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MASTER'S THESIS

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Identification of Innovative Improvements for Aquaculture Sector Using Arising Technologies

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ABSTRACT

The arising of new technologies as internet of things, machine learning, 3D printing, virtual reality and among others are starting to transform industries in different sectors, already calling this phenomenon as the 4th Industrial Revolution or Industry 4.0, and as any industrial revolution the companies must be aware of the importance to use these technologies to maintain or improve their position in the market.

The Norwegian Aquaculture sector was chosen for identify possible innovations, due to its growth and its importance for future generation due to the fast growth of the world population, and also given that the Norwegian aquaculture can be considered as a conservative sector there is a lot of space for improvements.

Innovative ideas were generated by utilizing a method, which identified improvements opportunities in the services, products and segments of salmon farming sector applying the arising technologies. After this process the ideas generated were evaluated in problem solving potential, economic potential and patent protection to classify the ideas with most potential of developing a business.

A few ideas presented very good potential making possible the idea of developing a business, showing that the method utilized can be a model to identify opportunities for new undertakings.

ACKNOWLEDGEMENTS

Undoubtedly this work is a mark for my studies with a great addition of knowledge, but this was possible with the help of a number of people.

I would like to express my gratitude to my supervisor Knut Bang with his guidance and to Muhammad Ahmad Tauqeer for his presentations and amazing videos explaining the technologies and business trends.

Many thanks to my great friend Rikard Andreas Davidsen, who participated in a big part of this work being part in numerous meetings and brainstorming to find ideas and making this project more enjoyable to realize.

My family deserve special thanks because even with the distance and difference of time from Brazil, they always support me to conquer my objectives.

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NOMENCLATURE

FAO – Food and Agriculture Organization

Kg – Kilogram

IoT – Internet of Things

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1- INTRODUCTION

1.1 – BACKGROUND

Creation of new technologies were always follow by changes in business, as well as in development of new product or changes in how to run business. One example is the change of steam power for electricity, the introduction of electric motors in the earlies years in the 20th century helped manufacturers to save from 20 to 60 percent in coal bills, plus other indirect savings by changing the configuration of the factories (Crocker, 1901). Another example came with use of internet to increase sales. Amazon one of the most famous ecommerce companies founded in 1994 was one of the first American ecommerce companies to sell products over the Internet and in 2017 reached a revenue of 178 billion U.S. dollars (Statista, 2018), the figure 1 below shows the evolution in Amazon's revenue by the years.

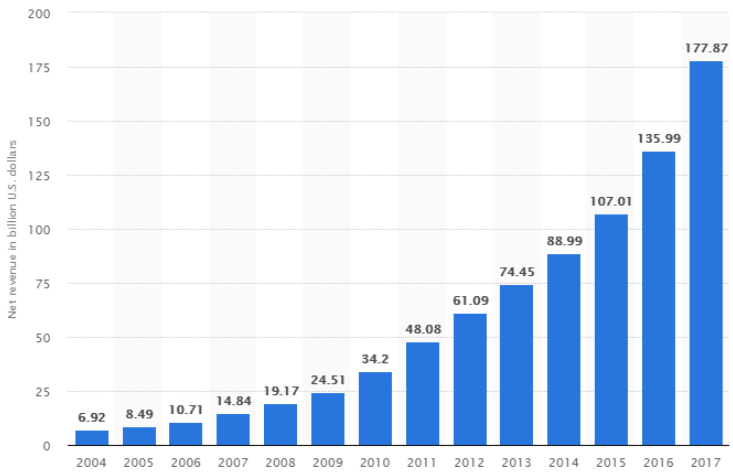


Figure 1 - Amazon's revenue growth over the years (Statista, 2018)

Although, today's it looks obvious to use electricity or sell products through the internet, all that happened because people saw how technologies could create or improve business. However, that doesn't happen with everybody, backing to the example of using of electricity in the American factories in the beginning of the 20th century, a study conducted by the economist Richard Caves indicates that manufacturing firms that were dominant in 1905 and still existing in 1929 lost their average market share from 69% to 45%. Electricity increases so much the productivity that made costs going down and impacting in lower prices, creating a disloyal competition for those who didn't adopt electricity as a power source.

Taking the Amazon's example, it can be noticed that with the development of the internet Amazon saw the potential of sales through the internet and starting what is call today E-commerce. Internet not only changes sales methods but also communication with customers introducing new ways to do marketing, communication with suppliers, etc. The Internet concept changed parameters in companies' business model which proportionated value creation for them.

Technology helps businesses to create value but is necessary to be open to accept and able to identify opportunities for innovation and be on the top of the competition and not be overcome by it. Now once again technology presents a great opportunity to identify innovations, since it has been considered that the world is living the 4th industrial revolution with different technologies, that it will be presented in the next chapters, together with new concepts of running business great opportunities can be spot.

Another point that indicates that now is a good moment for coming up with new business, is the challenges that the future holds. Even with the growth rate of the world population decreasing, it is still expected that world population number will reach 9 billion people by the year 2050 (United Nations, 2013). That means increase in consumption of food, energy and raw material in a planet that resources are scarce, and it is already suffering with environmental problems. Such problems that forced governments and groups to take actions creating green politics, as the use of renewable energies.

Thanks to these politics nowadays more countries adhered the use of wind and solar energies, and more and more we can see electric cars in the streets. However, the challenges that the growth population impose looks more demanding than change for renewable energy, which already is something hard to do, but what basically the growth population is imposing is to produce more what we produce today with less resources that we use nowadays.

According with Ranganathan (2013), the world will need to produce 69% more calories to feed the world population by the year 2050 comparing with the year 2006. Therefore, it is possible to say that food production market will be a great deal within future years. And although oceans cover more than two thirds of the world's surface, only 2% of the food energy for human consumption comes from the sea, showing huge gap in the food production which can be better explored.

Aquaculture has been developed to fill this gap increasing the seafood production. Aquaculture takes less resources and is friendlier to the climate compared to livestock. Since traditional fisheries are almost fully exploited, increased aquaculture production needs to play a major part in efforts to feed future generations (SalMar, 2014).

Therefore, by the present scenario above, it can be seen that aquaculture is a market with a high growth opportunity, and Norway being the 2nd world largest seafood exporter in 2014 only after China, has been showed great interest in developing this area in a sustainable way. And to achieve that the Aquaculture industry is aiming the use of innovative technologies to increase production and protect the environment at the same time.

1.2 – OBJECTIVE

The thesis has the objective to identify innovations in the Norwegian fish farm sector by using arising technologies. The innovations have the intentions, to improve the services and products presents in the sector, by solving the key challenges presented nowadays.

To identify the innovations a method was utilized, so as second objective the method utilized for identify the innovations is analyzed for its use as a model for identify innovations opportunities in any sector and from that initiate a new business.

1.3 – METHOD

The procedures for the achievement of the objectives are:

- A deep understanding of all services, products and segments from salmon farming, and detailing them.
- A deep understanding of the arising technologies, to understand how they work, what functions they can have and their currently applications.
- Identify innovations in the salmon farming sector by investigating which technologies can be used to solve key challenges, reduce cost and/or time.
- Screening the innovative ideas to identify the ones which are strong enough for the development of a business.
- Develop a business model Canvas for the innovations with most potential.

1.4 – DELIMITATIONS

The salmon farming value chain involves since the egg of the fish until reach the market, but on this work only the part where the salmon is transfer to sea water until the salmons be harvest is analyzed.

2 – INDUSTRY 4.0 AND ITS TECHNOLOGIES TRENDS

The fourth industrial revolution is also known as the Industry 4.0, a concept first introduced in Germany as a proposal for the development of a new concept of German economic policy based on high-tech strategies (Mosconi, 2015). It is predicted that the purpose of the technology will be aimed at collecting and analyzing data from the human environment to design a circular economy, increase revenues, lower capital spending, and improve services and mobility (Lasi et al., 2014).

The Internet transformation of the digital industry is still in progress, but artificial intelligence, big data, and connectivity indicate the certainty of a new round of digital revolution. Industry 4.0 is on the way and will have an important influence on the complete transformation of industry (Almada-Lobo, 2016; Schlechtendahl, Keinert, Kretschmer, Lechler, & Verl, 2015).

Companies are aiming to achieve, through all these new concepts, high-end quality services or product at the lowest cost, increasing profit and reputation. According with PwC company, in 2014 was expected that this digital transition would require a considerable investment, reaching 50% of the planned capital for the next five years.

According to PwC company (2014), there are three drivers that encourage companies to embrace such concepts, first one lies in the integration and better management in the horizontal and vertical value chains. The digitization and interconnection of product and services is the second driver, with this concept the company can enhance competitiveness. The third driver is the creation of digital business, which creates value to the customer, designing a personal solution for each customer, building an idea of flexibility.

The enablers to accomplish all this change, are the newest concepts of technology, which are presented below with a brief description of their functions.

Sensors

Sensors have the task to collect the necessary data to enable optimal operations. There are different sensors which collect different kinds of data, the figure 2 informs the different kinds of data the sensors can obtain.

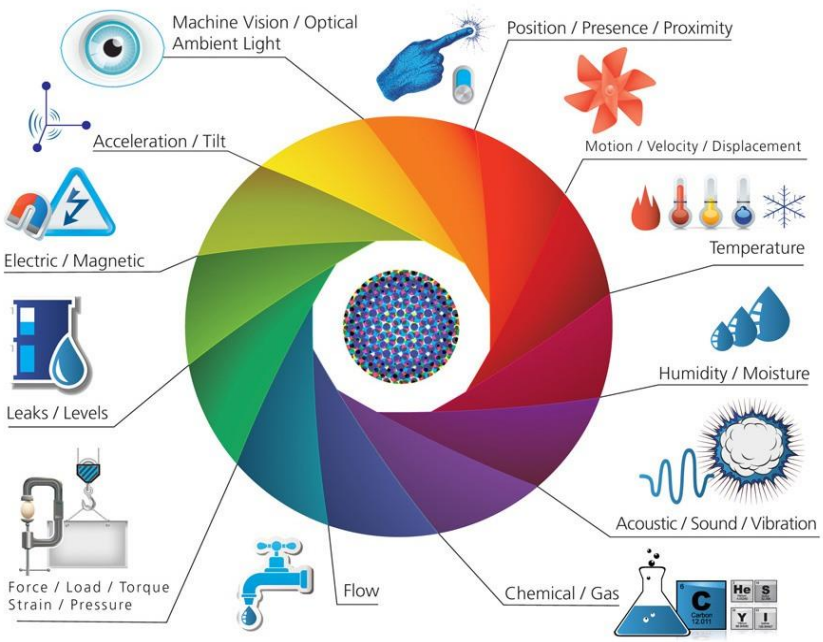


Figure 2 - Examples of sensors (Postscapes, 2016)

The sensor is a big important technology not only because of collecting data, but also because the sensors help in the development of other technologies, such as Internet of Things, which it still will be present.

Computer Vision

Computer vision is a field of computer science that works on enabling computers to see, identify and process images in the same way that human vision does, and then provide appropriate output. It is like imparting human intelligence and instincts to a computer. In the figure 3 a camera can identify and classify different kinds of vehicles.

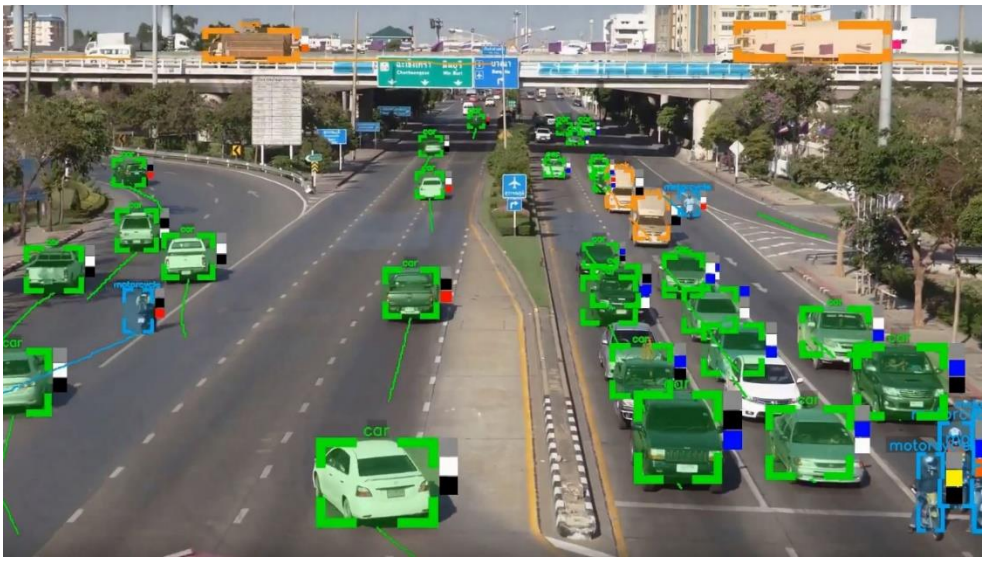


Figure 3 - Example of machine learning in traffic control (GoodVision, 2018)

Augmented reality

Augmented Reality turns the environment around you into a digital interface by placing virtual objects in the real world, in real-time. Augmented Reality can be seen through a wide variety of experiences allowing users to place life-size 3D models in their environment like in figure 4 or display contextual information, like in figure 5

Figure 4 - Augmented Reality in automotive industry (SolidSmack, 2015)

Figure 5 - Augmented Reality App (Medium, 2017)

Internet of Things

The Internet of things (IoT) is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and network connectivity which enables these objects to connect and exchange data. The Internet of Things is the logical next step in the evolution of the Internet and is a continuation of M2M (machine-to-machine) networks and technologies.

One example of the use of IoT, is the application in smart homes, where several of appliances are connected and they can be all control using a smartphone connected to the same network. The figure 6 shows components in a house that can be connected to IoT.

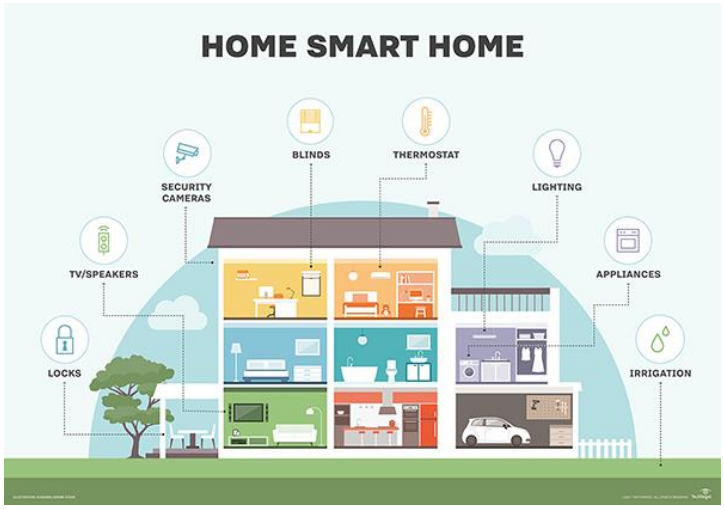


Figure 6 - IoT connecting house devices (Hedows, 2017)

Cloud Computing

Cloud computing is the process of moving data, applications or other business elements from an organization's onsite computers to the cloud or moving them from one cloud environment to another. Cloud computing has the objective to have data stored and managed remotely in multiple locations and by any device connected to the internet as it can be seen in figure 7.

Figure 7 - Devices connected with the cloud (Daniel Rosa, 2016)

Machine Learning

Machine learning is a data analytics technique that teaches computers to do what comes naturally to humans and animals: learn from experience. Machine learning algorithms use

computational methods to “learn” information directly from data without relying on a predetermined equation as a model. The algorithms adaptively improve their performance as the number of samples available for learning increases.

In figure 8 shows some of the utilization of machine learning nowadays.

Figure 8 - Examples of machine learning utilization (NVIDIA, 2016)

Virtual Reality

Virtual reality refers to computer-generated environments or realities that are designed to simulate a person’s physical presence in a specific environment that is designed to feel real. The purpose of VR is to allow a person to experience and manipulate the environment as if it were the real world. The best virtual realities are able to immerse the user completely. In figure 9 shows virtual reality being using truck driver training.

Figure 9 - Virtual Reality for teaching driving trucks (VR Motion, 2017)

Drone

Drones are a component of an unmanned aircraft system (UAS), which include a drone, a ground-based controller, and a system of communications between the two. The flight of drones may operate either under remote control by a human operator or autonomously by onboard computers.

Drones are being used for several functions, in figure 10 the drone is being used to spread fertilizer in a crop.

Figure 10 - Drone being used for agriculture (Dominic Hartnett, 2015)

Robotics

Robotics is the science that use technologies to develop machines that can substitute humans. The robots can be used in any situation and for any purpose, but today many are used in dangerous environments, manufacturing processes as in figure 11 robots are manufacturing engines, or where humans cannot survive as in figure 12 the Mars Rover robot. Such robots attempt to replicate walking, lifting, speech, cognition, and basically anything a human can do.

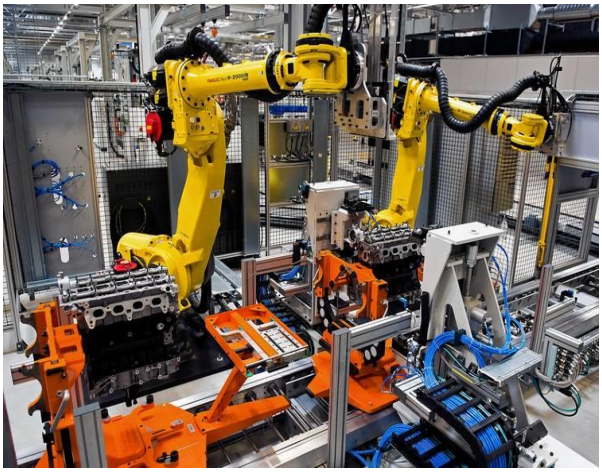


Figure 111 - Robots for manufacturing (Wall Street Journal, 2017)

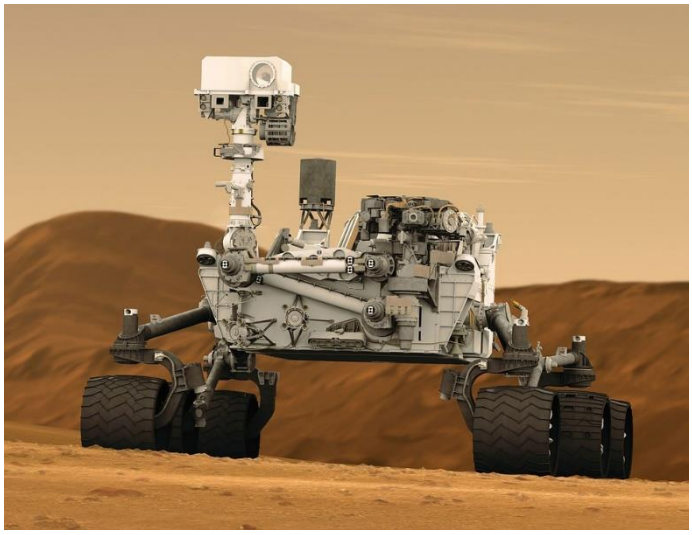


Figure 122 - Robot in uninhabitable place (Pixabay, 2016)

3D Printing

The process of 3D printing enables the produce of three-dimensional solid object from a digital file. A 3D printed object is the end result of additive processes where the object is created by laying down multiple layers of material, until the object is finished. In figure 13 show a small bench made by 3D printing.

Figure 13 - 3D printing manufacturing a bench (Tridilabs, 2016)

Autonomous Transport

An autonomous transport is unmanned transport that can sense its environment and navigating without human input. Autonomous transport uses a variety of technologies, some of them already mentioned above, to detect their surroundings, such as radar, laser light, GPS, odometry and computer vision.

Self-driving cars already started to be used, including transportation companies as Uber, in figure 15 shows a self-driving car of Uber. Other types of autonomous transportation are being developed, for example the company Yara from the agriculture sector started a partnership with the Kongsberg company for the development of an autonomous ship, the figure 16 shows the illustration of the ship.

Figure 14 - Self driving Uber (VEJA, 2016)

Figure 15 - Autonomous boat model (KONGSBERG, 2017)

Companies are introducing these technologies in their business for improving their already existing services or creating new ones. Below there are some examples of how companies are using the technologies and the consequence of that.

Rolls Royce is utilizing the software *Azure IoT cloud suite* to improve aircraft efficiency and availability while lowering engine maintenance costs. Data sets like engine health data, air traffic control information, route restrictions and fuel usage data are collected to detect operational anomalies and trends and then provide intelligent performance feedback on the findings. The goal is to improve their operational performance and increase fuel efficiency. The consequence of is that the firm is saving $250,000 per plane by reducing fuel usage by just 1 percent (Drinkwater, 2016).

Caterpillar now has a drone that map the jobsite taking high-resolution photos of the site and its topography. The drone together with a software identify changes in the landscape, letting the measurement of material movement and monitor how work is progressing, for example the movement of earth volume like in figure 16.

Figure 16 - Geospatial mapping (Airware, 2016)

Blue River Technology has designed and integrated computer vision and machine learning technology for an herbicide spreader. The spreader can differentiate cotton from weeds, as it can be seen in figure 17 and then spray the herbicide only when is necessary. According with Blue River Technology, the cost with herbicide can decrease in 90%.

