no regulations towards fishing activity and free fishing for all participants. The large volumes of fish caught caused the profitableness of the fishery to decrease due to the high supply, which meant fishers needed even bigger harvest volumes to maintain profitability (Bjarnar et al., 2016). Therefore, a "Tragedy of the Commons" situation appeared, referring to problems created by free access to a common resource (Hardin,1968; Burger & Gochfeld, 1998), because no regulations had been implemented for the fishery, despite the elevated fishing pressure and economic incentive.
The building pressure on the stocks eventually caused the important herring fishery to collapse from 1960 to 1970s (Lorentzen & Hannesson, 2004). With no regulations still in place, fishers continued targeting the declining stocks and hindered the herring's ability to recover (Hjermann et al., 2004). As a result, the Norwegian government eventually implemented some regulations after realized the implications a high continuous fishery effort had on the stock's ability to rebound. However, at this time, researchers believed ecological factors were the primary cause for the sudden decrease of herring, and not the fishing effort (Lorentzen & Hannesson, 2004). Therefore, the herring fishery only saw limited regulations, before fully banning fishing activity in 1978. Although the herring fisheries were open access until 1972, positive results from the limited regulations could be seen from the rebounding stocks (Bjarnar et al., 2016). This was a valuable lesson for the industry, as the consequences of overfishing a stock and the effects brought about by allowing stocks to recover could be visually observed by the fishers.

Following the collapse and instability of the herring industry, a brief period of reduced raw material in the fishmeal and oil industry appeared (Harbitz, 1993). However, the fleet looked toward potential substitute stocks, with the capelin fishery as the main solution. Smaller volumes of capelin were fished paralleled with herring starting from around 1964, although the major fishing activity began after the herring crash around the 1970s (**Figure 6**) (Bjarnar et al., 2016, p. 32).

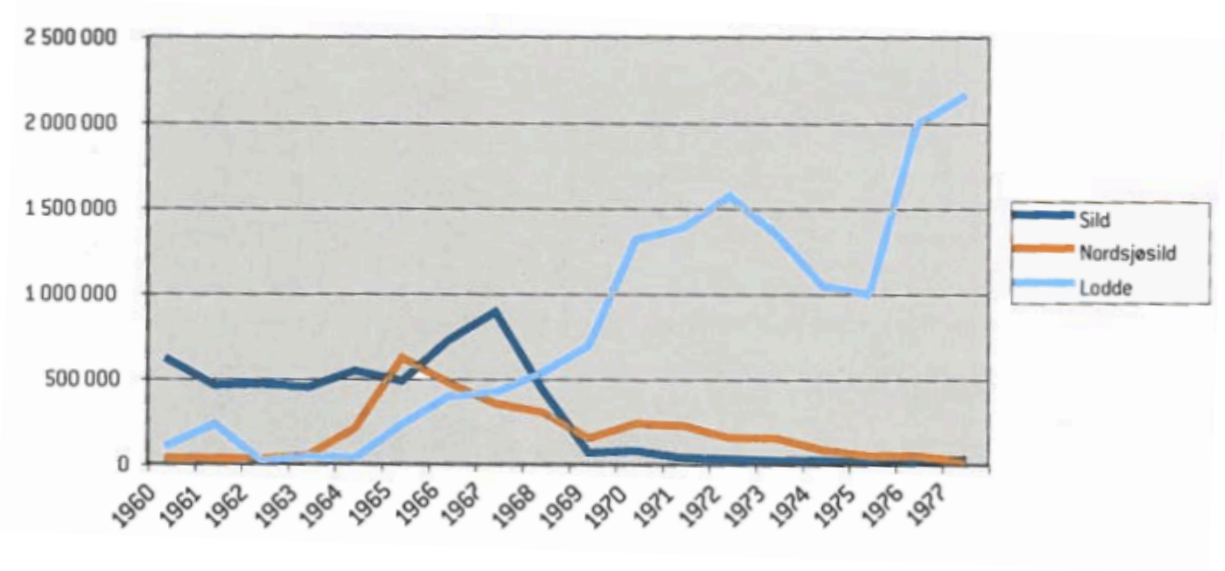


Figure 6. *Showing the Norwegian catch of spring-spawning herring (blue), North Sea herring (orange) and capelin (light blue) taken from (Bjarnar et al., 2016 p.32). Shows that as the herring stocks crashes, the capelin stepped in as a substitute and the harvest volume increased.*

4.5 The ups and downs of Barents Sea capelin fishery - 1970-2020

As capelin was another pelagic fish found in abundance around a similar area as the herring and had an equivalent size, it was a natural choice as a substitute, and a new primary source for raw fish material. As Norwegians did not consume capelin and had access to a large stock, it was suitable for the fishmeal and oil industry. However, a small share of the total catch was exported to Japan as a consumption product (Odden, 2020). This export of the capelin would later become an increasingly common method of utilizing the catch, as it could net a higher market value than if it was sold as a raw fish material. In addition, it allowed value based on the quality of the fish, which was not a priority when using capelin for the fishmeal and oil industry.

Two fishing periods targeted the same capelin stock, both winter capelin going to shore to spawn, and the summer capelin grazing on the plankton in the Barents Sea (Bjarnar et al., 2016). The purse seining fleet was still evolving, and vessel sizes increased as regulations on the fishery were yet to be implemented, and high volumes were needed to be profitable. However, the capelin stock at the time was vast, even among the other commercial fisheries, and it became the fleets' primary fishing activity and until 1986 (Harbitz, 1993). The

capelin fishery reached its peak around 1975-1977 **(Figure 7)**, with almost three million tons caught in a single year (IMR, 2019). After the peak of the fishery, the stock had declining volumes of catch and stock, until it collapsed in 1984. In the following two-year period of the fishery, the stock dropped by 95 % (Meeren et al., 2009). Later, the fishery consisted of short periods of large harvests followed by a hiatus of a few years before reopening, often with the new fishing intervals seeing a lower quota than previously (**Figure 7**). Three stock crashes took place between 1985 and 2006 (Gjøsæter et al., 2008). These on/off periods were introduced multiple times throughout the fishery's history, and the stock volume have not yet recovered to its original levels.

