LAND BASED SHRIMP FARMING

Exploring the viability of incorporating aquaculture of Crangon crangon *into small-scale sustainable aquaponics*

Charlotte van Bruggen; Hessel Postma; Cameron Stewart

Van Hall Larenstein,
Leeuwarden

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SUMMARY

The world population is growing. More people means a greater demand for food. The contribution of aquaculture to global food supplies has been increasing in the past years. Currently, fisheries and aquaculture are a crucial sector in meeting the FAO's goal of a world without hunger and malnutrition. The European brown shrimp (*Crangon crangon)* is an important fishery in Europe and has a large commercial value, due to its historic abundance in the wild and a sought-after taste for a variety of dishes. The problem for aquaculture of the brown shrimp is the fact the life cycle is not yet been closed within an intensive aquaculture system. Therefore, a steady supply of either larvae or undersized shrimp to grow out within the system is required. This is discussed in this report. It is a project from the company NoordOogst Aquaponics. The project seeks to utilize the undersized shrimp that would otherwise have been discarded from the shrimp boats and rear them to a marketable size. Biology, practicality, and financial aspects are discussed to assess the viability of this project.

The body of the brown shrimp is dorso-ventrally shortened, with a short rostrum and a rectangular carapace with 3 distinctive spines. In the wild, the diet of the brown shrimp is carnivorous and varied, predating on small meiofauna and a variety of epibenthic macrofauna. Conspecific cannibalisation is also highly common in both wild and cultured populations. The brown shrimp play a significant role as both predator and prey. For the water requirements, the shrimp has high tolerances and high adaptability making it a good candidate for intensive aquaculture systems. There is a wide range of tolerated temperatures and salinity levels. The current culture system within NoordOogst does not fit all the criteria for rearing the shrimp in an aquaponics system. The current system is not efficient for holding the shrimps. For the stocking density, cannibalism and conspecific predation present the largest problem. The current system can fulfil the water requirements of the shrimp. For collecting the undersized shrimp, the commodity chain needs to be known. The whole processing process of the shrimp happens aboard a shrimp trawl. In the normal process, the undersized shrimps are discarded by washing them away into the sea during the processing process. The market sized shrimps are being selected and filtered. To transport the shrimps to the rearing location they need to be captured aboard kept in a holding tank until the vessel returns to shore. Onshore they can be transported within a clear plastic bag. The market demand for fresh brown shrimp is good. Belgium, the Netherlands, Germany, and France are the countries with the highest consumption of the brown shrimp. For the financial picture, an overview of the costs and revenues as needed. The classification of costs was hard. It is based on the current system, but this system is not ideal for rearing shrimps. With the current hypothetical production based on the current system, it is below the break-even point. A few things can be done to fix this. The amount of floor space can be significantly increased while keeping water usage low by using stacked shallow raceways over the existing circular ponds.

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1.INTRODUCTION

Over the last century, the global population has been increasing immensely. In 1915, our planet was home to 1.8 billion people (Elferink, 2016). Today, according to the most recent estimate by the UN, there are more than 7.3 billion people on earth and predictions for the future go even higher as 10 billion (United Nations, n.d.). This growth, along with rising incomes in developing countries, which can result in dietary changes such as eating more protein and meat, is driving the global food demand up (Elferink, 2016). This can already be seen as FAO Director-General José Graziano da Silva said: Since 1961 the annual global growth in fish consumption has been twice as high as population growth, demonstrating that the fisheries and aquaculture sector is crucial in meeting FAO's goal of a world without hunger and malnutrition"(FAO, n.d.). Since there is such high demand nowadays, a rise in aquaculture production can also be seen clearly in the last few decades (Figure 1, FAO 2018)