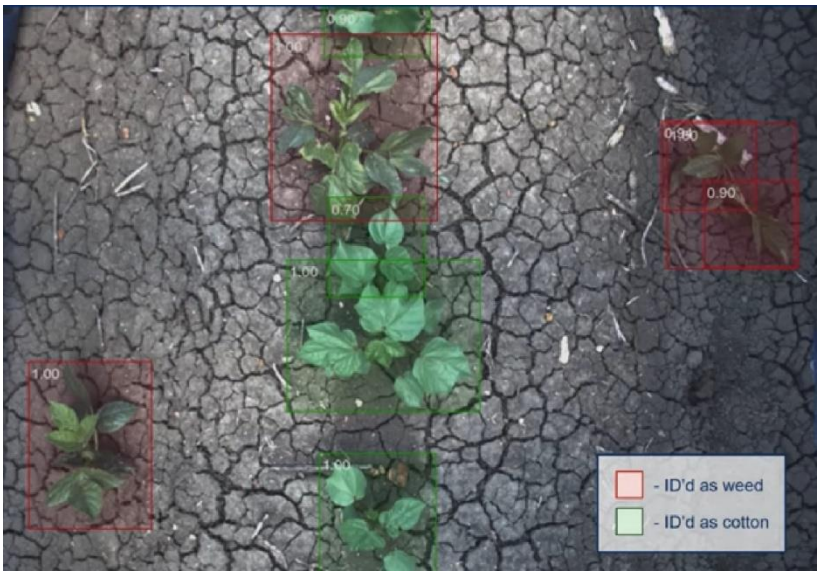


Figure 17 - Machine learning for agriculture (Blue River Technology, 2017)

IKEA launched an app, called IKEA Place app, in 2017 with augmented reality, which it helps its customers see exactly how more than 2,000 furniture items would look and fit in their homes. The app places photorealistic furniture items in the frame, as in figure 18, at the touch of the screen. Furniture is correctly sized down to the millimeter enabling a close look at fabrics and colors.

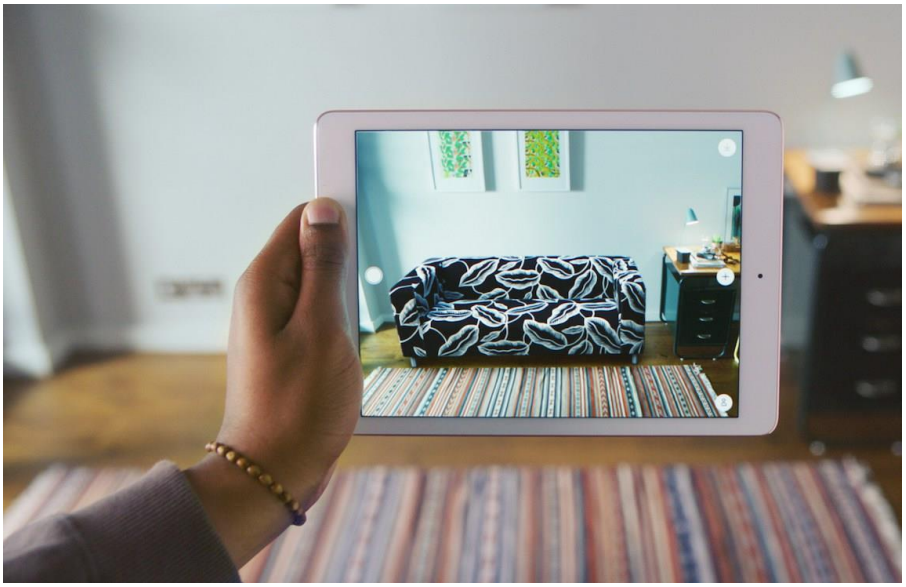


Figure 18 - IKEA App (Digiday, 2017)

As it can see different sectors are using the technologies and this work is about how these technologies can be applied in the aquaculture sector. Next chapter tells about aquaculture, how important it is, its growing, its processes, problems to be solve, etc.

3 – AQUACULTURE

The Norwegian aquaculture was selected for the identification of innovations due the importance of this sector for Norway and the importance of aquaculture for the future of the planet, therefore information is given below for a better understanding of this business

3.1 – OVERVIEW

Aquaculture has grown three times faster than agriculture has, at an amazing rate of 8.3% per year since 1970 (Diana 2009). Aquaculture provided for 48.4% of the world's seafood consumption in 2009 (FAO 2009). According with FAO (Food and Agriculture Organization) 2017, in 2015 the total fishery production was 170 million of tons, a number that have been increasing in the last ten years, as in the figure 19 shows.

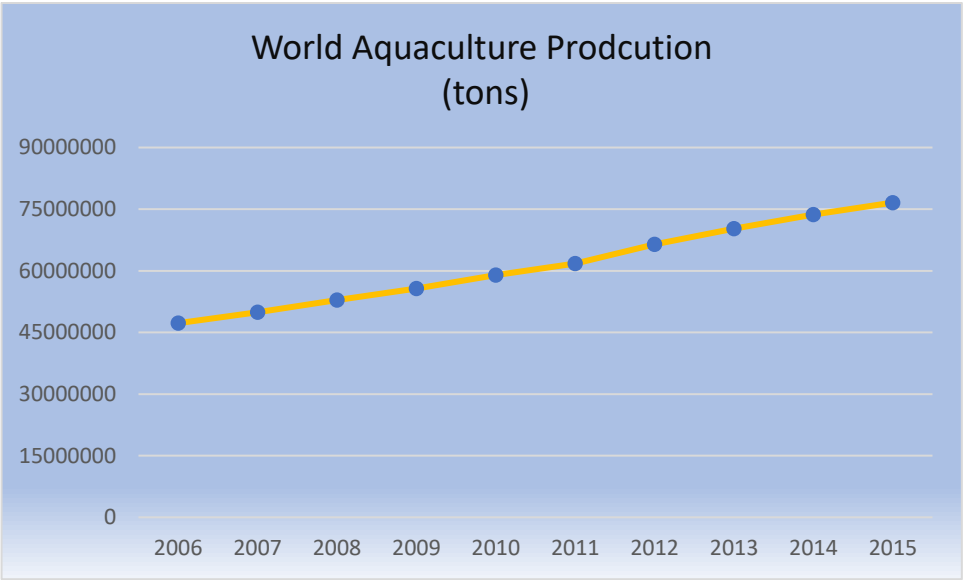


Figure 19 - World Aquaculture Production through the years

According with the 2015 year book of Fisheries and Aquaculture Statistics developed by FAO, Asia was responsible for 89% world aquaculture production of fish, crustaceans and molluscs. This number is supported because China is the biggest aquaculture producer country, reaching 47,6 million ton of production in 2015, 62% of the world production.

Although the considerable numbers from China, the number which call attention is related to the exportation. China comes on first as the country which more export, but surprisingly, Norway comes by second with a difference that does not reflect the demographic and geographic dimension differences between the countries. And being in front of countries like Canada, USA and Chile, a big salmon export as well, make the

Norwegian aquaculture even more impressive. Below the figure 20 shows the values of exportations from these countries.

Figure 20 - The biggest aquaculture exporters countries

According with FAO 2017, Norway aquaculture exportation reached 9,2 billion dollars against 19,7 billion dollars from China. Norway have been accumulated increases in its exportation, only one drop in 2015 due the lower price of salmon, which represents 90% of Norwegian aquaculture, but the production had a slightly increase anyway as it can been see in figure 21.

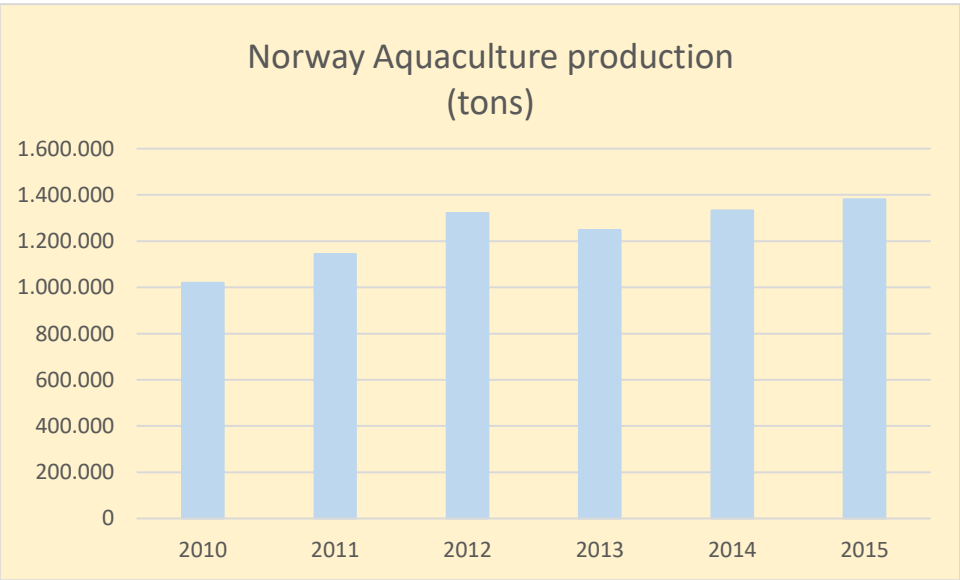
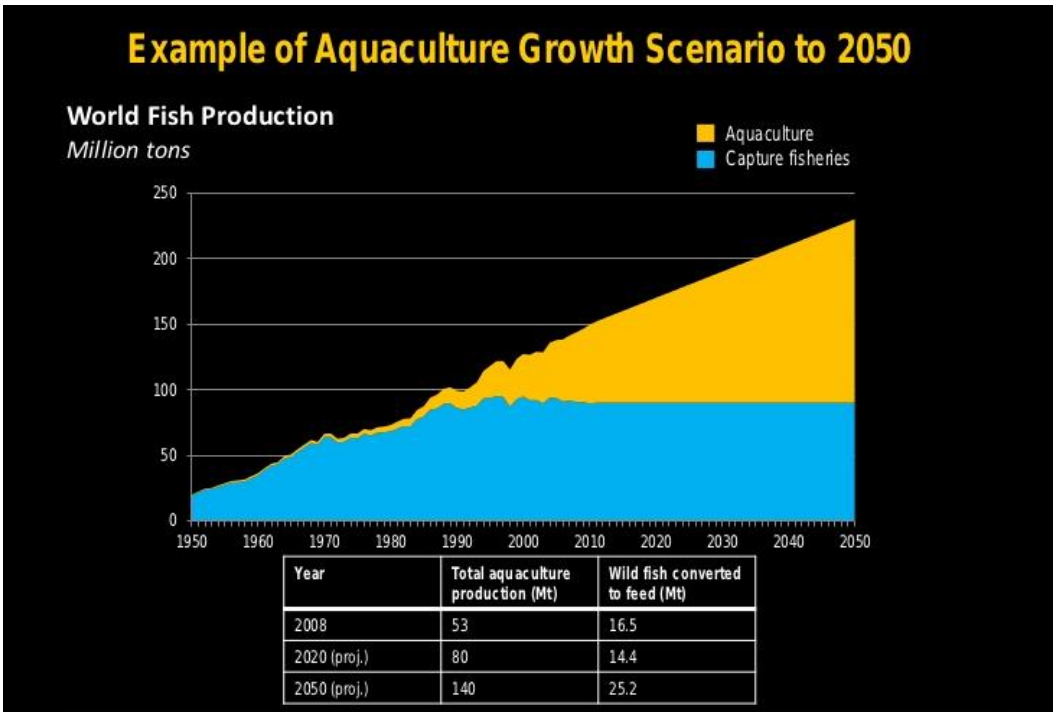


Figure 21 - Norway's aquaculture production

Given current trends, the world will be vastly different in 2050. Not only will the global population likely increase to nine billion, but that population will be increasingly urban and denser in developing countries (Cohen 2003). Water will be an even more precious resource, whereas new lands for agriculture expansion will be limited. About 50% more food (3 billion tons of cereal crops and 200 million tons of meat) will be needed to sustain the quality of human life (FAO 2009). Given the limits of agriculture, new production systems that does not demand a substantial quantity of land, freshwater, and nutrients and that require less energy, will be necessary for future generations.

Aquaculture represents the most sustainably efficient way to meet the needs for global meat/protein needs, the figure 22 illustrates the aquaculture expected growth until 2050. The sustainability of aquaculture businesses in 2050 will be dependent on continued identification of practices that improve environmental and economic performance through increased productivity. Thus, fewer inputs/resources will need to be used per ton of production, and costs per ton of product will decrease (Engle et.al, 2017).



Year	Total aquaculture production (Mt)	Wild fish converted to feed (Mt)
2008	53	16.5
2020 (proj.)	80	14.4
2050 (proj.)	140	25.2

Figure 22 - Aquaculture growth Scenario (World Resources Institute, 2012)

Norway is aware of the necessities for food production in 2050 and the Norwegian aquaculture industry established as a main goal a production of 5 million tons in 2050. Furthermore, another goal for the industry is to solve the environmental challenges and to do this, the industry must solve the issues related to genetic influence on the wild stocks

and escapes, illness including parasites, pollution and emissions, feed resources and available area for production. In addition, the industry is to continue to be one of the major employers in the Norwegian society (Finne, 2016, Olafsen et al., 2012).

Norwegian Petroleum had reported that is expected a decline of oil production in the years towards 2030, this decrease already can be seen using the years of 2015 and 2016, where in 2015 oil as gas production generated NOK433 billion while in 2016 the production was NOK346 billion. In 2012, the report *Verdiskapning basert på produktive hav I 2050* (Value creation based on productive sea in 2050) stated that the production of salmon and trout is expected to reach NOK238 billion in 2050. Therefore, with the decreasing value creation in the oil industry and increasing value creation in the aquaculture industry, supported by global megatrends, revenues from the Norwegian aquaculture industry may well be higher than the revenues from the oil industry in 2050.

In order that aquaculture achieve the necessary production capacity to feed future generations in a sustainable way the use of technology will be of a great necessity. Information technology will be more fully integrated all over in the aquaculture. Improvements in remote monitoring and sensing will contribute with more information, thus making big data analytics very important.

Beyond information technology, affordable automation of processes in large-scale production will reduce labor costs and increase economies of scale. Full automation, combined with ocean-scale satellite data and prediction technologies (e.g., weather, plankton, temperature, currents) may allow alternative forms of ranching and open-ocean farming (Engle et.al, 2017).

According to Finne 2017, the Norwegian aquaculture industry is characterized by a high degree of technological innovations. An advantage for the Norwegian aquaculture industry is that Norway possess a good resource pool for technology development and many individuals with great knowledge due to its offshore-industry. For the industry to be able to increase their production sufficient to reach the 2050-goals, more technological innovations and the attraction of talented personnel is necessary. New technological innovations are also necessary to handle the climate changes that are expected to occur in the future.

3.2 - AQUACULTURE PROCESSES

In this part will be present information about the processes that are involve in salmon farming in sea water. Salmon was chosen for the description of this section because represents most of the Norwegian seafood exportation.

Salmon farming production cycle starts with the Broodstock, where fishes with good qualities in growth, resistance to disease, maturity and color are selected for reproduction. After Broodstock, it comes the Spawning and Fertilization, where the eggs are removed from the female and are mixed with milt (the semen of a male fish) for fertilization. The fertilized eggs are kept in an incubator and after 25-30 days the eggs start to show “eyes” as it can be seen in figure 23.

Figure 23 - Salmon egg (Downeast salmon federation, 2017)

The next phase is when the salmon reach at the Alevins stage, figure 24, very small animal (< 2,5cm) in this stage the fish absorbs the yolk sack for nutrition. Then the fish is transported to fresh water tanks where the salmons go through three growth phases, fry, parr and smolt, as it can be seen in the figures 25,26 and 27 respectively. In this stage external feeding starts and medicine are introduced in the fish health and the fish experience biological changes to be able to adapt in sea water. The whole process from spawning to smolt takes from 10 to 16 months.

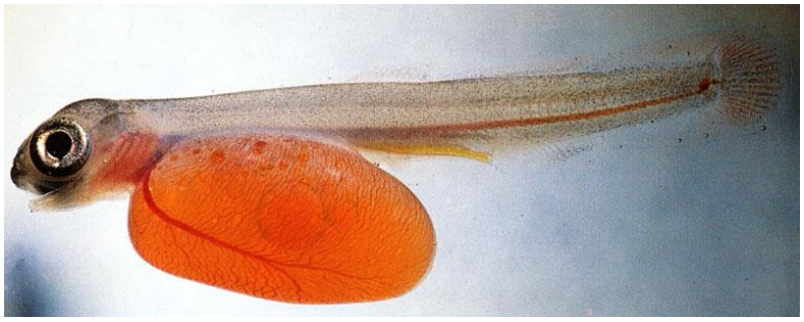


Figure 24 - Alevin (Hancock House Publishers, 2011)

Figure 25 - Salmon fry (Marine Harvest, 2018)

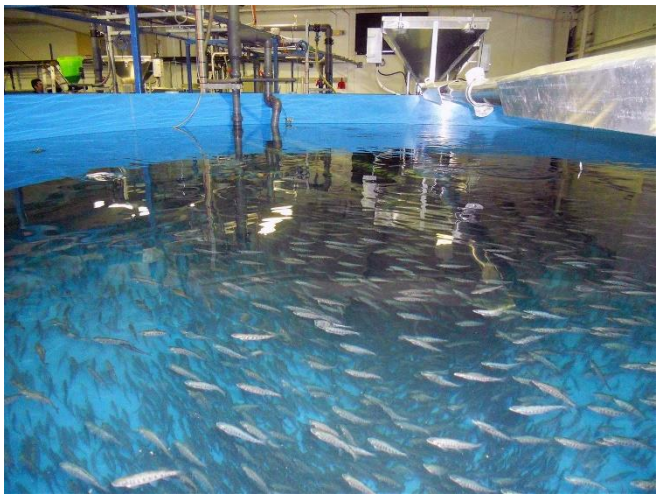


Figure 26 - Salmon Parr (Marine Harvest, 2018)

Figure 27 - Salmon smolt (Spey fishery board, 2014)

When the fish reach the smolt stage, it is transferred to offshore cages in sea water, figure 28 is an example of this cages, by well boats, this process occurs twice per year in Norway. The fish then is fed and treat until the it has reached a weight of around 4.5-5.5 kg, what it can takes 14-24 months. After that the harvesting stage comes, and the fishes are transported back to land to be slaughtered and processed. The salmons are gutted and packed and then sold.

Figure 28 - Salmon farming structure (The Seattle Times, 2017)

The total production cycle takes 24-40 months from fertilized eggs to harvested fish. The fairly large range is dependent on several factors like, amount of food given, water temperature, final weight and time spent at the different stages (Marine Harvest, 2015).

3.3 – FISH FARM EQUIPMENTS

On this part some of the present equipment's in a fish farm are showed:

Figure 29 is the Pen, it is where the salmons stay inside.

Figure 30 is the net to avoid salmon escaping.

Figure 31 is the barge, where the workers stay, the food for the fishes and the feeding system are.

Figure 32 is the cannons to distribute the food to the pens.

Figure 29 - Salmon pen (Stoeck, 2017)

Figure 30 - Net cage (Akvagroup, 2015)

Figure 31 - Barge (Akvagroup, 2015)

Figure 32 - Feeding cannons (Akvagroup, 2015)

4 – APPROACH

The objective of this work, as said in the introduction chapter is to use a model to identify possible use of technologies trends in the products and services in the aquaculture sector for the search of innovative products and services, thus achieve better productivity, decrease cost and time, and improve welfare for the fish.

This work focuses only on the services and products involved in the part when the salmon is transfer for sea water until reach the market size.

The methodology first step was to breakdown all the services, product and segments for better understanding and identify key challenges to solve. Therefore, tables such as in the figures 33,34 and 35 were filled.

Product		
Production	**Materials/Hardware** What gives it shape and structure?	
	Software/programming What software/if and makes it do what?	
	Cost/cost structure What are the main cost drivers of production?	
Market	**Functionality** What does it provide of functionality?	
	Needs covered What need does it cover?	
	Main customer groups What are the main customer groups?	
Labour	**Skills** What are the key skills in producing the product or bringing the product to market?	
Key	**Key challenges** What are the key challenges?	
Other	**Other factors**	

Figure 33 - Product breakdown

Service		
Service Production	**Technologies** What are the main technologies the service is based on??	
	Software/programming What software / algorithms are involved?	
	Skills What are the key skills in the service delivery process?	
	Cost/cost structure What are the main cost drivers of service delivery?	
Market	**Functionality** What does it provide of functionality?	
	Needs covered What need does it cover?	
	Main customer groups What are the main customer groups?	
Delivery	**Channels** What are the main service delivery channels?	
Key	**Key challenges** What are the key challenges?	
Other	**Other factors**	

Figure 34 - Service breakdown

Industry segment		
Value creation flow	**Process flow** What are the steps being taken to produce a product or service?	
	Skills What are the key skills required in the value creation process?	
	Cost/cost structure What are the main cost drivers of the process flow?	
Market	**Needs covered** What need does it cover?	
	Main customer groups What are the main customer groups?	
Key	**Key challenges** What are the key challenges?	
Other	**Other factors**	

Figure 35 - Segment breakdown

After profounder the knowledge in each product, service and segment the next step was to identify innovations opportunities using technologies trends. Once more, tables such as the figures 36,37 and 38 were filled by verifying the implementation of each one of the technologies in each product, service and segment and determinate if there is space for improvements.

