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Deliverable No. 5.4

DiscardLess

Strategies for the gradual elimination of discards in European fisheries

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Deliverable 5.4

Report on the 3D drawings and cost-benefit tools developed for Icelandic, North Sea and Bay of Biscay case studies

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Revision Control

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Executive Summary

The Common Fisheries Policy of the EU is currently implementing a landing obligation, which will require fishermen to land all catches that are subjected to catch limits (with some minor exemptions). This discard ban is to be fully implemented by 2019 and fishermen are currently struggling to see how they can meet with these requirements. The DiscardLess project is aimed at assisting the fishing industry to successfully adapt to the landing obligation. Work package 5 in the DiscardLess project focuses on providing stakeholders, such as fishermen and fishing vessel owners, with alternatives for on-board handling of the previously discarded catches.

This report provides an overview of the work that has been done in task 5.4 in the DiscardLess project. The aim of that work has been to take suggested solutions from previous tasks in the work package on on-board handling of unwanted, unavoidable catches for four different fleet segments and present those solutions in 3D drawings, accompanied with a simple cost-benefit tool that allows stakeholders to estimate the economic feasibility of investing in the suggested solutions.

The fleet segments selected represent a descriptive cross-section of European fisheries in terms of fleet composition and main challenges i.e. 11-meter coastal vessel, 23-meter Danish seiner/trawler, 39-meter bottom trawler and 50-meter bottom trawler.

The 3D drawings and the cost-benefit tool have been made available at the DiscardLess webpage http://www.discardless.eu/tools which enables stakeholders, such as fishermen and fishing vessel owners, to see in a visual manner how the suggested solutions can be fitted on the vessels and whether or not investing in them is likely to give economic returns.

The suggested solutions are first and foremost intended to provide fishermen with realistic alternatives for meeting the requirements of the landings obligation in Europe, as they are preparing for the implementation of the discard ban. The solutions do therefore need to be practical and economically feasible. Along with those suggestions we have also included recommendations for improved on-board handling technologies, which are expected to increase the value of catches regardless of the implementation of the landing obligation.

The solutions focus largely on separating between the target catches and the unwanted catches, and in particular to provide alternatives for processing and storing under Minimum Reference Size Catches, which cannot be utilised for direct human consumption according to the landing obligation of the EU Common Fisheries Policy.

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Report Highlights

- Available alternatives for handling UUCs on-board fishing vessels is primarily dependant on the vessels size, catch composition and how long the vessel is out at sea in each fishing trip.
- Best practice on-board handling when it comes to bleeding, gutting, cleaning and chilling of all catches increases the potentials for making high value products from the raw materials. This applies for target catches and UUCs alike. Poorly handled or spoiled UUC have limited options for utilisation, even if it is not intended for human consumption.
- The EU fishing fleet consists of roughly 85 thousand vessels, of which 85% are small coastal vessels below 12 meters in length. There are very limited options for this fleet segment to handle UUCs in special way. The most applicable alternative is to keep UUCs in different coloured boxes, this has particularly to apply for the catches below MCRS and other raw materials that are not meant for human consumption.
- The larger the vessels are, the more alternatives become available for handling UUCs. The catches intended for human consumption can generally be handled as the target catches. It is only the catches intended for non-human consumption that need special attention.
- Differently coloured boxes/tubs, bulk storage, mincing, compression, silage preservation, Fish Protein Hydrolysate, Fish Protein Concentrate and fishmeal/fish oil production are amongst the available alternatives for utilising UUC on board vessels that have the space available.

The methods/approaches followed:

- Suggested solutions from previous tasks in WP5 of the DiscardLess project on on-board handling of UUCs for four different fleet segments were drawn up in 3D and these drawings have been made available on the DiscardLess website, which allows stakeholders to see in a visual manner how solutions can be fitted on-board vessels.

How these results can be used and by who?

- The 3D drawings, along with the cost-benefit tool that is now publicly available at the DiscardLess website will enable fish business operators, vessel owners, fishermen, policy makers and other stakeholders to better understand some of the available options that can be used for handling UUCs on-board fishing vessels and as results contribute to a successful implementation of the Landing obligation.

Abbreviations

BoB	Bay of Biscay
CFP	Common Fisheries Policy
FPC	Fish Protein Concentrate
FPH	Fish Protein Hydrolysate
LO	Landing Obligation
MCRS	Minimum conservational reference size
RSW	Refrigerated Sea Water
UUC	Unwanted unavoidable catch

Table of Contents

1 Introduction

The Common Fisheries Policy (CFP) of the EU is currently implementing a landing obligation (LO), which will require fishermen to land all catches that are subjected to catch limits (with some minor exemptions). This discard ban is to be fully implemented by 2019 and fishermen are currently struggling to see how they can meet with these requirements. The DiscardLess project is aimed at assisting the fishing industry to successfully adapt to the landing obligation. Work package 5 in the DiscardLess project focuses on providing stakeholders, such as fishermen and fishing vessel owners, with alternatives for on-board handling of the previously discarded catches.