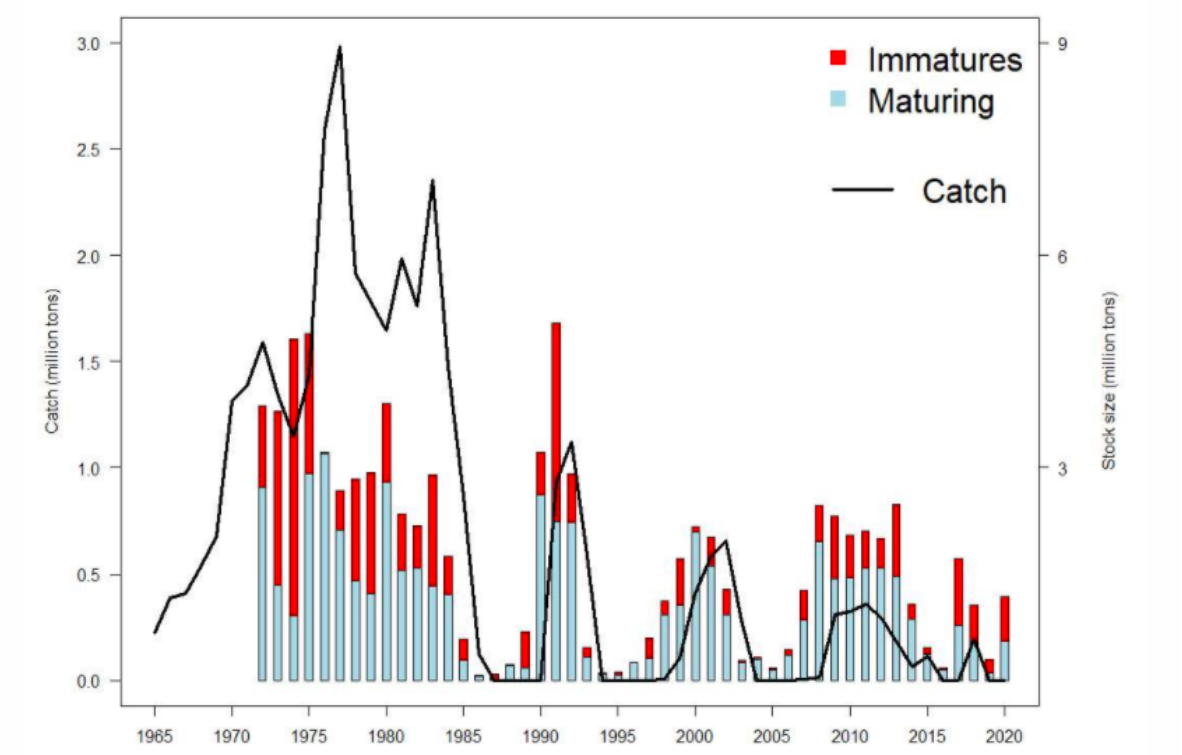


Figure 7. *Showing stock size and catch amount from 1965-2020 of Barents Sea capelin taken from (IMR, 2019).*

However, after a similar experience with the herring stock, fishers adjusted well to this volume change and found other fishing stocks to harvest. This adaption meant the fishmeal and oil industry was not as overwhelmed by the decline of capelin harvest volumes.

The main difference between the capelin and herring collapse was the more evident effect the drastic reduction of capelin stock had on the ecosystem. Numerous species became

affected. The important cod fishery saw a decline in both growth and recruitment, and increased predation following the capelin stock crash (Gjøsæter et al., 2008). In addition, other whitefish species, sea birds, and marine mammals were negatively affected (Meeren et al., 2009). The implications of the lack of capelin were especially apparent through the cod stock collapse in the late 1980s (Gjøsæter et al., 2008). This crash impacted the jobs and livelihood of fishers all along the coast, who were dependent on the cod as their main fishing activity (Winther, 2019). The reduction in the cod fishery started the ideology of the coastal fishing industry, believing that the capelin's role was food for other commercial species and not as a fishery itself. Realizing the consequences of high reductions in capelin had during the multiple stock crashes in the fishery, a gradual shift towards harvesting less capelin was implemented by the government. Further management efforts and restrictions began to shift towards the ecosystem-based fisheries management approach (EBFM), prioritizing capelin as food for the other stocks in the Barents Sea. However, the change towards EBFM was a long process as the research has been conducted on the Barents Sea capelin for over 40 years since first starting the fishery, through cruises measuring the different variables of the stock (Gjøsaeter, 2011).

With the quota volumes decreasing and the value potential of capelin rising, the fishery has gradually shifted towards focusing on a consumption-oriented fishing industry over the last 20 years following the on/off fishing pattern. In a 10-year period, the fishery has been open for five years (**Figure 5**), with 2022 ending a three-year closure (2019-2021). The NDF and Fisheries Director decided to reopen the Barents Sea capelin fishery based on the recommendation of the ICES. The quota amount for 2022 was set to a total of 70 000 tons between Norway-Russia (60/40 % share), which is represents a significant drop from the 2018 total volume (205 000 tons) (Institute of Marine Research, 2021). A surplus of participants signed up for the 2022 season, and the fishers were picked through a lottery method.

Despite the recent instability of the Barents Sea capelin fishery, there is a high interest in reopening the fishery due to the demand for capelin from the consumer market. The absence of consumption grade capelin caused abnormal price increases, along with record-breaking high capelin prices in 2021. The average price of capelin was 2,4 Norwegian kroner

(NOK) per kilo (kg) in 2018 but reached an average price of 14 NOK per kg in 2021, hitting up to 19 NOK per kg (Kvalsvik, 2021). This significant value increase is a result of the availability of consumption grade capelin from other fisheries decreasing. As for the fishmeal and oil industry, the average price for capelin remains more stable. As the factories has access to substitutes for raw fish material, the value potential follows the fishmeal and oil industry, instead of the direct value of the capelin.

