SYNNE VALLESTAD NONÅS AND KRISTINE OPØYEN BRATSETH
SUPERVISOR: RAGNAR TVETERÅS

Open Innovation and Knowledge Sharing

Towards a sustainable offshore aquaculture

Master Thesis, 2023
Master of Science in Business Administration
University of Stavanger Business School
Specialization: Business Development and Innovation

Synne V. Nonås – 9103
Kristine O. Bratseth - 9077

Abstract

This thesis explores knowledge sharing, open innovation, and skilled relatedness between two industries, the emerging offshore aquaculture industry, and the oil and gas industry. This research placed a significant emphasis on comparing these two industries using the theories presented in chapter two. To gather data for this thesis, a qualitative research method was utilized, which includes semi-structured interviews, a questionnaire, and a literature study.

The desire for sustainable development is a powerful motivator for consumer and company behavior, not to mention government mandates. According to the UN, the world´s food output must quadruple by 2050 to feed a rising population. The sea must provide a significant portion of the increasing food output. Aquaculture has been singled out as essential to enhancing the world´s food output.

Offshore aquaculture is an innovative method of fish production. Although this method has been researched for a while, we have never been as close to a functioning aquaculture operation at sea as we are now. Compared to the initial fish farming on land or near the shore, offshore aquaculture has presented additional difficulties. The physical environment will be different for offshore aquaculture compared to inshore aquaculture. Despite the distinct physical and climatic circumstances, many of the biological obstacles of offshore aquaculture will still be similar to those of traditional coastal fish farming, including today's well-known problems like lice, illness, and fish welfare. Offshore aquaculture developers were obliged to change their approach due to these challenges. Knowledge sharing, skilled relatedness, open innovation and spillovers from the oil and gas industry might all be advantageous for the growing offshore aquaculture industry.

Preface

For the past two years, we have studied our master´s degree in Business Administration at the Business School at the University of Stavanger (UiS). During our master´s study we have specialized ourselves in *Business Development and Innovation.* The process has been challenging and educational, but we will both remember this time with pleasure.

We would like to express great gratitude to our supervisor Ragnar Tveterås, professor at the Department of Innovation, Management, and Marketing. We wanted to write about innovation within the aquaculture industry, an important and growing industry. Within aquaculture, our supervisor Ragnar Tveterås has a lot of insight and exceptionally good knowledge. This was a huge benefit for us as he shared his knowledge of the aquaculture industry. Through good advice and feedback, we are left with positive experiences and a thesis we can be proud of. We would also like to thank our interviewees for insightful input and valuable information.

Finally, we would like to thank our family and friends for the great support and motivation they have given us throughout this process. Now we are looking forward to new experiences.

June 15th, 2023, Stavanger

Synne Vallestad Nonås

Kristine Opøyen Bratseth

Table of content

FIGURE LIST

TABLE LIST

PICTURE LIST

1. Introduction

1.1 Background for this master thesis

The sea contributes to the majority of Norwegian economic value creation. The oil and gas industry, aquaculture, shipping, and fisheries all have a long history of utilizing the natural resources from our shore. The industries are significant for settlement patterns, lifestyles, and the Norwegian identity in addition to the economy, employment, and the value production. With an increasing global population comes a greater demand for food, particularly nutrient-dense food. Although the potential is significant, we currently only use 3% of the food that comes from the sea worldwide (Tveterås, R., et al., 2020). Due to the low possibility of fisheries to improve their production, other possibilities must be considered, such as offshore aquaculture. Offshore Aquaculture is defined as aquaculture in offshore- and outer sea areas. That is, areas that lie outside the plan and scope of the Building Act, and at least 20 nautical miles outside the baseline, and areas that lie further from the coast, but within the Norwegian economic zone (University of Stavanger, 2022). The subject of this thesis will be the project of establishing a sustainable offshore aquaculture industry in Norway. The development of offshore aquaculture will be referred to as the project in the following sections of this thesis.

There are many challenges with a project of this kind. We will primarily concentrate on the cooperation challenges between all the many industries that have contributed to or attended in order to attain the same goal, which will increase the utilization of the sea and result in more sustainable solutions. One of the significant issues in this context is knowledge transfer, which is primary caused by enterprises operating in the same industry and the rivalry that exists between them. For development and value generation throughout the whole coast, aquaculture is an industry of vital importance. New enterprises in offshore aquaculture should be able to have a specific geographic spread as the industry continues to expand. This necessitates that there is access to essential knowledge in every location along the coast, as well as adequately functioning local industry ecosystems (Regjeringen, 2018).

Overlapping of knowledge, skilled relatedness and innovative solutions plays a significant role in execution of a sustainable offshore aquaculture. For this to be possible, collaboration is an essential factor. Through collaboration, between people and industries, we can benefit from the abilities and expertise of others to help improve technology, equipment, installations, environmental factors, and innovation processes. If the collaboration between the aquaculture

– and oil and gas industry is successful, this will increase the possibilities a sustainable offshore aquaculture.

1.2 Research question

In order to extract more from the sea in the future, we depend on offshore aquaculture, which requires close collaboration between a number of industries and businesses. As a result, we have decided to concentrate on the research question:

The roles of open innovation and knowledge sharing on the path to sustainable offshore aquaculture?

We have included a research statement in our thesis to support our research question.

To what extent will advantages and disadvantages of knowledge sharing and innovation influence offshore aquaculture.

1.3 Structure of this thesis

This thesis is divided into six chapters. The first chapter introduces our topic and provides some insights into the objective of this research. This chapter also describes the context of our research and motivation and presents the research question. The second chapter outlines the theoretical foundation for the innovation challenges in offshore aquaculture. In this chapter, we will offer a variety of theories, and they will be described in more detail. In chapter three, we will present the methodical options based on the qualitative data acquired.

Chapter four will present the project Green Platform (Norwegian: Grønn Plattform), and collaborations within this project. This chapter will also include a description of today´s method of fish farming, inshore fish farming, and offshore aquaculture. Chapter five consist of an analysis and discussion of our findings and the relevant theories presented in chapter two, also including an interview and questionnaire. Lastly, chapter six will offer a conclusion to our results, addressing our research question.

2. Theory

This chapter presents theories and concepts that will be employed in our empirical research. These theories are knowledge sharing, business clusters, skilled relatedness, open innovation, and collaboration. Because of their many connections, these theories are crucial to answering our research question. We introduce various influencing factors in the final section of the theory chapter to help us understand the advantages and disadvantages of the research statement.

This thesis will focus on the innovation processes within the offshore aquaculture industry. We will look at knowledge sharing and collaboration on an individual level. This is mainly because knowledge resides on an individual level within an organization. In contrast, knowledge is shared individually within an organization through collaboration. The theories: industry clusters, skilled relatedness and open innovation are at an organizational level. This industry includes R&D institutes, and both private- and public industries.

2.1 Knowledge sharing and knowledge management

It is essential to distinguish between knowledge management and knowledge sharing. The phrase "knowledge management" refers to a broad industry in which the main activities include sharing, inventing, reusing, cooperating, and learning. Knowledge sharing is one of five core tasks. However, knowledge management does not start until something is reused. Knowledge management aims to improve decision-making processes, encourage the reuse of intellectual property, and drive innovation (Leader to Leader, 2021). Knowledge sharing happens through a dynamic learning process in which businesses constantly engage with clients and suppliers to innovate or subtly imitate (Kim & Nelson, 2000).

2.1.1 Knowledge

“Knowledge is a familiarity, awareness, or understanding of someone or something, such as facts, information, descriptions, or skills, which is acquired through experience or education by perceiving, discovering, or learning”, (Librarianship studies, 2017, p.1). It is crucial to recognize the difference between knowledge and skills. Knowledge is something you passively have in your brain, while skills are something you actively use.

Knowledge distinguishes between tacit knowledge and explicit knowledge. Explicit knowledge is information available in the simplest basic form and is transferable. This is because such information is recorded and made available in written form, where it may be read, accessed, and interpreted by anybody. It is the knowledge that has been written down or recorded to make it easier to decide. Explicit knowledge should ideally be intended for reuse. As the name indicates, tacit knowledge is the information a person has gained via personal experience, insights, emotions, observations, and situations. It is kept in the knower's highly individualized and specialized thinking. Furthermore, cognitive processes play a role in it is acquisition. Such knowledge is challenging to describe, record, transmit, or measure (Surbhi, 2020).

2.1.2 Knowledge management

A variety of methods and approaches are used in knowledge management to maximize an organization's tactics and formalized expertise (Teece, 2000). Although it has multiple definitions, knowledge management typically relates to how businesses produce, retain, and distribute knowledge (Argote, 2012).

Stan Garfield distinguishes between knowledge management and knowledge sharing in the article *Organizational Innovation and knowledge management (2021),* stating, "Knowledge management is the term applied to the broad field in which the key activities are sharing, innovating, reusing, collaborating, and learning. One of the five core tasks is information sharing; however, knowledge management doesn't start until something is reused. Knowledge management aims to promote the reuse of intellectual property, facilitate improved decision-making, and drive innovation" (Leader to Leader, 2021, p.1).

Klaus North et al. (2004) researched the benefits of knowledge management. They claim that knowledge management is a fleeting trend in management that has little to no impact on business performance. Others contend that knowledge management initiatives may well have positive effects if the proper steps are taken to carry them out. One part of knowledge management that has existed from the start is knowledge sharing. Peer discussions among coworkers on the job, formal apprenticeships, corporate libraries, professional training, and mentoring programs are a few examples (Giftson, T., 2017).

2.1.3 Knowledge sharing

The definition of knowledge sharing can be based on the employee´s willingness to share their knowledge, such as experience and expertise, with their coworkers. That includes not just verbal knowledge but also written knowledge such as reports, templates, and documents (Nonaka, 1994). One of the most important management research topics now, both in commercial and public organizations, is information sharing (Serenko & Bontis, 2016). Knowledge sharing is the act of making information accessible to others. Transferring organizational knowledge and expertise to business processes through interpersonal contact is known as knowledge sharing in a broader sense (Serenko & Botnis, 2016). According to Darroch and McNaughton (2002), a company that supports knowledge sharing is more likely to generate fresh ideas and support creative skills.

2.1.4 The use of shared and distributed knowledge

Shared and distributed knowledge are concepts that relate to how information and expertise are shared and spread across groups of people or systems. Shared knowledge refers to the knowledge that is shared by individuals within a group or community. This can take many forms, such as conversations, presentations, documents, or other forms of communication (Hershkowitz, R. et al., 2007). Shared knowledge is essential because it allows individuals to build on the knowledge and experience of others, which can lead to more significant innovation and better decision-making (Romero, H. et al., 2021)

Distributed knowledge refers to the knowledge that is spread across different individuals or systems. This can include knowledge spread across various departments or teams within an organization or even across different organizations or communities (Fagin, R., et al., 2004). Distributed knowledge is essential because it can lead to greater collaboration and cooperation among individuals or systems, leading to more efficient and effective problem-solving (Smith, K., 2002).

In both cases, the sharing and distribution of knowledge are essential for enabling individuals and systems to learn from one another and work together to achieve common goals. Technology and digital platforms have made it easier than ever to share and distribute knowledge, which can be especially important for organizations and communities that operate across different geographic locations or time zones (Olaisen & Revang, 2017).

2.2 Business Cluster

In Norway, the phrase "business clusters" gained popularity in the 1990s (Kyst.no, 2018). A group of large and small information-based businesses, that interact and develop via substantial knowledge exchange and cooperation is known as a business cluster (Reve & Hagesæther, 2018). According to Porter (1990), clusters foster economic growth, contribute to a high level of specialized knowledge, and speed up the rate of innovation. This is due to the concentration of technological and commercial expertise found in business clusters. When establishing a complete industry cluster, specific participants and input elements are required (Reve & Hagesæther, 2018).

Several substantial research initiatives were conducted with the goal of identifying the Norwegian business clusters, with Michael E. Porter and his book "The Competitive Advantage of Nations" serving as the main inspiration (Kyst.no, 2018). The establishment of the business cluster marked a turning point in terms of company development (Porter, 1990). Industrial agglomerations, which Alfred Marshall, a classical economist, first introduced in 1890, provided the development of business clusters. Co-located businesses get access to a shared, specialized labor market, fewer transportation costs, and an unwritten industry knowledge (Reve & Sasson, 2012).

An American economist, Paul Krugman made a theoretical contribution to our understanding of business clusters (Reve & Sasson, 2012). The idea emphasizes the beneficial knowledge-based externalities associated with company clusters, i.e., how co-located businesses benefit from one another´s expertise in various ways, both through the labor and knowledge markets. The companies may create a shared infrastructure simultaneously, cutting expenses. Co-location provides businesses with considerable geographic advantages. Cluster research has developed in recent years to emphasize more on knowledge-based and innovative approaches (Reve & Sasson, 2012).

Natural resources and expertise continue to play a significant role in Norway´s business development and economic growth. The abundance of nature and energy resources gives Norway a competitive advantage over several other countries. In 2010, Jens Stoltenberg said in his new year's speech, "It is work and competence that we will live on in the future" (Reve & Sasson, p.19). In the project "Et kunnskapsbasert Norge" (Eng.: "A knowledge-based

Norway”), written by Torger Reve and Amir Sasson, they began with four principles that the business environment of the future must be capable of upholding. The businesses need to be: 1) client-driven; 2) knowledge-based; 3) international; and 4) environmentally robust. It is natural to focus on number 2 regarding this thesis. Knowledge-based, implies that the businesses´ goods and services, as well as the manufacturing process itself, must be highly knowledgeable. The production and delivery of knowledge content are subject to strict requirements, and knowledge-based services are becoming increasingly important. Reve and Sasson (2012) claims that there are three different types of knowledge and the combination of these are essential: technical, commercial, and experience based.

2.3 Skilled relatedness

According to the relatedness principle (Hidalgo, C.A., et al., 2018, p 453), “we say that two activities, such as products, industries or research areas are related when they require similar knowledge or inputs.” The degree to which skills are related to one another, or how closely they resemble one another, is known as skilled relatedness. Frank Neffke and Martin Henning (2013) examine skill linkages that exist among industries in their article “Skill relatedness and firm diversification.” They contend that skills acquired in one industry may frequently be transferred to another. A company will probably concentrate its diversification efforts in fields that call for expertise currently held by its employees (Neffke, F. and Henning, M., 2013).

According to Neffke and Henning’s (2013) theory, trends in labor flows and business diversification indicate a latent structure that links various economic activities (i.e., industries) together through their skill-relatedness. The same research has shown that the relatedness of economic activities affects a variety of corporate strategy issues, including alliance formation, corporate diversification, make-or-buy decisions, the relationship between the coherence of an organization’s portfolio of activities and it is long-term performance, and strategies for dealing with information asymmetries in corporate takeovers. The concept of relatedness and the techniques for calculating relatedness are sometimes unexpectedly ill-defined. There must be as many aspects to relatedness as there are different kinds of resources. If relatedness is defined as the similarities among the resources utilized in different businesses, this becomes a severe problem (Neffke, F. and Henning, M., 2013).

2.4 Open innovation

Open innovation is a decentralized and collaborative method of developing new ideas involving outside sources of information and skills, including partners, customers, and rival companies. It represents a change from the conventional closed innovation model where businesses only use internal resources to create new goods and services (Ollila & Yström, 2017). The term "open innovation" was first introduced by Henry Chesbrough in his book "Open Innovation: The New Imperative for Creating and Profiting from Technology" in 2003. Since then, open innovation has gained popularity and has been widely adopted by companies of all sizes and industries (Chesbrought, 2003).

Crowdsourcing, partnerships, and strategic alliances are just a few examples of the many shapes that open innovation can take. It can be used in any industry, not only within technology, healthcare, education, and financial industries. The ability for businesses to draw from a bigger pool of ideas and expertise, which fosters enhanced creativity and innovation, is one of the main advantages of open innovation. Furthermore, it can assist businesses in lowering research and development (R&D) expenses, accelerating time to market, and raising the general caliber of their goods and services (Gassmann & Enkel, 2004).

2.4.1 Sustainable open innovation

Sustainable open innovation is the process of developing anything that is, in some manner, economically feasible, socially responsible, and environmentally benign. This strategy entails working with external partners, such as clients, suppliers, and other stakeholders, to generate fresh concepts and provide cutting-edge responses to business difficulties (Bigliardi & Filippelli, 2022). Sustainable open innovation has gained popularity in recent years as companies seek to address growing concerns about environmental and social sustainability, and as the need to create value for customers and shareholders. By adopting a sustainable open innovation approach, companies can leverage the expertise and resources of external partners to develop innovative solutions that are both profitable and environmentally responsible (Harsanto, et al., 2022). Several frameworks and models have proposed to help companies implement sustainable open innovation, including the Sustainable Open Innovation Framework (SOIF) proposed by Huizingh et al. (2018) and the Sustainability-Oriented Open Innovation (SOOI) model proposed by Bi et al. (2021).

2.5 Collaboration

Collaboration is cooperating with others to achieve a shared goal or objective. Team members must cooperate, communicate, and collaborate (Hinds & Bailey, 2003). While collaborative learning is defined as “a situation in which two or more people learn or attempt to learn something together,” and more specifically, as joint problem solving (Dillenbourg, 1999, p.1).

According to Keegan and Turner´s (2021) study, several job and personal variables favorably relate to employability success. Because businesses involved in projects constantly need to learn new skills, it is critical that both the companies and those working for them are eager to collaborate and grow. Research has also shown that the need to perform and one's capacity or willingness to act are two different problems. The motivation to learn differs for project-based firms depending on various variables, such as how volatile the product/market domain is, where technological change is occurs, and how innovative or conservative the firm is. Even though businesses do not react similarly, adaptability in the face of variation in the quantity and quality of projects is crucial for longevity and success in a project-based company (Keegan & Turner, 2021).

According to Keegan and Turner's (2021) results, organizational focus, and power significantly impact how variety, selection, and retention balances organizational learning, with retention receiving the lion's share of weight in the number of initiatives. They concluded that the research reveals several obstacles to corporate learning, particularly exploratory learning. These include the propensity to centralize learning, a shortage of time and space for introspection at the project team level, and the postponement of learning to a later moment in time and space.

Social identity theory suggests that individuals derive part of their self-concept from membership in social groups. In the context of collaboration, this theory suggests that team members may identify with and feel a sense of loyalty to their team, which can enhance collaboration and improve team outcomes (Tajfel & Turner, 1979).

2.6 Influencing factors

Influencing factors are variables or circumstances that have an impact on how a certain process, system, or choice turns out. They might be internal or external, and they are crucial in determining how particular actions turn out (Dietrich, 2010). Several variables can significantly impact whether a project succeeds or fails. Understanding and being aware of these factors is essential because they might affect the result, costs, and time.

2.6.1 Coordination and recruitment

Several variables must be considered while creating and recruiting an effective project team. People have various perspectives, and not everyone works with others in the best way, which needs to be considered while assembling the best team. Knowledge sharing between project teams has been examined in research as an example of knowledge that crosses organizational unit boundaries. This form of knowledge exchange is important since the outcomes achieved by the teams, as well as the expertise gained through managing and managing projects, are beneficial to both the organization and subsequent projects (Rosness, R., Nesheim, T., & Tinmannsvik, R. K., 2013, p.44).

2.6.2 Management and control

Most of today's organizations have an information system that gives their employees a way to communicate and access information. In Ekambaram's (2008, p.2) Ph.D., he explains that knowledge transfer can help to decrease or eliminate having to "reinvent the wheel". Knowledge transfer happens through formal and informal systems. Traditional systems include things such as documentation or a knowledge database, whereas informal systems include, among other things, discussions during coffee breaks or social gatherings. Ekambaram´s study shows that most management prioritizes traditional systems, which is challenging. This could be improved, but traditional systems are not always user-friendly in certain circumstances.

