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MASTER'S THESIS

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Abstract

New technology emerges faster than ever before, and the development is increasing exponentially. The speed of development is too rapid for businesses to investigate and identify potential value from them. There is a need for a culture of innovation and technology adoption and must be treated as the backbone of the company's value chain.

This master will explore a systematic approach to investigate and evaluate innovation opportunities emerging from technology and business trends. The goal of the project is to prove that a systematic method may assist the industry in identifying and evaluating opportunities to achieve competitive advantages.

The method consisted of three main parts; 1. Selection and screening of industry 2. Screening of technology trends and business trends with potential for disrupting the industry 3. Identification and evaluation of ideas.

The selected industry was Norwegian salmon farming and segment was salmon sea farming production. In total, 14 ideas were elaborated in this thesis. 9 ideas were rejected by the first screening. 5 ideas reached the second screening where 3 ideas were rejected at this point. 2 ideas cleared the second screening had potential to be a business opportunity and was evaluated in a business model canvas.

The research prove that it is possible to systematically identify and screen innovation opportunity emerging from technology and business trends today. Time and access to information is identified as the two main enablers to increasing quality of the ideas, in addition to selecting an industry with innovation potential.

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I would also like to acknowledge Master student Marcio Rollin Pinheiro of the study programme Industrial Asset Management at the University of Stavanger. Marcio and me have collaborated for months to come up with various ideas which were later divided among us and further explored. I am grateful for the fantastic experience of cooperation, friendship, inspiration and patients.

Also, a big thank you to Grieg Seafood which gave me the opportunity to visit one of their salmon sea farming production locations and discuss challenges with operators in the field.

Finally, I want to acknowledge my partner Salva Marija Lukoseviciute. She has been the most important pillar throughout my five years as a student and it is in my belief that I wouldn’t have succeeded without her continuous support.

Author

Rikard Andreas Davidsen

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1. Introduction

1.1 Innovation and entrepreneurship

Companies that adapt to new and beneficial technology stays competitive while the ones that don't, fall fast behind. A historic proof of this is when the first manufacturing industries in the united states adopted to electrification. Early adopting factories contributed directly to mass extinction of traditional factories.

Technological innovation has been recognized as one of the most important drivers of success in the modern era of most industries (Schilling, 2010). Most actors in competitive markets are aware of this and have recognized the potential of disrupting technology, as explained by professor Brynjolfsson and McAfee in their book, S*econd machine age*:

> *"Where at an inflection point, a bend in the curve where many technologies that used to be found only in science fiction are becoming everyday reality"*
>
> - (Brynjolfsson & McAfee, 2016)

But, new technology emerges faster than ever before, and the development is increasing exponentially. In fact, they are emerging faster than businesses can identify value or adopt them. Many are investing heavily in technology implementation to not fall behind. In April 2018, SEB chairman Marcus Wallenberg formed an alliance consisting of two dozen giant companies in Sweden and Finland to combine knowledge and implement technology faster (Business insider, 2018). He stated:

> *"Personally, I am worried that we are not adapting to new technology fast enough"*
>
> - *Mark Wallenberg, 2018*

Innovation culture and technology adoption must have a more central role in most industries today and should be a part of the backbone of a company. Therefore, an unsystematic adoption of new technology may no longer be sufficed.

1.2 Objective

As emphasised in the introduction, technology development continues to exponentially increase and the businesses that doesn't take advantage of this, falls behind. There is a need for a culture of innovation and technology adoption and must be treated as the backbone of the company's value chain. This master will explore a systematic approach to investigate and evaluate innovation opportunities emerging from technology and business trends. The goal of the project is to prove that a systematic method may assist the industry in identifying and evaluating opportunities to achieve competitive advantages. This will be achieved by applying an approach of three steps developed at UiS and explained in the section below.

1.3 Methodology

The method which is to be explored in this project, is described below. It consists of three parts; 1. Industry, 2. Trends and 3. Ideas.

Part 1 - Industry

1. Select and screen an industry with potential for innovation.
2. Select and screen an industry segment.
3. Identify key challenges and existing solutions within the segment.

Part 2 – Technology and business trends

1. Create knowledge of technology trends and business trends

Part 3 – Innovation opportunities

1. Generate opportunities for innovation.
2. Screen and evaluate each opportunity in terms of becoming a business.
3. Rank these opportunities in terms of highest chance for business opportunity.

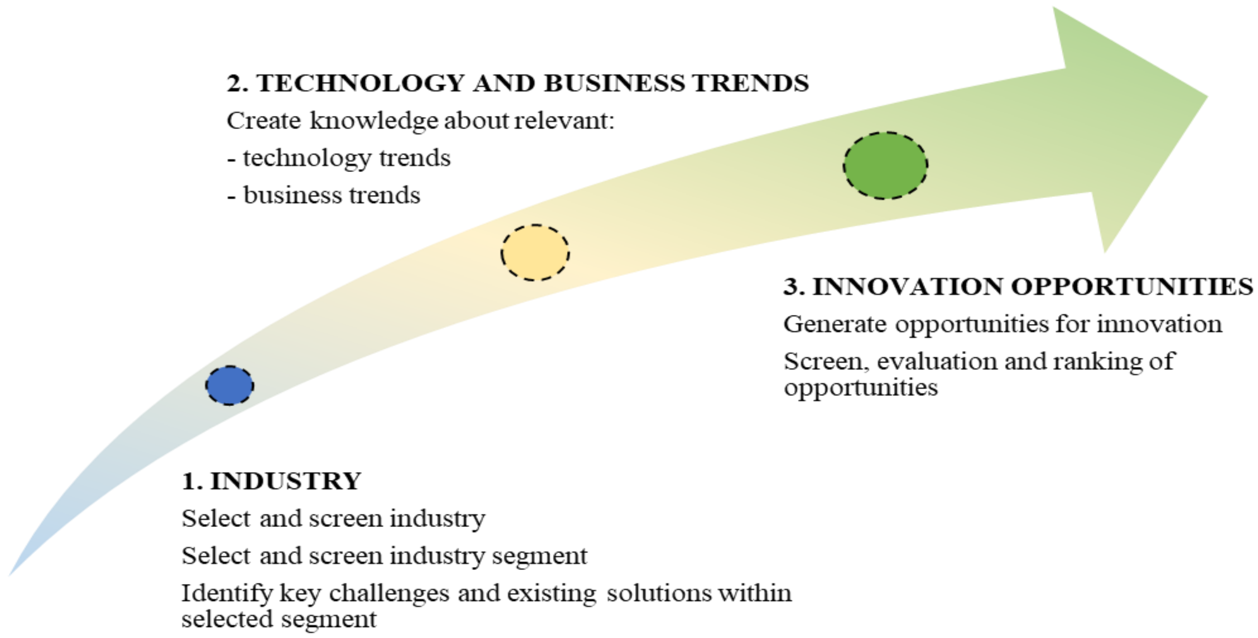


Figure 1 Process and main parts of the master thesis

1.4 Support for the project

Part 1 – Industry

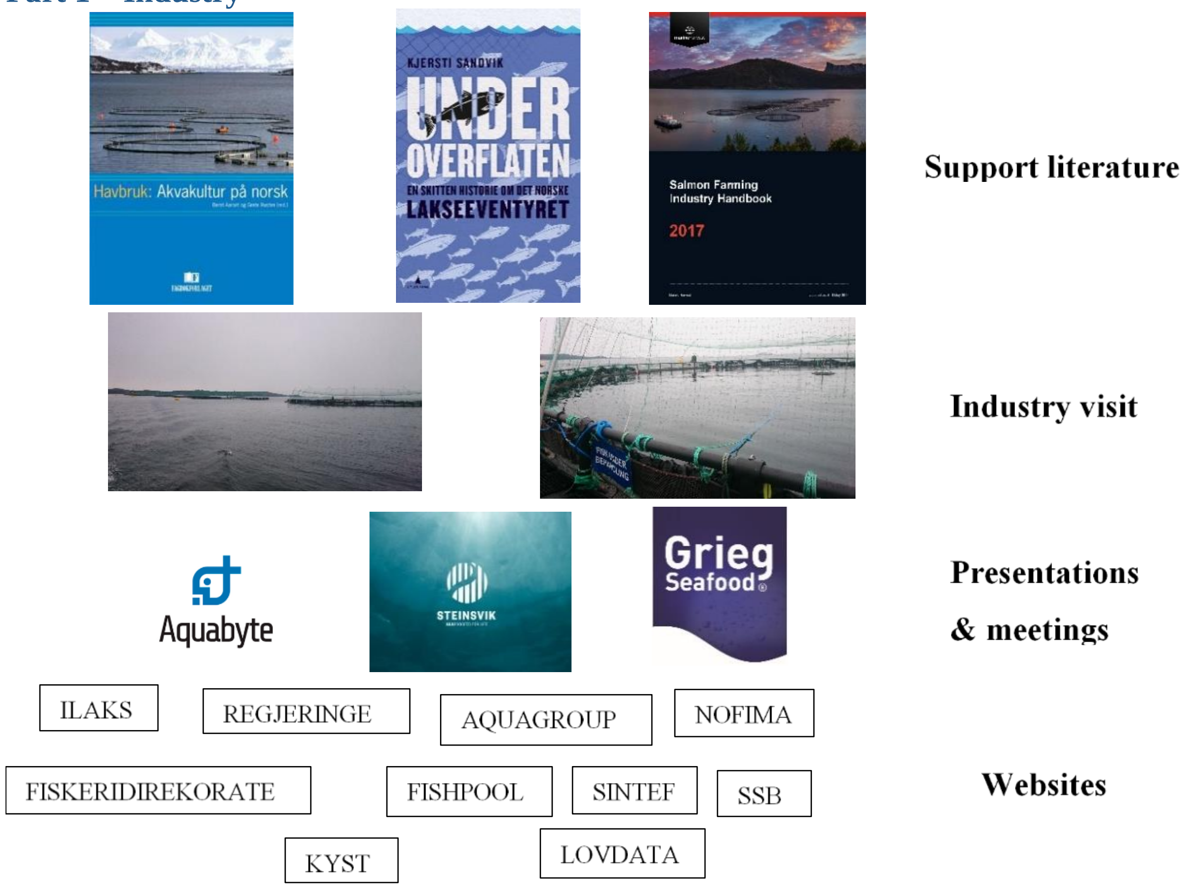


Figure 2 Resources supporting the research of part 1

Part 2 – Technology

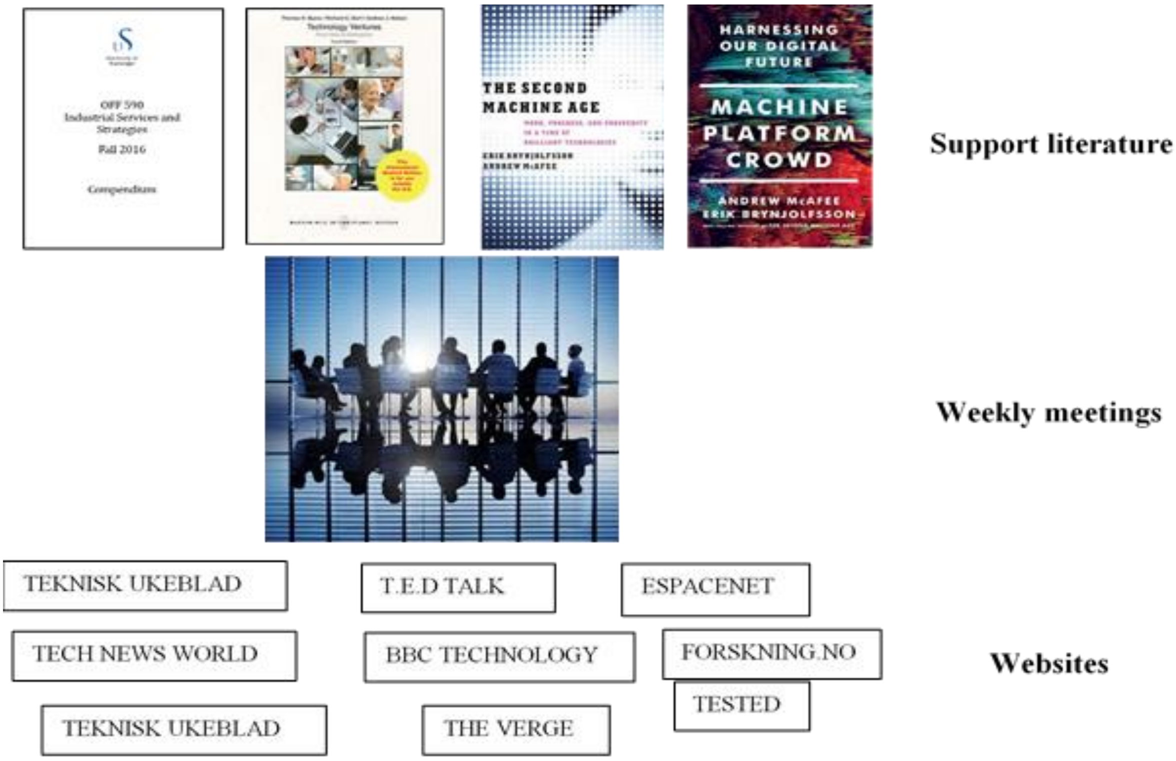


Figure 3 Resources supporting the research of part 2

Part 3 – Idea generating, screening and evaluation

The idea generation was the part of the thesis that required the most attention and research. This part was therefore a collaboration with a co-student, writing in parallel with this thesis. The ideas generated were divided in a fair manner, such that both thesis consists of ideas covering same size of problems and market. This guaranteed that the same idea wouldn’t appear twice. The process of screening and evaluation of opportunity is further elaborated in *Part 3 - Screening and evaluation of* opportunities.

2 Part 1 – Industry

The purpose of this chapter is to screen an industry for potential of innovation. The chapter will describe the industry today and discuss pros and cons and look at the future trend. Furthermore, the chapter will look deeper at a segment within the industry and screen the largest challenges.

2.1 Characteristics for selection of industry

Some characteristics should be in place to choose an industry with high potential for innovation. This list is subjective, and some points are elaborated by an individual brainstorming session by author and some are identified from the literature "*Strategic Management of Technology Innovation*" (Schilling, 2010)

1. The timing for innovation should be present such as pressure from society or government.
2. Volatile market creating loss of profit and encourage innovations to gain competitive advantage.
3. Technology-intensive commercial opportunities.
4. Profit margins must be present so that the customer have purchasing power.
5. A sizable market with space for new product and service providers.
6. Sizable problems that needs to be solved.
7. A favourable regulatory industry situation.
8. Low barriers for entrance
9. Location of market – Local, spatial or centred

2.2 Selection of industry – Norwegian salmon farming

Salmon farming is a type of fish farming which include industry processes from selecting brood stock eggs, onshore hatchery, growing the salmon to market size, slaughter and distribution to consumers. The largest market for salmon farming is supermarket (80% of the Norwegian salmon is distributed this market). The remaining market is HoReCa (HoReCa is a collective term for Hotel, Restaurant and Cafe) and fish shops. The industry value chain is visualized below.

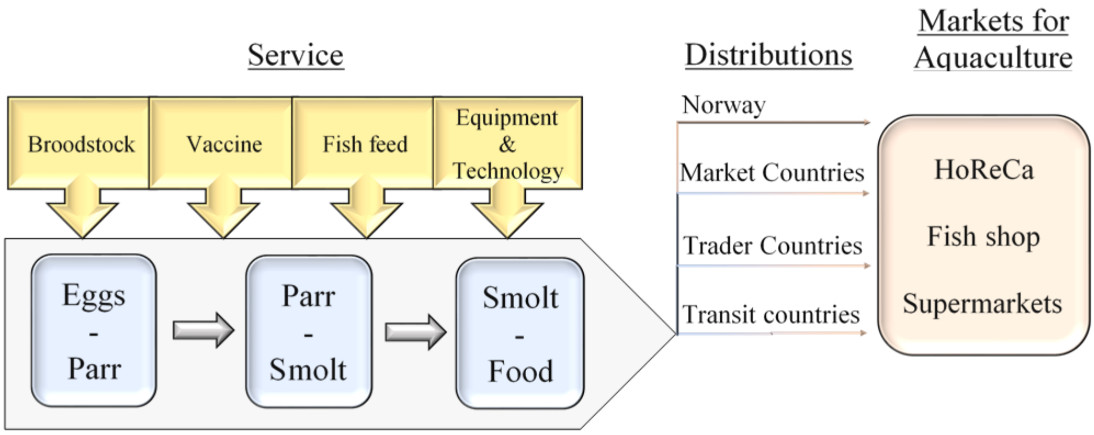


Figure 4 Value chain in Norwegian salmon farming

2.3 Screening of selected industry

Facts and numbers

70 % of the world's salmon production comes from salmon farms (Marine Harvest, 2017) . In 2016, the Norwegian production of sea farmed salmon employed 7 850 people in core activities (SSB, 2016). Most of the employment related to the industry consists of service providers, surveillance and regulation authority, logistics, technology and equipment providers, research and science, and salmon feed providers. This is estimated to be about 15000 people. Norway have the highest consumption of fish per capita in the world. Due to the small population, Norway export 95% of the total production. This makes it the second largest export seafood market in the world after China (World Atlas, 2017). Norwegian aquaculture sector was responsible for 72 % of the total export of Norwegian seafood, while wild fish export was 28 %. The aquaculture is dominated by Atlantic salmon farming with 95% share of the exported seafood from aquaculture (The farmed Atlantic Norwegian salmon represented 68,4 % total fish export in 2017). Total export sales of Norwegian salmon reached 64,7 billion NOK in 2017 (Norges sjømatråd, 2018).

Key Players

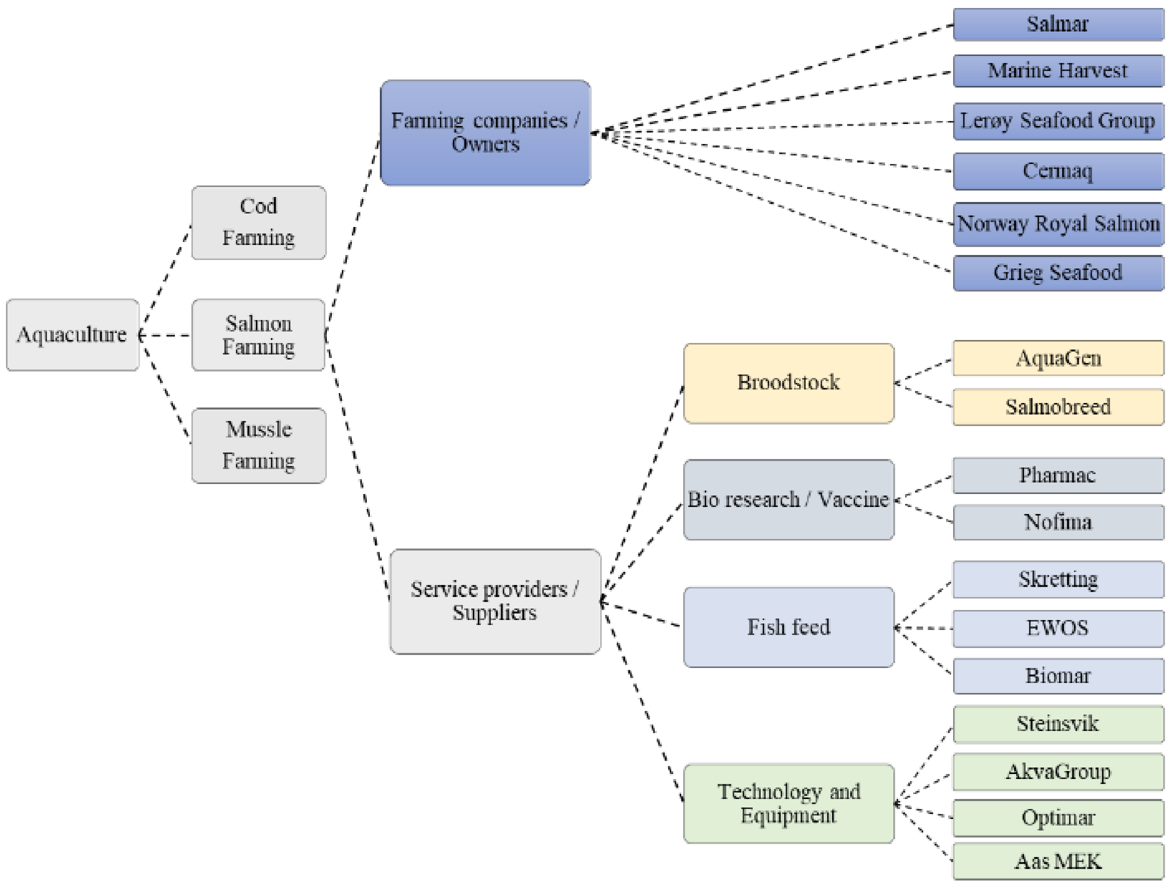


Figure 5 Mapping of the largest players

Future for the industry – Pros and cons arguments

The trend of the industry is hard to predict and influenced by many factors. Until 2016 the Norwegian salmon farming had growth in production and development. By 2016, the challenges related to aquaculture was many and only grew with the increase of production. The government therefor stopped delivering expansion permits and developed strict rules for mitigating the problems.

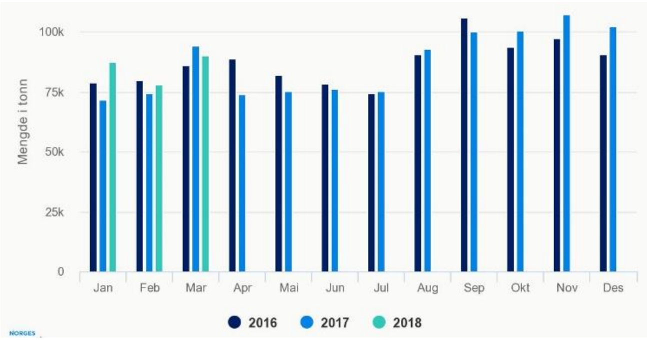


Figure 6 Export amount in 1000 Kg salmon compared to the three last years adopted from *Norges Sjømatråd*

There are many argument pro salmon farming. An argument often heard from the seafood actors are that the ocean is an obvious and logic choice for finding healthy and sustainable resources with a low impact on the environment. The reason is because the ratio to grow 1 kg of salmon is equal to 1,2 kg of fish feed making it the most efficient growth ratio among farm animals (Marine Harvest, 2017, p. 10). Another argument is that the total area the Norwegian aquaculture occupy (if all were merged into one area) it would only occupy 420 km² (The Norwegian sea is 1 383 000 km²). The continuous increasing global population will have scarcity of food. The UN estimates an increase to 9,7 billion people by the year 2050 (UN, 2015) and the Norwegian directorate of fishery estimates that the food consumption will increase 70 % by the same year (Nærings-og fiskedepartementet, 2017). Sintef estimates that the Norwegian aquaculture will therefor see the largest increase from now to 2050 (Sintef, 2012).

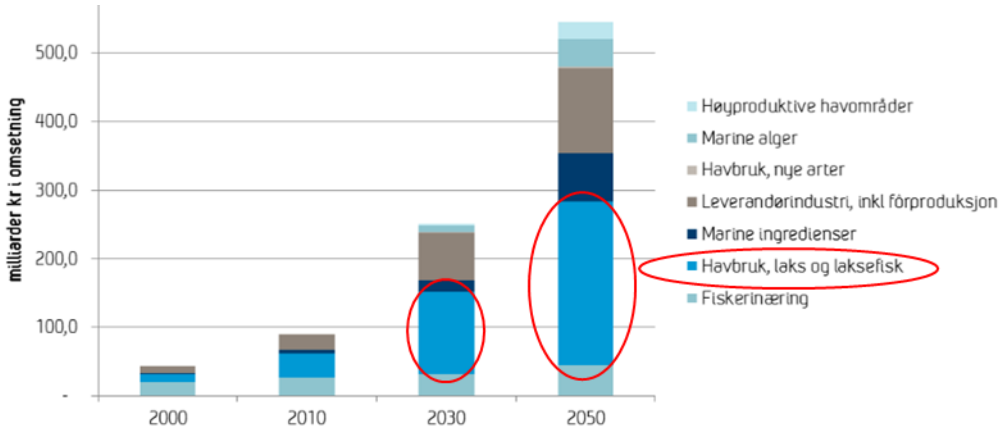


Figure 7. Scenario 2050 adopted from "*Verdiskaping basert på produktive hav i 2050"* report 2012

But there are also arguments against salmon farming. These are listed below:

- The salmon only represents 1.5% - 2% of the global fish consumption. There are other species that provides better options to sea farming.
- Fresh water versus salt water species.
- Land based instead of fjords or offshore.

It is also a very volatile market as seen in picture below. Export of Atlantic salmon in January 2018 was 58,2 NOK / Kg while in April it was 71,75 NOK / Kg (The price/Kg increased 10 % during one week in April 2018.). But the profit margins are high with a cost of production of around 34 NOK / Kg. Cost of production is constantly increasing as challenges in the industry continuous to grow.

Figure 8 Export price per Kg salmon adopted from Norges Sjømatråd website

Key arguments for selection of industry

Norwegian salmon farming is an industry with high potential for innovation. There are many reasons to this statement such as:

- It is one of Norway's most important industries with a growing trend.
- The industry is under the transition of being industrialized with fewer, but bigger actors involved, in opposition to many small traditional family owned fish farms.
- Many of the operations are still labour intensive and done in traditional ways.
- There are aquaculture equipment providers exploring newer technology today. But, there are still low barriers of entrance for entrepreneurs and technology start-ups that would establish and would still be early to the space. They wouldn't be first, but it wouldn't be so late that there are many participants with networks that have a stronghold.
- The expansion of Norwegian aquaculture has stagnated, but the demand has not. The reason for this will be further elaborated in Chapter 2.5 ***Feil! Fant ikke referansekilden.***.

2.4 Selection of segment – Sea farming production

The segment was selected because most of the challenges identified in the industry screening was pointed towards the sea farming production. The reasoning is that the largest market for technology ventures and development of new solutions to remove or mitigate challenges exists here.

2.5 Screening of segment

The industry segment today

Norway have between 3700 and 4000 cages owned by 1000 farmers distributed all over Norway. It is an impressive number for such a small country. It is the largest segment in the industry with an EBIT (earnings before interest and tax) of 22 billion NOK (EY, 2017).

Figure 9 Salmon farming production site inside a Norwegian Fjord adopted from (Norges sjømatråd , 2017)

Key challenges in the selected segments

There are many challenges to overcome in Norwegian salmon farming today. This chapter will give a brief introduction to the key challenges. The size of the problems will be discussed in Part 3 *Screening and evaluation of opportunities*.

Biomass estimation is the weight of salmon in a cage normally measured in tonnes. There are two main reasons why it is important to estimate the biomass. Firstly, the biomass will estimate how much revenue you have in the cage. It will estimate the size and weight of the salmon and estimate when they are young adults (Salmon are harvested as young adults because the farmer achieves the highest price per kilo and can sell to more expensive market such as France or Japan). The second reason is to stay inside the regulations limits. Each permit allows 7200 tonnes of biomass per location and a maximum of 200 000 salmon per cage. The reason for this regulation is to ensure that diseases doesn't spread too quickly between the fishes and to control that the pollution to the aquatic environment doesn't become too concentrated.

Lice attaches to the skin of the fish and slowly kills the fish. Lice spread fast, one female lice can lay 100 000 eggs. Today, the Norwegian industry use above 50 million NOK a year for research and development to mitigate the lice problem (Lusedata, 2018). There are no sustainable solutions for the lice problem today and it is one of the main reasons to why Norwegian Aquaculture expansion have come to a halt. If enough salmon have lice in a cage, the farmer is forced to either slaughter the fish immediately (which will lead to loss in revenue since the salmon isn't full size) or use mechanical delicing. To mitigate and avoid lice the most common practice is to use fish species that eats lice such as lump fish seen in the left figure below.

Figure 10 To the left; Lump Fish (SNHH, 2018), To the right; Lice attached to salmon (Seafood watch, 2018)

Fish health is defined as the status and wellbeing of salmon in a cage. There are some common diseases in Norwegian salmon farming. Pancreas disease affects the salmon's appetite. The salmon stops eating and eventually dies. ILA or Infectious Salmon Anemia kills the salmon fast and spread between salmon and cages like wild fire. Fish health also involve stress, fear, and right condition for the salmon to thrive such as, temperature levels, oxygen levels, salination levels, and water currents. Salmon dying in the cage is estimated to be an average of 16% between 2012 and 2016. This is further described in the table below (Jensen, 2017). Lice is related to fish health, but it is such a large problem that it is identified as an own challenge in this thesis.

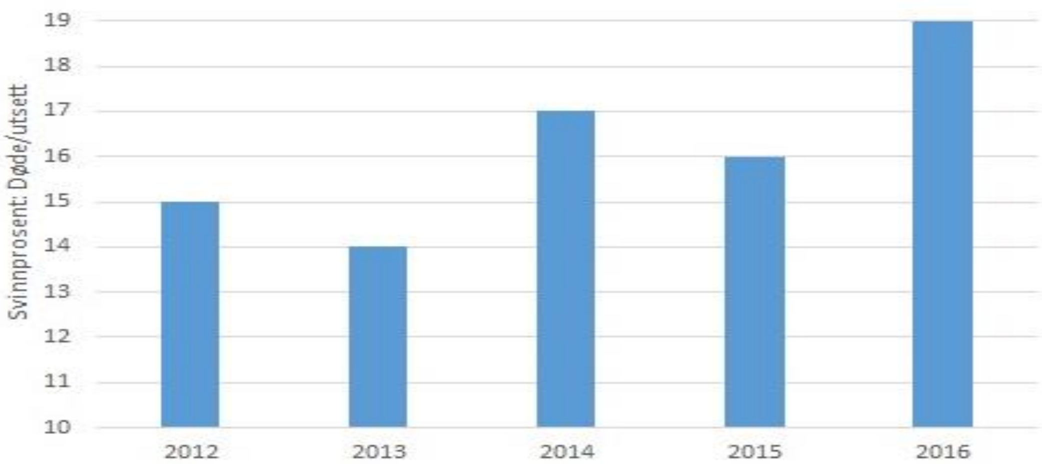


Figure 11 Yearly percentage of death of salmon in Norwegian sea farming production

Feeding operations is the feeding of salmon in the cage. Fish feed is the largest cost for fish farmers. The feed normally consists of 70% vegetable ingredients and 30 % of fish oil and fish flour. It takes 1.2 Kg of feed to produce 1 Kg salmon. The total cost to produce salmon in 2016 was 36 NOK/Kg. This is an 96% increase since 2005 and the main reason is the increasing price fish feed and lice (Iversen, 2017). The price of salmon pellets has increase from 9 to 18 NOK/Kg the same period (2005 - 2016) There is also a lack of standardization in the feeding operator (Anonymous, 2018) and every operator has their style of feeding. The lack of standardization makes the operation vulnerable to human error. The operator stops feeding based on two main variables. Movement of the fish (detects appetite) and pellets falling through the net (operator watches a subsea monitoring camera).

Fish escape is defined as the disappearance of salmon from the cage. The problem is often due to holes in net of the cage due to storms, manufacturing failure, damage by boat propellers (or other machines, operating near the cage such as cleaning equipment). Fish escape has consequences both for the fish farmer and for the surrounding environment. For the fish farmer, this means loss of revenues both because they lose the salmon and because the company must pay back each fish that a fisherman manages to catch. The other issue is that the escaped salmon travel upstream in rivers and spawns with the wild salmon. There was no standard that prevented fish escape until 2011. The government released a regulation called *"NYTEK - requirement for technical standard in floating aqaucultural facilities"* (Nærings- og fiskeridepartementet, 2011).

Food safety is an increasing global trend for consumers. The consumers want to be assured that the food they eat is safe and is produced under environmentally sustainable conditions. Firstly, a large issue in the food industry today is the lack of information about the food we eat. We see constantly in the media about food producers which are hiding information, being dishonest or tampering with results. Consumers are increasingly concerned and more involved in the value chain of food. This includes nutrition content, freshness, treatment and health of animals, genetical modifications, wages of workers, national or international processes and area of origins, climate emissions related to food process such as miles travelled.

Surveillance agencies. Today, surveillance agencies use a lot of resources to control and ensure that fish farmers are following rules and regulations. There are various agencies such as *Directory of fishery*, *Food Safety Authority*, *Norwegian Coastal Administration*, *County Governor* and *Norwegian Water Resources and Energy Directorate* that has supervisory tasks in relation to the environmental impact from fish farming sites (LAKSEFAKTA, 2016). The task includes control of biomass, authorized and approved equipment, pollution levels, knowledge within the company etc. There are no standardized methods to gather this information today, but the rules and regulations are written down in "*Akvakulturloven*", "*Matloven*" and "*Forurensningsloven*".

Supply chain such as logistics is seen as an important competitive advantage especially since the international sushi market is expanding. The main parameters here are time and cost of transportation and normally supply is slowed by complexity and lots of point to point communication between onshore, offshore and air providers, freight forwarders, custom authorities, approving agencies, customs brokers governments and ports.

Hazardous work condition is defined as the high risk and consequences of incidents and accidents within sea farming segment. In 2016, SINTEF named aquaculture as the second most hazardous place to work in Norwegian industry (fishermen were named as number one hazardous place to work). This study comprised both injuries and death of fish farmers. (Nodland, 2016). The most common accidents are drowning and hypothermia.

Figure 12 Fish farmers working in hazardous environment and with heavy equipment's.

Pollution to the surrounding aquatic environment occurs by three main reasons. Firstly, fish feed (pellets) that hasn't been consumed by the salmon fall outside the cage and pollute the sea bottom. Secondly, salmon droppings / faeces. The Norwegian salmon framing sewage was estimated to correspond to 8,8 million people straight into the fjords and ocean (hammerfjeld, 2010). The third reason is pollution from the barge, workboats and other boats used in operations and transportation. These normally run on diesel and gasoline.

Development permits are given by the directory of fishery and allows the salmon farmer to expand the production. One of the largest challenges for fish farmers today is to gain new development permits. There is no way to expand production once a permit has reach its limit of 7200 tonnes. The authorities have decided to not announce any new permits until the above-mentioned challenges are proven to be reduced. This means, that the lice problem must be under control, minimal disruption of aquatic environment and no fish escape. Today (16.04.2018), there are 62 development applications pending in Norwegian directorate of fisheries. So far 8 of these have been approved while 30 have been denied (Fiskedirektoratet, 2018). The main reason for denial is “not innovative enough” for sustainable solution. The UN also established seafood sustainability goals for global aquaculture for 2030 (Regjeringen, 2015). The goals for aquaculture is that the industry segment:

- Cannot have a negative effect on species diversity.
- Must be part of the solution to climate change.
- Will use the ocean in a way that promotes environmentally sustainable development.
- Will contribute to increasing world food production.
- Will contribute to a positive Norwegian society development.
- Will help to improve living standards in the world.

2.6 Conclusion for industry

This chapter have identified an industry with large challenges, a growing trend and large opportunities for innovations. To summarize, the world’s population is growing, and new food sources area assessed to supply the increasing demand. But, it is hard to predict what role the Norwegian salmon farming will play for the future of food demand. There are many species that are less labour intensive and easier to grow than salmon. Norwegian salmon is expensive and sold to people that can afford the luxury of Norwegian salmon. Either way there will be a market for salmon, question is if it will be for quality or quantity. Salmon farming will be an important part of Norwegian industry in the future. The industry has stagnated due to strict expansions permit and the government intend to keep it strict until the industry can deal with the challenges discussed above. The government have denied many permits due to not innovative enough and still use traditional method today. The industry holds the characteristics and opportunities to improve processes and operations with the emergence of new technology trends.

3 Part 2 – Technology and business trends

3.1 Technology trends

This chapter will present and describe the technology trends that will have an important impact on aquaculture industry and relevant to achieve the identified opportunities. Some of the technology are more developed than others, but this will be further elaborated in the evaluation of opportunities among other parameters. The figure below will describe the technology trends and sub-trends with the largest impact on the ideas in this master thesis.

