

Transportation and Packaging Aspects of Blue Mussel Farmed in the Baltic Sea

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1 Summary

There are a number of important nuances that should be taken into account when dealing with mussel transportation issue. These aspects vary and depend mostly on the needs of the customer and the characteristics of mussels, thus, significant role plays interaction between the customer and supplier as the more precise information concerning the product that should be supplied customer provides the more qualitative transportation options supplier might provide.

One of the most crucial aspects in the sphere of product transportation is the type of packaging, especially when dealing with mussel transportation. This is because mussels are marine products that can be easily spoiled. When choosing the right option for packaging below mentioned aspects should be considered. It should be known whether the product is meant for wholesale or retail, as it points out if packaging should be small or big, how it should look (ready to be sold in market or ready for the processing). Moreover here arises some other nuances, as for example, the environment of food packaging depends on whether the product should be processed or it should be as fresh as possible (what kind of cooling options should be used). Another aspect that should be distinguished is transportation distance and duration. One more detail and maybe the most important is the amount of money or balance between product quality and transportation costs that the customer is ready to consider.

If mussels are to be transported in large quantities then such types of packaging as bulk bags, tot pans and VATs, tubs, wooden boxes, and styrene boxes can be considered whereas if mussels are transported in smaller quantities then net bags, vacuum bags, waxed boxes can be used. It should be taken into account that these types of packaging can be mixed, for example a customer might ask to pack the product in small net bags or vacuum bags ready for retail but these bags are put into bigger packaging that can be card, waxed, styrene or wooden boxes.

Another issue that should be taken into account is cooling of the product. Several types of cooling options can be found, as for example, the use of block ice, small ice, flake ice, tube ice, slurry ice, or deep chill. For mussel cooling the most suitable option could be the use of small ice, slurry ice or deep chill. The use of cooling options mostly depends on customer needs.

WP4 GoA 4.1. focuses on economy analysis. The aim of the GoA 4.1. is to produce practical hands on information and knowhow for postharvest processing enabling investment calculations as well as action plans for establishment of transport systems and processing industry lines. GoA 4.1. is specifically designed to receive input from both internal and external stakeholders.

2 Introduction

Transportation is playing an important role in overall economy as it helps moving goods from one place to another. Movement of goods or animals might be done by air, rail, road, space, water etc. applying International Commercial Terms, like INCOTERMS 2010¹ (situation on 2018), as it deals with the handling and responsibility of risk during transportation (Bardi, Coyle & Novack, 2006). Usually the client is the one who chooses a mode of transportation, loading or unloading place and sets the transportation requirements etc. The satisfaction of customer requirements has increased the importance of transportation and storage services in overall economy.

To attract more customers and to provide them with a particular type of product it has led to the increase of importance of the settlement of logistics in the sustainable movement of goods (Chee, Noorliza 2010; Chen, Chang, Lai 2009; Huang, Huang 2012; Davidaviciene, Meidute 2011; Jaiswal 2008; Jayawardhena 2010; Meidute, Litvinenko, Aranskis 2012; Mentzer, Flint, Hult 2001 etc.).

There were more than 1.1 million enterprises in the EU-28's transportation and storage service sector in 2014, equivalent to 4.9 % of the non-financial business economy enterprise population. Employed 10.5 million persons and recorded value added of EUR 515.3 billion, which represented 7.7 % of those working in the non-financial business economy and 7.8 % of the wealth generated in the non-financial business economy (Eurostat, 2018).

A conjunction of factors and economic developments lies behind rising transportation costs. High transportation costs have influenced the shift from transportation using own transport to use of logistic service. The quality of logistics service has increased by investing in technologies and providing better and innovative solutions. At the centre of today's transport challenges are oil prices (Russell et.al, 2014).

Transportation price, productivity and contribution to economic growth analysis highlight benefits for transporting goods (National Research Council, 2002). Transportation price depends on distance, amount of cargo, the way it should be transported and many other obstacles. Productivity of Logistics Company and mussel farmer as well as distribution of product in time and delivery options are directly affecting product price and economic growth.

Transportation of live product requires greater involvement of sender and receiver in the overall process. Transported live bivalve species like oysters, mussels, manila and hard-shell clams can survive for extended periods out of water and can be traded for human consumption as live animals. The primary aim of capturing, holding and transporting live mussels is to deliver them to market in the best possible condition (Barrento, Keay, Lupatsch, 2013). There are many cases when due to inappropriate transportation options (e.g. chosen wrong packaging, cooling, and transport) the whole cargo of mussels has been destroyed.

Also, mussels are exposed to some level of stress during all or part of the trade chain. Stress can be defined as any factor (either external or internal) causing a physiological disturbance to the mussels. In the live mussel industry these factors include capture, declumping, fluctuating temperatures, sunlight and other bright lights, wind or drafts, handling and physical damage, poor water quality during holding, conditioning and purification. Mussels are generally able to recover from such stresses, however if any or a combination of those stresses are sufficiently intense, then it may result in mussel

¹ <https://iccwbo.org/resources-for-business/incoterms-rules/incoterms-rules-2010/>

poor quality (broken shells, gaping, unpleasant smell) or that they become dead. Thus, transportation systems need to ensure that mussels are held in conditions that keep stress to a minimum. (Barrento, Keay, Lupatsch, 2013).