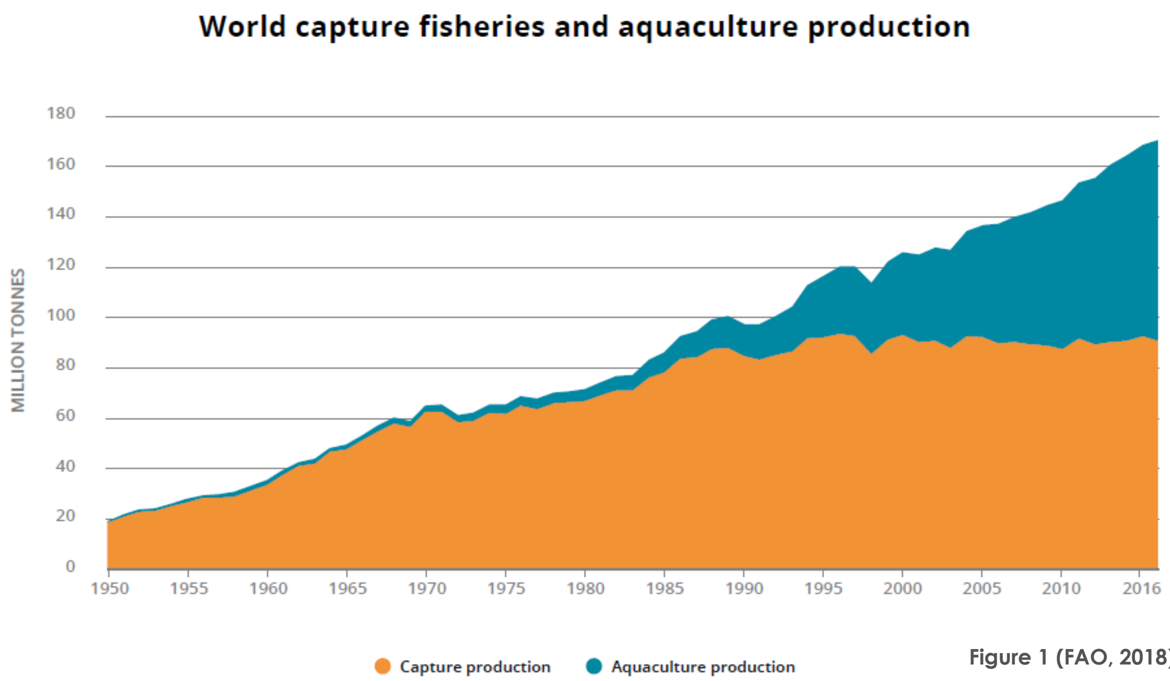

Figure 1 (FAO, 2018)

The European brown shrimp (*Crangon crangon)* is an important fisheries sector in Europe and has a large commercial value. Approximately 26,000 tons of cooked brown shrimp were landed in 2016, valuing €100M. More than 500 ships from the UK, the Netherlands, Germany, Belgium, France and Denmark contributed to this catch (ICES, 2016). The demand for large live shrimp (>70 mm) has been steadily increasing in the past few years. Live brown shrimp have a 20-30% higher sales revenue than cooked brown shrimp. With the demand for live *C. crangon* rising, and the value higher than cooked shrimp, this species is quite attractive for anyone wanting to cultivate these in aquaculture (Delbare, Cooreman, & Smagghe, 2014).

In general, aquaculture production is divided into three successive stages: seed production, nursery and grow out (Global Aquaculture Alliance, 2019). In case of *C. crangon*, a great deal of information about each life phase is already available, but the life cycle has not yet been reliably closed in captivity (Delbare, Cooreman, & Smagghe, 2014), in part due to problems experienced in larviculture. This means that to cultivate shrimp you need a steady supply of either larvae or undersized shrimp to grow out. This brings us to the project at hand. Erik Moesker of NoordOogst Aquaponics wants to utilize the discarded undersized shrimp from the shrimp fisheries to rear them to commercial size. Noordoogst Aquaponics is a company based in Groningen, the Netherlands, motivated to contribute to the issues of potential food shortages innovatively and creatively. Currently, their focus is on marine aquaponics, with this assignment focussing on the feasibility of small scale shrimp farming to potentially scale up to a larger size, as the amount of shrimp discarded almost equals the amount of shrimp caught (Steenbergen, 2012). In this report, the biology of the shrimps, the practicality of the rearing system and the financial aspects will be looked at to establish if the rearing of the *Crangon crangon* is economically and ecologically viable.

2.BIOLOGY

2.1 PHYSIOLOGY

The body form of *C. crangon* (Figure 2, (Fischer, Bianchi, & Scott, 1981)) follows that of other caridean shrimp, with a dorso-ventrally shortened body, a short rostrum, and a rectangular carapace with 3 distinctive spines. Adults are between 30-50 mm in length, with records reaching as large as 90 mm (Campos, Moreira, Freitas, & van der Veer, 2012). As *C. crangon* is the type species for the genus *Crangon*, they share the characteristic subchelate first pereiopods: the movable finger of the pereopods closes onto a short, static projection.