This report provides an overview of the work that has been done in task 5.4 in the DiscardLess project. The aim of that work has been to take suggested solutions from previous tasks in the work package on on-board handling of unwanted, unavoidable catches for four different fleet segments and present those solutions in 3D drawings, accompanied with a simple cost-benefit tool that allows stakeholders to estimate the economic feasibility of investing in the suggested solutions. The fleet segments selected represent a descriptive cross-section of European fisheries in terms of fleet composition and main challenges i.e. 11-meter coastal vessel, 23-meter Danish seiner/trawler, 39-meter bottom trawler and 50-meter bottom trawler.

The work presented in this report is largely built on solutions that were identified in another report published within the DiscardLess project (Deliverable 5.2). That report identified and gave recommendations for on-board solutions for handling Unwanted, Unavoidable Catches (UUC). Those solutions have now been further expanded on and they made more presentable for stakeholders by drawing them up in 3D.

The suggested solutions are first and foremost intended to provide fishermen with realistic alternatives for meeting the requirements of the landings obligation in Europe, as they are preparing for the implementation of the discard ban. The solutions do therefore need to be practical and economically feasible. Along with those suggestions we have also included recommendations for improved on-board handling technologies, which are expected to increase the value of catches regardless of the implementation of the landing obligation.

The solutions focus largely on separating between the target catches and the unwanted catches, and in particular to provide alternatives for processing and storing under Minimum Reference Size Catches, which cannot be utilised for direct human consumption according to the landing obligation of the EU Common Fisheries Policy.

The report is broken into seven main chapters. The first chapter provides basic information on the importance of proper on-board catch handling and the main steps needed to maintain quality of the raw material from catch to landing. The next four chapters are devoted to presenting the alternatives for each of the selected vessels/fleet segments i.e. small coastal vessel, small Danish seiner/trawler, medium sized bottom trawler and large bottom trawler. The sixth chapter briefly introduces the cost-benefit tool and the final chapter contains a general discussion on the results of the report.

This report is only a documentation on the work that has been done to develop the 3D drawings and the cost-benefit tool that is now available on the DiscardLess webpage http://www.discardless.eu/tools. The drawings and the tool are the real products of this work.

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2 On-board catch handling

This chapter provides basic information on the importance of proper on-board catch handling and the main steps needed to maintain quality of the raw material from catch to landing. The same principles apply to target catches and UUC alike, where the potentials for making valuable products severally reduce if the handling is not according to best practice.

2.1 Catching and handling before bleeding

The catching of the fish and the process of bringing it on board is the first step in a long chain which eventually leads to the final consumer.

The importance of this process is often ignored regardless of vessel size and fishing gear. Typical issues arising are for example when using trawl that the fishermen catch too much in a haul or haul for too long time; when using gillnets, they sometimes leave their nets out for too long; and when using hooks they sometimes gaff the torso of the fish.

Figure 1: Gaffing done correctly.

For boats using trawls, it's highly important not to catch too much in each haul, as it will result in bruising and gaping when the catch is hauled up the shoot. Catching too much in a haul will also make it impossible for the crew to bleed the fish before it is dead. Similar results come from trawling for too long time, as that will also lead to bruising and gaping, from the fish tumbling around in the cod-end. In addition, trawling for too long will stresses the fish which has effect on rigor; and that has then effects on yield and quality.

When using gillnets, it is important to haul the nets as frequently as possible. If the fish is dead in the nets, it is more or less impossible to produce high value products out of those materials. Fish that is bleed post-mortem will be reddish colour and have significantly reduced shelf-life.

When using hooks and lines it is also important to haul as frequently as possible. It is also hugely important to take care when gaffing the fish, as any damage made on the torso will make it impossible to produce valuable products from the raw material. **Error! Reference source not ound.** shows how gaffing should be done correctly, gaffing the head of the fish instead of the more valuable parts of the fish.

Proper use of the fishing gear and the way the gear can be designed and applied to increase selectivity is of significant importance with respect to the LO. Larger mesh sizes can for example allow under MCRS catches and other unwanted catches to escape. Applying different strategies while fishing is also a possibility to avoid UUC. These can then be a part of reducing volumes in each haul and make sure that everything that comes aboard is of the highest possible quality.