Product				
Production	**Changes to software** – Are there possible improvements from this technology trend to the programming?			
	Changes to hardware – Are there possible changes to the hardware/shape/structure from this technology trend?			
	Changes to costs – Are the production costs changing or the cost of operating the product from this technology trend?			
Market	**Increased functionality** – Can the technology trend contribute to increased functionality?			
	New needs covered – Can this technology trend contribute to covering potential new needs?			
	New customer groups – Can this technology trend make the product attractive for other customer groups?			
Key	**Solving key challenges** - Can the technology trend help solve one of the key challenges?			
	Increased intangibility – Can the technology trend contribute to making the product less tangible/more of a service?			
Other	**Other factors**			

Figure 36 - Changes in the product due to innovations

Service				
Service delivery	**Changes to software** – Are there possible improvements from this technology trend to the programming?			
	Changes to service delivery method – Are there possible changes to the service delivery from this technology trend?			
	Changes to costs – Are the service delivery costs changing from this technology trend?			
Market	**Increased functionality** – Can the technology trend contribute to increased functionality?			
	New needs covered – Can this technology trend contribute to covering potential new needs?			
	New customer groups – Can this technology trend make the service attractive for other customer groups?			
Key	**Solving key challenges** - Can the technology trend help solve one of the key challenges?			
	Increased intangibility – Can the technology trend contribute to making the product less tangible/more of a service?			
Other	**Other factors**			

Figure 37 - Changes in the service due to innovations

Industrial segment				
Value creation flow	**Changes to process flow** – Are there possible improvements from this technology trend to the process flow?			
	Changes to required skills – Are there possible changes to the required skills from this technology trend?			
	Changes to costs – Are the process flow costs changing from this technology trend?			
Market	**New needs covered** – Can this technology trend contribute to covering potential new needs?			
	New customer groups – Can this technology trend help attract other customer groups?			
Key	**Solving key challenges** - Can the technology trend help solve one of the key challenges?			
	Increased intangibility – Can the technology trend contribute to making the value creation process less tangible/more of a service?			
Other	**Other factors**			

Figure 38 - Changes in the segment due to innovations

After generating ideas for innovations, the ideas were screening following three checks:

1. Check 1: Ability to solve a problem.

Looking in how better the product or service is comparing with the current ones and also the size of the problem solved by the innovative product or service. Using the graph in the figure 39 below the ideas were positioned and the colored regions in the graph shows how likely the chance of the idea be accepted in the market. The dark blue region demonstrates a small or no chance that the innovative idea is accepted, on the other

hand the light blue region demonstrates a great potential to the innovative idea be accepted.

2. Ability to make a profit.

The second step for the screening process was to conjecture profit margins with the size of the market. The graph in the figure 40 below shows a red region where the product doesn't give any profit margin and four areas delimiting High/Low sales and High/Low margins. The red region and the Low sales X Low margins area inform that the product is not good for business, the two areas High sales X Low margins and Low sales X High margins can be good for business and the region High sales X High Low stays the best business opportunities.

3. Can it be protected – Or ability to make a profit over time.

The third step of screening was to analyze if the product can be protected, i.e. if it can be patented. The patent protection supports the business by keeping high margins or growing them, and the same happens for the market, the patent protection enables the business goes globally without be affected by copies made by the competition. The graph in the figure 41 below shows how patent protection can improve profit margins and size market.

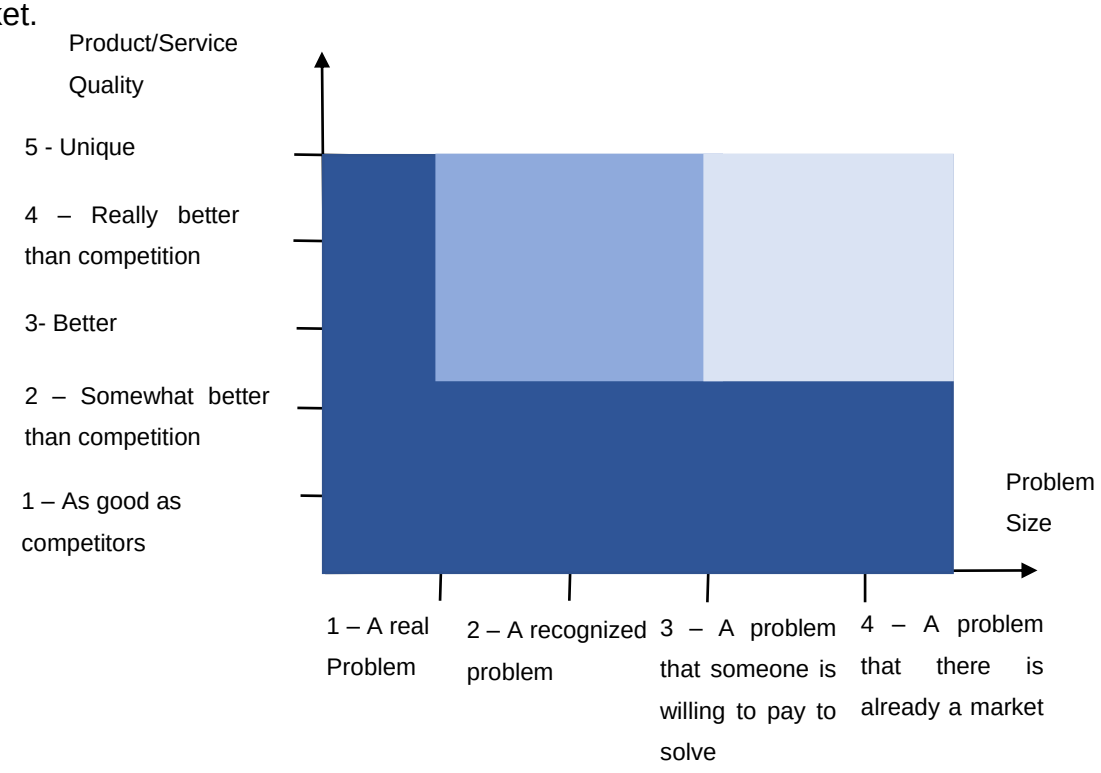


Figure 39 - Graph Ability to solve a problem

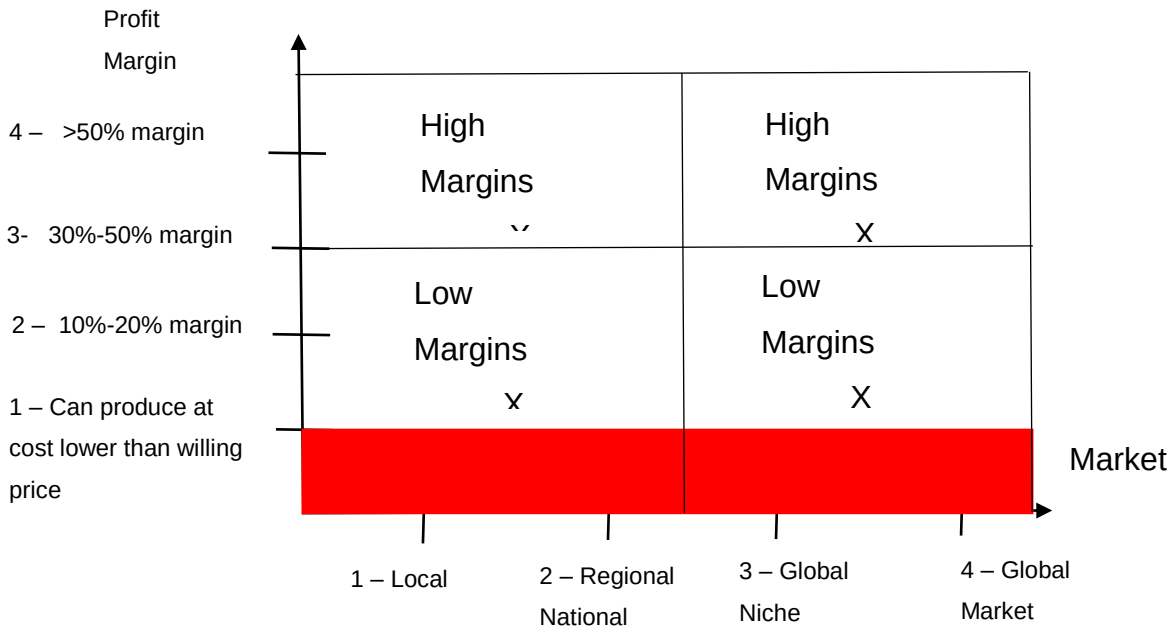


Figure 40 - Graph Ability to make a profit

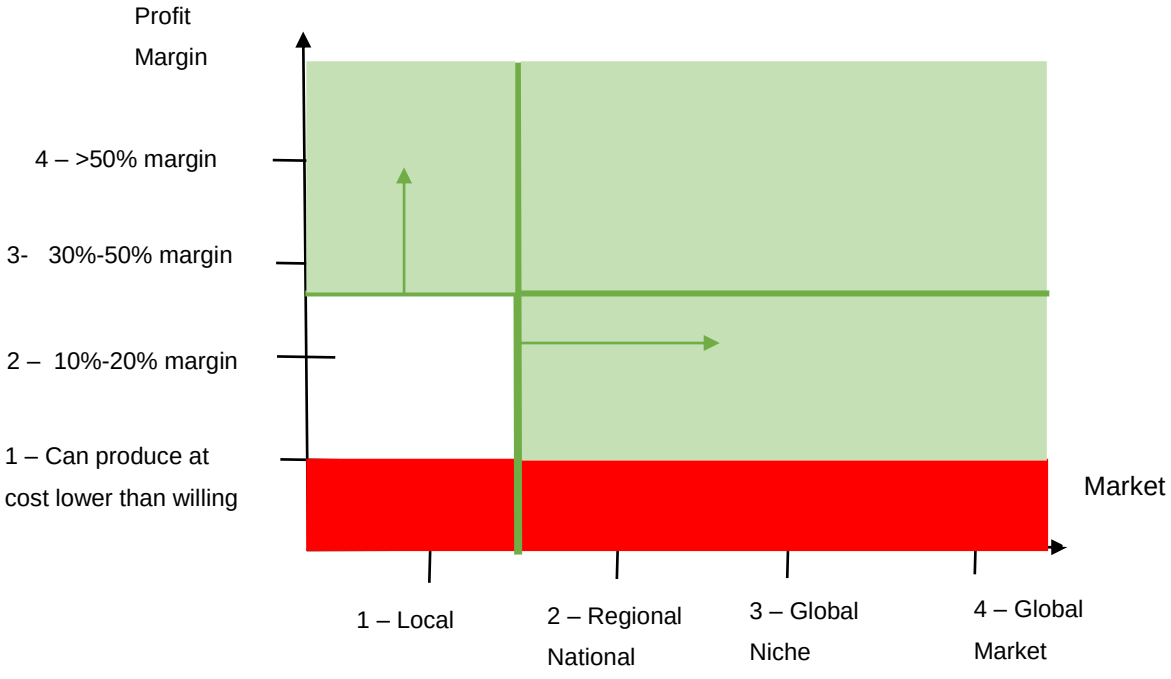
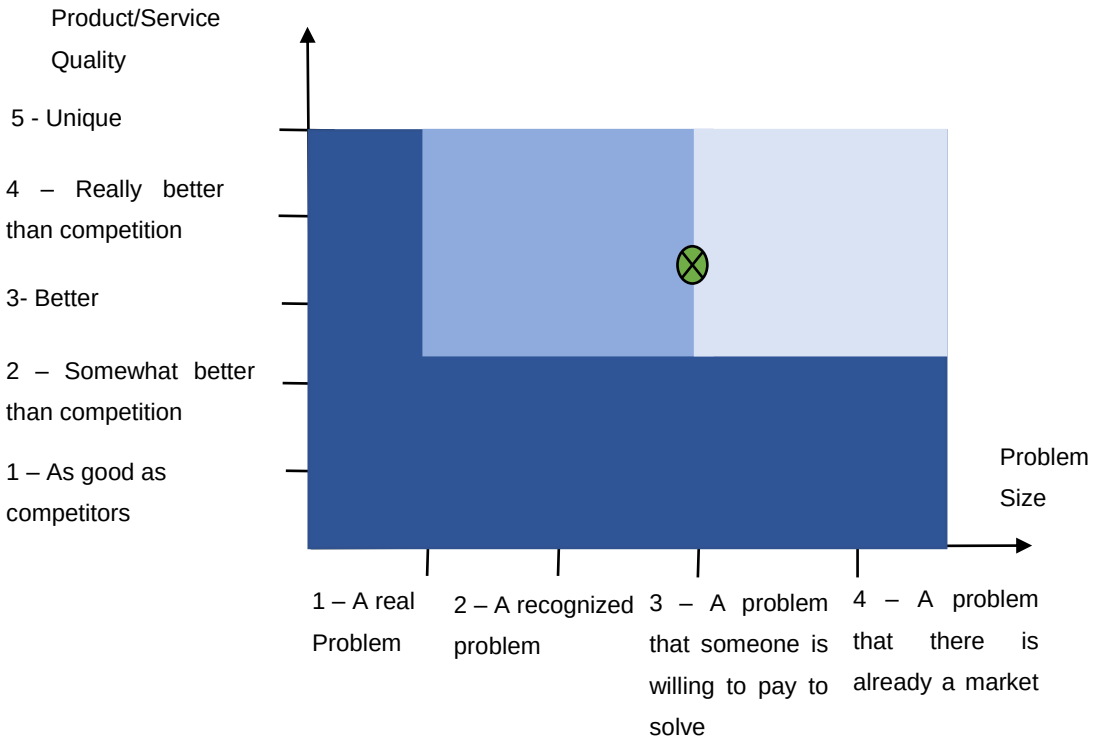


Figure 41 - Graph influence by patent protection

After the screening process the ideas were filtered to select the best ones for later to develop a business model using them. The process to filter worked first separating the ideas that can be patented, and then using the graphs were given scores to the ideas in respect with ability to solve a problem and ability to make a profit, then these scores were sum and the ideas with a score higher than 6.5 were selected to develop a business model.

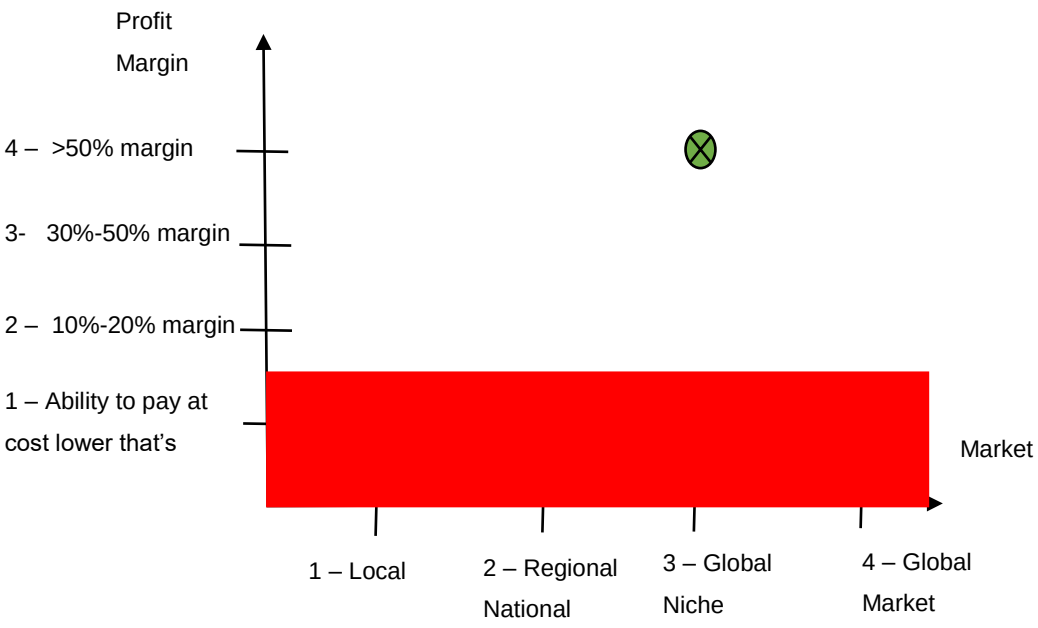
Example:



Axis X: 3

Axis Y: 3.5

Score: (3+3.5)/2 = 3,25



Axis X: 3

Axis Y: 4

Score: (3+4)/2 = 3.5

	Score
Problem Size	3.25
Economics	3.5
Total	6.75

The idea obtained a total of 6.75, therefore if the idea can be patented it could use to develop a business.

The breakdown of the product, services and segments plus the effort to generate innovative ideas were run by several brainstorm meetings together with another Master student. With two different points of view were possible to identify constraints or improve even more the ideas. The screening part took of meetings occurred with a computer science PhD student and the supervisor/professor of Technology Innovation and Entrepreneurship course.

As the ideas were created by the author and another student, they were sorted in two works, but both of them contain innovative ideas for different problems sizes in aquaculture.

5 - IDEAS

In this chapter the ideas and the screening process will be presented emphasizing the topics:

- Existing service/products
- Idea description
- Problem Solving Potential
- Economic potential

The tables involving the products, services and segments breakdown together with the tables of products, services and segments after the implementation of a technology can be found in the appendix.

5.1 – AUTONOMOUS DEAD FISH COLLECTOR

One of the daily operations jobs in a salmon cage is to collect the dead fish from the bottom of the cage. This service has the objective to keep the cage clean, avoid that diseases are spreaded out, for controlling of the biomass and to identify causes of death.

Existing service/products

In today's operations an equipment with a cone shape, given the name of Mort Cone, is positioned in the bottom of the cage, as can be seen in figure 42, the dead fish sink to a big plate to be collected after. For collect the dead fish, employees have to go by boat to the cage, connect a hose in the dead fish handling equipment to the boat, start the air compressor and then the fish is sucked to the boat, in the figure 43 a photo took from a visit in a fish farm can illustrate the process.

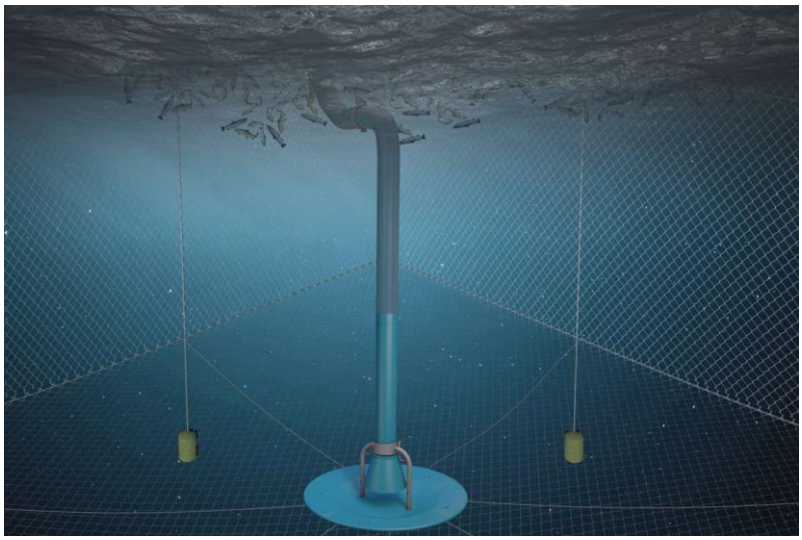


Figure 42 - Dead fish equipment (Steinsvik, 2018)

Figure 43 - Dead fish process

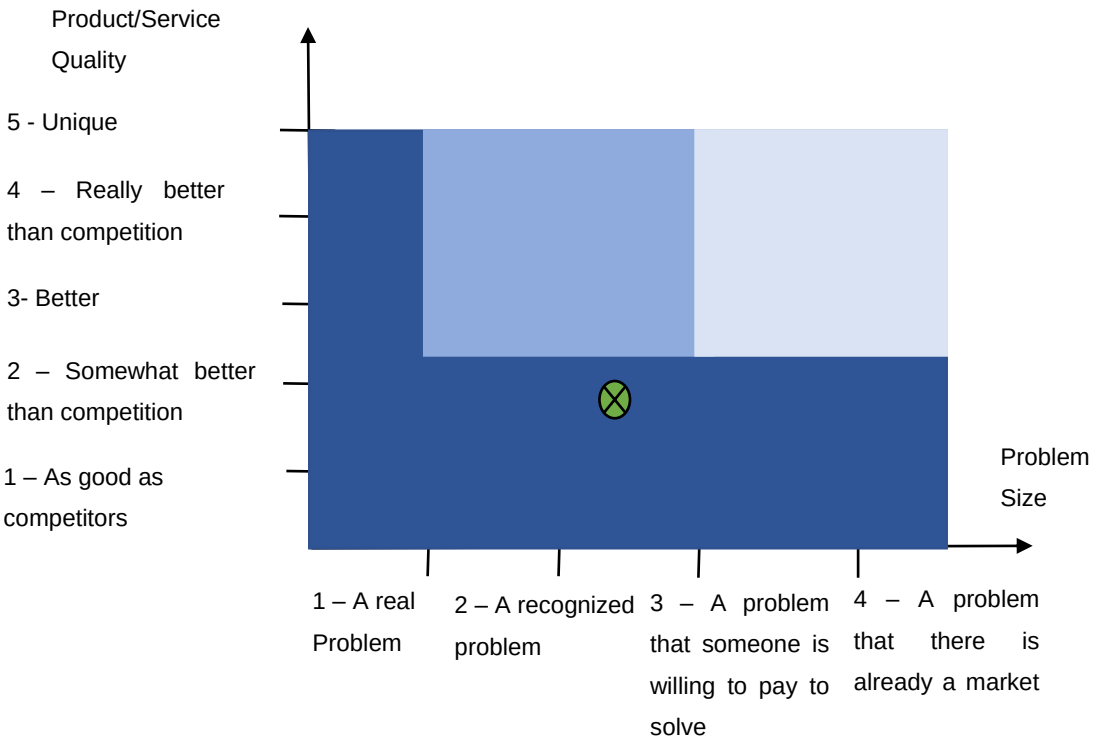
Idea Description

An idea is to replace the common boat with people by an autonomous boat, a concept that has been growing.