4.6 Current situation of the Barents Sea capelin fishery - 2022

As of writing this thesis, the 2022 Barents Sea capelin fishery has concluded. According to a post season capelin review meeting, only 1 081 of 42 346 tones went to fishmeal and oil due to not being high enough grade for consumption (Garvik et al., 2022). Prices ranged from 2,52 to 12,55 NOK. In addition, there was a low amount of cod bycatch. The catches at the end of the season fetched the highest price. According to Informant D, who participated in the purse seiner fishery, a single catch was often more than enough to fill the allowed quota. Because of the low quota volumes and high density of capelin, some vessels purposely went out of their way to target less dense areas of capelin to avoid a risk of overfishing. There were large stocks of capelin seen from the perspective of the fishers. In addition, some vessels did not head out to sea because of the high fuel prices in fear of it not being economically viable. As for the quality of the catch, 5 of a total of 102 catches were denied consumption grade quality. There were 19 complaints about the catches, with two towards quality. The rest of the 17 complaints were due to deviation in capelin samples from the vessels. Overall, the season was deemed as successful despite the low volumes and slight reduction from last year historic prices.

4.7 Stock measurement and IGJM-capelin

As for the current management of the fishery, a revision is planned arranged by ICES. The management method will be revised in May/June 2022, allowing potential changes to be implemented (Skaret & Slotte, 2021). Revisions are usually done every five years of the fishery, but implementing changes is not guaranteed. If changes are to be made, it would need approval by both ICES and Russia, as it is a joint fishery. The revision of the management method is a collaborative effort with the IGJM-capelin.

IGJM-capelin is another larger capelin population with similarities to the Barents Sea capelin. The population of IGJM-capelin is situated around the Southwest coast of Iceland. Some similarities are shared in the biology and ecosystem conditions between the two capelin populations (Carscadden et al., 2013). However, an essential difference in IGJM-capelin is that the fishing period is earlier in the year, from January to February. This population is close to the Norwegian fishing zone in Jan Mayen, and there is a shared quota with Norway, Greenland, and Iceland. The Norwegian quota share percentage is minimal compared to the total quota, unless a further quota share is received through the loophole agreement (5 % share of total IGJM-quota before trading) (IMR, 2019b). This lets Norway have two capelin fisheries to extract fish from and provides Norway with a substitute capelin stock. Informant A pointed out that the IGJM has contributed capelin to the consumer and fishmeal and oil industry in periods when the Barents Sea fishery was closed. However, this stock also suffers regular closing and fluctuation of quota volumes, as shown by the fishery shutting down in 2019-2020. Furthermore, the IGJM-capelin is usually suited for the fishmeal and oil industry as the capelin is less sturdy (Isaksen et al., 2011), despite 60 % of the 2022 season going towards consumption (Garvik et al., 2022).

IGJM-capelin follows a similar harvesting rule to the Barents Sea fishery, but the measurement of the population is the main difference between the two fisheries. IGJM-capelin stock is measured using the data collected from the regular cruise during the spawning season, but also a winter cruise measurement before the fishery starts. The extra stock information allows for a measurement closer to the fishing season. The two periods of data collection differ from the Barents Sea fishery, which mainly uses data retrieved from the previous year. According to the interview with informant B, this difference in measurement has caused the fisher side of the industry in Norway to question the accuracy of using older stock data to determine the current stock size and quota.

4.8 Summary of development in the fisheries and management

In summary, the Norwegian fishing fleets evolution, is a story of a high effectivization of harvest potential, paired with a then lack of management and understanding the environmental impacts these fishing efforts caused. The history of the fishery can be divided

into two phases. The early development phase had a high fishing pressure, and the consequences of overfishing were not understood. With innovations in harvesting, increased economic profitability from the large fishing volumes caused the fishing pressure to expand beyond what the stock could handle. Some regulations were implemented, but only limited amounts as the impact on other fisheries were yet to be apparent.

The second phase came after capelin became the new primary fishery, as the still high fishing pressure caused the stock to collapse. With capelin, the consequences of the collapse could be seen on the ecosystem, and the number of regulations was increased. As the positive sides of implementing regulation became apparent, a shift towards ecosystem management was formed. The capelins' importance grew as its position in the ecosystem was understood.

5. Impact of capelin management and industry

The following chapter analyses the results the on/off management and capelin industry. Describing the detailed management efforts, primary drivers of the fluctuation and how the quota is distributed is further elaborated. In addition, the effect the fluctuations have on the markets and its consumers is described.

5.1 The current fishery impact and quota regulation on the stock

As stated earlier, previous breaks in the fishery were prolonged by the then high fishing pressure. Looking at the influence and the quota the fishery has today versus the total capelin stock, the impact of the current fishery is minimal. Explained in detail by informant B, the current low quotas and non-fishing periods are unrelated and not a direct reason caused by the fishing effort. Recent years of low stock recruitment are a result of biological causes and the sizes of predatory stocks. Looking at historical data (**Figure 7**) compared with the recent fishing efforts (**Figure 8**), the quota is considerably lower today (2022). Therefore, the primary driving force of the low volume is not a result of the fishery, but from natural causes. Hence the uncertain biological aspect of the stock also has some implications for the quota advice and management measures. As the environmental implications are difficult to govern as opposed to fishing activity, it has consequences for the harvest control rule for the

Barents Sea capelin. With the caplin being particularly vulnerable due to its biology and ecosystem, a precautionary approach needs to be taken. This precautionary principle means quotas are implemented with caution, as it possesses a high risk of having negative impacts (Hønneland, 2014).