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2.2 Bleeding and gutting

Bleeding the fish is a critical process in maintaining quality. Insufficient bleeding will result in more blood getting trapped between muscle layers, leading to bacterial growth and enzyme activity. It is vital not to cut any excess pathways into the fish as this can also cause spoilage bacteria to gain free access into the muscles. When the fish experiences stress, the clotting time of the blood will decrease and if the bleeding procedure is conducted after that time has passed, blood will still be present in veins and fillets. For that reason, it should be a priority to bleed all caught fish as soon as it comes on board. Usually, seawater is the applicable option as the bleeding medium. Recirculating the water in the bleeding tank is important, as is to exchange the water regularly. The time needed to bleed each fish depends on the setup on board, but it is generally thought to be appropriate to allow each fish 10-20 minutes in bleeding, depending on the circulation and water exchange rate.

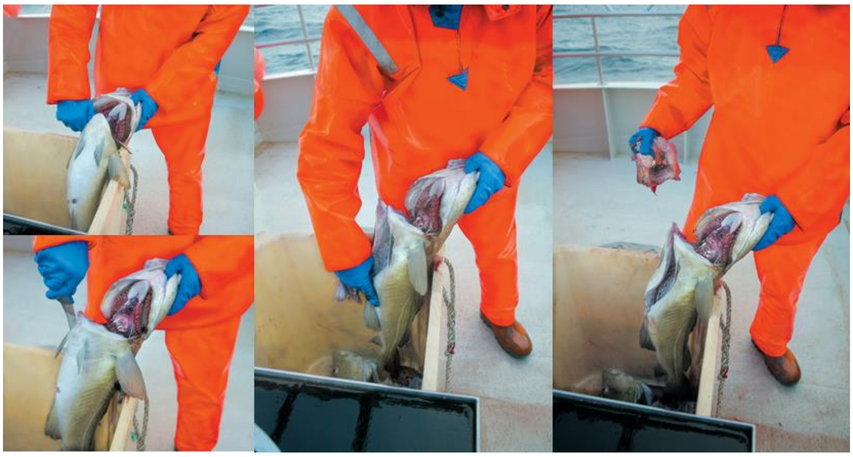

Figure 2: Adequate gutting shown in a few simple steps.

The gutting procedure can either be performed parallel to the bleeding where fish is bled and gutted with one stroke or the preferable option in most cases, to gut the fish after it has finished bleeding in seawater. This promotes to better bleeding and whiter fillets as when the fish is left to bleed with its organs within, the fish will have more energy to twist, which helps with the removal of the blood. Research has shown that the heart keeps beating for a short time after the fish has been bled, which helps with the removal of blood. Veins can even take up seawater to circulate if the upper arteries are cut, which helps with successful removal as well. Figure 2 demonstrates an example of how the gutting can be performed.

There are many types of bleeding and washing mechanisms available. An example of those can be seen in Figure 3. Other solutions, such as simple batch related tanks are also common. They usually have a circulation of seawater and are constructed with a lift in the bottom of the tank to make the fish more easily accessible.

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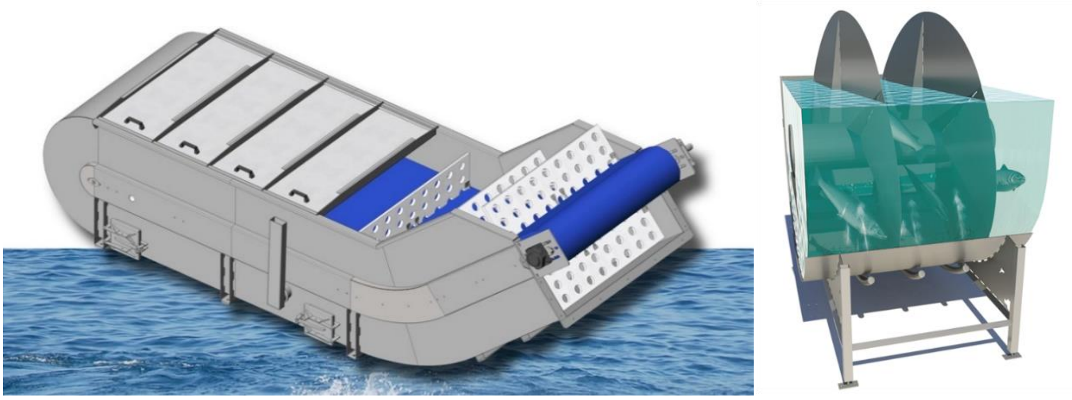

Figure 3: Bleeding and gutting conveyor tanks from Micro Ltd (Left) and rotex from Skaginn 3x Ltd(Right)

Bleeding and gutting tanks need to be designed with first-in-first-out approach and the time each fish is in the tank needs preferably to be controlled. Using these tanks can also be the first step in initiating pre-cooling of the catch.