The autonomous boat would contain the container to storage the dead fish and would be send to the cage and connect to the hose for the dead fish system and start the air compressor. All this operation would be automatic and could be operate remotely eliminating the necessity of sending people to the cage.

Problem Solving Potential

The idea doesn’t demonstrate a huge opportunity to be accepted by the aquaculture sector, due to not solving a big issue for the farmers, and also it doesn’t change so much the current design of the dead fish handling service, so for that the idea can be classified as not a big opportunity and place in the graph in somewhat better than competition and a recognized problem.



One way of improving the product and be more in front of the competition would be the implementation of more technologies such as, computer vision, machine learning, sensors, internet of things and cloud storage to automate even more the process.

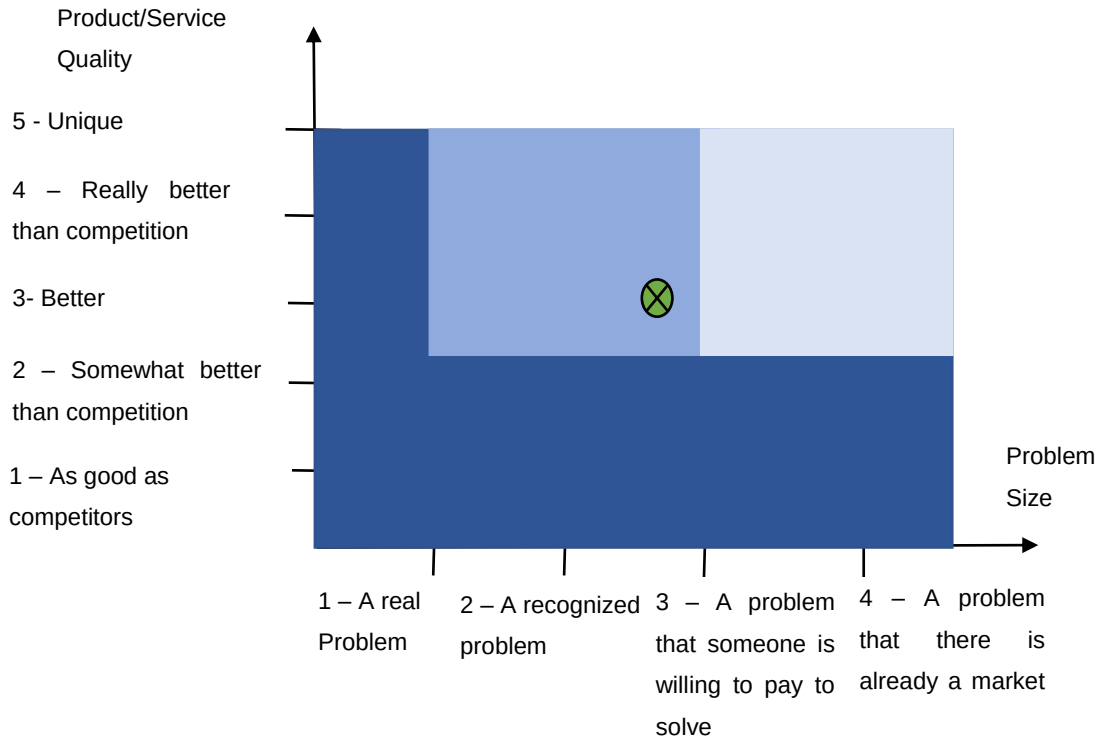
The equipment in the autonomous boat could have sensor to count how many dead fishes were collected, and with the implementation of a camera with computer vision plus an algorithm of machine learning, the cause of death would be identified. In the figures 44 and 45 can illustrate an example how the machine learning would operate.

Figure 44 - Fish dead by lice

Figure 45 - Fish dead by deformation

Together with internet of things all this data can be send to a cloud storage for remote access.

After the implementation of these technologies the product would increase the level of being better than the competition as it can be seen in the graph below.

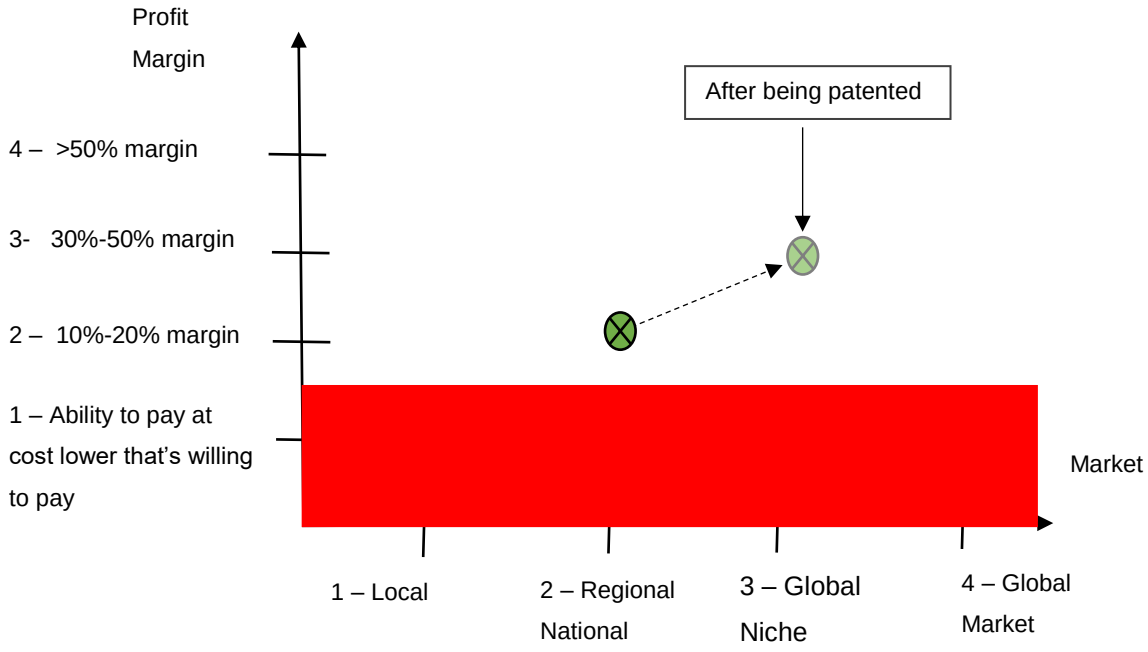


Nevertheless, the idea would have problems to be accepted because is not solving a problem that fish farmers are concern about. However, the idea of using an autonomous boat to collect the dead fish would be more accept in an offshore fish farm, but this concept is still new, having only one model in Norway for testing, research and development.

Economic Potential

Regarding to profit, the product can offer good profit margins due to the necessity of doing the dead fish handling service is a daily service, the service could be provided for farms in any location and not having the necessity of have human labour could lower cost. About the market, it would be inserted in a regional national market, such as in Norway, however the product can be protected and with the patent protection the business can go globally and be present in other regions where the presence of aquaculture is strong such as, Chile, Canada and Asia.

Therefore, the product initially would be positioned in the High margins x Low sales area in the graph, but with patent protection the product can migrate to the area High margins x High sales.



	Score
Problem Size	2.75
Economics	3.0
Total	5.75

5.2 - FIRST PERSON VIEW CAMERA FOR FEEDING AND GENERAL MONITORING

Monitoring the fishes is important to check their health and behavioral. In conjunction, the feeding process needs constant monitoring since the number of pellets given to the fishes are according with their behavioral.

Existing service/products

Nowadays the practice is quite simple, a camera is installed inside of the cage and an operator uses a screen to monitor the fishes behavioral. A real example can be seen in figure 46

Figure 46 - Monitor with different cameras view

Idea description

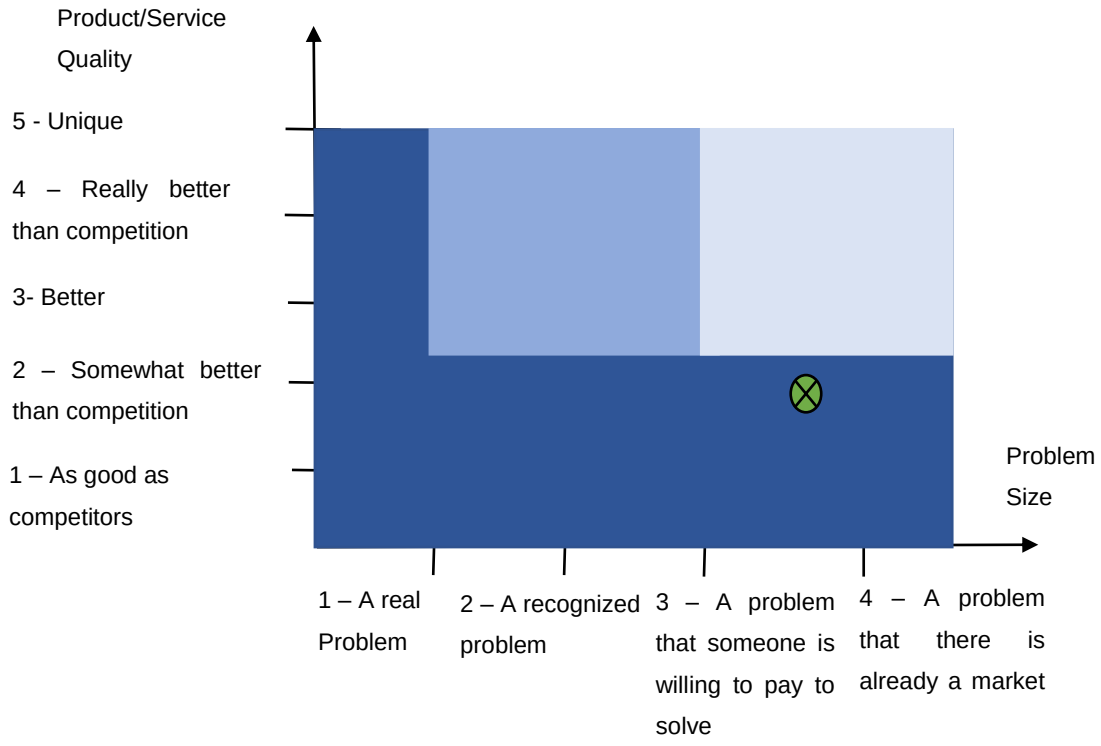
The idea is to use first person view to monitor the fishes, the idea comes from aeromodelling, which a camera is installed in the small plane and the operator use a google to see the images capture from the camera in the plane, an example can be seen in figures 47 and 48. It is expected with the introduction of the first-person view monitoring operator would have a better view, would have a better interpretation of the fish behavior and it would be a more ergonomic way to do monitoring.

Figure 47 – A person using first person view goggles (Essential RC, 2017)

Figure 48 - View from the plane and the position of the plane (Essential RC, 2017)

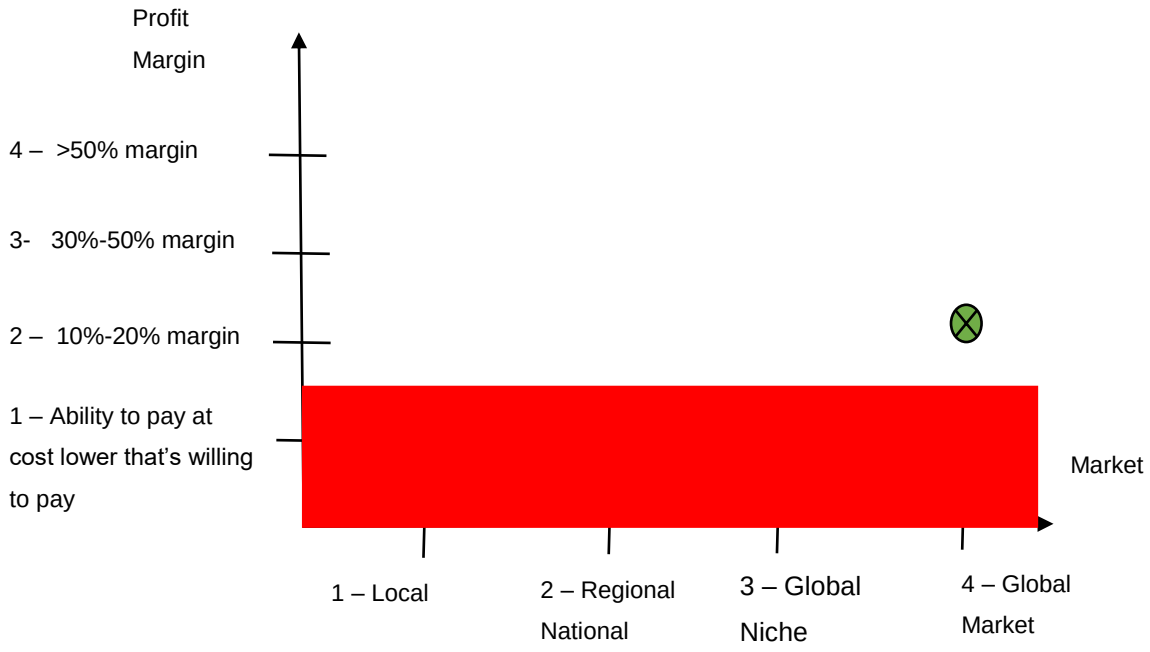
Problem Solving Potential

Fish health and feeding are big issues for salmon farming, however the idea doesn't present an enormous advantage comparing with what there is in the market today, and it also doesn't demonstrate that the farmers will have great financial return if investing in this product. Therefore, the idea is place in a not privilege part of the graph.



Economic potential

The idea of using first person view could be expand to other industries sectors, rather than only aquaculture, thus it could be place in a global market. However, the first person view technology is already common knowledge, therefore, the product would be hard to patented and consequently the profit margins wouldn't be high, placing the idea in the region High sales X Low margins and without possibility of change



Since the idea cannot be patented the scores weren't calculated.

5.3 - MANUFACTURING SPARE PARTS USING 3D PRINTING

Fish farms keep a big space in the barge for storing spare parts for different equipment's, allowing workers to change these parts in case of necessity.

Existing service/products

The figures 49,50 and 51 show the numerous parts which are storage inside of the barge.

Figure 50 - Spare Parts inside of the barge

Figure 49 - Spare Parts inside of the barge

Figure 51 - Spare Parts inside of the barge

Idea description

One solution for improve the use of the space of the barge could be an installation of a 3D printer on the barge to manufacture the spare parts on the time that they are needed. The spare parts, such as in figures 49,50 and 51 would be digitalized as a 3D drawing and with the drawing the parts would be able to be manufacture as the demanded. The figures 52 and 53 illustrate an example how to use 3D printer.

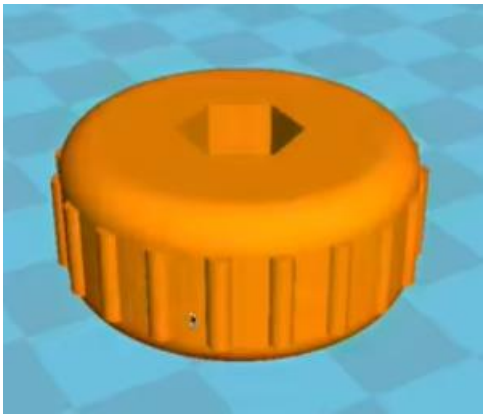


Figure 52 - 3D digital model of a small piece (I Like to make stuff, 2015)

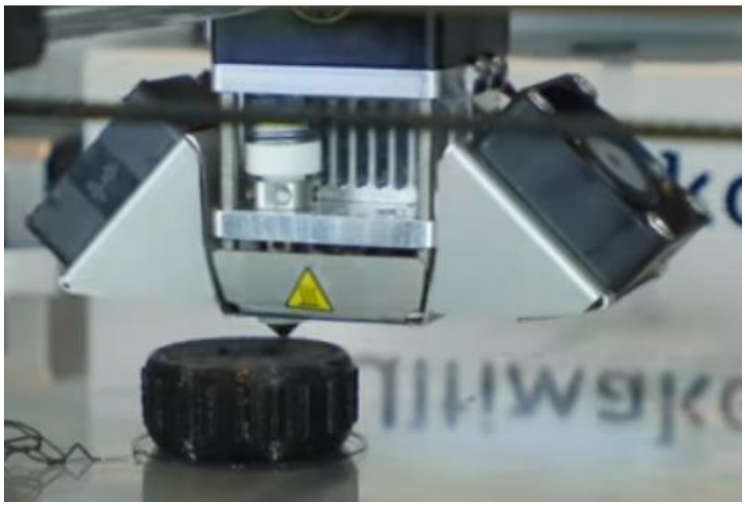
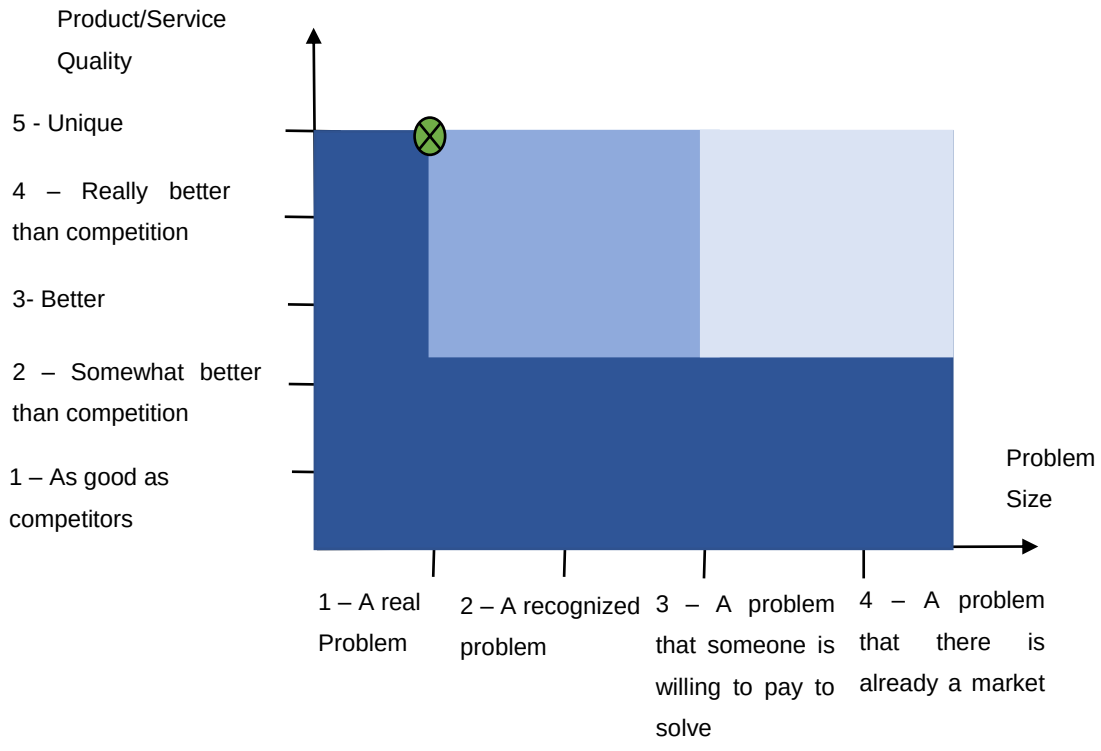


Figure 53 - The small piece manufacture by 3D printer (I Like to make stuff, 2015)

Problem Solving Potential

The 3D printer inside of the barge would make possible a design of a smaller barge, with less space for storage, which could decrease the cost of it. Another benefit using the 3D printer would be the less spending in maintenance since the spare parts would be manufactured on demand. The product would be unique in the market however, storage is not a big issue for owners of fish farms, thus the product wouldn't solve a problem which farmers are concerned.