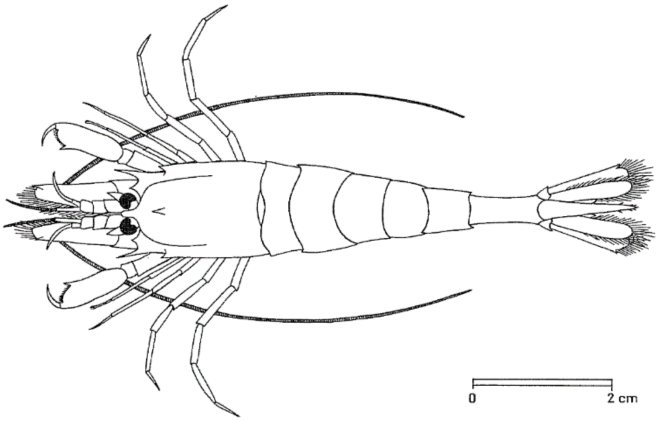

Figure 2. *Crangon crangon*, Brown shrimp, body form

2.2 TROPHIC LEVEL – WILD FEED

In the wild, the diet of the brown shrimp is carnivorous and varied, predating on small meiofauna and a variety of epibenthic macrofauna. Among these are polychaetes like Nereis spp., and recently settled post-larval bivalves and crustaceans – including the cannibalisation of *C. crangon* themselves (Pihl & Rosenberg, 1984). The polychaetes are considered invaluable to the growth and maturation of both caridean and penaeid shrimp as they contain polyunsaturated fatty acids which the shrimps cannot produce themselves (Benzie, 1997). They determined that as the shrimp grow the principal food changes, starting with the meiofauna and switching to the macrofauna species with increased length. In the north-eastern Atlantic and the North Sea, *C. crangon* plays a role as both predator and prey of flatfish like plaice and dab and are frequently found near nursery areas for these fish. Predation by the shrimp targets early settlers and metamorphosing immature stages, while the larger fish predate the shrimp (Campos, Moreira, Freitas, & van der Veer, 2012).

Pihl & Rosenberg determined an estimate of total food intake between 10-12.1% of the body wet weight of the shrimp. The shrimp were also observed to have the main feeding period during darkness with peaks at dawn and dusk, with the food leaving the stomach within 2 hours (Pihl & Rosenberg, 1984).

2.3 BEHAVIOUR AND LIFE HISTORY

The life cycle of the common shrimp is complex. It consists of several seasonal, sex-linked and size-related migrations (Roelofs, et al., 2013). The basic life cycle consists of the following life stages. First is the egg stage. Spawning of the eggs occurs after 48h of mating. It takes then 4 to 8 minutes to complete the egg extrusion and up to 30 minutes to attach at the body of the female. The time it takes to hatch depends on temperature and salinity. It can be 2-3 weeks at 20°C or up to more than 3 months at 6°C. With higher temperatures, egg development can occur at lower salinity. At salinities below 15 PSU eggs fail to develop and are lost by the females. The second stage is the larval stage. In this larval stage, there are 5 pelagic stages and an extra post-larval stage. The first planktonic stages occur in higher salinity areas. The growth is big in the larval stage. After hatching the length is 2 mm and in the larval stage, it increases to 4.6-4.7 mm at the end of the last larval stage (Campos & van der Veer, 2008). The larvae stay in the pelagic environment for around a month (Addison, Gaudian, & Knapman, 2007). After the last larval stage, they settle. Settlement is the following life stage. It occurs after 2-5 months of development. This is possible when larvae reach the sediment. A lot is unknown of this stage. Whether they are triggered by something to settle or if the larvae can transport by themselves or that they are dragged and swirled by the currents. After settlement, there is the juvenile stage. The shrimp keeps developing here and is growing. The last stage of the life cycle of the shrimp is the adult stage. (Campos & van der Veer, 2008).

Brown shrimp produces eggs all year round with peaks in summer and winter (Temming & Damm, 2002). Egg-bearing female shrimps occur throughout the whole year in the population. They are less common in the autumn than at other times of the year (Addison, Gaudian, & Knapman, 2007). There is a strong influence of temperature on the timing and the shape of the juvenile shrimp peak. After a cold winter period, the peak of the juvenile shrimp occurs several weeks later. The peak of juvenile shrimp in the shallow parts of the German and Dutch Wadden sea is observed in May/June. Further on there is a connection between temperature in the winter period and the juvenile shrimps in spring. Several species show stronger recruitment after cold winters. (Temming & Damm, 2002).

The length of females at maturity in the wild is reached within one year and is around 55 mm. At this length, 50% of the females will carry eggs. The fecundity of females ranges from 2.000 to 10.000 eggs. The amount of eggs is dependent on the size of the female. The size and number of eggs are dependent on the season. The egg production can be separated in summer and winter eggs. The development of the eggs is dependent on the temperature. (Addison, Gaudian, & Knapman, 2007).

The size of the shrimp is correlated with the depth of the water. Most adult shrimp are found in waters within a depth of 5 and 30 m (Addison, Gaudian, & Knapman, 2007).

2.4 WATER QUALITY NEEDS

The brown shrimp has high tolerances and high adaptability. The species is found from almost freshwater estuaries to waters with salinities up to 30 PSU. The tolerance of temperature is also very high. Temperatures may range from 0 degrees to 35 degrees Celsius (Addison, Gaudian, & Knapman, 2007).

For larval development, this is not the case. This is only successful at a narrow temperature range of 9°C to 18°C and with a narrow salinity range of around 32 PSU. Mortality occurs at salinities below 16 PSU and there is a slower development of the larvae at a salinity of 25 (Campos & van der Veer, 2008).