The base organization is an ongoing organizational structure that, among other things, provides systems and staff for the initiatives. The fundamental structure of the enterprise in which managers continue operations. The business unit that started the project and gave it a purpose. Although management at base organizations invested more in formal system implementation, project participants depended more on the informal procedures and interaction channels

(Ekambaram, 2008). Ekambaram´s (2008) study indicate that utilizing informal systems has a significant potential for knowledge transfer. Organizational management could place a greater emphasis on the use of informal mechanisms to facilitate knowledge transfer. Ekambaram believes that social components of companies may handle or arrange so that knowledge transfer becomes a deliberate, integrated part of initiatives. This does not imply that everything must be formalized and structured. However, one might endeavor to create the circumstances for knowledge transmission.

2.6.3 Motivation

According to Stenmark (2000), motivation drives us to do something. People are unlikely to share information without sufficient personal motives. We distinguish between internal and external motivation in this current dissertation. In this thesis, external motivation defined as the source of incentive being outside the activity, such as a bonus or commodities. Internal motivation refers to the source of motivation that exists within the activity. Regarding knowledge transfer, the external motivation to share is the rewards received from sharing knowledge.

The reward for sharing knowledge

Individuals' actual and perceived benefits and consequences for sharing and not sharing knowledge also effect on the knowledge sharing process. Incentives have found to have a substantial impact on knowledge sharing, particularly in organizations that use technology-based platforms (Ipe, 2003). According to Ipe (2003), there is a link between various types of knowledge sharing and monetary compensation systems. Individual contributions to databases, formal interactions inside and across teams, knowledge sharing across work units, and information sharing through informal encounters recognized as four processes of knowledge sharing. In the first three mechanisms, Ipe proposes that monetary incentives may encourage information sharing. In contrast, informal knowledge sharing would reward by intangible incentives such as increasing people´s competence and recognition.

Mutual benefit as motivation

The mutual benefit of sharing knowledge and skills can also motivate people. Sharing knowledge and skills, such as problem-solving, benefits the organization. Company members can use a solution that an employee has devised for a problem if it proves to be the best one in the end (Lam, A., & Lambermont-Ford, J. P., 2010). Knowledge sharing and skill-relatedness will also benefit the employees by enabling better and faster decision-making and stimulating innovation and growth. Organizations may capture explicit and tacit knowledge through knowledge sharing, which can eventually help them stop huge losses (Stevens, R. H. et al., 2010).

The relationship with the recipient as motivation

The relationship between the sender and the recipient is one of the external elements that affects the desire to impart knowledge. Trust and the recipient's power and status are two essential components of the relationship with the recipient (Abzari, M. and Teimouri, H., 2008). According to Bartlett and Ghoshal (1994), one of the four main dimensions in organizations that affects people's behavior is trust. The importance of perceived trustworthiness to knowledge sharing in organizations is further reinforced by Andrews and Delahaye (2000), who found that the role of trust was central to the way individuals shared knowledge. Their research showed that formal knowledge sharing procedures were insufficient to encourage people to share their knowledge with others in the same working environment when there was a lack of trust. High levels of competition make environments where knowledge sharing is problematic due to trust-related problems even more likely (Andrews, K.M. and Delahaye, B.L, 2000).

2.6.4 Opportunities

Opportunities are one influencing factor that could offer a competitive edge to an organization (Kenton, W., 2023). This chapter will discuss the different organization capability to share and transfer knowledge in the project for the best outcome and some strategies to achieve this.

1. Use communication and collaboration-enhancing technological platform:

Any business or group must effectively communicate and share information to succeed. This ensures that everyone is communicating effectively and that no crucial details are overlooked or misconstrued. Clarity, conciseness, and completeness are attributes of effective communication, according to Scott DeRue, et al. (2011). Additionally, it needs to be courteous, suitable, and timely.

Organizations may enhance communication and information exchange in several ways. Utilizing a range of communication methods, including social media, in-person meetings, and email, is an essential tactic. This guarantees that all people have access to the same information and enables information to reach a large audience. Developing explicit rules for information exchange is another crucial tactic. This can entail creating a hierarchy of information, reserving information for particular people or groups, and laying down precise rules for when and how information should be shared (Postolache, A., 2017).

The most pressing issue from an organizational perspective is sustaining links between people with diverse areas of knowledge and people with the same area of competence, as in a project (Verteramo & De Carolis, 2009). Several online platforms can help people with different backgrounds and areas of expertise work together, communicate, and share information, such as Teams, Workplace (Facebook), Skype, etc. Finally, fostering an environment of openness and trust inside the company is critical. This may be accomplished by encouraging staff to ask questions and offer feedback and by having open and honest communication.

2. Encourage and reward knowledge sharing:

Building and maintaining connections between individuals with various fields of knowledge and skill relies on encouraging and supporting knowledge sharing. Ensuring team members have access to the necessary knowledge, skills, and resources is essential. When encouraging the transmission of knowledge, regular team meeting, training session, and workshops might be planed. When people are motivated, knowledge exchange is more likely to happen. If the information shared is unreliable, participants risk losing their special insights or reputation. The intention to share knowledge will decrease if there are no rewards to offset individuals' costs (Chang & Chuang, 2011).

Bartol & Srivastava (2002) identified some reasons for a person not to share knowledge. The four different reasons are:

- Fear of losing superiority arising due to ownership of the knowledge
- Perception of not being adequately rewarded for a knowledge sharing action

- Lack of time and resources to share knowledge
- Lack of trust associated with inferiority and superiority complexes that are usually prevalent as a result of cultural and racial ranges

3. Encourage an environment of open communication:

According to Henri Tajfel and John Turner (1979), the social identity theory clarifies how membership in a group influences a person's behavior. Respecting the other person´s identity and communicating in a way that considers and values their point of view are both essential components of open communication. Open communication is key to building and sustaining relationships, trust, and collaboration. This will ensure that each team member's contribution and ideas are recognized and promote open communication among the team members. This is done by fostering an atmosphere where people feel comfortable speaking openly and safely about their ideas.

4. Create a project plan that is precise and clear:

The Project Management Body of Knowledge (PMBOK) is a comprehensive framework created by the Project Management Institute (PMI) that offers rules, best practices, and standard terminology for project management. Five project management process groups—initiating, planning, executing, monitoring, controlling, and closing listed in the PMBOK. The planning process group is particularly pertinent to project planning because it entails generating a Work Breakdown Structure (WBS) to list all the tasks necessary to finish the project, developing a project management strategy, and defining the project's scope (Edition, P. S., 2018).

Creating a project plan involves defining the project´s scope, setting goals and objectives, and identifying tasks and resources required to complete the project. Creating a clear and simple project plan is necessary for everyone to understand their roles and responsibilities. This can help avoid miscommunications and guarantee that everyone is strives for the same result (Lutkevich, B, 2021).

2.6.5 Culture

The culture in a project refers to the shared values, beliefs, and norms that influence how team members interact and work together (Cameron, 1988). It can have a significant impact on project success and team morale.

Organizational culture

According to Schein (1990), culture is a "pattern of basic assumptions" (p.7) that a community creates as they work through and come up with answers to common issues. When these presumptions are proven to be accurate and reliable, new members are instructed to use them as the best strategy for solving these issues. Schein continued by expressing that a fundamental component of every culture is a set of presumptions about how to discern the truth or learn about it, as well as how members of a group act, how they discern what is relevant information, and when they have enough of it, to determine whether to act or what to do. As a result, culture represented in the organization's values, norms, and practices, whereas values expressed in norms that, in turn, influence certain activities (De Long & Fahey, 2000).

Knowledge sharing

Research has demonstrated that even the finest knowledge exchange strategies are insufficient. It must be based on a solid foundation and supported by all essential enablers that will reduce barriers to information sharing, such as inadequate organizational structures and a lack of sharing-friendly organizational cultures (Davenport & Prusak, 1998). The organizational culture, which serves as the overarching framework, must be conducive to utilizing other crucial success elements for information sharing. The key success components, as modified from Ismail AL-Alawi, et al., (2007), include communication, trust, Information Communication Technologies (ICT), and rewarding people for knowledge sharing.

Trust

Trust is essential to the sharing, spreading, and using of information (Dube & Ngulube, 2012). The use of socialization techniques builds teammate trust and gives partners more time, opportunity, and drive to deepen and expand their relationship. It has been shown to have a favorable impact on interactions in relationships, especially when it comes to conveying cultural norms, enhancing communication, and fostering trust (Lawson et al., 2009).

According to the Social Penetration Theory (Altman, I., & Taylor, D., 1973) self-disclosure, or the act of sharing private information about oneself to others, is a necessary component of open communication. People’s relationships grow stronger, and their trust and understanding increases when they divulge more private and sensitive information. Irwin Altman and Dalmas Taylor first proposed this theory in 1973.

3. Methodology

This chapter will outline the process and data requirements for choosing a qualitative approach. It will present a comprehensive and logical framework that will eventually lead to an empirical solution to our research question. The research technique will determine the specific analyses used to construct this thesis. This thesis makes use of a qualitative research method by using semi-structured interviews, a questionnaire, and a literature study. By utilizing these methods in the light of skilled relatedness, knowledge sharing and open innovation we will hopefully find an answer to our research question.

This chapter is structured as follows: starting with an explanation of the research method, followed by some opportunities and challenges with the chosen method. The following section includes a description of the sample and data, which we have extracted from an electronic questionnaire and semi-structured interviews. In the last part of chapter three, the SECI model will be defined.

3.1 Qualitative research method

There are two primary categories of research methodology: qualitative and quantitative. The qualitative research method is recognized as one that produces and uses of non-numerical data. Qualitative research is defined as implementing various methods to examine the perspectives and connections of the participants. The basis of quantitative research is the idea that the subject of the study may be quantified through numerical data that can be processed through statistical analysis (Mcleod, 2023).

3.1.1 Opportunities with chosen method

The research method utilized in this thesis is qualitative research. This method refers to a broad category of research methodologies lacking statistical methods or quantification that depict and clarify people´s experiences, behaviors, interactions, and social circumstances (Fossey, E., et al., 2002). It tries to address how people perceive their own experiences. According to Dörnyei (2007), qualitative research "focuses on describing, understanding, and clarifying a human experience, and therefore qualitative studies are directed are describing the aspects that make up an idiosyncratic experience rather than determining the most likely, or mean, experience, within a group." (p.126). As a result, the sampling size is smaller and may not accurately reflect a substantial portion of the population, as may be the case with quantitative data.

We decided that a qualitative research approach would be best for this research since it would allow for the inclusion of any crucial follow-up questions. In contrast to a quantitative research approach, where the researcher would not always be able to develop trust and empathy with the participants, it also allowed for more genuine replies (Melles, 2005). Green Platform (Norwegian: Grønn Plattform) is a startup project with limited available data. This project has encountered challenges because of their difficulties obtaining development licenses. Therefore, we decided that the most beneficial way to collect data was through a qualitative research method.

3.1.2 Challenges with chosen method

In contrast to quantitative research, qualitative research frequently focuses on particular situations and employs lower sample numbers. Due to this, it makes it difficult to extrapolate the results to a broader population (Guest, G., et. al., 2006). Our electronic questionnaire was sent to students at the University in Stavanger (UiS). It pertains to a particular group of people, primarily students. This indicates that a small sample of people have responded to the survey. Most are probably in the same age group, which also reduces the representativeness of our findings. An interviewee's answers to a question tend to be based on personal experience. This implies that the data obtained from an interview must be evaluated considering their own experience.

A qualitative research method might be time-consuming and resource-intensive (Elliott & Timulak, 2005). The process requires a lot of time and attention to detail to gather data using techniques including interviews, observations, and document analysis (Creswell & Poth, 2016).

3.2 Sample and Data

In response to the research question, a qualitative method was used to consider how knowledge sharing and skilled relatedness between two industries could lead to success. This includes two methods for data collection: 1) an anonymous electronic questionnaire and 2) semi-structured interviews with two distinct individuals. The first individual has experience in both industries, both the oil and gas- and aquaculture industries. The second individual is employed by a company with several fish farm facilities in Vestland- and Rogaland County.

3.2.1 Electronic Questionnaire

The research question was addressed through an electronic questionnaire explicitly created for this research in April 2023. We were advised to encourage as many individuals as possible to respond to the questionnaire to obtain the most accurate representation of the experience. We sampled data from 53 respondents between the ages of 20 to 50+. Different data were then extracted from the electronic questionnaire in an Excel file. The respondents were made aware of the objective of this research, that the data gathered would only be used for this research, and that they could raise any questions to us regarding the questionnaire. All respondents to the questionnaire were anonymous. The only personal information we gathered was age. After the questionnaire´s due date, a completely anonymized data file was made available for our further analysis.

The reason for choosing a self-completion electronic questionnaire to collect qualitative information is that a questionnaire makes it possible to collect responses quickly and affordably from many people (Mcleod, 2023). Additionally, a questionnaire is a cheap way to reach tens, hundreds, or thousands of respondents using a form. This electronic questionnaire was set up through the Microsoft app named “Forms”. This questionnaire's aimed to figure out if the respondents felt there were any synergies between the oil and gas industry and the offshore aquaculture industry. And in the case of yes, which synergies?

The questionnaire was developed based on the theory we gathered for this thesis. When we made the questions, we decided we should strive for simplicity in the questions, with them being short, concluding sentences. In Appendix 1 we have listed our questions and response options for some of them.

3.2.2 Semi-Structured Interviews

A structured interview is an assessment method used to gather and evaluate interviewee responses. The interviewee is questioned about prior encounters and/or suggested fictitious situations. High response rates are typical for semi-structured interviews, and the interviewer is present to explain to prevent respondents from misinterpreting the question. The interviewee´s viewpoint may also have an impact on the interviews. But it can take time to get ready for a semi-structured interview. Additionally, if throughout the interview, new directions of research sound interesting to explore, they are not given the same flexibility in the choice of predefined answers that are fixed and cannot be modified by the researcher (Queirós, et al., 2017).

In the interview process, we spoke to people working in different industries. The information that emerges during the interview is based on personal knowledge, impressions, and opinions. We have spoken to an engineer with a long education and a lot of experience in the offshore industry and a fish health biologist in education who also has experience working in fish farming. In Appendix 5 we have presented the general interview guide we have followed during the interviews. Due to personnel consideration, this guide is not filled out.

3.2.3 Literature study

We have utilized a traditional literature study as a method for summarizing already existing literature, and research that can help us answering our research question. The purpose of this method is to gain a broad understanding and overview of the subjects (NTNU Undervisning, 2018). This method involves reviewing and collecting previous research and literature in the field that we wish to examine in more detail. Since previous research is used, no new knowledge emerges, but it can still create a whole in the form of connections, insights, and other perspectives (Aveyard, 2010).

The method of literature study has both advantages and disadvantages. The advantages are that you can easily find a large amount of data and literature and acquire additional information about the subject. Throughout the work, one can quickly return to the sources. Disadvantages include a limited amount of relevant research and inability to find what you are looking for (NTNU Undervisning, 2018).

3.3 SECI-model

The SECI model is a knowledge management framework first introduced by Ikujiro Nonaka and Hirotaka Takeuchi (1995) in their book "The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation." The SECI model is an abbreviation for Socialization, Externalization, Combination, and Internalization, and it explains how knowledge is created and shared within organizations. This model is predicated on the notion that tacit and explicit knowledge continuously interact to generate and share knowledge. Tacit knowledge is difficult to articulate or codify, whereas explicit knowledge can be easily documented and transferred. According to the SECI model, knowledge is created through a four-step process:

Socialization: This is the process of sharing tacit knowledge through direct interaction between individuals. It involves creating a shared context and understanding through social interactions, such as observation, imitation, and joint activities.

Externalization: This is the process of converting tacit knowledge into explicit knowledge. It involves articulating and codifying tacit knowledge in a form that can be easily shared and communicated.

Combination: This is the process of combining different pieces of explicit knowledge to create new knowledge. It involves synthesizing and integrating explicit knowledge from various sources to create new insights and understandings.

Internalization: This is the process of embedding new knowledge into individuals' tacit knowledge. It involves applying and internalizing new knowledge through direct experience and practice.

The SECI model has been widely adopted by organizations as a framework for managing knowledge and promoting innovation. It has been applied in various contexts, including product development, customer service, and organizational learning. The model emphasizes the importance of social interactions and knowledge sharing in creating new knowledge and fostering innovation, looking at Figure 1. The spiral illustrates how this process is perpetual (Nonaka, I. & Takeuchi, H., 1995).

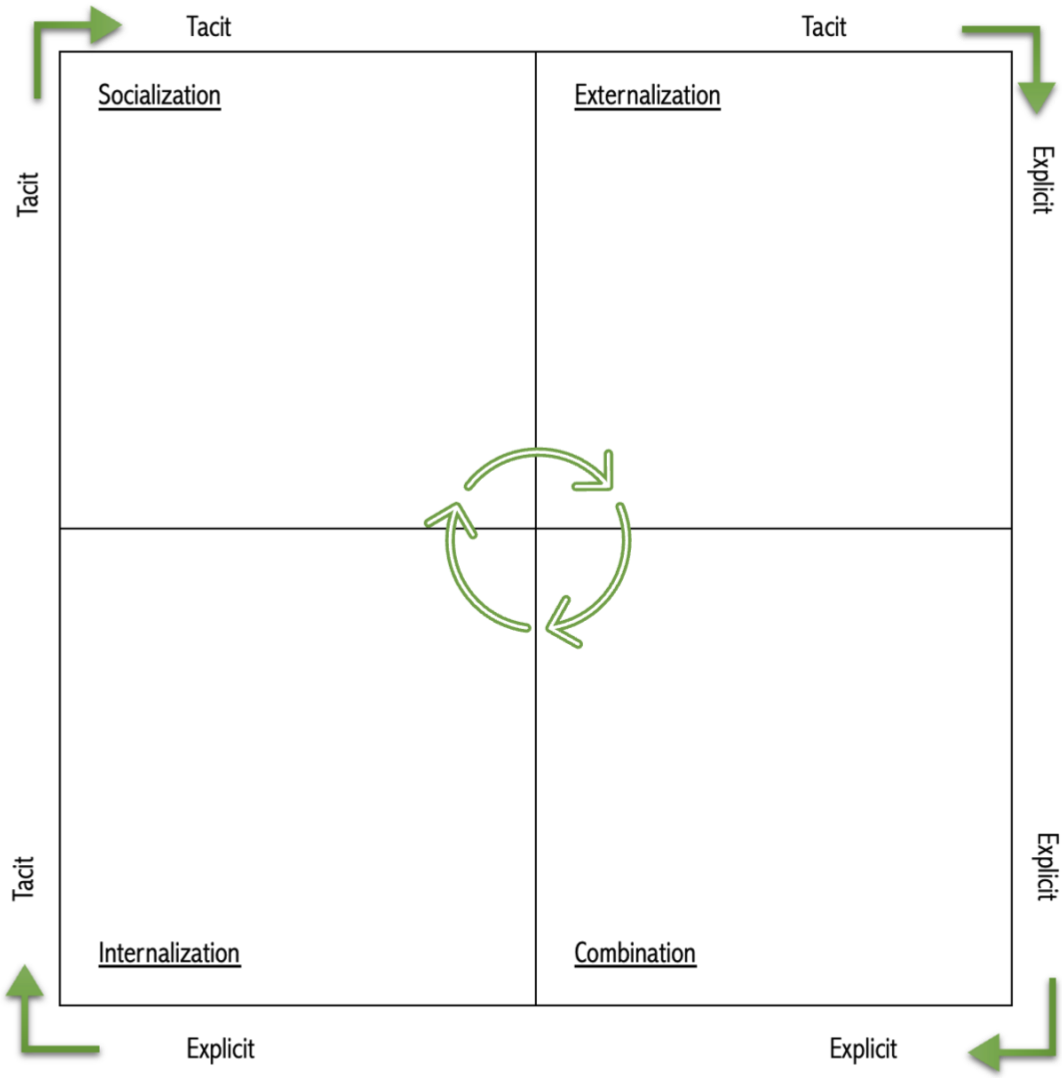


Figure 1 - SECI-Model (Nonaka, I. & Takeuchi, H, 1995)

4. From Inshore to Offshore Aquaculture

In this chapter we will outline the current state within fish farming, which is inshore aquaculture. Inshore aquaculture faces several difficulties, which has led to innovative thinking about a new sustainable aquaculture offshore.