Also, certain part of product amount might be lost doing different activities, like harvesting, transporting, loading and unloading etc. It has to be taken into consideration that 20% of waste of product that has been detected from rope mussel production to processing in mussel farming (Barrento, Keay, Lupatsch, 2013).

Obviously, there should be class A classification before harvesting and both water and mussels must be without toxic algae. The harvest of mussels in the Baltic Sea probably cannot be done in August due to the strong blooms of cyanobacteria, and this makes the harvest time more limited compared to customer demand.

3 Types of packaging

Packaging is chosen considering various aspects – amount of mussel, delivery destination and time needed for storage.

Before delivering mussel to the customer, the byssal hair should be removed as it is undesirable part of the mussel, especially for human consumption.

Considering the freights, volume and distance, some main types of currently used eco-friendly and more or less hazardous packaging and containers are mentioned below.

3.1 Mussel packaging for human consumption

3.1.1 Modified atmosphere packaging

Modified Atmosphere Packaging (MAP) is also known as gas flushing, protective atmosphere packaging or reduced oxygen packaging.

MAP enables fresh and minimally processed packaged food products to maintain visual, textural and nutritional appeal. The controlled MAP environment enables food packaging to provide an extended shelf life without requiring the addition of chemical preservatives or stabilisers. Processors and marketers of food products rely on MAP to assure fresh and flavourful products that continually meet the consumer's expectation for brand quality, consistency, freshness and in-stock availability.



Figure 1 Modified atmosphere packaging (Packaging Today)

MAP is an optimal blend of pure oxygen, carbon dioxide and nitrogen within a high barrier or permeable package. A finely adjusted and carefully controlled gas blend is developed to meet the specific respiration needs for each packaged food product.

Plastic films, foils and other packaging materials that demonstrate specified gas permeability properties and/or water vapour permeability properties are selected for use. These high barrier substrates become MAP after they are formed into trays, lid stock or bags and filled with a select blend of oxygen, carbon dioxide and nitrogen environmental gasses.

Packaging films are selected to match the characteristics and needs of the food product. Film permeability, water vapour transmission rates and sealing characteristics need to be measured and tested at film selection and again at package converting and product fill stages, since the ability of a film to handle MAP performance characteristics may vary within each stage.²

² <https://dansensor.com/solutions/modified-atmosphere-packaging-food-and-beverage-industry>

3.1.2 Vacuum bag

When mussels are vacuum packed, many of the shells often break, and moreover the subsequent cooking in water is too slow for the mussel meat to coagulate satisfactorily. The invention solves this problem by packing the product to be preserved, in the first place mussels, in a somewhat flexible plastic container which is sealed. On the top side of the container there is a venting hole which permits the escape of steam during boiling but which is sealed immediately as microwave heating ceases, whereupon a vacuum arises inside the container as the steam condenses. A vacuum packed and pasteurized product is thus obtained in one and the same operation. (Haamer, 1998).



Figure 2 Vacuum bag (AquaFresh)

3.1.3 Net bag

Net bags usually are transported in bins. The most common size of net is 1-5 kg and mesh bag size is approx. 25 kg. Net bags are used to package oysters, clams, mussels. Shape of nets might be hexagonal or diamond.³

Net bags might be sealed with iron shelf. ⁴ This kind of packaging best suits for retail mussel selling as they are packed fresh in small quantities.



Figure 3 Net bags (Wegmans)

3.1.4 Wooden box

For better grades of mussels, plastic grid boxes or wooden boxes are used. Clams are packed in plastic mesh bags holding 2, 1, or 0,5 kg, and wooden boxes for the better grades. Oysters are usually sold in tightly closed, wooden boxes, packed with fresh fern, clean straw, or hardwood shaving, containing 12, 25, 50 or 100 oysters (Ottwell, 2018).

Mussels packed in wooden boxes are delivered to restaurants or retail outlets, providing a visually appealing look.

Not all types of wood are allowed to be used as wooden box material, such as poplar, beech.

In wooden boxes, a film or similar material is put so that the product is not in direct contact with wood material.



Figure 4 Wooden box (Embarbox)

³ <http://www.industrialnetting.com/applications/aquaculture/shellfish-bags.html>

⁴ <http://www.plastic-mesh.com/extruded-net/extruded-net-bag.html>

3.1.5 Waxed box

Wax boxes are commonly used for iced shipments that are delivered by refrigerated trucks or held in refrigeration for long periods of time.



Figure 5 Wax boxes (Packaging Product Corporation)

Features:

- tough construction won't fail on you;
- efficient & cost effective
- longer term ice exposure
- shipped flat - space saving
- over 30 sizes always in stock
- free custom graphic design⁵

Waxes are used in food packaging materials because they have good moisture barrier characteristics. As such they can protect dry foods from environmental moisture or reduce moisture loss of the food stuff (Riederer, 2001). Further, a wax coating may protect food stuff during transport and handling (Food Packaging Forum).

Yet, there is concern that waxes and their other components may migrate into food stuff, particularly if they are part of the food contact layer. A study by Varner (2012) et al. showed that it was possible to measure benzophenone in paraffin waxes used in food contact materials, but no migration studies are available to this point (Varner, 1991; Food Packaging Forum).