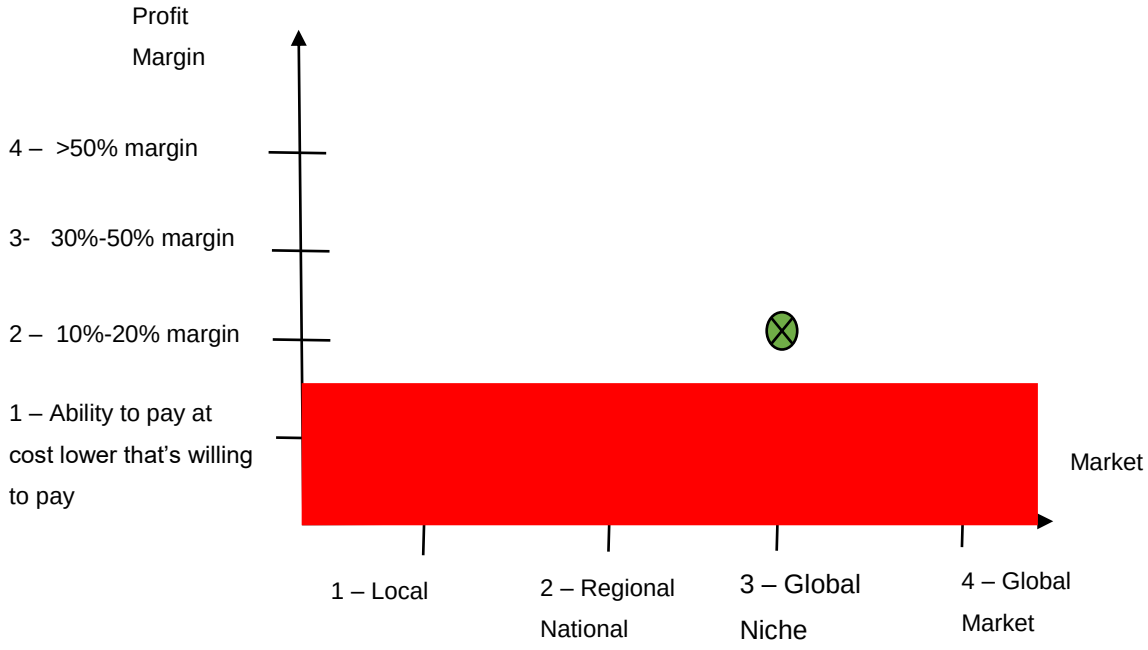


Economic potential

For this product to be launched, a partnership with a company that manufacture equipment's for salmon farm would be required for the technical information's of the equipment's parts, so the market of the 3D printer for fish farm would be dependent of the company's market, for that we can assume a global niche market.

Although the products of the supposed partner company have the possibility to be protected, the 3D print concept for fish farm cannot. Therefore, the idea of using 3D printing for spare parts can be adopted by companies that manufacture fish farm equipment's or other partnerships could be make, thus the 3D printer product could go against a great competition.

Assuming a global niche market but, knowing that the 3D printer is a worldwide know, there is the possibility of big competition reflecting that on the profit margins. Therefore, the product is placed as High sales X Low margins.



Since the idea cannot be patented the scores weren't calculated.

5.4 – BIOMASS ESTIMATION USING COMPUTER VISION AND MACHINE LEARNING

Biomass estimation is important because this is how to know the total amount of weight of fish inside of the pen, and with that we have information about the development of the salmon, like how much the fish grow and how much until reach the market size, and of course knowing the weight it also can estimated the value of the harvest. Another reason

for the biomass estimation is related to licenses that governments give to the farmers. The licenses demand a maximum allow biomass to avoid disrupt the environment, so farmers must respect this limit, or they can be punished by the government.

Existing service/products

Nowadays the methods to measure the biomass are very poor, with very low accuracy. Some farms measure the biomass by collecting a sample of 200 fishes and measure their size by using a ruler and then with an equation the biomass is calculated.

Other method used is a camera that is introduce inside of the pen and take pictures of the fishes, and with the use of a software you can calculate the biomass, but for that the fish must be in a perfect position in the picture and then mark the size limits of the fish, figure 54 illustrated the process.

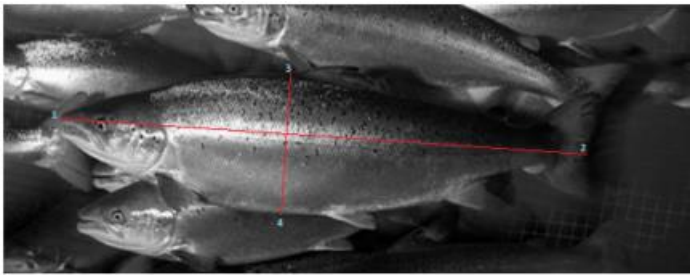


Figure 54 - Fish being measuring (Akvagroup, 2015)

This method presents constrains such as, taking many pictures and then selecte the ones which have a good view of the fish, to mark the size limits of the fish is manually and must be done many times to have a good sample to calculate the biomass, so this methods takes a lot time to be concluded.

Idea description

To have a better result for the biomass the idea is to use computer vision and machine learning. For that a product would be develop with a cylinder shape with cameras inside, one in the top and other in the side. The figure 55 below illustrates the product.

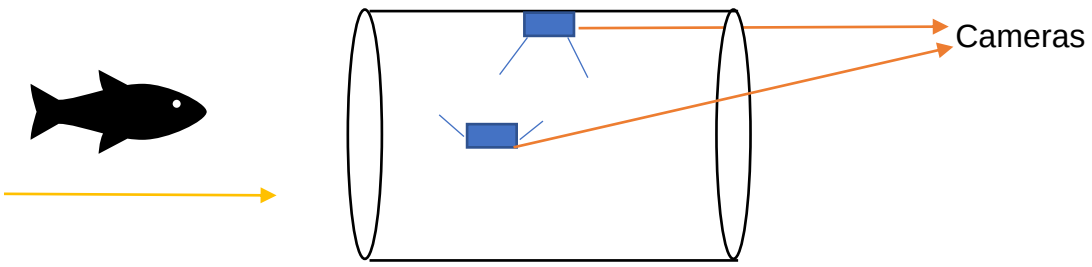


Figure 55 - Illustration of the biomass estimation using machine learning and computer vision

The cameras with machine learning would recognize the fish and with the computer vision the length and the width of the fish would be measured, figures 56 and 57 illustrate the idea, and with this data the biomass would be calculated, digitalizing the whole process.

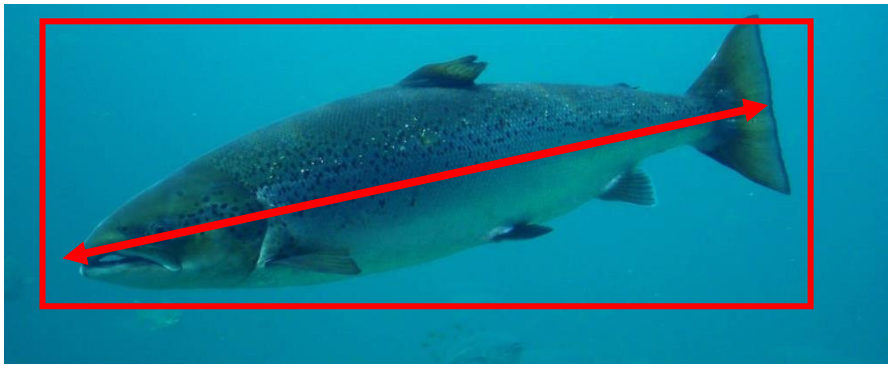
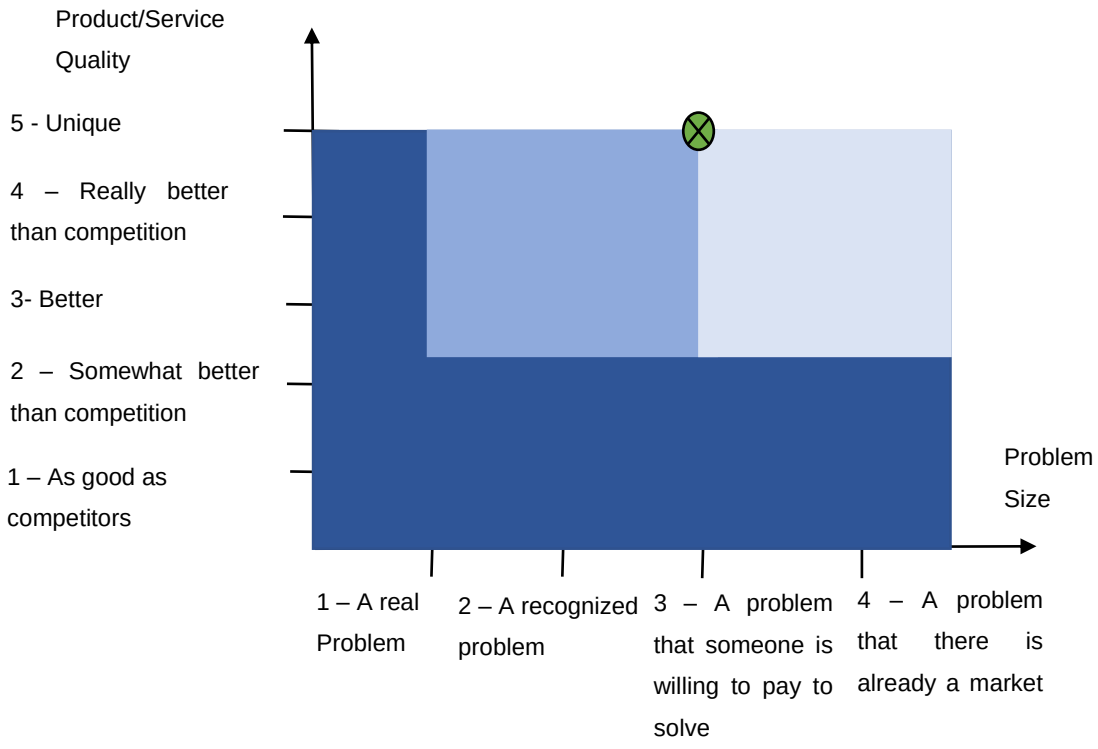


Figure 56 - Measuring vertically the fish (CBC News, 2018)

Figure 57 - Measuring horizontally the fish (CBC News, 2017)

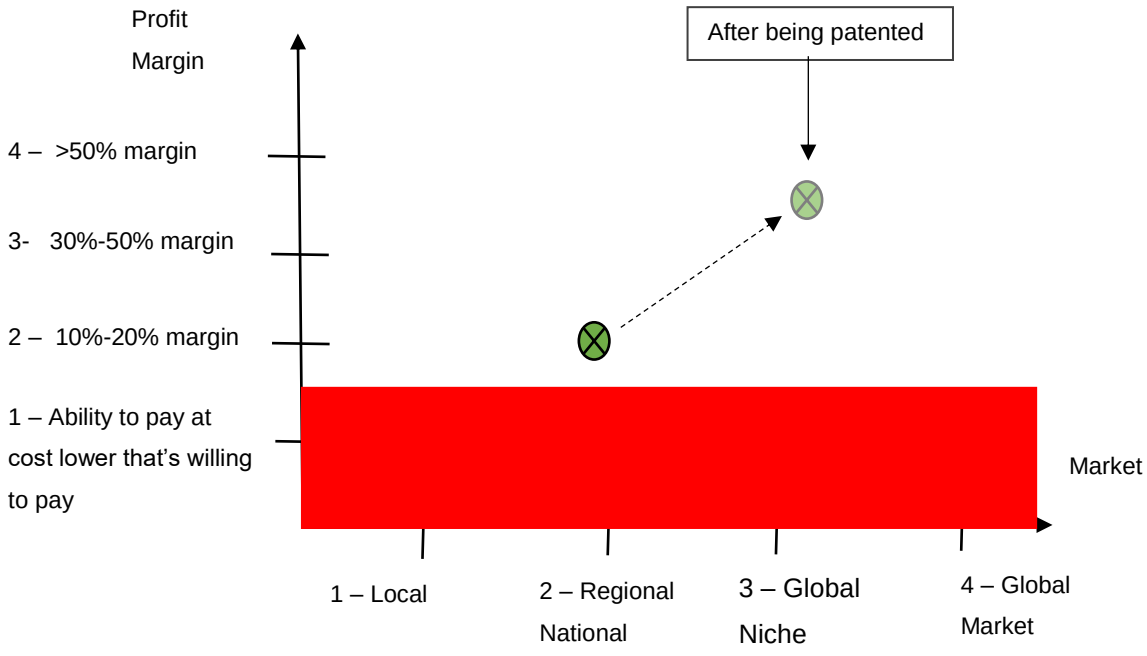
Problem Solving Potential

It is important to measure the biomass and the methods used in todays are very inaccurate and they take a lot of time to be concluded. Therefore, the product presents a large advantage comparing to the current methods placing the product in a privilege region in the graph.



Economic potential

Since the product presents great advantages and a simple design it can be considered that the profit margins would be high and can have a great presence in a regional market. The product can be patented so it can be introduced in a global niche market, placing the product in the region of High sales X High profits.



	Score
Problem Size	4.0
Economics	3.25
Total	7.25

5.5 – INTERNET OF THINGS FOR BIOMASS ESTIMATION

Another method to calculate the biomass or perhaps a method which could give a base to compare results could be create by collecting data from different services, which can be related to biomass and with internet of things all this data could be storage in the same place to calculate the biomass.

Existing service/products

The information is the same as in the item 5.4

Idea description

The idea is to use a software to calculate the biomass, collecting data from feeding, dead fish and weather conditions. The quantity of pellets that are consume and the kind of pellets used, are related to the size of the fish, more pellets and bigger pellets consumed means the fish are growing. Collecting the dead fish would update the number of fishes inside of the pen. The environment is a great influencer of the growing of the salmon, specially temperature, so it is important to collect data from the environmental sensors. With the IoT all this data is integrated to a software and calculate the biomass estimation. The figure 58 demonstrates the idea by showing which data is collected and from where until calculate the biomass.

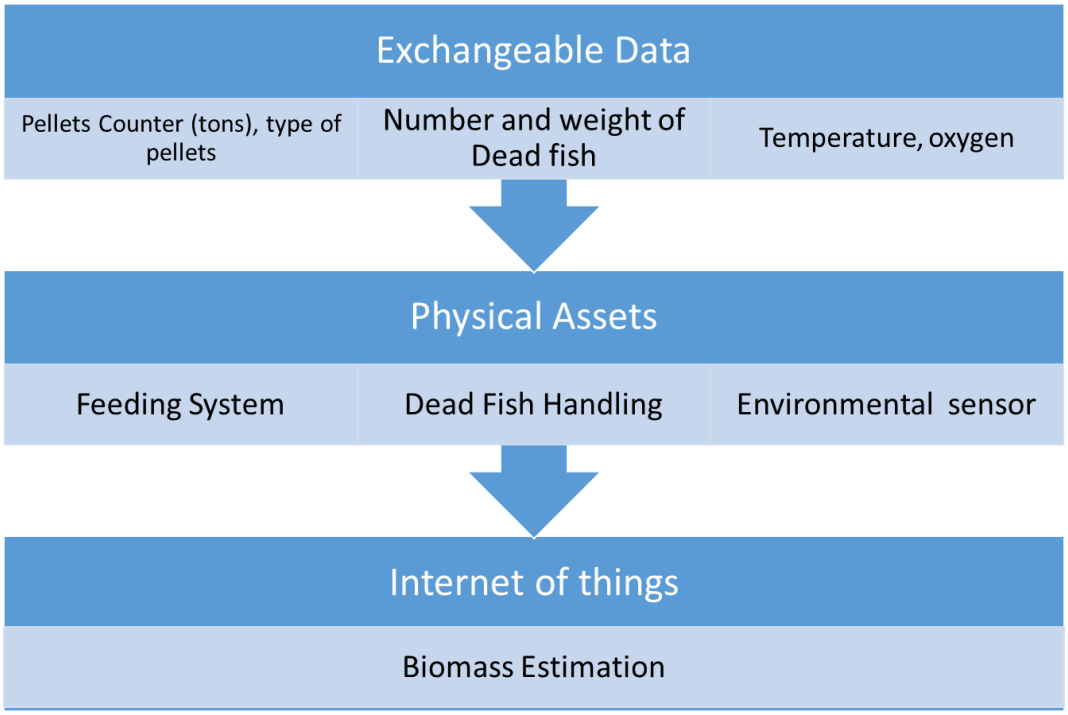
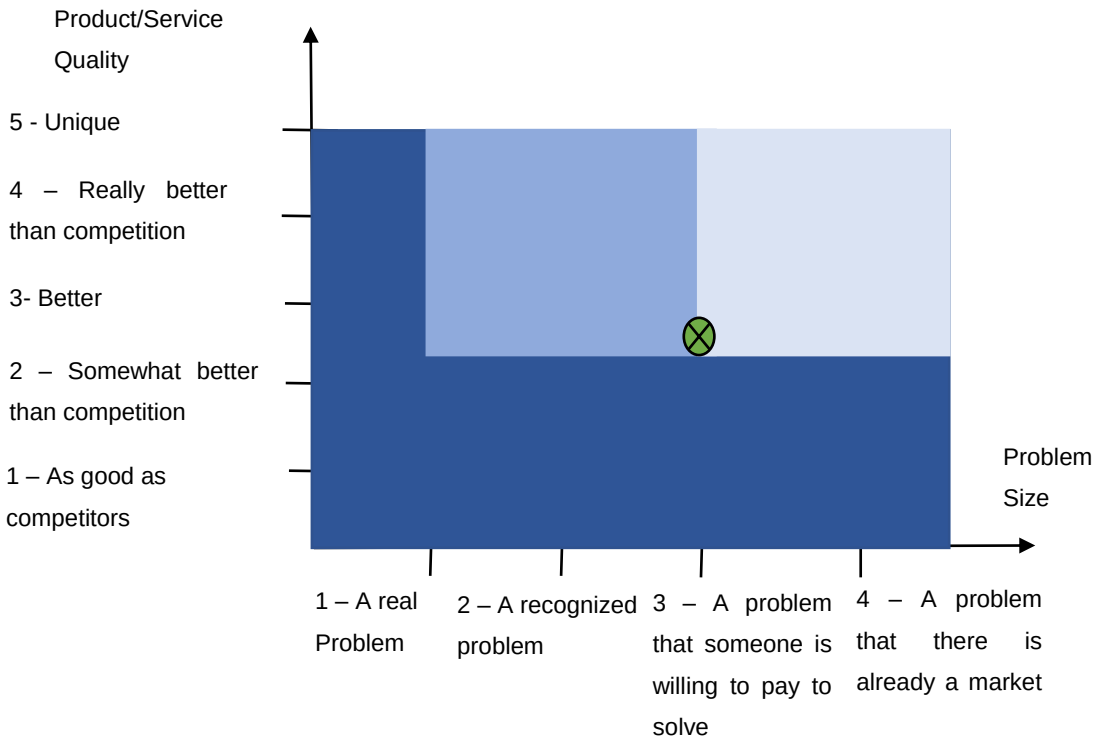


Figure 58 - Necessary data to calculate the Biomass Estimation with the software

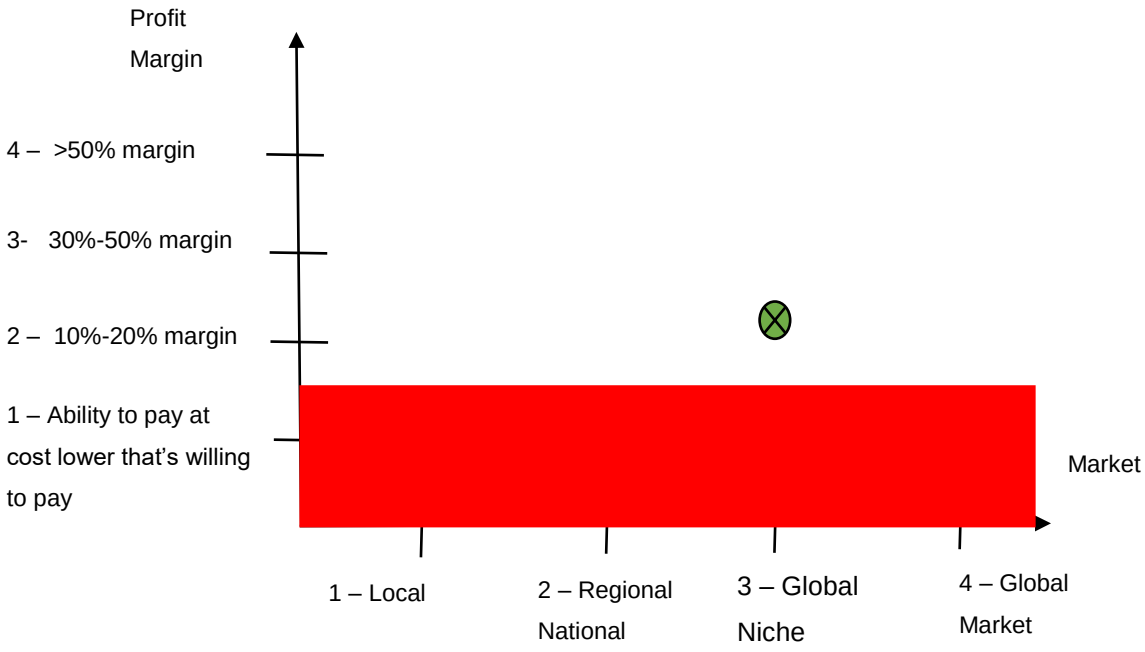
Problem Solving Potential

The idea could take place of the todays methods, digitalizing the process of calculating the biomass, saving a lot of time and money however, the software needs an algorithm for the calculation, and the algorithm needs to be well developed to correspond well the salmon growing process, and that can be a difficulty for the idea, making it not so better than the actual methods.