Salmon harvest has stagnated, fish are escaping, there are issues with salmon lice, and there is a shortage of land, which has forced both the government and the aquaculture business to reconsider their strategies (Regjeringen, 2018). As a result, new laws, new licensing procedures, and several innovative ideas for marine farming exist. A few of the farming industries' tendencies include the relocation of fish farms to more exposed areas, and the discharge of larger fish than in the past.

4.1 Inshore Aquaculture

The aquaculture industry consists of companies that impact organisms in seawater or freshwater before they are harvested or caught (Misund, B., 2023). Aquaculture exists in a variety of ways, for example inshore aquaculture. The way different types of aquacultures are defined is determined by their location. Inshore aquaculture is located along the coast and inside the fjords in Norway (Leidar, n.d.).

Picture 1 - Fish farming facility with cages in Selfjorden, Lofoten (Sunde, H., 2005)

Picture 1 shows an inshore fish farm facility located in Selfjord in Lofoten (Sunde, H., 2005). One of the main differences between inshore and offshore aquaculture is the size of the fish facility. The standard inshore fish farm facility includes between six to ten cages. Each cage contains up to 200 000 salmons in an area 20-50 meters deep, and 50 meters in diameter. The maximum density in the cage is 25 kg/m3 and 10 kg/m3 with an ecological production (Lybæk, S., 2017).

Today, Norway has land-based and inshore aquaculture. Production of fish in open cages in the sea leads to several different forms of environmental impact. Inshore aquaculture has caused unrest and conflicts due to salmon lice, escapes, and fjord deterioration (Aurdal, B., 2022). According to the Norwegian Environmental Directorate (2022) these are some of the environmental challenges:

- Escape of fish and the spread of salmon lice have a significant impact on wild salmon.
- Discharge of feed residues, excrement from the fish, copper from the facilities and other chemicals and foreign substances (including pharmaceuticals) affect the marine environment.
- Noise and land occupation can affect seabirds

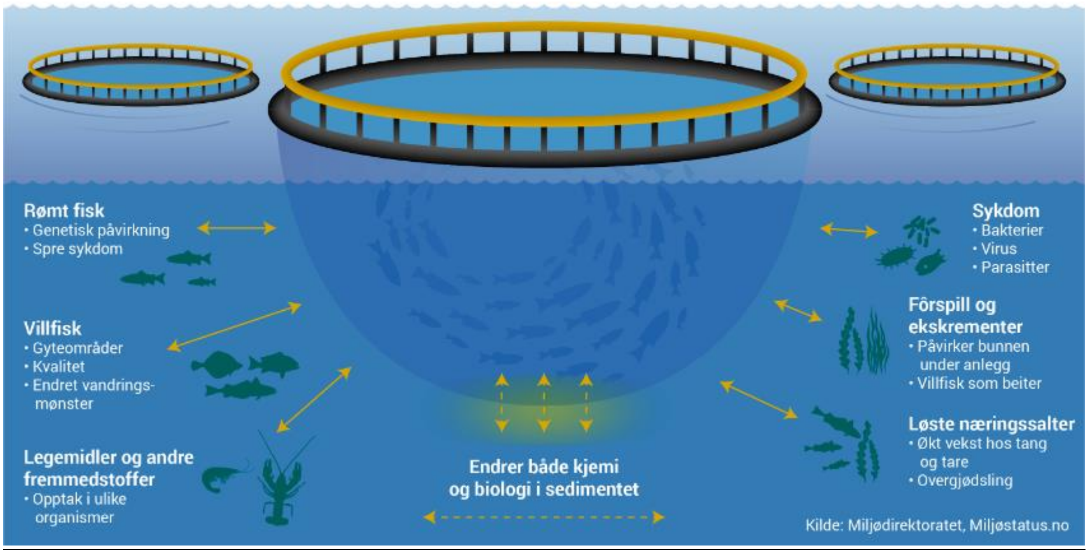
As a result, several fish farmers wanted to relocate the fish farm facility further out on the coast (Aurdal, B., 2022). Breeders must know their emissions and how they can affect the environment (Miljødirektoratet, 2022).

4.2 Negative external effects of inshore aquaculture

An industrial facility for raising aquatic animals for human consumption is known as inshore aquaculture. Here, the fish farms are located close to land where the weather is generally stable. According to the Pollution Act, do the state administrator issues separate permits to those who manages fish farms. This is because raising fish in open cages causes a broader range of environmental effects (Miljødirektoratet, 2022).

If aquaculture facilities had no environmental impact, most of the basis for regulating output would have evaporated. The primary reason for regulating the output of an aquaculture firm is because it has negative external repercussions on other players in the form of contagion and emissions that it does not absorb in it is own corporate financial records and operations. This is an example of market failure, which occurs when the market cannot address the problem on its own (Tveterås, R., et.al., n.d.).

Through infectious agents, salmon lice, runaway fish, and other factors, the production of farmed salmon in one site can have a negative external impact on other farming facilities and salmon rivers. It is critical to stress that the undesirable external effect is not the result of the production process. Theoretically, a firm may reduce adverse external consequences for a given production volume through technological selections and operational activities (Naturvernforbundet, 2020).



Picture 2 - Impacts from fish farming (Miljødirektoratet, 2022)

Picture 2 illustrated different negative impacts from inshore fish farming like escaped fish, disease, foreign substances and discharge. Throughout this chapter we will present the negative external effects in detail.

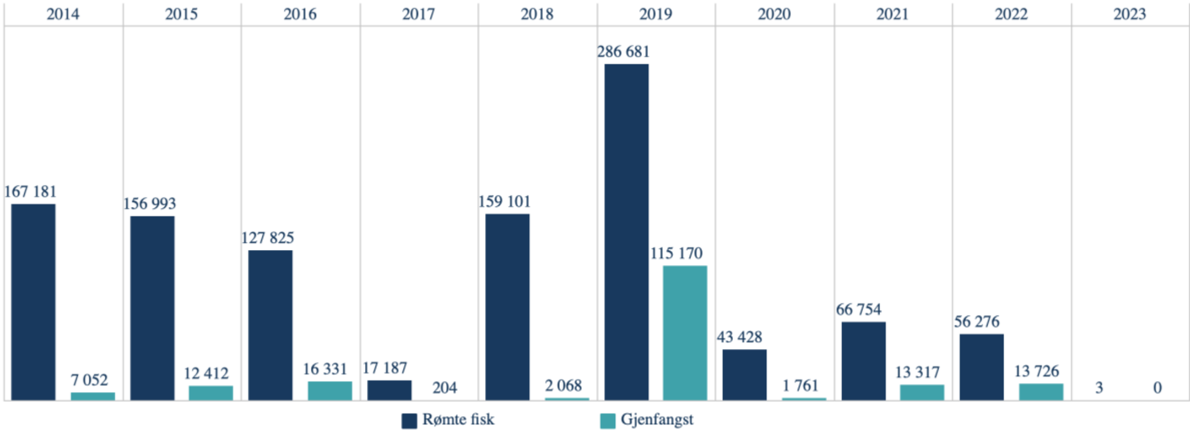
4.2.1 Salmon lice

Salmon lice are a significant problem in Norwegian aquaculture. The salmon lice destroy the skin of the fish and stresses the salmon. The lice may quickly spread from open facilities and through escaped farmed fish in addition to living on the farmed salmon in the fjord. The breeders must spend a lot of time and money on treating and preventing salmon lice. The farmed salmon can also die from the de-lice treatment. The cost of salmon lice to the farming industry is at least NOK 5–10 billion annually (Misund, B., 2023).

Several techniques have been tested to prevent lice infestation, such as freshwater lids, deep-water salmon feeding, strategic lighting in cages, barracks, and sound. Another solution that has been implemented to prevent lice infestation is cleaning fish. Cleaning fish is an important preventive measure against salmon lice and is used across most countries. For a period of years, *the fisheries and aquaculture industry's Research funding* (Norwegian, Fiskeri- og havbruksnæringens Forskningsfinansiering, FHF) has made a considerable investment in cleaning fish with the goal of providing a knowledge basis for regulated production, optimal survival, and effective use of cleaning fish. Nowadays, cleaner fish are produced in well-regulated industrial environments or caught and released in cages with salmon (Fiskeri- og havbruksnæringens Forskningsfinansiering, n.d.).

4.2.2 Escapes from facilities

According to marine biologists in Norway, the two main environmental challenges facing fish farming today are escapement and salmon lice. Escaped salmon enter the same rivers as the wild salmon and spawn there, and researchers are concerned that this will impact the genetic material in the wild salmon in a negative way (Misund, B., 2023). Picture 3 illustrates the reported escaped salmon and recaptures from 2014 to 2023 (Fiskeridirektoratet, 2023). The dark blue poles show the escaped salmon, and the light blue indicates the number of recaptures of the escaped salmon. In the past ten years, there have generally been between 30 and 40 salmon escape events per year, but there is a wide range in the quantity and size of the fish that escape (Regjeringen, 2021). Complex factors contribute to the escape of farmed fish. The direct causes are technical, like holes in the water or bad weather, whereas the underlying causes are organizational and human (Thorvaldsen, T., n.d.).



Picture 3 - Number of reported escaped salmon and recaptures from 2014 to 2023 (Fiskeridirektoratet, 2023)

SINTEF has developed five strategies in its study to prevent fish from escaping (Thorvaldsen, T., n.d.). These are:

1. Pay attention to the node, plumb line, and extra equipment.
   Holes in the node are the main cause of escape. Therefore, frequent, and good node inspection is central to prevent escape. Larger leaks can be caused by larger holes, which often happen when the node comes in to contact with other equipment on the plant. The risk is particularly high when the node is deformed in a strong current. The node must not come in contact with other equipment on the plant. In particular, this applies to the disordering, dead fish pump in the mooring, and additional equipment. A good coating and/or stronger node materials can increase the node´s resistance to wear from high-pressure washing and other things (Thorvaldsen, T., n.d.).
2. Pay attention when transporting fish and de-lice operations.
   Transport of fish and de-lice operations involve handling weights and nodes, using powerful lifting equipment. This increases the likelihood of holes in the node and escape. It is important to watch the weights, so they do not come in contact with the node when handled. The proper circumstances for a safe operation are created by organizational measures such effective planning, risk assessment, responsibility distribution, training, enough personnel, and enough time (Thorvaldsen, T., n.d.).
3. Establish good processes for escape protection during storms.
   Storms and strong currents have been linked to several major escape events. It is important to ensure that the system is assembled so that the node will not come in contact with tight ropes, chains, and shackles when it moves in strong current, and that the soldering down is sufficient. Good inspection practices and ongoing equipment

maintenance are essential for being well-prepared in the event of a storm. Storm-related escapes have also resulted from loose equipment slipping into nodes and inadequate node anchoring (Thorvaldsen, T., n.d.).

4. Learn from your own and others' experiences.
   Escape can be avoided by learning from past events, near-misses, and concerns. Investigating incidents is a helpful approach to understanding why fish escape. Experience may be transferred within a facility/location, but also across facility/locations and companies. An incident database with examples is maintained by the Directorate of Fisheries. To ensure that equipment is user-friendly and does not raise the chance of escape, it is important for suppliers and breeders to share their expertise (Thorvaldsen, T., n.d.).
5. Work systematically with measures at an organizational level.
   Organizational factors such as planning, training, staffing, working hours, operation and maintenance, requirements, choices, and assessments are key areas to address. Organizational measures may reduce the overall risk of escape by assisting in preventing various sorts of escape incidents (Thorvaldsen, T., n.d.).

4.2.3 Environmental monitoring

All aquaculture facilities for fish in the sea have a duty to monitor how discharges affect the area beneath and around the fish farm facility. This is necessary to continuously assess whether the environmental impact is always reasonable and sustainable, both for the specific locality and the entire region. Fish farmers are required to hire independent, qualified professionals to conduct the environmental survey and to submit their findings to the Directorate of Fisheries (Fiskeridirektoratet, n.d).

It is crucial to monitor the conditions at the bottom because this helps to keep the ecosystem in balance. The creatures that reside at the bottom ensures that the organic material that sinks from the cages is effectively consumed and disappears. Suppose too much organic material is added to the bottom compared to what the creatures are able to consume. In that case, they will die, and the organic material will build up, which in turn causes the environmental condition under the cage to become badly (Fiskeridirektoratet, n.d).

The monitoring will provide greater opportunities to implement measures in places where the environmental challenges are intolerable, such as places where there is little organic material turnover. Increased monitoring or fallowing, which involves halting operations and draining the facility of fish, may be used to follow up on such facilities. For an operation to operate in an environmentally sound manner and to enable long-term and good economic operation, the interaction between production, environmental monitoring, and fallowing is crucial. (Regjeringen, 2021).

4.2.4 Production Process

The production process of farmed fish is illustrated in Figure 2. Salmon starts their life in fresh water, were small yolk sac fry hatch from the eggs. Within fish farming, it normally takes 8 to 18 months in fresh water to produce a smolt of around 100 grams, ready to enter seawater. See Figure 2, illustration number 1 and 2. The production of large smolt, which weigh between 250 and 500 grams, is what the industries are concentrating more on these days. As a result, production may be more evenly distributed throughout the year. Furthermore, increased production of large smolt can help to reduce the sea phase, thereby facilitating a higher utilization of permits at sea. Fish health and welfare may benefit from larger, more disease- and parasite-resistant smolt that are more cost-effective due to their shorter sea phase.

On the other hand, production of large smolt can be a cost driver, partly because the land-based production of smolt is more energy-intensive. The smolt is placed in rearing cages in seawater when it reaches the desired size (illustration no. 3). This part of the production cycle is often called the sea phase. In the sea phase, the salmon grows until it reaches the desired weight (illustration no. 4) before it is slaughtered (illustration no. 5). The breeders also want to slaughter the salmon before it reaches sexual maturity. This is because maturation has several negative consequences for fish farms´ growth, feed utilization, quality, welfare, and health. During the sea phase, the salmon increases in size over a period of 12 to 18 months, reaching a slaughter weight of about 3-6 kg, depending on factors like water temperature and feeding (Norges Offentlige Utredninger, 2019).

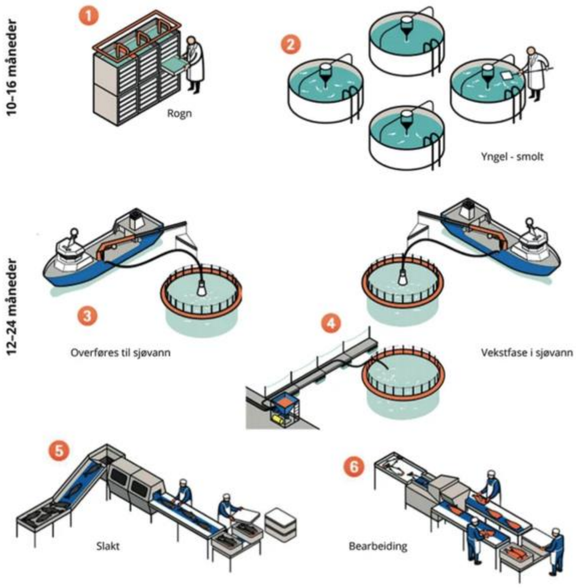


Figure 2 - Production Process (Norges Offentlige Utredninger, 2019)

4.3 Value Chain

With more than 90% of production going overseas, the Norwegian seafood industry is export focused. The Norwegian economy's second-largest export product category is seafood, with offshore petroleum products taking the lead. Figure 3 shows the institutions supporting Research and Innovation (R&I) in the Norwegian seafood industry and it is value chains. Aquaculture and fisheries are the two primary value chains, as shown in Figure 3. Institutions providing R&I financing, services, and infrastructure, mostly funded by the Norwegian government, are close to these two value chains. Most seafood innovation systems comprise the value chains and the surrounding institutions (Bergesen & Tveterås, 2019).

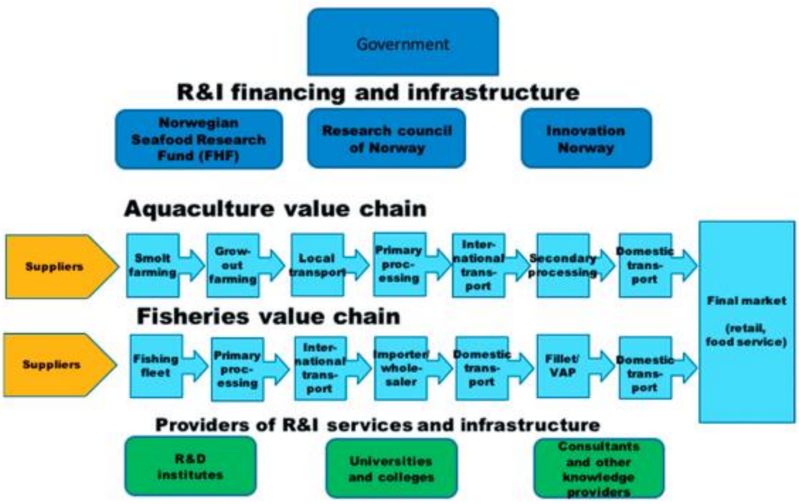


Figure 3 - Seafood value chains and institutions supporting research and innovation in Norway (Bergesen & Tveterås, 2019)

The various phases of the aquaculture and fishing value chains are shown in Figure 3. As an alternative, the value chains for the seafood industry can be broken down into three generic stages: (1) capital equipment, material, and service suppliers; (2) fishing boats and aquaculture farms supplying raw fish; and (3) downstream seafood processing and export marketing. For fisheries and aquaculture, suppliers and producers differ significantly. Hatcheries, feed manufacturers, equipment suppliers, and service providers are significant input sources for aquaculture. Shipyards and equipment manufacturers are significant fisheries suppliers. Producers make use of the inputs. Fish farms are the producers in aquaculture, while fishing boats are the producers in fisheries. Similar tasks are carried out by downstream companies in the aquaculture and fishing industries. Raw materials are transformed by food processors into intermediate food items and food suitable for end users. Food is sold by distributors and exporters to retail chains and intermediaries (Bergesen & Tveterås, 2019).

4.4 Offshore Aquaculture

Offshore Aquaculture is defined as aquaculture in offshore areas, and outer sea areas. That is, areas that lie outside the plan and scope of the Building Act, and at least 20 nautical miles outside the baseline, and areas that lie further from the coast, but within the Norwegian economic zone (University of Stavanger, 2022). Offshore aquaculture has several potential advantages over land-based aquaculture, including access to larger areas for farming, the ability to use natural water currents and nutrient cycles to reduce waste and increase productivity, and the potential to grow species that are better suited to marine environments. However, there are also significant challenges to offshore aquaculture, including issues related to infrastructure, environmental impact, and regulation (Havforskningsinstituttet, 2022).

One of the key drivers of interest in aquaculture at sea is the increasing demand for seafood, particularly in developing countries. According to a report by the Food and Agriculture Organization of the United States (FAO), global seafood consumption has more than doubled over the past 50 years, and aquaculture has been responsible for much of the increase in production. By 2030, it is projected that aquaculture will account for 62% of global seafood production (Food and Agriculture Organization, 2013).

Analyzing aquaculture productivity in proportion to population tells us something about the degree of self-sufficiency for seafood. It also indicates the degree to which a country has specialized in aquaculture. Norway will be in focus in this section. Figure 4, retrieved from the report "Offshore Aquaculture" (Norwegian: Havbruk til Havs) (Tveterås, R., et al., 2020), illustrates that Norway is in a unique position internationally, with an output of 252 kilos per person. Chile, with only 58 kilos per person, finishes in second place behind Norway. There is a significant gap between these two countries. Norway specializes in aquaculture to a degree that surpasses the required local demand. Several countries are currently investing in aquaculture at sea, including Norway, which has developed a large and successful salmon farming industry in its coastal waters.