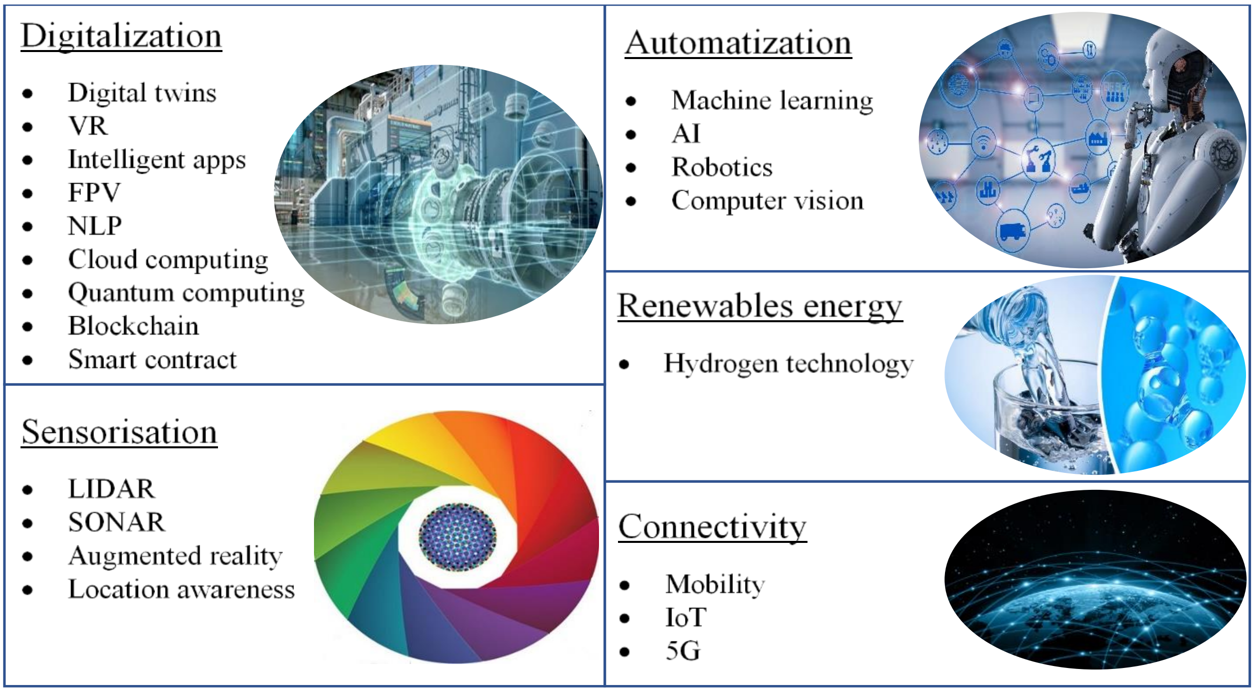


Figure 13 Overview of relevant technology trends

Sensorisation

Since hardware are getting smaller and cheaper, sensors become cheaper to produce. The result is multiple sensors in one system, monitoring various wanted parameters. Today sensor can sense motions, positions, presence, humidity and moist, acoustics, vibrations, flow, force, accelerations and much more (Muhammad Ahmad Tauqueer, 2017).

LIDAR (Light Detection and Ranging) is the use of a laser transmitter, emitter and receiver. It can use different light sources and target everything from metal, clouds to single molecules (Wikipedia, 2018). The LIDAR transmit a laser pulse, and when the pulse hits an object it reflects to a receiver. LIDAR can emit many 100 000s of laser pulses every second (Team, 2016). The technology is mostly used for mapping and scanning surrounding areas and therefore commonly used to create autonomous cars. The LIDAR becomes the eyes of the car and can navigate safely through traffic.

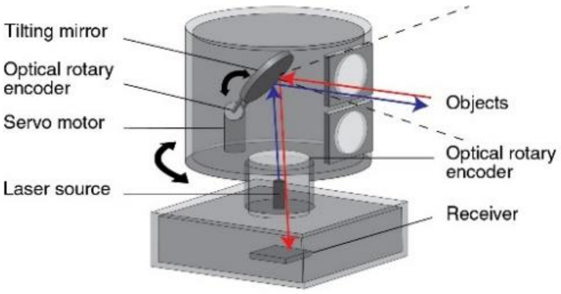


Figure 14 360° LIDAR adopted from webpage Renishaw innovation (innovation, 2018)

SONAR (SOund Navigation And Ranging) works in a similar way but instead of light, it emits and receives different frequencies of sound. SONAR is the use of ultrasonic sensors. It consists of transducers to convert electrical signal to sound and opposite, and transceiver that transmits and receives sound. It is commercially used by fishermen to find scholars of fish. In this case, the sound wave echoes back to the sonar when it hits an object, and the fish is seen on a screen on the boat. The figure below is a typical image of sonar imaging. The reason for using sonar instead of LIDAR is that sound travels better than light underwater.

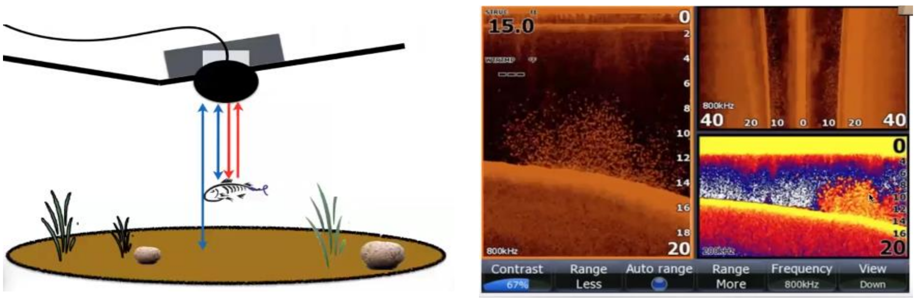


Figure 15 Sonar to detect fish and image from boat adopted from (Kirt Hedquist, 2016)

Until recently, the right picture above was the best quality you could get from a fish detecting sonar. But now, it is possible to separate each individual and create 3D image as seen in the picture below. The sonar also detects other objects in the water like different type of seabed soil, rocks and seaweed.

Figure 16 3D image from fish sonar (Kirt Hedquist, 2016)

LIDAR and SONAR can create digital images and becomes the eyes of a machine. Furthermore, if the machine can be taught to process, interpret and understand the elements in the digital images, we call this computer vision (see technology trend *Computer vision* and *Machine learning*).

Augmented reality is an environment where the real reality is combined with illusions, created by artificial sensory impressions. These are merged with natural impressions so that they can be part of an overall reality experience (Store norske leksikon, 2018). An example is the Astro reality app, where the user can point the camera of the phone towards an object and an app recognizes the object (see picture below). This will have many applications in the industry in the future, for example, monitoring of machines.

Figure 17 Example of the Astro reality app adopted from (Tested, 2018)

Location awareness trend is to achieve continuous knowledge about locations to objects. A well-known system is GPS which is operated by the US Department of Defense, and the space segment consists of 24 satellites (Department of Defense , 2018). The system will has enabled autonomous vehicles and vessels.

Digitalization

Digitalisation in this setting is explained by the below quotation from IT glossary (Gartner, 2018):

> *"Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business." – Gartner, 2018*

Digital twin is a digital representation of an object in the form of software. (IT-ord, 2018). One of the main enables for this technology is Moore's law which results in cheaper storage and processing of data. A gigabyte in 2000 cost 11$ while in 2016 it was 0.02$ (Brynjolfsson & MCAfee, 2017).

The twin can provide information about asset condition and will have a large application in inspection segments in the future. This technology can also be used to run simulations to try various options and solutions before applying it on the real asset.

Virtual reality is an illusion, usually generated by a set of goggles placed in front of the user's eyes. The system exploits different information technology, which gives the user an experience of being in a fictional place. VR will have a great impact for design of concepts. Both to present the design but also to enable global collaboration of design. The technology can also create a virtual room where people can have meeting without being there. This has been tested in the Norwegian offshore oil and gas industry.

Intelligent apps have increased exponentially since smart phones came to existence. They are only intangible and can deliver personalised services for each of the users. Apps are being used in most professional settings today, such as reporting of hours, check lists, reading emails etc. The intelligent app exploit machine learning and collect various data available from the smart phone to improve the user experience.

FPV glasses (First Person Vision) are 360° glasses, like virtual reality glasses but won't reflect a virtual world. It is an improved interface which can monitor operations and remove distractions that comes with screens today (background distraction such as light and noise). The user can move the head with the FPV glasses on and a camera, monitoring an operation, will respond. The technology uses a gyroscope to move with the motion and movements of the head. Today it is mostly used in hobby drone activities.

NLP (Natural Language Processing) is computer speech recognition. This technology hasn't matured enough to be reliable in industries today. But it will have a large impact as an interface as it matures. For example, an operator can easily ask for information about maintenance schedule or real-time data from an asset. The head of the machine learning department at Carnegie Mellon university said in 2016:

> *"Where at the beginning of a ten-year period where we're going to transition from computers that can't understand language to a point where computers can understand quite a bit about language."*
>
> \- Tom Mitchell

Cloud computing enables people to store, co-create and share data, models, software's and other intangible values, globally. This have benefitted for example, ecommerce such as Amazon to rent out algorithms / digital platforms to companies that need to collect user data to personalize a product or service.

Quantum computing exploit quantum mechanical phenomena, such as superposition and quantum compression, to perform calculations, and is fundamentally different from a classic computer. It will be one of the pillars for fast big data processing, real Artificial Intelligence and make computers much smaller as seen in the figure below.

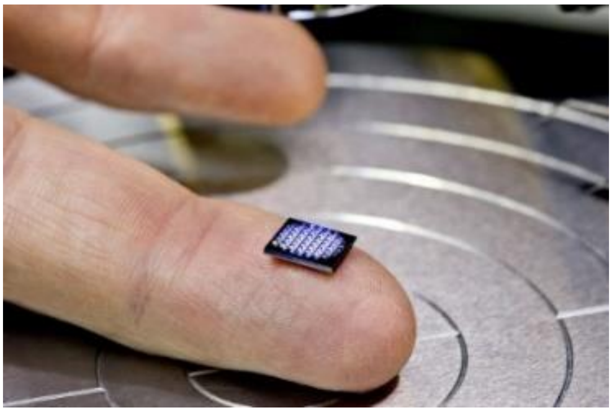


Figure 18 Worlds smallest computer from IBM – Size of a grain of salt (Miller, 2018).

Blockchain is a list of records. The record can contain data about a transaction, a digital contract (smart contract), approved projects, logistic permits etc. The records are referred to as blocks. Each block contains data about the block, a timestamp and a link (hash pointer) to previous blocks. The blockchain is distributed between various actors / peers with interconnected machines. The peers must verify and validate a transaction before it is approved, these people are called miners. Once the transaction is recorded, it is given a block, permanently linked to the chain and secured. The idea is to create a paperless, tamperproof and transparent data system. By tamperproof it means if one peer tries to change the data in a block, the other peers in the chain will notice and stop the change. The technology is explored by some industries. One example is an Irish agricultural company that made a 100 000 $ transaction using blockchain in 2016 (Andrew McAfee, 2017). Transaction example using blockchain:

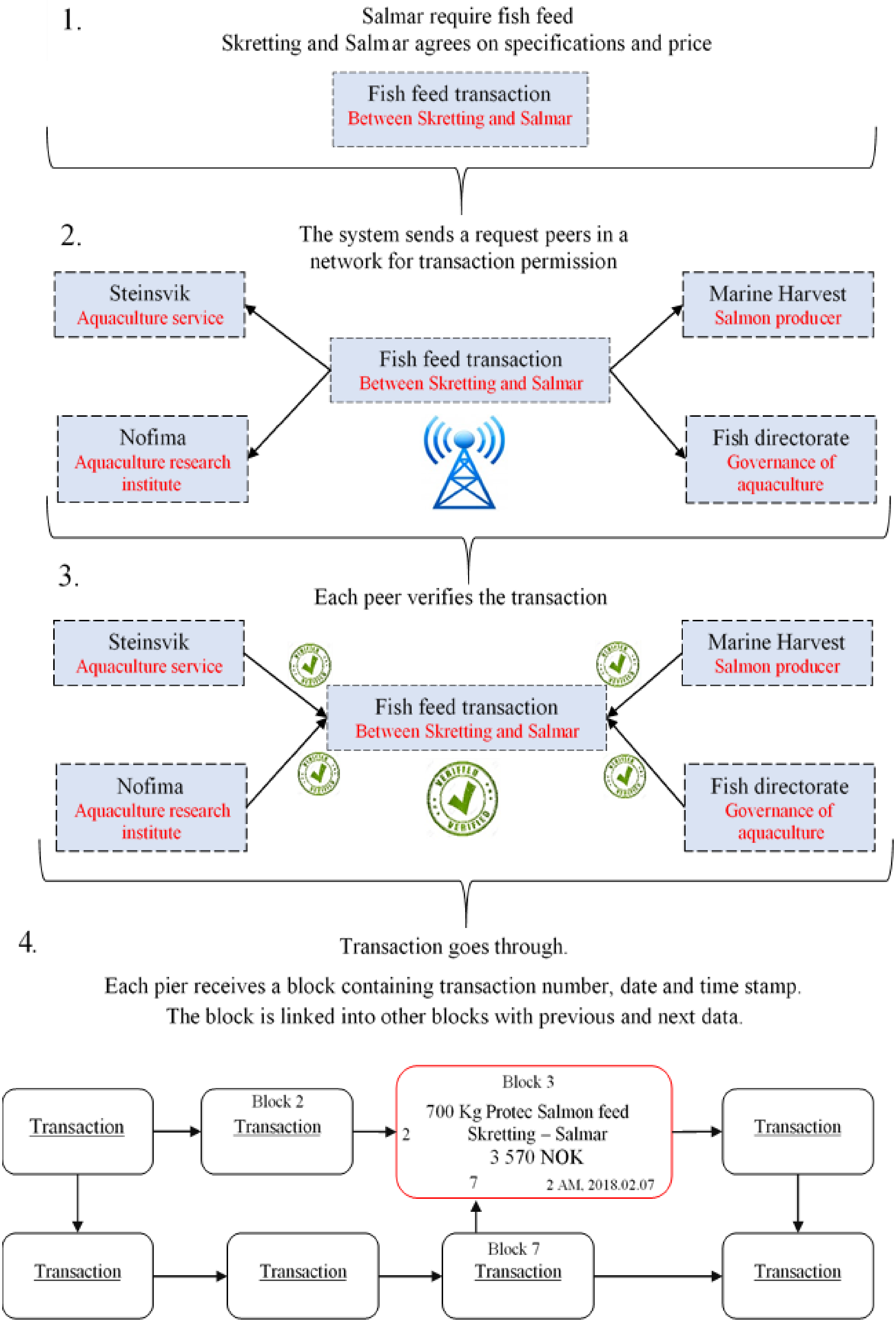


Figure 19 Example of transaction process within blockchain

Smart contracts are digital contract only without a middleman / owner that can change the contract. In the same way as transactions, the contract is verified by multiple peers, copied, stored and distributed among the blockchain network.

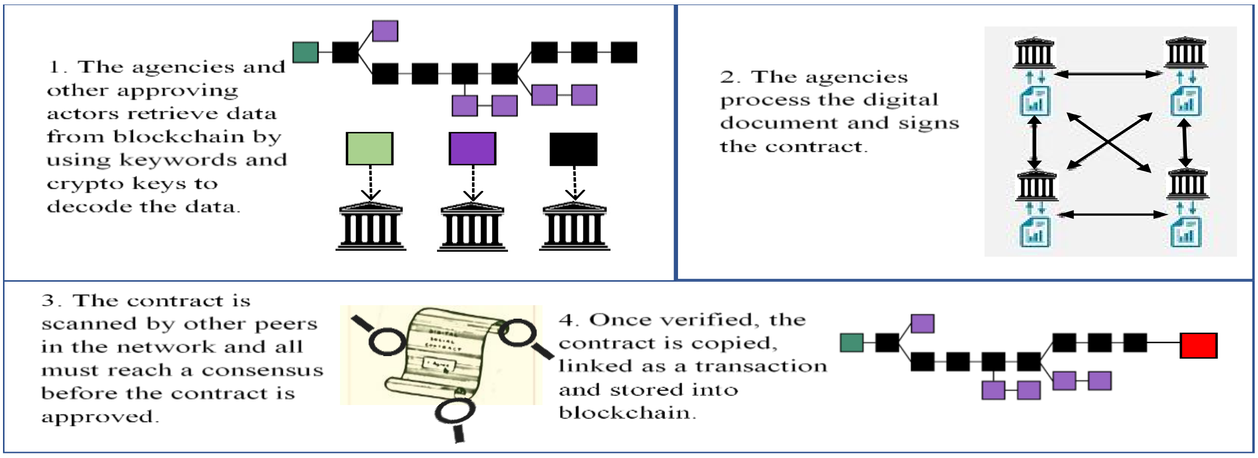


Figure 20 Example of smart contract using blockchain technology

Automatization

Automatization can be defined as making things autonomous, creating machines to have self-control and operate without human intervention. (Muhammad Ahmad Tauqueer, 2017)

Machine learning is achieved when a computer can independently make models and look for tracks in large amounts of data, without being told exactly what to look for (PWC, 2018). A normal computer will have an input and an algorithm and create a result. A computer with machine learning will have access to an input and a result but must create an algorithm to achieve the result. The technology is now most importantly used to analyze pictures of cells to recognize cancer. The technology will improve its algorithm by every data point the machine is fed.

AI can be described as the ability to acquire and apply knowledge and skills (McGregor, 2018). A big step for AI is the robot Sophia which also have acquired a passport and citizenship in Saud-Arabia (The Jakarta Post, 2017). Sophia utilize technology such as machine learning, computer vision, robotics, quantum computing, and natural language processing. Another use of AI in digital newspaper industry is SCI-gen, article generation. It produces articles based on wanted information. The newest AI developed (09 May 2018) is Google AI which now can make appointments and delivering orders by talking to people on the phone. This will impact most businesses that are dependent on customer service. (Digg , 2018)

Robotics are used to replace manual labour to achieve higher precision, faster process and lower cost such as car manufacturing industry. It can also replace manual labour that is hazardous for humans to do, for example replacing divers to inspect offshore structures and vessels with ROVs. Another type that can be classified as robotics is additive manufacturing / 3D printing. A lot is happening in this area and summarized in the figure below. The outlook for additive manufacturing will be a new partnership between nature, human and technology. The designer co-produce with technology. We can simply tell a software what we want to achieve, and the software will generate millions of options.

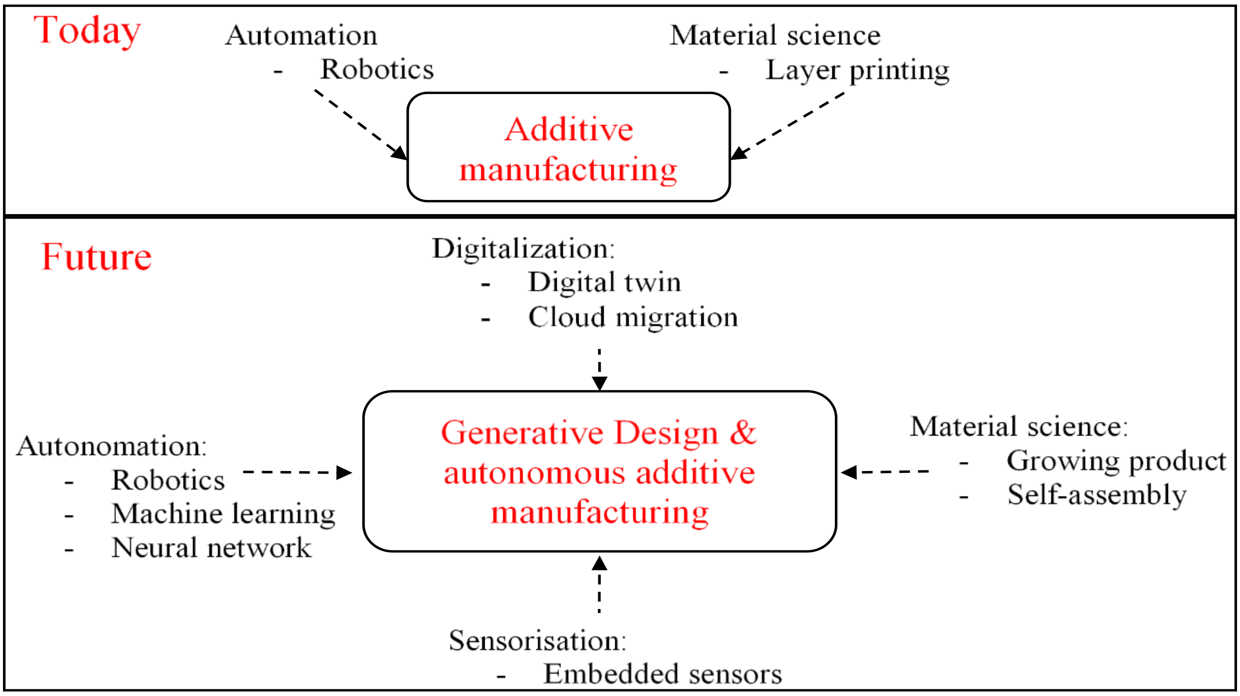


Figure 21 Summary of how the additive manufacturing will grow as a trend in the future

Computer vision is a method for the computer to sense its environment. The computer has sensors such as LIDAR, SONAR, camera etc. that gathers data. The computer has already learned characteristics of various objects and will then interpret the data that the sensors transmit. This is used most commonly to achieve autonomous vehicles to navigate safely on the road.

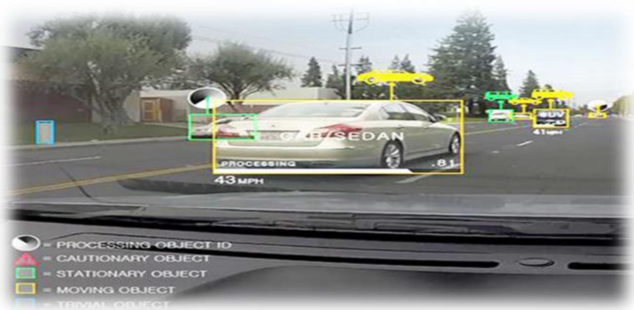


Figure 22 Example of self-driving car with computer vision adopted from report from PhD UiS (Tauqeer, 2018)

Connectivity

Connectivity is when assets, devices, machines, platforms, systems, sensors and other things that generate data, are connected. (Muhammad Ahmad Tauqueer, 2017)

Mobility, we see an increase in machines being mobile today, meaning wireless. Technology that have led up to this is sensors, location awareness and robotics. For example, instead of ROV (remotely controlled vehicles) we now research the options for AUV (autonomous unmanned vehicles). An industry that have especially been disruptive by the trend is lawnmower manufacturer. Drones are also disrupting the delivery industry such as amazon.

IoT enables equipment and assets to become intelligent by talking to each other. Things that can be connected are anything that have data of value such as machinery, equipment, materials, structures, computers etc. The largest enablers to IoT are sensors, increased process power, battery technology and wireless technology (can also encompass cloud computing). It can make a smart environment reducing waste (electricity, water, food, CO_2 etc) and optimize processes. It can for example, help monitoring machine health and schedule maintenance, improve inventory management and ordering, measure vibration and strength of structures during construction, increase productivity and spot bottlenecks, and increase safety of both staff and asset etc.

5G is the latest generation mobile network and is estimated to be mainstream in 2020 (Salomonsen, 2015). The new network will be a hundred times faster than the 4G network. There are still some barriers towards this technology such as new security threats, privacy for user, collaboration and consensus of development and creation of standards. The 5G will be a large enabler for most technology trends discussed above since they all require processing big data.

Renewables energy

Renewable energy is the creation of electricity with low impact on environment and does not decrease / exhaust earth resources in the process.

Hydrogen power technology is created by separation, storage and usage of hydrogen atoms. The separation is done by an electrolysis process in water. The reaction will be formation of positive and negative ions which is drawn against each electrode. The reaction will cause hydrogen gas and oxygen gas to rise from each electrode. The process demands electricity from a battery and one cubic meter hydrogen gas requires 4,2 kWh (Nohrstedt, 2018).

Today, only 20 cars in Norway uses hydrogen as fuel. There are two main reasons for this. The first one is that the process to separate hydrogen difficult and relies on an external energy source. But the price and difficulty for turning hydrogen to fuel is the same as producing petrol (Nohrstedt, 2018) . The second reason is that hydrogen is highly explosive if exposed to sudden large amount of energy, a smaller car collision can therefor escalade to fatal injuries.

The reason for writing about this energy source, is because a university in Sweden (Kungliga Tekniska Høgskolan) are researching solutions to the issue. The university in collaboration with car manufacturers are launching a hybrid car fuelled by electricity and hydrogen in the end of 2018 (Nohrstedt, 2018). The idea is to fill distilled water in the fuel tank. The electricity is then used to create hydrogen gas. In this way, there is not enough stored hydrogen at any point in time to be fatal. The vehicle will double the range from an electrical car and the emission released from the vehicle is water as hydrogen atoms attach to oxygen again.

3.2 Relevant business trend

Various business trends were explored in this master. The figure below will describe the some of the business trends with largest impact for businesses today.

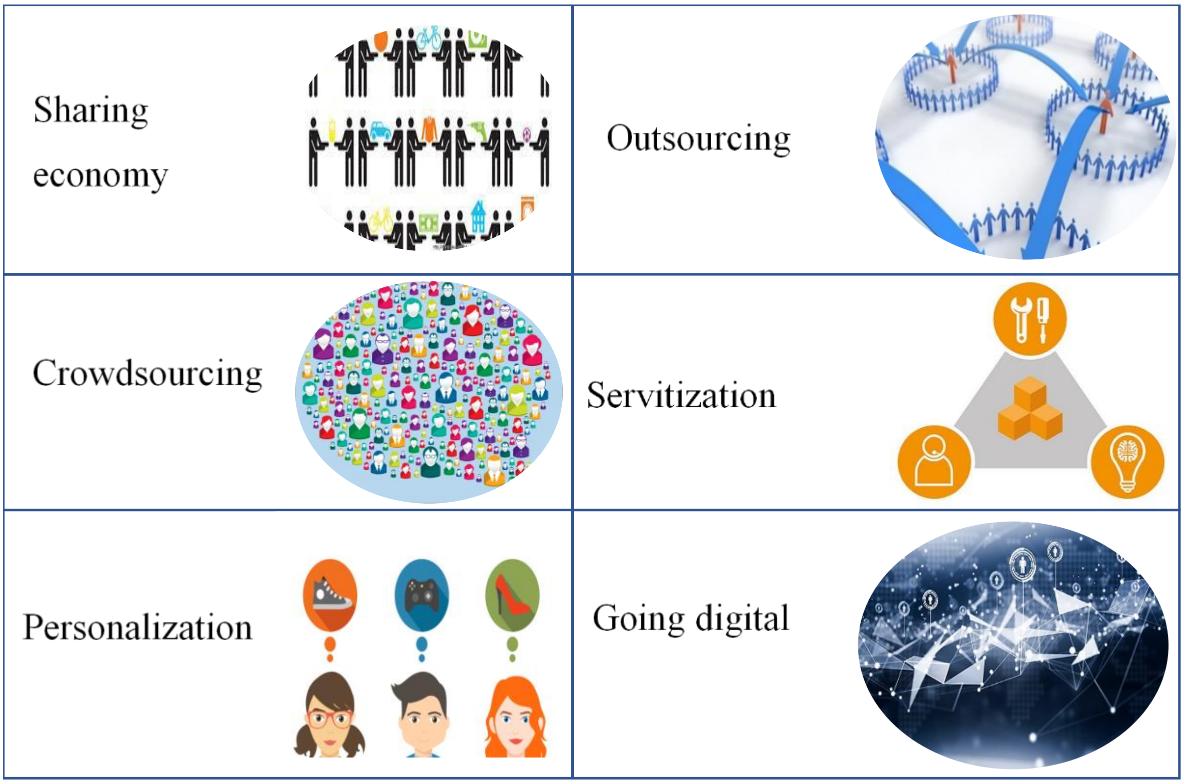


Figure 23 Overview of most relevant business trends

Crowdsourcing is collaboration and sourcing of ideas by involving more people. The trend enables people to collaborate globally to achieve greater solutions. One method to achieve great ideas through crowdsourcing is to search and combine the most valuable ones. The largest technology enabler for crowdsourcing is ICT (information and communication technology). One of the earlier example of this is from NASA. In the 1970s, NASA had no method available to predict solar flares. NASA tried internally to solve the problem for 35 years. Eventually, NASA posted the problem online and got a solution from a retired radio frequency engineer (Erik Brynjolfsson, 2017). Another more present and successful example, is Wikipedia (Wikipedia is a digital library where any person can contribute with knowledge and information). Another way of using crowdsourcing is to get validation of development of new products. The manufacturer can release concept of various models and the product that gets the best response will be manufactured.

Servitization is the opposite to selling products. For example, if a person wants a 1-inch hole in the wall, he can either buy a drill (buy a product) or hire a guy to drill the hole (buy a service). The consumer trend is that we only want the value of the result without creating an ownership of how to achieve the result. To evaluate if a solution should be a product or a service is based on the enablers and barriers of the services. A product or service doesn't have to be fully tangible or intangible. For example, a machine can be sold as a product with a service contract for maintenance. Leasing is an increasing method where the consumer pays a fee for using a product without taking ownership. The leasing agreement normally cover updates, maintenance and other costs associated with owning the asset.

Going digital is a trend that have grown with the expansion of the internet. It can be described as various parts of the value chain becoming digitalized to tap into a global market for a much lower cost and instant. For example, more and more businesses today see the benefits with the use of social media as marketing. The table below is a statistic of Norwegian salmon farming companies using social media.

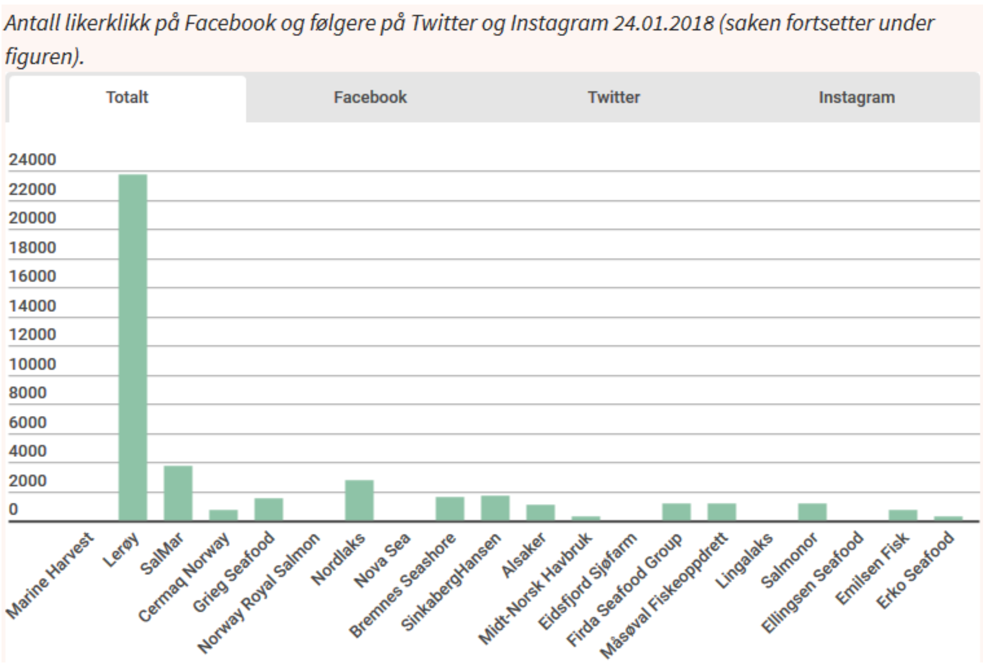


Figure 24 Statistics of followers and activity from various social media platforms (ILAKS, 2018)

Another benefit of going digital is to have AI customer support online. This means that customer globally can ask questions and order products and services from a business by chatting with an AI software. This enables a 24 hour up-time of the business without any extra manual labour.

Outsourcing is a long-going trend but is growing because of increased control and trust through digital tools. Almost all activities in the value chain can be outsourced such as production, marketing, logistics, sales, customer service, HR, IT, R&D etc.

Personalization is the trend of modify or customize each product or service to fit the customers need. This is done by gathering of various data such as cookies form websites, location, profession, public information like Facebook such as age, gender and so on. But not only product and services are personalized but also the market. For example, this master requires various online searches for information online about aquaculture. Therefore, commercials on various webpages sends information of fish farm equipment and other aquaculture related products. This is often done by artificial intelligence marketing software's.

Sharing economy is the sharing of assets to utilize larger part of owned resources such as products and services. A Norwegian example of this is *Naboen* (The neighbour) where people can borrow equipment, tools, machines for house-renovation or other repairs of buildings (Naboen.no, 2018). The main enabler for this trend is global connectivity such as internet where people can create platforms for a low cost and share information and connect peer-to-peer. The largest and most recognised companies using this trend is Uber and Airbnb. They don't own any products or services but a platform where peers can share their cars or homes.

3.3 Conclusion of technology and business trends

The purpose of this chapter is to give a brief introduction to the technology trends and business trends disrupting industries. The trends will further be used in the next chapter to generate and screen ideas.

4 Part 3 - Screening and evaluation of opportunities

4.1 Approach

A set of models was used to evaluate each idea generated. The purpose is to screen each idea with the same criteria to further rank them in terms of innovation opportunity. As earlier mentioned in the beginning, *Method – Part 3 Innovation opportunity*, the research for this master was in collaboration with a co-student and therefore ideas were divided among us.

Screening 1 – Initial screening of idea

Each idea will be investigated in a systematic and standardized way to easily achieve full overview of the idea. These are elaborated in the table below.

Table 1 Structure for initial screening

Criteria	Description
Title of idea	The title includes what problem it will solve and what technology will be used to achieve it.
Existing method	The paragraph explains existing methods to deal with the problem.
Problem size	The problem is explained and categorised from 1-4 (more information about this below).
Description of idea	The product or service idea and its function is explained and often illustrated.
Hardware	Explanation and often illustration of hardware for product / service
Software	Explanation of function of software and often illustration of software for product / service.
Revenue model	A short description of how to create revenue: One-time payment, service contract, leasing, subscription or hybrid models etc.
New customer groups	Discussion if the idea will create new customer segments outside salmon farming.
Key challenges solved	Description of benefits from this idea.
Issues with the idea	Details that aren't fully addressed and may create problems with realizing the idea.
Ranking of idea	Idea is ranked and illustrated in a diagram (this is explained below).

Lastly, as a conclusion of the idea, the quality of the idea and the problem size will be rated in a graph. It consists of two important criteria's and will eliminate the ideas with no potential for innovation opportunity. This will be done for each idea individually and for all ideas in one graph in the end of the chapter to simply see which ideas to pursue.

Table 2 Idea screening

Criteria	Description
Problem size	What problem is targeted. Is it a known problem that is well known, and salmon farmers are willing to pay for? If so, does it solve a small or a recognized problem. Is the market being willing to pay to solve this problem?
Quality of idea	How good is the idea based on the initial findings? Does it solve the problem better than existing methods today or is the idea just as good as the competitors?

Each idea will be screened in a diagram as seen below. The y-axis represents the quality of the idea. The ideas achieve a yellow or green colour will qualify for the second screening. The x-axis represents the problem size. Size of the problem varies for each key challenge (these are listed in Part 1 Industry, *Key challenges within segment*. The size of problem can be interpreted in numbers as described below (The Y-axis and X-axis interpreted in numbers was elaborate by my thesis mentor, professor Knut Erik Bang).