The maturation process of the shrimp is affected by salinity, with reared females becoming ovigerous sooner at 25 PSU (32 days), as well as an observed higher fecundity in females reared at 25 PSU than compared to those reared at 15 PSU. (Delbare, Cooreman, & Smagghe, 2014)

The diel behavioural patterns observed by Pihl and Rosenberg (1984) indicate much of the activity of *C. crangon* is during the night, with peaks at dusk and dawn. Experiments have been conducted whereby shrimp are exposed to circadian cycles of light and dark (12h L:12h D) and non-circadian (8:8 L-D and Random L-D) and the results show the significance of the circadian LD cycle on the physiological efficiency and development of the shrimp (Dalley, 1980).

3.PRACTICAL

3.1 CULTURE SYSTEM USED

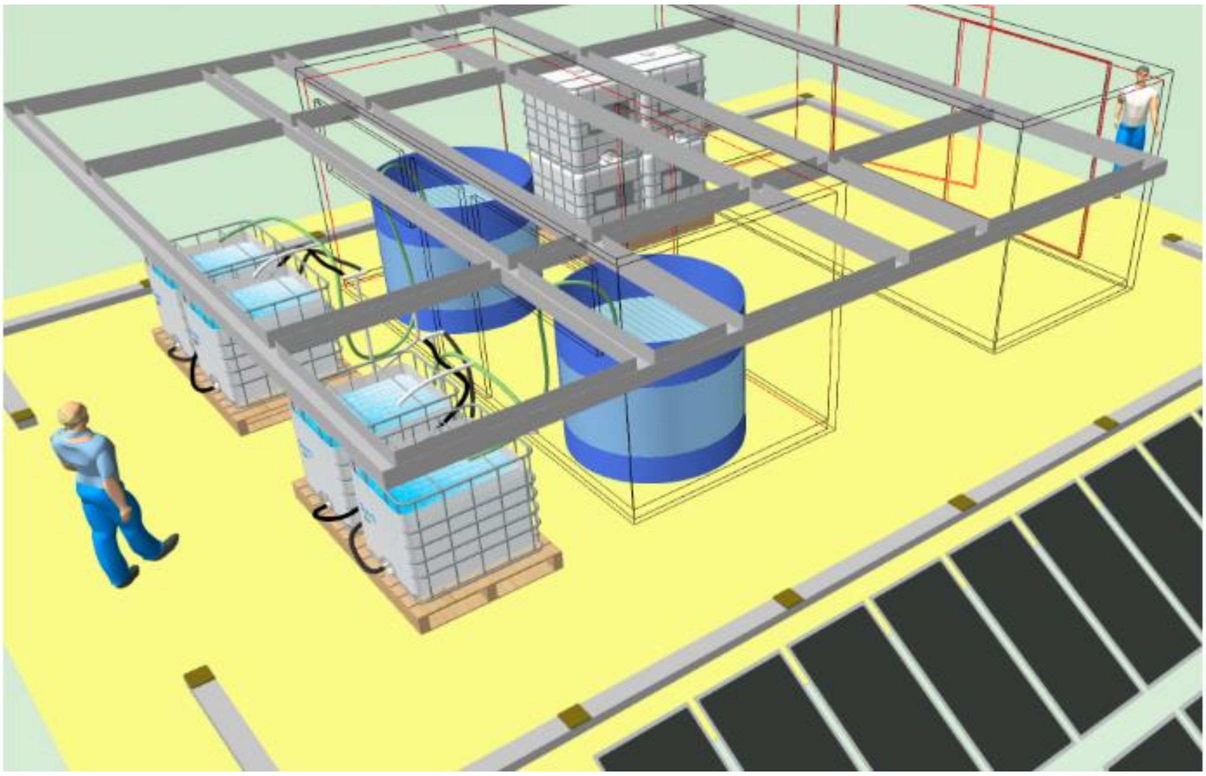

Figure 3 Current NoordOogst facility (Moesker, 2020)

3.1.1 CULTURE UNITS

The current culture units at NoordOogst are 2 x 5000L systems, figure 4 (Moesker, 2020). Due to their deep volume, they will likely be unsuitable for the rearing of *C. crangon*. As with other species in the genus, it is an epibenthic shrimp, requiring a soft-sediment (Campos, Moreira, Freitas, & van der Veer, 2012). Post-metamorphic juveniles settle on the bottom and burrow into the sand during daylight hours, only leaving to feed during the night (Pihl & Rosenberg, 1984). Due to this a culture system that allows for the use of a soft substrate like sand is recommended. Delbare *et al.,* (2015) describes a shallow raceway system (SRS) of long, shallow rectangular tanks comparable to those seen in intensive flatfish aquaculture (Figure 4). This system can accommodate a layer of sand with a grain size between 125 and 710 µm. This allows for the burrowing behaviour of the shrimp – reducing stress and cannibalism rates.