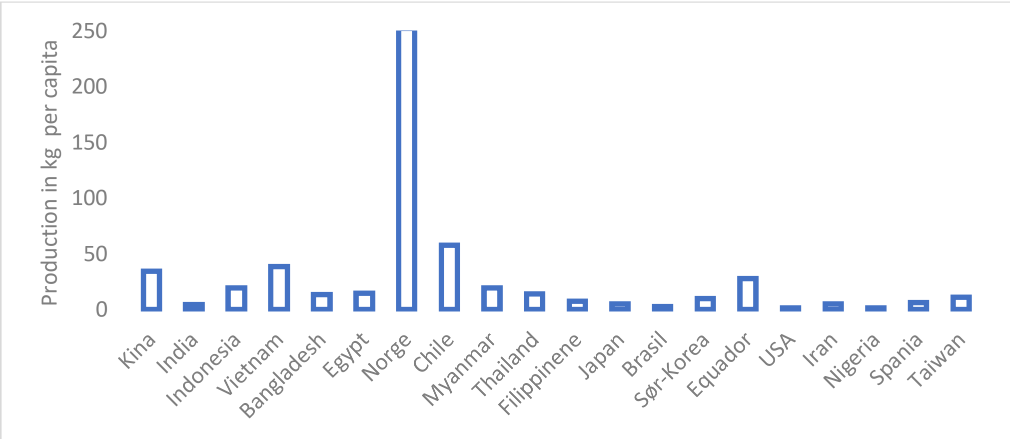


Figure 4 - Aquaculture production in kg per capita for twenty major producing nations in 2016 (Tveterås, R., et.al., 2020)

4.4.1 Ocean Farm 1

With the intention to strengthen and concentrate its efforts on the industry of offshore aquaculture, SalMar and Aker Solution they formed the business SalMar Aker Ocean AS. SalMar is a significant company within the fish farming industry, while Aker Solution is a world known technology and engineering company, within the oil and gas industry. The collaboration between the companies had the goal to establish the first major offshore farming firm in the world, with the goal of producing 150 000 tons of salmon annually. Ocean Farming AS, a subsidiary of SalMar, received eight aquaculture development licenses in 2016, later converted to permanent production licenses in 2020. (SalMar, 2023).

Ocean Farm 1 (OF1) was the world's first offshore fish farm. This facility, based on outstanding Norwegian aquaculture and offshore technology, aims to address key difficulties associated with the aquaculture industry´s sustainable expansion. Ocean Farm 1 is intended to evaluate both the biological and technological facets of fish farming as a full-scale pilot operation (SalMar, 2016). SalMar Aker Ocean have already completed two successful production cycles with Ocean Farm 1 (SalMar Aker Ocean, n.d.). The picture below shows Ocean Farm 1. This facility has a capacity of 1,5 million fish, and a volume of 250 000 m^3. Ocean Farm 1 has a diameter of 110 meters, and a construction cost of approximately NOK 690 million. The Ocean Farm 1 project received eight development licenses from the Directorate of Fisheries, which corresponds to 6,240 tons of salmon. SalMar is also working on a similar, but larger-scale project, the Smart Fish Farm. Smart Fish Farm will have twice the capacity of Ocean Farm 1 and is expected to cost around NOK 1,5 billion (iLaks, 2018).

Ocean Farm 1 will be able to withstand waves of up to 31 meters in height. This means that the cage could be located far out in the Norwegian Sea. SalMar has work to identify the most environmentally friendly location for the establishment (iLaks, 2018). Ocean Farm 1 is primarily based on existing technology within the aquaculture- and the offshore industry. Design and system integration is provided by the Stavanger-based company Global Maritime AS, while the construction and assembly were done in Qingdao in China (SalMar, n.d.). The further development of the technology of Ocean Farm 1 will take place with expertise and experience from Aker Solution (SalMar Aker Ocean, n.d.).

Picture 4 - Ocean Farm 1 (Halleraker, J. H.,2019)

4.4.2 Development licenses

The Norwegian government has contributed to developing new aquaculture technology by issuing development licenses in response to the growing demand for access to the area (Regjeringen, 2018). The licenses' goal is to encourage greater investment in sustainability, desirable modifications to production processes, innovation, and higher value generation across the board within fish farming (SalMar, 2023). The license reduces the actors' risk when creating projects that demand a lot of ingenuity and capital. For the duration of the development project, free development licenses may be given if the requirements for receiving one are fulfilled. The license might be modified for a price if the development project's allotted time runs out without any progress being made. The cost per license is 10 million NOK (Regjeringen, 2018).

The Salmon Allocation Regulations and the Aquaculture Act's framework for the existing permit system were primarily designed from the beginning of the industry based on the requirements for conventional farming in coastal areas. Permit distribution has taken place in various methods over time, evolving with shifting political goals and in response to various market constraints. In addition to the system of development licenses, a new system of growth for commercial permissions was formed as of 2017. Later, license for environmental technologies and offshore aquaculture were also suggested (Føre, M., et.al, 2022).

With a March 2023 deadline, the license system is being investigated, and modifications to the system's design are anticipated. An arrangement and allocation procedure for licenses for offshore aquaculture that are quite different from those that apply to coastal aquaculture were proposed in the spring of 2022. It includes a step-by-step process where the environment and carrying capacity are key factors, and the process needs to be coordinated at the national level, among other things. The process must involve several industry authorities, and the business players themselves must oversee various investigations to show their competency (Føre, M., et.al, 2022).

The challenges and consequences include conducting effective studies and foster effective communication and interaction between central government actors. It also includes how the system can ensure that the licenses contribute to protecting business interests and societal interests. In addition to ensuring proper production are all important questions relating to the procedure, and framework for granting licenses for offshore aquaculture. For instance, it is still unclear where offshore aquaculture can be established, how to grant licenses, how many actors can operate within a block, which studies and decisions must follow one another, and what knowledge must be in place to ensure production is conducted in a way that is responsible for the environment, fish, people, business operators, and society. There will be a need for further information on how to implement a system for the distribution and other management of development licenses. This strikes a balance between consideration of administrative burden/resource use, adaptation of production according to sustainability criteria, and value creation for society. It ensures that the local carrying capacity will not be surpassed in this way (Føre, M., et.al, 2022).

4.4.3 Green platform

The Green Platform project supports the commercialization of green transformation driven by research and innovation. The greatest initiatives, from research and technology development to complete solutions, are what they seek in cooperative partnerships. The goal is to construct a sustainable business model that protects the environment and the climate while generating profits (Grønn Plattform, n.d.).

With challenging environmental conditions, large distances to infrastructure, and undiscovered circumstances for farmed fish, offshore aquaculture introduces a new set of issues. The project will bring technologies and information about lower energy consumption, lower climate footprint, and improved fish life circumstances at every level in the new value chain. The advances cover topics such as offshore floating feed, closed marine facilities with strong post-smolt, electrification at all stages, multi-operational boats, semi-autonomous operation and decision support for decreased environmental footprint and mortality. The objective is to contribute to the appropriate creation of public rules and oversight that have not yet been created through a structured debate arena with public and private parties (Tveterås, R. et.al., 2020).

4.4.4 Collaboration Green Platform

In September 2021, the project *Low-emission value chain for Offshore Aquaculture* (Norwegian: “Lavutslippverdikjede for Havbruk til havs") was granted NOK 93 million in support from the state support scheme Green Platform. Stiim Aqua Cluster was the original source of the project, which now involves 18 top-tier aquaculture businesses, suppliers, and research organizations. The project aims to develop innovative technologies and management practices for sustainable offshore aquaculture. With difficult environmental conditions, great distances to infrastructure, and uncharted conditions for farmed fish, the Green Platform project presents entirely new challenges (Grønn Plattform, n.d.). In Table 1 you can see the companies in the Green Platform project and their main tasks.

Company name	Company type	Company information and tasks
Greig Seafood	Business partner and Technology supplier	- Annual turnover 2020: 4,4 billion NOK - Fully integrated international aquaculture company
Skretting	Business partner and Technology supplier	- Annual turnover 2020: 7,3 billion NOK in Norway and 26,5 billion NOK global - Global leading feed supplier
Salmar Ocean	Business partner and Technology supplier	- Annual turnover 2020: 13 billion NOK - Fully integrated multinational aquaculture company
Moreld Aqua	Business partner and Technology supplier	- Annual turnover: 6,8 billion NOK - Moreld: Offshore energy service - Moreld Aqua: Aquaculture, design, digitization, and autonomy
FishGlobe	Business partner and Technology supplier	- Annual turnover 2021: 70 million NOK - Develops and delivers closed marine facilities
Ovum	Business Partner	- Annual turnover: 4,4 million NOK - Building the first post-smolt unit now - Delivering closed marine facilities.
BluePlanet	Business Partner	- Annual turnover: 20 million NOK - Knowledge provider aquaculture. Active role in knowledge sharing for offshore aquaculture.

Norce	Research institution and R&D supplier	- Project management - Digitalization and autonomous operations - Markers environmental effect on the water column and benthos - Fish welfare post-smolt - Real-time monitoring
Veterinærinstituttet	Research institution and R&D supplier	- Management - Biosecurity and survival - Real-time infection monitoring - Biomarkers and microbiome - Fish health, welfare, and stress
Havforsikringsinstituttet	Research institution and R&D supplier	- Management - Fish welfare in waves - Robust fish
NMBU	Research institution and R&D supplier	- Biomarker studies
NTNU	Research institution and R&D supplier	- Digitization and satellite-based monitoring - Semi-autonomous operations
University of Stavanger	Research institution and R&D supplier	- Project management - Techno-economic and life cycle analyses - Digitization infrastructure - Responsible research and innovation lab - Decision support
University of Bergen	Research institution and R&D supplier	- Development of robust fish - Fish welfare and health
Simula	Research institution and R&D supplier	- Long-term research within software and communication technology
Høgskulen på vestlandet	Research institution	- Responsible research and innovation - Risk analyses - Decision support
University of Florida	Research institution	- Techno-economic analysis - Decision support

University of Melbourne	Research institution	- Fish welfare and health

Table 1 - Collaboration Green Platform (Tveterås, R., 2022)

4.4.5 Fish health and welfare

It is essential to have a separate R&D section dedicated to fish health and welfare in offshore aquaculture locations because fish are the primary component of any aquaculture operation. Therefore, there must be rules and regulations in place. On that occasion, modifications to offshore aquaculture rules are required, such as restricting the number per unit and addressing infectious disease outbreaks. The European Union Reference Laboratories (EURL) for diagnostics and animal health rules must also be considered (Nielsen, K. et al., 2022).

The report *Research and development for the realization of aquaculture at sea. Input for strategic priorities towards 2040* (Norwegian: Forskning og utvikling for realisering av havbruk til hav. Innspill til strategiske prioriteringer mot 2040), which was written by several research institutions, including NTNU, SINTEF Ocean, and the company SalMar Aker Ocean, there are listed some important topics regarding fish health and fish welfare (Føre, M., et.al, 2022). The aspects that we believe are most crucial are:

- **Interaction between the fish and its surroundings.**
  Even though knowledge about the behavior, welfare, health, and growth of farmed fish has steadily increased in recent decades, it will still take focused research to understand why offshore conditions are so different from those in coastal waters. One of the key difficulties for offshore aquaculture is the behavior of the salmon in an exposed environment. The salmon's tolerance limit for currents, waves, and combinations of these needs to be better understood. By assessing the size, season, and offshore production, it is crucial to determine which locations are the best.
- **Development of new methodology.**
  Creating innovative approaches in many fields, including digital health and welfare monitoring, is necessary. Then, one requires a methodology that records the welfare of the fish in new structures, equipment, and facilities. Other welfare indicators, such as behavioral change and lice, must also be monitored.
- **Saturation and flow of oxygen in the facility**.
  Learning more about these issues is crucial because they are essential for the fish´s welfare, survival, and development.

4.5 Inshore versus offshore aquaculture

Moving the aquaculture industry to more exposed areas offshore can present different challenges within administrative, technological, personnel safety, value chain, facility concepts, and innovation processes. The facilities that will be located further out in the sea must withstand significantly more wind and weather difficulties than the inshore facilities. The forces at sea are undoubtedly the most significant difference between inshore- and offshore aquaculture. In this case, we imply that the facilities placed offshore will be larger and contain more fish, in addition to the fact that the weather conditions will be stronger, which in turn leads to more wind and larger waves. Another crucial element is the sea currents, which are stronger in offshore aquaculture. This is also revealed in the report from the Norwegian Institute of Marine Research (2019), which evaluates offshore aquaculture and discovers that environmental variables like current, waves, and temperature could put limitations on the facility´s capacity and the welfare of the fish (Albretsen, J., et.al., 2019).

4.5.1 Waves and wind

Waves are created by the wind. The higher the waves, the stronger the wind. The waves will be huge if the wind is allowed to work on the water for an extended length of time and across a considerable distance (Amundsen, B., 2018). As described in Hvas et al. (2019), the effects of waves on aquaculture are little studied. However, it is evident that waves become a more significant issue for offshore aquaculture. It is necessary to know the wave environment for different potential locations and effects on facilities and fish at different wave heights and periods. The oil and gas sector has conducted extensive research on the impact of waves on their offshore facilities. At the Meteorological Institute in Oslo, Johannes Röhrs studies waves. He claims that oil and gas installations in the North Sea have improved wave monitoring (Amundsen, B., 2018). Valuable knowledge about waves and their impact on facility concepts can be transferred to the offshore aquaculture industry and help develop new innovative processes to prepare the best possible equipment and facilities.

Inshore aquaculture does not need the same assessments as offshore aquaculture regarding a high-stress environment. This includes huge waves, strong currents, and wind. These assessments are critical for offshore aquaculture to be achievable. Waves can affect installations offshore and lead to escape or reduced fish welfare. Ocean Farm 1 will be able to withstand waves of up to 31 meters in height (iLaks, 2018). This does not apply to an inshore aquaculture facility. Inshore aquaculture rarely sees waves similar to those experienced in offshore aquaculture. Violent storms inshore can cause damage to the facilities that could cause fish to escape. The regulations for inshore aquaculture require that the facilities must withstand the storms that can be expected over a 50-year period. This regulation was established in 2004 and had several requirements for the certification of equipment, and for third-party assessments of moorings and facilities (Albretsen, J., et al., 2019).

4.5.2 Distance

Aquaculture at sea will have significantly greater distances from land as the facility is located at sea. This can present difficulties, for example, in relation to logistics if the facility needs to be fixed or concerning the transport of fish or personnel. Facility concepts offshore are larger than traditional aquaculture facilities inshore. The large offshore facilities have the capacity to produce more fish. This will also indicate that larger quantities of feed are required compared to an inland fishing farm. In case of bad weather, it is necessary to secure supplies for the facility's employees and the fish. The distance to land will require a greater focus on preparation and various backup solutions, compared to inshore aquaculture, this will not be as relevant (Regjeringen, 2018).

The spread of disease is another distinction between the different locations of the breeding facilities. When the fish is produced in high-density, there will be a greater chance of spreading disease, which requires treatment. Compared to inshore aquaculture, there will be less of an opportunity for spread in offshore aquaculture. The reason for this is that inshore fish farms consist of six to ten cages in the same facility in a restricted area. There are strict rules regulate the location of inshore fish facilities. This leads to less suitable areas inshore than offshore (Regjeringen, 2018).

5. Analysis

This chapter will present an analysis of the relevant theories that are presented in chapter 2 – theory. Our focus will be on the following theories: knowledge sharing, open innovation, business clusters, skilled relatedness, collaboration, and the SECI model. In order to carry out this analysis, we used tools such as a questionnaire, semi-structured interviews, and an analysis of literature. The first thing presented in the analysis is the qualitative methods, such as a questionnaire and interviews, followed by an analysis of the theories with examples related to offshore aquaculture. This has been analyzed in a way that our research question, *The roles of open innovation and knowledge sharing on the path to sustainable offshore aquaculture?* will be answered. This will be accomplished by examining the advantages and disadvantages of the various theories related to offshore aquaculture.

5.1 Questionnaire

Some of the questionnaire findings are provided in this chapter. Based on the theory and research questions of this thesis, these questionnaire findings are examined and discussed. The project mentioned in this questionnaire is the development of offshore aquaculture in Norway. As described in Chapter 3.0 Methodology, this questionnaire aims to determine whether the respondent thinks there are any possibilities for knowledge sharing and synergies between the two industries, oil and gas- and the offshore aquaculture industry.

The answers the respondents chose in the upcoming question had great significance for further analysis. This question was about their knowledge of offshore aquaculture.

Answer	Frequency	Relative Frequency
Yes	12	23 %
No	41	77 %
Total	53	100 %

Table 2 - Knowledge of Offshore Aquaculture

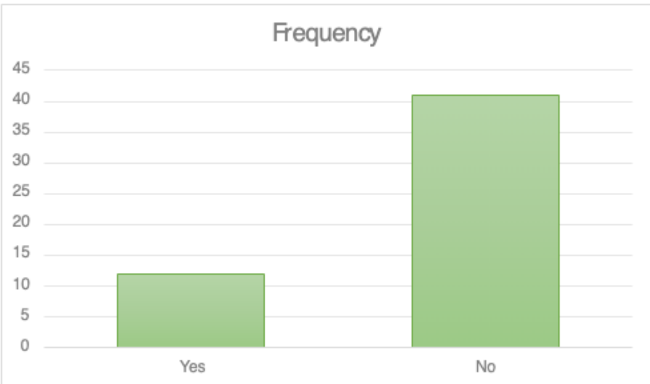


Figure 5 - Knowledge to Offshore Aquaculture

Based on the responses we got, 12 of the respondents knew about the project, shown in Table 2, and Figure 5 . It is obvious that the initiative must be seen by a younger demographic who are going to depend on offshore aquaculture in the future. We chose not to include this electronic questionnaire based on the responses we acquired from it. This is due to the fact that 77% of the respondents lack knowledge about offshore aquaculture. The entire survey with answers is presented in Appendix 2.

Even though we decided not to disregard the responses to the questionnaire in our analysis, we would like to go into more detail about two of the open questions we had. In the first question, we asked if they could specify which technical solutions the respondents thought were relevant for offshore aquaculture. In Appendix 3, we have listed all of the answers, but the ones we thought were most interesting were:

- The oil and gas industry already knows a lot about operating in the sea, building at sea, and the tools/technology needed to work around waves etc.
- Equipment used for drilling and other seabed analysis. Offshore supply chain knowledge.
- Aqua medicine, energy sustainability, circular economy, ROV/underwater drones, housing, and accommodation at sea
- Reusing old platforms to create coral reefs for fish to hide.
- Technological solutions from wind turbines to sea
- Solar Energy
- Chip technology, where condition data can be obtained on equipment to determine the need for maintenance/inspection. Also, chip technology for the health and quality of the fish?

For the second question, we asked if the respondents believed any synergies existed between offshore aquaculture and other industries. For this inquiry, the respondents could clarify which industries there could be any relevant synergies. All the answers are presented in Appendix 4. However, the ones we found most intriguing were:

- Offshore Oil industry and offshore power generation (Norwegian: Offshore oljeindustri, kraftproduksjon til havs).
- Windmills at sea
- Digitalization, Internet of Things (IoT), offshore- subsea - and maritime - technology.
- Any industry that works in or around the sea.
- Oil and subsea
- Maybe the fisheries industry, but unclear in what way. Technology from the oil and gas industry also might prove beneficial.

Even though the respondents do not know much about offshore aquaculture, we believe the answers are fascinating and relevant because of the creative ideas that came forward. This could indicate that more innovative ideas might surface if people were better informed and educated about this topic. The university and research institute could address this issue by including offshore aquaculture in the course of study, where students can learn about the opportunities and difficulties of this subject.

5.2 Qualitative interview

The fishing- and the oil industry have a major common factor, and that is the sea. Aquaculture operations can be highly exposed as they are easily affected by unstable weather leading to large waves, currents, and winds. This presents several challenges that must be resolved for it to be possible to develop offshore aquaculture, which we are referring to as the project. For our master's thesis, we interviewed people from various industries to gain as much insight as possible into how the sharing of knowledge takes place in the project, in addition to their view of the project and whether it’s feasible or not. We have interviewed an engineer with experience from the offshore industry and a fish health biologist, in education, with experience from work at inshore fish farming.

The interviewees were experienced as reflective and open through pleasant Teams meetings. Nevertheless, there is a limit to what can be answered in relation to knowledge about other professional fields and mentions of other companies. Therefore, the interview guide was used as a general template to keep us within certain limits for the research question, shown in Appendix 5. The chapter is divided into collaboration, advantages, and disadvantages extracted from the information from the interviews.