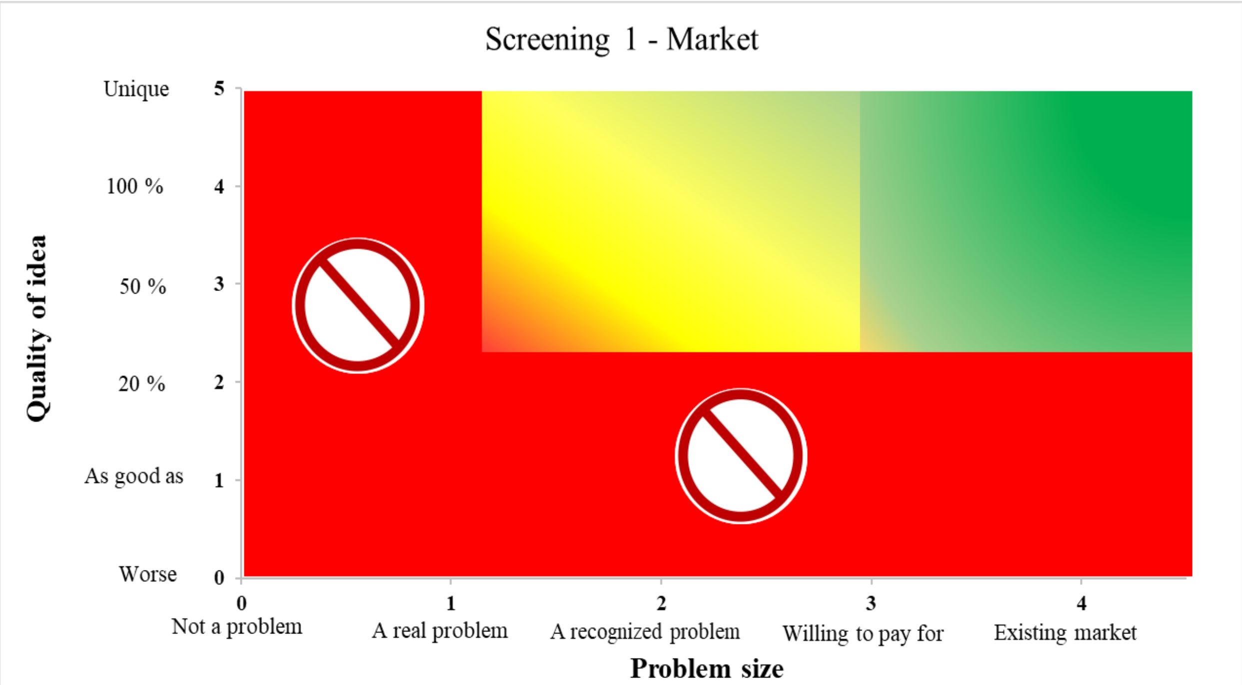


Figure 25 Initial idea screening graph

Screening 2 – Opportunity

The ideas that successfully past the first screening are now opportunities. But the opportunity must have the ability to generate a profit. Hence, the next step is assessing the size of the market and if there are possibilities to make a profit. The description of the criteria is described in the table below.

Table 3 Opportunity screening

Criteria	**Description**
Market size	How large is the market for the opportunity? Local to global
Profit margin	How large are the yearly profit margins? How will they evolve with product maturity?

Furthermore, the opportunity must be evaluated if it can be protected to ensure long-term success. Different potential intellectual property rights (IPR) will be assessed. These are described in the table below and chosen since they are the most common way to achieve IPR in Norway.

Table 4 Relevant IPR

IPR	**Description**
Patent	Protects machines, manufactured products, processes and technical innovations. The patent can last up to 20 years.
Copyrights	Forbid other to replicate documents, research and intangible assets such as software codes. The copyright will last the lifetime of the creator plus 70 years. (Thomas H. Byers, 2014)
Trademarks	A marked and unique sign, logo, design or expression used to identify products or services of one firm from others. (Thomas H. Byers, 2014) A trademark lasts 10 years but can be renewed multiple times.
Company secrets	Private information about methods, ideas, Know- how. These are secured by Section 28 of the Marketing Practicing Act law in Norway and must fulfil three conditions. (Thomas H. Byers, 2014) 1. It must be a secret. 2. The value is within the secret. 3. steps has been taken to keep it secret.

Screening 3 - Business opportunity

Lastly, the opportunities that achieve the highest ranking and include necessary characteristics can potentially create a business opportunity. Here, the opportunities will be further investigated and applied in a business model canvas. The canvas is a study of the fundamental areas of a business and will assist in identifying what needs to be established to create a business opportunity (osterwalder, 2018). *Figure 26 Business model canvas* illustrates the areas for assessment.

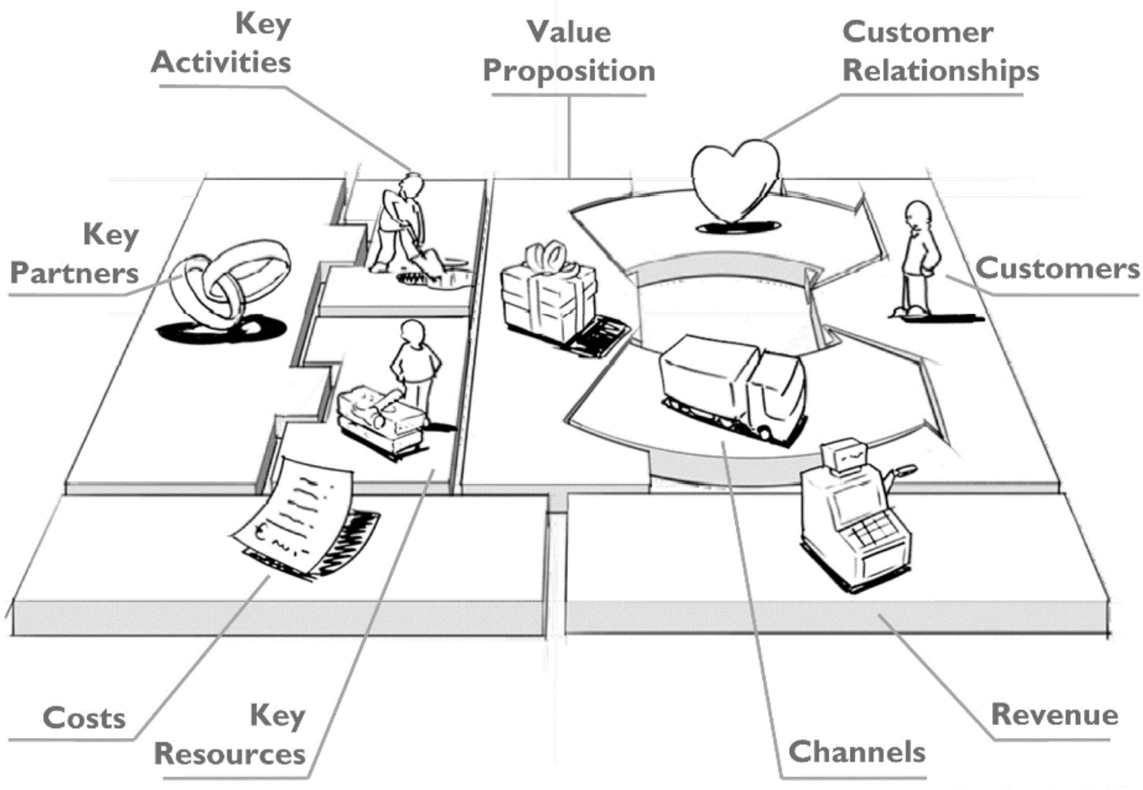


Figure 26 Business model canvas based on the concept of Alex Osterwalder

4.2 Initial screening of ideas – Problem size & Product quality

1. Biomass estimation using LIDAR, Machine learning & Computer vision

Existing method

Today, the farmer estimates the size of the salmon by examine 200 salmon from each cage by measuring them and report manually. Another way is to lower down a camera in the cage, take picture of the salmon and then upload the pictures to a computer and do the manual measuring there.

Problem size

Firstly, fish farmers experience up to 20 % difference in estimated biomass and actual slaughter weight (information retrieved from a visit to a local fish farm). Secondly, authorities require fish farmers to constantly update and report numbers to make sure that they stay within the permits limits. Thirdly, too high concentration of fish inside one cage can result in diseases spreading quickly. Lastly, biomass estimation also determines when the salmon is ready for slaughter. The more accurate prediction for slaughter, the higher price per Kg. The problem size is estimated to be 3 *"A problem someone is willing to pay for"*.

Description of idea

The LIDAR technology described in part 2, *Technology trend - LIDAR*, can be used to improve estimation of salmon biomass. A 360° rotating LIDAR is lowered and moved sideways in the cage by two winches. The LIDAR will create a digital 3D image of the inside of the cage. The digital image will be processed and analysed automatically by a software. Here, amount, size and weight of the salmon will be estimated. The LIDAR might not map each fish but collect enough data to create an average with low uncertainty. The uncertainty limit will be related to time spent on data collection. The documentation of biomass will be sent to the salmon farmer as a PDF file with necessary information for further distribution.

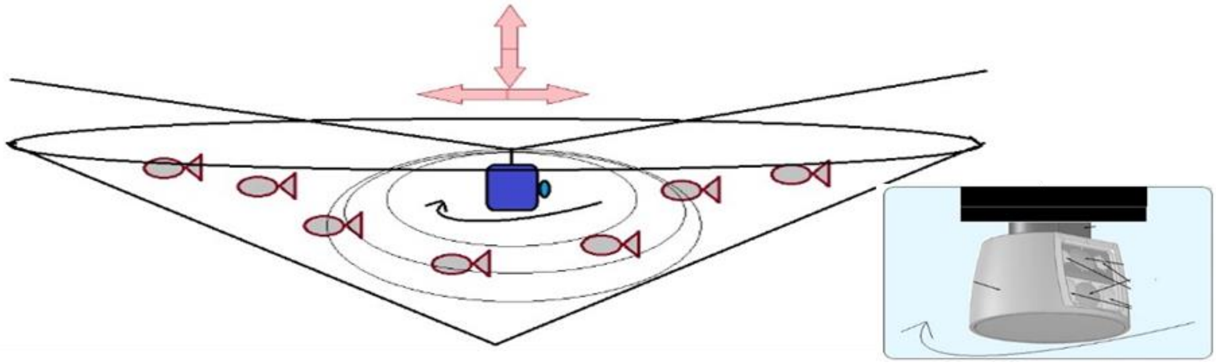


Figure 27 Using LIDAR in salmon cage to estimate biomass; idea 1

Hardware

LIDAR (further elaborated in part 2 – Technology trends). The LIDAR is protected against water with transparent hard plastic that won't obstruct light to travel. Two wires are attached to position the system (vertically and horizontally).

Software

The data is collected and stored in the product. After the service is delivered, the product is connected to a computer with a software that automatically process, analyse and report back the data and digital images. Computer Vision with machine learning algorithms recognising and separating salmon inside the cage (the system will improve as more data enters the system). The distance between the salmon and LIDAR is calculated by the time it takes for the light to travel to the object and reflect. When the distance is calculated the software can measure the fish (height and length and width, if the fish is in correct position). When the software has estimated the size (volume) of the salmon, weight can be estimated by using history data of size and weight relations. The software does the same process with as many salmon as recognised. The software will sum the weight (biomass) and divide it on number of salmon analysed (average weight). Furthermore, the software will present the biomass of each cage as seen below.

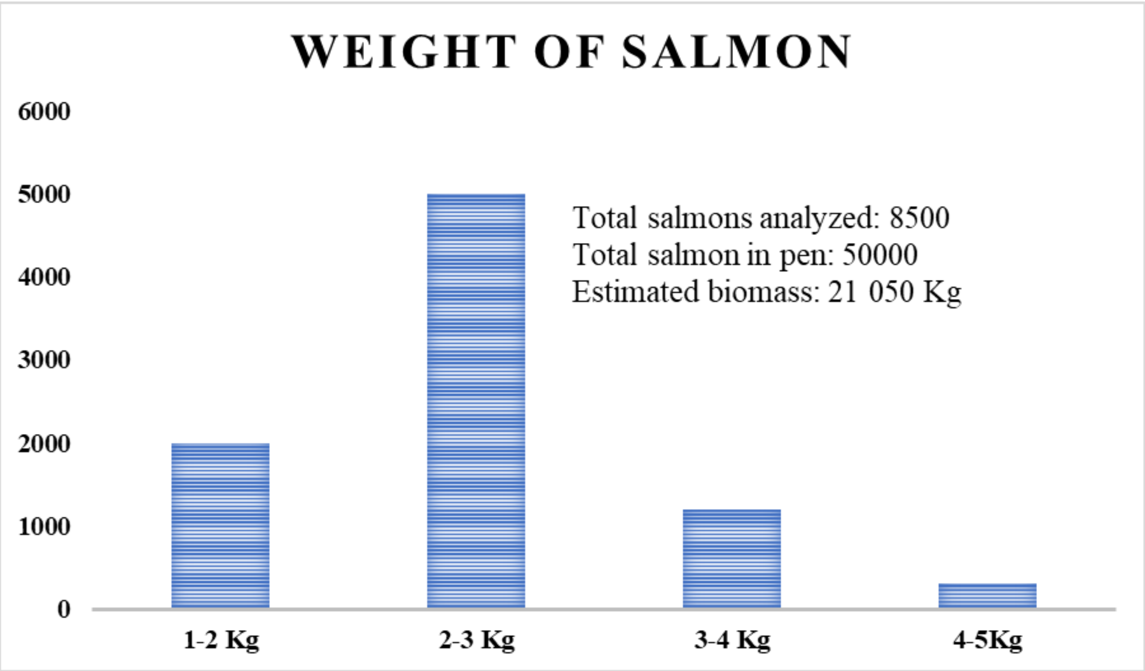


Figure 28 Example of how software will present biomass; idea 1

Revenue model

The biomass estimation will be intangible and delivered as a service. The data collected will be used for machine learning, to improve algorithms to further improve estimation. The data is delivered as a PDF-format to the farmer through email.

New customer group

Local salmon farmers would be the first market. But as the company scales, the product can be customized for more aquatic species farmed in cages such as carp, tilapia, catfish and other type of salmons. They are all dependent on knowing how much revenue they can expect from each harvest. The system can be adapted to the other species, with only changing machine learning for the selected species.

Key challenges solved

The product will give the fish farmer a more precise estimation of biomass and it is less labour intensive. The fish farmer can better predict revenue and plan harvest. The reporting to the authorities will also be much easier as the software creates a report that can be distributed to relevant actors.

Issues with the idea

Problem with this technology is that light does not travel efficiently under water. There are some frequencies that travels better such as green light. It penetrates the water and create clear digital images enough for processing and analysing.

Ranking of idea

The idea is 100 % better than the existing method explained above, and the problem size is seen as a sizable problem that someone is willing to pay for.

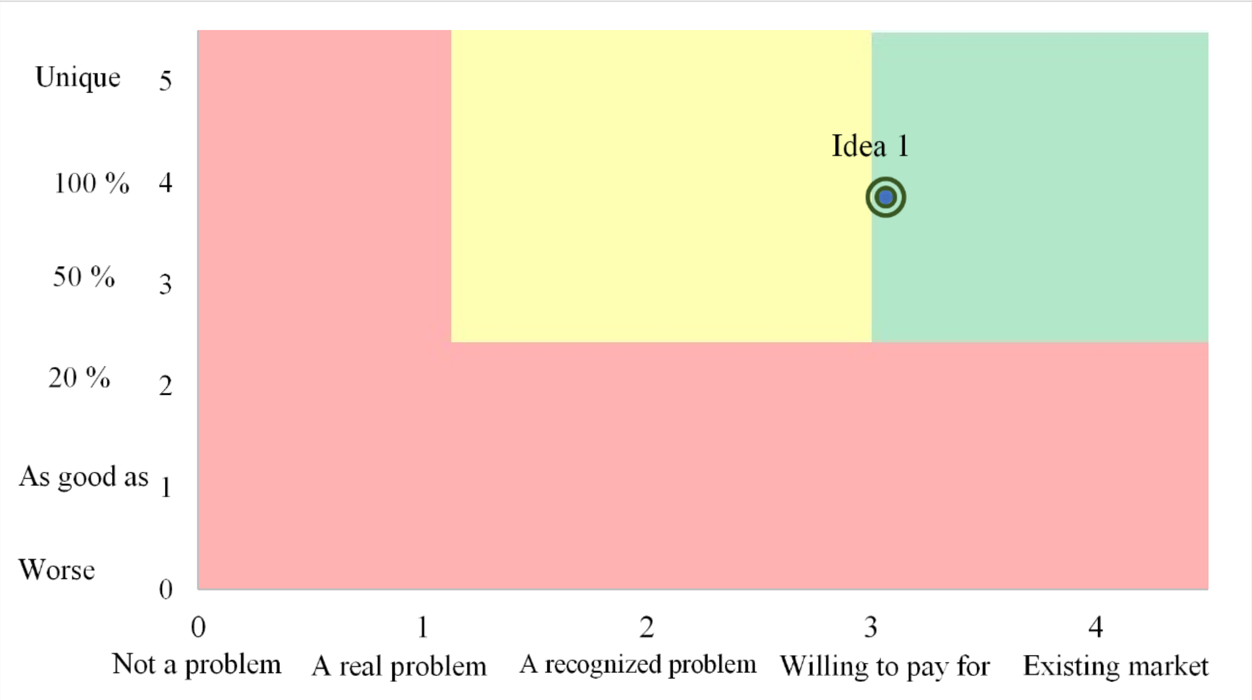


Figure 29 Ranking of idea 1

2. Biomass estimation using SONAR, Machine Learning & Computer Vision

Existing method

Same as idea 1

Problem size

Same as idea 1

Description of idea

The SONAR is described under part 2, Technology trends - SONAR, and could be adopted to estimate biomass inside the cage. The sonar can be placed in one end of the cage and travel to the other side at the same time as it transmits and receives sonar data. The sound wave will reflect on the salmon and the net. A screen will show the image of the inside of the cage. The digital image would contain necessary information to estimate the biomass and can be done automatically with computer vision and machine learning as explained in idea 1.

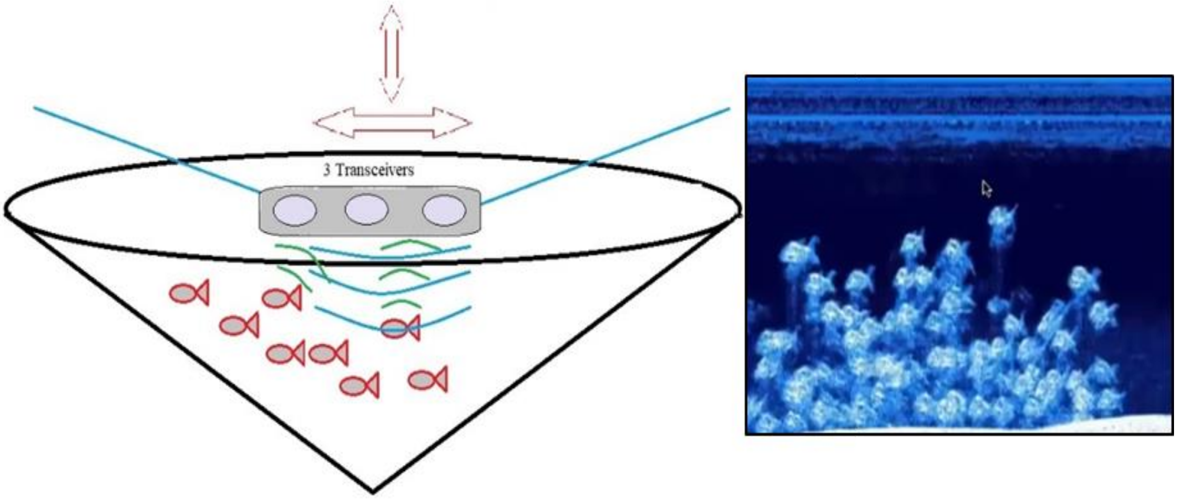


Figure 30 Using SONAR in salmon cage to estimate biomass; idea 2

Hardware

A hard-plastic cover to prevent water to penetrate the product. Two adjustable wires to keep it at wanted water depth. A transducer and transceiver inside the plastic cage.

Figure 31 Transducer to convert signal and transceiver to transmit and receive sound adopted from (Sure control Inc, 2018)

Software

Same principle as idea 1, only difference is that machine learning must understand different digital images.

Revenue model

Same as idea 1

New customer group

Same as idea 1

Key challenges solved

Same as idea 1

Issues with the idea

Some issues were identified with this idea. Firstly, there are other elements in the cage such as dead fish handling. But if we remove the mass of the non-fish elements (assuming we have this information), the remaining mass should be fish. The second problem is that SONAR needs distance between its object and the emitter to visualize each fish in the cage. But today, there are sonars used in fishing activities in waters less than 5 feet deep (Owen, 2017). Another issue may be that the fish are swimming to close to each other. On the other hand (by law) a fish cage can only contain 5 % (of the total volume) fish. Suggested solution is described below to solve the issues discussed.

Description of alternative solution

The idea is to connect 4 SONARs and lower them into the pen to create a 3D image of the fish. The SONAR can operate on different frequencies to avoid interference. Each sonar emits soundwaves with different frequencies at the same time and only receives same sound waves back. A GPS tracker on each sonar can position the SONAR and each SONAR reports back the X-, Y- and Z-coordinate of objects in the cage. A computer can then process each digital image with the location and join the images to create one 3D picture. The objects from the different SONARS with the same coordinates will be merged into a 3D image as seen in the bottom right corner of the picture below.

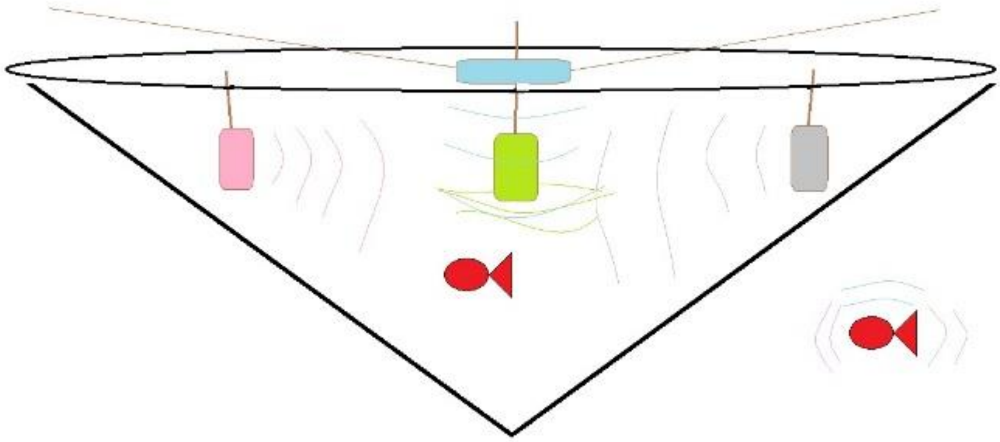


Figure 32 Using 4 SONARs in salmon cage to estimate biomass; idea 2

Ranking of idea

The idea is only 50 % better than the existing method explained above, and the problem size is seen as a sizable problem that someone is willing to pay for.

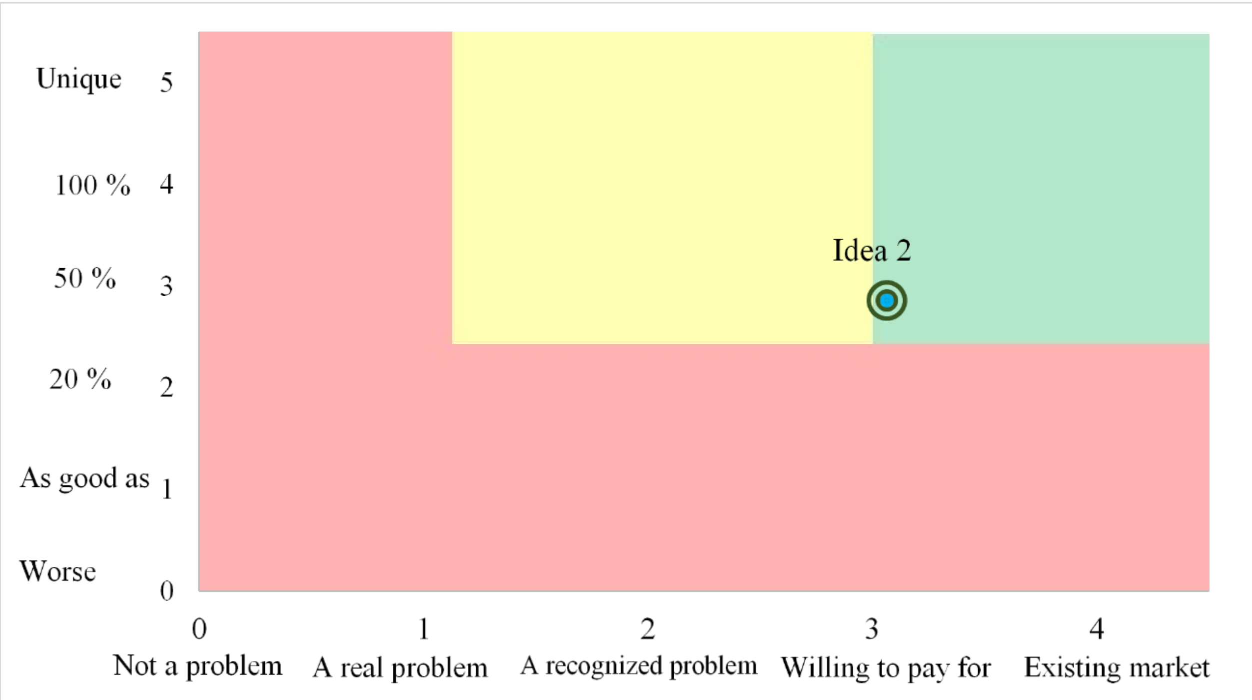


Figure 33 Ranking of idea 2

3. Lice removal by using Waterjet, Machine learning & Computer vision

Existing delicing method today

To prevent or mitigate lice today, the farmer normally introduces other type of fishes in the cage that eats lice such as Lumpfish as explained in Part 1, *Industry - Key challenges in the selected segments - Lice*.

Problem size

Main problem with Lump fish is that only 1 of 4 eat lice. This means that the farmer must buy a lot to mitigate or avoid lice. The price per Kg Lumpfish in 2017 was 34 NOK (Fiskeri bladet, 2018). Also, lice are not their main food, it is more as a snack and the farmer must provide feed for the lump fish as well. Lice is seen as the largest problem in Norwegian salmon farming today and the government have issued a full stop of expansion until this problem is under control. Problem size is categorized as 4 "*A problem with existing market*".

Description of idea

The idea is to flush the lice off the skin of the salmon as they swim through a transparent cylinder. Small water nozzles are placed in the middle of the cylinder and flushing the fish as it swims by. The salmon swims past a "lice recognizer" located in the start of the cylinder and if it detects lice, the water jets will flush the fish. The temperature is slightly higher than the surrounding temperature (One common way today to remove lice is mechanical flushing with high temperature water bath and is very effective against lice. This is described in *Part 1 – Industry - Key challenges in the selected segments).* The water velocity and temperature must be adjusted so that it doesn't harm the salmon, but high enough to chock the lice. In addition, a rubber filter, gently strokes the skin of the fish as it swims out of the cylinder to remove the remaining lice.

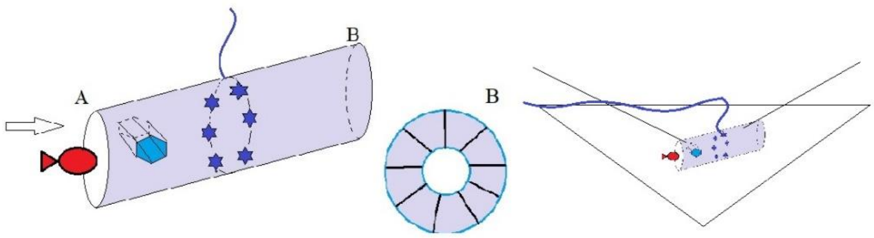


Figure 34 Illustration of delicing tube; idea 3

Hardware

Transparent plastic cylinder. Camera with electrical cable, data transfer cable and computer vision to detect lice. Water jets / nozzles connected to a water hose. Water hose connected to a boat with a water pump and heater. A rubber filter in the end of the cylinder to stroke of the remaining lice damaged by the water beams. Two wires to place the cylinder at wanted level.

Software

Electrical cable and data transfer cable to the camera connected to a computer with software on the boat. Software controls camera with computer vision and machine learning algorithms to recognising lice as the salmon swim in the tube. The software also regulates the water temperature and starts and stops the water jets as the salmon pass.

Revenue model

Increased intangibility by delivering as a service. The service would take time, but the service company can dock their boat with equipment to the cage and let it run for as long as necessary.
It could also be sold as a product to the fish farmer.

New customer group

For future development: This system can be adapted to more aquatic species farmed in cages such as carp, tilapia, catfish and other type of salmons. These species have other diseases and lice that can be flushed from the skin of the fish.

Key challenges solved

Reduce cost in both purchasing and feeding other species such as Lump fish. Effective lice removal.

Issues with the idea

Since the idea never got tested or applied in a fish cage, there is no way to tell if the fish will swim through the cylinder. Also, large uncertainty if the effectiveness of the solution is enough to remove lice without damaging the fish.

Ranking of idea

The idea is 100 % better than the existing method explained above, and the problem size is seen as a huge problem with an already existing market.

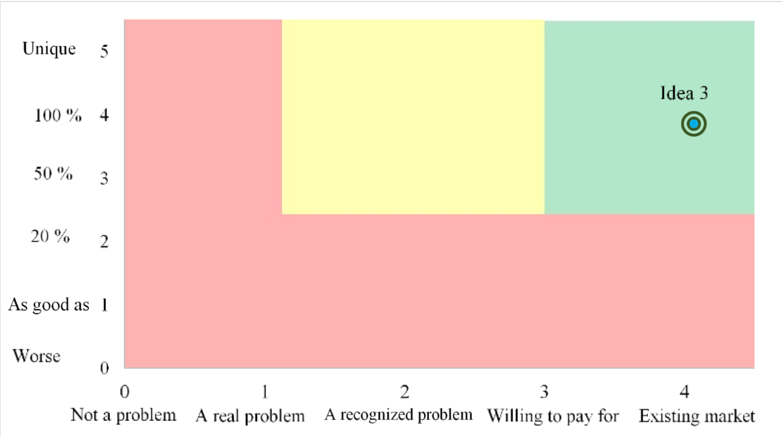


Figure 35 Ranking of idea 3

4. Lice removal by using Machine learning & PLC

Existing delicing method today

Mechanical delicing such as Thermolicer that pump the salmon into a boat containing a hot water tank. Here, the salmon enters the tank with 25°C hot water and stays there 20 – 30 seconds before released into another cage. The problem with this method is that the farmer must empty the cage.

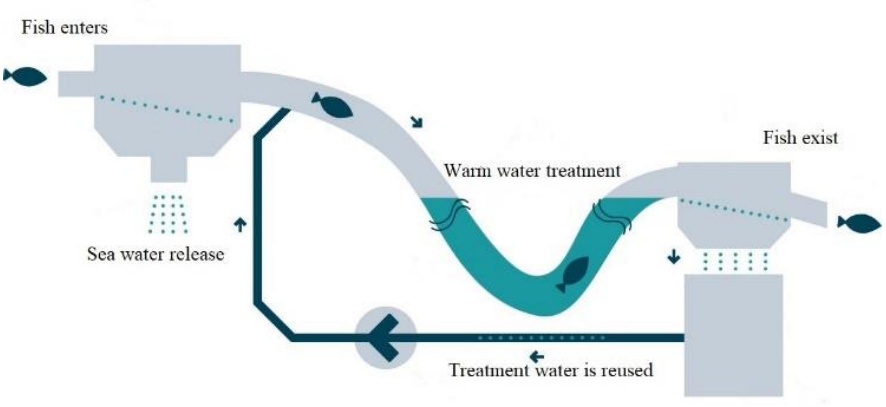


Figure 36 Mechanical delicing today (Steinsik, 2018)

Problem size

As described in Part 1, *Industry - Key challenges in the selected segments - Lice,* the mechanical delicing is very effective but it is estimated to killing 25 % of the salmon due to stress, chock of hot water, internal and external bleeding due to hitting the machine when it gets sucked in.

Also, Marine harvest reported killing 95400 salmon (460 tonnes) in one attempt of using mechanical delicing in 2016 (Edwards, 2016). The reason for this was to hot water in the tank and that the salmon stayed in the tank too long. The salmon was boiled to death. The problem size is categorized as 4 "*A problem with existing market*".

Description of idea

The idea is to only delice the salmon that have lice. This idea will extend the existing product explained above. A camera with computer vision and machine learning for detecting lice is placed in the beginning of the suction tube. As the salmon enters the suction tube, a PLC controlled system will decide if the salmon will proceed to the warm water tank or released into the cage again. This will ensure that only the salmon with a lice problem will be deliced while the healthy fish will not be exposed to any harm.

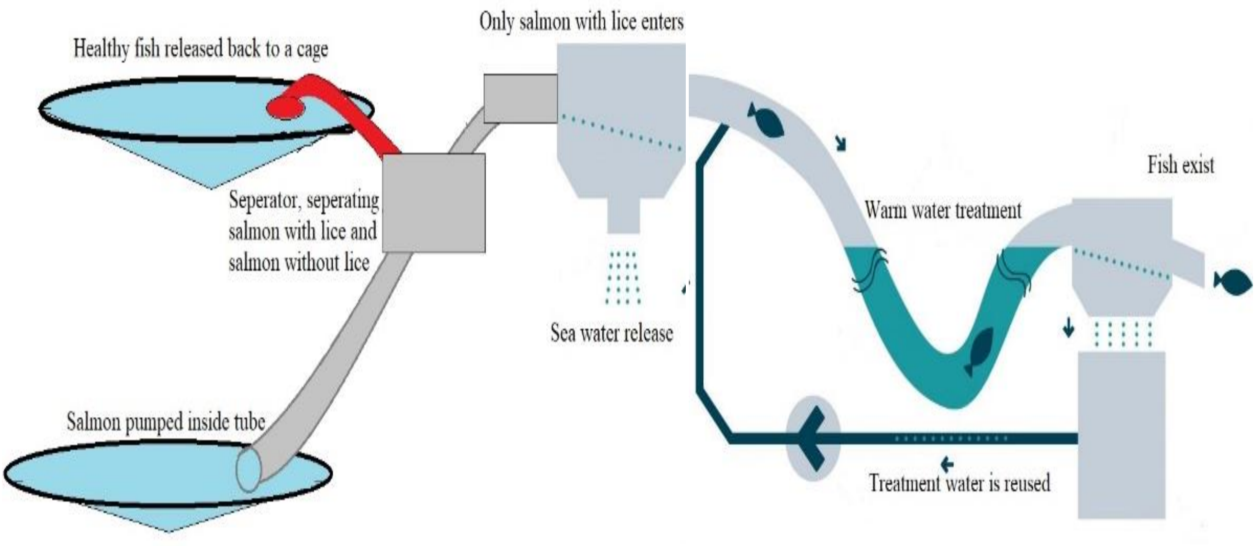


Figure 37 Only delicing salmon with lice; idea 4

Hardware

Existing Thermolicer, lice recogniser and counter (See “A” in figure below), Separator box (See “B” in figure below), valve opening to transfer salmon to either hot water tank or to a fish cage (See “C” and “D” in picture below).

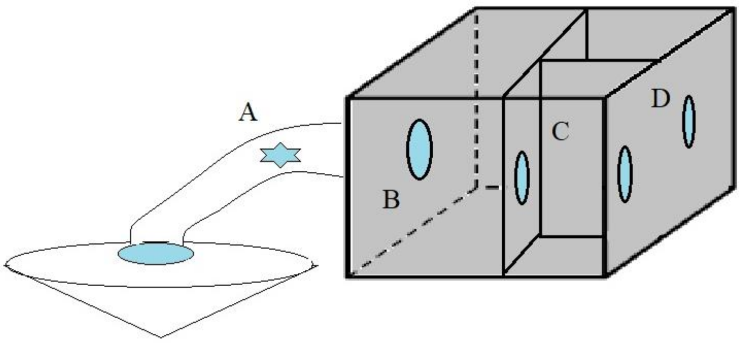


Figure 38 Separation of salmon with and without lice system; idea 4

Software

Machine learning identifying and counting lice, send a signal to PLC system to select valves.