⁵ www.pkgprod.com/wax-and-wax-alternative-boxes/

3.1.6 Styrene (polystyrene) box



Figure 6 Polystyrene box (Alibaba)

Polystyrene box provides thermal protection like no other packaging and can sustain a stable temperature under 5°C for as long as 48 hours when your goods are pre-chilled or frozen and our ice sheets are used.⁶

Polystyrene box is commonly used to transport fish products, too.

Polystyrene is very inert meaning that it doesn't react particularly well with either acidic or basic solutions. This characteristic cause polystyrene to last a long time in the natural environment which poses a litter hazard as the material is typically thrown away after an extremely short useful lifespan⁷.

The polystyrene box can take 20 kg of goods for transport and cold storage. With an internal volume of 48 litres, and internal depth of 290 mm, this box is also suitable for storing ice and keeping drinks cool at parties and barbeques.

Polystyrene is sturdy and has excellent thermal regulation properties, making this an inexpensive yet highly effective cool storage / transportation option. The 20 kg Ice Box is food safe and airline approved for transportation of food.⁸

Mussels are packed in a reduced atmosphere 1kg VAC bag, chilled and then placed in a 12 kg styrene polystyrene box with ice. Styrene boxes are rather expensive.

⁶ <https://www.jbpackaging.co.uk/>

⁷ <https://www.creativemechanisms.com/blog/polystyrene-ps-plastic>

⁸ <https://www.foamsales.com.au/products/seafood-esky-20kg>



Figure 7 Polystyrene box

3.2 Mussel packaging for processing

3.2.1 Bulk bag

Bulk bags (approximately 800kg) are common to deliver large amount of product.

Bulk carrier bags are used to deliver bivalve molluscs to feed processing sites such as chicken feeders. Bulk carrier bags can hold approximately 800 kg of bivalve molluscs, and bags are easy to move with dump trucks, and at delivery points they tend to be sprinkled by cutting the bag. A bag with a larger volume costs around 5-15 EUR. The price varies according to the amount ordered.



Figure 8 Bulk bag (Microfab)

3.2.2 Card boxes

Card boxes are used after packaging in other material. Card box might suffer from water.

When packed in a paper box, it is likely that it will leak in moisture. The paper boxes are relatively cheap and they tend to be wrapped with a stretch film.



Figure 9 Card box

Stock boxes are light weight, and this makes them extremely convenient to package, load, and unload. Corrugated boxes are entirely recyclable, and this makes the environmentally friendly. These boxes can be found in any size, shape, colour, or design. They can be created based on the specific customer requirements, which is especially helpful because business needs are often very diverse. A corrugated box will have tear resistant qualities, and this is helpful in keeping the packaging intact and will protect the products from being exposed to the elements. The materials needed to create corrugated boxes are inexpensive, and that leads to boxes that are highly affordable when they are compared to alternatives that are on the market. Corrugated boxes have higher capabilities for graphics and printing, and this makes them effective when it comes to marketing, branding, and promotional purposes. Many companies use these boxes to print their

company name and logo. The availability of these boxes is widespread, so they can be found in almost any region of the world to support international business.

These boxes may become deformed if they are exposed to extreme pressure or when stacked. Corrugated cardboard is not the best option for weatherproofing. Water and other types of liquid can saturate these products, and it may also seep into a box and damage the contents. Corrugated boxes are not always a good option for the packing of heavy items. This is because their endurance to mechanical stresses is relatively low.⁹

3.2.3 Tubs (1 – 5 kg)



Figure 10 Tubs (Saeplast)

Tubs (405 and 705 litre) and wet storage containers are constructed from double-walled food-grade polyethylene filled with polyurethane, are the only insulated containers of their kind on the market today. They are suitable for the storage and purification of live mussels, oysters, clams and other shellfish.

The tub's design ensures that an even flow of water is maintained through it, resulting in the optimum oxygenation of each individual shellfish. It also includes a number of technical features including an integrated grid waste separator and water circulation system designed to achieve maximum flow and water renewal. Like all tubs and containers, they are ergonomically designed for maximum strength, ease of handling, stacking, and optimum hygiene.

They are designed so that they stack perfectly together. Lateral support for the grid is provided along the entire interior perimeter of the box, while corners are rounded for easy wash-down. Easily repaired if damaged, these tubs come with a host of built-in safety features, including integrated water channels, fast release plugs for rapid emptying, and emergency air inlet plugs for use in the event of a failure in water flow. And as both tubs operate without the need for any external pipe or drain connections, they can be used in both closed and open-circuit systems.¹⁰

⁹ <https://www.instabox.com/corrugated-box/> (2014)

¹⁰ <http://europe.saeplast.com/en>

3.2.4 Tote pan and VAT

TOTE PAN and VAT is common package in mussel farming. Vats offer a better control over quality affecting criteria – temperature and handling stress. Vats are insulating and require less ice to maintain temperature. Therefore cost saving on ice purchases may be realized. Moreover, adopting vats in all aspects of mussel production is HACCP and quality friendly (Barrento, Keay, Lupatsch, 2013).

Vats are easier loaded and unloaded, large volumes can be transported but they have their own weight.



Figure 12 VAT



Figure 11 Tote pan

Nevertheless, they are cost effective as once they are bought they can be used long-term which is comfortable when dealing with regular clients as vats should be transported back. Moreover, vats can be used for mussel's quality maintenance as vat structure is designed so that a flow of water passes through it, thus, cleaning mussels from soil and dirt.