Economic potential

Considering the idea of using a software, the commercialization can be easy, so it could be introduced as in global niche, the costs very low and charging the customers to have a license the margin profits can be good. However, a software is hard to be protected so competition can come with similar ones decreasing sales placing the idea in Low sales X High profit.



As cannot guarantee that the idea can be protected the score is not calculated.

5.6 – INTERNET OF THINGS FOR CLEANING THE NET

One of the services involved in salmon farming, is cleaning the nets, as it can be seen in figure 59 the net can be very dirty and the consequence for that is the drop of level of oxygen which is bad for the fish health and also can increase the weight of the cage structure what can cause damage on it.

Figure 59 - Net full of mussels (April Bencze, 2017)

Existing service/products

For cleaning the net, farmers contract services for that, the service of cleaning the net can be realized by using divers as in figure 61 or using a machine like a ROV, which is the most common way nowadays, the figure 60 shows a model of this machine. Both methods use the same idea of using a wet jet to blow the dirtiness from the net.

Figure 61 - Diver cleaning the net (Cavitcleaner, 2017)

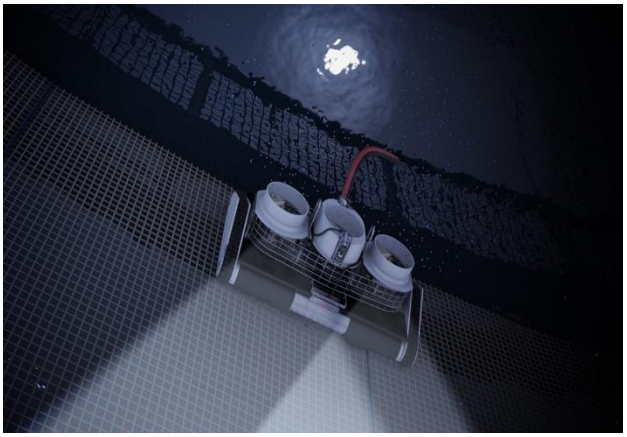


Figure 60 - Machine to clean the net (Yanmar, 2016)

Idea description

The idea is not replaced these methods but to support farmers to have a better plan for when is necessary to clean the net by using data collection and internet of things. The idea is similar with the idea from the item 5.5, collecting the data that influenced in the dirtiness of the net and use a software for better clean maintenance. The figure 62 describes the data to be collect, such as the quantity of pellets since some pellets are wasted and it can pollute the environment, from biomass the important data comes from the size and quantity because of the fish feces, so more and bigger the fish more feces are produced, data such as current movements is important since the current can transport dirty to the cage, and most important the oxygen level. All this data would be collected and integrated by using internet of thing to a software that can predict with an algorithm when the net should be clean.

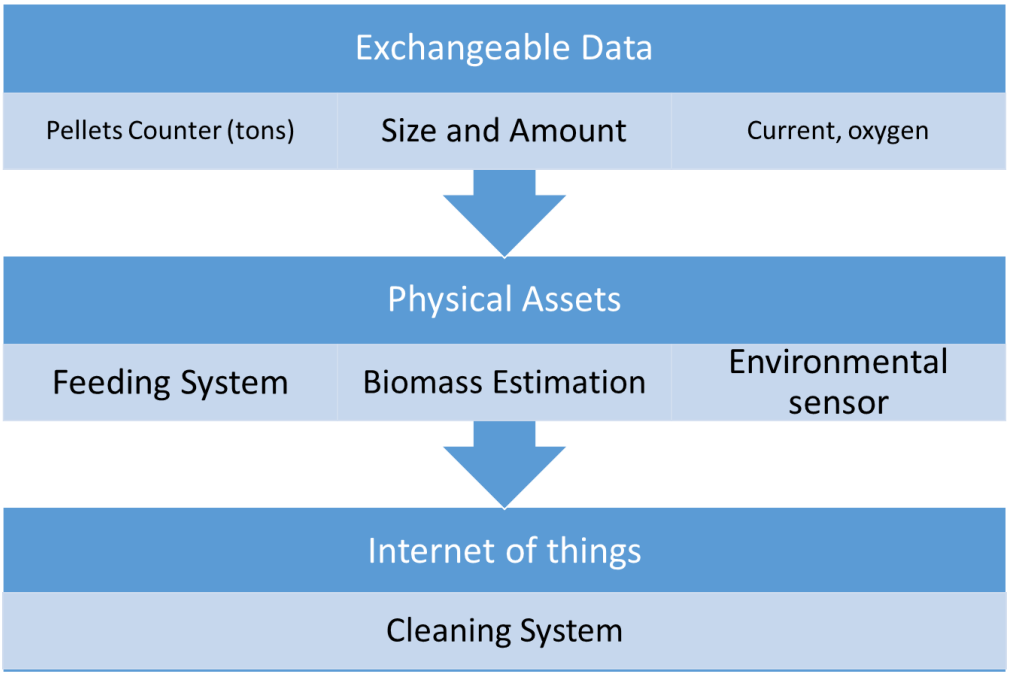
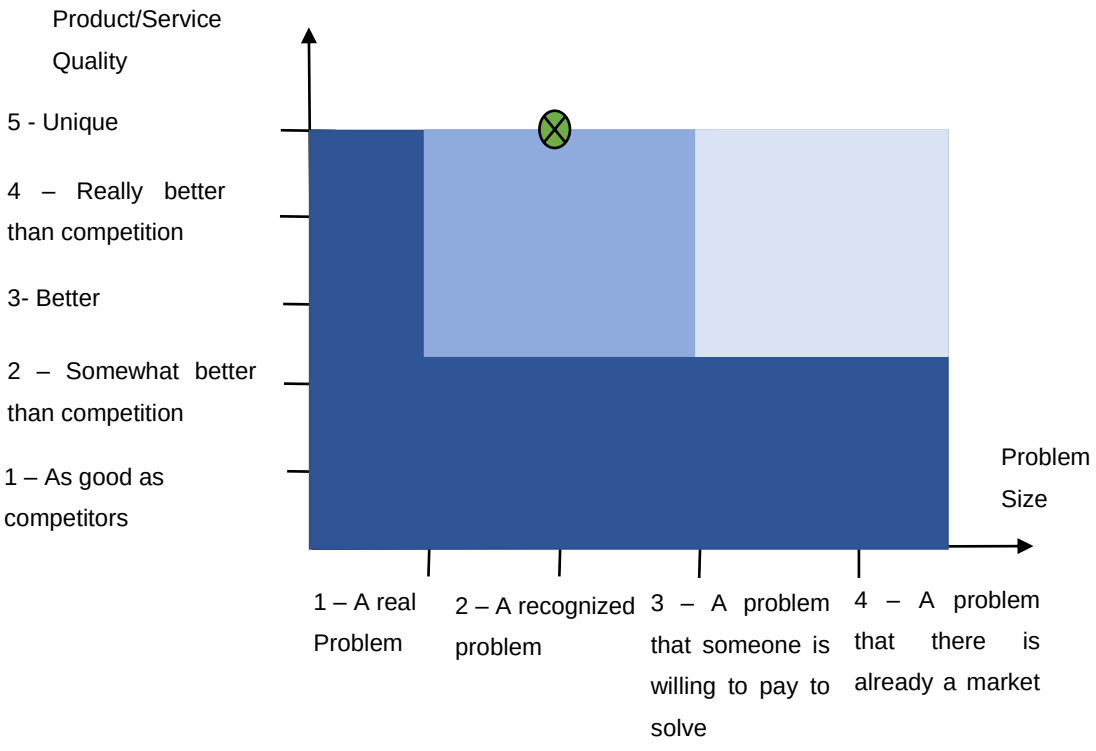


Figure 62 - Necessary data to calculate preventive cleaning with the software

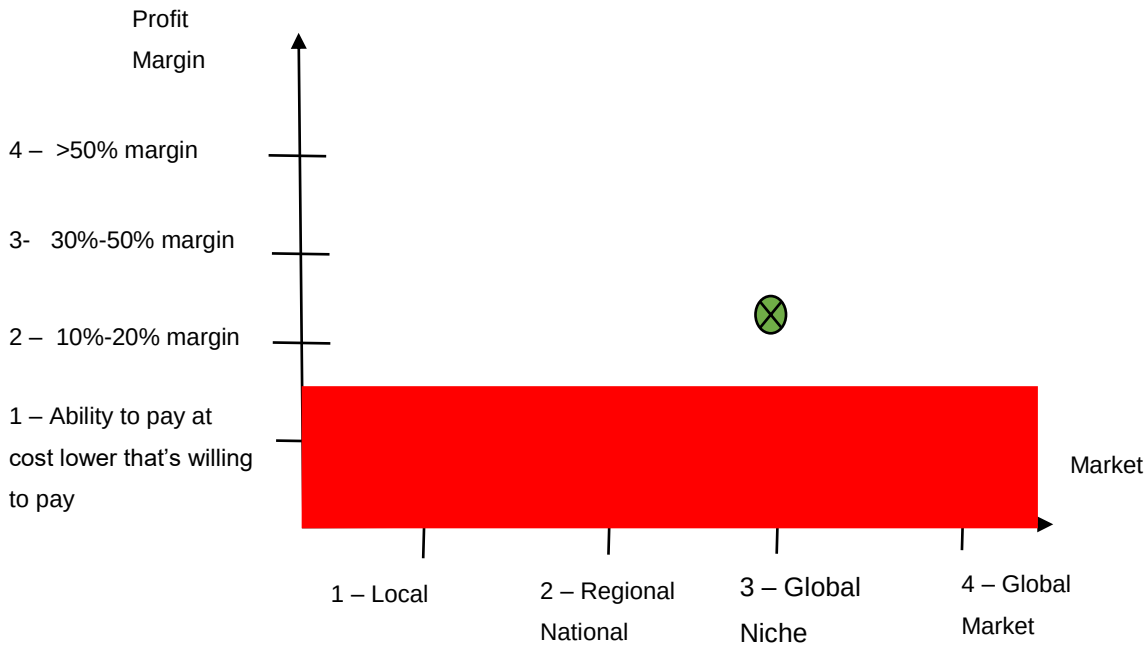
Problem Solving Potential

The idea is not solving a cleaning issue, but it could help for maintain the fish with a good health since cleaning the net is one of the factors that influenced on it, and also avoid damages in the cage structure due to the dirty increase the weight of it. Therefore, the idea can be considered as unique, but it is not solving a big issue for farmers.



Economic potential

In an economical point of view can be use the same thought as in item 5.5, the software can be easily commercialized, but hard to be protected, so competition can increase over the years. So, the idea would be placed as High sales X Low profit.



As cannot guarantee that the idea can be protected the score is not calculated.

5.7 – CAMERA FEEDING USING COMPUTER VISION AND MACHINE LEARNING

One of the criteria's that control the feeding is the movements of the fish. When the fishes are more agitated and move fast means that the fishes are hungry and when they start to slow down means they are starting to be satisfied.

Existing service/products

For now, the control of the movement of the salmon is supervised by a human operator by looking monitors such as in the figure 63 with images provided by cameras inside of the cage.

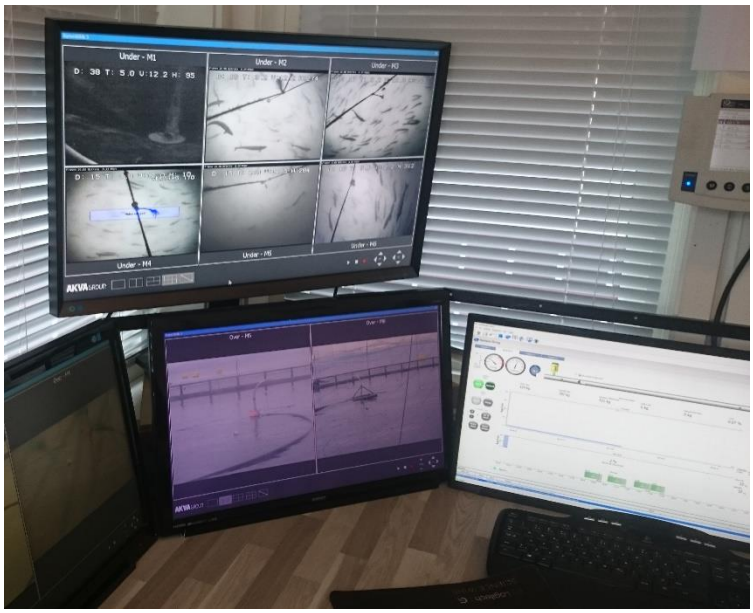


Figure 63 - Monitoring the fish nowadays

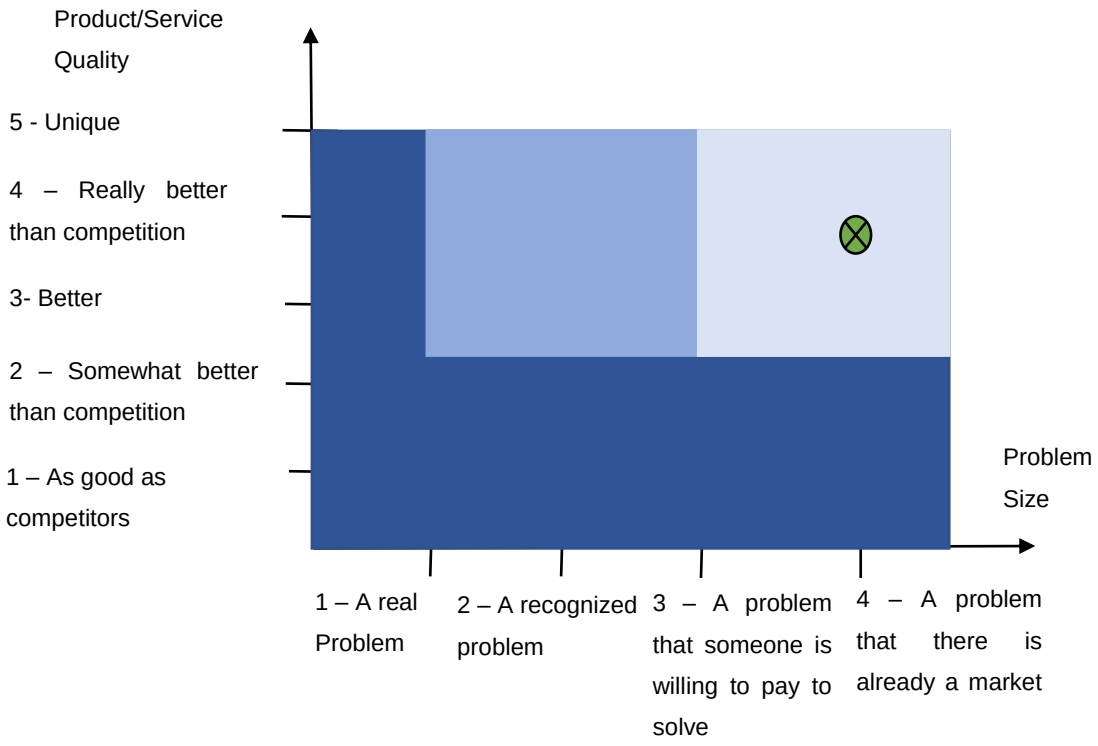
Idea description

The idea is to use the technologies computer vison and machine learning to digitalize the process. The camera with computer vision could read the speed of the fishes, similar to use for identifying the speed of a car like in the figure 64, and with this data import in a machine learning algorithm would support finding patterns of the salmon movements and then finding an optimal feeding quantity based on the fish movements.

Figure 64 - Measuring speed of vehicles with computer vision (Janaka Liyanage, 2008)

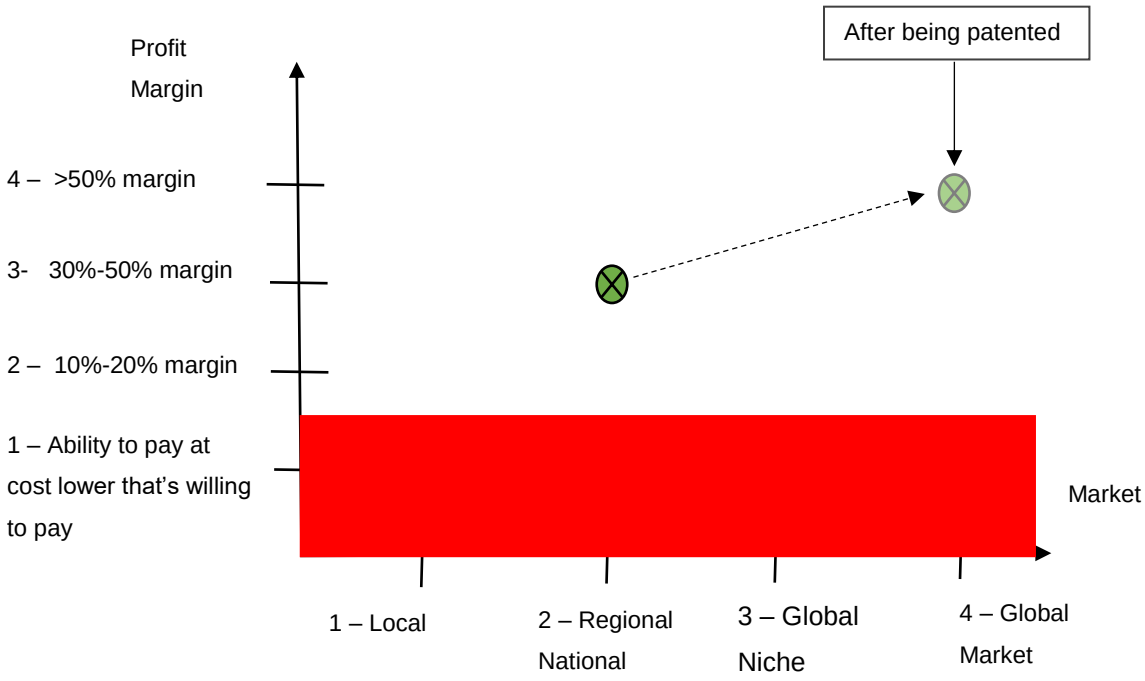
Problem Solving Potential

Since the feeding concentrates from 50 to 70 percent of the cost production in salmon farming (Partos, 2010), is in an important issue for the farmers. Therefore, it already brings the product to a big importance. The product digitalizes the feeding process, making possible to standardize, then decreasing the waste of food and saving more money.



Economic potential

The product could take the lead in the competition if proved that can eliminate waste of food and saving costs. The product can be patented so, it can be sold in in a global market with none or a few competitors, placing the idea as High sales X High profits.



	Score
Problem Size	4.0
Economics	4.0
Total	8.0

5.8 – ULTRAVIOLET LIGHT FOR TREATING LICE

Lice disease is the biggest problem in salmon aquaculture at the moment and the existing treatments are not enough yet to solve this problem. The lice get stick on the fish like in figure 65 and if it is not treat cause the death of the fish. Another issue of lice is that it spreads very fast which could damage the whole harvest.

Figure 65 - Salmon lice (Pål Mugaas Jensen, 2016)

Existing service/products

In todays practice, the most common is to use a machine for treating lice on the fish. The machine uses thermal treatment since the lice have a low tolerance for sudden changes in water temperature. The process works with the fish passing through the system and bathed in lukewarm water. This temperature change kills the sea lice and the salmon are released back into the pen. The figure 66 illustrates the process.

1. Fish enters the system
2. Water separation
3. Sea water is filtered and released
4. Fish passes through warmer 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 into the system for re- use

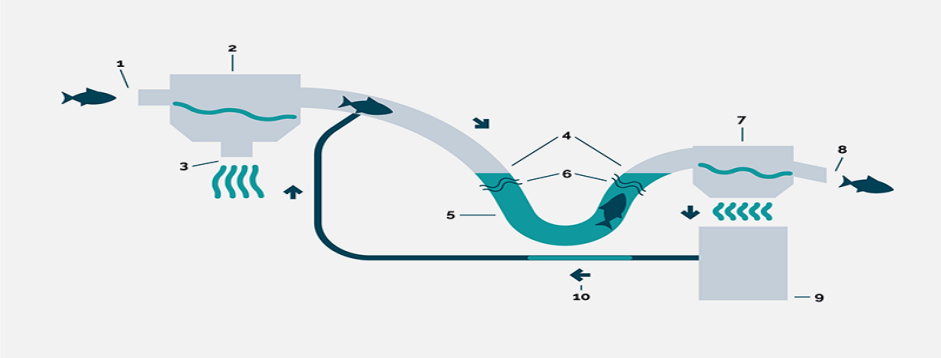


Figure 66 - Thermal method to treat lice (Global Salmon Initiative, 2018)

Despite of the method has 95% rate of killing the lice according with Marine Harvest, 2016 the treatment has its negative points as having ah chance of killing the fish instead of improving its health. One case in Scotland where more than 175,000 salmon died when the water they were swimming in was overheated, cost millions of pounds and led to over 600 tons of dead salmon having to be incinerated.