Collaboration

At the start of this thesis, before the interviews, our perception was that knowledge sharing in this project was problematic due to lack of time, investment from the participants, and other general uncertainties surrounding the project. Based on the interview we had with an engineer on the project, we understand that groups are made up of many different people, and everything is about the interest of the individual person and how invested one is in the project. According to the interviewee, his group was composed of a former platform manager with a lot of important and relevant information and knowledge, an engineer, and a third person with a lot of knowledge and experience around cyber technology and electronics. Other knowledge that emerges as important in such a project is hydrodynamics, structure engineering, marine technologies, economics, and risk assessment.

Challenges in relation to collaboration in the project seem individual. There are both those who want to share knowledge but at the same time are interested in acquiring new knowledge, and vice versa; those who do not say too much and keep their "cards close to their chest." So, who really holds the power in such a project? According to the fish health industry, this mostly goes beyond their professional field, and thus they should have the last word. Their skepticism from them is mostly about the possible consequences in relation to the fish that may arise. Because the development of the offshore aquaculture industry has developed faster than biology, the consequences that may occur are not yet apparent. Nevertheless, the authorities have much to say concerning development permits, and the Norwegian Food Safety Authority also wants to provide input early in the project phase.

Advantages

A great deal of knowledge, structure, and logistics comes from the oil and gas industry and is currently used on platforms. There is much to be learned from this industry to create the fish farm's facility so that it´s adapted to the location on the Norwegian continental shelf. It emerges that the most important qualities such a facility must be robustness to wind, waves, and currents. Since it used so much knowledge, experience, and material that already exists before, the project leads to increased learning from other professions, such as lawyers, biologists, and veterinarians, where they share knowledge.

In this case, fish are well suited to swimming in and against currents as they swim back into the river they came from when they spawn. The river has currents that can be compared to currents in some places in offshore- and outer sea areas. There are also various technologies and technology services where you can simulate how the fish will withstand the currents in offshore- and outer sea areas. If the project has enough resources, then this will be technology that the project can use to better ensure fish health in offshore aquaculture. According to Maxime Thys (n.d.) for SINTEF, there is already a sea basin where testing is possible.

Another advantage that emerges in the interviews is the offshore fish farm facility´s location. A fish facility that is placed on the Norwegian continental shelf have the possibility to have a greater distance between the facilities. An offshore location means more currents and larger waves, this leads to more water exchange. As a result, the spread of diseases can decrease. In inshore aquaculture, the climate is different, with smaller waves and less currents. With the maximum density of fish, the spread of diseases will increase. Which in turn will be a significant consequence if not treated.

Disadvantages

The biggest challenge in such a project is the time it takes to get all parts in place. Applying for permits, testing equipment, and finalizing everything is a long and time-consuming process. When it comes to the construction of a fish farm facility that will withstand offshore- and outer sea climates, there are several challenges that emerge. One of them is the physics of the waves; in this case, meaning a small window of time to get certain jobs done, such as lifting work. There are a lot of calculations that need to be done here in order to do things correctly and to maintain the facility and the equipment in the proper condition. The fact that the equipment must now contain living organisms is something that must also be considered compared to before. It is also important that the equipment is made in such a way that the fish can be lowered gradually into the sea if they are to be far below the surface. This is so the fish will survive the pressure it´s exposed to.

Fish welfare is something the engineers do not know much about. As they are making some of the equipment that the fish will be in, they depend on effective communication with the veterinarian/biologist to create equipment adapted to the environment where the fish can thrive. There is also little insurance and testing on fish welfare on a general basis, and it is, therefore, difficult to know whether the fish will thrive in this type of environment and what is needed for the fish to thrive more. There will be organisms living both inside and outside, therefore biosecurity is crucial. Although the salmon is adapted to swimming in rivers, the fish cannot tolerate too much current, and the river cannot always be compared to the sea. The salmon use a lot of energy to swim in the river and are not necessarily able to do this over a long period. The fact that the fish farm facility is located in the middle of the sea also means that the facility can be larger and thus store more fish. This leads to more significant consequences in case of escape, as there will be more fish on the way, which may make some a little skeptical.

Other disadvantages that emerge are the competition with large companies that can "buy" the best expertise and knowledge offered. They patent equipment, technology, and solutions, which makes it difficult for others to get involved. When it comes to projects like this, it is no secret that patience can be a challenge as such a project takes time, both with resources and permits. To start such a project, there are many development licenses that must be in place. It is, therefore, a challenging task to convince the authorities that this can be done in practice due to little research in the area.

5.3 Knowledge sharing

5.3.1 Knowledge sharing between industries

There are several innovative solutions and technologies that the marine industries believe have transfer potential across the “blue industries.” What the different stakeholders believe will be vital for growth over the next ten years, as well as what could be barriers and opportunities for realizing the suggested synergies. The Research Council's declaration of spillover opportunities within ocean-based industries is necessary to extract synergies across different ocean-based industries (Holte, E. et al., 2016). The report written by Holte, E. (2016) shows results that indicate recommendations to Research Council (Norwegian: Forskningsrådet) and Innovation Norway (Norwegian: Innovasjon Norge) to identify the need for research and development (R&D). A positive interaction between industry, research, administration, and political organization is crucial to ensure success. The barrier to future progress is frequently not a lack of technology or knowledge but how we can use them and integrate them into new applications and markets, emphasizes how important this is.

Knowledge sharing is a terrific approach to provide the entire organization/industry access to rare knowledge. Formerly, traditional methods like forums, training sessions, presentations, white papers, etc. served with purpose. Still, today more interactive and peer-to-peer knowledge sharing questions & answers (Q&A) platforms are facilitating more accessible access to different knowledge (Holte, E. et al., 2016). The new ways of knowledge sharing will improve innovation processes between industries.

5.3.2 Knowledge management

North, K., and Reinhardt, R., (North, K., et al. 2004) conducted a survey, and the respondents were all either from the Swiss Knowledge Management Forum or German Association for Knowledge Management members. Their participation percentage is 30%, and the members participating in the survey were managers, consultants, and scientists. Gives an overview of the factor's knowledge management effects, from a scale of 1 to 5 (1 = not at all & 5 = Absolutely yes), based on the survey conducted by North, K., et al. 2004. The results below are crucial:

- The survey respondents' expectations do not go beyond a middling level
- Knowledge management is associated with long-term competitive advantages from a content perspective, but there are only tenuous connections to the conventional determinants for strategic success.

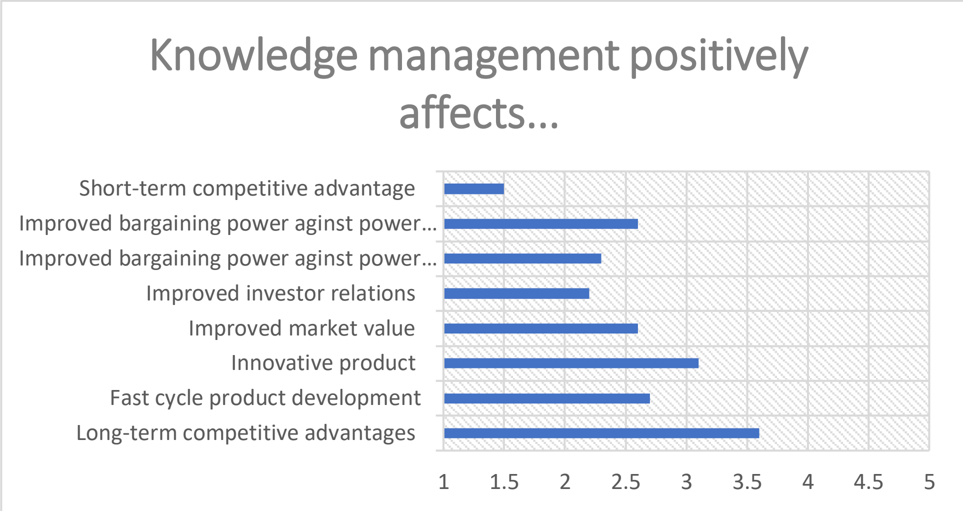


Figure 6 - Strategic benefits of Knowledge Management (North, K., et.al. 2004)

Figure 6 illustrates how knowledge management may improve innovation and provide a competitive advantage. Offshore aquaculture may benefit from this in the future to enhance the innovation processes and competitive advantage. Knowledge sharing and management will be crucial components of a long-term, sustainable solution within offshore aquaculture.

5.4 Business cluster

For businesses to prosper, localization is essential. Businesses want to be in areas with easy access to finance and knowledge and join environments that support continuous improvement and innovation. This is particularly evident in knowledge-based industries such as Information and Communication Technology (ICT) and biotechnology, but the mechanisms are the same in all industries (Reve & Sasson, 2012). Businesses will be in well-known business clusters with high expertise if a company is concerned with innovation and knowledge growth. Companies that want to keep manufacturing costs as low as possible would insted operate independently in locations where they can act as a monopolist in the labor market (Reve & Sasson, 2012).

The cluster model shifts the attention from the manufacturing side of a business to the customer and supplier side of a business. Knowledge-based services, education, research, and development are given a prominent place in the cluster model. For the transfer of knowledge among industry participants, knowledge-based services, research, and development are particularly crucial. This speaks to the cluster model´s central tenet – the positive knowledge-related external effects that happen between linkages of actors. The interaction between all industry participants is crucial, but so is the total (Reve & Sasson, 2012).

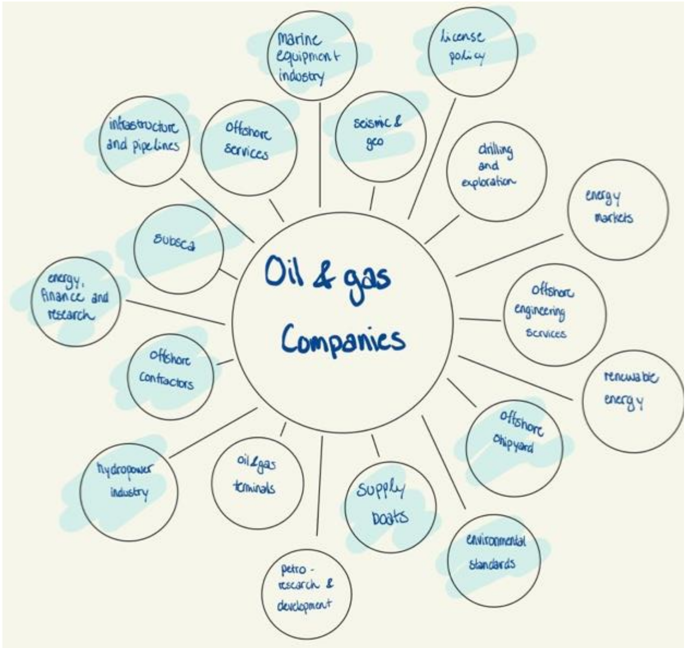


Figure 7 - Cluster map: Oil and gas (Reve & Sasson, 2012)

Figure 8 - Cluster map: Offshore aquaculture

In today´s world, the agricultural industry is the main driver of the Norwegian maritime cluster (Kyst.no, 2018). A cluster network or a cluster map, which depicts the most significant organizations and players and their connections, is a standard tool for showing an industrial cluster (Reve & Sasson, 2012). According to Reve and Sasson (2012, p.34), "the oil and gas industry grew with a base in the large petroleum resources that were discovered in the North Sea." The Norwegian offshore environment is provided as an example of a whole industry cluster in Figure 7 - Cluster map: Oil and gas (Reve & Sasson, 2012). Figure 8 - Cluster map: Offshore aquaculture, represent the Norwegian offshore aquaculture environment. Figure 7 and Figure 8 may be compared to highlight the commonalities across the various businesses. We can draw lines connecting the two statistics and identify several knowledge sharing opportunities. Figure 7, illustrates areas highlighted in blue. These represent areas that we believe are common for both industries. Some of them being subsea equipment, working in a high-stress environment, and sensor monitoring. This indicates opportunities for knowledge sharing, skilled relatedness, and spillovers between the two industries.

It is important to research ways to improve a few of the coastal business environments so they can obtain the benefits of successful business clusters. This will guarantee industry innovation as well as a wider geographical distribution of potential new employees brought on by the growth of offshore aquaculture. Although it may be claimed that the clusters were created to advance an already existing industry rather than to investigate new business prospects, it has been demonstrated that the clusters impact innovation. The clusters started new industry-wide partnerships after the price of oil dropped in 2014. Along with other things, GCE Subsea and NCE Seafood have been working together to transfer technology across the oil/gas and aquaculture industries (Regjeringen, 2018).

5.5 Skilled relatedness

5.5.1 Skilled relatedness between industries

Although offshore aquaculture and the oil and gas industries may seem unrelated, they share certain skills. One of the skills both industries cover is engineering. These skills are needed to plan, construct, and maintain their infrastructure. Engineers are required in the oil industry to plan and construct drilling platforms, pipelines, and other structures like hydrodynamic structures. For the fishing industry – engineers are needed for the planning and construction of fish hatcheries, fish processing factories, and other aquaculture infrastructures. Environmental management is another area where the two industries converge. Offshore aquaculture and the oil industry can have a significant influence on the environment, both positive and negative. The oil and gas industry are renowned for its effects on the quality of the air and water, as well as for the possibility of oil spills. Environmental effects from fish aquaculture might include waste buildup and disease transmission to wild fish populations. To lessen these effects and ensure that their operations are sustainable, both industries need experts in environmental management. These experts may be found in both industries.

The oil and gas industry has a wide specter of knowledge regarding the marine environment. To build platforms for extracting oil and gas, they need to have an overview of the harsh environment offshore. Every industry that operates offshore needs to understand and assess the physics of waves and the impact the waves will have. This is important knowledge that needs to be transferred to offshore aquaculture. Offshore aquaculture needs to assess the impacts on the electronic system, structures, fish, and nodes. SINTEF provides an ocean pool in Trondheim for basic and applied research on marine structures and operations. In this pool, SINTEF can mimic a wide range of climatic conditions in the pool, including wind, waves, and currents (Thys, M., n.d.). This offers a rare chance to evaluate models in real-world scenarios, both for offshore aquaculture and oil and gas industries.

Furthermore, there are certain regulatory compliance commonalities between the two industries. Government rules governing business operations apply to both industries. To guarantee worker safety, environmental preservation, and compliance with regulations pertaining to oil exploration and production, the oil industry is extensively regulated. Comparable laws governing the health and welfare of fish, the safety of food, and environmental preservation apply to fish farming. Both industries require experts in regulatory compliance to ensure that their activities comply with these standards.

5.5.2 Skilled relatedness from different industries

The report published by SINTEF - *The potential for the development of transversal technologies and technological equipment for use in the marine, maritime and offshore sectors* (2016) (Norwegian: Potensialet for utvikling av tverrgående teknologier og teknologisk utstyr til bruk i marin, maritim og offshore sektorer) shows that they have examined the possibility for synergies between the industries that are dependent on the sea. This is especially aimed at technology solutions and knowledge that might help the maritime industry expand further (Holte, E., et al., 2016).

Many technical alternatives were investigated within the marine industry (Holte, E., et al., 2016). One of them being:

- Solutions that contribute to food rafts attend to oversee logistics and the transfer of dynamic positioning to well boats and vessels that interface with cages and facility structures.

The oil and gas industry provides diverse technological solutions with potential use in offshore aquaculture (Holte, E., et al., 2016). Several technological solutions involve the following:

- ROV (Remotely Operated Vehicle), AUV (Autonomous Underwater Vehicle), and UVMS (Underwater vehicle-manipulator system) for inspection of facilities and fish nodes, environment monitoring, and systematic monitoring of the marine environment before and after operations.
- Sensors for installation monitoring and a better knowledge of the environment's impact on buildings and facilities.
- Safer installation methods.
- Optimization of feeding rafts and other aquaculture systems.
- Feed tubes that can be submerged for optimal area usage. Utilize the expertise in pipe building to create more resilient feed hoses.
- Dimensioning and dimensioning procedures for exposed installations.
- Competency in operations in high-stress environments.
- Technique for lowering margins of error, particularly when dealing with undesirable circumstances like escape and lice problems.
- Shared knowledge about "Baseline" before activities start. Reduce the environmental footprint. Technology-based approaches to barrier management and environmental monitoring

The following two technologies are thought to be pertinent for offshore aquaculture taken from offshore wind (Holte, E., et al., 2016).

- Vessel technology transfer for installation and intervention of cages and fish farm facilities.

- Seabed analyses. The same technology can be used for the analysis of the ocean/seabed before, under, and after the activities.

A crucial point that was emphasized by the informants participating in the SINTEF report (Holte, E., et al., 2016) was that technology transfer could not be entirely and naively translated and adapted between the different industries. The most effective cross-sectoral technology and knowledge transfer require scalability and adaptation. The dismantling of barriers across industries, particularly regarding protectionism, regulation, framework conditions, and cost levels, is necessary for cross-sectoral technology and knowledge transfer (Holte, E., et al., 2016).

The SINTEF report (Holte, E., et al., 2016) asserts that several barriers prevent knowledge transfer. The main obstacles were rules and framework requirements, cost and protectionism, cultural differences, and politics. These are several of the influencing factors that prevent the growth of offshore aquaculture.

Competency in operations in high-stress environments

In offshore aquaculture, effective methods must be developed to withstand powerful natural pressures. Exposed localities, or areas subjected to powerful natural forces, are characterized by high waves, disordered, and complicated current conditions, strong and unstable winds, and considerable distances to shore. It will take extra time for staff to reach the location to assist in a crisis. The facilities that will be run here require strong emergency readiness to assure safety.

SINTEF has its own test facilities and infrastructures that enable testing and verification of various marine constructions and components under various environmental conditions. In addition, SINTEF has self-developed software – FhSim. This software can visualize and simulate the effects of various environmental forces on aquaculture facilities. The following knowledge is included in the employees' competency in sturdy constructions (Reite, K. J., n.d.):

- The structures´ physical properties and how environmental loads affect and are affected by the structures
- Mooring dynamics and anchoring
- Numerical analyses of aquaculture facilities, incl. deformation and loads
- Numerical simulations of fish behaviors

- Notch constructions and materials, as well as their physical properties and response to environmental loads
- Digital twin
- Hydroelectricity

SalMar acquired ownership in the Arctic Offshore Farming development project by purchasing Norwegian Royal Salmon (NRS). Offshore farming is a strategically significant investment that creates and improves offshore technologies for aquaculture business. The technology differs from Ocean Farm 1 and Smart Fish Farm, which include two submersible cages and a barge connected between the cages. The first production cycle, scheduled to begin in the summer of 2023, will begin with both cages erected on the property and ready. The most exposed farming location in Norway is "Fellesholmen." Within 2022, the business will have better knowledge of the site´s harsh winter conditions and will be more adept at lowering the cages to submerged positions (SalMar, 2023).

Technique for lowering margins of error, particularly when dealing with undesirable circumstances

The world´s first aquaculture plant at sea is called Ocean Farm 1 (OF1). The facility may mark the beginning of a new age in aquaculture. Ocean Farm 1 was created with the assistance of internationally leading Norwegian experts in fish farming and offshore and will be used to evaluate how aquaculture may expand in a sustainable way. On September 3rd, 2018, an extremely damaging incident happened after the facility was put into operation. The incident happened after water ingress into the sliding bulkhead causing the plant to tip over so that the outer ring fell into the sea surface. This created an opportunity for the fish to swim out between the top of the mesh construction. Several improvement activities/ projects were implemented to avoid a similar incident in the future.