Due to environmental concerns there are various activities that are on the way to use environmentally friendly and recyclable and are 100% ocean bound plastics.¹¹

Regardless the chosen materials as the best option for the packaging, be sure you follow the latest environmentally friendly trends to be in line with the cutting – edge technologies and follow the best practice in corporate social responsibility to ensure the sustainability in your business.

Besides well organized, wealthy and healthy packaging for the transportation, storage conditions and delivery terms are important to keep product fresh as long as possible.

According to the studies carried out by Marta Bernandez and Laura Pastoriza *On quality packaging of live mussels during storage as a function of size and oxygen concentration*, it was concluded that packaging atmosphere with richer oxygen concentration favours the longevity of Mediterranean mussels stored at 2 ± 1 °C. Higher O₂ concentration ensures diminished production of metabolic substances and the size of mussels plays an important role in the ratio of metabolism present in the product.

For commercial purposes as good indices constituting 75-85% O₂ of packaging atmosphere are considered to be the optimum reached for refrigerated storage. Such product is healthy for food preparation.

¹¹ :<https://www.plasticpackagingfacts.org/plastic-packaging/resins-types-of-packaging/>

4 Product cooling options during its delivery

The customer, being aware of his own needs and financial affordability, may freely choose the best option for packaging and transportation.

In order to expand the longevity of mussels cooling plays an important role, thus the type and technologies used for ice production and acquisition are crucial (Barrento, Keay, Lupatsch, 2013).

There are various types of ice that is used in food cooling and transportation.

4.1 Block ice

The traditional method is to immerse cans filled with water in a bath of low temperature brine. Size of block may range from couple of kilograms to 135 kg or more; 150 kg is considered to be the largest size of block a man can conveniently handle. A thickness of at least 18 cm is desirable if the block is to remain stable when being moved about on edge. (Waterman, 2001).

Very large blocks are usually made only in large installations that operate continuously, since the freezing time can be 18 hours or more. Losses during distribution in warm climates are less with large blocks since they take much longer to thaw. Blocks are harvested by immersing the cans in warm water or brine to release the ice; a 24-hour cycle has been found to be most practicable in large installations. (Waterman, 2001).

Probably block ice is used mostly in warm climate zones and could be less suitable for the Baltic Sea area.

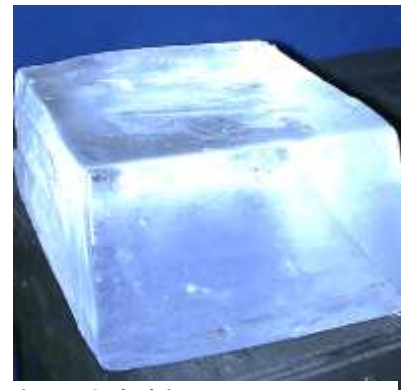


Figure 13 Block ice
(Seafoodwarehouse 2018)

4.2 Small ice

The term small ice is used here to describe the many kinds of ice made in small pieces under a host of brand names. The range includes snow or powder ice, flake ice, cube ice, scale ice, plate ice, tube ice, ribbon ice and many others. (Waterman, 2001).

All of the methods are based upon the formation of a fairly thin skin of ice on a smooth refrigerated surface, and the removal of that skin either by mechanical action or by warming of the surface. Freezing time varies as the square of the thickness of the ice layer; in theory it is therefore more economical to harvest the ice in thin layers. If heat is used to remove the ice, some of this advantage is lost; mechanical harvesting should be less wasteful. (Waterman, 2001).



Figure 14 Small ice (Justcought UK)

4.3 Flake ice

Flake ice is normally removed by a wedging action from the drum on which it has been frozen; the cutter may rotate on the inside of a vertical stationary drum or the drum may rotate horizontally against a fixed knife; there are also other variations. No heating is employed to remove the ice (FAO, SIFAR 2001).



Figure 15 Flake ice (Healthandcare)

4.4 Tube ice

Typical pieces of tube ice are a little more than 3.8 cm in length and of about the same outside diameter, with a hole through the middle about 1.3 cm in diameter. Some of the pieces are whole, some broken, usually longitudinally. The ice is often moist on discharge since a hot gas defrost system is used to release the ice (FAO, SIFAR 2001).¹²



Figure 16 Tube ice (Francis Sia)

4.5 Slurry ice

Slurry ice (known also as fluid ice, slush ice, flow ice, liquid ice) is well known for its advantages of rapid fish chilling during harvesting and processing. For many years, studies have documented these advantages to the point of establishing that processors can charge a premium of additional money per pound, for fish that has been chilled and stored in slurry ice. Wide scale acceptance of slurry ice has been retarded by the lack of industrial equipment rugged and large enough for this application. Slurry ice cools products much more quickly than either air or water because it has a far greater heat absorbing capacity.¹³



Figure 17 Slurry ice (Sin Ocean)

Ethanol, ethylene glycol and propylene glycol are the most commonly used freezing point depressants in the mussel farming industry (Barrento, Keay, Lupatsch, 2013).

¹² <http://www.fao.org/wairdocs/tan/x5901e/x5901e01.htm>

¹³ <http://www.icegen.com/PDF/Brochure.pdf>

4.6 Deep Chill

As an option for cooling of mussels DeepChill system can be used. (Sunwell)¹⁴

High-end food producers and processors use DeepChill systems in more than 35 countries worldwide to achieve results unattainable with conventional ice.