2.3 Cooling

Once the bleeding has been carried out sufficiently, the fish is passed on to the cooling unit. Normally for boats operating without any automated units, the custom is to put ice into water obtained from the sea and that way create a refrigerated sea water (RSW). This method is in some ways good to obtain proper cooling but it requires full attention of the crew on board as the tubs are not completely insulated and heat from the environment will eventually bring the temperature up. However, optimal cooling is obtained with specially made cooling tanks that bring the temperature of the fish down properly. The temperature of the water inside the cooling tanks should be at around -2 °C to -3 °C as the fish should be able to reach -0.9 °C when in equilibrium. That is the temperature at which the first ice crystals start to form in lean fish such as cod or haddock, but for fattier fish, the temperature of the muscles should reach around -1.2 °C but not lower than -1.5 °C. The time spent in the cooling medium is different depending on the size of the fish as well as the relative water content of the muscle, but for most species 30 minutes to an hour in -2 °C water will bring the temperature to sub-zero figures. This is a good estimate to go by prior to placing the fish in insulated tubs or boxes in the storage hold. By cooling the fish sufficiently before storing, the rigor process is slowed down considerably.

2.4 Storage

After the raw material has passed through the pre-cooling mechanism, it is vital to maintain the temperature that has been reached by placing the fish in insulated tubs or boxes along with ice. If those options are not viable and crates or cases are to be used instead, like for most ships in the European fleet operating in the Bay of Biscay, utmost importance should be placed on keeping the cargo hold cool and maintain the temperature of the fresh catch. Conveyer belts and slides sending the fish down to the hold should be designed to minimise outside impacts on the fish, as they will cause torn muscles and gaping.

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After being placed in the storage hold, the fish should be iced properly to allow for temperature fluctuations without impacting the state of the raw materials. Care should be taken not to put too much fish in each tub/box as the material at the bottom experiences extreme loading with every extra layer of fish added to the tub. Figure 4 shows an example of tubs that can be used.

Figure 4: Typical insulation tubs used by the Icelandic fleet (left) and fish being iced (right).

Most of the European fleet uses the traditional plastic fish boxes (Figure 5). The benefits of these boxes are that they stack very easily and can easily be moved between places, even when full of fish. They are available in various sizes and different colours, which may help with separating between target catches, UUC and fish under MCRS. The disadvantages however, is that they are uninsulated, which means that heat from the environment has easier access into the tray which can cause the ice to melt and possibly lead to heating of the fish as well. In addition, large fish may not fit into these boxes, which can result in fish being bent in the boxes increasing the risk of gaping between the muscles fibres. This occurs when the fish goes into rigor mortis. For this reason, some of the recommendations suggests in the following chapter include replacing boxes with larger 460L insulated tubs.

Figure 5: The original small fishing trays commonly used in Europe

A few factors need consideration in relation to the use of these large tubs. Special care must be taken not to over stack them with fish, since it can put too much pressure on the fish at the bottom leading to bruises and damages in the fish muscle, even though the danger of over stacking the boxes is much less than with the tubs.

3 Small coastal vessels

Statistics for 2015 show that the EU fishing fleet consists of roughly 85 thousand vessels, of which 85% are small coastal vessels below 12 meters in length (EU, 2016). This coastal fleet is quite variable depending on geographical location, target species, age, construction material, engine power and design, ranging from single deck old style wooden jiggers with manually operated handline, gillnet, longline or pot-fishing gear and very moderate engines; to double decked fiberglass boats that are able to reach speeds in excess of 30 nautical miles and equipped with state-of-art autoline systems. It is therefore difficult to recommend solutions that can fit everyone within such a diversified fleet. The lack of space on-board these vessels does also seriously reduce available options. However, with the current development of on-board handling solutions for this fleet, as well as the consensus amongst fishing operators that a good product handling after bringing the catch on board is essential; the recommendations for this fleet segment are mostly awarded to best practice on-board handling of all catches, rather than just for UCC. These recommendations or suggestions have been drawn up in 3D and are now available at the DiscardLess webpage.

An example of a visualization of the hauling station can be seen in Figure 6. Typically, there are two or three crewmembers operating on boats like this, so it is anticipated that one is manning the hauling, another is in charge of bleeding and cooling; and the third is making sure everything goes to plan when putting the fish down in the cargo hold. Naturally, these steps could be performed by two crewmembers, but that would involve more distribution of work and possibly more batch-related fishing instead of a continuous hauling, bleeding, cooling and storing.