The lice treatment is a service offered by some companies. Some companies also have products to lice treatment, one example is the use of lasers to kill lice. A very interesting product is one that can identify lice and automatically shot a laser in the lice, killing it. The figure 67 illustrates the product.

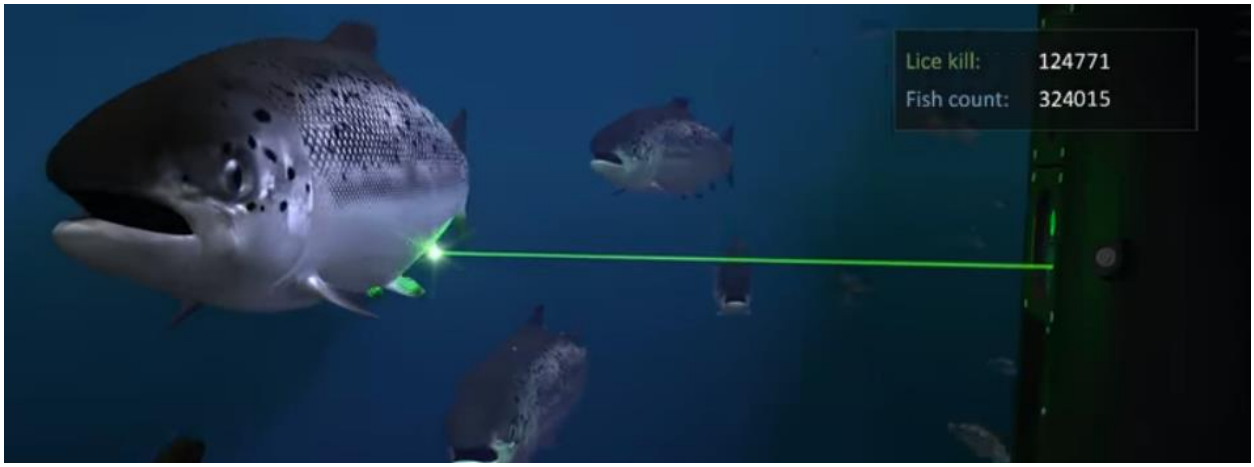


Figure 67 - Laser treatment for salmon lice (Stingray, 2017)

Idea description

The idea is to use the thermal concept but in a less stress way for the fish. Using ultraviolet light to increase the temperature, the lights would be installed in a cylinder. The light would attract the fish to go inside and the difference of temperature caused by the lights inside would kill the lice and the skin of the fish would protect it thanks to the skin reflections properties. The figure 68 illustrates the idea.

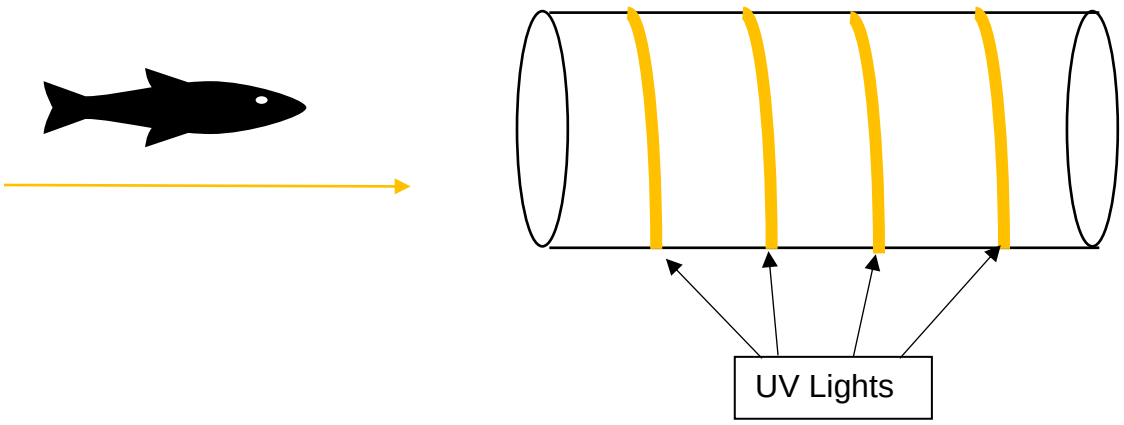
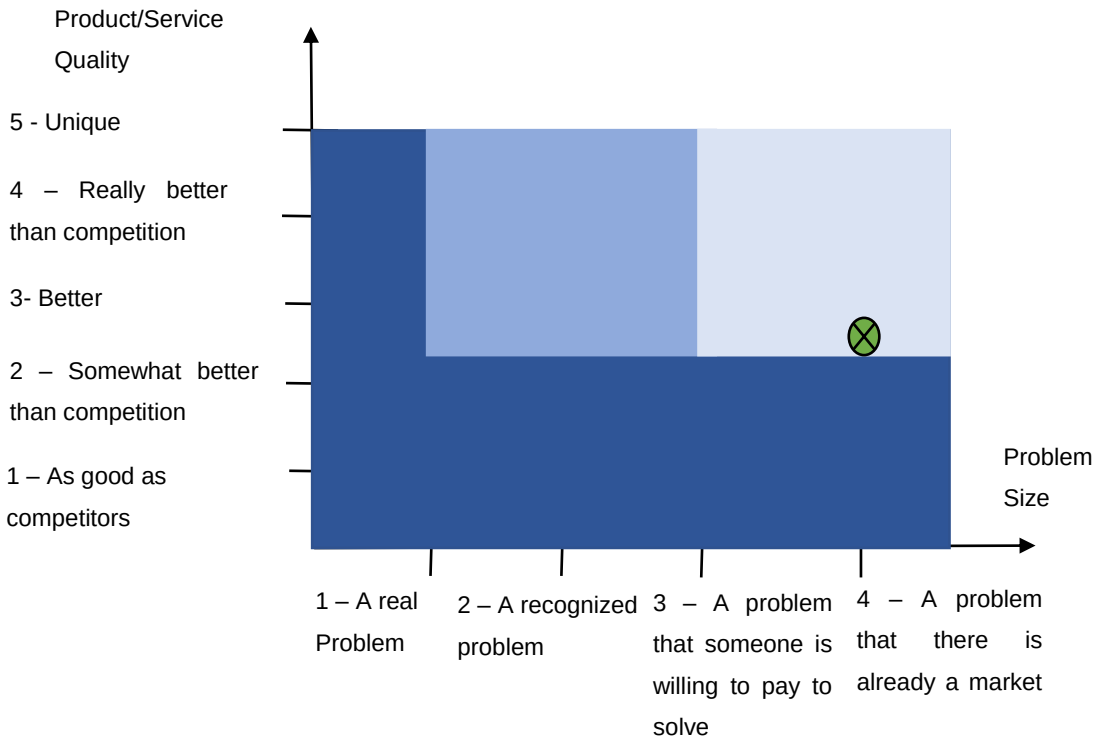


Figure 68 - Illustration of the idea to use UV lights for lice treatment

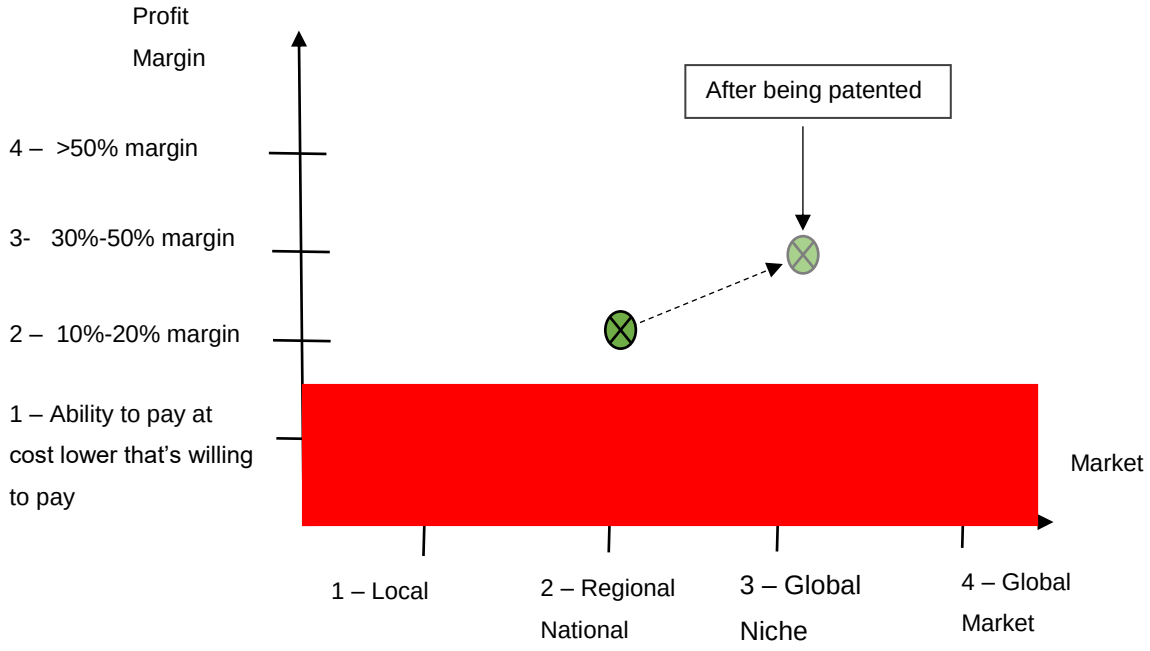
Problem Solving Potential

As lice is a big problem for aquaculture right now the product could be well accepted in the market, although a lot of research would need be done and check the results to see if it really solves lice problems. Assuming that the product has similar results to the competition the product has advantages comparing to its simplicity what can be reflect in the price.



Economic potential

Having good results would make the product competitive in the market, due to the low cost for manufacturing and for operation plus lice treatment a big issue the profit can be high. The product being patented can be launched in the global niche.



	Score
Problem Size	3.25
Economics	3.0
Total	6.25

5.9 – SENSORS FOR FISH SCAPE

One of the concerns that fish farmers have is when there is fish escape. Fishing escape is a problem because the fish is the value for the farmers so if fish escapes money is lost, and it can be bad for the environment due to mixing of wild salmon with captive salmon.

Existing service/products

There is not service or product to avoid fish escape, what farmers do is to monitor their fish and installations daily, the site managers are obliged to have the necessary knowledge to prevent, detect and limit escapes and the development of risk assessments to minimize the risk of escapes. Despite all the planning to avoid it still can happen and when it happens is hard to identify and rescue the escaped salmon. It cost money to

rescue fish, some of the fish can be caught by fishermen and then farmers pay to have it back.

Idea description

The idea is to help on identify when there is a fish escape, by using flexible sensor, such as in the figure 69 on the fish and place a buoy with a sonar transmitter and receptor and with an antenna some kilometers away from the cage. In case of escape the sensor on the fish would receive a signal from the buoy and send it back to the buoy and the antenna would transmit a signal saying that a fish has escaped. The figure 70 illustrate the idea.

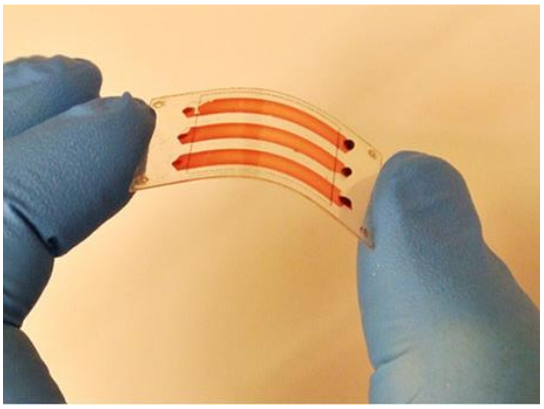


Figure 69 - Flexible sensor (Medgadget, 2015)

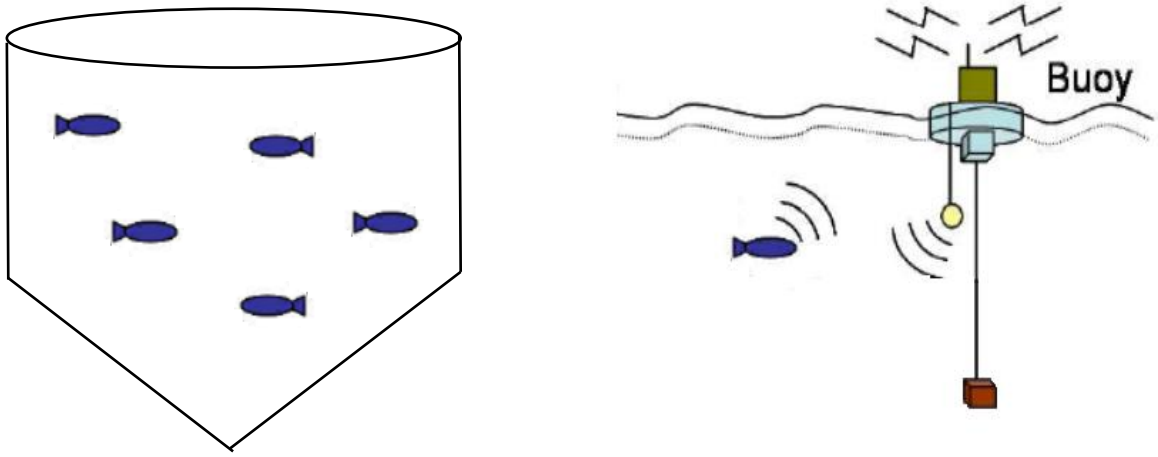
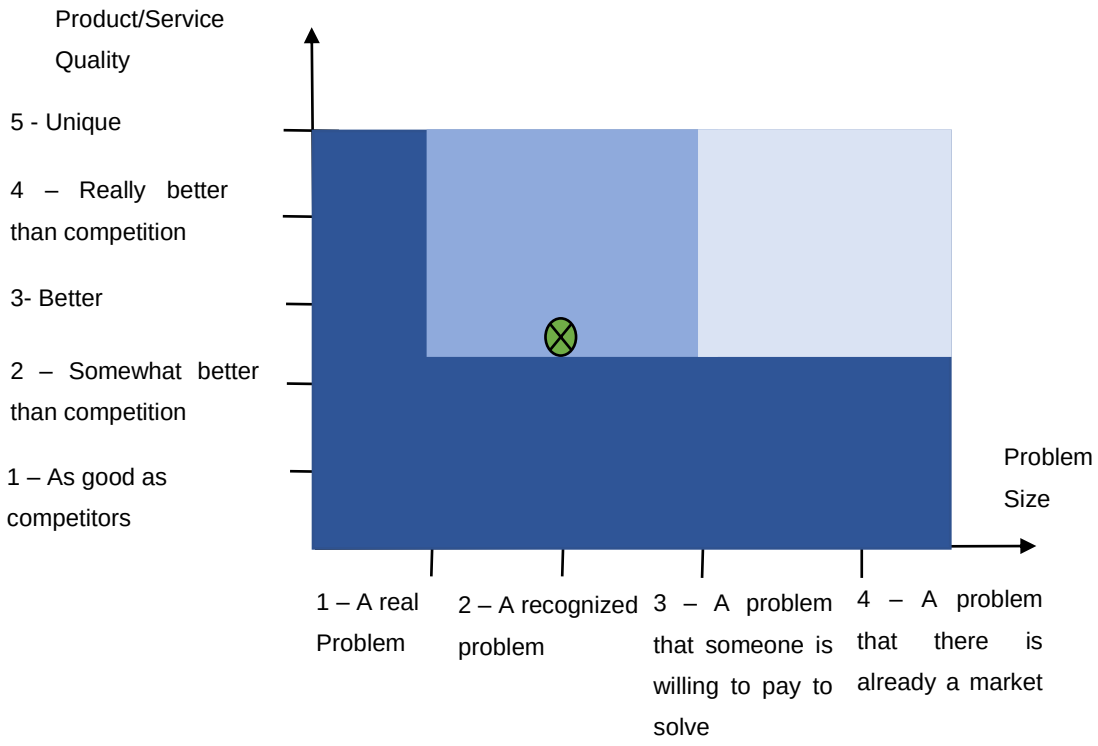


Figure 70 - Illustration of the idea to identify when there is a fish escape

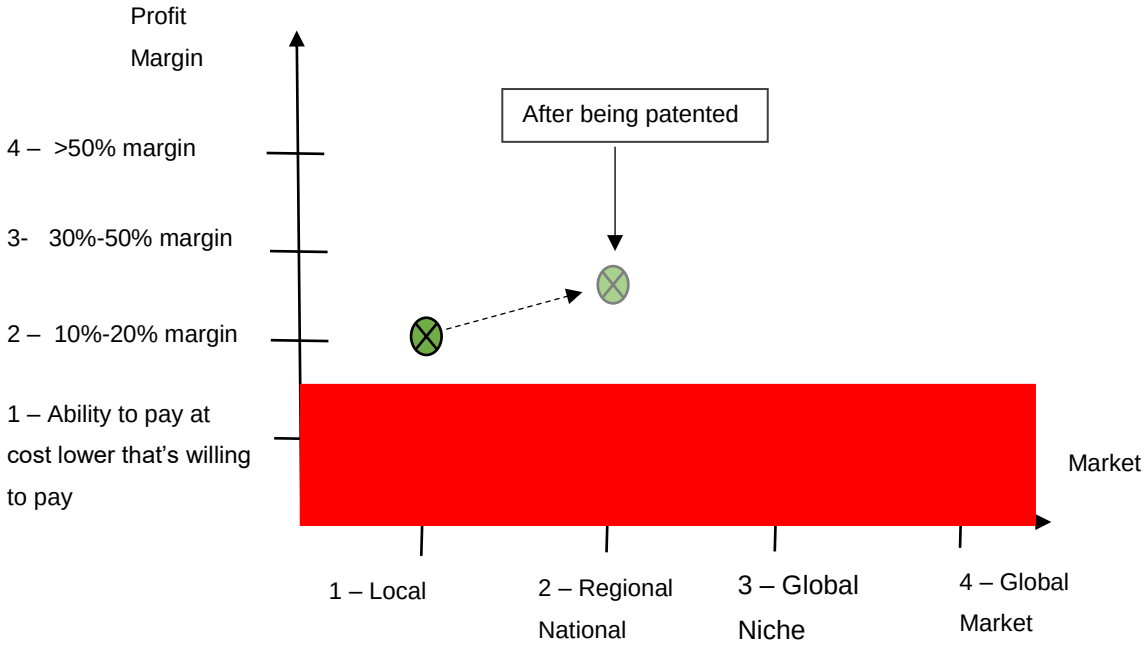
Problem Solving Potential

As there is no product or services with the same objective of the product presented, it wouldn't have competition, however the trick part of the idea is to put the flexible sensor in every fish what could be a very hard procedure, but after that the operation would be very simple.



Economic potential

Sensors manufacture are become cheaper, the operation costs are low but the process to put the sensor in the fish, probably a machine would be necessary and then increasing the costs for the product. The sensor technology and the method to put the sensor on the fish could be patented and protect allowing the product to be expanded in the market.



	Score
Problem Size	2.25
Economics	2.25
Total	4.5

5.10 – IDEAS RANKING

All the ideas now are presented, and the table below shows the ranking of the ideas based on the score of each idea and if they can be patented.

Ideas	Score
CAMERA FEEDING USING COMPUTER VISION AND MACHINE LEARNING	8.0
BIOMASS ESTIMATION USING COMPUTER VISION AND MACHINE LEARNING	7.25
AUTONOMOUS DEAD FISH COLLECTOR	5.75
SENSORS FOR FISH SCAPE	4.5
INTERNET OF THINGS FOR BIOMASS ESTIMATION	NOT PATENTABLE
INTERNET OF THINGS FOR CLEANING THE NET	NOT PATENTABLE
MANUFACTURING SPARE PARTS USING 3D PRINTING	NOT PATENTABLE
FIRST PERSON VIEW CAMERA FOR FEEDING AND GENERAL MONITORING	NOT PATENTABLE

The only two ideas that are patentable and achieved a score of more than 6.5 were:

- Biomass Estimation Using Computer Vision and Machine Learning
- Camera Feeding Using Computer Vision and Machine Learning

Therefore, these two ideas have potential for develop a business, and for that a business model will be present in the next chapter for the ideas.

6 – BUSINESS DEVELOPMENT

In this chapter business propositions will be developed for the ideas which passed through the screening. For developing the business, the Business Model Canvas will be used. The figure 71 is a diagram of the Business Model Canvas.

A business model describes how a company creates, delivers and captures value. The Business Model Canvas, is a visual representation of business models, generally used by strategic managers. The Canvas provides a holistic view of the business as a whole.