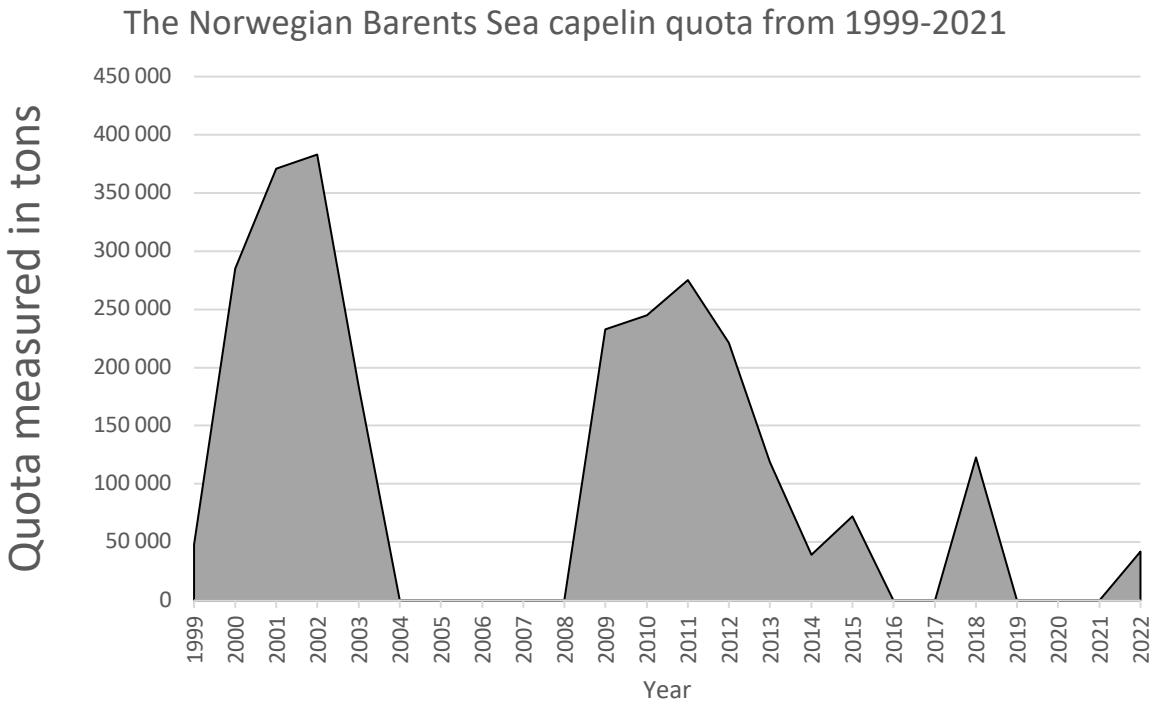


Figure 8. *The Norwegian Barents Sea capelin quota from 1999-2021 with data taken from the 2021 governmental report on Barents Sea capelin from NDF.*

5.2 Harvest control rule, quota advice and measurement limitations

The primary rule for maintaining a sustainable capelin quota is measuring the current population according to the critical spawning stock level (Blim). This formula (Blim), which refers to the biological limit, controls that if the TAC is not higher than a 95 % likelihood of at least 200 000 tons of capelin are allowed to spawn, the commercial fishery stays closed. This management rule is the primary reason why the fishery has experienced gaps in its fishing activity. This management rule is necessary to ensure the capelin stock recovery, which stops the harvest when capelin reaches a critical level. This biological safety of the stock is the top priority of Norwegian Fisheries Management (NFM). As the stock has shown to be highly fluctuating, the amount allowed to fish is strictly regulated to combat the possible

volatility. This regulatory management rule cannot be changed. It is in place to ensure a stock healthy enough to allow for its recovery if the stock suddenly experiences unexpected low recruitment.

Although this management rule is in place and the stock is frequently monitored, mistakes can happen when determining the exact quota. The NDF report from 2021 states that oversights were made in quota volumes from 2017. The quota at the time was set to be substantially lower than the possible harvest amount, as the actual stock levels were much more significant than anticipated. The miscalculation caused the quota to increase in the following 2018 fishery season. A poor research cruise giving inaccurate data was the reason for this mistake in measuring the stock. Another example of a similar situation from the 2014 meeting, the 2014 quota then was initially set as 8 900 tons, recommended based on the biological data collected. Because of another poor data collection measurement, it was determined that the total population was higher than measured and was increased to 39 000 tons. With uncertainty in the volume levels, many stakeholders from the NDF meeting were critical of the accuracy of the quota advice. As these new quotas deviated from the original ones, many organizations were skeptical about the following quotas and the risk of repeating past measurement mistakes. Therefore, the growing concern about management method caused a shift towards some stakeholders previously supportive of a capelin fishery, now wanting no fishery at all, even if ICES approved a quota.

5.3 Distribution of the Norwegian quota

As described in chapter 4, the stock is divided between Norway and Russia (60/40 split) according to the long-standing allocation agreement (Jørgensen & Hønneland, 2013). The quota is then distributed further between the three main groups: Purse seiners, trawl, and the coastal group (**Figure 9**). This split between the Norwegian fisheries groups has stayed the same throughout the analyzed period (2003-2022). In addition, there is a small quota dedicated to research with changing volumes.

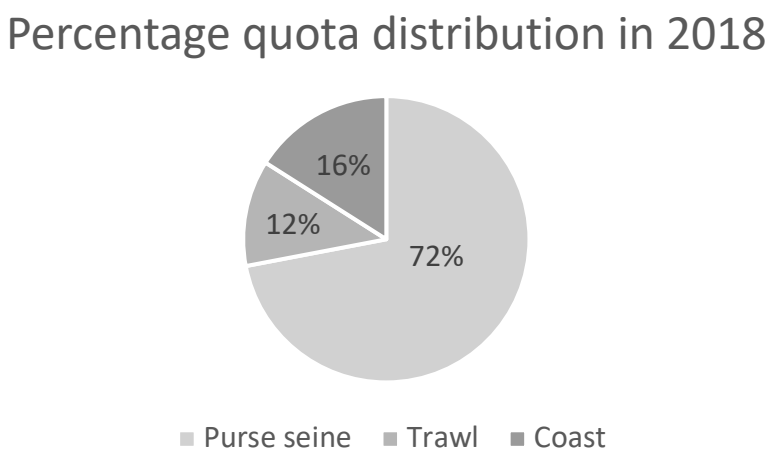


Figure 9. *Pie chart showing the percentage quota distribution of the Norwegian quota divided between the different fishing groups with data taken from NDF 2021 report.* 2018 numbers used, but the distribution has stayed the same for 2003-2022.