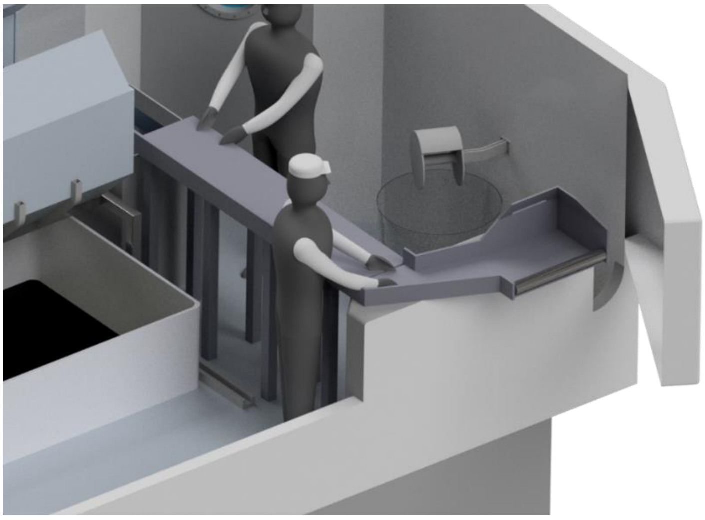

Figure 6: A visualization of the hauling mechanism

The figure above shows the hauling setup as well as giving a glimpse of the bleeding. It is anticipated that after the fish has been hauled on board that it is fed straight to bleeding, where it is cut by the second operator and dropped into a specially designed bleeding tank, like seen on Figure 7.

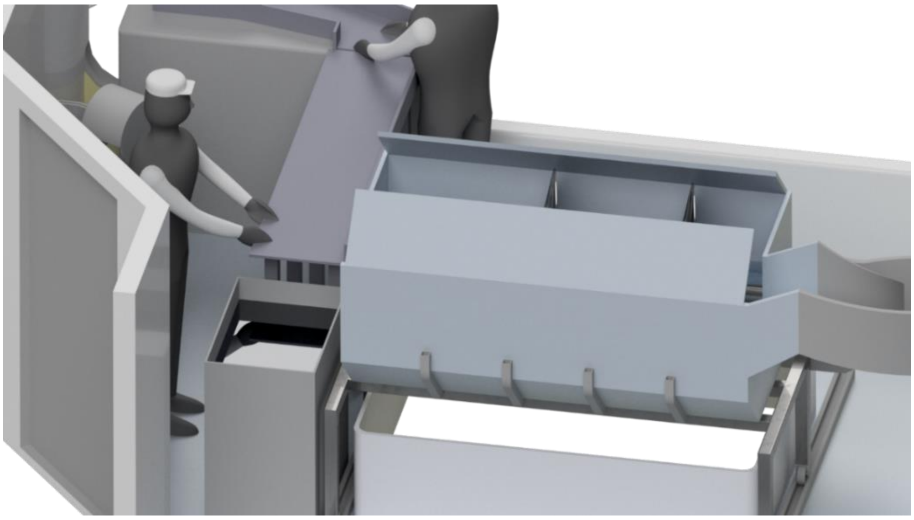

Figure 7: On left, batch related bleeding tank and on right is rotary cooling tank.

Once the bleeding has been carried out sufficiently, the fish is passed on to the cooling unit. Normally for boats operating without any automated units, the custom is to put ice into water obtained from the sea and that way create a refrigerated sea water (RSW). This method is in some ways good to obtain proper cooling, but it requires full attention of the crew on board as the tubs are not completely insulated and heat from the environment will eventually bring the temperature up. Therefore, the tubs must be re-iced regularly, especially during storage on warm days to keep the catch cool. It is therefore suggested in this case to insert a small version of a cooling unit to move the fish through cooling. The unit displayed in the following figures is just an example of what can be installed, but there is a need for some stimulation of the water during the time the fish is transferred through the component. These special rotary systems are also not a necessity, but there are also examples of shovel-type coolers, transferring batches at a time through the cooling units. An example of a visualization of these solutions as well as an example of setup in some boats belonging to this fleet segment can be seen on Figure 8.

As can be seen on the left side of Figure 8, the rotary unit is located above the opening down to the hold. However, the rails seen on the deck floor work as a sliding mechanism, so the unit will be moveable to the side when landing the catch. This is one of the ideas as to how the problem of locating the unit above the deck can be solved. The cooling mechanism can also be fixed at a predetermined location, but that would involve permanently taking up space on the boat for those operations. A fixed setup can be seen on Figure 9, where the bleeding is located beside the cooling tank. However, those tanks are operating in batches, but don't take continuous input like the ones presented in Figure 8. Nevertheless, this setup is also an example of the correct measures for on-board handling. To feed the rotary tank with cold fluid for the cooling process, a specially made refrigerating unit must be installed. This unit must be able to convert enough amount of seawater to slurry to efficiently cool all the material that comes on board.