The competency program for operators onboard OF1 has been improved because of the incident. The improvements were prepared in collaboration with NTNU Ocean Training and the Offshore Simulator Centre (Myrebøe, G., 2019). The program´s alignment with the company´s objectives and guidelines for operations and readiness received special attention. Enhancing competency in the following areas has been the goal (Myrebøe, G., 2019):

- Stability and ballasting
- Business Relationship Management (BRM)/ Enterprise Risk Management (ERM)/Customer Relationship Management (CRM) Joint training Havmerd – Ships
- Safety Management Systems
- Full-scale preparedness exercises together with the *Hovedredningssentralen* (Eng.: Main Rescue), the central office, and the Directorate of Fisheries

Optimization of existing equipment

Aquaculture's value chains require special solutions that support all relevant aspects. Optimizing the already exist tools in the industry is therefore important to extract more from the sea. In offshore aquaculture, there will be a need for feeding pipes that provide food further down into the sea to utilize the area and the human visibility of the equipment in nature. Then there is a different climate offshore with significantly more currents, waves, and wind; these are key factors that must be considered while making the equipment that will be used. Among other things, artificial intelligence can be used here to continuously optimize the operation of the equipment. Some examples where artificial intelligence could be utilized in offshore aquaculture include automatic monitoring of feeding, weather conditions, inspection of cages, equipment and technology.

ROV (Remotely Operated Vehicle), AUV (Autonomous Underwater Vehicle), and UVMS (Underwater vehicle-manipulator system)

ROVs and AUVs are highly maneuverable underwater machines that can be used to explore ocean depths while operated by someone at the water's surface. The difference is that the AUV operates independently from the ship and has no connecting cables, while ROVs are connected to an operator on the ship. In offshore aquaculture, the ROVs and AUVs can be used to inspect facilities and fish nodes, monitor the environment, and systematically monitor the marine environment before and after operations (Cohan, 2008).

An underwater robot called an Underwater Vehicle-Manipulator System (UVMS) is designed to maneuver dexterously in a more extensive area than a manipulator with a fixed base. The workspace is restricted by the manipulators' fixed base, despite their dexterity and accuracy in handling and manipulating things. Therefore, the workspace would be enhanced by mounting the manipulator on an underwater vehicle (Grønstad, 2019). If it is not adequately controlled, the overpopulation of fish aquaculture poses a severe threat to fish welfare. Here, ROVs can use a lot of equipment and knowledge already in the offshore industry. They can also further develop the products so they can be used for cleaning the submersible infrastructure, such as floating jobs, bottom rings, feeding rafts, and pipes (Haugaløkken, 2023).

Grab operations	Dead fish	Waste in the cage	Lost equipment
Construction and repair	Repair holes	Fasten Ropes	
Washing	Washing of grooves or structures	Washing of anchor line	
Detailed inspection and monitoring	Detailed Note inspection	Inspection of anchor line	
Sensors	Install and retrieve sensors in/near cages	Wash sensors for long-term exposure	Charging sensors (battery)
Sampling and harvesting	A sampling of sediment under cages	Harvesting of species in/by cages	

Table 3 - Examples of operations for UVMS at sea (Haugaløkken, 2023 - Undervannsfartøy-manipulator-systemer)

According to Haugaløkken's 2023 presentation, there may be both benefits and drawbacks to using underwater robotics. One benefit is the concentration on autonomy in developing ROVs, allowing them to perform tasks other than "just looking." Additionally, operations will be able to occur more frequently, ensuring a good and secure environment. In addition to avoiding having many divers at work, divers will be relieved so that they are not subjected to operations that pose harm to their lives and health. This area still has significant difficulties due to shifting constructions, natural pressures, and living creatures. There are also just a few firms that create aquaculture-specific robotic arms. There are opportunities for the offshore aquaculture industry to optimize the use of aquaculture-specific robotic arms adapted to their use. This is partly due to the equipment's high cost and complexity, which might increase the risks and uncertainties associated with the operations.

Underwater surveillance

The oil and gas industry has used equipment such as monitoring systems used on drilling rigs where you can follow the procedure. The information here is collected continuously and compared in a database that contains all previous events. In this way, one can recognize symptoms and determine what consequences it has led to in the past. This technology is used in several places in the oil industry and is now used in the health, financial, and IT industries. In the health industry, it has been used to monitor and compare symptoms with previous events. In the next industry, finance, it is used to see if the customer takes more risk and is burdened, buy too much, or make other deviant purchases. Finally, in the IT industry, it monitors real-time data to find symptoms that have previously led to downtime and slowness (Qvale, P., 2014).

With this technology, it is also possible to monitor and map the seabed using camera technology and hyperspectral imaging, which will make it possible to see what is on the seabed and identify objects automatically. This will make it possible to have a form of environmental monitoring to gain better knowledge of the environment's impact on installations, equipment, and facilities (Qvale, P., 2014). It can also be used for environmental monitoring in connection with fish health, in addition to monitoring when the fish have had enough to eat. In Table 4, you can see the importance of feeding monitoring when it comes to fish:

Potential benefits of good feed management	Potential Consequences of Underfeeding	Potential consequences of overfeeding
Optimal Growth	Poor growth	Increase feed waste
Low FCR	Increased FCR	Increased FCR
Reduced environmental impacts	Decreased condition factor	Increased environmental degradation
Good condition factor	Increased size heterogeneity	Increased interactions with wild fish
Reduced size heterogeneity	Increased mortality	Excessive fat deposition
Low mortality	Poor welfare	Decreased water quality
Good welfare	Reduced disease resistance	Detrimental to fish health
Improved disease resistance	Poor flesh quality	
Good flesh quality		

Table 4 - Feeding monitoring (Sæther, Bjørn-Steinar, 2023)

5.6 Collaboration

In the modern workplace, collaboration is becoming increasingly crucial since it may boost output, creativity, and innovation – crucial factors in project-based work. Communication and sharing ideas, tasks, and resources are necessary for effective teamwork (Lai, 2011). According to research, cooperation can promote decision-making, productivity, creativity, communication, and work satisfaction (Kahai & Cooper, 2003; DeChurch & Mesmer-Magnus, 2010; Hinds & Bailey, 2003). By combining various viewpoints and areas of knowledge, collaboration may also raise the quality of the job.

Cooperative collaboration, coordinated collaboration, and collaborative problem-solving are a few of the several methods of collaboration that can be used in this project. Each of these strategies strongly emphasis certain areas of collaboration, coordination, and communication (Castañer & Oliveira, 2020).

1. Cooperative Collaboration:

Cooperative collaboration can be identified as team learning, where people work together. They cooperate to accomplish their or the company's goal and may exchange ideas and resources to get there. This is particularly pertinent to the offshore aquaculture because it entails collaboration between various industries to provide a particular product in addition to each business attempting to create new innovations in technology, equipment, and theories. The contribution of resources and ideas from other companies involved in the project is also necessary to succeed.

2. Coordinated Collaboration:

Coordinated collaboration is about splitting up tasks, activities, and responsibilities. The team members rarely ever interact with one another as each person works independently to reach the shared goal. As the companies also have other work in addition to this project, this is also a chance for the offshore aquaculture initiative. Each member contributes the best work to the final product by working independently on their duties in which they are experts.

3. Collaborative Problem Solving:

Collaborative problem-solving is associated with team (or group) work when people come together to address a particular issue. They will create a solution and exchange knowledge, ideas, and resources. This will work better when the project approaches completion. When it approaches, issues, challenges, and potential solutions might be discussed to produce a completed project.

Some of the benefits of collaboration for offshore aquaculture are:

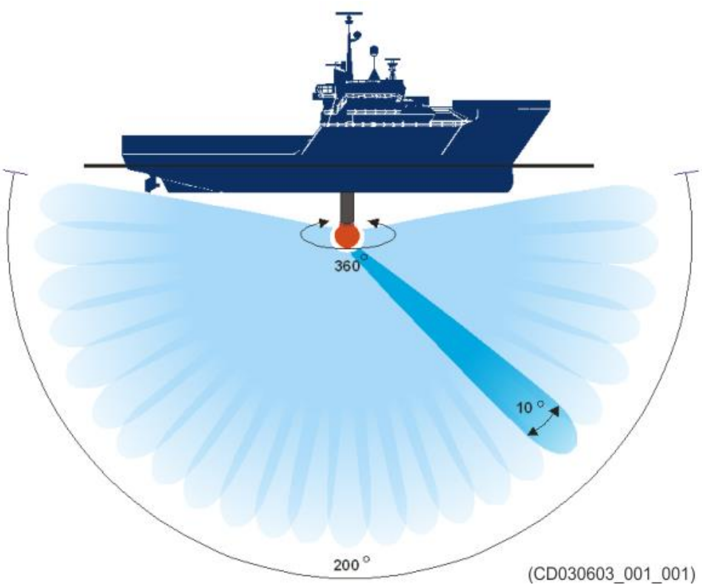
- **Better decision-making:** Through collaboration, people can benefit from the abilities and expertise of others to help their decision-making.
- **Increased creativity:** Working in a team environment can promote innovation by allowing people to build on one another´s ideas.
- **Greater efficiency:** Collaboration can improve efficiency by delegating tasks to team members and allowing them to focus on their areas of expertise.
- **Effective communication:** This is essential to collaboration since it can increase productivity and prevent misunderstandings.

- **Greater job satisfaction:** By enabling people to feel that they are part of a team and are working toward a common goal, collaboration can boost job happiness.

5.6.1 High Precision Acoustic Positioning

In 1992, Simrad and Statoil launched a project to develop a gadget that would enable them to improve underwater navigation accuracy (Oljeindustriens Landsforening (OLF), 2003). Simrad has grown to be the world´s most recognized name for professional fishing equipment (Kongsberg, n.d.). Statoil wanted equipment that targeted more accurate, efficient, and reliable laying of pipelines on the seabed (Oljeindustriens Landsforening (OLF), 2003).

The result of this collaboration came four years later with a product they named HiPAP (High Precision Acoustic Positioning). This is a transmitter and receiver device that hangs beneath the boat and transforms underwater audio waves so you can "see" in all directions, illustrated in Picture 5. Over 250 ships had HiPAP in 2003 worldwide (Oljeindustriens Landsforening (OLF), 2003). The project of HiPAP is one of many examples of how important collaboration between industries is. It has been vital that industries can work together when there is a mutual advantage and find workable solutions when there are competing interests. The different industries at sea are compelled to look for ways to ensure the resources serve Norwegian society without harming anybody else since the marine environments have such high value both above and below the seabed.



Picture 5 - High Precision Acoustic Positioning (Kongsberg Maritime AS, 2021)

5.7 SECI-model

Analyzing Figure 9, the SECI model starts with *Socialization*, where knowledge is known as tacit. The spiral continues into the process called *Externalization*. Knowledge here transforms from tacit to explicit. *Combination*, the following stage in the diagram, is when explicit knowledge is merged with explicit knowledge from another source. The last phase of Figure 9,Figure 9 is called *Internalization*. Here, tacit knowledge is generated by transforming explicit knowledge (Nonaka, I. & Takeuchi, H., 1995).

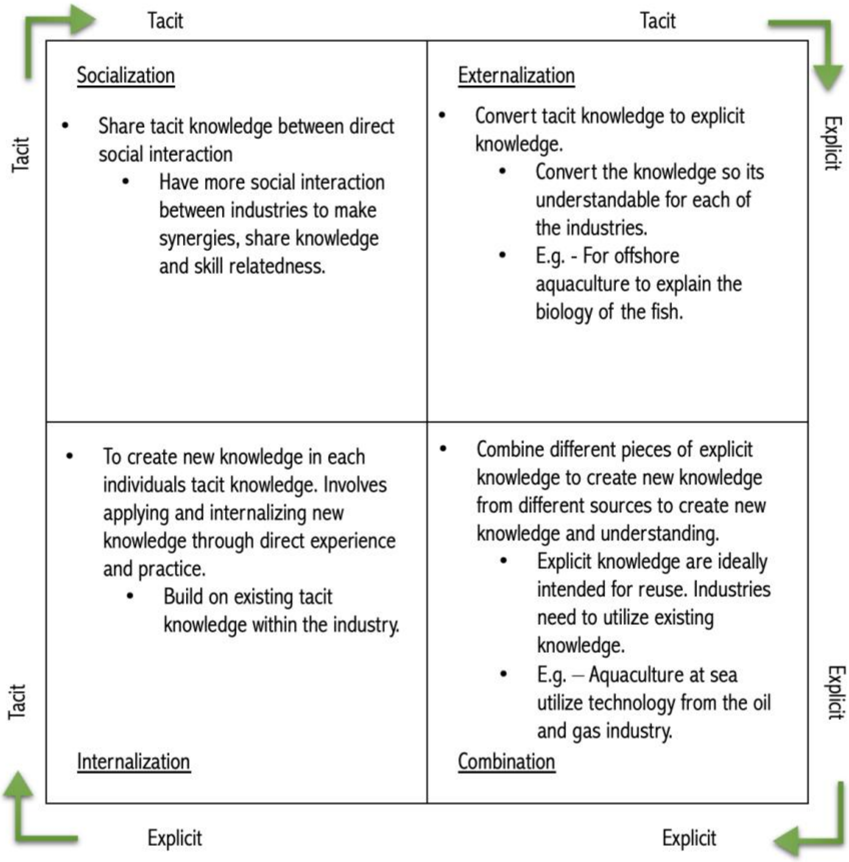


Figure 9 - SECI-Model in Offshore Aquaculture

Knowledge is created and shared through a process of continuous interaction between tacit and explicit knowledge. Regarding offshore aquaculture, the process of the SECI model is shown in Figure 9.

Socialization

With increase social interaction between the oil and gas industry, and offshore aquaculture, there will be easier to share knowledge, skilled relatedness and create synergies between the two industries.

Externalization

To convert tacit information into explicit knowledge is to make it comprehensible to both industries. A good example of this is when biologists, who are specialists in fish biology and health, explain how fish behave so that the oil and gas industry have a better understanding of fish welfare.

Combination

Combine different pieces of explicit knowledge to create new knowledge from different sources to create new knowledge and understanding. By combining knowledge from the oil and gas industry and offshore aquaculture industry, new knowledge will be created.

Internalization

Each person must apply and internalize new knowledge through hands-on practice in order to add it to their tacit knowledge. It takes hands-on experience and practice in the offshore aquaculture or oil and gas industries for someone to gain a tacit knowledge of each business.

5.8 Barriers affecting knowledge

Different barriers affect knowledge sharing in a project with different actors. Davenport and Prusak (1998) acknowledged some barriers which we can include in offshore aquaculture, some of them being:

a) Lack of trust

Trust is one of the most crucial elements in developing strong working relationships with teammates and stakeholders. A project cannot succeed without trust since people hesitate to share, work together, and follow someone they don't feel they can trust.

b) A difference in culture, language, and frame of thought

Decision-making, negotiation, and communication can all be impacted by cultural differences. Every culture has established norms and values that are taken for granted by the people in the culture. People from diverse cultures have different presumptions about how to work together and communicate in an organization.

c) Lack of meeting space and time

Due to the fact that each participant in this project comes from a different business or organization, they will not all be located together. Since so many individuals now need to adjust to this, it may pose issues with meeting times and locations. Fortunately, communicating online has become simpler, thanks mainly to technology and technological solutions.

d) The limited conception of productive labor

There are many factors that can affect productivity, like the work environment, human capital, and technology. For many, productivity depends on someone personally receiving something in exchange for their labor, such as cash or product ownership. It also involves having good technology tools to make the job simpler and a good working environment, both of which are crucial for efficiency and well-being.

e) Owners of knowledge receive status and benefits

In a project, knowledge can be power, which can therefore be a problem with sharing knowledge. It is, therefore, important that sharing knowledge is recognized, rewarded, and promoted.

f) The receivers' inability to absorb or conviction that knowledge is related to particular groups

It can be challenging to become comfortable with the information supplied and/or to add expertise when something is new or inside a different industry. If the degree of comprehension is not the same, it may be challenging to collaborate. The same holds if you personally find no use for the information offered.

g) Intolerance for errors and a lack of assistance

For optimal results, Cooperation is crucial in a project of this nature. These are the types of personality characteristics and character traits, such as a propensity to cooperate, that might lead to issues. For the optimal outcome, there must be room for feedback and support.

Knowledge management in projects can be challenging. A distinctive challenge is transferring knowledge across projects – either directly or by way of extraction so that it becomes a part of the organizational memory and is helpful for future projects. Knowledge sharing and management is crucial because it links individuals and the organization by transferring the knowledge that the individual possesses to an organizational level. In offshore aquaculture knowledge management must be transformed into an advantage for the offshore aquaculture company´s financial stability, innovation processes and competitiveness (Kasemsap, 2014).

6. Results

This research aimed to understand the importance of open innovation and knowledge sharing between the oil and gas- and aquaculture industry on the path to a sustainable offshore aquaculture. Further, this research aims to understand to what extent the advantages and disadvantages of knowledge sharing and innovation influence offshore aquaculture. Regarding technology, sustainability, and innovation, offshore aquaculture is a revolutionary approach to aquaculture.

From the extensive literature review, conducted interviews, and research, we have developed some expectations on the importance of open innovation and knowledge sharing for developing a new industry. One of the most crucial elements for the future of the project of offshore aquaculture is knowledge and the sharing of this. The concept of skilled relatedness also contributes to the project's viability. Utilizing technology, logistics, knowledge, and equipment already in use in another industry saves money and time.

There are both advantages and disadvantages central to offshore aquaculture. We have seen that fish health and fish welfare are the most crucial factor for this project to be possible. The knowledge of fish welfare is strongest in the aquaculture industry, represented by veterinarians and biologists. Meanwhile, the oil and gas industry have the longest experience and most knowledge regarding the high-stress environment and construction at sea. Therefore, a collaboration between these industries is necessary to develop offshore aquaculture.

Professionals with specialized engineering, environmental management, and regulatory compliance knowledge are needed in both industries. The overlap of skills and knowledge between these two industries may become even more crucial as the need for sustainable innovation and food production rises. One of the examples of successful collaboration between the oil and gas and the aquaculture industries is between SalMar and Aker Solution. SalMar Aker Ocean is a pioneer in the new industry of sustainable offshore aquaculture. To strengthen the Norwegian offshore aquaculture industry, the organizations established Ocean Farm 1. SalMar Aker Ocean saw the long-term opportunities with OF1 and started a new project called Smart Fish Farm, which is currently under development with twice the capacity of Ocean Farm 1.

Despite the potential advantages of offshore aquaculture, significant disadvantages must be addressed to ensure its sustainability. These include issues related to the environmental impact of aquaculture, including the potential for pollution and the spread of disease, as well as concerns about the effects of aquaculture on wild fish populations and marine ecosystems. Overall, aquaculture at sea has the potential to play an increasingly important role in meeting the world's demand for seafood. However, its development must be carefully managed to ensure that it is sustainable and does not negatively impact the environment or local communities.

Through this research, we have seen that a sustainable aquaculture offshore must be established to develop the Norwegian aquaculture industry further. The biggest challenges to inshore aquaculture are salmon lice and fish escape. When the fish is produced in a high-density inshore at a contained space, there will be a greater chance of spreading disease. An offshore location will provide more currents and larger waves, which leads to more water exchange. This will again lead to less chance of spreading salmon lice. Offshore aquaculture is dependent on the high-stress environment knowledge from the oil and gas industry to build facilities with robustness to wind, waves, and currents to prevent escape.

It is clear that the development of knowledge in the marine industry is increasing significantly, and new methods and technology are constantly being used to develop and improve offshore aquaculture production. Ultimately, the production costs will be decisive for which technologies and operating methods will be used in the future. In the case of knowledge sharing, skilled relatedness, and collaboration, the production costs will be distributed as there are technological solutions and knowledge that already exists, which can be further developed and optimized as needed. As it is well known, the fishing industry is an essential part of Norway's economy, where economic value creation is mainly based on the sea. If offshore aquaculture is successful, this will likely be an essential part of Norwegian aquaculture and the Norwegian economy for a long time.

Through this thesis, we have looked at several factors that indicate that a shift from inshore aquaculture to offshore aquaculture is necessary for the future of the aquaculture industry. Even though the oil industry and aquaculture at sea may appear to be two very different industries, they share considerable spillovers. The aquaculture industry needs knowledge, skills, and innovation from the oil and gas industry to further develop a sustainable offshore aquaculture industry. This suggests that a sustainable offshore aquaculture industry is possible.