In some instances of the yearly fishery, as seen from the 2021 NDF report, the Norwegian TAC has been higher due to trading capelin quotas with Russia, through the quota trade agreement for herring quotas. As for the stakeholder input from NFD reports, the purse seiners and coastal fishery have stated that they want a more significant share percentage. The coastal fisheries believe that they have a right to a larger share as the capelin goes into the coastal water to spawn. They also state that if the purse seiners overfish, the coastal fleet will be impacted in capelin capture volumes and impacting the cod fishery, their primary commercial exploit. As for the purse seiners, confirmed by informant D, if the quota becomes too small, there will need to be a higher volume to fish to increase the overall economic profitability, which becomes minimal if the quotas are too small. This different perspective has some implications for the management system and what is actually defined as sustainable management. As a result, and to avoid bycatch purse seiners have to fish outside a 4 nautical mile radius from the coast. These regulations became implemented in 2018 after larger bycatch amounts in 2015 (NDF, 2021).

Another regulation towards the capelin fishery if there are more than 35 kg of cod per 100 tones of capelin or abundance of capelin below the minimum size allowed to catch. Multiple stakeholder inputs from the purse seiners organizations stated that they would prefer if these criteria were lowered. There have been some instances of fishermen fishing in areas

where it is forbidden as it is too close to the coast or the field being shut down because of bycatch. Along with the possibility of having bycatch, there is also challenges towards the correct reporting of it. There are indications that not all bycatch is registered, and the amount in the end report do not always correspond with the reported amount digital. Often the report shows low or zero bycatch when there is no supervision by the inspectors. As there are limited inspectors and not easy to monitor all vessels, there are some leeway for unethical fishing activity to occur among the many participants in the fishery.

5.4 Capelin consumption and market implications

Another important element affected by the biology and fluctuation of capelin is the market. With stakeholders favoring capelin for consumption, there needs to be a market willing to pay for the product. With a high focus on maintaining ecological sustainability, the current low volumes are suited for consumption. As the consumption market is limited, there were growing indications from the stakeholder input, stating the quota should only be large enough to cover the consumption market, as large harvest volumes are more suited for the fishmeal and oil industry. Another important driver for the consumption industry is the higher value to be gained from having consumption grade capelin.

As for the product value of the capelin there is a large difference between the summer and winter fishery and the capelin's attributes depending on the season it is harvested. Barents Sea capelin is fished during the summer season. According to informant C, this gives the Norwegian capelin more durability than competitors after the fish is thawed, which is preferred for further processing in other countries. As an example, informant A stated the winter season capelin, has a high-fat percentage suited for oil and meal production. Because of the high amount of feed content in the stomach during the winter grazing period, the fish captured fish can turn to into mush. In addition, raw material products from other fisheries were preferred over the summer capelin for the fishmeal and oil industry, which is when Norwegian fishery targets the stock.

As for the prices and product value of the individual catches their quality can vary. The prices received is dependent on:

1. Roe percentage
2. Quality
3. Female percentage
4. Capelin size
5. How much food is in their digestive system (åte)

Asked to describe their feelings around the current fishery, informant D stated it resembled a lottery. With the fishers never quite knowing what quality of fish they are going to get until they check it onboard. Even if the catch is fished in the same vicinity as boats with good catches, there is no guarantee that it is high quality. In addition, the longer boats wait during the season to fish, the higher the likelihood of better capelin prices, as seen from the chapter on the 2022 fishery mentioned earlier.

After the fish is caught, there are several additionally post-harvest activities that are affected by the on/off fishing periods. Expressed by informant C, retail-buyers and distributors prefer a stable flow of product. As for the capelin consumers, their preferences are dependent on the roe percentage, quality and size. Capelin can be considered as a niche product, with high willingness to pay in the right markets. Most of the fish go to Japan, China, Russia and Ukraine. Several of these markets buy capelin, further processing the fish to meet the high demand of main consumers in Japan. Therefore, the informant representing the consumer industry, reaffirmed that a smaller fishery each year would be better than a fishery with higher volumes and gaps, to maintain a steady flow of product.

5.5 Impact of the management and industry summary

As the fishery is highly fluctuating the management need to accommodate the possibility of capelin volumes swaying. The main drivers of changes in quota volume is the management taking into account the biological fluctuations, and not the fishery itself. This management causes strict harvest control rules, which halt the fishery if it reaches a certain threshold. Two main perspective is present among the capelin fishery, one side who wants capelin as

food for the ecosystem, and the other which want to utilize it as an economic resource. The decided quota is divided on both a national and regional level between the different fisheries through the long-standing fishery agreement. As for the market the prices vary based on the biological factors of the catch. As the consumer industry gives a higher value and is suited for lower quota volumes, it has become the current preferred utilization method of capelin.

6. Discussion

In this thesis the NDF governmental reports and in-depth interviews were utilized to find the challenges that appeared, preventing the overall sustainability of the Barents Sea capelin fisheries management. An indication of the importance of capelin, was that all stakeholder interviewed stated in different ways that sustainability of the resource and fishery was the most important aspect of the industry. However, as mentioned earlier in the paper sustainability has different meanings for most parties.