DeepChill's unique properties maintain peak product quality, significantly increase yield, improve shelf life, and reduce operating costs. And, because DeepChill systems are closed systems, they can enable better HACCP compliance for your operations.

Before processing, mussels are put through a flushing process that removes any impurities they may have ingested prior to arriving at the plant, ensuring they meet the highest standards for quality and freshness. A de-bearding process and hand grading follow. Finally, mussels are packed by weight in mesh bags from approx. 1 kg to 10 kg and placed in containers weighing from approx. 4.5 kg to 450 kg, according to customer request (Sunwell)¹⁵



Figure 18 DeepChill (Sunwell)

DeepChill systems use seawater to generate the DeepChill crystals, and automatically deliver a thick slurry to various locations at the facilities. The thick DeepChill ice slurry is sprayed into each container and flows through and around the mesh bags, filling every crevice, and quickly cooling each individual mussel to just above 0°C. Since the slurry is in the mesh bags, and not just surrounding them as with other icing methods, the mussel bags can be packed more densely in the boxes. With more bags, more DeepChill is used and therefore, more cooling power is present, enabling the low temperature to last longer. Prince Edward Aqua Farms' General Manager Jerry Bidgood stated, "DeepChill has helped us improve as a company financially and allowed us to supply consistently superior product that our customers recognize and keep returning for repeat orders." (Sunwell)¹⁶

According to the information provided by project MUSSELALIVE the crucial issue is to add ice as quick as possible either to 5 kg net bags, which are transported to restaurants in bins each with 50 bags (250 kg) covered with ice or to bulk bags (800 kg) that are transported to the group (MUSSELALIVE, 2018). Also in the report was mentioned that in general mussel producers have no idea of mortality after transport because there is no feedback from the client. One of the interviewees commented that farmers may never realize that the system is not working just because they are not kept up to date.

To prevent mussels from gaping the crucial moment is to add ice as quickly as possible. In this case the most suitable chilling solutions could be the use of slurry ice, deep chill or small ice, once again depending on what kind of packing is used.

Sustainability is gaining importance in the packaging sector. From the very first step to the final stage of product transportation their path has to be fully traceable. Although such lifecycle considerations are controversial among experts this is at present presumably the simplest way to determine the ecological footprint of packaging within a reasonable time. Direct comparison of materials is difficult, for their resource and energy consumption varies depending on the application. Cardboard can be

¹⁴ <http://sunwell.com/mussels/>

¹⁵ <http://sunwell.com/mussels/>

¹⁶ <http://sunwell.com/mussels/>

more expensive than plastic, the production of tin sheet costs even more but is profitable in the overall balance because it can be recycled and once in the can hardly anything spoils. Some plastics can also be down cycled and re-used. In the eco-balance glass is more advantageous than plastic but only if the transport distances are less than 50 km. No packaging material is per se “good” or “bad” or superior to another. And this also applies to packaging materials made of paper, which are allegedly particularly ecological. But they are often coated with a plastic film as a moisture protection, as in the “coffee to go” mugs.¹⁷

¹⁷ <http://www.eurofishmagazine.com/sections/processing/item/137-high-technology-for-fish-packaging>

5 Transportation aspects

5.1 Delivery option

The choice of transportation depends on agreements concluded by the customer and supplier, terms set for the delivery distance of goods, recipient and other relevant specification. Notwithstanding the means of transport used for the purpose of delivery, whether it is road, rail, air or water, the management of logistics is applied.

To successfully design and implement durable and economically beneficial chain of transportation system there are number of various factors that are interlinked. The synergy in synchronous and well organized flow is a key element to meet all the requirements in order to secure and provide all the parties concerned with services and goods in due manner, time and quality.

Correct and precise provision of information of origin and fulfilment of processes in various phases of the transportation and delivery chain, as scheduled, are crucial.

Following the biological requirements of alive invertebrate, health and safety requirements of its (mussels) end product user - consumer, the transport system is conditioned to a certain time framework.

The origin of harvesting (water and weather conditions), processing phases (depuration sites and their workflow, biological requirements of mussel longevity in transfer phase), as well as resources used during the chain of logistics are to be considered to ensure that all the transportation chain to wholesaler or/and retailer, or/and end user function in compliance with the methodologies designed in order to ensure optimal conditions for delivery of live mussels to the market.

According to the information provided by EUROFISH modern smart technologies like "Tracking and tracing", or "Track & Trace" are applied to monitor and report the departures and arrivals of individual deliveries and product within the inter-destination points of the chain. The exact whereabouts and any movement of the object are identified and recorded so that the delivery route can be accurately traced.

Considering the size of enterprise and market share the development of new fit - to - size and purpose software and hardware intelligent traceability systems, solutions and tools can be developed to be adoptable in local market and be more user- friendly.

Small companies still use barcodes as they are cost efficient, technically not demanding, provide security and supply all the information required for reliable traceability systems and following the individual needs and trends these barcode systems are changed and technically improved for company needs. The print quality for barcodes is defined in ISO/IEC 15416, and data structures are defined in ISO/IEC 15418. When printing barcodes, users usually choose between three technologies: high-resolution inkjet printers, laser printers that reproduce fine details and allow high speeds, and thermal transfer printers or direct thermal printers.