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Figure 8: A visualization of the cooling above deck in Cleopatra 38 or equivalent sized vessel (left) and a real setup on a slightly larger boat, Cleopatra 50 (right).

Figure 9: A fixed setup on a Cleopatra 38

The normal catch that is the target species of the respective fishing vessel in question should be adhered to as described above and put into the respective tubs. However, the catch that is not a part of the target catches, should nevertheless go through the same steps as the main catch. The difference is however that UUC and particularly catches below MCRS should be kept separate in the hold, in specially labelled tubs or boxes. These tubs could be of different size or colour. An example of this can be seen in Figure 10 where the normal tubs are displayed in yellow and the tubs assigned for UUC/MCRS are displayed as blue.

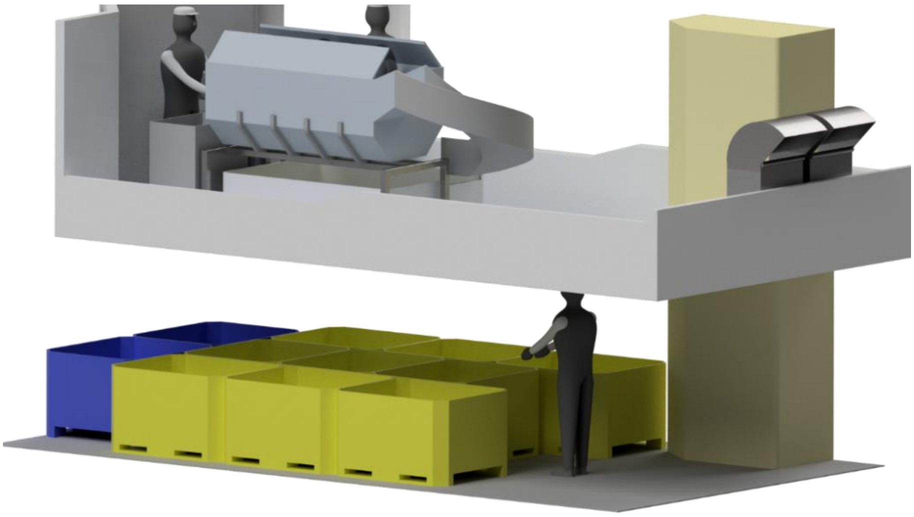

Figure 10: An illustration of the setup in the hold - yellow tubs for normal catch and blue for the UUC

It should be noted that this is not necessarily what is applicable to all vessels operating within this fleet segment, but it shows the recommended way of dealing with the UUC on a double-decked 11-merter long coastal vessel. It is essential to deal with the catch in some way and since there is little to no space on board for any special solutions adhering to these additional species and sizes, they should be handled optimally, just as the target catches being fished and attended to until landing. By doing that, it is ensured that the additional material brought to shore is in good condition and is of more value as results. The 3D drawings are available on the DiscardLess webpage where it is possible to get more information on the recommended solutions. A simple cost-benefit tool that allows stakeholders to estimate the cost of installing and operating these solutions, along with expected value creation is also available at the DiscardLess webpage

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4 Small bottom trawlers and Danish seiner

Small bottom trawlers and Danish seiners are an important segment of the European fishing fleet. The vessels are typically 18 to 30-meter-long, fishing for demersal species such as cod, haddock, hake, place, Nephrops etc. These vessels are variable in size, setup and design. Some are designed to haul the gear in at the rear end while others haul it up against the side. Some of the vessels have the wheelhouse in the front, whilst others have it at the back. Some have the sorting, bleeding, gutting and cleaning on the upper-deck, whilst others have it on the lower deck. This affects the arrangement on the main deck and makes it more difficult to develop one-fit-for-all solutions. The following suggestions are therefore built on the principle of optimal catch handling which can be implemented to almost any boat in this fleet category. A small Danish bottom trawler (similar to the one in Figure 11) has been selected for the demonstration and two main solutions are presented. The first one is a state of the art handling solution with separated bleeding, gutting, cooling stations and sorting of UUC and fish under MCRS. The second solution includes a silage preservation processing unit, which allows for utilization of viscera and offals.

Figure 11: The upper figure shows a trawler similar to the one used for the demonstrations and the lower shows technical drawing of the current processing arrangements on board (1. Reception - 2. Bleeding and gutting - 3. Bleeding / cleaning tank)

As always, the first stage of processing is to bleed the catch and place it in the bleeding tank. The tank can either be constructed as a simple batch related bleeding tank or with conveyor belt to ensure first-in-first-out. This arrangement seen on Figure 12, improves the current bleeding procedures seen on Figure 11, as the fish enters the bleeding tank directly after being cut and doesn't have to wait in the reception tank until gutting is finished. With this arrangement, the fish can be left to bleed with its organs within and the fish will have more energy to wiggle, which helps with the removal of the blood.