Figure 4 Shallow raceways used for intensive flatfish culture at FryMarine NL (Stewart, 2020)

These tanks have the significant advantage of being stackable and thus increasing the density of shrimp that can be grown in the small space available at the NoordOogst facility. Alternatively, outdoor raceways are a possibility, however, these take up significantly more area. When laminar flow is established in these shallow raceways, which can be achieved with baffles at the inlet and a settling zone before the outlet, it is possible to include sandy substrate whilst removing uneaten food particles. (Akvaplan-Niva, 2003)

One such raceway system has been developed by Dr Maurice Kemp at Texas A&M and is licensed exclusively by Royal Caridea, LLC (European Patent Office Patent No. EP3277081A1, 2018). The technology allows for the use of a modular system that fits into a 16.5m (53 feet) shipping container. While the technology is proprietary to Royal Caridea, they are a US-based company and potential partnership and licensing with them could be a solution to the challenge of culture units and a significant step to producing fresh never-frozen shrimp for the European market.

3.1.2 WATER TREATMENT

The water in the system needs to be treated. According to Menezes, Soares, Guilhermino, & Peck (2006), this can be best done by refreshing 50% of the water every week. If the level of nitrites is higher the refreshing needs to be done more often. The nitrite level was kept below 0.1 mg/L. The tanks in this research were 40 L carried around 100 organisms per tank. The temperature in the room was around 20°C and the salinity level in the water was around 20 PSU. The dissolved oxygen was maintained above 80%. The water was made with deionised water and Sera Premium Sea Salt.

While concrete safe parameters for *C.crangon* are not available, safe levels for peneid shrimp farming are advisable as guidelines. These are below (Delbare, Cooreman, & Smagghe, 2014).

- 0.1 mg N-NH_3 L^{-1} (Ammonia),
- 0.18 mg N-NO_2^- L^{-1} (Nitrite)
- 158 mg N-NO_3^- L^{-1} (Nitrate)

Encouraging the oxidation of nitrite to nitrate through the use of bacterial oxidization is recommended, which can be achieved using the aquaponics system outlined below in 3.1.2. This less-toxic compound can then be utilised by the crop plants.

3.1.3 WASTEWATER & AQUAPONIC SYSTEM

Currently, the NoordOogst facility is equipped with an integrated water treatment system consisting of 2 swirl filters and 2 floating bed filters. This runs in conjunction with the aquaponics system which consists of 3 growing beds (250 L volume) of terracotta clay pebbles connected to a 500 L sump. With a shallow laminar-flow raceway as described in section 3.1.1, the removal of uneaten food without removing the sediment is possible through screens and settling zones at the outlet. These screens will need to be regularly checked for build-up of moults and mortalities.

Keeping the water parameters within the guidelines outlined in 3.1.2 and 2.4, the growth of vegetables should be possible using the aquaponics system as the biofilter.

3.2 FEED AND STOCKING

While a number of studies have been conducted on the diet of *C. crangon* in the wild (Pihl & Rosenberg, 1984) and in small-scale aquaria (Hufnagl & Temming, 2011), there remains little data on diets suited to intensive aquaculture. Hufnagl et al. (2011) experiments determined a mean growth rate of 0.56 ± 0.1 mm d-1 at 25°C. The results indicate that diet has a significant impact on growth rates, with 18 mm shrimp fed diets of frozen *C. crangon*, artificial pellets or brine shrimp reaching median growth rates of 0.2 mm d-1 over 28 days. The introduction of live copepods to the diet increased mean growth rates by 0.14 mm d-1. However, it is also noted that there is significant variability in growth rate due to seasonality when the shrimp are caught.

As mentioned in section 2.2, dietary supplementation of polychaete worms is also recommended at a rate of 2 worms d^{-1} $shrimp^{-1}$ (Delbare, Cooreman, & Smagghe, 2014). Using a live feed comes with risks, in that wild-caught supply can be variable in both abundance and quality. Additionally, there is a risk of introducing disease to the system. Therefore, the primary feed should be an artificial feed pellet suitable for the life stage of the shrimp, supplemented with Specific Pathogen Free (SPF) polychaetes. The Danish aquaculture feed producer BioMar produces a pellet, Larviva, available in nursery and post-larval formulations. A local and sustainable source for fresh SPF polychaetes is the Dutch farm Delta Farms. Due to the location of the NoordOogst site, it may be possible to obtain live copepods in suitable quantities to be used as a diet supplement from the nearby Wadden Sea.

The wild feed conversion rate observed by Pihl & Rosenberg (1984) and highlighted in section 2.2 was 10-12%. A comprehensive diet comprised of the recommendations above should result in a greater feed conversion rate as the closed system allows for ideal water and light conditions.

When considering stocking density, cannibalism and conspecific predation present the largest problem. Pihl & Rosenberg (1984) found that immature conspecifics account for 20% of the diet of *C. crangon*. Low stocking densities and high feeding frequencies have been shown to reduce, but not eliminate cannibalism (Delbare, Cooreman, & Smagghe, 2014). In the wild, density reaches densities of 60-80 individuals m^{-2} (Neal, 2008). Experiments with extremely high densities of up to 582 individuals m^{-2} an observed mortality rate of 66% was observed and could be almost entirely attributed to cannibalism (Regnault, 1976). Due to this evidence, the maximum stocking density for the shrimp should not exceed 100 ind m^{-2}.