Revenue model

Delivered as a service to customer with a lice problem.

Key challenges solved

Only delice the salmon that have lice causes less stress, damage and mortality to the salmon that doesn’t have lice. The fish farmer will have lower loss of revenue due to less mortality of fish.

Issues with the idea

This idea is an extension of an existing product. The owner of the product will therefor hold the right to make the changes. The mechanical delicing machine is a highly expensive and not very often used product. There would be high barriers for entry such as patents to get around, competition with similar machines and high manufacturing cost.

Ranking of idea

The idea is around 30 % better than the existing method explained above, but the problem size is seen as a huge problem with an already existing market.

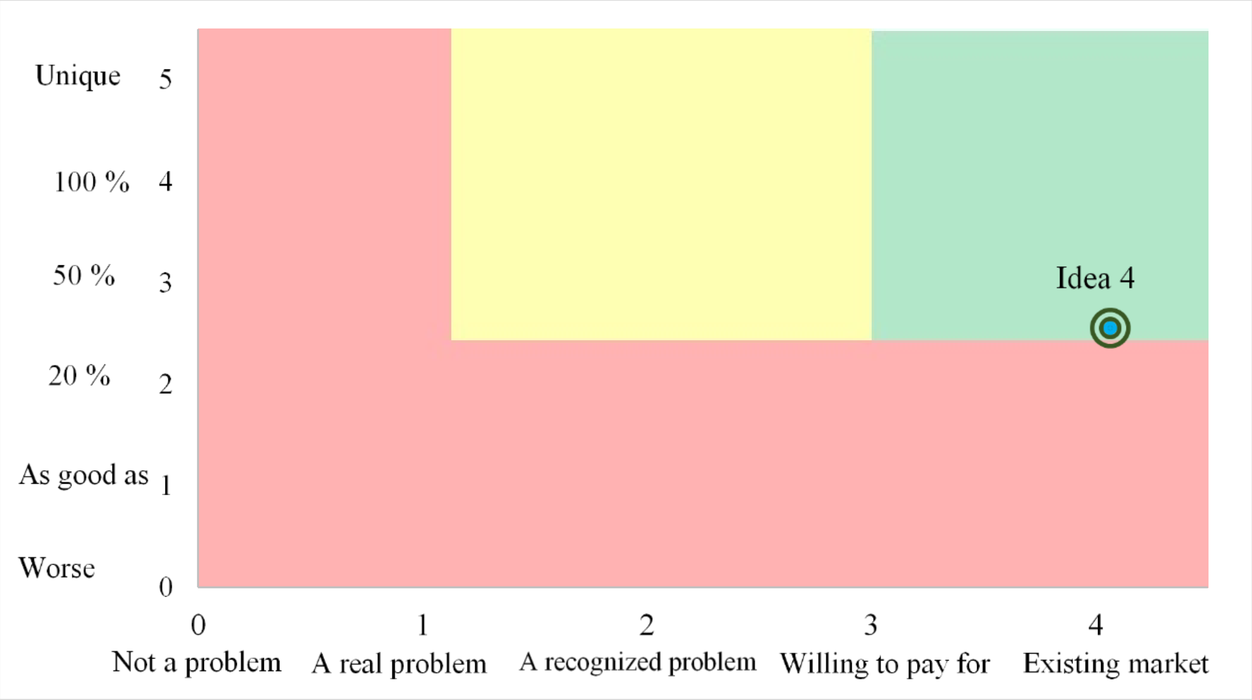


Figure 39 Ranking of idea 4

5. Feeding monitoring and control by analyzing Big Data and using IoT

Existing method

The operator monitors the underwater feeding camera, watching the current and adjusts and stops feeding when pellets start to fall through the net or if the movement of the fish changes (detects appetite). Every operator has their style of feeding. There is no standardized method and is vulnerable to human error (waste of pellets).

Problem size

As earlier mentioned in Part 1, *Industry - Key challenges in the selected segments - feeding*, the cost of pellets and feeding is recognised as the largest cost for fish farmers. There is a large focus on reducing waste in feeding to lower the cost and reduce harm to the environment. The problem size is categorized as 3 "*A problem someone is willing to pay for*".

Description of idea

This idea is not a product but a software using technology trends such as IoT and Big data analysis. Internet of things can connect data for better feeding plan and operation. Data must be available to be analyzed and combined to reach optimized feeding. The idea is to standardize the operation by always collecting the same parameters of data. Furthermore, the operation can be automated completely. This software will collect data for all location it is used. That means, more locations and customer equal more data which again results in more accurate and better feeding operations.

Software and collection of data

- The salmon is given different type of food depending on the size and age of the salmon. With data from **Biomass estimation,** the amount and type of pellets can be selected automatically.
- With a camera with **computer vision** combine with **machine learning** (this product does not exist at the moment, but a Silicon Valley based company is developing this product with pilot product in end of 2018 (Aquabyte, 2018)**)** it is possible to identify the movements patterns of the fish to identify appetite (when to start and stop the feeding).
- **Dead fish handling** will provide data about the number of dead fish which will improve the decision of how much pellets will be given. If the software can analyze the cause of death, it could detect disease problems and select pellets with correct medicine to mitigate the problem.
- **Environmental sensors** can provide data such as, current and weather to place the spreader in a better position to avoid waste of pellets.

The feeding will be personalized / customized for each location depending on what data the software collects.

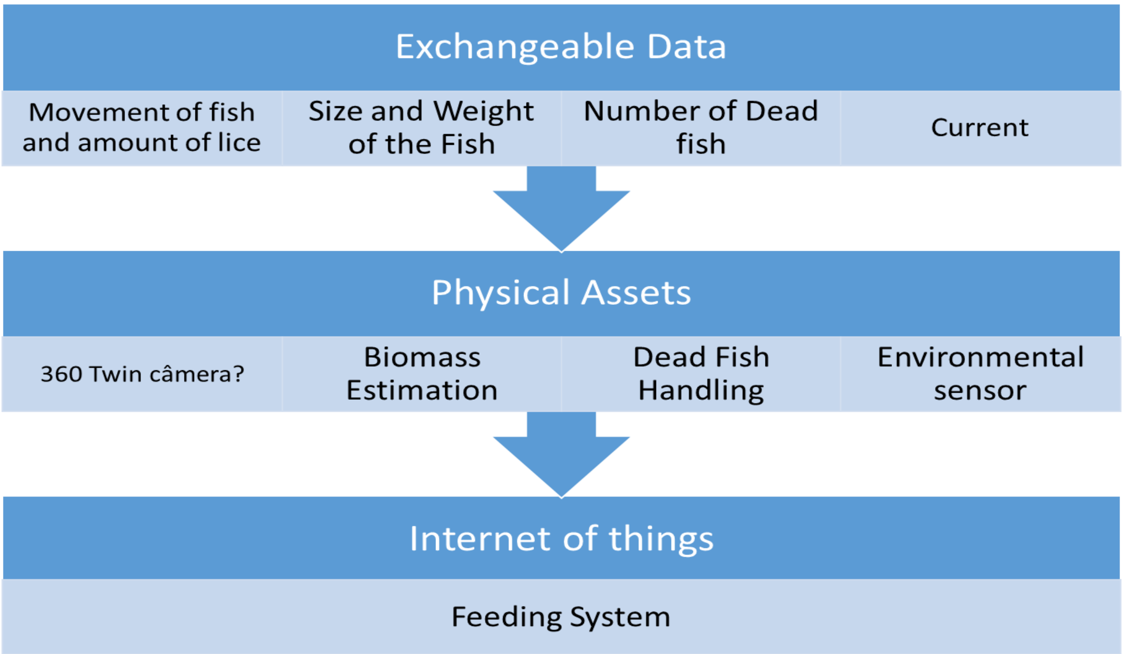


Figure 40 Sources of data explained for IoT

<u>Revenue model</u>

Cloud-based service. The software can be downloaded by purchasing a licence.

<u>Key challenges solved</u>

Waste of pellets, avoid damage to the environment, improve fish health, better estimation of storage and transaction of pellets. Reduce cost in pellets due to better estimation and prediction of amount of food.

<u>Issues with the idea</u>

Fish farmers have different ways to collect data and the challenge is to make the data readable and compatible with the software. The data today is mostly collected manually and are vulnerable to human error which again will affect the choices the software will suggest.

Ranking of idea

The idea is 100 % better than the existing method explained above, and the problem size is seen as a sizable problem that someone is willing to pay for.

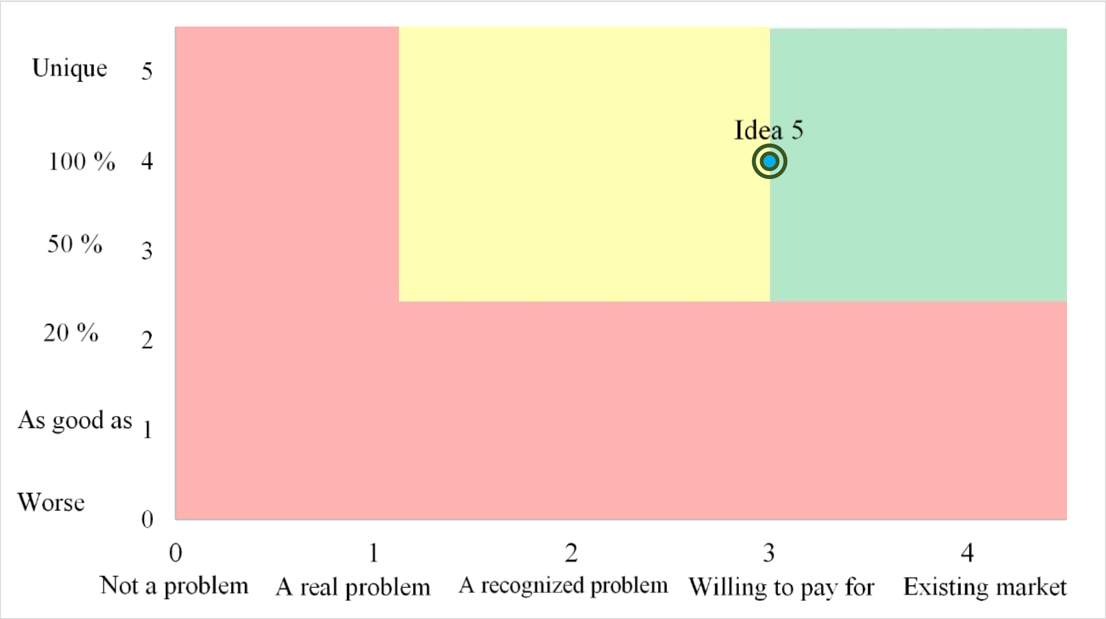


Figure 41 Ranking of idea 5

6. Optimize feeding system by using carpet

Existing method

The most common way to feed is to have:

- a silo of pellets on the barge
- a doser to control the number of pellets to the system
- a compressor / feed blower and an air cooler
- a selector that selects which cage will be selected and a tube moving the pellets from the barge to the cage
- a rotating spreader / hose that the pellets exit through

Figure 42 Feeding system adopted from (AKVAgroup, 2018)

Problem size

The feeding system is complex and requires most of the space on a barge. Another problem is that the tubes connecting the barge to the cage gets clogged up with pellets. The farmer then must disconnect the tube and clean it manually, which is labor intensive and time consuming. The feeding operation is critical, and issues must be addressed immediately. Problem size 3 *"a problem someone is willing to pay for"*.

Description of idea

The idea is to remove the existing system and only attach a conveyor belt and spools on the cage. The first spool (1) is a "feeding carpet" and consist of a net with pellets attached. The feeding carpet will be attached at point 1 in picture below and rolled out to a second spool (2) further out in the cage. The idea is that the salmon will eat directly from the conveyor belt and when a part of the belt is empty for pellets it will roll out more pellets. The empty carpet will be rolled in on a third spool (3). The spool (3) will be changed when the whole conveyor belt is rolled over and emptied for pellets. The fish farmer can simply detach the empty spool (3) and attach a new spool (1). The system can be operated manually from the barge or automatically. A camera will be attached at spool number 2 which will detect if the feeding carpet contains pellets at this point.

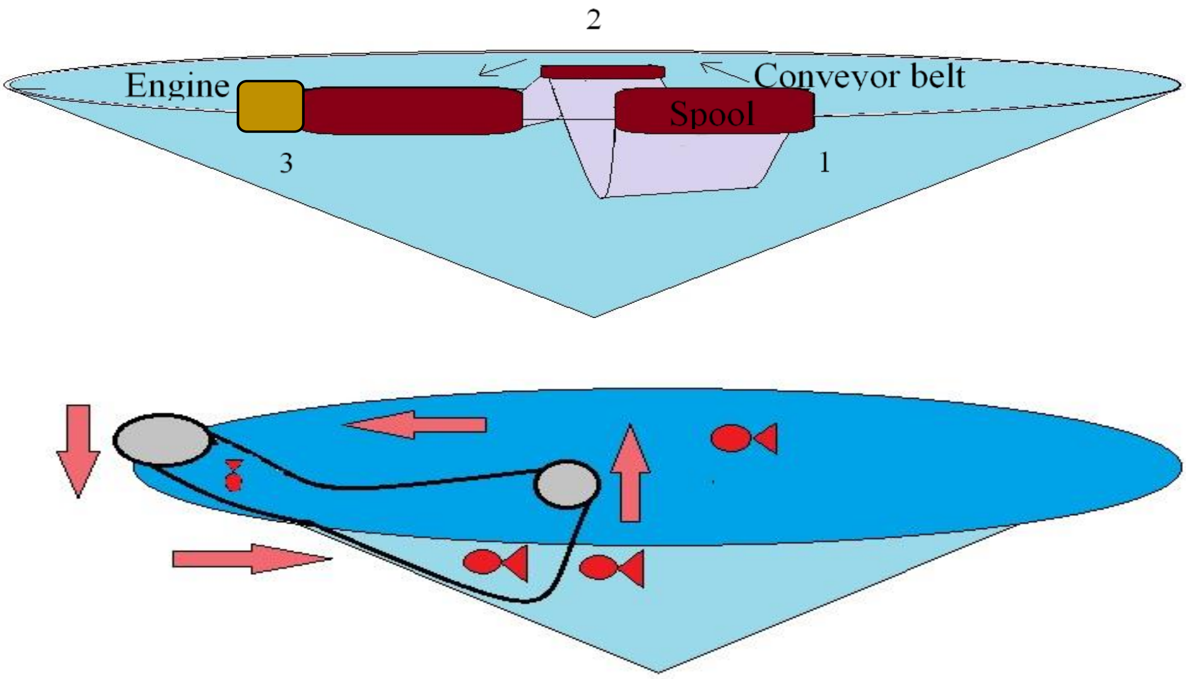


Figure 43 Illustration of function; idea 6

Hardware

The system consists of three spools. Number one and three are attached to the cage structure and number 2 is floating and moored in a fixed position inside the cage. Spool number 3 also contains an engine to pull the conveyor belt. The conveyor belt is a nylon net with pellets attached. The pellets are attached to the net in the production phase of the pellets. The idea of production is to lay down a nylon net and then melt and mould the pellets on the net.

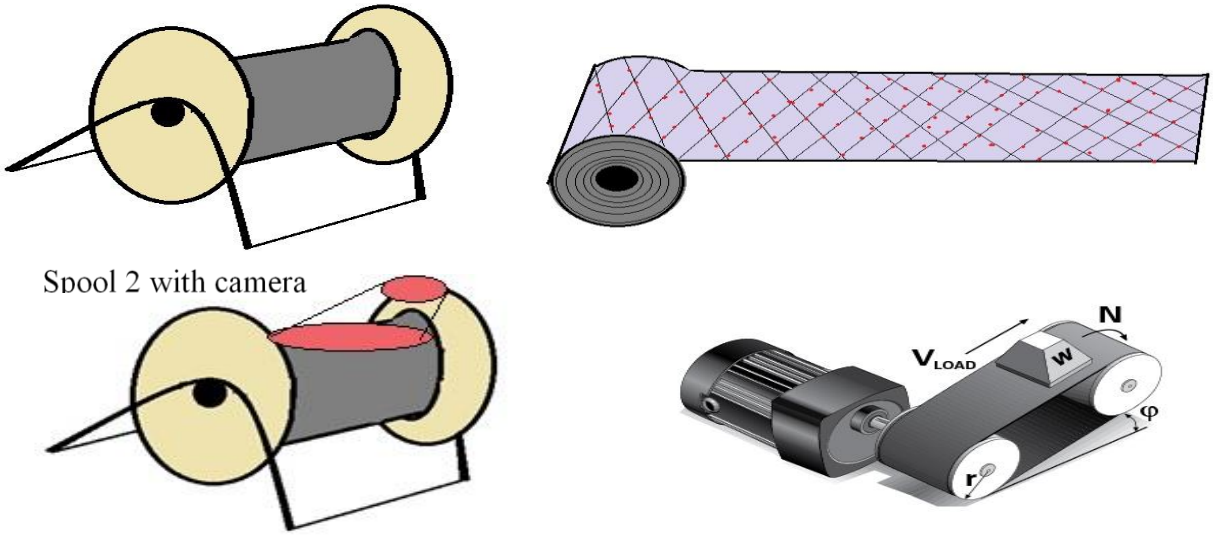


Figure 44 Illustration of hardware; idea 6

Revenue model

The spools with pellets will be delivered as a service to the barge or attached directly to the cage structure. The empty spools will be gathered and returned to the service provider.

Key challenges solved

Remove waste of pellets since they are attached to a carpet and salmon eats directly from there. This will result in less deterioration of environment and reduced cost in pellets. It will also use less space on the barge, remove tubes to the cages and remove issues such as clogging.

Issues with the idea

The pellets dissolve quickly in contact with water. That means that the pellets may fall off the carpet. The solution must consist of a new type of pellet or a type of carpet that creates a chemical reaction that keeps the pellets stuck to the carpet. Another issue is the weight of the system. If the spools are too big, the weight will be too large but if the spools are too small they must be changed often. Another issue is to find a method for the sensor to reflect the correct data (spool 2) for the engine to start spinning the "carpet".

Ranking of idea

The idea is below 20 % better than the existing method explained above, but the problem size is seen as a sizable problem that someone is willing to pay for.

Figure 45 Ranking of idea 6

7. Avoid fish escape by net inspection using LIDAR, Machine Learning and Computer vision

Existing method

Today, farmers hire service companies to inspect the net of the cage. The service is most commonly delivered by divers every twelfth week (information received during a visit to a fish farm). Another way the fish farmer know that they have a hole in the net is by receiving external information from local fishermen that catches unnormal amount of salmon in the area.

Problem size

As earlier mentioned, salmon escape has consequences both for the fish farmer and for the surrounding environment. For the fish farmer, this means loss of revenues both because they lose the salmon and because the company must pay back each fish that a fisherman manages to catch. Marine harvest reported that 56000 salmon escaped from a cage containing 180 000 salmon for first month of 2018. The local fishermen will receive 300 NOK for each salmon they manage to catch. (Fishfarming experts, 2018). The other issue is that the escaped salmon travel upstream in rivers and spawns with the wild salmon. Many scientist (and other people) are worried that the wild salmons are disappearing (some even argue that wild salmon doesn't exist anymore). The problem size is estimated to be 2 *"A recognised problem"*.

Description of idea

As described in idea 1, a LIDAR will reflect light and map the net structure. The LIDAR is attached to a wire and a winch to move it up and down. The winch is also attached to a rail / track under the walking area of the cage in a way that the LIDAR can scan around the whole cage, 180° each way. The LIDAR can also detect dirt on the net, meaning it can suggest schedule of cleaning service and estimate the oxygen level.

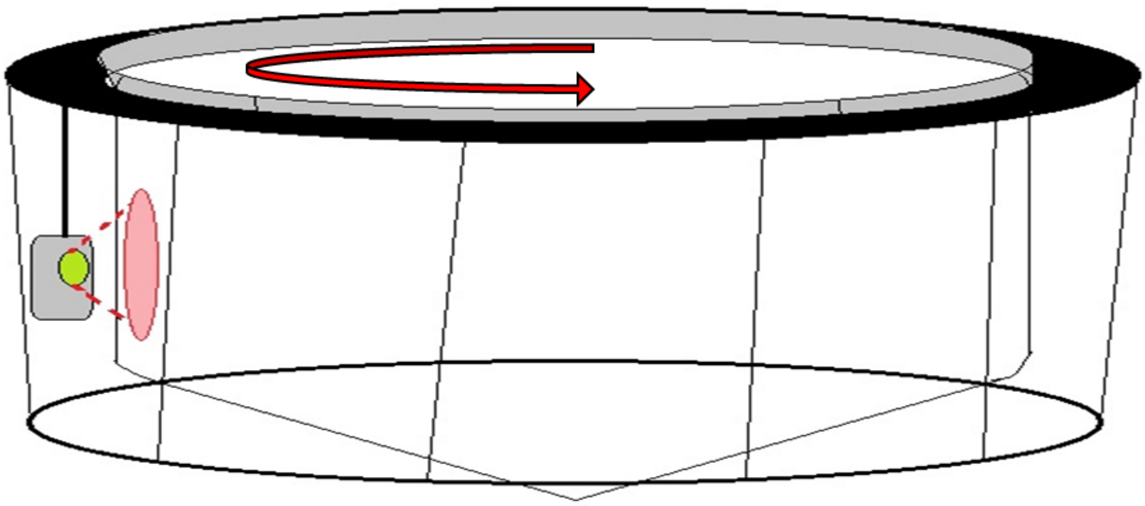


Figure 46 Illustration of function; idea 7

Hardware

LIDAR and protection against water with transparent hard plastic that won’t obstruct light to travel. The winch can move the LIDAR up and down and a track / rail under the walking path will move the LIDAR along the x-axis. Both the LIDAR and the winch require electricity and the LIDAR requires a data transfer cable. The LIDAR will therefore be able to scan the total net but only move half the way 180° of the cage and then back.

Figure 47 Illustration of hardware; idea 7

Software

LIDAR will send data through a cable to the barge where a software is installed on a computer. The software will map the net and automatically detect defects or holes in the net. A 3D model of the mapped area is also shown on the computer screen for the operator to inspect.

Revenue model

The system would be leased with regular software updates and product updates. Maintenance of the inspection system such as, cleaning LIDAR, lubricate winch and rail/track and update software will be services provided.

Key challenges solved

Automatic inspection of net. Faster response to holes in net and salmon escape. Better oxygen level meaning better growth of salmon and reduced cost due to better planning of net cleaning.

Issues with the idea

Each cage need their own system. The system is underwater and will require maintenance. Current can move the net of the cage making it difficult to map in strong current conditions.

Ranking of idea

This idea is not good enough due to the complexity of the system, extensive maintenance and that each cage needs its own system. The idea below (Idea 8) will continue to build on this idea to achieve a better solution.

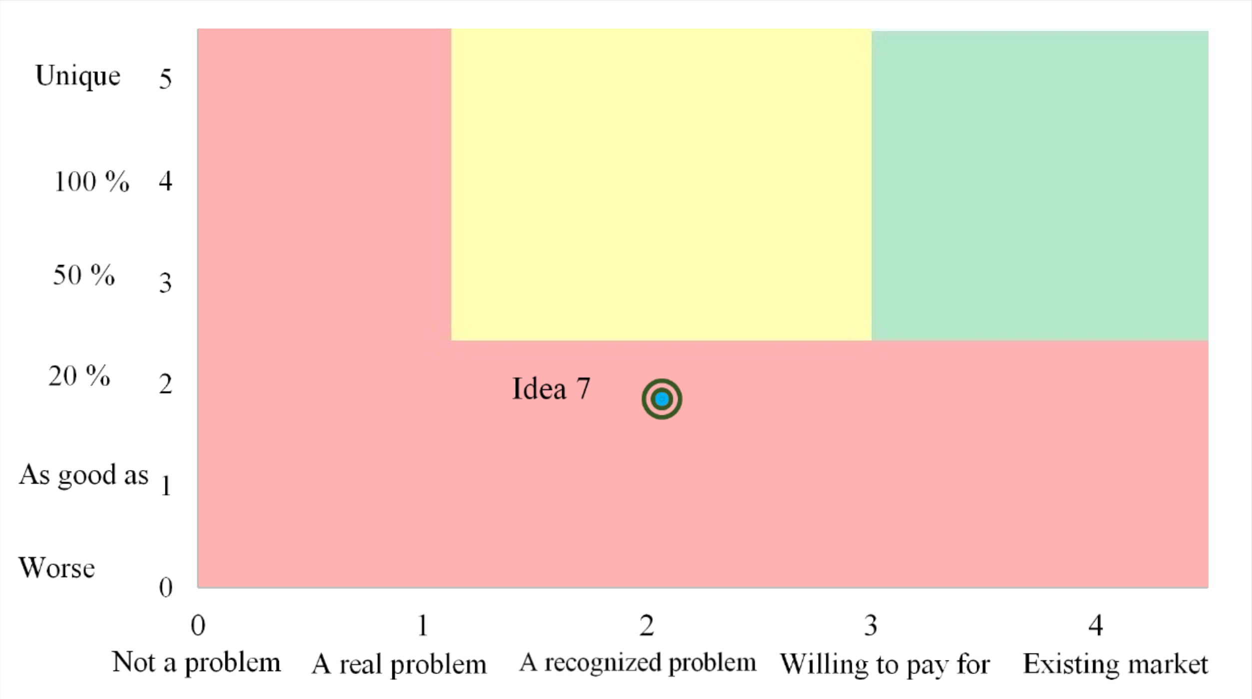


Figure 48 Ranking of idea 7

8. Avoid fish escape by net inspection using AUV

Existing method

Same as idea 7 above.

Problem size

Same as idea 7 above.

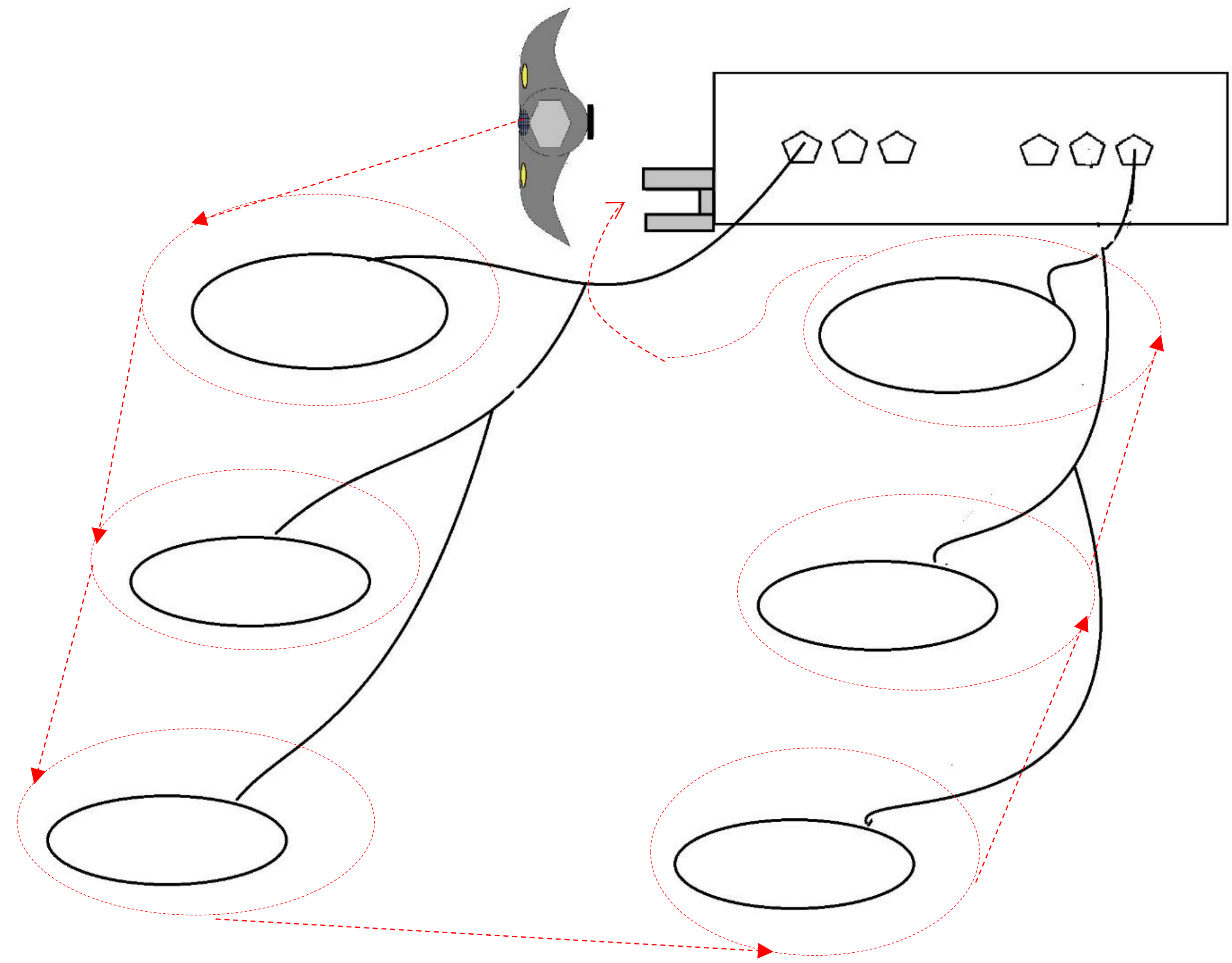
Description of idea

The idea is to have an autonomous underwater vehicle (AUV) moving between the cages and inspecting holes in the net and dirt with same LIDAR as above. The AUV will be wireless and have access to an underwater HUB / station attached to the barge wall, which will be the starting and ending point for the inspection.

The HUB will provide induction charging point and induction data transference from the mapping from the AUV (Data transference through induction is theoretically possible but not commonly done yet. The theory is explained under title *Hardware* below.). When the AUV is stationary and charging, the HUB will be lifted (with AUV inside) above sea level to avoid corrosion and easy access for maintenance.

The AUV will move and position in the water by using satellite GPS. The signal does not transfer through water so the AUV will stay close to the water surface and have a 1-meter antenna. When the AUV reaches the cage, it will dive down and scan the net. When the scan is done, it will rise to the surface again and move to the next cage.

The AUV will have a save and retrieve system if it would lose GPS signal and get lost. The AUV will rise to the surface and send a continuous signal until retrieved.



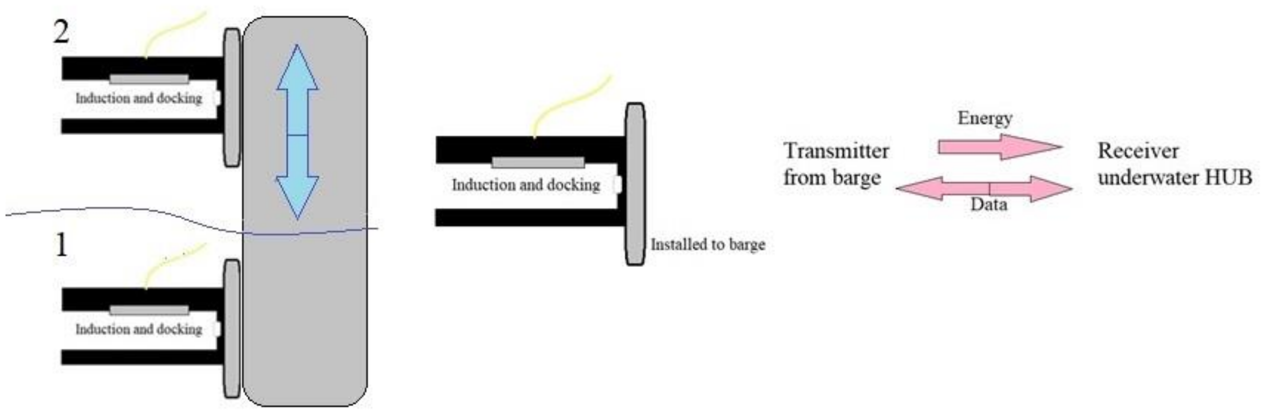


Figure 49 Illustration of function; idea 8

<u>Hardware</u>

The AUV is a similar shape of a stingray with wings and flat structure to improve fluid dynamics and avoid current resistance. A LIDAR is placed in the front for scanning the net. A 1-meter GPS antenna is placed in the middle of the back of the AUV. A sensor to measure depth, a computer to receive and store data from sensors, a steering propeller to move the AUV and a battery to run the system. A docking point with induction charging and data-transfer is placed on the lower back of the AUV. The propeller is protected against harming the net.

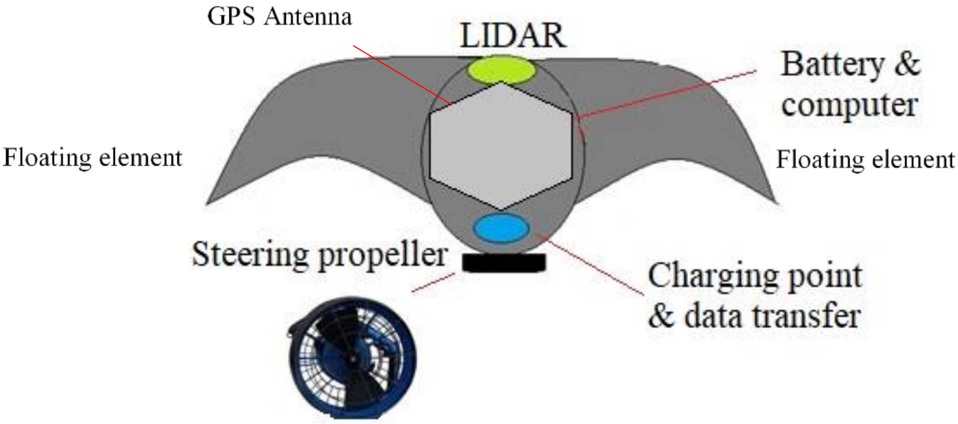


Figure 50 Illustration of AUV system; idea 8

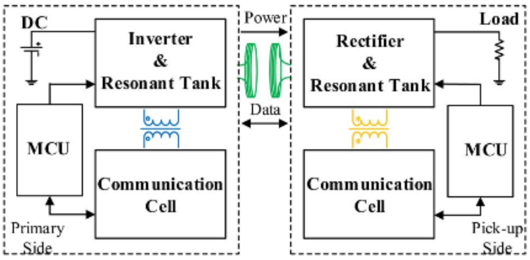


Figure 51 Theory of how charging and data will be transferred through induction adopted from report (Jiande Wu, 2015)

Software

The operator can monitor and track the AUV with a software during operations. The AUV will transfer data when it is connected to the HUB. It will transfer information about time spent, energy consumption, water temperature and net integrity. The data will be analyzed in the software installed in one of the computers. Here, the operator can retrieve a 3D model of the scanned net as seen in the picture below.

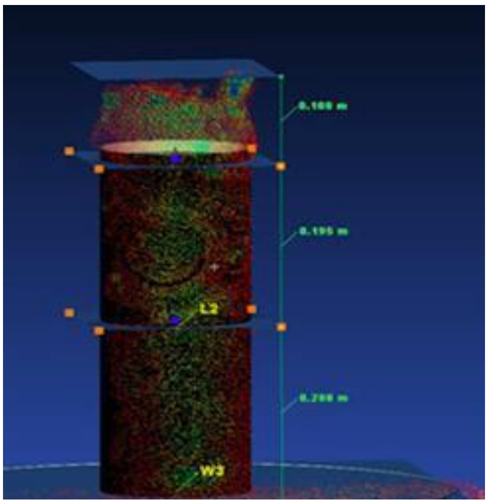


Figure 52 Example of software 3D model from LIDAR

Revenue model

Leased on contract with service contract for maintenance.