6.1 The two sides of the capelin fishery

According to the subjects interviewed and as seen from the NDF input reports, the Barents Sea capelin fishery is a topic with strong opinions. With the ecological importance of the fishery and the impact of overfishing on the stock, its sustainability is questioned as it has consequences for the whole ecosystem. With the potential negative effects overfishing capelin can create, along with the capelin's biology and unstable history, the optimal way of utilizing the fishery remains in question. This leads to different views between the various parts of the industry of what to do with the capelin and how manage the fishery. As the implications of capelin can affect other fisheries as well, multiple stakeholders have opinions on how to best make use of the resource. As mentioned in the previous chapter there are two main views on how to best manage the capelin, due to the high fluctuations in the stock. These two sides (**Figure 10**) are:

1. Maintaining capelin as food for other species (no fishing).
2 Those who see it as mainly an economic resource (fish more).

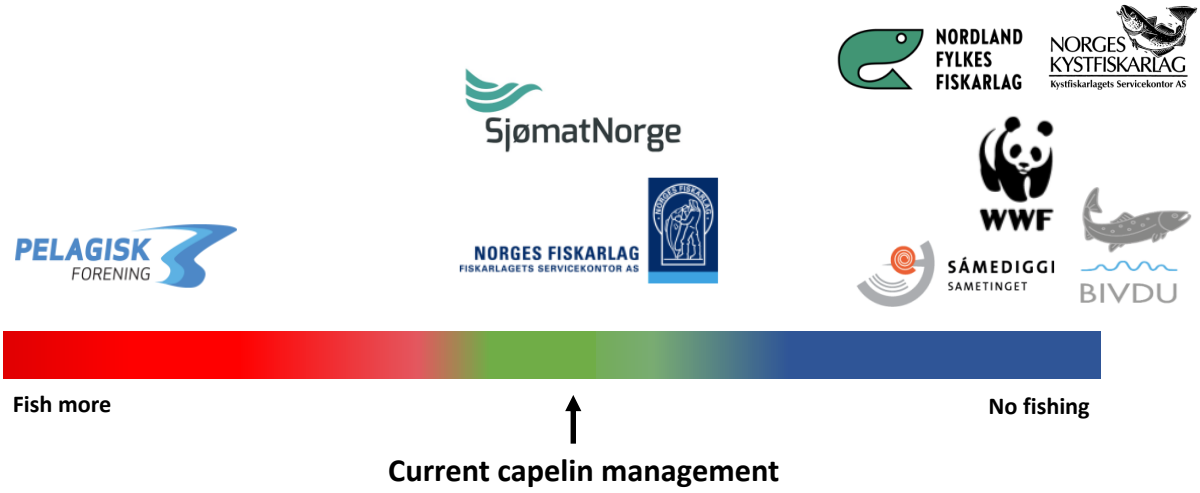


Figure 10. *A model showing the two sides of how organizations wants to manage the fishery with left (fish more) and right (no fishing). In the middle is the current management, a balance between the two. All logos were taken from the NDF reports stated in Appendix A.*

The first perspective is that capelins role in the ecosystem is too important to continue as a fishery. As the volumes are unstable, a low stock can have consequences for the commercial fishery and the ecosystem. Therefore, it is best left as a food source for others, as the main fishing fleet has other fishing alternatives. The second opinion of how to manage capelin, considers capelin to be a profitable fishery. As capelin has a high value and perish after spawning, one can potentially lose out on a fish resource. As the stock has shown it is capable of bouncing back, the fish is suitable as an economic resource when possible.

On one end of the scale the Sami Parliament and Bivdu (**Figure 10**), representing sea Sami fishers, do not want the fishery to be open because of its significant role in the Barents Sea ecosystem. This position is also supported by the costal fishermen organizations, because of the importance of capelin for cod. WWF support a halt in the fishery, as they want to preserve balance the Barents Sea ecosystem. On the other side of the spectrum, organizations representing the pelagic fishery and fleet, are positive to the reopening of the fishery, and if possible, want a higher quota both through an updated management method and the quota trade agreement with Russia. These two views on the management are contradictory, but both want changes in the capelin fishery.

However, not all stakeholders and organizations pick sides, and favours a middle ground between the two views. Norges fiskerilag (the fishing fleet part of the organization) support limiting the ecological impact, while having some amounts of fishing activity. The organization Sjømat Norge (Norwegian Seafood organization) also supports the current method and wants to continue the fishery, without further changes. This middle ground between the two standpoint is where the current management can be categorized (Figure 10), limiting catch and maintaining healthy stock levels, as all management needs a balance.

According to the results and previous research on the topic (Isaksen et al., 2011), there are some implications on the economic profitability of the fishery caused by an on/off fishery, which could be solved by having a more stable fishery. However, the economic factor are not the main drivers when regulating the fishery. The ecological implications of opening the fishery are strictly followed because of the high importance of the capelin's role as a keystone species. To maintain the fish stock within its biological limit, is what can be classified as sustainable in regard to Norwegian management. Therefore, the fish stock's safety is the main priority of the management process. Securing the stock is a response from the previously mentioned cybernetic management system. The cybernetic system is a feedback from the stock data the researchers collect from the capelin, which triggers a response depending on the stock levels. However, even if the system triggers a response, it is still up to the ministry to decide whether they will follow the advice or want to give more priority to the economic system. Therefore, the final decision of how to manage the fishery is through a political assessment. Although the quota in the 2022 season was seen as small according to fishers, viewing "more than enough" capelin at the fishing fields to increase the quota, this does not affect the final decision of the fishery. Rather, researchers and the cybernetic system stick to biological statistics and models to determine the quota, as to not repeat the history of multiple crashed capelin stocks.