3.3 ANIMAL WELFARE

To keep the animal welfare standards high, a variety of factors must be considered. The criteria for good animal welfare are normal behaviour, good feed, good habitat, and good health (Groen kennisnet, 2019).

In the described system the animal welfare criteria are met. As described above in chapter 3.2 the density of the stock needs to be less than 100 ind m^{-2}. If this number is exceeded the cannibalism rate will increase and therefore the animal welfare will decrease. Further on the water quality is also important for animal welfare (Håstein, Scarfe, & Lund, 2005). If the water quality is bad it can cause more stress for the shrimp. Therefore the water needs to meet the water requirements of the shrimp. Last, good feed is important. The feed provides the energy for the shrimp. Without good feed, animal welfare will decrease (Groen kennisnet, 2019).

One significant risk to animal welfare is that the incoming undersized shrimp are a significant vector for the introduction of disease. Wild shrimps are susceptible to the viruses *Crangon*

crangon Baculovirus (CcBV) and White spot syndrome virus (WSSV), bacterial infection in the form of black necrosis and Filamentous bacterial disease, as well as dinoflagellate or microspore infections. As the infection rates for some of these diseases can reach as high as 100% in the wild, this risk will need to be addressed through either an antibiotic treatment or an inoculating vaccine. (Delbare, Cooreman, & Smagghe, 2014).

3.4 COMMODITY CHAIN

3.4.1 ABOARD THE SHRIMP BOATS

The shrimps are captured with a shrimp trawl. This is different from the beam trawl. The shrimp trawl consists of lighter gear and has a footrope instead of tickler chains (Nederlandse vissersbond, 2020). The footrope is light, rubber blocks that drag on the ground. Their purpose is to startle the shrimps a little so they jump up and are easy to catch with the net (Vist ik het maar, sd).

Onboard the shrimp trawl, the shrimps are cleaned, cooked, and chilled. Onshore they are tested, sieved, weighed, and sold. (Nederlandse vissersbond, 2020).

Figure 5 shows the schematic overview of the onboard shrimp processing. The first step is to deposit the shrimps in the cisterns (1). After the shrimps are in the cisterns they are moved upwards (2) to the sorting belt (3). Any marketable fish caught are sorted and gutted by a crew member. (Vist ik het maar, sd).

The shrimps and undersized fish are being deposited in the transport channel (4). After the transport channel, they end up in the sorting mill (5). Here they are washed and sorted. This mill separates the shrimps from the catch. The discards are being released back to the sea through the drain channel (6). (Vist ik het maar, sd).

After the mill, the shrimps go to the well (7). In this well shells and dirt can sink. After this, the shrimps go through the transport channel (8) to the automatic cooking kettle (9). Here they are cooked. The cooked shrimps are stocked in a basket. When the basket is full it is emptied by a crew member into a reel (10). In the reel, the shrimps are being washed and chilled. After the reel, they go to the search bin (11). In the search bin possible dirt is being removed. Finally, the shrimps are delivered to the hold via a chute. Down in the hold, the shrimps are refrigerated for storage. They put ice in the bins and bags with shrimps on top of that. (Vist ik het maar, sd).

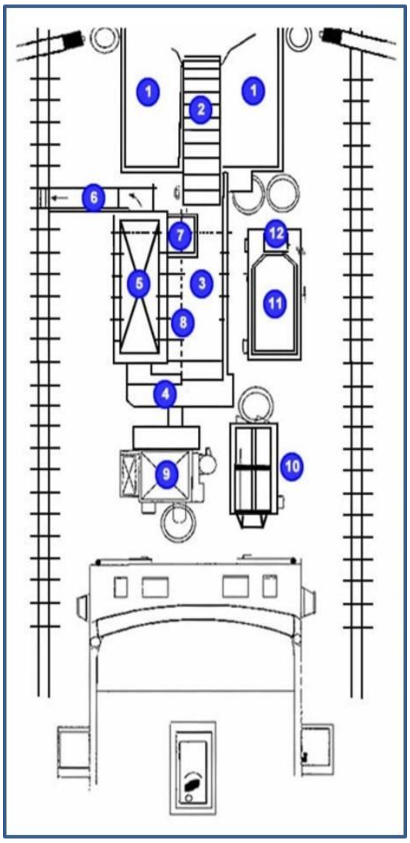

Figure 5 Schematic overview of the on board processing process (Vist ik het maar, sd)

3.4.2 HOW ARE UNDERSIZED SHRIMP CURRENTLY DISCARDED

Currently, the undersized shrimps are discarded from the processing process on board. Like shown above they are flushed back into the sea through the drain channel. (Vist ik het maar, sd). To obtain undersized shrimp to rear to market size NoordOoogst will need to establish a relationship with a shrimp fisher and develop a protocol to store the live undersized shrimp (section 3.4.3).