Another track and trace solution to be considered is Radio-frequency identification (RFID). RFID is a transmitter-receiver radio wave system technology used for contact-free identification and location of objects and living beings. This code-bearing technology is innovative and is designed replace barcodes. Due to decrease of cost of using RFID, this track and trace solution has been more widely used in various

fields of the economy. Barcodes and radio frequency identification are the common labelling technologies on which traceability systems within international goods transport are based today.

Internationally recognized standard ISO 28000 which specifies the requirements for security management in logistics are met in application of barcodes and radio frequency identification systems, ensuring a high degree of control and transparency in product labelling and are at the same time flexible enough to be able to integrate new requirements resulting from changes to the Food Information Regulation at any time.

Understanding the market and supply chains the best and financially affordable and profitable transportation models are chosen. If the rail freight is the option, as key benefits of such a way of transport we might mention reliable schedules, transit times, cost effective deliveries for long distances, it is the best option for large amounts as many trucks can be loaded. It usually has strong safety records.

Road freight provides flexible service, designed upon individual needs and schedules. The road freight is very well organised and there are most suitable for delivering cargos with weight up to 20 tons.

As key benefits of air freight should be mentioned time saving quick transit, less documentation and cargo handling, precise arrivals and departures.

The benefits of the multimodal transport are efficient and cost-effective delivery options, document effective handling, and movement of cargo to any destination by using multiple modes of transport. It reduces the distance for the goods between the manufacturer and consumer, can deal with one entity to handle all modes of transport under one document.

There is no one certain distribution way how to supply product. It depends on customer and supplier agreement. Distribution place might be one but the customers should be more than three, otherwise it might affect the business risk.

Each involved partner in distribution chain should bring and provide higher value of product. By involving more partners in supply chain it might increase the cost.

5.2 Different transport conditions and re-watering

If large vehicles use ice chilling in hot weather and produce significant amounts of waste water, then environmental regulations and local bye-laws may require the fitting of waste water collection tanks to these vehicles. Detailed recommendations for such tanks are given in the Sea fish Guidelines for Fish Landing Places (1997).

Parts of vehicles in which molluscs are held or with which they may come in contact should be designed and constructed to be easily cleaned. They should be constructed of durable, hard wearing materials capable of being cleaned frequently. These parts must have smooth, corrosion resistant surfaces.

The design of these parts should be simple and unadorned, where necessary with smooth linings, to avoid the lodging of debris, the harbouring of vermin and to facilitate cleaning.

These parts must be well drained to avoid the accumulation of pools of water and to facilitate cleaning.

5.3 Inventory management

Stock management is an important factor in manufacturing and processing companies. Such companies usually follow the FIFO (first in first out) principle.

Stock management is important for both the shipper and the recipient, because nobody wants to accumulate the product for a longer period of time. The shellfish producer is advised to keep bivalve molluscs in water than to harvest mussels and then to think about where to sell them.

Inventory management affects cash flow. Processing site or mussel farmer has its own capacity to storage stock.

In the mussel farming it is possible to manage stock, e.g. in Canada mussel farmers leave mussels in the water while waiting for higher demand price. Comparing with other agriculture products, like potatoes or grain, such possibility is limited. Also leaving mussels in water- in its natural environment, it does not require extra costs, like storing, packaging, transportation, which will raise after the harvesting.

Inventory management is important in processing site too. High stock amount and inappropriate storing requirements might reduce the quality of product or even make them useless.

5.4 Parcel service

Small amount of product or product for specific purposes, like laboratory, test might be sent using a parcel service, like DHL, UPS, TNT etc.

Parcel service price depends on technical requirements and conditions, delivery time, sender and delivery address, amount etc.

Mussels might be delivered packed and covered with ice to maintain temperature low. Mussels can be packed in modified atmosphere packaging.

Some households use this service to obtain fresh products directly from farms using internet website, such as Amazon.

Fresh Maine Blue Mussels - 12 pounds by Cape Porpoise Lobster Co. Inc.

- Only 13 left in stock - order soon.
- Shipped from: Cape Porpoise Lobster Co., Inc.
- Price for mussel- 113 EUR, + 3.80 EUR shipping (delivery to Sweden)



Figure 19 Fresh mussel (Amazon, 2019)

Parcel service is very helpful to deliver small amount, and many restaurants use this service to provide clients with fresh product, because freshness is essential in shellfish consumption.

The small amount might be costly for farmers, on the other hand the customer will pay higher price than retailer or wholesaler.

Also, some fish farming companies use direct supply company' service to provide customers with the best product.

Delivery of products using parcel service requires both transportation conditions and compliance with food and veterinary requirements; therefore, many companies do not want to take this risk and prefer to refuse production. Therefore, it is advisable to evaluate the capabilities and requirements of the timbered company and only then to ensure that the product will be delivered through the parcel service.

Stability of the supply volume is regular, therefore, in order to ensure this, we need to focus on product quality and customer cooperation. If a customer regularly requests a product, this indicates that he is satisfied with both the quality of the product, the price and the delivery.

Logistics companies specializing in delivering small loads can extend the supply of exclusive products as a separate business niche in a specific region, but exclusive products have their own disadvantages - production which is significantly lower than the supply of large quantities of products, where one of the most important factors is the price.