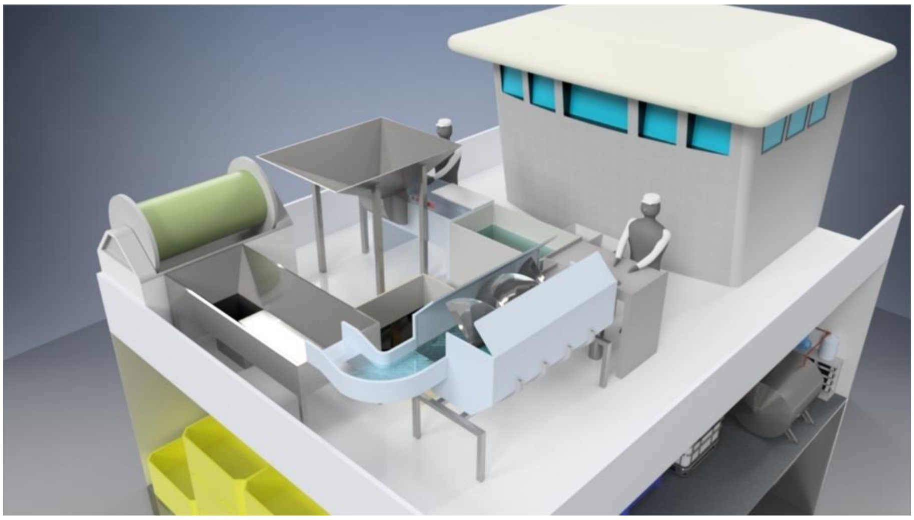

Figure 12: The suggested setup on-board a small Danish Trawler. (1. Reception - 2. Bleeding - 3. Bleeding / cleaning tank – 4. Gutting – 5. Cleaning/Cooling tank – 6. Down to hold)

When the bleeding has been carried out in the bleeding tank, where each fish has been left to bleed for approximately 15 minutes, the fish is gutted at the gutting station. The gutting table as seen on the right-hand side of Figure 13, has built-in holes intended for separation of roe and viscera. The roe can be stored on ice in closed fish tubs and the viscera is either sent to the discard chute or it can be processed into silage.

With this arrangement, it's also possible to sort all UUC and fish under MCRS on the gutting table before send it directly down into specific fish tubs in the hold, in the case these catches do not necessarily have to be cooled to storage temperatures (Figure 13).

The target catches are all sent into the cooling directly after the gutting, which not only cools the fish down but also cleans them. This minimizes the risk of bacterial growth as unwanted liquids and parts from viscera will be removed as well. Cooling of the fish takes approximately 25-30 minute depending on the size of the fish, ambient- and sea temperatures and the amount of slurry ice used. This setup of refrigeration tanks requires installation of a separated refrigerator unit on board the boat for production of slurry ice which is then pumped into the cooling tank. There is a wide variety of cooling tanks available and in principle they are not so different from the bleeding tanks discussed above. The installation of a refrigeration system, however, is slightly more complicated as the boat operators need to make sure that the boat has capacity to produce all the electricity needed for the system.

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Figure 13 shows the bleeding and gutting stations. The figure shows will the tow tubes that are placed next to the person on the gutting station, which lead down to different coloured tubs in the hold for separation of UUC, and fish under MCRS from the main catch (Figure 14). With this arrangement UUC and MCRS catches can be sorted out early in the process which eases the handling. The use of this option is however only applicable if the is no need to properly clean and pre-cool the UUC.

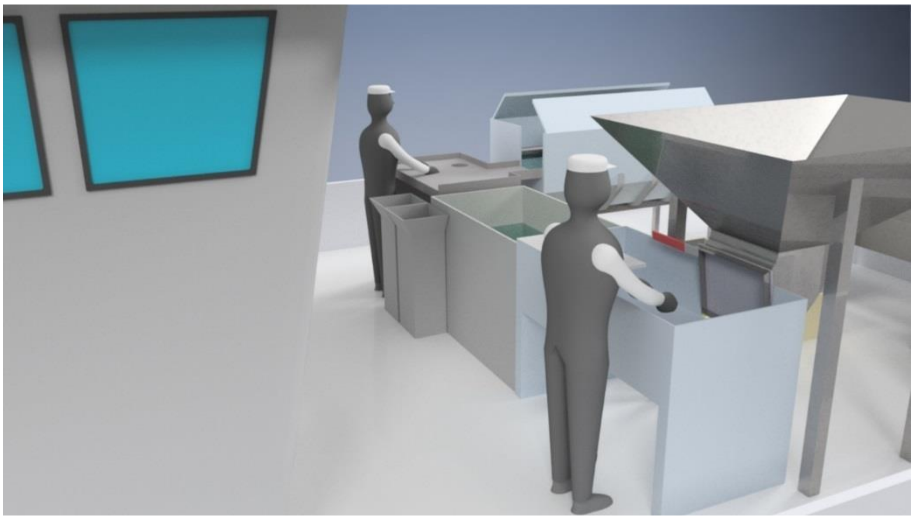

Figure 13: The upper deck of a small bottom-trawler. From right to left is reception, bleeding, bleeding tank, gutting/sorting, tubes for UUC and MCRS and a cooling tank