Going back to the pillars of sustainability and Charle's fishery systems, in the interplay between the three pillars: economic, ecological and social, the ecological pillar given the highest priority of the three. The ecological focus is also one of the reasons the capelin fishery is not the main source of income for the fishing fleet, as it would be unfeasible due to its inconsistency. However, the ecological elements in this fishery situation needs extra

consideration because of the nature's high unpredictability. In addition, the capelin's important role in the Barents Sea ecosystem is a key argument towards having strict regulations and a precautionary principle. If the quota is too high because of inaccuracies in stock measurements, the whole fishing industry and ecosystem suffers, causing a negative impact on other fisheries and marine life. Although a small quota each year would solve some of the current market problem, this for the time being is not seen as possible solution due to precautionary principle of capelin management. As the ecological precautions are taken into account, it affects the economic pillar and market side of the capelin industry. Therefore, the market tried to create as much economic stability as possible despite the regulations, through the flexibility of targeting the fish for consumption (low volumes) and only using the fishmeal and oil industry if necessary (high volumes). That means the challenges for the post-harvest sector in terms of stability, will likely will not go away.

Older articles and the interviews points out that a stable average quota would be better, than having periodically high and low fishing volumes of capelin, followed by nothing. This balance quota would help contribute solving some of the post-harvest implications that the Barents Sea capelin fishery has. Despite this, respondent B, along with the capelin researcher leading the 2022 spawning cruise (Lindbæk, 2022) from the IMR, stated that this would likely be complicated due to the agreed upon harvest control rule. As a stable quota could risk future stock volumes, it is difficult to implement, as it goes against the principles that guide Norwegian fisheries management. Therefore, although stable low volume quota would be a good resolution towards solving some of the challenges the market side of the industry faces, it is an unattainable solution to the problem with the current regulations towards the quota. Nevertheless, there is also an argument to be made about the sustainability of not utilizing the resource. As capelin usually dies after spawning, the resources potential could be wasted, as some organizations in the NDF report claim it is food for bottom dweller. However, the capelin has a limit to its uses and cannot hold the entire blame for a declining ecosystem.

As the quota volumes have declined the industry has adapted to the changes. Previously, the number of fish oil factories were multiple in most coastal counties (Harbitz, 1993), but was reduced to six in 2011 (Isaksen et al., 2011). This means there are less option in deciding

where to transport the capelin for further processing. Since the Barents Sea capelin is caught at the edge of Norway close to the Russian border, the transportation cost can become large if the buyer is located further South of Norway. With the rising fuel costs, the difficulty of making the trip economically viable is a worry for the fishers if the quota volume declines further.

6.2 The potential of a management method revision

Through the trails of capelin spawning measurement cruises, researchers have stated that a more accurate stock measurements can be achieved (Mæland, 2022). In addition, the trial method of implementing a further measurement cruise has been ongoing for 4 years. Informant B stated that an additional measurement cruise could contribute with more precise stock data. If the original cruise has suboptimal weather conditions, it can create to difficulty in accurately measuring the stock. In addition, it provides a reassurance of the previous measures of data with the traditional measurement cruise taking place in autumn. As the fishers looks for a solution to increase the stability of the quota, a new measurement could possibly bring changes to the fishery. However, there is no guarantee that the quota and stock volume will be more stable. A new, potentially more precise management initiative will not change the uncertain behaviour of capelin, and effects are uncertain since it has not yet been implemented. The capelin will likely continue to fluctuate, as it is simply a part of its nature.

7. Conclusion

The purpose of this thesis was to analyze the Barents Sea capelin fishery along with the various implications that appear when trying to manage an on/off fishery. The thesis has shown that there are several implications that appear when trying to implement sustainable management in a fluctuating fishery. The current fishery management follows, and changes according to the biological parameter of the stock, limiting the continuous fishing activity.

As for how the pillars of sustainability is balanced, the biological pillar favored to maintain an overall healthy fishery. Implications caused by an ecological focus are the main challenges towards creating stable economic profits and market. However, this is a necessary precaution to accommodate the fluctuations of the capelin. The biological side of fishery

have multiple natural drivers, which are the main cause of the fluctuations and instability of the fishery in the first place, forcing regulations on the fishing activity. Adapting to these biological challenges is an inescapable effort and a part of the fishery's identity, which likely will not change in the future. Because of the capelin's high importance in the ecosystem, it has caused two main perspectives between the stakeholders: those in favor of fishing and those who wants to close it down. These opinions are a result of the optimal solution to exploit the capelin fishery is yet to be unanimous. Therefore, the current management method is between the two, harvesting only what is deemed as sustainably possible.

In order to maintain economic profitability, the fishery will have to continue stay flexible to the fluctuating quota. Even with proper management, reduced quotas, and fishery impact, the causes of the quota decline in current times are related to natural causes: recruitment of stock, predator stock size and the fishery system. Therefore, improving sustainability further cannot be solved in the biological department, as the quota will continue to follow the biological limitations. As for the possible impact of a management revision, it could have an effect on the accuracy of the stock management, but it will unlikely change the on/off situation and quota volumes. Capelin will likely always continue to fluctuate as it is a part of its nature and its history. Therefore, the sustainable management of the fluctuating Barents Sea capelin fishery is a difficult, but necessary task to maintain a healthy ecosystem.

7.1 Future research recommendations

For future research on this topic, the author of the study would recommend diving even deeper into the details of the capelin industry. As the governmental documents does not show the whole situation, a further cooperation and insight into the capelin fishing industry could provide different results. By finding the exact implications of an on/off fishery, a proper solution to the implications could be found. These details could in return give a higher profitability and better management.