3.4.3 TRANSPORTING UNDERSIZED SHRIMPS TO REARING LOCATION

To collect the undersized shrimps and transport them to the rearing location a few adjustments need to be made. The first adjustment that needs to happen is to change the process on board of the shrimp trawl. As described in 3.4.1 and 3.4.2, currently the shrimps are washed away to sea during the processing process (Vist ik het maar, sd). The system of the processing process needs to be changed first to be able to collect the undersized shrimps. Instead of washing away the shrimps, they can be collected.

The shrimps need to be collected in a bucket or a tank with water. This water needs to meet the requirements of the shrimp otherwise they will die before getting onshore. The research conducted by Menezes, Soares, Guilhermino, & Peck (2006) collected the shrimps on the beach and moved the shrimps within containers with water. The water was coming from the sampling side in the laboratory. It was adjusted to 10 PSU with Sera Premium Sea Salt. It seems this procedure does not cause alterations on the enzymatic activities of the shrimp.

Another approach of transporting the undersized shrimp according to Hufnagl & Temming (2011) is to keep the shrimps in a flowthrough seawater basin on the ship. In this flowthrough system, the fresh seawater is provided through the seawater pump of the vessel. The excess water can spill over the edges. Further on the shrimps collected from the beach were transported in clear plastic bags filled to one-third with seawater and on top of that a layer of pure oxygen. According to Hufnagl & Temming (2011), this method is commonly used for shipping and transporting live fish and shrimps.

Onboard of the shrimp trawl it would be recommended to use the flow-through system to transport them during shipping. On land, it would be recommended to transport the undersized shrimps in the water of the NoordOogst facility. If this is not possible it is recommended to transport the shrimps in water with the same values as the water of the Noordoogst facility.

4.ECONOMICS

4.1 MARKET ASPECTS

In this chapter, the financial side of farming the European Brown shrimp is assessed.

4.1.1 COUNTRIES OF CONSUMPTION AND MARKET DEMAND

The countries of consumption and potential market for Brown shrimp mainly constitutes of Belgium, the Netherlands, Germany and France. Belgium is the largest consumer of Brown shrimp, with over half of the entire EU market going there. The EU market is estimated at 35.000 t, with over 90% of this being peeled. The largest consumer of unpeeled shrimp is France, closely followed by Belgium (A.N.D. International, Johann Heinrich von Thunen-Institut, 2011).

This shows that there are many options to choose from when looking for a market.

4.1.2 INVESTMENT AND OPERATION COSTS

The investment and operating costs were a bit difficult. All the costs were based on the current system in place at NoordOogst Aquaponics and as mentioned before, this system is not ideal. The shape of the tanks limits production to 10 m2 of surface area. With a max of 100 indv. p/m2, and a growing time of 6 months per batch this results in 2000 indv shrimp per year. Heiploeg states that when shrimp have a good size you can find 350 in a kilo (Parlevliet, 2020). This means that 2000 indv, shrimp equals 5.7 kg. The market price for shrimp keeps changing per season and is therefore difficult to pin down. But as said in the introduction, live shrimp are worth 30% more than processed ones giving us a kg price of 38,35 euro/kg (Bluiminck, 2017).

The costs are comprised of general income tax over the revenue. Electricity costs based on a 50W 5000L/h pump at 21 cents per kWh, resulting in 28 cents in power costs. For the feed an average FCR of 1.5 was maintained, resulting in 8.5 kg of feed per year for 5.7 kg of shrimp. Transport was calculated using the Visafslag at Lauwersoog as a pickup for the undersized shrimp, resulting in a total of 88km driven for a round trip. At 31 cents a km (Watkosteenauto, n.d.) this results in €61,60 in transport costs from Lauwersoog to Groningen twice a year. But € 0,19 can be asked back by the government (Belastingdienst, 2020), resulting in € 16,72 cashback.

The one thing that couldn't be calculated was the price of the undersized shrimp. This needs to be negotiated with the fishermen. It could result in giving it for free, but it could also be quite expensive because of the extra effort put in.