References

Abzari, Mehdi and Teimouri, Hadi (2008). *The Effective Factors on Knowledge Sharing in Organizations.* The international Journal of Knowledge, Culture & Change Management

Albretsen, J., Bech, A.C., Biuw, M., Huserbråten, M., Kutti, T., Kvamme, B.O., Skagseth, Ø., Utne, K.R., Vikebø, F., Wennevik, V. (2019). *Havbruk til havs – Fysiske miljøbetingelser og økosystempåvirkning.* Rapport fra Havforskningen. https://imr.brage.unit.no/imr-xmlui/bitstream/handle/11250/2640411/RH%2b2019-41.pdf?sequence=2&isAllowed=y

Al-Alawi, Ismail, A., Yousif Al-Marzooqi, N., & Fraidoon Mohammed, Y. (2007). Organizational culture and knowledge sharing: critical success factors. *Journal of knowledge management*, *11*(2), 22-42.

Altman, I., & Taylor, D. A. (1973). *Social penetration: The development of interpersonal relationships*. Holt, Rinehart & Winston.

Amundsen, Bård (2018). *Verdens høyeste bølger er i havet utenfor Norge.* Forskning.no. https://forskning.no/fysikk-havforskning-naturvitenskap/verdens-hoyeste-bolger-er-i-havet-utenfor-norge/278415

Andrews, K.M. and Delahaye, B.L. (2000), *Influences On Knowledge processes In Organizational Learning: The Psychosocial Filter*. Journal of Management Studies, 37: 797-810. https://doi.org/10.1111/1467-6486.00204.

Argote, L. (2012). *Organizational learning: Creating, retaining, and transferring knowledge*. Springer Science & Business Media.

Aurdal, Bendik (2022). *Regjeringen åpner for oppdrett til havs.* Finansavisen. https://www.finansavisen.no/nyheter/sjomat/2022/11/01/7954847/regjeringen-apner-for-oppdrett-til-havs?zephr_sso_ott=5fkCwa&fbclid=IwAR3BNYgbT2Xol0CVoTPB5nbNxnkmYw-wvmE1Ee6eYWAN1cjIf0y6YDdk4-Q

Aveyard, H. (2010). *Doing a Literature Review in Health and Social Care*, Resour. Open University Press.

Bartlett, C. A., & Ghoshal, S. (1994). *Changing the role of top management: Beyond strategy to purpose*. Harvard business review, 72(6), 79-88.

Bartol, K. M., & Srivastava, A. (2002). *Encouraging knowledge sharing: The role of organizational reward systems*. Journal of leadership & organizational studies, *9*(1), 64-76.

Bergesen, O & Tveterås, R (2019) *Innovation in seafood value chains: the case of Norway*. https://www.tandfonline.com/doi/epdf/10.1080/13657305.2019.1632391?needAccess=true&role=button

Bi, J., Yang, J., Wang, W., & Wu, Y. (2021*). Sustainability-oriented open innovation model: Development and empirical study*. Sustainability, 13(4), 1889.

Bigliardi, B., & Filippelli, S. (2022). *Sustainability and open innovation: Main themes and research trajectories*. Sustainability, *14*(11), 6763.

Cameron, K. S. (1988). *The conceptual foundation of organizational culture*.

Castaneda, D. I., & Cuellar, S. (2020). *Knowledge sharing and innovation: A systematic review*. Knowledge and Process Management*, 27(3), 159-173.*

Castañer, X., & Oliveira, N. (2020). *Collaboration, coordination, and cooperation among organizations: Establishing the distinctive meanings of these terms through a systematic literature review*. Journal of Management, *46*(6), 965-1001.

Chang, H. H., & Chuang, S. S. (2011). *Social capital and individual motivations on knowledge sharing: Participant involvement as a moderator*. Information & management, *48*(1), 9-18.

Chesbrough, H. W. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Harvard Business Press.

Cohan, S. (2008). *Trends in ROV development.* Marine Technology Society Journal, 42(1), 38-43.

Costello, C., Cao, L., Gelcich, S., Cisneros-Mata, M. Á., Free, C. M., Froehlich, H. E., ... & Lubchenco, J. (2020). *The future of food from the sea. Nature*, 588(7836), 95-100.

Creswell, J. W., & Poth, C. N. (2016). *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Harvard Business Press.

Darroch, J., & McNaughton, R. (2002). *Examining the link between knowledge management practices and types of innovation*. ("(PDF) Examining the link between knowledge management practices and ...") *Journal of intellectual capital*.

De Long, D. W., & Fahey, L. (2000). *Diagnosing cultural barriers to knowledge management.* Academy of Management Perspectives, 14(4), 113-127.

DeChurch, L. A., & Mesmer-Magnus, J. R. (2010). *The cognitive underpinnings of effective teamwork: A meta-analysis.* Journal of Applied Psychology, 95(1), 32-53.

DeRue, Scott., et al. (2011). *The Communication of Leadership: An Investigation of Leadership Communication Across Multiple Levels of Analysis*. Journal of Business Communication, 48(4), 414-441.

Dietrich, C. (2010). *Decision making: Factors that influence decision making, heuristics used, and decision outcomes*. Inquiries Journal, *2*(02).

Dillenbourg, P. (1999). *What do you mean by collaborative learning?* http://tecfaetu.unige.ch/staf/staf-h/notari/staf17/periode4/what%20do%20you%20mean%20by%20collaborative%20learning.pdf

Dube, L., & Ngulube, P. (2012). *Knowledge sharing in a multicultural environment: challenges and opportunities.* South African Journal of Libraries and Information Science, 78(1), 68-77.

Dörnyei, Z. (2007). *Research Methods in Applied Linguistics.* Oxford: Oxford University Press.

Edition, P. S. (2018). *A guide to the project management body of knowledge.* Project Management Institute. Pennsylvania.

Ekambaram, A. (2008). *The role of knowledge transfer in reducing reinvention of the wheel in project organizations.* Norwegian University of Science and Technology, Faculty of Social Science and Technology Management, Department of Industrial Economics and Technology Management. http://v1.prosjektnorge.no/files/pages/104/siva_ekambaram_doktorgrad_oppsummering.pdf

El Maalouf, N., & Bahemia, H. (2022). *The implementation of inbound open innovation at the firm level: A dynamic capability perspective*. Technovation, 102659.

Elliott, R., & Timulak, L. (2005). *Descriptive and interpretive approaches to qualitative research. A handbook of research methods for clinical and health psychology*, 1(7), 147-159.

Fagin, R., Halpern, J. Y., Moses, Y., & Vardi, M. (2004). *Reasoning about knowledge.* MIT press.

Fiskeridirektoratet (n.d). *Miljøovervåkning.* https://www.fiskeridir.no/Akvakultur/Drift-ogtilsyn/Overvaaker-miljoepaavirkningen

Fiskeridirektoratet (2023). Rømmingsstatistikk. https://www.fiskeridir.no/Akvakultur/Tall-og-analyse/Roemmingsstatistikk

Fiskeri- og havbruksnæringens Forskningsfinansiering (n.d.). *Oppsummering: Lakselus*. https://www.fhf.no/resultater/utvalgte-tema/lakselus/?gad=1&gclid=CjwKCAjwsvujBhAXEiwA_UXnAJkEkG2XzHFAzVE0Uo-p1x85toPZyjlaR5bqGXVkaZC86uZY1uBnbxoCMtIQAvD_BwE

Food and Agriculture Organization of the United States (FAO). (2013). *Fish to 2030: Prospect for Fisheries and Aquaculture.* World Bank Report number 83177-GLB.

Fossey, E., Harvey, C., McDermott, F., & Davidson, L. (2002). *Understanding and evaluating qualitative research.* Australian & New Zealand journal of psychiatry, 36(6), 717-732.

Føre, M., Sørensen, A., Asbjørnslett, B., Greco, M., Hartmann, K., Halse, M., Hammerens, A., Hukkelån, T., Mjønes, J., Bjelland, H., Størkarsen, K., (2022) *Forskning og utvikling for realisering av havbruk til havs – innspill til strategiske prioriteringer mot 2040.* NTNU, SalMar Aker Ocean, SINTEF Ocean

Galbraith, C. S., & Galbraith, J. R. (2008). *Leading the virtual workforce: How great leaders transform organizations in the 21st century.* John Wiley & Sons.

Gassmann, O., & Enkel, E. (2004). *Towards a theory of open innovation: Three core process archetypes.* In R&D Management Conference (Vol. 20, pp. 1-18).

Giftson, T (2017.). Assistant Professor, Department of Social Work, Bishop Heber College, Tiruchirappalli–620017, Tamilnadu, India. *Knowledge Management Practices - A Human Resource Perspective*, ISO 690.

Grønstad, F. (2019). *Modelling and simulation of underwater vehicle-manipulator system* (Masters thesis, NTNU).

Grønn Plattform (n.d.). *Om prosjektet.* https://gronnplattform.stiimaquacluster.no/om-prosjektet/

Guest, G., Bunce, A., & Johnson, L. (2006). *How many interviews are enough? An experiment with data saturation and variability.* Field methods, 18(1), 59-82.

Halleraker, Jo Halvard (2019). *Ocean Farm 1* (Picture) https://snl.no/fiskeoppdrett

Harsanto, B., Mulyana, A., Faisal, Y. A., & Shandy, V. M. (2022). Open Innovation for Sustainability in the Social Enterprises: An Empirical Evidence. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(3), 160.

Haugaløkken, Bent Oddvar Arnesen (2023). PPT *«Undervannsfartøy-manipulator-systemer»* From: EXPOSED-konferansen

Havforskningsinstituttet (2022). *Tema: Havbruk til havs.* https://www.hi.no/hi/temasider/akvakultur/havbruk-til-havs

Hershkowitz, R., Hadas, N., Dreyfus, T., & Schwarz, B. (2007). A*bstracting processes, from individuals' constructing of knowledge to a group's "shared knowledge".* Mathematics education research journal, 19, 41-68.

Hertel, G., Geister, S., & Konradt, U. (2005). *Managing virtual teams: A review of current empirical research.* Human resource management review, 15(1), 69-95.

Hidalgo, C. A., Balland, P. A., Boschma, R., Delgado, M., Feldman, M., Frenken, K., ... & Zhu, S. *(2018). The principle of relatedness. In Unifying Themes in Complex Systems IX: Proceedings of the Ninth International Conference on Complex Systems 9* (pp. 451-457). Springer International Publishing.

Hinds, P. J., & Bailey, D. E. (2003). *Out of sight, out of sync: Understanding conflict in distributed teams.* Organization Science, 14(6), 615-632.

Holte, Even Ambros, Sønvinsen, Signe Annie and Holmen, Ingunn Marie (2016). *Rapport Havteknologi*. SINTEF & MARINTEK, Norsk Marinteknisk Forskningsinstitutt AS.

Huizingh, E. K., Conn, S., & Tippmann, E. (2018). *Sustainable open innovation: State-of-the art and future perspectives.* Journal of Cleaner Production, 195, 710-713.

Hvas, M., Folkedal, O., Oppedal, F. (2019). *Havbasert oppdrett – hvor mye vannstrøm tåler laks og rensefisk?* Havforskningsinstituttet. https://www.hi.no/hi/nettrapporter/rapport-fra-havforskningen-2019-37

Ipe, M. (2003). Knowledge sharing in organizations: A conceptual framework. *Human resource development review*, *2*(4), 337-359.

Johnson, P., & Duberley, J. (2000). *Understanding management.* Oxford University Press.

Kahai, S. S., & Cooper, R. B. (2003). *Exploring the core concepts of media richness theory: The impact of cue multiplicity and feedback immediacy on decision quality.* Journal of Management Information Systems, 19(4), 99-126.

Kasemsap, K. (2014). *The role of knowledge sharing on organizational innovation: An integrated framework. In Quality innovation: Knowledge, theory, and practices* (pp. 247-271). IGI Global. ISO 690

Keegan, A., & Turner, J. R. (2001). *Quantity versus quality in project-based learning practices.* Management learning, *32*(1), 77-98.

Kenton, W., (2023). *SWOT analysis: How to with table and example.* https://www.investopedia.com/terms/s/swot.asp

Kim, L., Nelson, R. R., & Nelson, R. R. (Eds.). (2000). *Technology, learning, and innovation: Experiences of newly industrializing economies.* Cambridge University Press.

Kongsberg (2021). *HiPAP - High Precision Acoustic Positioning Product description.* https://www.kongsberg.com/contentassets/7a73952ac48b4ca3900423dc35f6b142/400578f-hipap-pd.pdf

Kongsberg, (n.d.). *Simrad – Technology for sustainable fisheries.* https://www.kongsberg.com/maritime/contact/simrad/

Kyst.no (2018, March 17th). *Næringsklynger i Norsk havbruk*? https://www.kyst.no/naeringsklynger-i-norsk-havbruk/350861

Lai, E. R. (2011). Collaboration: A literature review. Pearson Publisher.

Lam, A., & Lambermont-Ford, J. P. (2010). *Knowledge sharing in organizational contexts: a motivation-based perspective.* Journal of knowledge management, 14(1), 51-66.

Lawson, B., Petersen, K. J., Cousins, P. D., & Handfield, R. B. (2009). *Knowledge sharing in interorganizational product development teams: The effect of formal and informal socialization mechanisms.* Journal of Product Innovation Management, 26(2), 156-172.

Leader to Leader (2021). *ORGANIZATIONAL INNOVATION AND KNOWLEDGE MANAGEMENT/KNOWLEDGE SHARING*.: 68-69. https://doi.org/10.1002/ltl.20605

Leidar (n.d.). *Fisk fra råvare til produkt*. Kunnskapsfilm.
https://kunnskapsfilm.no/prosjekter/matfag/fisk-fra-ravare-til-produkt/

Librarianship studies (2017) *Knowledge*. https://www.librarianshipstudies.com/2017/11/knowledge.html

Liebowitz, J. and Megbolugbe, I. (2003) *A set of frameworks to aid the project manager in conceptualizing and implementing knowledge management initiatives.* International Journal of Project Management, 21 (3) (2003), pp. 189-198

Lutkevich, Ben (2021) *Project scope.* https://www.techtarget.com/searchcio/definition/project-scope

Lybæk, Susanna (2017) *Fiskeoppdrett I Norge.* https://dyrevern.no/article/fiskeoppdrett-i-norge/

Mcleod, Saul (2023). *Qualitative Vs Quantitative Research: Methods & Data Analysis.* *https://www.simplypsychology.org/qualitative-quantitative.html*

Melles, G. (2005). *Beyond the Romantic impulse for authentic data and coconstruction of meaning in interview-based educational research.* Qualitative Research Journal; v.5 n.2 p.21-30; 2005, 5(2), 21–30. https://search.informit.org/doi/10.3316/aeipt.160700

Miljødirektoratet (2022). *Akvakultur*. https://www.miljodirektoratet.no/ansvarsomrader/vann-hav-og-kyst/Akvakultur-fiskeoppdrett/

Misund, Bård (2023) *Akvakultur*. https://snl.no/akvakultur

Misund, Bård (2023). *Fiskeoppdrett*. Store Norske Leksikon. https://snl.no/fiskeoppdrett

Myrebøe, Gunnar (2019). *Sluttrapport. Prosjekt Ocean Farm 1.* https://www.salmar.no/wp-content/uploads/2016/06/OF_SR_16122019.pdf

Naturvernforbundet (2020). *Oppdrett.* https://naturvernforbundet.no/laer-mer/hav-og-strand/oppdrett/

Neffke, F., & Henning, M. (2013). *Skill relatedness and firm diversification.* Strategic Management Journal, 34(3), 297-316. ISO 690

Nielsen, K; Patel, S; Tveterås, R. (2022) *Fiskehelse og – velferd i verdikjeden for havbruk til Havs.* PPT.

Nonaka, I. (1994). *A dynamic theory of organizational knowledge creation*. Organization science, 5(1), 14-37.

Nonaka, I. & Takeuchi, H. (1995). *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation.*

North, K., Reinhardt, R., & Schmidt, A. (2004). *The benefits of knowledge management: some empirical evidence*. In Fifth European Conference on Organisational Knowledge Learning and Capabilities, Innsbruck, Austria.

Norges Offentlige Utredninger (2019). *Skattlegging av havbruksvirksomhet.*

NTNU Undervisning (2018). *Litteraturstudie som metode.* https://www.youtube.com/watch?v=KF3PtpaDsm8

Olaisen, J., & Revang, O. (2017). *Working smarter and greener: Collaborative knowledge sharing in virtual global project teams. International* Journal of Information Management, 37(1), 1441-1448.

Ollila, S., & Yström, A. (2017). *An investigation into the roles of open innovation collaboration managers.* R&d Management, 47(2), 236-252.

Oljeindustriens Landsforening (OLF). (2003). *Sameksistens.* https://offshorenorge.no/contentassets/29fa66aa2d7547888d75b0240005033c/sameksistens.pdf

Pinho-Lopes, M., & Macedo, J. (2016*). Project-based learning in Geotechnics: cooperative versus collaborative teamwork.* European Journal of Engineering Education, 41(1), 70-90.

Porter, M.E. (1990). *The competitive advantage of nations*. Harvard Business Review, 2.

Postolache, Andra (2017). *5 Benefits of Knowledge Sharing within an Organization.* https://www.quandora.com/5-benefits-knowledge-sharing-organization/

Queirós, A., Faria, D., & Almeida, F. (2017). *Strengths and limitations of qualitative and quantitative research methods*. European journal of education studies.

Qvale, Peder (2014). *"Her er 26 av de viktigste teknologiene fra oljebransjen»* from: https://e24.no/energi-og-klima/i/yvBnwg/her-er-26-av-de-viktigste-teknologiene-fra-oljebransjen

Regjeringen (2018) *Havbruk til havs. Ny teknologi – nye områder.* https://www.regjeringen.no/no/dokumenter/havbruk-til-havs/id2625352/

Regjeringen (2021). *Havbruksstrategien - Et hav av muligheter.* https://www.regjeringen.no/no/dokumenter/havbruksstrategien-et-hav-av muligheter/id2864482/

Regjeringen (2022) *Regjeringen vil konsekvens vurdere områder for havbruk til havs.* https://www.regjeringen.no/no/aktuelt/regjeringen-vil-konsekvensvurdere-omrader-for-havbruk-til-havs/id2947003/

Regjeringen (2023) *Nok en viktig milepæl på plass i arbeidet med havbruk til havs.* https://www.regjeringen.no/no/aktuelt/nok-ein-viktig-milepal-pa-plass-i-arbeidet-med-havbruk-til-havs/id2971350/

Reve, T. and Hagesæther, O. (2018). *Hva er næringsklynger?* https://www.bi.no/forskning/business-review/articles/2018/02/hva-naringsklynger-er/

Reve, T. and Sasson, A. (2012). *Et kunskapsbasert Norge.* Universitetsforlaget.

Reite, Karl Johan (n.d.). *FhSim - Simulering av marine operasjoner og systemer.* https://www.sintef.no/programvare/fhsim/

Romero-Hidalgo, J. A., Isiordia-Lachica, P. C., Valenzuela, A., & Rodríguez-Carvajal, R. A. (2021). *Knowledge and innovation management model in the organizational environment. Information, 12*(6), 225.

Rosness, R., Nesheim, T., & Tinmannsvik, R. K. (2013). Kultur og systemer for læring. *En kunnskapsoversikt om organisatorisk læring og sikkerhet*. (15.03.2023)

SalMar (n.d). *Offshore fish farming.* https://www.salmar.no/en/offshore-fish-farming-a-new-era/

SalMar (2023). *Annual report 2022.* https://ml-eu.globenewswire.com/Resource/Download/a2fe8fe1-aec2-435b-8dba-830bca5058b9

SalMar Aker Ocean (n.d). *Sammen skal vi skape: Norges nye industrieventyr*. https://salmarakerocean.no

Schein, E. H. (1990). *Organizational culture* (Vol. 45, No. 2, p. 109). American Psychological Association.

Serenko, A., & Bontis, N. (2016). *Negotiate, reciprocate, or cooperate? The impact of exchange modes on inter-employee knowledge sharing.* Journal of Knowledge Management.