New customer group

For future scaling:

- Harbour inspection
- Hull and vessel inspection for maritime industry
- Oil and Gas offshore structures
- Mapping of marine littering in fjords and harbours

Key challenges solved

Reduced cost in net inspection. Reduced cost of cleaning due to better planning and optimal oxygen level. Fast feedback of fish escape. Less maintenance than idea 7 since it is lifted above water level when not in operation. Less labour intensive than existing method.

Issues with the idea

AUV is still a new technology with challenges to overcome. The cost of production would therefore be high but as development becomes more commercialized, the price will go down.

Ranking of idea

This idea is an improvement from the last idea (idea 7) as seen in the table below, but it should be improved more to be evaluated as an opportunity. See idea (idea 9) below for further development of idea.

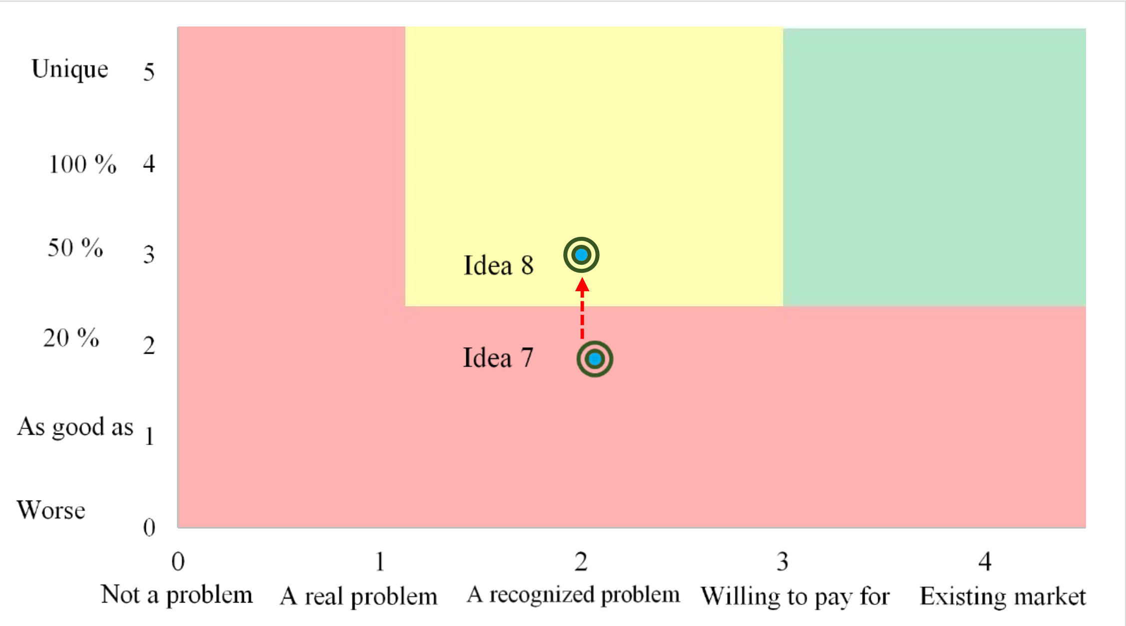


Figure 53 Ranking of idea 8

9. Avoid fish escape and improve fish health by net inspection and net cleaning using AUV.

Existing method

The reason for cleaning the net is to have optimal oxygen level and current in the cage. Today, service companies come with a boat with a crane, a pump and a net cleaner (see right side figure below). The cleaner is lowered into the cage and is placed on the net. The net-cleaner has one water hose and one electrical cable attached. The cleaner is then controlled by a remote control and a camera that the operator uses to navigate. Another more traditional way is to use divers with cleaning equipment (see left side figure below).

Figure 54 Existing product FNC8 from Akvagroup (Akvagroup, 2018)

Problem size

In addition to the inspection of cage explained in idea above, the cage also need cleaning. The operation is extensive and time consuming. Each cleaning service can cost in the area of 150 000 NOK each time and is done every 10th day in the summer period and less frequent in winter period (information received during a visit at a fish farm). This is therefore one of the largest cost for fish farmers today. Problem size is categorized to be 3 *"A problem someone is willing to pay for"*.

Description of idea

This idea builds on the product from idea 8 meaning, it will have the same system as above with additional net cleaning. The AUV will place itself on the outside of the net and start a reversed impeller (centrifugal pump) that will create a suction of water. The dirt will go from the net and through the impeller and out on the other side of the AUV. The suction will keep the AUV attached to the net. This will not be as high pressure as traditional tools. To compensate for the lack of power, six additional brushes will be scrubbing the net to loosen the dirt. The AUV will circle each cage and return to the HUB when finished. The operator can track the operation via GPS when the AUV is afloat as explained in last idea.

Hardware

In addition to idea 8, it will have a centrifugal pump and engine centered to suck water. Seen from above is the outlet of water (discharge side). Seen from below is the brushes and reversed impeller (suction side). The picture of the centrifugal pump below (Engineering expert, 2018) is a similar solution but without suction and discharge in opposite directions (⇔).

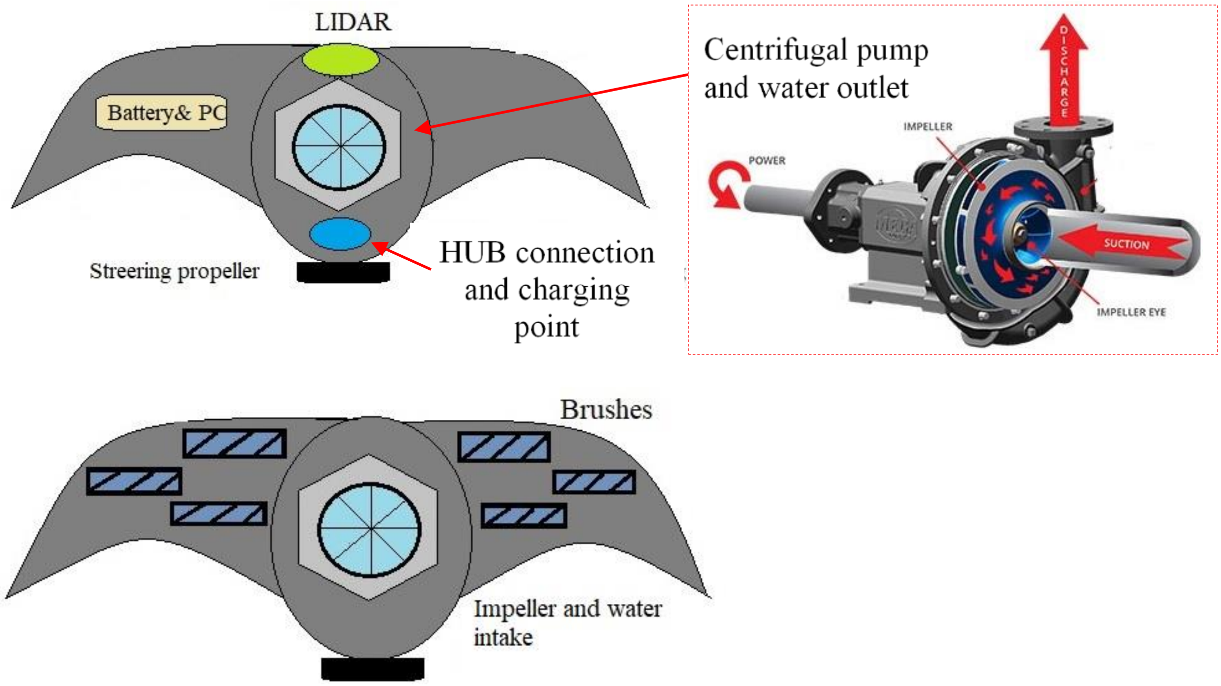


Figure 55 Illustration of function; idea 9

Software

In addition to the idea 8, the AUV will transmit data about cleaning time and results scanned by the LIDAR.

Revenue model

Same as idea 8

New customer group

For future scaling:

- Cleaning harbours
- Cleaning ship hull
- Cleaning oil and gas offshore equipment

Key challenges solved

In addition to idea 8, it will replace the cleaning service and reduce the cost of cleaning

Issues with the idea

The normal net cleaner uses a compressor and pump water through a high-pressure pump from inside the cage and out. The AUV will use reverse impeller and suck the water through the machine. This will not give the same effect, but a more frequent use will compensate for the lack of power in cleaning. The AUV may require additional maintenance service to clean brushes and empty centrifugal system for dirt.

Ranking of idea

After improving the idea, it is now above 100 % better than the existing methods explained above, and the solution is solving two problems (cleaning and inspection). The size of the problem can therefore be seen as a huge problem with an already existing market.

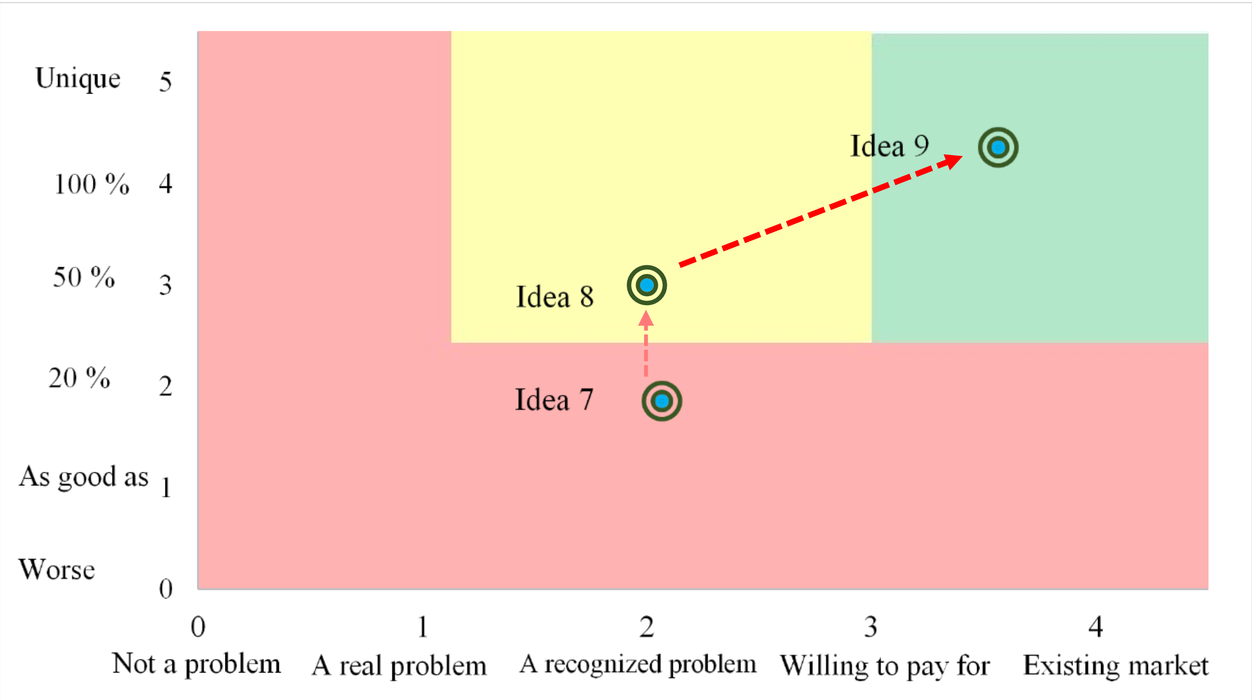


Figure 56 Ranking of idea 9

10. Fish escape: Estimating inspection of net, mooring and barge using IoT

Existing method

As earlier mentioned in idea 7, the inspection of asset integrity occurs every 12 weeks and does not rely on any data besides previous inspections. Therefore, if a problem occurs between the last and the next inspection it will not be identified.

Problem size

Same as idea 7, problem size 2 "*A recognized problem*".

Description of idea

The product is a software installed on one of the operator's computer. It gathers historic data mentioned above to better predict when the barge, mooring lines or cage needs inspection. The goal is to remove unnecessary inspections, predict hazards and improve up-time of system. The data will be collected from various existing sensors and information manually input from the operator and service companies. It is important that the information exists for this product to work optimal. **Data gathering from cleaning system**: The data about the cleaning interval will provide information such as wear and tear of the net from the frequency of usage of the machine and the amount of dirt in the net can add extra weight and can cause integrity problems. The information from the cleaning service will also provide a history of preventive maintenance. It is important to create a standardized digital check-list for the service provider to fill in each time the service is provided.

Data gathering from biomass: This will provide information about the size and weight of the fish. The number and the size of salmon may affect the system integrity. The operator will fill out a digital standardized check-list for biomass.

Data gathering from existing environmental sensors: The data will assist in prediction of the state of the assets. Historical data such as strong currents, temperature, windspeed, wave heights and other weather conditions (snow etc.) will assist in predicting the integrity of moorings, cages and barge. This data will be collected from existing sensors.

Data gathering from previous inspections: The data from history of inspection can be digitalized by a standardized and digital check-list is filled out by the service company after each inspection.

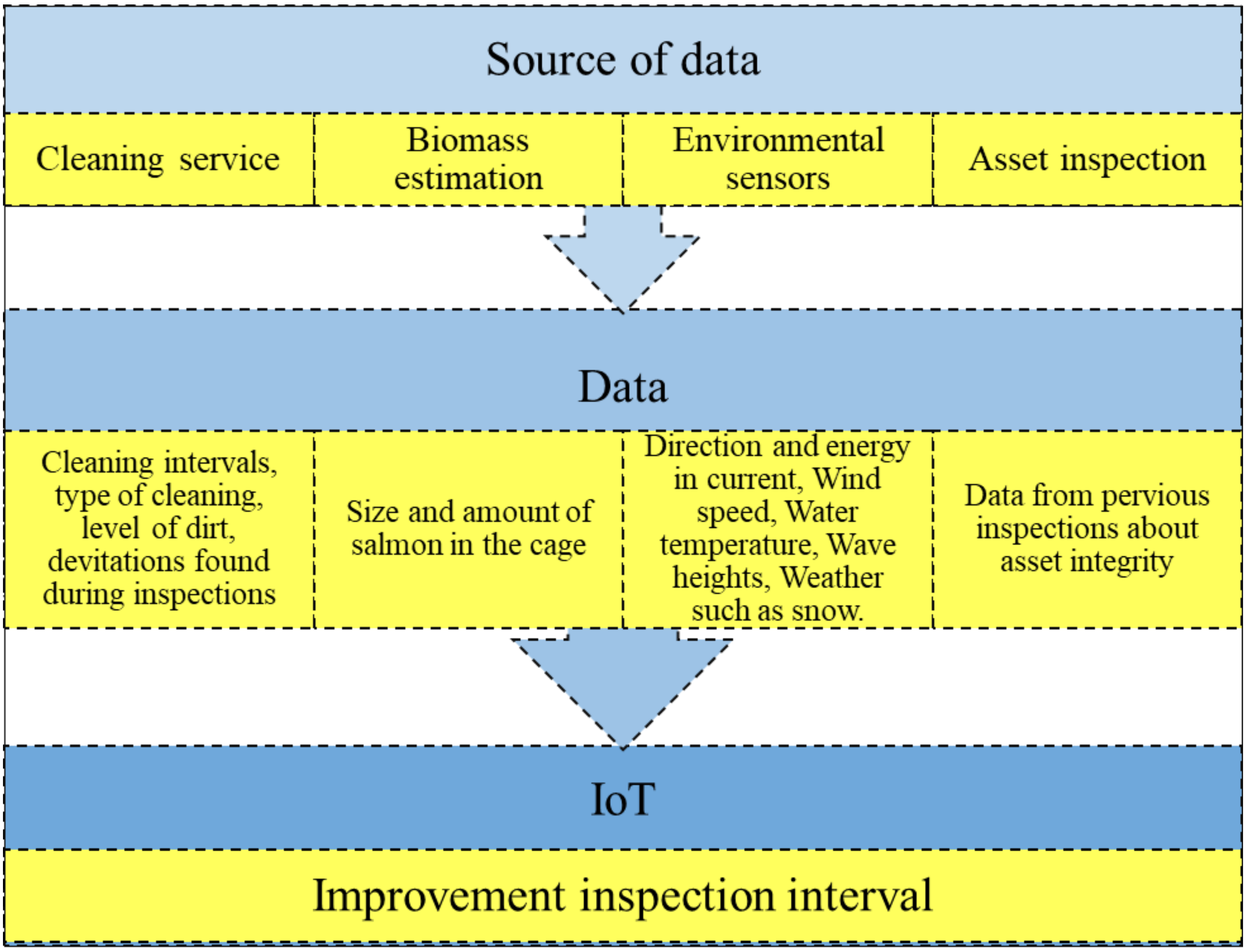


Figure 57 Illustration of information gathering; idea 10

Software

The software is installed on one of the computers. It is easy to interpret with understandable information about the asset integrity. The uncertainty level will also be available for the operator and will be calculated corresponding to the amount and various data available.

Revenue model

The software will be available online and can be downloaded through a cloud. The customer pays a subscription to use the software.

Key challenges solved

- Remove inspections costs by creating condition-based inspection intervals.
- Predict hazards and decrease chance of equipment failure.
- Improve up-time of system and reliability of system.

Issues with the idea

The question is if the data will be available and how large the uncertainty will be. The software will create better estimation depending on how many sites and various data it has available. Therefore, the software will be dependent on a type of network effect which will improve its algorithms by each new customer.

Ranking of idea

The idea is only 20 % better than the existing method explained above, and the problem size is small but recognized problem.

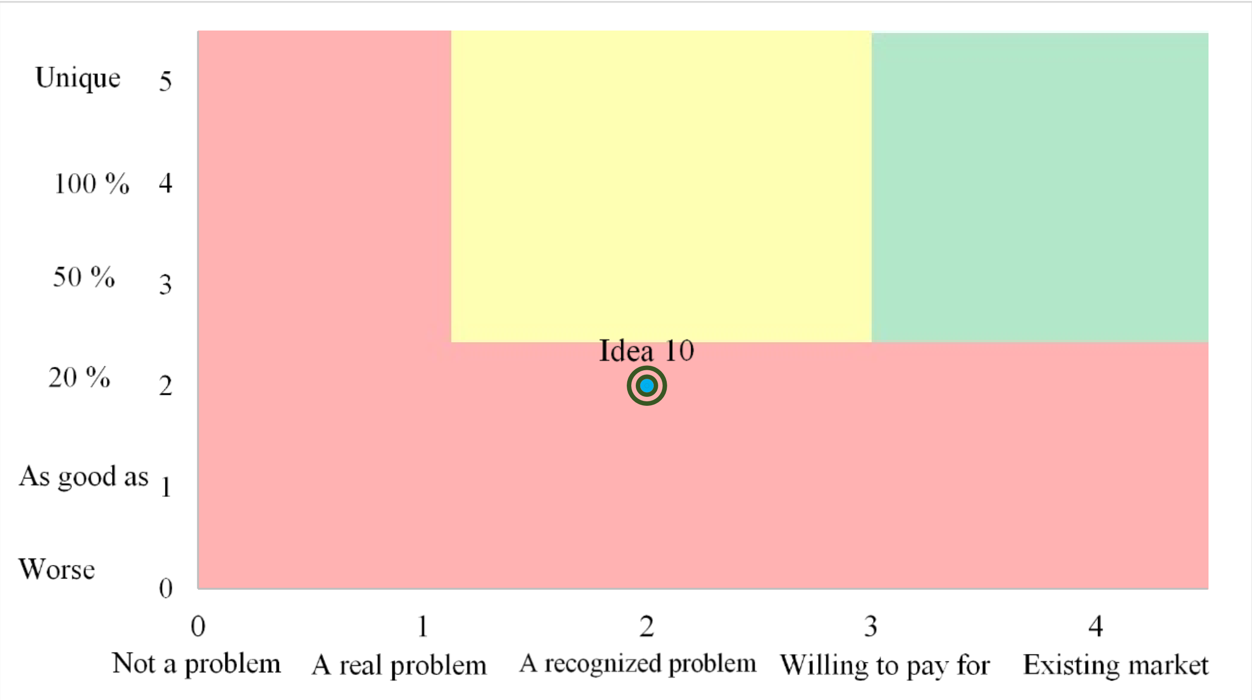


Figure 58 Ranking of idea 10

11. Transparency and food safety: Blockchain and intelligent app

<u>Existing method</u>

There is little or no transparency in the Norwegian salmon market today. There are some organisations that certifies products today such as “*Friends of the sea*”,” *Debio”* and *“GGN”*. The EU is the largest marked for Norwegian salmon today, and France is the largest single market for high-quality Norwegian salmon (Simen Follesø Røiseland, 2018) and requires labelling of the following parameters: Origins, Ecology, Taste and Quality.

<u>Problem size</u>

The problem size is categorized as 2 “*A recognized problem*” and is discussed below.

Food safety: Firstly, a large issue in the food industry today is the lack of information about the food we eat. The largest customer for Norwegian salmon are supermarkets and encompasses 80% of the market. They require additional services such as documentation of how the product is produced and treated.

Surveillance agencies: Secondly, surveillance agencies use a lot of resources to control and ensure that fish farmers are following rules and regulations. Such as biomass, use of authorized and approved equipment, pollution levels, knowledge within the company etc. There are no standardized methods to gather this information.

Lean supply chain: Logistics is seen as an important competitive advantage especially since the international sushi market is expanding. The main parameters here are time and cost of transportation and normally supply is delayed by complexity and lots of point to point communication between onshore, offshore and air providers, freight forwarders, custom authorities, approving agencies, customs brokers governments and ports (IBM, 2018).

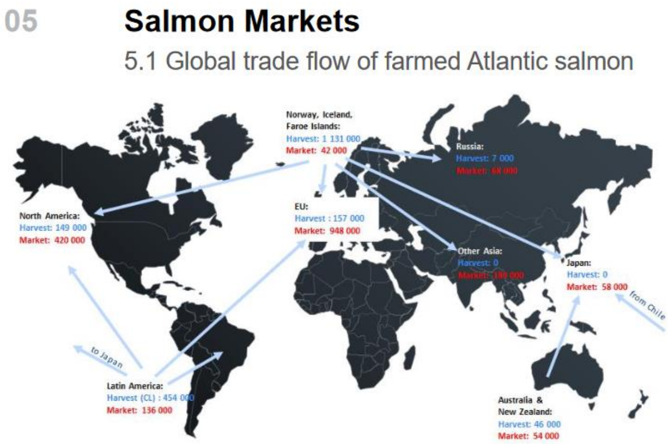


Figure 59 International distribution of farmed Atlantic salmon adopted from (Marine Harvest, 2017)

Description of idea

The idea is to create a computer software with an app that can easily retrieve documents, reports, create contracts and generally share information automatically. This will be done through a digital cloud platform where information is systematically stored for software and app to easily retrieve information. The idea is to create transparency, stream line supply chain by removing third party interference such as surveillance agencies and other actors that slow down the process without losing trust or increase chance of tampering with documents. The technology to achieve this is a blockchain system.

Food safety: The blockchain will record acquisitions, transaction and details about all actors involved, locations of farming and life stages of salmon, equipment used and logistics. This is recorded today, but mostly manually on paper. The idea is to create a platform where all data can easily be added to. The consumer will have an app and a QR code to scan at the supermarket to retrieve necessary information about the salmon to ensure consumer trust (as seen in picture below). The fish farmers using this system will have an easy and standardized way of reporting and storing data, at the same time creating trust with clients and consumers. This will most likely increase market share.

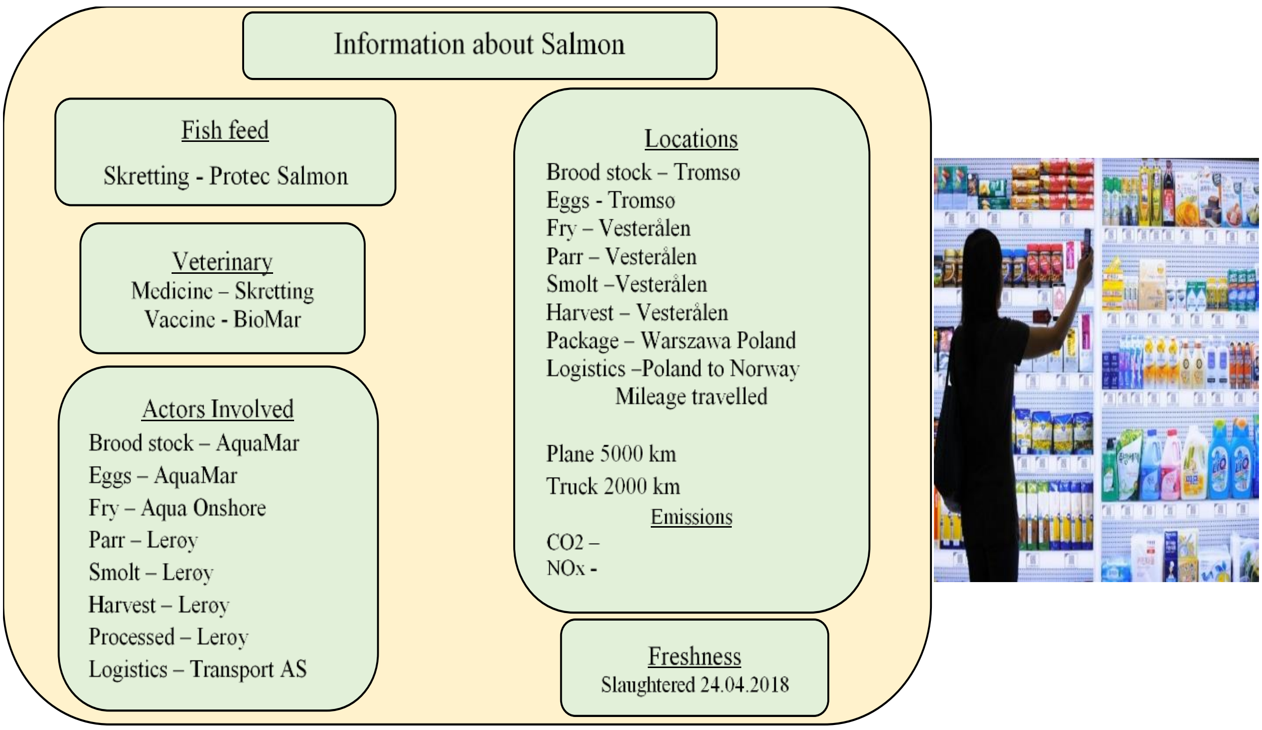


Figure 60 Illustration of information from scanning QR code and consumer using QR code adopted from (Pinterest, 2018)

Surveillance authorities: Same as above just without QR code + app and instead, a software. The information about each farmer will be easily retrievable for the surveillance agencies of the current condition to provide a systematic and holistic overview. The idea is that the farmer will fill out a standardize digital form that will be distributed to relevant actors. Below is an example of data the farmer must fill in on a standardized digital software:

Number one from the left: Reporting and documentation of biomass to relevant authorities and the company to ensure the limit stays inside the permit.

Number two from the left: Knowledge about type and number of pellets. Can also assist marine biologists in mapping, researching and controlling cause of death, lice problems and growth rates much easier.

Number three from the left: Reporting and documentation of amount and cause of death.

Number four from the left: Reporting and documentation of delicing.

Number five from the left: Reporting and documentation for fish to prove the integrity of the cage system and ensure transparency.

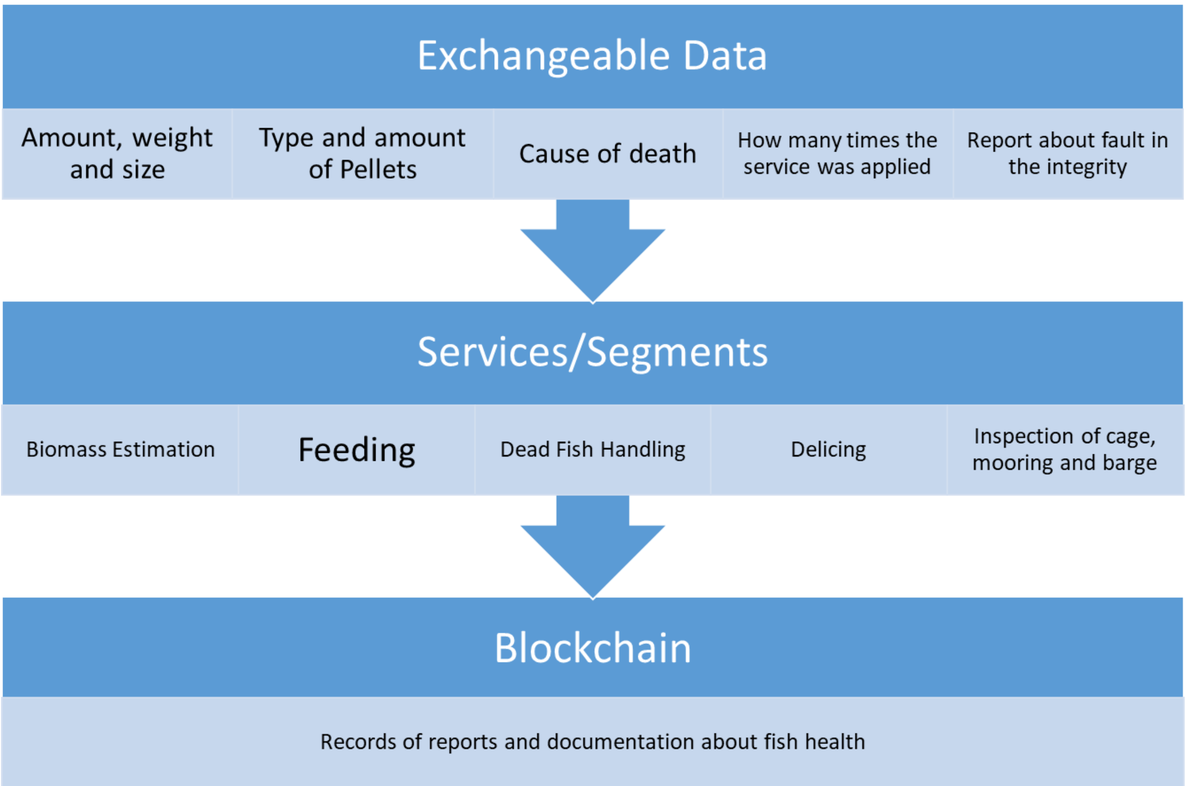


Figure 61 Reported information will be stored in tamper proof ledgers to ensure trust and transparency

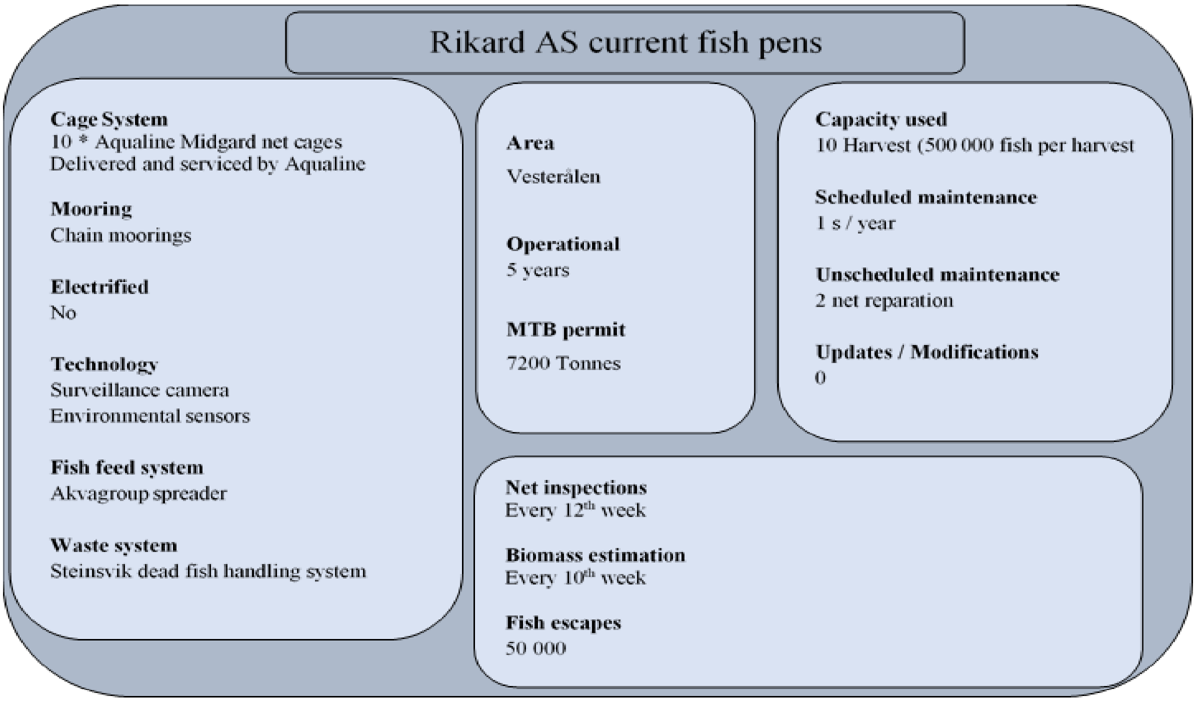


Figure 62 Example of presenting data about fish farmer to surveillance authorities

The standardized format will also help in applying for new permits and speed up the application process as shown in the figure below. The reason for this is because the history of the fish farmer exists and the request for new permit will be shown in the same standardized and systematic method.

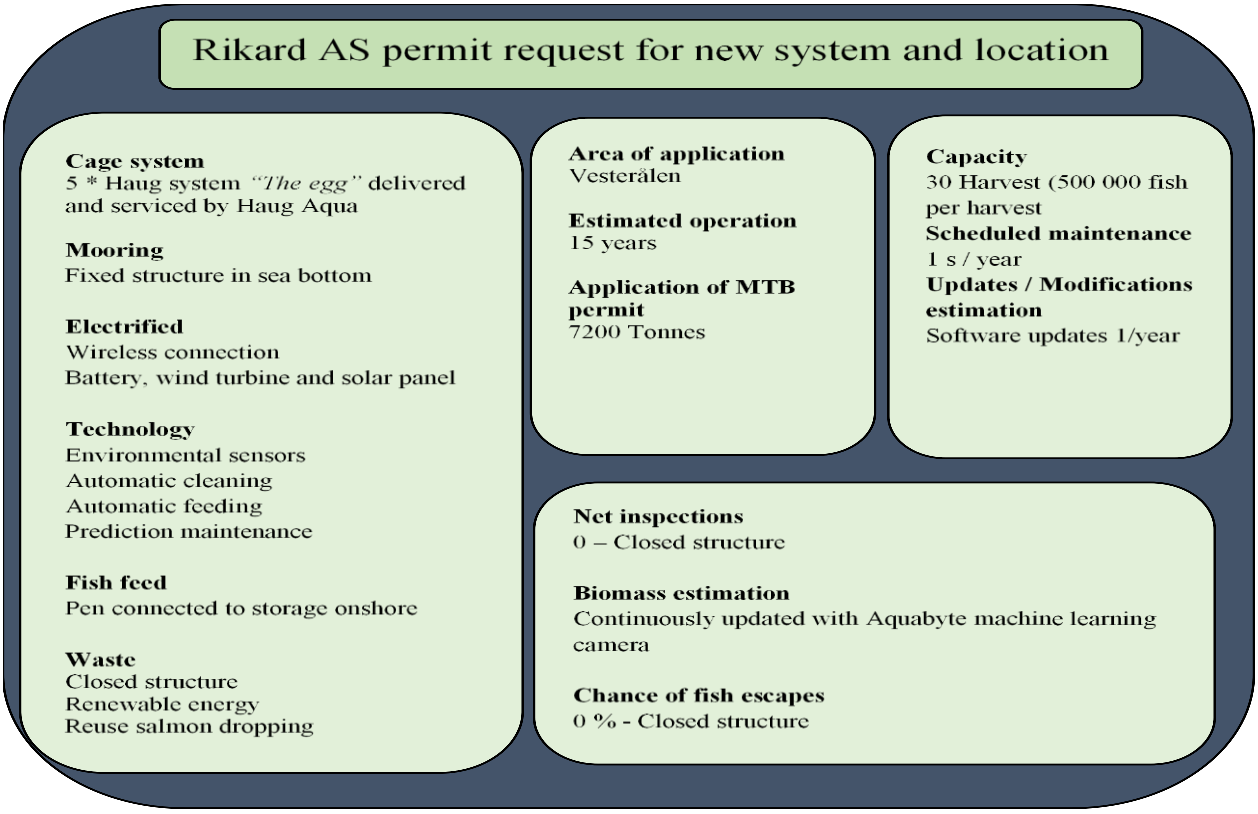


Figure 63 Example of applying for new permit

Lean supply chain

Improve international relations, simplify global trade, and ease documentation handling for international distribution by digital document handling and smart contracts. The idea is that a digital document will be created when a container of salmon leaves the Norwegian harbour. The document will be live updated as relevant stakeholders signs the paper. This is done through a digital cloud and a digital platform. It should be a simple log-in, to access the cloud and sign the document with a digital signature (for example, bankID). The idea is to streamline the process and give an easy overview of where the shipment is and follow the process live. The goal is to finish as much paperwork as possible before the delivery has arrived without worrying about tampering or falsification of documents.