R.Ratray mentioned in this research that "Physical distribution of logistics costs are up to 30% of sales value".

5.5 Transportation distance and cost

In order to receive transport service prices, 10 companies (September 2017 - 2018), which are engaged in the transport of goods on a given route, were commissioned and specialized in the supply of fresh and frozen fish products were inquired.

Several companies were willing to provide information on specific requirements, but given that one of the potential processing sites is Tromsø, only 3 companies provided information on supply options and costs from Danish or Swedish mussel farms. Several companies have cars that can provide a special temperature mode, but trucks with freezers may not always be available.

Several companies did not show interest if the order is casual and does not follow the regularity, especially for long distances.

When interviewing the transport company, it was found that it is best to provide a full truck load corresponding to about 18 tons of output. The delivery of composite cargo, if required by the temperature regime or long distance, is not offered for specific loads.

Transport costs affect the distance, delivery method, conditions for the recipient of the service, loading / unloading requirements and facilities, specific requirements (temperature regime, refrigeration regime, etc.) and other factors.

Transportation costs of fresh / frozen blue mussel considering the distance (based on experts' interviews, 2017-2018)

	Riga-Tallinn	Riga-Warsaw	Riga Moscow	Tyrislöt-Tromsø	Korsør -Tromsø
EUR/kg	0.05-0.06	0.08-0.10	0.17-0.20	0,12-0,20	0,15-0,25
EUR/km	3,2	2,4	3,7	1,4	1,3
km	310	670	920	1778	2300

Transportation costs are rising, with changes in distance, delivery options and conditions. For deliveries outside of the European Union, delivery time may be delayed by complying with the Food and Veterinary Requirements at the border, which is why these jobs are usually entrusted to a transport or Logistics Company that is more experienced and knowledgeable in supplying the product. Prior to shipping, it is recommended that the documentation requirements are clarified in advance.

Occasionally delivery of products may be limited or delayed due to customs formalities, which may extend the delivery time and, consequently, have an effect on the quality of the product.

In relation to the supply of products to sites exceeding 400 km, it is necessary to examine the supply chain in order to make it understandable in identifying all possible risks.

When transporting to remote locations, transportation costs may be reduced if the cargo is shipped in both directions, for example, shipped with fresh bivalve molluscs, but sent back with recycled and packaged bivalve molluscs.

In the presentation Bandman, Schmohl, Kaller (2017) have highlighted packaging costs which include:

- Packaging material (it is advisable to find out the costs of higher quality and lower quality packaging materials)
- Packaging factors (weight, type, size material, price are main factors)
- Product return (yield loss from damaged packaging; possibility to recall product in certain situations, packaging return)
- Sterilization (sterilization cost might be variable or fixed cost)
- Inventory cost (transportation and inventory cost)
- Packaging:
 - Equipment - machine
 - Pallet and stretch-wrap cost
 - Shelf carton cost
 - "Instruction for use" cost
 - Labelling and printing cost
 - Labour rate cost
 - Packaging cycles per minute
 - Material losses

Packaging cost varies from 2% of product market price till 50% of packaging in consumer sales unit / distribution costs.

6 Conclusions

There are many transportation companies and only part of them can provide trucks with cooler. Experienced customer might recommend the transportation company.

According the experts' suggestions the companies which already transport fish products might be the most suitable companies for delivering blue mussel. Since in some cases the distance to the processing site can significantly exceed the recommended shipping distance (48h), it is important to assess the type of transportation and possible risks that may adversely affect the quality of the product. In general it can be concluded that coordination between customer and supplier plays significant role as most frequently mussel farmers even do not realize the condition in which mussels arrive to the destination. This is crucial point as having feedback can help maintaining the whole mussel transportation process.

When carrying mussels to the client various packaging solutions can be used. The destination point, that is, duration of transportation is one of the main factors that affect the choice of packaging. The most convenient solution for transporting mussels in large quantities, as it allows you to save on transportation costs.

Package costs are specific and change with changing requirements, opportunities, product, etc. If the production is planned to be delivered on the chicken feed processing, it would be advisable to use large bags that can be palletised and conveniently transported by road and in factory, and they are not expensive.

Sustainability is gaining importance in the packaging sector.

Transport and packaging costs must be commensurate - **distribution chain should bring and provide higher value of product. By involving more partners in supply chain it will increase the cost.**

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Annex 1

Example of Transportation aspects in the EU and third countries

Transportation aspects in the EU

The EU goods are:

- goods wholly obtained in the customs territory of the Union and do not contain goods imported from countries and territories outside the customs territory of the Union;
- goods brought into the customs territory of the Union from countries or territories outside the customs territory of the Union and released for free circulation; or
- goods obtained and manufactured in the customs territory of the Union, either solely from the goods referred to in point (b) or from the goods referred to in (a) and (b).

The customs declaration must be drawn up upon the importation of goods from parts of the customs territory of the Union where the value added tax Directive 2006/112 / EC (third territory is determined in accordance with Section 1, Paragraph 28 of the Value Added Tax (VAT) Law) and / or the Excise Duty Directive 2008/118 / EC (territories listed in Section 2 (3.1) of the Law "On Excise Duty"). For example, the Åland islands, the Canary Islands, Mount Athos, the French overseas departments, the Channel Islands (Article 1, Paragraph 3 SMC, Art. 134, paragraph 1).