SINTEF (2023). *Åtte år med eksponert oppdrett oppsummert.* https://www.sintef.no/siste nytt/2023/enter-the-title-atte-ar-med-eksponert-oppdrett-oppsummert-of-the-page/?fbclid=IwAR06M90qd9NDQINqxvLmbr7ifLo9j-y_LiaqzyiW2XzTZ8pn_8bErWXMKI0

Smith, K. H. (2002). *What is the 'Knowledge Economy'? Knowledge intensity and distributed knowledge bases.*

Stenmark, D. (2000). *Leveraging tacit organizational knowledge*. Journal of management information systems, 17(3), 9-24. ISO 690

Stevens, R. H., Millage, J., & Clark, S. (2010). *Waves of knowledge management: The flow between explicit and tacit knowledge.* American Journal of Economics and Business Administration, 2(1), 129.

Sunde, Helge (2005). *Fiskeoppdrettsanlegg med merder i Selfjorden, Lofoten. https://snl.no/fiskeoppdrett*

Surbhi, S. (2020) *Difference between explicit knowledge and tacit knowledge.* From: https://keydifferences.com/difference-between-explicit-knowledge-and-tacit-knowledge.html

Sæther, Bjørn-Steinar (2023) PPT: *Oppdrettsteknologi FKS-2010 For og foringsteknologi 2,* UIT.

Tajfel, H., & Turner, J. C. (1979). *An integrative theory of intergroup conflict.* In W. G. Austin & S. Worchel (Eds.), The social psychology of intergroup relations (pp. 33-47). Monterey, CA: Brooks/Cole.

Teece, D. J. (2000). *Strategies for managing knowledge assets: the role of firm structure and industrial context.* Long range planning, 33(1), 35-54.

Thorvaldsen, Trine (n.d.). *Hvordan hindrer vi at oppdrettslaks rømmer?* SINTEF. https://www.sintef.no/fagomrader/havbruk/romming_fisk/

Thys, Maxime (n.d.). *Havbassenget*, https://www.sintef.no/laboratorier/havbassenget/, SINTEF.

Tveterås, R (2022). *«Grønn plattform ekstern presentasjon»* PPT

Tveterås, R., Hovland, M., Reve, T., Misund, B., Nystøyl, R., Bjelland, H., ... & Fjelldal, Ø. (2020). *Verdiskapingspotensiale og veikart for havbruk til havs.* English: Value creation potential and roadmap for offshore aquaculture). Report. Stavanger.

Tveterås, R., Sveen, E.T., Molvik, G., Røsstad, J. S., Rykhus, K., Strøm, Løfsnes, O., Pedersen, R., Nilsen, S., Grøttum, J. A.. (n.d.). *Sjømat 2030 Fremtidig regulering av produksjon og vekst I havbruk.* SjømatNorge.

iLaks (2018). Giganten «Ocean Farm 1» blir liten sammenlignet med SalMars nye havmerd. https://ilaks.no/giganten-ocean-farm-1-blir-liten-sammenlignet-med-salmars-nye-havmerd/

University of Stavanger, 2022. *Ny kunnskap og teknologi for mer bærekraftig oppdrett av laks til havs*. https://www.uis.no/nb/ny-kunnskap-og-teknologi-for-mer-baerekraftig-oppdrett-av-laks-til-havs

Verteramo, S., & De Carolis, M. (2009). *Balancing Learning and Efficiency Crossing Practices and Projects in Projectbased Organisations: Organisational Issues.* The Case History of" Practice Groups" in a Consulting Firm. *Electronic Journal of Knowledge Management*, *7*(1), pp179-190.

Appendix:

Appendix 1: Electronic Questionnaire

With the increasing population there is a higher demand for food. Today we only use 3% of the food that comes from the sea. Offshore Aquaculture would increase the usage of the sea so more food would be provided from it. Norway could become self-sufficient, and also export fish over the borders at sea. The possibilities are endless. Windmill Park around several fish farming facilities, cross trained people working and living in the middle? Fish is the new oil?

1. What age group are you in?
   a. 20 – 35
   b. 36 – 50
   c. 50 +
2. Have you heard of offshore aquaculture in Norway before this survey?
   a. Yes
   b. No
3. Which of the options do you believe would be beneficial for offshore aquaculture, ranking them from most to least important?
   a. Environmental factors
   b. Technological development
   c. Economic factors
   d. EU´s Sustainability Goal 2050
   e. Less visible in nature
   f. Knowledge sharing
   g. Other - please clarify in the next question
4. If you answered "Other", please clarify:
5. Which of the options do you believe would be a disadvantage for this project, ranking them from most to least important?
   a. Environmental factors
   b. Technological development
   c. Economic factors
   d. Less visible in nature
   e. Knowledge sharing
   f. Other – please clarify in the next question

6. If you answered "Other", please clarify:
7. Do you think Offshore Aquaculture can be the future of fish farming in Norway?
8. If no on previous question, why?
9. Do you believe offshore aquaculture could benefit from knowledge sharing from the major maritime- and offshore industries?
    a. Yes
    b. No
10. Do you think there could be technical solutions for Offshore Aquaculture in the oil and gas industry?
    a. Yes
    b. No
11. What technical solutions do you believe Offshore Aquaculture could benefit from?
12. Do you believe that there could be any synergies between Offshore Aquaculture and other industries?
13. If you answered Yes on the previous question, please clarify which industries you are thinking of.
14. After the information given in the start, do you believe this project would be successful?
    a. Yes
    b. No

Appendix 2: Presentation of Electronic Questionnaire

Here are the results from the question related to the respondents´ background information that we collected, which was age. When asked about age, the respondents answered the following:

Age		
Years	**Frequency**	**Relative Frequency**
50 +	5	9 %
36 - 50	7	13 %
20 - 35	41	77 %
Total	53	100 %

Table 5 - Age

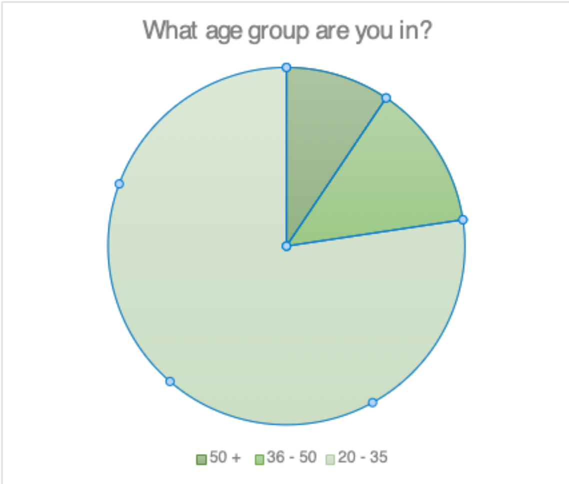


Figure 10 – Age group

As we can see in Table 5 and Figure 10, the largest proportion of students responding to the survey are within the age group 20 – 35 years, with a total of 77%. Given that the questionnaire was sent to UiS students, the majority of whom fall within this age group, this seems reasonable.

In Figure 11, you can see an overview of the most answered options to the question: *Which of the options do you believe would be beneficial for this project, ranking them from most to least important?* The responses that were provided to this question are listed in order from 1-7. Most of the respondents placed *environmental factors* first, followed by *technological development*.

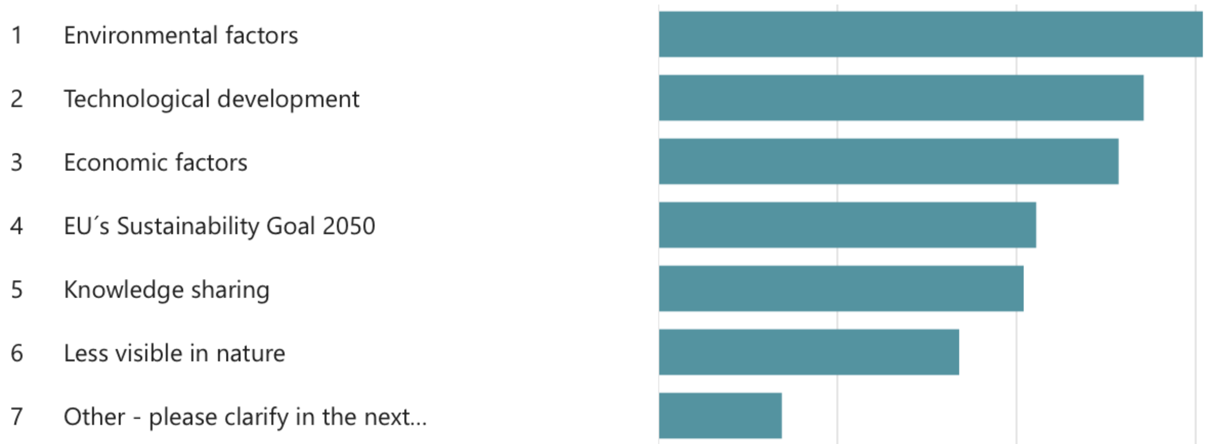


Figure 11 - Which option would be beneficial for this project?

According to the responses in Figure 11, the respondents believe that the *environmental factor* of this project is its greatest asset. The ones that answered *other*, have different opinions of what would benefit the offshore aquaculture project. The ones that intrigued our interest the most were:

- Bio security – health of product
- End consumer awareness/preferences
- Societal factors

In contrast to the last question, which asked about benefits, the next question asks about disadvantages. *Which of the options do you believe would be a disadvantage for this project, ranking them from most to least important?* The responses that were provided to this question are listed in order from 1-6. As the previous question, most of the respondents rated *environmental factors* first as a disadvantage for the offshore aquaculture project, shown in Figure 12.

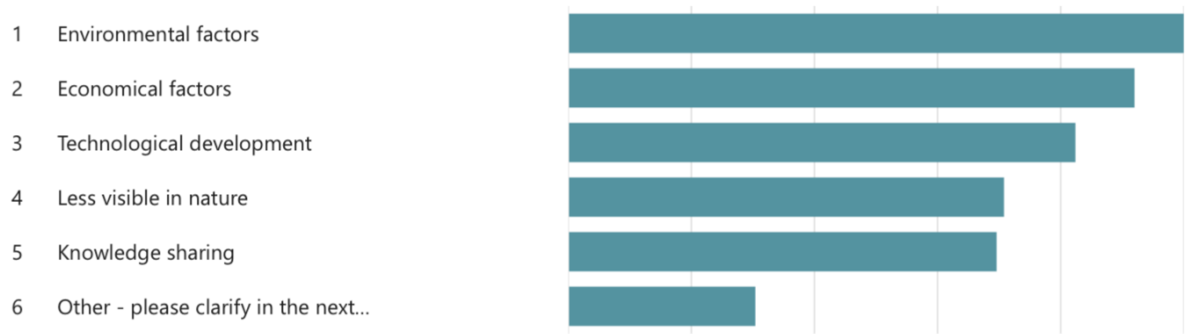


Figure 12 - Which option would be a disadvantage for this project?

For this question, some of the respondents commented when answering number 6: *other* were: Sustainability (EU 2050 Goal) and biological factors.

The answers the respondents chose in the upcoming question had great significance for further questioning. This question was about their knowledge of offshore aquaculture.

Answer	Frequency	Relative Frequency
Yes	12	23 %
No	41	77 %
Total	53	100 %

Table 6 - Knowledge of offshore aquaculture

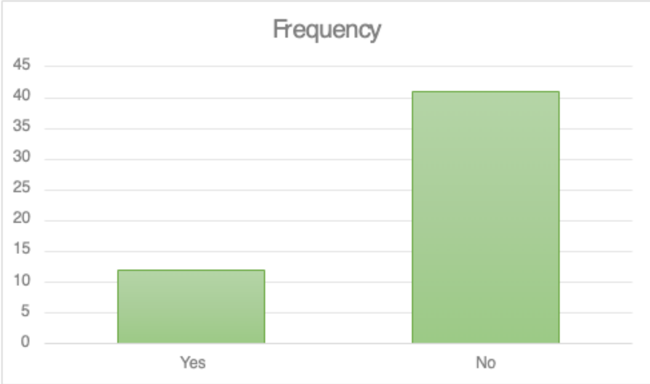


Figure 13 - Knowledge to offshore aquaculture

Based on the responses we got, 12 of the respondents knew about the project, shown in Table 6, and Figure 13. It is obvious that the initiative must be seen by a younger demographic who are going to depend on offshore aquaculture in the future.

The following question asked respondents if they believed that knowledge sharing between the major maritime- and offshore industries may enhance offshore aquaculture.

Answer	Frequency	Relative Frequency
Yes	52	98 %
No	1	2 %
Total	53	100%

Table 7 - Any knowledge sharing benefits?

In Table 7, we clearly see that the respondents see the connection between offshore aquaculture and the major maritime- and offshore industries. It is beneficial because it will allow fresh perspectives and innovative solutions to emerge as the project gains popularity, especially among the younger generation.

In this question, we sought to determine whether the respondents thought the oil and gas industry offered any technical solutions to offshore aquaculture. The majority of those that reacted favorably in this case, illustrated in Table 8.

Answer	Frequency	Relative Frequency
Yes	52	98 %
No	1	2 %

Table 8 - Any technical solutions?

For the previous question, we also had a follow-up question, asking if they could specify which technical solutions the respondents thought were relevant for offshore aquaculture. In Appendix 2 we have listed all of the answers, but the ones we thought were most interesting were:

- The oil and gas industry already knows a lot about operating in the sea, building at sea, and the tools/technology needed to work around waves etc.
- Equipment used for drilling and other seabed analysis. Offshore supply chain knowledge.
- Aqua medicine, energy sustainability, circular economy, ROV/underwater drones, housing, and accommodation at sea
- Reusing old platforms to create coral reefs for fish to hide.
- Technological solutions from wind turbines to sea
- Solar Energy
- Chip technology, where condition data can be obtained on equipment to determine the need for maintenance/inspection. Also, chip technology for the health and quality of the fish?

For the final question, we asked if the respondents believed that there were any synergies between offshore aquaculture and other industries. Table 9 shows the results; the majority, 74%, believe that there are synergies between offshore aquaculture and other industries.

Answer	Frequency	Relative Frequency
Yes	39	74 %
No	14	26 %
Total	53	100 %

Table 9 - Any synergies between offshore aquaculture and other industries?

We also got a follow-up question for this inquiry where the respondents could clarify which industries there could be any relevant synergies. All the answers are presented in Appendix 4. However, the ones we found most intriguing were:

- Offshore oljeindustri, kraftproduksjon til havs. (Eng. Offshore Oil industry and offshore power generation)
- Windmills at sea
- Digitalization, Internet of Things (IoT), offshore- subsea - and maritime - technology.

- Any industry that works in or around the sea.
- Oil and subsea
- Maybe the fisheries industry, but unclear in what way. Technology from the oil and gas industry also might prove beneficial.

Appendix 3: What technical solutions do you believe Offshore Aquaculture could benefit from?

- Det har vært sett på å lage korallrev av gamle plattformer, plasser fro fiske å "gjemme seg". Det er gjerne muligheter å dra synergier fra f.eks vindmøller til havs.
- How the platform won't sink to the bottom. Check out what's the problem with ocean farm 1 is
- Use of high educated engineers
- ROV- teknologi, maritime operasjoner offshore, chip- teknologi, hvor tilstandsdata kan innhentes om utstyr for å avgjøre behov for vedlikehold/ ettersyn. Også chip- teknologi for fiskens helsetilstand og kvalitet?
- Farming on land and many oil service techs with regards to optimalization IMR work
- The oil and gas industry allready knows a lot about operating in the sea, building at sea, and the tools/technology needed to work around waves etc.
- Equipment used for drilling and other seabed analysis. Offshore supply chain knowledge.
- I am not technical
- Oilrigs, windmill
- Offshore/maritime technology
- I have never heard about it before and can therefore not make up an opinion
- Solcelle Energi
- Aquamedicine, energy sustainability, circular economy, ROV/underwater drones, housing and accomodation at sea
- Technology and innovation

Appendix 4: Do you believe that there could be any synergies between offshore aquaculture and other industries?

If you answered Yes on the previous question, please clarify which industries you are thinking of.

- Offshore oljeindustri, kraftproduksjon til havs.
- It's always room for improvement. It could be technical so the fish can be produced without handling. And tech to improve fish welfare.
- Answer based on Atlantic salmon, to increase productivity, consider other species that can be more cost efficient. Both cost and health wise and have tech to support that species.
- In general, all Linda of on land industries
- Windmills at sea
- Digitalization, Internet of things (ioT), offshore- subsea- and maritime technology
- Oil gas, reeneables, farming, greensectors
- Any industry that works in or around the sea.
- They could be synergies between the financial sectors and the public sector
- Geology, biology and other micro plastic-informed industries.
- Oil and subsea
- Farmer, chickens
- General food industry, supermarkets and so on
- Oil/gas and fishing
- I have never heard about it before and can therefore not make up an opinion
- Oljelekkasje fra plattformer i nærheten
- Maybe the fisheries industry, but unclear in what way. Technology from the oil and gas industry also might prove beneficial.
- Technology
- Refine waste from aquaculture and turn this into profitable goods/services
- Political, environmental areas

Appendix 5: Interview guide

"Knowledge sharing between different industries in offshore aquaculture"

The main research statement for the interviews is:

Innovation and knowledge sharing on the path to an effective offshore aquaculture solution.

Interviews are estimated to last approx. 45 minutes – 1 hour, and data will be collected using teams, and transcribed using functionality in teams.

Part 1—general question for all industries and regions

1. *Short biography of interviewee*

To begin with, could you shortly introduce yourself and discuss your role in the organization/region?

- Examples of question points:
  a. Role in the organization?
  b. For how long have you worked in this organization?
  c. What is your education and previous work experience? (i.e., in the same industry/different industries)
  d. What is your role in the region?
  e. What is your current and previous role in local/regional/national/international networks/initiatives?
  f. About the firm: what type of industry, size, history, revenue, number of employees. Are you a fully digital company?

2. *Background questions: Knowledge sharing between industries*

How is knowledge transfer in the project between different industries?

- Example of question points:

1) What type of methods is used?
2) Company's view of knowledge sharing/transferring
3) How were projects identified?
   a. Market potential?
   b. Environmental/carbon footprint indicators
   c. Demands
   d. Overall technological/economic feasibility of a project

    e. Alignment/relatedness between the company's internal resources/people with project

3. *Corporate strategy & tactics for identifying and deploying resources to the "Offshore Aquaculture" project*

➢ Example of question points:

4) How were internal capital and people identified for the project?
    a. Relevant expertise
    b. Relevant experience
    c. Relevant technology
    d. Idleness/availability of resources
    e. Other
5) How were external resources identified?
    a. Relevant expertise
    b. Relevant experience
    c. Availability of resources
    d. Other
6) What skills and background characterize the people who have been deployed?
    a. Skills and background
    b. Operative experience (what specific types?)
    c. Financial/economic (what specific types?)
    d. Strategy/leadership (what specific types?)
7) What skillset from other industries are relevant for you on this diversification projects?
8) Have you observed movement between your industry/project and other industries?
9) Barriers from skill transfer?
10) Do you find it hard to work with people from different industries?
11) What is the advantage and disadvantages in relation to offshore aquaculture

4. *Background questions: Knowledge sharing between industries*

How is knowledge transfer in the project between different industries?

➢ Example of question points:

12) What type of methods is used?
13) Company's view of knowledge sharing/transferring

14) How were projects identified?

    a. Market potential?
    b. Environmental/carbon footprint indicators
    c. Demands
    d. Overall technological/economic feasibility of project
    e. Alignment/relatedness between the company's internal resources/people with project

5. Corporate strategy & tactics for identifying and deploying resources to "Offshore Aquaculture" project

- Example of question points:

15) How were internal capital and people identified for project?

    a. Relevant expertise
    b. Relevant experience
    c. Relevant technology
    d. Idleness/availability of resources
    e. Other

16) How were external resources identified?

    a. Relevant expertise
    b. Relevant experience
    c. Availability of resources
    d. Other

17) What skills and background characterize the people who have been deployed?

    a. Skills and background
    b. Operative experience (what specific types?)
    c. Financial/economic (what specific types?)
    d. Strategy/leadership (what specific types?)

18) What skillset from other industries are relevant for you on this diversification projects?
19) Have you observed movement between your industry/project and other industries?
20) Barriers from skill transfer?
21) Do you find it hard to work with people from different industries?
22) What is the advantage and disadvantages in relation to offshore aquaculture