<u>Revenue model</u>

The software can easily be downloaded through cloud service and the customer will pay a licence fee. A yearly members fee for maintaining the application and QR codes and to promote the company in the trusted distributed ledger.

<u>Key challenges solved</u>

Food safety for consumers: Avoid tampering and forgery to ensure trust. The blockchain gives consumers an easy way to track the salmon's lifecycle and fish farmers supply chain along with all actors involved. It also reflects if the salmon was produced safely, responsible and sustainable.
Surveillance agencies: Easier and faster permit process for expansion of fish farms or implement of new processes, equipment or technology.
Supply chain: Blockchain will make it easy to spot bottlenecks in the supply chain. Blockchain technology can facilitate document handling and electronic contracts which can streamline and increase efficiency in processes.

<u>Issues with the idea</u>

Blockchain is an early phase technology with still some barriers to fully function. An issue is that all stakeholders must collaborate, use the same software for standardized compatible data.

First barrier is that the miners use time and storage to verify and keep copy of blockchains in their system. No one is willing to do this for free and if transactions of small payments must occur each time, the fees for transactions will be expensive to. At the same time, peers will only mine data that gives the highest payments. A solution is unassisted mining. This is a technology from the digital ledger company IOTA (IOTA, 2018) which uses AI and machine learning to remove human miners and only control supervision. In theory the new system will work in a way that every time a person sends a transaction it approves two other transactions (these two will be pointers to the persons transaction).

Second barrier is limited storage on hardware. A block is limited to 1 megabyte (Cryptonauts, 2017) and the more people entering the blockchain, the slower the network will be. But, exponential increase in both cloud storage and hardware expansion are enabling larger ledger systems. Another enabler for this barrier is development of quantum computers and trinary processor systems (using +1, 0, and -1) are on the horizon and will replace the original binary processors (0 and 1).

The third barrier is bad timing. Blockchain and Bitcoin had a lot of momentum because of recession time in economy where people saw that centralized and regulated economy didn't have control. The drive is then the decentralization of economy, so no entity will have control or majority.

Fourth barriers of Blockchain is that China dominate over 42% of Bitcoin exchanges and control 70 % of all equipment necessary to mine Bitcoin (which is the opposite of a decentralized economy). (Brynjolfsson & McAfee, 2017).

The fifth barrier is fluctuation of the most popular Blockchain technology, Bitcoin. It has contributed to the low acceptance of the technology because one of the main pillar of economy is stability and predictability.

Figure 64 Screenshot of history including todays value of bitcoin (Coindesk, 2018)

Ranking of idea

The blockchain technology is growing and more industries starts to see benefits from such a system. The consumer trend of salmon is showing increased requirement of transparency, authorities require easier tracking, and distribution is a large bottleneck with huge improvement potential for competitive advantage. But it is an extensive idea with many barriers to overcome. The largest problem with the idea is timing, but both problem size will grow and potentially lower barriers in the future as the technology mature.

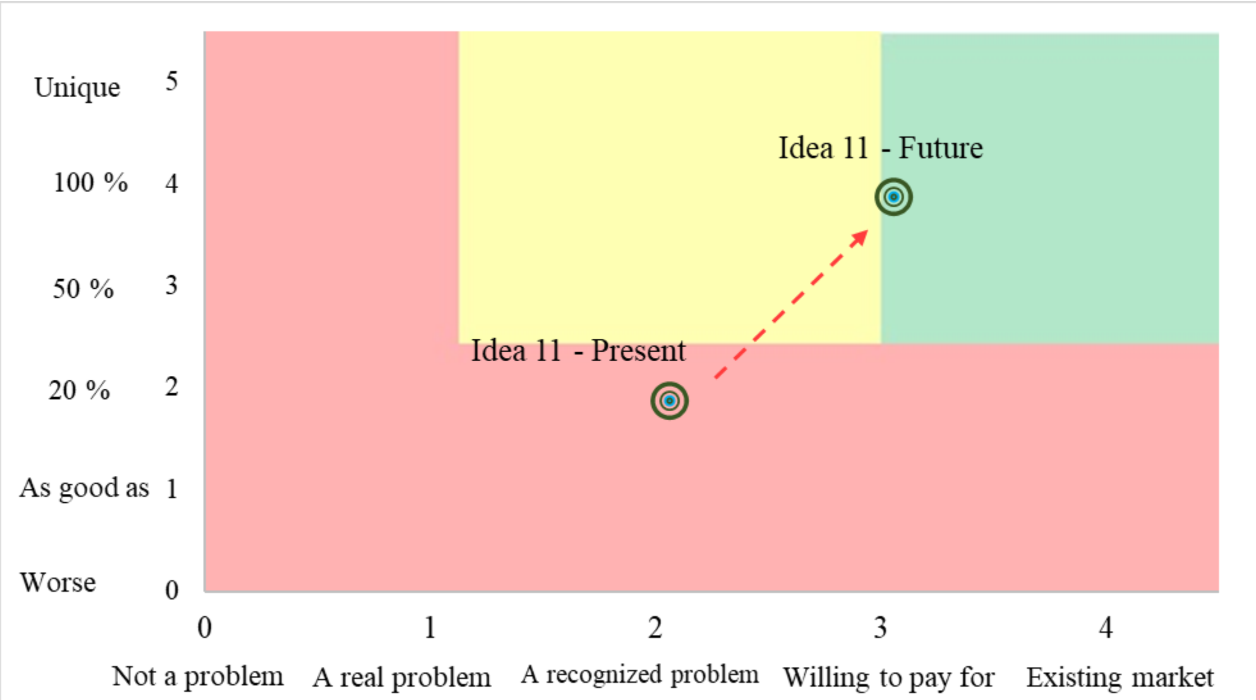


Figure 65 Ranking of idea 11

12. Hazardous work condition - Above sea-level asset inspection using drone and computer vision

Existing method

The asset inspection is legally required to be done each day. This is regulated by the Norwegian aquaculture law, chapter 2 paragraph 12. This is done manually. The operator travels from barge to the cage with boat. The boat is docked to the cage and the operator walks around each cage to visually inspect integrity of system.

Figure 66 Visual inspection during visit to fish farm

Problem size

As earlier mentioned in Part 1, Industry - *Key challenges in the selected segments- hazardous conditions*, the sea farming industry was voted the second most dangerous place to work because of the operators are exposed to unsafe environments. They are frequently exposed to strong winds and gusts, waves, snow and rain. The problem size is categorized as 3 *"a problem someone is willing to pay for"*.

Description of idea

The idea is to introduce a drone to do visual inspection above sea level such as check holes in bird net, birds inside the cage, visual inspection of floating cables and feeding system, movement of fish on surface and integrity of other above sea-level assets. The operator will monitor this from a safe environment using remote control and display.

Hardware

Water resistant drone, 180° movement and 4k camera, remote control and display for operator.

Figure 67 Example of drone adopted from (Komplett, 2018)

Revenue model

Product sold as a one-time transaction to the fish farmer.

Key challenges solved

- Less manual labour.
- Reduced risk for incidents and accidents.

Issues with the idea

High barriers for entry since it is a lot of actors in the market with years of experience and cheap methods for manufacturing the product. At the same time, it is used in other industries and the same drone can be applied in this industry without large modifications.

Ranking of idea

Since the existing competition have good enough solutions, the chances of implementing more technology to improve the product and make it attractive for customer is small. Also, this is a crowded market with low production cost and small profit margins.

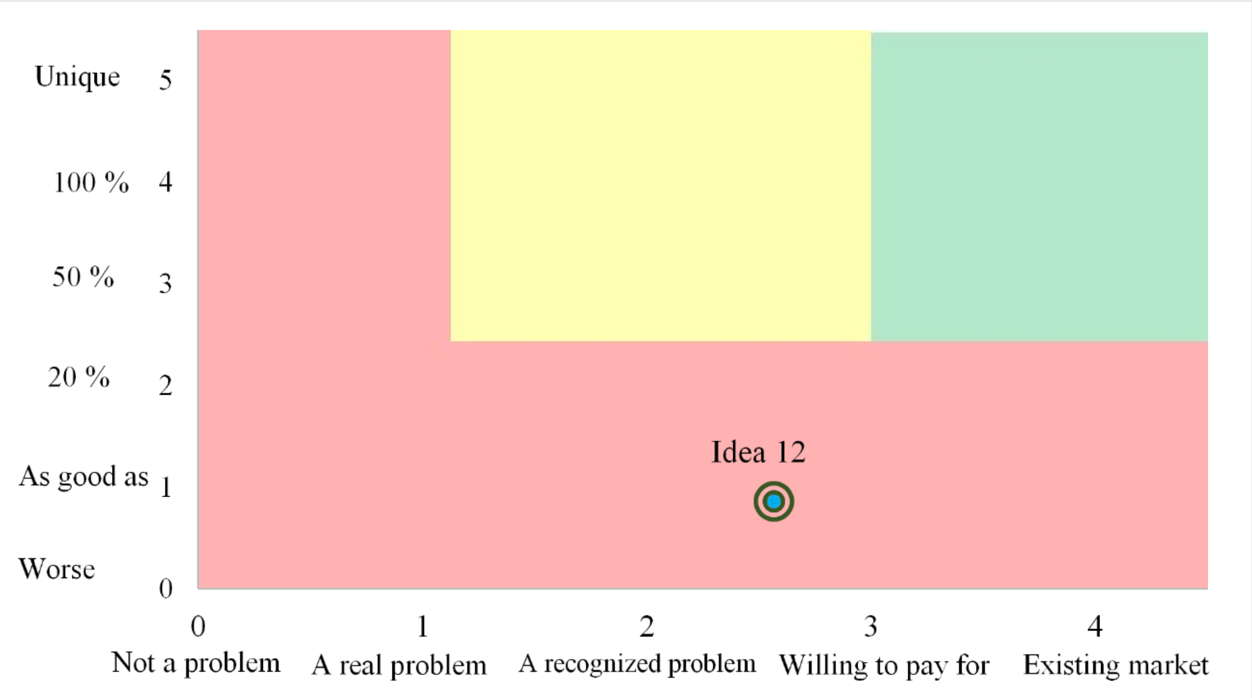


Figure 68 Ranking of idea 12

13. Hazardous work conditions: Increase safety with sensorisation - smart clothing

Existing method

Water and tear resistant coveralls and a lifejacket are used when going out to the fish cage. This will keep the person afloat and dry for some minutes if fallen in the water.

Figure 69 Picture of coveralls used on visit to farm

Problem size

The problem is that it is easy to slip and fall into the water or on obstacles. Firstly, because of the weather as mentioned above, but also because of the obstacles on the pathway and the slippery surface as illustrated in the picture below. The clothes will keep a person alive for a few minute if fallen into the water but it won't rescue the person. The problem is categorized as idea above, 2 *"a recognized problem"*

Figure 70 Obstacles in pathway on pathway observed while visiting fish farm.

Description of idea

The idea is to create an automatic way to alert other personnel to quickly respond to a search and rescue of a person who have fallen in the water, slipped and fell on the path way or other unsafe conditions such as heart attacks, strokes, cuts and bleedings. The personnel will receive an alert through an APP on phone or software on computer. A flashing light will start blinking on the coverall when unnormal condition is detected to ease the search and rescue.

Hardware

The overalls will have sensors to monitor important parameters of the operator such as, heart rate, core body temperature and geographic position. The coverall will consist of three different sensors, one data transmitter, one battery and one flashing light.

Sensors

-1 EKG sensor in lower left arm (arm wrist). The EKG is hidden in the sleeve, located as seen in left picture below and the operator can adjust the tightness as seen on the picture below.

Figure 71 Example of EKG sensor hidden in working clothes / overalls

- 5 temperature sensors placed to monitor core body temperature as seen in picture below.

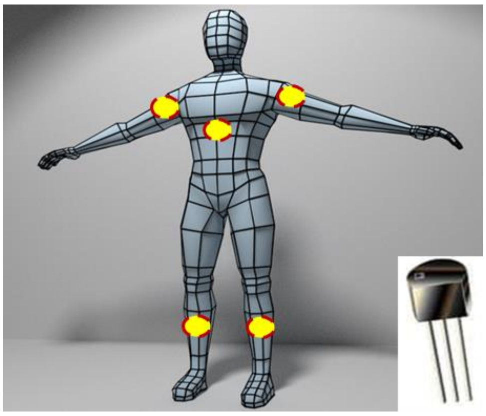


Figure 72 Type and placement of sensors. Sensor in lower right corner taken from (M.electronic, 2018)

- 1 GPS Tracker to transmit position. Placed in a closed pocket on the upper back as shown in picture below. The pictures are merges from (Polar, 2018) and (EBAY, 2018).

- 1 Flashing light activated when unnormal readings from sensors placed on the chest as illustrated in the right picture below.

Figure 73 Illustration of GPS from POLAR and flashing light adopted from (C.adventures , 2018)

- 1 battery pack, 1 wireless transmitter and communication network between sensors. The battery is detachable and will be charged after each use.

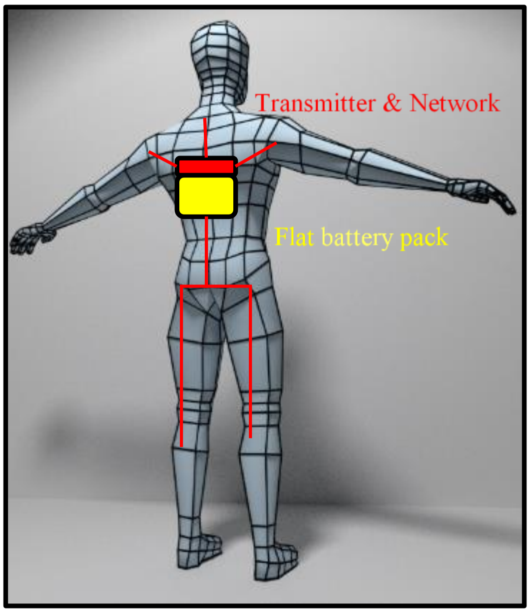


Figure 74 Sensor transmitter and communication and battery pack

<u>Software</u>

The point is not to have a continuous monitoring of the parameters but for the software to alert other personnel in the barge if it detects unnormal changes or patterns suggesting harm or danger to the operator. The software will illustrate the unnormal parameters on a screen and show location of the person (as seen in picture below). The software will continuously live-update the parameters if the search and rescue are under operation. The system may be reset, from the software or from the coverall.

Figure 75 Example of how software would display

Revenue model

The clothes are leased for a monthly fee and yearly contracts. The leasing includes software updates, and the customer have the option of product updates.

New customer group

Offshore operators such as:

- Fishermen
- Personnel on vessels
- Offshore platform personnel
- Military navy personnel

Key challenges solved

Increased safety for operator because of faster response to accidents and easier locating of person.

Issues with the idea

Even though aquaculture was voted as second most hazardous place to work in Norway, there are minimal accidents that leads to fatality or long-term damages. The product is therefore not attractive now, but could change depending on future accidents, statistics and new rules and regulations. Also, the solution doesn't reduce the risk of accidents or remove the hazardous elements which means it doesn't solve the problem to an extent for customer to pay for the solution.

Ranking of idea

Timing is wrong for this product. Increased safety for Norwegian salmon farmers is not the focus today, due to larger problems in the industry such as lice, other fish health issues and green technology.

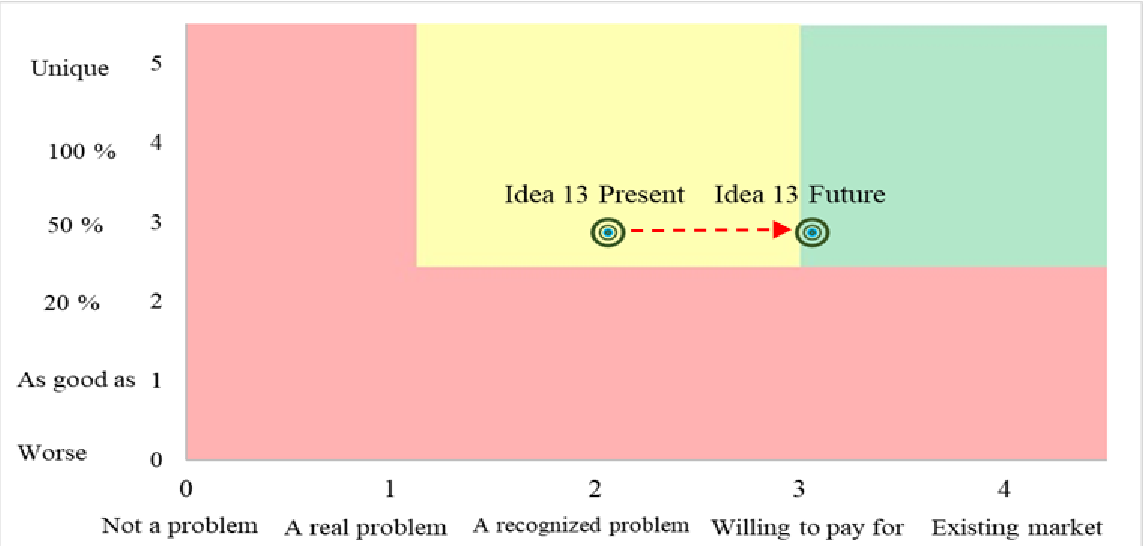


Figure 76 Ranking of idea 13

14. Pollution to the aquatic environment: Renewable energy - Hydrogen as energy source

Existing method

The power supply varies depending how far the farmers location is from shore. The fixed barge structure close to shore normally have power lines hooked up to a grid system. But, more locations are moved further out from fjords and out to open water to avoid high concentration of pollution of the marine life. These locations most commonly use floating barge, powered by fossil fuel.

Problem size

A large focus in the Norwegian salmon farming industry is green technology. It is important to reduce the damage to the environment, but also to acquire new expansion of permit, and brand recognition to increase market share. The green technology does also encompass the power supply to run the daily activities. The problem size is therefore categorized as 3 *"A problem someone is willing to pay for"*.

Description of idea

Most of the studies found during the research for this idea is on solar and wind power. This idea will investigate the opportunity to implement Hydrogen power as a source of electricity. The barge will have its own power supply and be disconnected from the grid. Salmon farmers have a huge advantage in applying this technology since they are surrounded by water and the bi-product from hydrogen power is pure water. The hydrogen technology will filter the surrounding water to achieve the pureness needed to separate hydrogen from water. One of the main problems with hydrogen is that it is highly explosive and should therefore not be stored in large volume too close to people. To solve this, the process of separating hydrogen from water will be done on demand when needed. The tank containing hydrogen will alert when a lower limit is reached, and a software will estimate how much power is needed for each activity by running through previous data and other input information. But there must be a small energy consumption to produce hydrogen. A small wind turbine would be sufficient.

Hardware

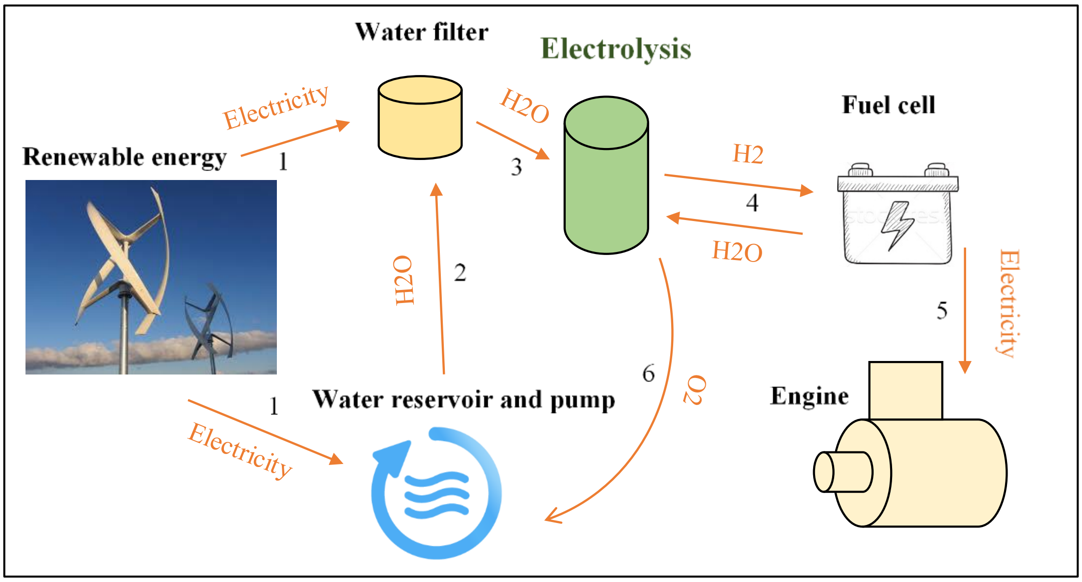


Figure 77 Example what hardware would be necessary on the barge.

Software

- Software is installed on computer and monitor power supply and control ratio of energy conversion.
- Running algorithms to estimate production schedule automatically with manual input from operator.

Revenue model

The product will be delivered, installed and maintained by manufacturer. The product can be sold as a one-time payment with a service agreement for maintenance.

New customer groups

Cars, smaller boats, harbours, other structures close to water.

Issues with idea

The system has only been tested in theory and is not fully developed. Even if the new system is safe and explosive proof, there are still inherent biases against hydrogen as a power supply.

Ranking of idea

The conclusion is that the timing is wrong. The public and customers are not ready for this product yet and technology development is not mature enough. But, Mercedes and other car companies are developing cars running on such a system (Hildonen, 2017). A prediction can therefore be that in few years, when it becomes more commercialized, it will be a reliable power supply with large market opportunity

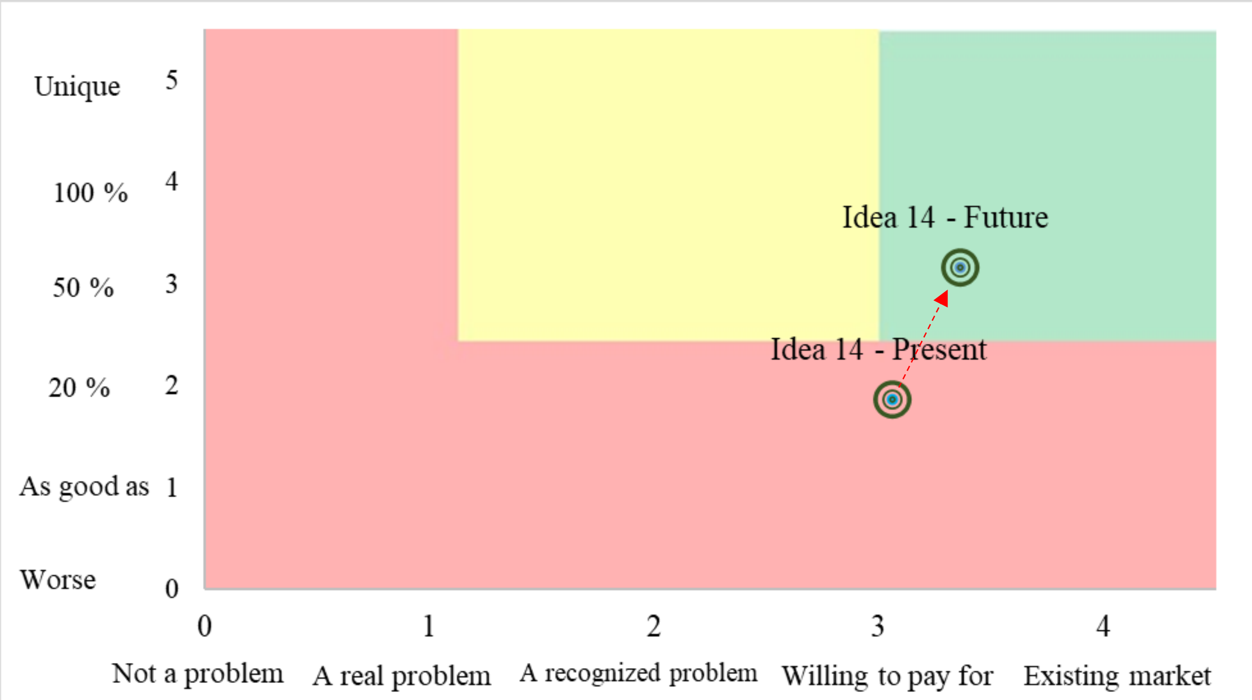


Figure 78 Ranking of idea 14

4.3 Conclusion of initial idea screening

The ideas that achieved the highest ranking from the initial screening will further be investigated as an opportunity for a business. The selected ideas are:

Idea 1 – Biomass estimation using LIDAR, Machine learning & Computer Vision

Idea 3 – Lice removal by using Waterjet, Machine learning & Computer vision

Idea 4 – Lice removal by using Machine learning & PLC

Idea 5 – Feeding control by software

Idea 9 – Asset inspections and net cleaning using AUV

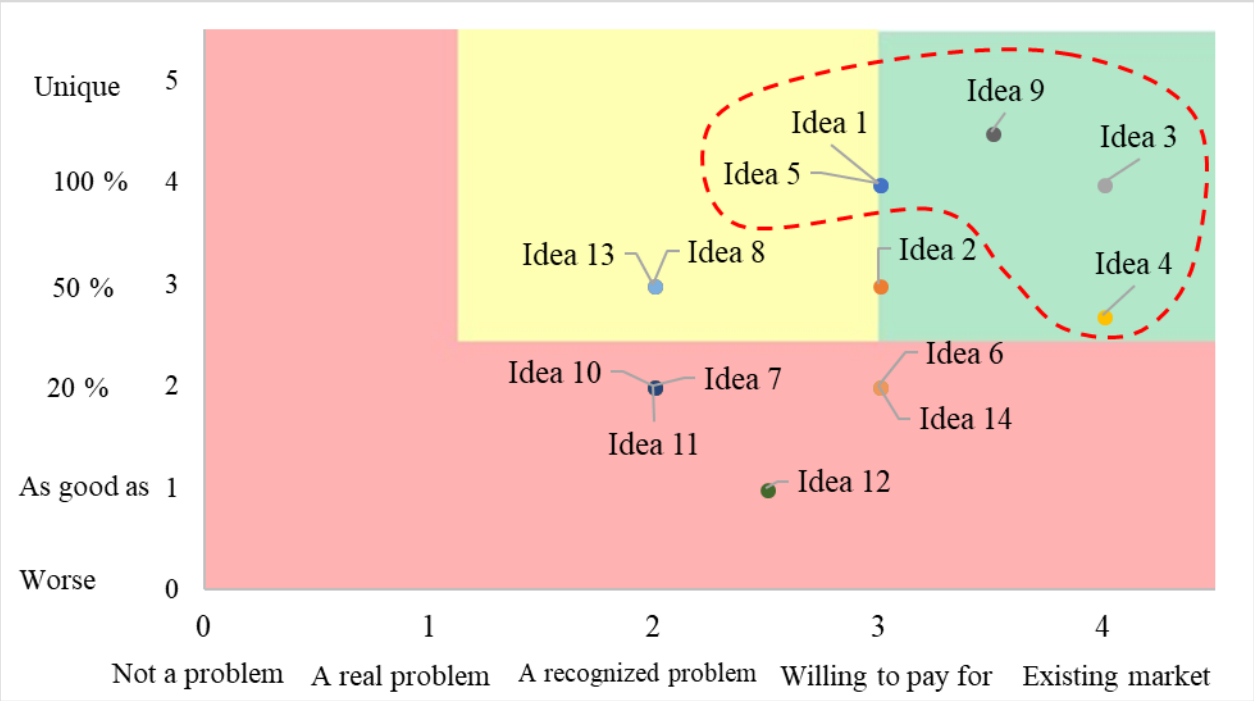


Figure 79 Ranking of all ideas in same diagram

4.4 Opportunity screening – Market size, Profit margins & IPR

Opportunity 1: Idea 1 – Biomass estimation

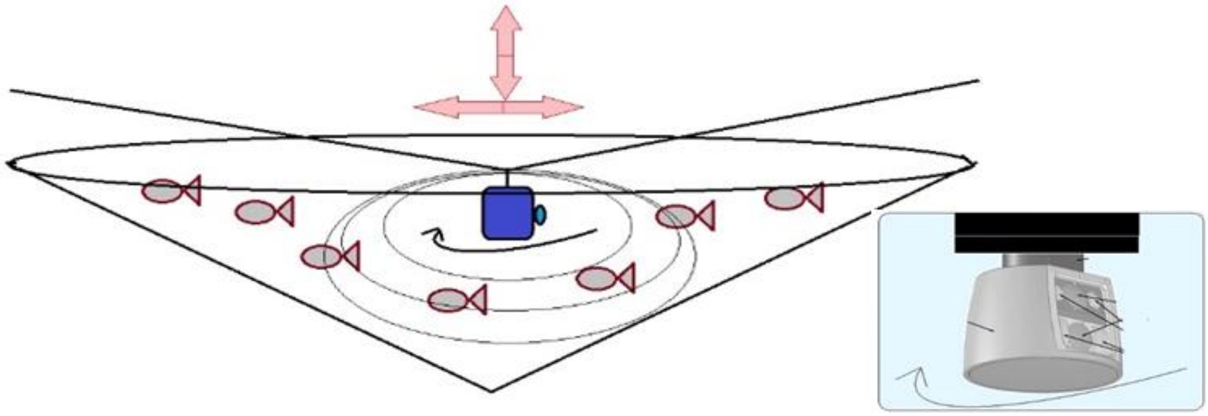


Figure 80 Biomass estimation using LIDAR

Market size

Every salmon farmer must report biomass in Norway, and biomass estimation is equal to revenue estimation. This means that all farmers benefit from knowing what is inside the cage. There are more aquatic species being farmed in cages and the system (machine learning) could be customized to fit these species at a later stage. The potential market size is categorized as *global market.*

Profit margins

Biomass estimation is legally required by Norwegian aquaculture law and states that the salmon farmer must have updated numbers at all times. The service could therefore be applied once every third month. The biomass should be delivered as a service to maximize revenues. The service may use an hour per cage (depending on how many data points the software needs to achieve a good estimation) and requires two people to execute. Applying the service at one site is a full work day for two people. The main cost will be labour. The development of the product is not too expensive since LIDAR technology in general is commercialized and can be procured from a manufacturing company. The highest cost would be development of software, but once created it can be replicated for almost zero cost.

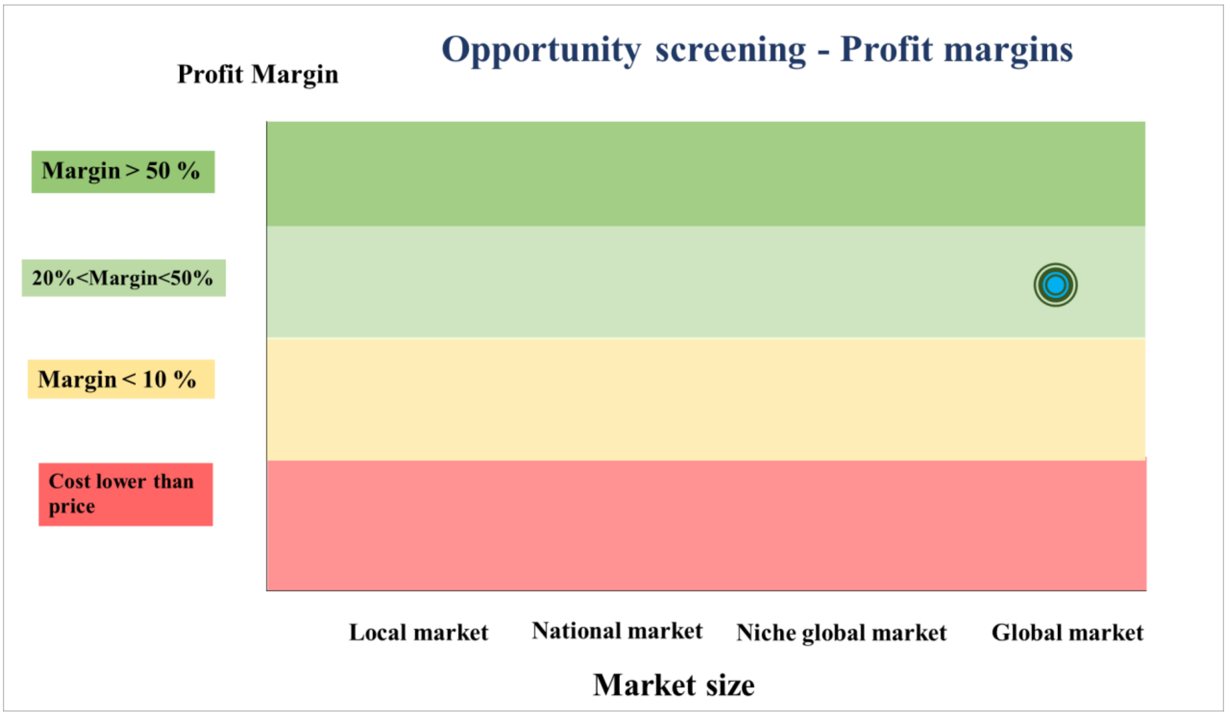


Figure 81 Opportunity to make a profit; opportunity 1

<u>Patents</u>

The product must be protected to keep the profit margin. The most effective way would be to patent the product, a copyright and patent for the software and keep the method as a company secret.

Opportunity 2: Idea 3 - Lice removal

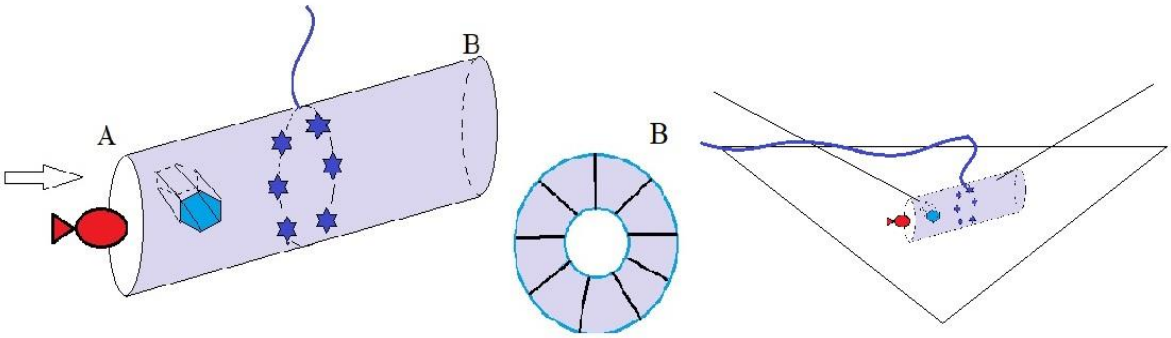


Figure 82 Delicing using waterjet

Market size

There are around 4000 cages in Norway and lice is a problem that comprise almost all the fish farmers. But, if the method is proven to work, the service may be potentially (at a later phase) be delivered at a global scale, meaning it will be a niche global market.