Table 1 Balance sheet of predicted Outgoing and Incoming expenditure

Outgoing						Incoming				
Taxes	**%**	**Over**				**Production**	**€/kg**	**kg production**		
Income tax	9%	€ 235.32			€ 21.18	Live shrimps	€ 38.35	5.7		€ 218.60
Electricity	**L/H**	**frequenty/y**	**usage**	**€/KWH**		**km**	**€/km**			
waterpump	5000.00	52	0.05 KWH	0.21	€ 0.28	88	€ 0.19			€ 16.72
Feed	**€/kg**	**kg needed**								
Feed	€ 1.50	8.5			€ 12.75					
Water refreshment	**€/L**	**Annual L refresh**								
Water	€ 0.000642	260000			€ 166.92					
Transport	**€/km**	**transport p/y**								
88km	€ 0.35	2			€ 61.60					
Subtotal					**€ 262.73**					
Financial buffer					€ 26.27					
total					**€ 289.00**	**Total**				**€ 235.32**
						loss				-€ 53.69

4.1.3 BREAK-EVEN POINT AND PROFIT

Break-even point is calculated using a set of formulas, as seen below. The first formula calculates the break-even point using fixed cost divided by contribution per unit. The second formula calculates the contribution per unit by deducting the variable cost per unit from the selling price per unit. The break-even point will show the minimum number of kilos or ''units'' that need to be sold to turn a profit.

$$A: Break - Even\ point\ (Qty) = \frac{Total\ fixed\ cost}{Contribution\ per\ unit}$$

$$B: Contribution\ per\ Unit = Selling\ price\ per\ unit - Variable\ cost\ per\ unit$$

Figure 6 The formulas used to calculate the Break-even point

Table 2 Break-even point of costs and revenues

			Break-Even point (kg)
Total fixed cost	€	228.8	7.6 kg
Contribution per unit (Formula B)	€	30.1	
Selling price per unit	€	38.35	
Variable cost per unit	€	8.19	

Table 2 shows that with our current production hypothetical production of 5.7 kg, we are well below the break-even point shown in table x. This means that two things can be done: either the 10 m2 of surface get extended, resulting in higher water usage, higher electricity costs and therefore higher variable costs. Or the 10,000 L system takes on a different shape. If the system is reshaped in raceways of 40cm deep, the same amount of water is used but instead of 10 m2 you now have 25 m2. If 10 m2 produces 5.7kg this means 0.57 kg p/m2.

25 x 0.57 kg is 14.2 kg p/y times the price per unit (€ 38.35) = € 547.85.

The revenue of the system can be more than doubled and turn a profit if a different shape of tanks is used. This still does not consider the price of the undersized, otherwise discarded shrimp.

5.DISCUSSION

The main issue looked at in this report was whether shrimp farming on land was feasible. The answer to that is yes, but not with the current system. As mentioned in chapter 3.2, the amount of individuals per m2 is rather low at 100. The current system has enough water for a successful small-scale pilot, but the shape of the tanks is wrong. Simply flattening the tanks and widening the surface should drastically increase production. If flat raceway shaped tanks are implemented, the system could be expanded by a huge margin whilst being more efficient with water usage. Therefore, to know if large-scale rearing of shrimp is possible, the pilot system needs to be altered.

But that is not the only bottleneck. The biggest potential problems arise when looking at the supply of undersized shrimp. The supply chain starts at the shrimp fishing vessel. As mentioned before in 3.4 a crewmember sorts out the fish and discards the undersized shrimp and fish. This means that there is not just a mechanical factor in this process but also a human one. To let a captain, devote one of his crewmates to spend time gathering undersized shrimp has to come with the proper incentive, either financial or otherwise. Luckily, as far as we can tell, it is possible without major alterations to the process. Another thing we could not find with certainty was whether bringing those undersized shrimps ashore is legal. This is something that also needs to be discussed with the fishermen and with legal counsel concerning fisheries.

If the crew of the shrimp trawler are willing to take the time to sort the shrimps, they need to agree to install a storage place or container that will keep shrimp alive. This will take up valuable space in the cargo hold of the vessel, as on deck it is a liability. This container will have to be adjusted to keep the shrimp alive and well. This would probably require an investment of unknown size. The transport from the vessel to NoordOogst should be fine if the water is the same as on the farm.

The last thing to consider is the impact a large-scale farm might have on the population. The usually discarded undersized shrimp make up 50% of the shrimp caught. Of these undersized shrimps nearly 80% survives being discarded (Steenbergen, 2012). This is including predation by seabirds. This means that a lot of these shrimps will survive until full maturity when given back to the ocean. A lot of the discarded shrimps could potentially contribute to the population by spawning. Taking them out of the ecosystem in large quantities to supply a giant farm before they have had a chance to do so might interfere with the population growth and could have disastrous consequences.

6.CONCLUSION

In this report, the biology of the shrimp, the practical part of rearing shrimps and the financial overview of the project has been discussed. From all this info it can be concluded that the current system is not fully suitable for rearing the brown shrimp on land. At this moment the system is not efficient enough to run the project with good profit. The surface is too small to rear enough shrimps for a good profit. It turned out there are two options for making the project viable. Expending the system and making the surface bigger which is also making the costs higher. Or changing the shape of the system to make it efficient for rearing shrimps and make it profitable with the same surface and amount of water. From the report, it can be conducted that changing the shape would be the best option. This does not give many extra costs to it and still makes it efficient for shrimp rearing on land.

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