The Business Model Canvas categorizes the processes and internal activities of a business into 9 separate categories, each representing a building block in the creation of the product or service. These categories represent the four major aspects of a business; customers, offer, infrastructure, as well as financial viability (Martin, 2015). The 9 blocks are:

- Customer Segments
- Customers Relationships
- Channels
- Key activities
- Key Resources
- Key Partners
- Value Proposition
- Cost Structure
- Revenue Streams

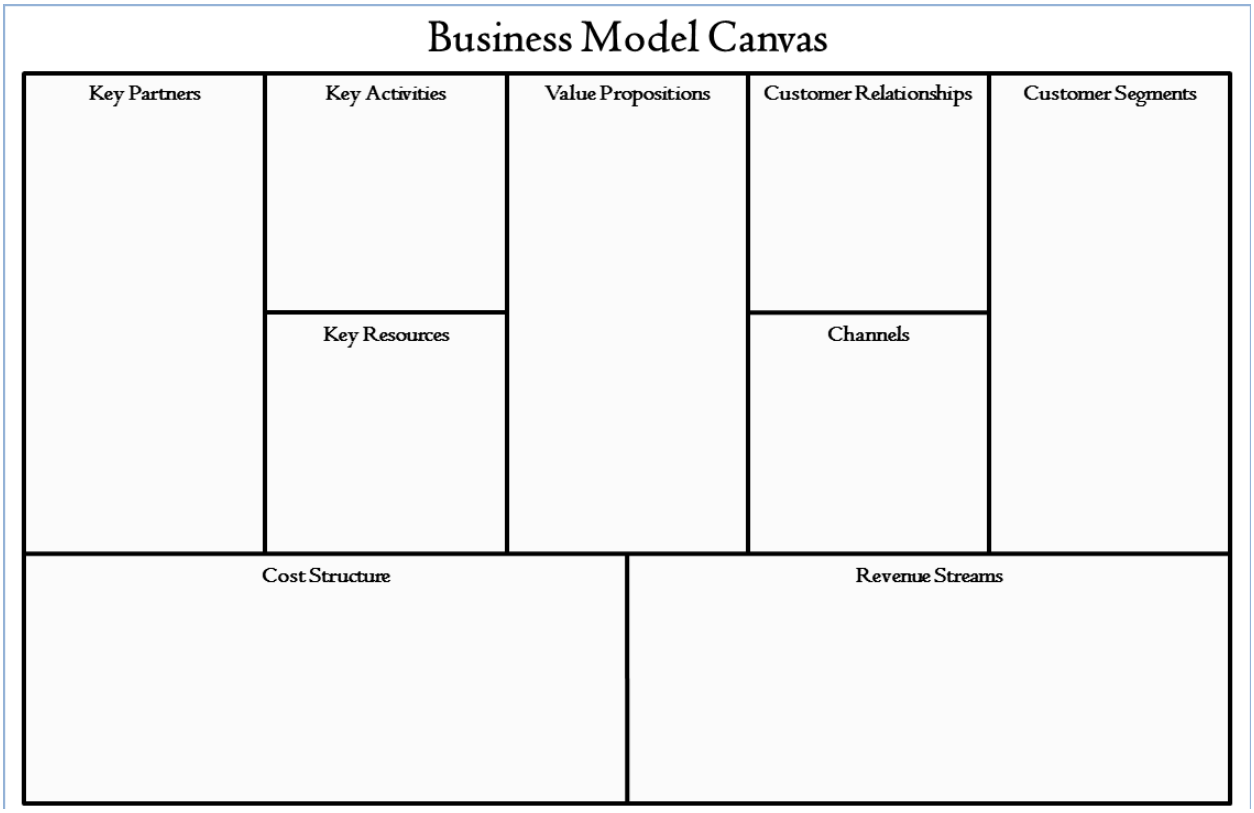


Figure 71 - Business Model Canvas Template (Jonathan Sandling, 2014)

6.1 – BUSINESS MODEL CANVAS FOR BIOMASS ESTIMATION USING COMPUTER VISION AND MACHINE LEARNING

Customer Segments

The customers for the product would be salmon farmers who want to know the growth development and the value of the harvest, and the government for inspection due to the biomass limited in according with the license given to the farmers.

Value Propositions

The product will calculate the biomass with high accuracy, automatically, reducing human labour, faster and low cost.

Channels

The channels which will be used to reach the customers will be website, advertisement in technology websites or magazines and be part of aquaculture conventions.

Customer Relationships

The company can relate with customer by, email, phone, webchats and one to one in conferences. The company realize service covering all the process of it, for its customers, giving a fast and satisfactory resulted to them.

Revenue Stream

The revenues stream is Usage fee. The company charges the clients by supporting them with a service to calculate the biomass of the harvest.

Key Resources

The key resources for providing value are:

- Cameras with computer vision
- Machine learning algorithm
- Employees to realize the service

Key Activities

The key activities for the business are:

- Operating the service
- Collect data
- Updating the algorithm
- Advertisement

Key Partnerships

The manufacture of the cylinder structure can be outsourced so one key partnership would be the manufactory company. Other partners are the camera technical suppliers and companies that can offer boats to transport the staff to the farm and realize the service.

Cost Structure

Cost structure can be separated in four categories

1. Fixed cost: transportation to the farm; employee payroll.
2. Variable costs: marketing & advertisement; manufactory; R&D.
3. Economies of Scale: Costs decrease in case of operating the service in different cages on the same day.
4. Economies of Scope: not applicable

In the figure 72 is the diagram of the Business Model Canvas for the service of calculating the biomass by using the product from the idea developed.

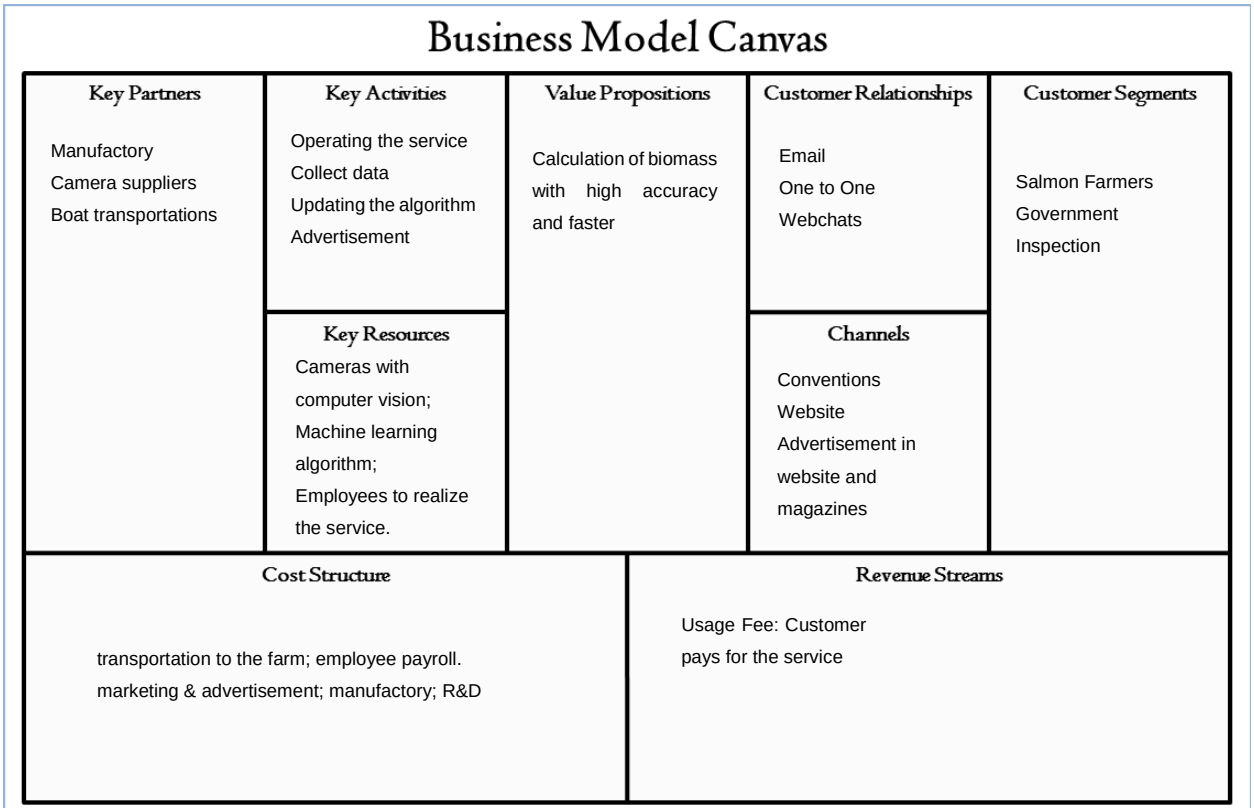


Figure 72 - Business Model Canvas template for biomass estimation using computer vision and machine learning

6.2 - BUSINESS MODEL CANVAS FOR CAMERA FEEDING USING COMPUTER VISION AND MACHINE LEARNING

Customer Segments

The customers for the product would be salmon farmers who want to have an optimal rate of feeding.

Value Propositions

The product will recognize fish patterns and decide how much food the fishes need, lowing the costs of food by avoiding waste.

Channels

The channels which will be used to reach the customers will be website, advertisement in technology websites or magazines and be part of aquaculture conferences.

Customer Relationships

The company can relate with customer by, email, phone, webchats and one to one in conventions.

Revenue Stream

The revenues stream is Asset Sales. The company sells the product to the customer.

Key Resources

The key resources for providing value are:

- Cameras with computer vision
- Machine learning algorithm
- Software to control the feeding system

Key Activities

The key activities for the business are:

- Sells
- Collect data
- Updating the algorithm
- Installation of the product
- Advertisement
- Maintenance

Key Partnerships

Camera technical suppliers and distributors

The know-how about the camera would be outsource, letting the company focusing only in the programming. The distributor has the structure already to delivery products so it would be easier for the company to establish a partnership with a distributor for delivering the product.

Cost Structure

Cost structure can be separated in four categories

5. Fixed cost: Distributors; employee payroll.
6. Variable costs: marketing & advertisement; manufactory; R&D, Maintenance.
7. Economies of Scale: Costs decrease by increasing the manufactory of the product.
8. Economies of Scope: the product can be developed for other functions besides to find an optimal feeding rate.

In the figure 73 is the diagram of the Business Model Canvas for the camera with computer vision and machine learning for fish feeding.

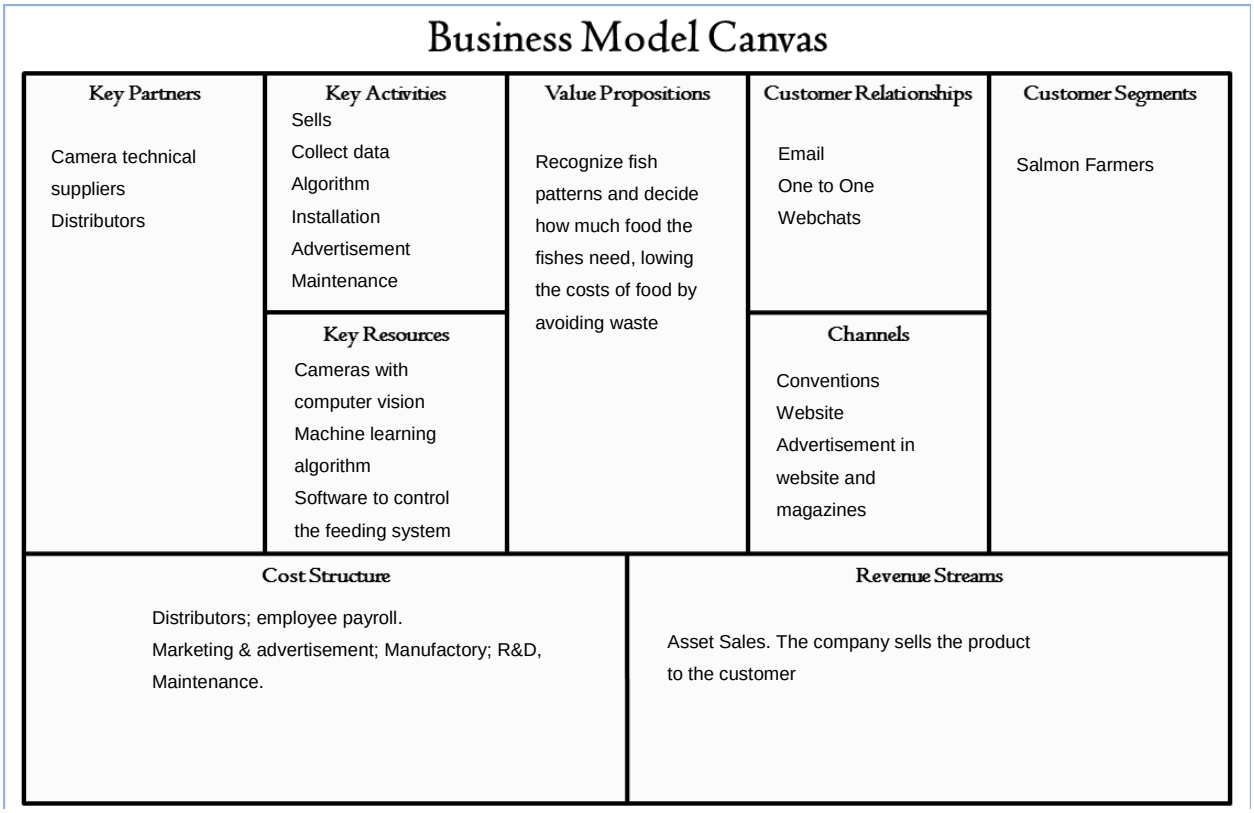


Figure 73 - Business Model Canvas template for camera feeding using computer vision and machine learning

6.3 – COMPARATION OF THE DEVELOPMENT BETWEEN THE BUSINESSES

For the selection of the most potential business a comparations is made between the two businesses, taking in concern which one requires more resources and time for development and which one can give return faster.

The one which will require more resources and time for development would be the product of biomass estimation, due to its development has to start from the scratch building a structure favorable for the salmon to pass through and the cameras take an imagine from it and measure its weight. Therefore, many tests should be done before release the product, such as if the salmon will pass through the structure, where is the best location to install the product to capture the most number of samples, if in some way can hurt the salmons. So, a lot of time and many resources are expected to develop this product.

While the feeding camera the development looks easier, since the technology of computer vision to identify the speed already exists, so the work would be more the adaptation of this technology for the use in salmon farming and the implementation of this technology in the already existing cameras. Therefore, this business presents that less resources and time would be consumed.

In respect of returns, the feeding camera with computer vision can give faster return, since the feeding is responsible for mostly of the cost in a salmon farming, and the product offers a reduction of cost in this department, therefore the product has a great chance to be accept very fast in the market. While the biomass estimation product would need more time to prove its value, because it is a whole new way to calculate the biomass, so the farmers can be skeptics, so a lot of marketing would be necessary to show that the product can deliver value for them.

Assessing both business, it is clear that the feeding camera product presents most potential to develop a business and start a new enterprise.

7 – CONCLUSION

The method assisted in identify the possible improvements in the aquaculture sector by analyzing all the products, services and segments involved in this sector and by analyzing them thoroughly, the higher costs and key challenges of each of them were identified being a good point to start to look how the technologies could solve the challenges and/or decrease costs.

From that several ideas were generated, proving that the method is useful for discovery innovative improvements, but due to limited time the ideas were just brief developed, having to consider many assumptions to justify the efficiency of the proposed idea. However, just to have the ideas is not sufficient they also need to be accept in the market and be profitable.

According with Bill Gross, the founder of Idealab a company specialize in grow successful business entrepreneurship, five facts are important to launch an idea and start a business: Idea, Team, Timing, Business Model and Funding.

In Bill Gross TedTalk in 2015, he reveals that the most important is the timing. Even some companies being pioneers in some service, they didn't succeed because people weren't ready for it or the structure behind the service wasn't good enough, but after some time other companies tried similar services after and succeed because the structure to support the service had been created. Other examples that shows that timing is important are Airbnb and Uber, due to recession time people needed extra money, so people started to support these services for earning more money.

Therefore, the screening part is very important in the process to launch a product or start a service, because it informs if the time is right for that. The screening part is important because it separates the ideas that would not be successful form the ones which could be. The screening was realized in a simple and subjective way, but proving efficiency for this work, although a better method of screening could be realized by researching more about the sector and talking with people from the sector to identify better the need of it.

Although the method shows some constraints the method presented itself to be efficient, since nine ideas were generated and two of them passed for the screening part and a business model was able to be developed for each one of them, showing that the method could be a model to start future entrepreneurships.

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APPENDIX

The tables below show in details of services, products and segments which are present in salmon aquaculture currently. The products and services were based on two companies, Akva Group and Steinsvik.

Service		**Dead Fish Handling**
Service production	**Process flow** What are the steps being taken to produce a product or service?	1. Employees go to the cage by boat 2. Connect the Hose of the Dead Fish Handling equipment to the boat 3. Start the air compressor 4. The fish is sucked to a container in the boat. 5. The dead fish is transported to be treat with acid.
	Technologies What are the main technologies the service is based on??	Boat Air compressor Mort Cone
	Software/programming What software / algorithms are involved?	None
	Skills What are the key skills in the service delivery process?	Driving Boat
	Cost / cost structure What are the main cost drivers of service delivery?	Labour Fuel consumption
Market	**Functionality** What does it provide of functionality?	Eliminates the Dead Fish inside of the pen
	Needs covered What need does it cover?	Avoid a dirty environment, and damage to fish health
	Main customer groups What are the main customer groups?	Fish farmers
Key	**Key challenges** What are the key challenges?	Daily Routine

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 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 lence
Other	Other factors	It needs 50 frames to estimate mass of 100 fish

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 **Sub 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

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 What are the main cost drivers of the process flow?	Fish pellets
Market	**Needs covered** What need does it cover?	Growing salmon to right size and health to be ready for harvest
	Main customer groups What are the main customer groups?	The fish farmers
Key	**Key challenges** What are the key challenges?	1. Waste of pellets 2. Disruption of environment (high concentration of droppings, diseases and lice from salmon + leftovers from pellets) 3. Fish health – Lice and diseases 4. Storage and Transportation
Other	**Other factor**	

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 What are the key skills required in the value creation process?	**Røkter / Operator** technical skills (measuring and use the equipment)
	Cost/cost structure What are the main cost drivers of the process flow?	Time consuming Labour
Market	**Needs covered** What need does it cover?	Respects the permit
	Main customer groups What are the main customer groups?	fish farmers
Key	**Key challenges** What are the key challenges?	Uncertainty in the measure human erros Not Standardized Third part
Other	**Other factor**	

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 What are the key skills in the service delivery process?	Salmon knowledge Mechanical operation of system Software skills
	Cost / cost structure What are the main cost drivers of service delivery?	Labour Construction R&D Fuel consumption
Market	Functionality What does it provide of functionality?	Remove lice from salmon
	Needs covered What need does it cover?	Fish health and quality
	Main customer groups What are the 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 What software/if and makes it do what?	Thermolicer control unit
	Cost / Cost structure What are the main cost drivers of production?	Manufacture and assembly Spare-parts and maintenance
Market	Functionality What does it provide of functionality?	Cleans the fish from lice
	Needs covered What need does it cover?	Healthy fish
	Main customer groups What are the main customer groups?	
Labour	Skills What are the key skills in producing the product or bringing the product to market?	Welders Logistic Management Mechanical engineering Marin experts
Key	Key challenges What are the key challenges?	Time consumption Requires a visual inspection after the process Spare-part storage
Other	Other factors	

The tables below show the changes when using the technologies to come up with innovations.

Product		**Dead Fish Handling**
Production	**Changes to software** – Are there possible improvements from this technology trend to the programming?	Remote Operations Software
	Changes to hardware – Are there possible changes to the hardware/shape/structure from this technology trend?	Autonomous Boat
	Changes to costs – Are the production costs changing or the cost of operating the product from this technology trend?	Replace common boat and human labour for an autonomous boat
Key	**Solving key challenges** - Can the technology trend help solve one of the key challenges?	Automated a daily routine task

Service		**Cleaning System**
Service delivery	**Changes to software** – Are there possible improvements from this technology trend to the programming?	Software that use all the data collect and give a prediticon for when the cleaning should be done
	Changes to costs – Are the service delivery costs changing from this technology trend?	Better cost-efficiency due to better planning
Market	**Increased functionality** – Can the technology trend contribute to increased functionality?	Continuous optimal level of oxygen due to customization (frequency of cleaning, which product)

Industrial segment		Biomass estimation
Value creation flow	**Changes to process flow** – Are there possible improvements from this technology trend to the process flow?	The whole process would change for digital, collecting the necessary data and calculate the biomass using them
	Changes to required skills – Are there possible changes to the required skills from this technology trend?	Computer skills
	Changes to costs – Are the process flow costs changing from this technology trend?	The cost would decrease, due to the digitalization of the process
Key	**Solving key challenges** - Can the technology trend help solve one of the key challenges?	Decrease uncertainty in the biomass estimation due to the extra parameters

Industrial segment		Biomass estimation	Feeding System
Value creation flow	**Changes to process flow** – Are there possible improvements from this technology trend to the process flow?	New step 5 - Algorithms recognize images patterns	Step 2 – Machine recomendation of feeding planning and operation Step 4 – Machine Monitoring Feeding operation
Key	**Solving key challenges** - Can the technology trend help solve one of the key challenges?	Less manual work	Less waste of pellets Improve fish health Avoid damaged to the environment
Other	**Other factors**	*connect with IoT and Camera with Computer Vision, cloud Computing	Connect with computer vision and IoT

Service		Delicing
Service	**Changes to costs** – Are the service delivery costs changing from this technology trend?	The costs would decrease due to the simplicity of the product
Key	**Solving key challenges** - Can the technology trend help solve one of the key challenges?	It does not harm the fishes
Other	**Changes in the Process Flow**	Introduce the product inside of the cage and let there for a while