Profit Margins

The hardware and manufacturing for this product are not expensive or hard to require. There is no need for a large storage facility since the product is small. According to Moore's law, sensors in general are decreasing in price. The most expensive part will be development of software, but when it is created it can be replicated without any additional cost. The most profitable solution can be to deliver it as an intangible service. The larger cost will then be execution of the service, meaning manhours, fuel for boat, water heater and pump. The industry is willing to pay to solve the problem, but the cost for delivering this service will in time be too high as competition may solve same problem but cheaper.

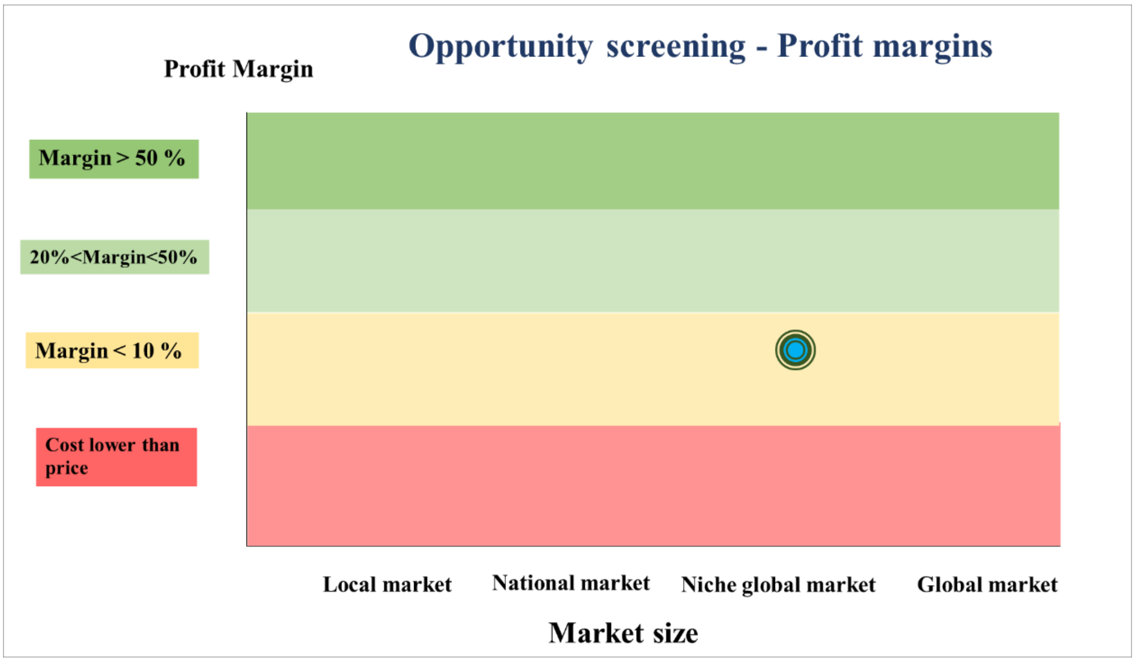


Figure 83 Opportunity to make a profit; opportunity 2

Patents

There are many actors trying to solve the lice problem. This idea must be protected in a way that the competitors can't replicate the product. The most lucrative method would be a combination of product patent, software patent and copyright and company secret of the method. A patent for a method is easy to get around for competitors and will be available for public knowledge if patented. The best way is to only deliver the service and make reasonable steps to keep it a secret such as contracts about not disclosing the method for other actors.

Opportunity 3: Idea 4 – Lice removal

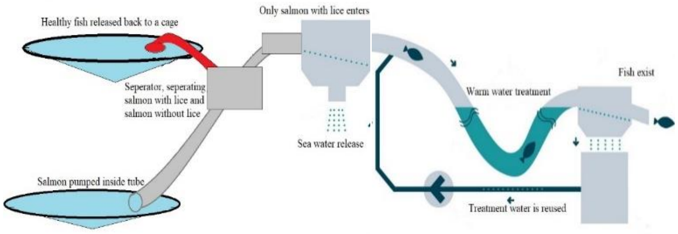


Figure 84 Mechanical delicing with machine learning and separator

Market size

There are around 4000 cages in Norway and lice is a problem that comprise almost all the fish farmers. But, the fish farmers try to avoid using this method and is therefore not often used. The service may be delivered at a niche global scale, but not used very often.

Profit margins

Most of the system does already exist and is used as a service today. It would not be expensive to add the extra sensors and tube system for the separator. But the software will be a large cost to create but once it is created it is free to replicate. The service today is very expensive. The fish farmers see this method as a “last way out” and only use it after surveillance authorities have forced the farmer to deal with the problem. The solution is too expensive for its market and profit margins would therefore not be high enough.

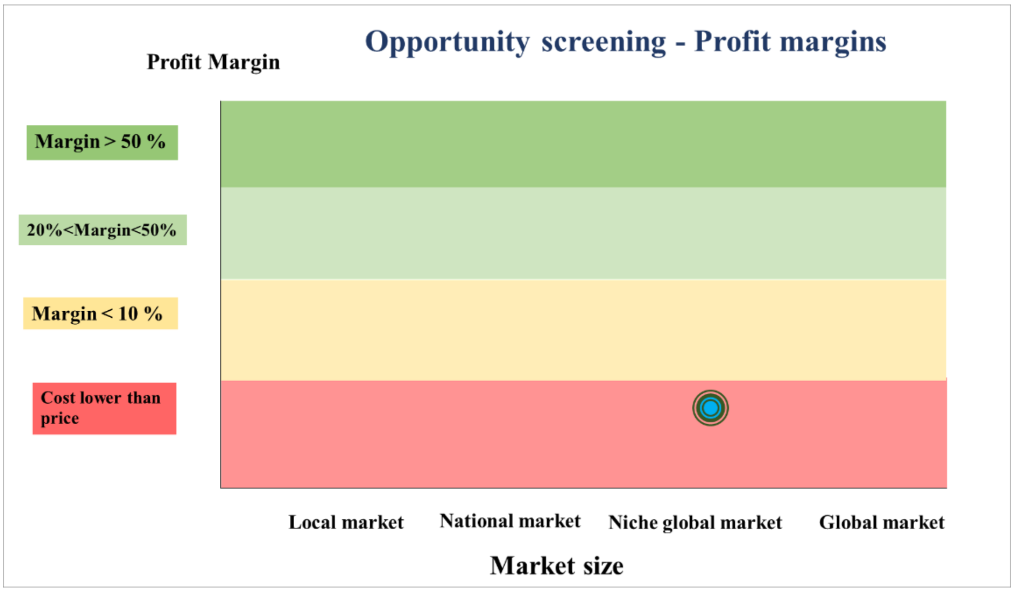


Figure 85 Opportunity to make a profit; opportunity 3

Patent

The solution does not generate enough profit to pursue and does not need a patent.

Opportunity 4: Idea 5 – Feeding control

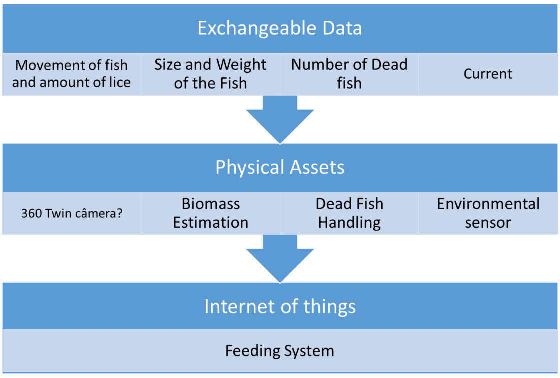


Figure 86 Data for better feeding control

Market size

The market would encompass most fish farms in the world and the product would be easy to deliver since it can be downloaded from a cloud. But since Norway have extra high prices on fish feed (sustainable production), the problem and market only exist in Norway. It also requires fish farmers to assist in gathering and digitize the data needed. The markets size is categorized as "*national market*".

Profit margins

The software would be expensive to create but can be replicated for free. The software can be downloaded in exchange for a monthly fee. The largest cost would be customer service and computer engineers working on upgrades and bugs. Most Norwegian salmon farmers buy the feeding software together with other systems, such as feeding camera and monitoring software. The software alone (without a product) may not be enough to enter the market.

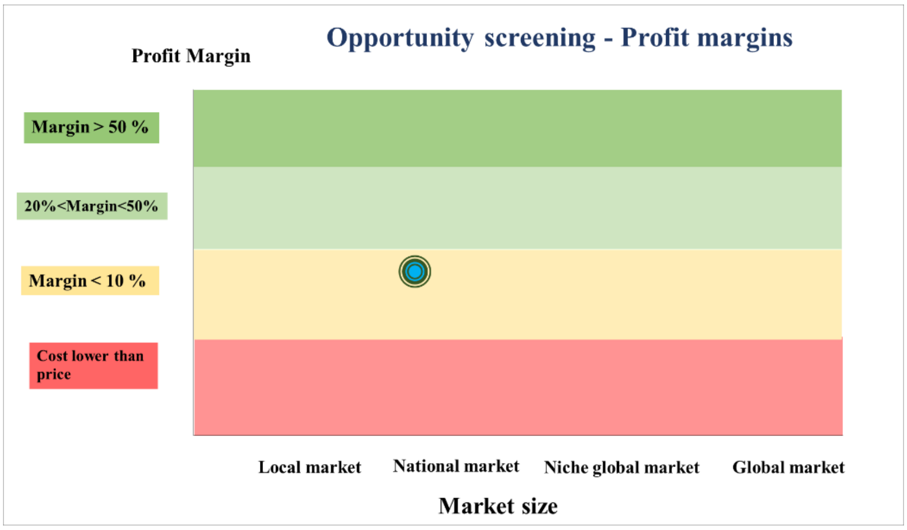


Figure 87 Opportunity to make a profit; opportunity 4

Patents

The demand for this product is too small to pursue and does not need a patent.

Opportunity 5: Idea 9 – Cage inspection and cleaning with AUV

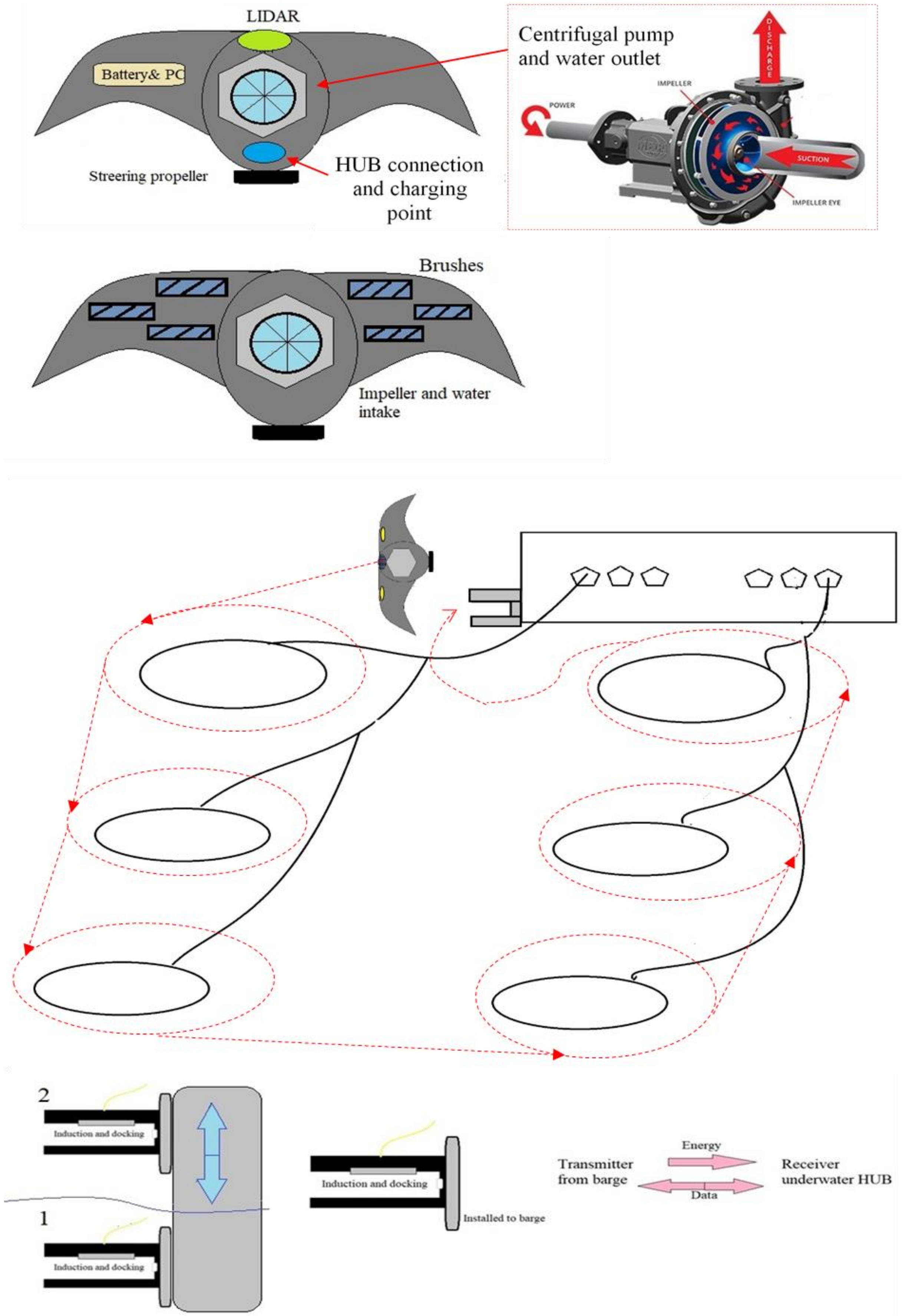


Figure 88 Net inspection and cleaning using AUV

Market size

Fish escape and net cleaning is a large focus and regulated by in Norway and other Northern European countries with Atlantic salmon farming. The product will probably be most interesting for the farmers in this area. The market size is niche global market (North Europe).

Profit margins

Development of this product would be time consuming and costly (both HUB with induction and AUV). AUVs are not fully commercialized or used in common practise today. The software will also be expensive to develop but once it is done it can be replicated for free. The system can be sold as a product. This business model would give large profit in the launching of the product but would quickly be reduced. This model requires that a new product is under development and can be launched when profit margins are reduced.

Another business model (better method) is leasing. The fish farmer will pay an initial payment and then monthly fees. The product would stay with the customer, but the seller will provide maintenance, software updates and possibilities for other product upgrades and / or extensions. This would ensure the seller to accumulate stable revenues and create profit as more customers leases the product.

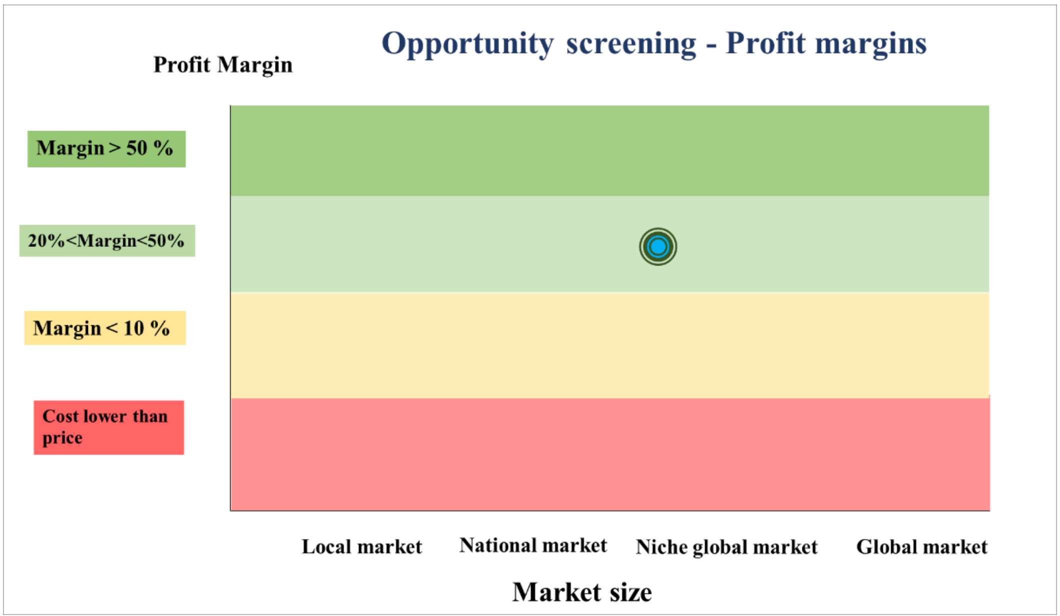


Figure 89 Opportunity to make a profit; opportunity 5

Patents

To achieve the long-term profits and a competitive place in the market, the opportunity must be protected. The technical innovation must be patented, the design must be patented, software must be copyrighted and patented and the method must take steps to be a company secret.

4.5 Conclusion of opportunity screening

The opportunities that have potential to create a profit and can be patented will further be pursued in a business model canvas. The opportunities with the highest potential are:

Opportunity 1 - Biomass estimation using LIDAR

Opportunity 5 - Cage inspection and cleaning with AUV

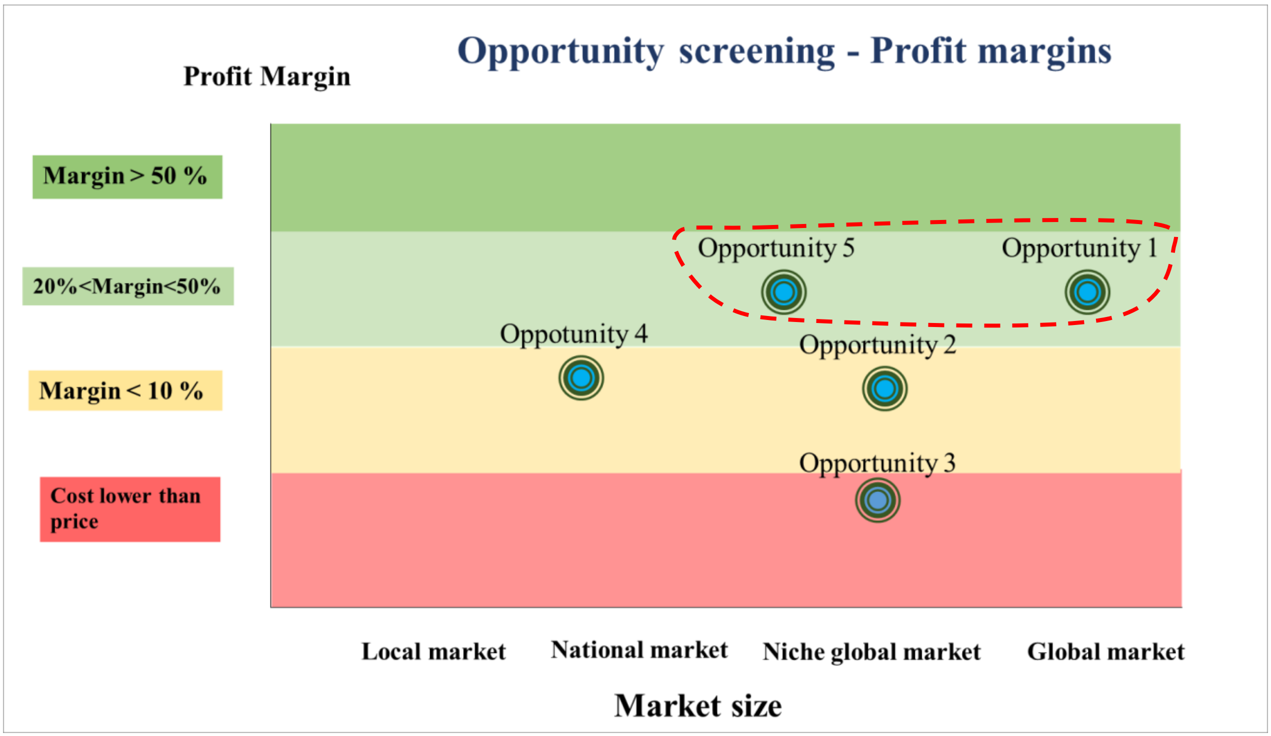


Figure 90 Opportunity to make a profit; opportunity 5

4.6 Business opportunities screening – Business Model Canvas

Business model canvas of opportunity 1 - Biomass estimation using LIDAR

1. Value proportion

What problem does the opportunity solve?

The solution reduces uncertainties and bad estimations of biomass. It reduces the cost, time and labour associated with the operation.

What needs does the opportunity cover?

The solution will increase the control of revenue, improve planning of harvest and assist in documentation and distribution of biomass information to the surveillance authorities and other actors involved.

What are the key features of the product that match customer problems?

The solution will automatically create documentation of amount of salmon in the cage and estimate biomass of each individual salmon (and total mass) in the cage.

2. Customer segment

Who are the most important customers?

Norwegian salmon farmers established in fjords or further offshore along the Norwegian coast. At a later stage (scaling), the market proportion may expand to other global salmon farmers and the solution can be adjusted to identify other aquatic species in other segments.

What are their archetypes?

The main customer are farmers and their archetype are growing salmon for food production.

What job do they want to get done for them?

The customer wants to have a biomass estimation with little to no uncertainty, with less labour effort.

3. Channels

Through what channels does the customer segment want to be reached?

The opportunity is delivered as a service where the service provider visits the salmon farm, execute the operation and report the data to the customer via a PDF file to an email.

Table 5 Channels to reach customer segment for biomass business opportunity

Start-up scale	**Sales**	**Distributions**
Early phase	The service will be directly delivered to customer through website, email or telephone.	The service will be delivered by the company.
Later phase (globally)	The company will keep sales inhouse and hire an own sales manager.	As the company scales, the company must hire people and establish new offices to deliver the service globally.

4. Customer relationship

How will the opportunity get, keep and grow customers?

At the start create a network of local salmon farmers who can try the service for free the first time and furthermore create a one-year contract if satisfied with the result. When proof of success exists (estimation of biomass is same or close to harvest volume) the start-up will expand through the coast of Norway. The next scaling is then global salmon farming (northern Europe). The next scaling will be to personalize the product to fit other farmers, producing other aquatic animals and wants to cover same need.

Table 6 How to get, keep and grow customers for biomass business opportunity

Start-up scale	**Marketing**
Early phase	Create a network with local salmon farmers by sending emails and meeting. A website, Facebook page, LinkedIn and YouTube demonstration videos can be created for almost zero cost.
Later phase (globally)	Stands at global conventions, Google Ads and commercials in relevant salmon magazines.

5. Revenue streams

How does the opportunity create revenue?

It would be a transaction revenue where the customer makes a payment for the service of documentation of biomass estimation. The biomass estimation today, are applied many times during one harvest. The optimal solution would be to create a long-term customer relationship / contract. This would secure stable revenues and profit would increase with the customer growth. An important aspect is that the IPRs are in place. The long-term revenue plan is to create a portfolio of products and a strong brand name to stay ahead of competition. The price will vary depending on the different factors explained below.

What are the pricing tactic?

The price would be variable, and the pricing factors are:

- Manhours per cage: The service will be delivered by two people and the time will vary depending on size of cage, amount of salmon in the cage, cage structure and acceptable uncertainty limits.
- Number of cages in the site.
- Use of product.
- Documentation ready for distribution and reporting.

Equation for pricing:

$$Manhours \times cages \times +use\ of\ product + documentation = customer\ price$$

Example of pricing:

$$\left(2\ Person \times 200 \frac{NOK}{Hour\ and\ Person} \times 2\ \frac{Hour}{Cage}\right) \times 5\ \frac{Cage}{Site} + 7000\ \frac{NOK}{Site} + 1000\ \frac{NOK}{Site} = 12000\ \frac{NOK}{Site}$$

6. Key partners & Key suppliers

Who are the key partners?

Partnership critical to succeed would be a salmon farmer willing to let the product be tested at their site. Could also be an advantage to have machine learning experts as partners in the early phase.

Who are the key suppliers?

Suppliers critical to succeed would be LIDAR manufacturer. The most common relationship and most suitable for this case would be a Buyer – Supplier relationship (Cleverism, 2018). In addition, the company would need software developers. In this situation it may be good to have a co-operation meaning, we share the risk (better software will be rewarded with larger percentage from sales) to create motivation of good results.

What are we getting, and what are we giving?

We would get knowledge about machine learning, accumulate a software, and hardware to assembly in exchange for money. We would get a test area for product development from salmon farmer in exchange for free biomass estimation and free service for an agreed period.

7. Key activities

Value chain - What key activities do we require?

Table 7 Key activities for biomass estimation business opportunity

Early phase	
In-house	***Outsource***
Research and development with assistance from expert to create know-how. Production - planning and execution of assembling product + inventory and maintenance. Marketing Sales and Customer service Delivery of service / Operations HR	Manufacturing of LIDAR technology Manufacturing of protection case. Manufacturing of wires. Creation of software (co-operation)
Later phase - Scaling	
In-house	***Outsource***
Research and development with assistance from expert to create know-how. Delivery of service / Operations Sales and Customer service (AI service) Update of software	Manufacturing of LIDAR technology Manufacturing of protection case. Manufacturing of wires. Assembling of hardware. HR Marketing

8. Key resources

<u>What key resources do we require?</u>

Table 8 Key resources needed for biomass estimation business opportunity

Human resources	Financial resources
Visionary - Innovators with an entrepreneurial mind-set. Computer science Expert Business administrator	Initial investment such as support from actors such as *Innovation Norway*, loans from a bank, crowdsourcing among salmon farmers and other relevant actors interested in seeing the product succeed.
Physical resources	**IPR**
Work shop for assembling and a space for a couple of office desks.	Product patent Software copyrights Method and know-how as company secret Confidentiality agreement among suppliers and key players

9. Cost structure

<u>What are the most important inherent costs?</u>

Table 9 Cost structure of biomass estimation business opportunity

Variables	Fixed
Salary	Outsourced - Procurement of LIDAR technology and other hardware mentioned earlier
Electricity and rent for workshop / office	Outsourced - Software development
Logistics related to delivering of service	Loans (if necessary)
	IPR fees

Business model canvas of opportunity 5 - Cage inspection and cleaning with AUV

1. Value proportion

What problem does the opportunity solve?

It reduces the cost of having service-divers inspecting the net every twelfth week. It detects fish escape much faster and removes the uncertainty of fish escape and other asset integrity issues. It reduces the cost of cleaning service coming every tenth day.

What needs does the opportunity cover?

It covers the need of better and cheaper cage integrity inspection, mooring lines inspection and barge inspection. It ensures that the salmon haven't escaped and ensures that the salmon have optimal oxygen and waterflow in the cage.

What are the key features of the product that match customer problems?

LIDAR technology and AUV matches the cage, mooring and barge inspection.

Centrifugal pump and brushed matches the cleaning of cage net.

2. Customer segment

Who are the most important customers?

The maintenance service would be delivered by the start-up company and frequency of maintenance would be weekly. The focus customers in an early phase would Salmon farmers in local market.

What are their archetypes?

The main customer are farmers and the archetype are growing salmon for food production. The main characteristics of customers will be the need for inspection and cleaning in shallow waters (up to 50 meters)

What job do they want to get done for them?

- Cage, mooring lines, and asset inspection.
- Cleaning of cage net.

3. Channels

Through what channels does the customer segment want to be reached?

Table 10 Channels to reach customer segment for cleaning and inspection business opportunity

Start-up growth	**Sales**	**Distributions**
Early phase	The product will be leased directly to customer through website, email or telephone.	The product will be distributed by the start-up company in the beginning when the market still is local.
Later phase (globally)	The company will keep sales inhouse and hire an own sales manager.	Transport agencies such as Bring, will be used for bigger distances. But installation and maintenance must be done by the company and require personnel to be present in new market. When scaling globally (if the new market is big enough), channels such as amazon can be used, or the product can be manufactured at the new market. Installation and maintenance can be outsourced, or the company can create an office in a new market.

4. Customer relationship

How will the opportunity get, keep and grow customers?

Local Norwegian salmon farmers will be the main target in the beginning. The idea is to create a network of local salmon farmers who can try the product for free and in exchange for using the site as a test area. The salmon farmer can then get a discount on the first product if satisfied with the result.

In a later phase, (if the AUV system is proven to work flawless) it can be adopted to other industries in the local area such as inspection of ships and harbours can use it to provide a service to cruise ships (cleaning and inspection of ship hull). Since the product requires weekly maintenance, it is best to stay in the local area and enter different markets. When the company scales it can establish businesses in other locations in Norway and globally.

Table 11 How to get, keep and grow customers for cleaning and inspection business opportunity

Start-up growth	**Marketing**
Early phase	Create a network with local salmon farmers by emails and meetings. A website, Facebook page, LinkedIn and YouTube demonstration videos can be created for almost zero cost.
Later phase (globally)	Stands at global conventions, Google Ads and commercials in relevant salmon magazines.

5. Revenue streams

How does the opportunity create revenue?

Today, the salmon farmer spends around 8 million NOK every year on cleaning and inspection. The salmon farmer should therefore be willing to pay at least 60% of the original amount for a new system. The development cost will be high. The main driver is to create long-term customer relationships which will create increasing and stable profit for the first 3 years if the company scales correctly and IPRs are in place.

What are the pricing tactic?

Option 1: The AUV can be sold as a product but it requires both rapid maintenance and software updates. An additional service agreement must be in place.

Option 2 (most lucrative option): The AUV can be leased to the salmon farmer. The farmer will only pay a monthly fee for an agreed period. This may be the most reasonable option because of the rapid technology advancement today. The product and the software may find new and better updates every year.

6. Key partners & Key suppliers

Who are the key partners?

Partnership critical to succeed would be a salmon farmer willing to let the product be tested at their site. The product also need AUV expert, LIDAR expert, Induction experts, software experts.

Who are the key suppliers?

Suppliers critical to succeed would be AUV manufacturer, centrifugal pump suppliers, LIDAR manufacturer, induction charging and data transference developers. In addition, the company would need software developers.

What are we getting, and what are we giving?

We would get knowledge and hardware to assembly and customize for own use. We would exchange this for money.

7. Key activities

Value chain - What key activities do we require?

Table 12 Key activities inhouse and outsources for cleaning and inspection business opportunity

Early phase	
In-house	***Outsource***
Research and development with assistance from expert to create know-how. Assembling of hardware. Marketing Delivery of product and additional service Sales and Customer service (AI) HR	Manufacturing of LIDAR technology Manufacturing of AUV Manufacturing of Induction HUB Creation of software
Later phase - Scaling	
In-house	***Outsource***
Research and development Delivery of product and additional service Sales and Customer service (AI) Update of software	Manufacturing of LIDAR technology Manufacturing of AUV Manufacturing of Induction HUB Assembling of hardware. HR Marketing

8. Key resources

<u>What key resources do we require?</u>

Table 13 Key resources for cleaning and inspection business opportunity

Human resources	Financial resources
Visionary - Innovators with an entrepreneurial mind-set. Mechanical engineers Electrical engineers Subsea engineers Computer science Engineer Business administrator	Heavily initial investment because of high development costs. Support from actors such as *Innovation Norway*, loans from a bank, crowdsourcing among salmon farmers and other relevant actors interested in seeing the product succeed.
Physical resources	**IPR**
Work shop for assembling and a space for a couple of office desks.	Product patent Software copyrights Method and know-how as company secret Confidentiality agreement among suppliers and key players.

9. Cost structure

<u>What are the most important inherent costs?</u>

Table 14 Cost structure for cleaning and inspection business opportunity

Variables	Fixed
Electricity and rent for workshop / office	Outsourced - Procurement of technology and other hardware mentioned earlier
Salary	Outsourced - Software development
Logistics related to delivering of service	Loans (if necessary)
	IPR fees

4.7 Conclusion of business opportunities

The two business opportunities above have different characteristics and therefor different business models. One of the major differences is the creation of revenue. The biomass estimation will be delivered as a service with either yearly contracts or just one-time payments while the cleaning and inspection will be a leasing contract. But the largest difference between the opportunities are:

- The biomass estimation using LIDAR have lower development cost which means it requires less initial investments and less risk is then undertaken in case of failure.
- The biomass estimation using LIDAR have higher maturity of technology which means that it is easier and bigger chance of realizing the product and get to market faster than AUV.
- The biomass estimation using LIDAR have a less complex system which requires less maintenance and have less movable parts that may fail during operation.

As a start-up company, the easiest business opportunity to realize and is more likely to succeed would be the biomass estimation using LIDAR. The AUV could be a side project or a part of future development of a larger product portfolio.

5 Conclusion

Objective of project

The purpose of this master was to explore a method to systematically identify and screen innovations opportunities emerging from technology trends and business trends. The goal is to prove that the method will assist the actors in the industry (or entrepreneurs entering an industry) in identifying business opportunity and achieve competitive advantages.

Results from project

The selected industry was Norwegian salmon farming and segment was salmon sea farming production. It is an important industry for Norway facing large challenges such as lice, environmental pollution, biomass estimation and many more. Using the method, a total of 14 ideas were elaborated in this thesis. 9 ideas were rejected by the first screening. These showed little potential to either solve the problem or that there was no market for the generated solution. 5 ideas reached the second screening where 3 ideas were rejected at this point. These showed little potential to create profit or couldn't be protected. The 2 ideas that cleared the second screening had potential to be a business opportunity and was evaluated in a business model canvas. Number 1 was a complex idea, with high development cost and unmatured technology. Number 2 was a much simpler idea involving known and tested technology with much lower development cost. The business opportunities must be evaluated from two points of view. As an entrepreneurial point of view, idea number 2 would be the best option and later create idea number 1 when the company scales and needs a larger portfolio. As a well-known technology delivery company point of view, idea number 1 could be the best options since the idea include higher risk but also higher reward.

Key finding from project

Time and access to information are the two main enablers to increase quality and quantity of ideas generated (in addition to selecting an industry with innovation potential). This means that the method may increase the chances of innovation, but it is still time consuming.

Timing is one of the most important factors to succeed with the idea. Timing includes both maturity of technology and that the problem size isn't big enough yet and therefor no existing market for the solution.

It is a large advantage to already work in the industry which will reduce the time spent on research and have access to information.

Consideration of future development

This project could be extended and further developed. For future development of this project could elaborate generic tool to investigate and evaluate innovation opportunities. To achieve this, it should be a digital tool with a standardized format. The tool could be distributed among various industries for testing and feedback. There may be that the method doesn’t suit all industries and need adjustments.

The key results from project

It is possible to identify and screen innovation opportunity emerging from technology and business trends using a systematic approach. Technology and business trends are disrupting most industries today and the companies that will succeed in the modern era must integrate innovation activities as a larger and more central part of the value chain.