To deliver goods of the Europe Union, thereafter – EU, (grown / processed in EU or goods are prepared for free circulation in EU custom territory), they must apply to the customs procedure – exports, i.e. the export declaration and the related formalities must be drawn up.

Custom requirements transporting to Norway from Latvia

Further will be explained the custom requirements transporting goods to the third countries. Transportation of goods from Latvia to Norway (situation and requirements on September, 2017) is taken as an example.

An export declaration must be prepared with code EU A for exporting goods to Norway,

1. Must be prepared accompanying documents - invoice, transport document (for road transport - CMR), certificates (for example, origin - depending on the requirements of the consignee for customs clearance in the country of destination), depending on the type of goods, if necessary, permits / licenses of different institutions (for example, veterinary certificate), various other documents, if necessary - package leaflets, contracts. The information in the accompanying documents (basically it is an invoice) must be sufficient to properly fill out the export declaration (i.e. identify the product code, indicate gross and net weight, quantity, delivery terms, value of the goods, information about the sender and the recipient, etc.). If customs formalities are performed by another person, there should be a power specifying the extent of the mandate and the type of representation - direct (liability of the creditor) or indirect (liability of the agent);
2. The persons involved in the recovery must have an EORI number. If a legal entity has made any customs formalities, then it will have received its EORI number and will use it each time for customs formalities. The EORI number assigned to natural persons is valid for one month and must be repeatedly requested. This means that if the exporter still does not have an EORI number, he must obtain it before submitting an export declaration.

Information on receiving an EORI number can be found on the SRS website: Customs / Regulations / EORI number

In Latvia: <https://www.vid.gov.lv/en/eori-numurs>

3. Goods must be loaded onto a vehicle;
4. An export declaration must be submitted to the Export Control System of the Electronic Customs Duty Data Processing System (EMDAS). If the customs formalities are carried out by a representative, he shall submit a customs declaration. The export declaration is an electronic document, i.e. the submission of a declaration is deemed to be signed at the time of its submission, hence this document is legally valid. It is possible to print it out for an informative purpose as an export accompanying document. Since the completion of an export declaration requires specific knowledge of goods declaration, it is better to entrust this work to the firm
5. Upon completion of the export declaration (in the status of "released goods"), the movement of goods to the customs office of exit at the border may be initiated in order to leave the customs territory of the Union and to be delivered to the consignee in a third country;
6. Upon arrival at the customs office of exit, the carrier must have at his disposal information on the goods to be exported - the export declaration MRN or the accompanying document of the export declaration printed out from the system;
7. The customs office of exit (regardless of the EU Member State) shall make the export declaration electronically in the Export Control System. At the time of clearance, neither

the customs office of export nor the customs office of exit carry out any marking on the printed export accompanying document.

Information on trade policy measures (bans / restrictions, licenses / permits) at the time of export of goods for a specific code for a specific country can be obtained from: SID's website: Customs / Regulations / Application of Customs Tariffs / TARIC - see link to ITVS. Ibid - the telephone number, where to call, if there is no clear indication of the ITVS, classification of the goods, etc.

Latvian customs site: <https://itvs.vid.gov.lv/itms/>

Transportation requirements in Latvia

Mussel transportation restrictions are described in the “Baltic Blue Growth” project document “*Legislation Issues Status Report*” (Rossner, 2017) and in the document “*Atzinums par tiesību un normatīvajiem aktiem, kuri tieši vai pastarpināti ietekmē gliemju audzēšanu un ieguvi Latvijas teritorijā un to realizāciju komerciālos nolūkos Latvijas teritorijā*” prepared within the project “BalticEcoMussel” (Lancmane, 2013)¹⁸.

Mussel transportation is regulated by directives and regulations of the European Union, by local legal acts and regulation documents.

In **Regulation (EC) No.1069/2009** of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption:

- Mussel and mussel meal producers must keep a record of the products they despatch, transport or receive, along with the required documentation (Art. 21) (commercial documents and health certificates).
- Mussel and mussel meal producers must inform national authorities of the products and premises they use during the manufacturing chain. The manufacturing chain must meet hygiene standards (Art. 25) and requires formal approval.
- EU Member States competent authorities approve (Art. 24) and register (Art. 23) establishments that handle mussels and the mussel meal. They also draw up and make public up-to-date lists of these establishments (Art. 41).
- To ensure that producers collect, identify and transport their products without delay and treat, use or dispose of them according to the rules, EU Member States carry out official checks (Art. 4 (3), Art. 45).
- Mussel meal may be used as fish feed at the end of the manufacturing chain (Art. 14 (d (i)), Art. 31). Mussel meal is categorised as fish meal (Annex I (7) 142/2011/EU).

In Latvia **Veterinary Medicine law** pursuant to which mussels are aquaculture animals and their farming sites are animal depositaries.

¹⁸ http://lvif.gov.lv/uploaded_files/sadarbiba/balticecomussel/Jurista_atzinums_final_redits.pdf

Cabinet regulations no 274 of 17.04.2012. Order of enterprise recognition and equipment and person registration that are involved in processing of animal by-products and derived products that are not intended for human consumption.

Packaging requirements are described in the **Regulation (EC) No.142/2011**. Packages of mussel meal (category III) must have green signs.