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9. Appendix

Appendix A. NDF reference list

All NDF references. The following documents are used from the Norwegian Fisheries Directorate Regulatory meetings: https://www.fiskeridir.no/Yrkesfiske/Dokumenter/Reguleringsmoetet2

Date	Documents name	Reference
Nov,2021	Lodde I Barentshavet Vedlegg (ICES) Sametinget Nordland Fylkes Fiskarlag Pelagisk Forening Norges Kystfiskarlag Sjømat Norge Bivdu Referat	https://www.fiskeridir.no/Yrkesfiske/Dokumenter/Reguleringsmoetet2/November-2021
Nov, 2017	Lodde – Barentshavet Sametinget Norges fiskarlag	https://www.fiskeridir.no/Yrkesfiske/Dokumenter/Reguleringsmoetet2/November-2017

Nov, 2015	Lodde Kystfiskerlaget WWF Pelagisk forening Norges Fiskarlag Lodde - Barentshavet	https://www.fiskeridir.no/Yrkesfiske/Dokumenter/Reguleringsmoetet2/November-2016
Nov, 2014	Referat – del 2	https://fdir.brage.unit.no/fdir-xmlui/handle/11250/284053
Nov, 2013	Referat – del 2 Innspill	https://fdir.brage.unit.no/fdir-xmlui/handle/11250/224156
Nov, 2012	Referat fra reguleringsmøtet Innspill fra de ulike organisasjonene	https://fdir.brage.unit.no/fdir-xmlui/handle/11250/130161
Nov, 2011	Referat fra reguleringsmøtet Innspill fra de ulike organisasjonene	https://fdir.brage.unit.no/fdir-xmlui/handle/11250/130210
Nov, 2010	Referat fra reguleringsmøtet Innspill fra de ulike organisasjonene	https://fdir.brage.unit.no/fdir-xmlui/handle/11250/130219

Nov, 2009	Referat fra reguleringsmøtet Innspill fra de ulike organisasjonene	https://fdir.brage.unit.no/fdir-xmlui/handle/11250/130222
Nov, 2008	Referat fra reguleringsmøtet Innspill fra de ulike organisasjonene	https://fdir.brage.unit.no/fdir-xmlui/handle/11250/130216

Appendix B. Interview guides

Interview 1 – Fishmeal and oil industry representative (Respondent A)

The goal of this qualitative interview is to gain insight and understand the various implications and position the capelin industry has on the different stakeholders working with the resource. Question about the general thoughts of the capelin industry, as well as the future direction of the fishery is inquired from the participants. In this interview a member of the fishmeal and oil industry was interviewed to learn what their thoughts of the capelin industry were and possible implications.

Date of interview conducted: 13. January. 2022, 07:00-08:00.

Theme	**Interview questions**
Personal introduction	- Work position, responsibility, experience
General	- Introduction to the company - General impressions of the capelin and the industry - Thoughts on the future of the capelin fishery?

Product value	- What is the value of capelin as a resource versus other species? - What is the difference between oil and consumption? - How will the value of capelin used oil and fishmeal develop in the future?
Management	- What are your thoughts on the Barents Sea capelin quota today? - Would a stable delivery of capelin be more suitable than the current method?
Ecological	- Is there a large difference between summer and winter capelin? - Is there a large difference between male and female capelin?
Ending remarks	- Is there something you would like to add or something that is often overlooked in the industry?

Interview 2 – Caplin fisheries and management representative (Respondent B)
The goal of this qualitative interview is to gain insight and understand the various implications and position the capelin industry has on the different stakeholders working with the resource. Question about the general thoughts of the capelin industry, as well as the future direction of the fishery is inquired from the participants. In this interview a researcher working on capelin fisheries and management was interviewed to learn what their thoughts of the capelin industry were and its possible implications.

Date of interview conducted: 08. February. 2022, 14:30-15:30.

Theme	**Interview questions**
Personal introduction	- Work position, responsibility, experience
General	- Introduction to the company - General impressions of the capelin and the industry

	- Thoughts on the future of the capelin fishery? - Why is the capelin fishery so difficult to manage?
Management	- What are your thoughts on the Barents Sea capelin quota today? - Would a stable delivery of capelin be more suitable than the current method?
Ecological	- How are the ecological wellbeing of capelin monitored? - How is the stock now versus the last time the fishery opened? - Is there a large difference between summer and winter capelin? - Is there a large difference between male and female capelin?
Ending remarks	- Is there something you would like to add or something that is often overlooked in the industry?

Interview 3 – Caplin consumption industry representative (Respondent C)

The goal of this qualitative interview is to gain insight and understand the various implications and position the capelin industry has on the different stakeholders working with the resource. Question about the general thoughts of the capelin industry, as well as the future direction of the fishery is inquired from the participants. In this interview a person working with selling capelin for consumption was interviewed to learn what their thoughts of the capelin industry were and its possible implications.

Date of interview conducted: 25. February. 2022, 17:30-18:00.

Theme	**Interview questions**
Personal introduction	- Work position, responsibility, experience
General	- Introduction to the company

	- General impressions of the capelin and the industry - Thoughts on the future of the capelin fishery?
Product value	- What is the value of capelin as a resource versus other species? - What is the difference between oil and consumption? - How will the value of consumption capelin develop in the future?
Management	- What are your thoughts on the Barents Sea capelin quota today? - Would a stable delivery of capelin be more suitable than the current method?
Ecological	- Is there a large difference between summer and winter capelin? - Is there a large difference between male and female capelin?
Ending remarks	- Is there something you would like to add or something that is often overlooked in the industry?

Interview 4 – Caplin purse seiner representative (Respondent D)

The goal of this qualitative interview is to gain insight and understand the various implications and position the capelin industry has on the different stakeholders working with the resource. Question about the general thoughts of the capelin industry, as well as the future direction of the fishery is inquired from the participants. In this interview a fisherman working on a purse seiner was interviewed to learn what their thoughts of the capelin industry were and its possible implications.

Date of interview conducted: 09. March. 2022, 16:30-17:30.

Theme	**Interview questions**
Personal introduction	- Work position, responsibility, experience
General	- Introduction to the vessel - General impressions of the capelin and the industry - Thoughts on the future of the capelin fishery?
Product value	- How is the fishing in the Barents Sea capelin fishery versus other fisheries? - How will the value of consumption capelin develop in the future?
Management	- What are your thoughts on the Barents Sea capelin quota today? - Would a stable delivery of capelin be more suitable than the current method? - How is your experiences of the fishing season?
Ecological	- Is there a large difference between summer and winter capelin? - Is there a large difference between male and female capelin?
Ending remarks	- Is there something you would like to add or something that is often overlooked in the industry?