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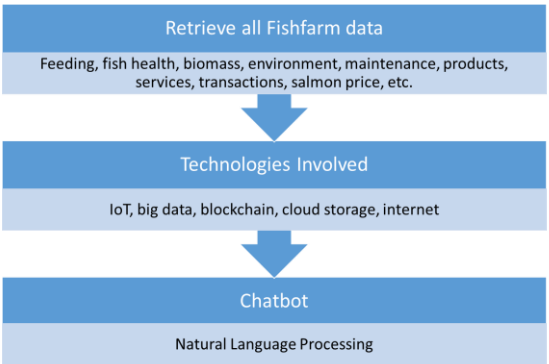
7 Appendix

7.1 Ideas that wasn't elaborated in the idea screening

Improve interface with pc system using NLP (Natural language processing)

1. Replace the way of retrieving information by talking to the computer instead of search in files and online. Simply ask for information. For example, *"When was the gasket replaced on the feeding selector"* or
   "When is Skretting coming to refill the silos with fish feed".
2. Replace manual entering parameters with voice commands for example "*Increase feeding velocity of spreader in pen 3"* or *"Delay feeding in cage 2 with one hour"*



Fish escape: Removing obstacles by introducing inside trail track for multiple use

<u>Description</u>

The idea is to replace the winches and ropes that keeps the feeding system and feeding camera in place. The improvement will give a much "cleaner and less messy cage" (see picture below of todays practice)

Figure 91, obstacle remover
Upper left corner: Winches to position feeding camera
Upper right corner: ropes to move spreader
Lower right corner: A reel machine on the working boat, rotating to assist in moving feeding spreader

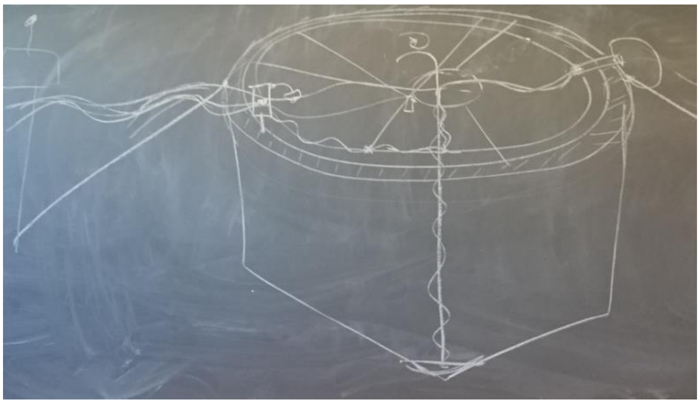


Figure 92 Illustration of cables, ropes and winches attach in todays practice.

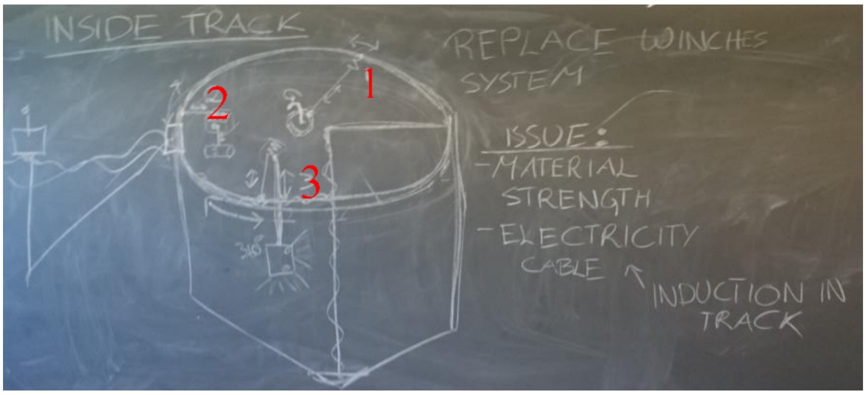


Figure 93 Idea to remove winches, ropes and some cables.

An inside trail track to move different objects 360° around the cage.

See 1 in the picture above. An extendable arm is attached to the feeding spreader and can be place anywhere in the cage.

See 2 in picture above. The trail track can attach a second extendable arm for other purposes. For example, a floating device with a winch underneath to move vertically. The purpose can be delicing tube or biomass tube or attach cleaning system or even a cage integrity camera to check for holes. See picture below for closer details.

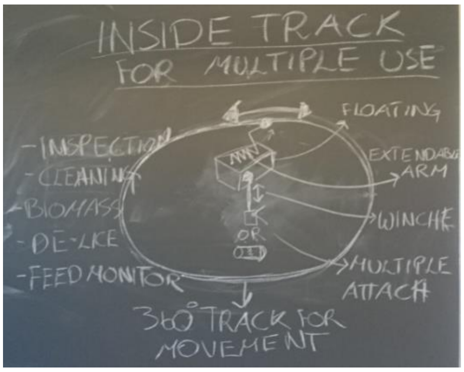


Figure 94 Example of extendable arm attached to cage track and with floating device with a winch to move different objects up and down

See 3 in picture 3. The feeding camera ca be connected to this system as an independent arm to move freely horizontal and vertical.

Issues solved

Winches and manual labour removed.

Ropes are removed and less messy cage.

New issues

Material strength

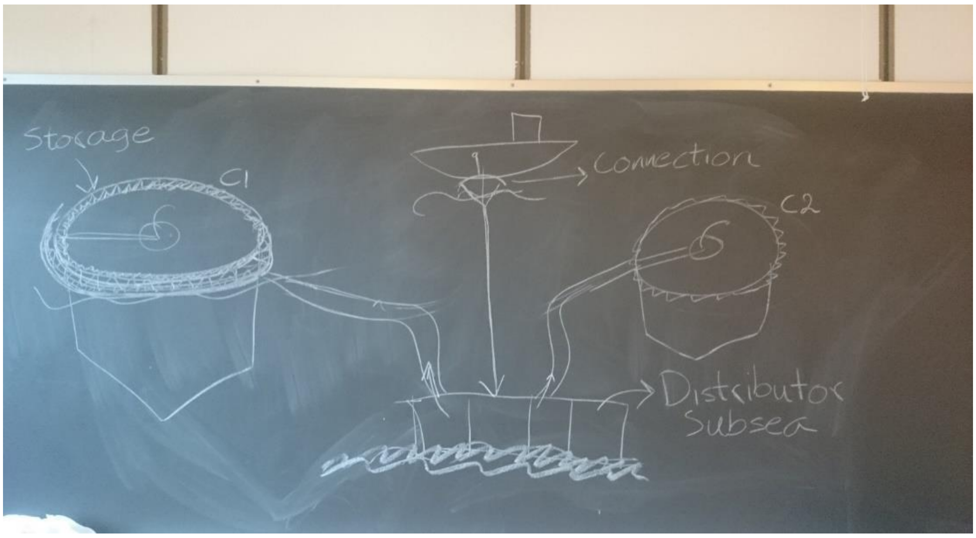
Lubricants to system

Electricity to system (induction can be a solution or onboard batteries)

Feeding operation: Storage of pellets using new cage system

Description

A storage and distributor (with compressor) of fish feed on the seafloor. A flexible tube and a connector is floating on the water surface for boats to attach and refill the distributor. The distributor has different compartments for different type of feed and can select which cage to send feed to. The cage has an own storage of pellets. The pellets can be stored in a tube with 20 cm diameter around the pen. This would result in a storage of 2 cubic meters or 2000 L of pellets for each cage.



Solving key challenges

- Storage on barge
- Tubes from barge to pen
- Easy connection to feeding boat and refill

New challenges

- Weight of cage
- Cost of subsea installation

New development permits: Improve collaboration and problem solving by using open source platform (Business trend)

As mention in the table of challenges for the industry (refer to table). This will provide a solution for collaboration to find the best solutions.

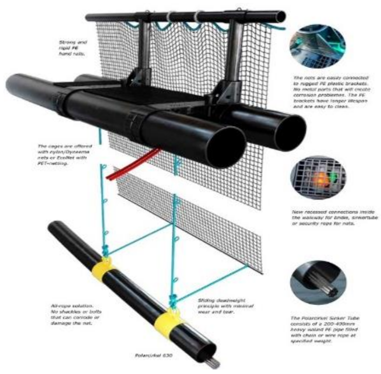
Make a **Kickstarter** where solutions can be presented and funded and commented maybe even built on for everyone interested.

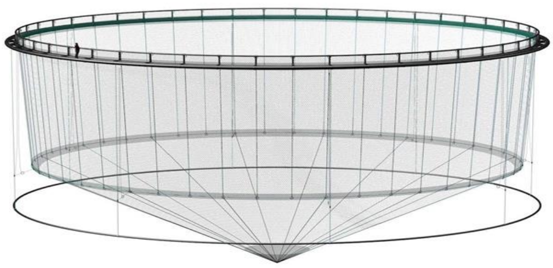
New development permits: Closed cage manufacturing by using additive manufacturing and generative design

Virtual reality
VR for global collaboration of design and manufacturing parts.

Operators are normally at the barge and cage system, meaning attendance in meetings can be done virtually. This has been tested in the offshore oil and gas industry

Additive manufacturing
Many parts and equipment's are made of different compounds of plastic for example, cage/pen, dead fish handling system, tubes and floaters to the feeding system etc. For example, the cage is assembled as modules





<u>Early phase</u>
Aquaculture technology manufacturer produce different parts in a 3D-printer then transport to customer. Embedded sensors transmit data back to the manufacturer. The design software improves the design and suggest actions to the designer within prefixed constraints

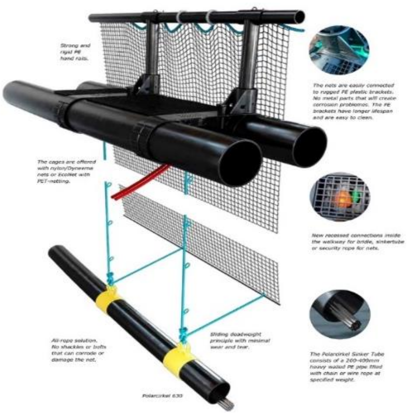
<u>Later phase</u>
Customer owns 3D-printer. Do not need to keep spare-part on barge or wait for manufacturer – produce them yourself.

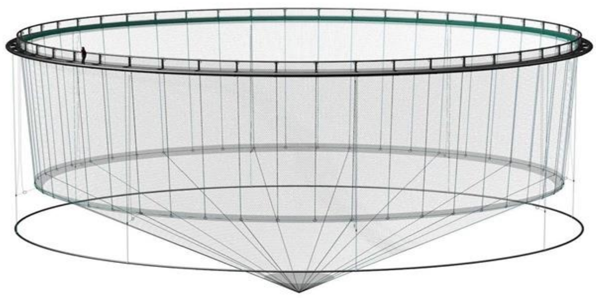
7.2 Tables used in breakdown of existing products and services

The information and pictures seen in this sub-chapter for breakdown of products and services was retrieved mainly from AkvaGroup product catalogue (Akva Group, 2018)

Product	**Workboat**	
Production	Material / Hardware What gives it shape and structure?	Bow propeller Manual bilge pump Electric bilge pump with sensor Hydraulic steering with servo assisted steering wheel Motor, battery, cabling, main power switch Fuel tank Fire extinguisher benches with lockers LED lights in ceiling) Mast with lanterns on roof Motor control instruments, navigation equipment Control handles
	Programming / Software	
	Cost / Cost structure What are the main cost drivers of production?	Procurement Fuel Maintenance
Market	Functionality What does it provide of functionality?	Operations such as visual inspections, ıaintenance of various assets, dead fish handling, s in service operations such as delicing, cleaning process Transport personnel from and to work
	Needs covered What need does it cover?	Transportation in various operations
	Main customer groups	Fish Farmers
Labour	Skills	Boat licence
Key	Key challenges What are the key challenges?	Fuel storage on barge Can't operate in bad conditions Limited space Human risk

Product	Plastic cage	
Production	Material / Hardware What gives it shape and structure?	Net Nylon net Pipes and pipework – PE and stainless steel Brackets Railings - PE and stainless steel Bird net - Nylon
	Programming / Software	
	Cost / Cost structure What are the main cost drivers of production?	Maintenance Inspection
Market	Functionality What does it provide of functionality?	Keep the fish enclosed
	Needs covered What need does it cover?	Get the fish to market size
	Main customer groups What are the main customer groups?	Fish farmers
Labour	Skills What are the key skills in producing the product or bringing the product to market?	Basic aquaculture knowledge
Key	Key challenges What are the key challenges?	Fish escape Maintenance Hard to monitor Hard to detect fault





<table>
<tr><td colspan="2">Service</td><td>Inspection of system integrity (barge, cage and mooring)</td></tr>
<tr><td rowspan="4">Service production</td><td>Process flow
What are the steps being taken to produce a product or service?</td><td>1. Diver inspects integrity of
- Cage, mooring and barge
2. Films and take pictures for further analysis
2. Diver clean / preventive maintenance
3. Report and documentation</td></tr>
<tr><td>Skills
What are the key skills in the service delivery process?</td><td>Diving
Aqua knowledge
Equipment knowledge</td></tr>
<tr><td>Cost / cost structure</td><td>Diving equipment
Labour</td></tr>
<tr><td>Functionality</td><td>Visual and documentation of integrity</td></tr>
<tr><td rowspan="4">Market</td><td>Needs covered</td><td>Identify and make sure that the integrity is good</td></tr>
<tr><td>Main customer groups</td><td>Fish farmers</td></tr>
<tr><td>Channels</td><td>Phone, internet</td></tr>
<tr><td>Key challenges
What are the key challenges?</td><td>Manual labour
Human error
Risk in work
Not real time data (come every twelfth week)</td></tr>
</table>

Product		**Biomass estimation camera**
Production	Material / Hardware What gives it shape and structure?	2 Cameras Battery or cable 16 kg camera + 12 kg computer USB connection
	Programming / Software	Biomass estimator
	Cost / Cost structure What are the main cost drivers of production?	Procurement Installation Operations
Market	Functionality	Obtain a representative weight sample of fish
	Needs covered	Biomass estimation
	Main customer groups	Fish Farmers
Labour	Skills	Aquaculture knowledge and Fish health
Key	Key challenges What are the key challenges?	Limited by cable Heavy and clumsy Manual estimation **The quality is dependent on these conditions** Small and calm fish Clear Water Good lighting Several fish must swim by the camera in correct distance from the lens
Other	Other factors	It needs 50 frames to estimate mass of 100 fish

Biomass Estimator

The new Vicass HD (High Definition) will provide farmers with accurate and efficient biomass estimation, taking high quality digital stereo images of the live fish swimming in the cage.

The images are analysed to determine average weight of each fish. Vicass HD has high accuracy, capacity and speed.

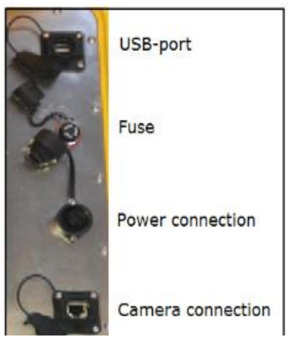
The camera unit captures 300 - 500 images at three different depths before they are analysed.

New Vicass features:

Possible to zoom images for exact data input

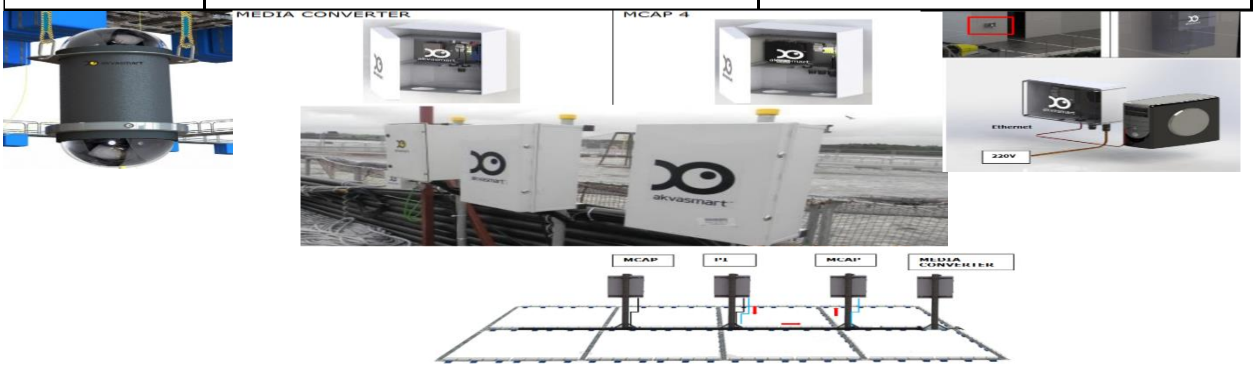
The weight distribution curve is continually updated while fish is being entered/recovered by clicking

Measures fish sizes at a distance from 60 cm up to 2 m from the camera



Better image overlap because lenses on the new camera are located as little as 15 cm apart

Product		360 twin cameras
Production	Material / Hardware What gives it shape and structure?	2 lenses - 360 twin view Winches Ethernet and electricity cables through feeder MCAP, TDP, Media Converter
	Programming / Software What software/if and makes it do what?	**AKVAconnect** is used for camera surveillance, at the same time as data and other information is gathered from all components in all operating levels from one or several aquaculture sites. The program also shows all current values measured with available equipment installed and connected in the site(s). This improves control and surveillance of technical processes, providing improved company cost control.
	Cost / Cost structure	Cables Ethernet
Market	Functionality What does it provide of functionality?	Feeding and inspection colour camera from cage, workboat or barge via internet Built in depth and temperature sensor
	Needs covered	Visual Monitoring
	Main customer groups	Fish farmers
Key	Key challenges What are the key challenges?	Limited by cable Weekly inspection Monthly cleaning 2 people installations Tools for installation



Product		**Super HR camera**
Production	Material / Hardware What gives it shape and structure?	1 lens Winches Ethernet and electricity cables through feeder MCAP, TDP, Media Converter
	Programming / Software What software/if and makes it do what?	AKVAconnect is used for camera surveillance, at the same time as data and other information is gathered from all components in all operating levels from one or several aquaculture sites. The program also shows all current values measured with available equipment installed and connected in the site(s). This improves control and surveillance of technical processes, providing improved company cost control.
	Cost / Cost structure	Cables and Ethernet
Market	Functionality What does it provide of functionality?	Feeding and inspection colour camera from cage, workboat or barge via internet Built in depth and temperature sensor
	Needs covered	Monitoring
	Main customer groups	Fish farmers
Key	Key challenges What are the key challenges?	Limited by cable Monthly cleaning 2 people installations
Other	  CAP = Cage Access Point	

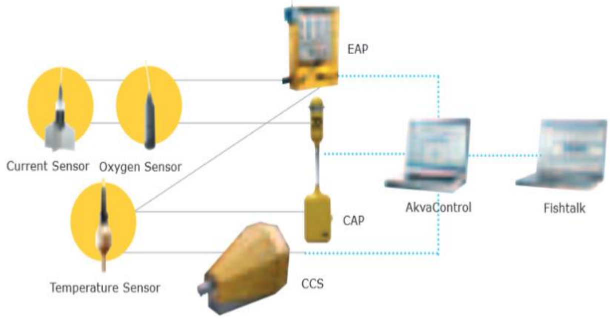
Product		Environmental sensors
Production	Material / Hardware What gives it shape and structure?	1. Temperature sensor: Bronze outside and Polyethylene inside 30m cable 2. Oxygen sensor: Optical sensor, Polyethylene 50 m cable 3. Current sensor: Acrylic, POM, Aluminium, 30 m cable, electronic tilt 4. Sensor Buoy, polyethylene, Oxygen, salinity, doppler, satellite transmitter
	Programming / Software What software/if and makes it do what?	Fish talk Akvacontrol Real Fish
	Cost / Cost structure What are the main cost drivers of production?	1. Procurement 2. Procurement 3. Procurement 4. Procurement
Market	Functionality What does it provide of functionality?	1. Provides real time readings of the temperature conditions for the fish. 2. Connected to feeding, to stop feeding when oxygen drops. 3. Measures current up to 100 cm/sec. The sensor contributes in preventing feed from being carried out from the cage before the fish gets the chance to eat it. 4. Continuous measure of salinity, oxygen and movement of fish / doppler
	Needs covered What need does it cover?	1. Temperature - the foundation for feeding and growth models. 2. Optimize feeding and thereby the fish farms cost benefits also important for fish growth and welfare 3. Optimize feeding and thereby cost benefits 4. Monitoring environment
	Main customer groups	Fish farmers
Key	Key challenges What are the key challenges?	1. 3.5 kg with cables and restricted to 30-meter cable. 2. Cable restriction and 0,9 kg 4. 45 kg and 2.5 meters 4. Changing battery (4 to 6 month) All need power supply
Other	Other factors	If the current speed is too high or oxygen level too low, the feeding stops automatically

Temperature Sensor | Oxygen Sensor | Current Sensor | Multi sensors | EAP Hardwired network

CAP Wireless | Environmental Sensor System | AKVA Safeguard

The AOS Box contains:

- ON/OFF-button (1)
- Internal antenna (2)
- 3 batteries (3) *(underneath the cover)*

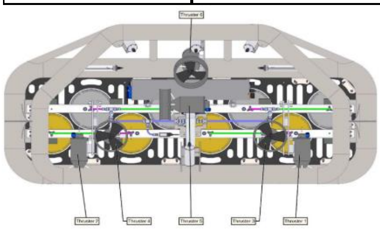
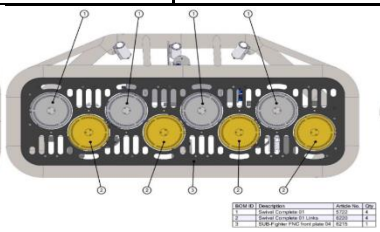
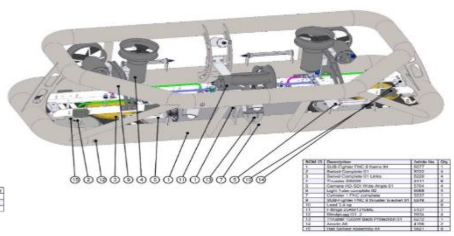


AOS Box with bracket

Oxygen sensors

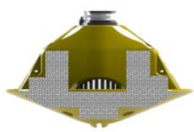
Salinity sensor

Product		**Cleaning system**
Production	Material / Hardware What gives it shape and structure?	Sensors: Water pressure cleaning unit, depth sensor, moist sensor, disc speed sensors Fibre optical cable communication Electronic house 2 * Led Lights 2 * HD camera High pressure Water hose 6 * Thrusters Remote Controller 360 kg 2,6 meters 350 Bar working pressure
	Programming / Software	Auto depth and auto heading (vertical and horizontal move, and depth control can be automated)
	Cost / Cost structure	Procurement, maintenance, fuel,
Market	Functionality	Speed is 0 - 1,5 m/s 5000 square meters per hour
	Needs covered What need does it cover?	Cleaning the net Oxygen level and avoid damage in the structure
	Main customer groups	Fish farmers
Labour	Skills	Mechanic
Key	Key challenges What are the key challenges?	Boat with pump Time Size Cost Energy source Cable is only 100 meters Storage and transportation - large and heave

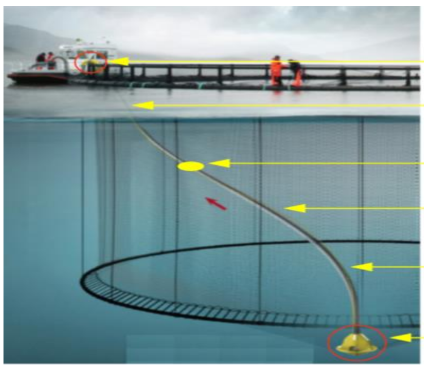




Product - Feeding system		
Production	Material / Hardware What gives it shape and structure?	**Feeding pipes Steel and rubber** **Couplings to hold pipe in place** **Selector valves – Aluminium and stainless steel** LF: O-rings for s-pipes 2 years LF: Blocking device/ wing 2 years LF: Engine and gears 1 year **Dosers - 75 – 95 kg, feed distributor –cast iron and stainless steel, bolts and nuts, gasket between doser and silo and in the rotor.** LF: Gasket 1 year LF: Engine and gears 1 year Feed auger – Stainless steel **Rotor spreader – Stainless steel, aluminium rotor pipe, POM, 30 - 35 Kg, 3-meter-high, bearings for rotors spreader and bolts.** LF: ball bearing: 480 – 600 tons of pellets LF: Aluminium rotor spreader 480 tons LF: Stainless steel pipe outlet – 1000 tons **ub feeder – 63 Kg, 8 meters, Cyclone, stainless steel, floating collar, main pipe, distributer, Manifolds, pumps** **Air blower – Belts and air filter**. LF: Belts 2 years or 15000 hr LF: air filter 2500 hr or every year **Cooling system – Blades, radiator, engine fan, hose and pipe connection, electric engine cables** **Air control** **Cleaner for feed pipes**
	Programming / Software	AKVAconnect feeding control Control feeding process
	Cost / Cost structure	Maintenance and procurement
Market	Functionality	Transport pellets from barge to fish pen
	Needs covered	Feed fish
	Main customer groups	Fish farmers
Labour	Skills	Operation and maintenance of fish feeding system. Training and manuals are provided by manufacturer.
Key	Key challenges	Ideal flow of pellets Unpredicted maintenance and down-time

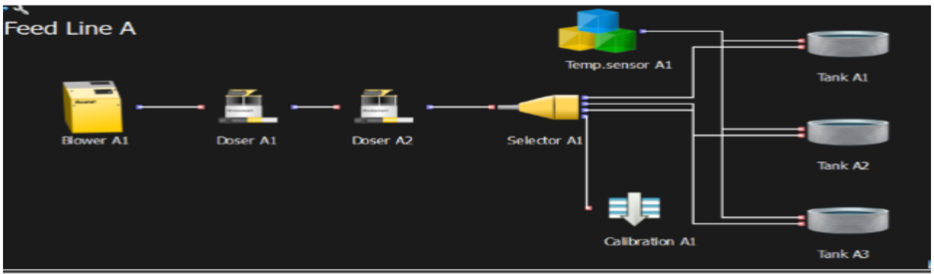
Product		Dead Fish Handling
Production	Material / Hardware What gives it shape and structure?	Compressor Ball valve Air hose (from compressor to mort cone) System for carrying mort’s from cage to ensilage tank Handrail pipe 2 hose clamps, a piece of layflat hose and tape Upper layflat hose • length = cage radius 2 hose clamps, a piece of layflat hose and tape - Buoy Lower layflat hose • length = depth from surface 8m 2 hose clamps, a piece of layflat hose and tape Hose joiner 2 hose clamps, a piece of layflat hose and tape Helix hose, 16 feet (5m) Mort Cone with lifting rope (crows foot) Ballast and/or stabilization weight.
	Cost / Cost structure	Maintenance Energy consumption
	Functionality	Eliminates the Dead Fish inside of the pen
Market	Needs covered	Avoid a dirty environment, and damage to fish health
	Main customer groups	Fish farmers
	Skills	Technical installation Mechanical fluids Engineer
Labour	Key challenges What are the key challenges?	Installation must be accurate, if it doesn’t can provide damage in the net. The system must run every day or at least once every three days due to maintenance needs.

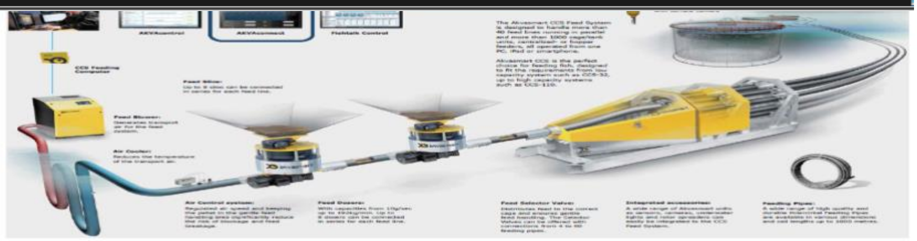


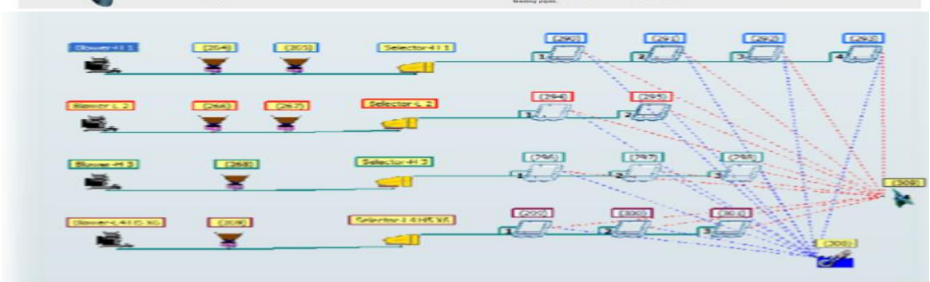
nformation about running and maintaining the compressor is ound in the compressor manual.



Product		Software Akva Smart
Production	Material / Hardware What gives it shape and structure?	Computer Tablet Smartphone
	Programming / Software What software/if and makes it do what?	1 - Akvaconnet 2 - Akvacontrol
	Cost / Cost structure	Licence
Market	Functionality What does it provide of functionality?	Full farm overview at a glance System capacity planning Advanced meal planning Hooper control Integrated feeding camera control Wizards Powerful reporting and analysis tool
	Needs covered	Connect the whole feeding system
	Main customer groups	Fish farmers
Labour	Skills	Service Technician and operators computer basic skills
Key	Key challenges	interface, bugs, compatibility with other devices, remote access no cloud storage
Other	Other factors	the installation is through a CD, a worker from Akvagroup must go to the site to install and start the software by the first time and train the operators







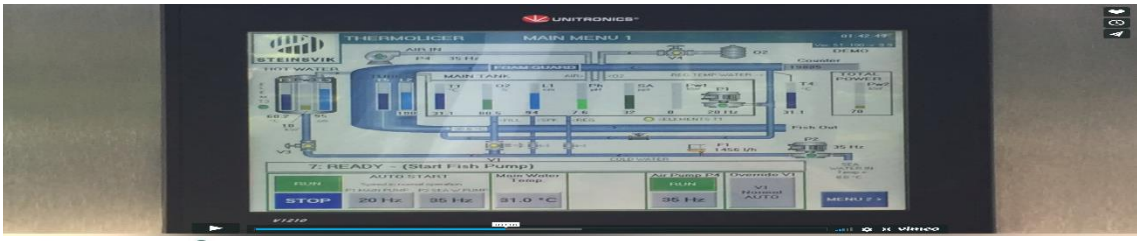
Industry segment		**Visual inspection of assets**
Value creation flow	**Process flow** What are the steps being taken to produce a product or service?	**Visual inspection of** Birds net Feeding system at the cage Electrical cables and tube Feeding tube Air pressure tube Moorings above water level Cage above water level Dead fish system above water level Work boat Barge Fish activity above water level
	Skills	Marine and aquaculture skills
	Cost/cost structure	Human labour
Market	**Needs covered**	Integrity of assets above sea level
	Main customer groups	Fish farmers
Key	**Key challenges** What are the key challenges?	Time consuming Human error and biases Hidden faults hard to see with human eyes Bad conditions will reduce quality of inspection

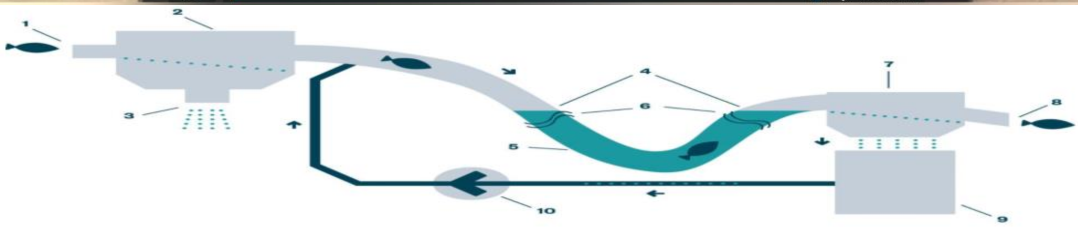
Industry segment		Feeding Operation Process
Value creation flow	**Process flow** What are the steps being taken to produce a product or service?	**1 - Fill the Silos with the fish food** **2- Plan feeding operation / Select food** **3- Start feeding** **4- Monitor the Feeding / Adjust Feeding parameters**
	Skills What are the key skills required in the value creation process?	Marine Environment knowledge Computer Skills Basic knowledge about Fish Food Monitoring the fish
	Cost/cost structure	Fish pellets
Market	**Needs covered**	Growing salmon to right size and health to be ready for harvest
	Main customer groups	The fish farmers
Key	**Key challenges** What are the key challenges?	Waste of pellets Disruption of environment (high concentration of droppings, diseases and lice from salmon + leftovers from pellets) Fish health – Lice and diseases Storage and Transportation

Industry segment		**Biomass Estimation Process**
Value creation flow	**Process flow** What are the steps being taken to produce a product or service?	1- Working boat to the pen 2- Collect 200 fish samples with the net 3- Measure the fishes with a ruler 4- surveillance authority monitoring the process 5- plot number in a computer and documentation 6- report
	Skills	**Røkter / Operator** technical skills (measuring and use the equipment)
	Cost/cost structure	Time consuming Labour
Market	**Needs covered**	Respects the permit
	Main customer groups	fish farmers
Key	**Key challenges** What are the key challenges?	Uncertainty in the measure human erros Not Standardized Third part

Service	Cleaning process	
Service production	**Process flow**	Boat transporting the FNC (flying net cleaner) Lift the FNC with crane into position Start water pump Operate FNC with remote control Monitor operation with HD camera and
	Technologies	See product cleaning product Remote controller
	Software/programming	Auto depth and auto heading (vertical and horizontal move, and depth control can be automated)
	Skills	Cleaning skills Cage knowledge Operating remote control
	Cost / cost structure	Labour Training new personnel R&D Maintenance of equipment
Market	Functionality	Cleaning the net without breaking it.
	Needs covered What need does it cover?	Increase waterflow to provide sufficient oxygen level inside the cage. This also increase the speed of growth and faster “ready for market - time”
	Main customer groups	Fish farmers
Delivery	Channels	Phone, internet
Key	Key challenges	The cleaning process is labour intensive, heavy machinery and weather dependent, time consuming, a lot of cables.

Service		**Delicing**
Service production	**Process flow** What are the steps being taken to produce a product or service?	1. Fish enters Thermolicer after pumping. 2. Water separation. 3. Sea water is filtered and released. 4. The fish is exposed to lukewarm water. 5. Treatment loop. 6. Water surface. 7. Water separator for treatment water. 8. Fish exits the system. 9. Heated water is circulated to water tank for filtration, aeration and reheating. 10. Treatment water is pumped back to the treatment loop. 11. Inspection of sample salmon to see if they are clean.
	Technologies What are the main technologies the service is based on??	Pump system Fish counter Water separation Temperature and oxygen level monitoring PLC control unit
	Software/programming What software / algorithms are involved?	Thermolicer control unit to start and stop operation, monitor and controls water temperature, water levels, waterflow, oxygen level, counting the salmon.
	Skills	Salmon knowledge Mechanical operation of system Software skills
	Cost / cost structure	Labour Construction R&D Fuel consumption
Market	Functionality	Remove lice from salmon
	Needs covered	Fish health and quality
	Main customer groups	Fish farmers
Delivery	Channels	Phone, internet
Key	Key challenges What are the key challenges?	Time consumption Visual inspection after treatment Re-do the operation if it doesn't work Fuel consumption Fish health - Stress and damage to the fish





Product		Thermolicer
Production	Material / Hardware What gives it shape and structure?	Boat Office Pump Water separator Filters Valves Sensors - Temperature, O2, waterflow, and voltage, levels Plastic Tubes Stainless steel Pipes Salmon counter Interface - Handheld device to monitor with cable connection Interface - Tablet on the outside of the wall of the barge PLC control unit Handheld collection net (hov)
	Programming / Software	Thermolicer control unit
	Cost / Cost structure	Manufacture and assembly Spare-parts and maintenance
Market	Functionality	Cleans the fish from lice
	Needs covered	Healthy fish
	Skills What are the key skills in producing the product or bringing the product to market?	Welders Logistic Management Mechanical engineering Mari experts
Labour	Key challenges	Time consumption Requires a visual inspection after the process Spare-part storage

Product		**Underwater lights**
Production	Material / Hardware What gives it shape and structure?	1. **Acrylic & POM** 6 kg, 1350W, 35-55 m cable PUR 3G1,5 **2. Borosilicate glass & POM** 8,5 kg - 11 kg, 100W - 400W 35 m - 55 m cable PUR 3G1,5 Cooling fluid: Silicone oil **3. Borosilicate glass & POM** 7 kg - 21,6 kg, 250W-2000W 35 m -55 m cable PUR 3G2,5
	Programming / Software	Controlled by app
	Cost / Cost structure	Cables
Market	Functionality What does it provide of functionality?	Luminosity at different depths Control perception of season
	Needs covered What need does it cover?	Keep fish under lice belt Control growth rate Assist in visual monitoring Compensate for the lack of sunlight
	Main customer groups	Fish Farmers
Labour	Skills	Electric engineer Marine Biologist
Key	Key challenges What are the key challenges?	Provide electricity Harsh environment