Figure 14: The setup in the storage hold of the studied Danish trawler

Regarding the target catch or the most valuable species intended for human consumption, special attention must be placed on good handling, the sliders in the hold need to be set up so the fish won't fall or crush into the tubs in the hold. By filling tubs with some slurry ice before placing the fish can reduce the fall and at the same time contribute to better quality.

Crewmembers must be informed about these things and rules defined and made visible of how the fish should be handled. To throw fish when it is being placed in tubs is never acceptable.

One of the alternatives for this fleet segment is to process the excess raw materials, such as UUC, viscera and offal into preserved silage. These secondary material streams are most often sent directly to the discard chute after the gutting procedure. However, these solutions aim to recover this material by producing preserved silage, which could eventually be utilised into silage, fishmeal or other animal feed. The material is gathered on the gutting station, where specific holes on the gutting table are designed to receive the UUC, viscera and offal. Afterwards, the materials enter a mincer that shreds the material and then pump that into a storage unit. The volume is measured during the pumping and the correct amount of acid is then mixed with the material, before entering the storage unit. Simple solutions for storage can be used, such as conventional IBC tanks (Figure 15).

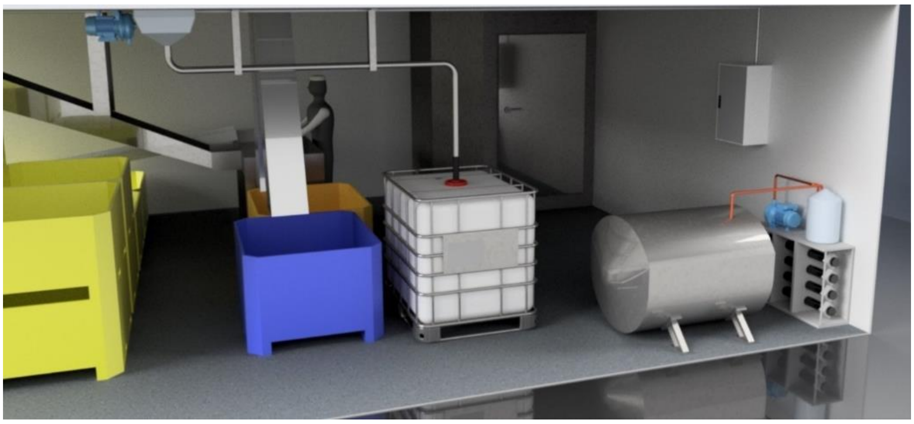

Figure 15: The setup in the storage hold, the slurry ice tank is at the right side, the IBC silage tank in the middle, the fish tubs indented for UUC and fish under MCRS on left.

According to the operators of the bottom trawler used for reference, 86% of the catch consists of cod and lemon sole. These species are very unlike with respect to appearance and the gutting ratios as well. To clarify, the gutting ratios can be around 4% for sole species and 16% for cod. These ratios may, however, vary dramatically between seasons and fishing grounds. Based on this, it is estimated that the average gutting ratio in the catch may be around 10%. This can be roughly translated into volume of silage per fishing trip, as the maximum capacity of the boat is considered 14 tons of gutted weight. According to this, these boats may expect up to 1.6 tons of viscera in each fishing trip, which can translate to about one and a half IBC tank, with each tank worth around 120 EUR. The 3D drawings are available on the DiscardLess webpage where it is possible to get more information on the recommended solutions. A simple cost-benefit tool that allows stakeholders to estimate the cost of installing and operating these solutions, along with expected value creation is also available at the DiscardLess webpage.

5 Medium sized bottom trawlers in the Bay of Biscay

Bottom trawlers ranging between 30-45 meters are common in some countries within the EU. There are for example a large Spanish fleet operating in the Bay of Biscay (BoB) that belongs to that fleet segment. The Spanish BoB bottom trawlers are typically between 34 and 44-meter-long vessels targeting demersal species (Figure 16). These boats face considerable diversity of species in the catch, which has led to high discard ratios of UUC and fish under MCRS. The main target species and the ones that return the highest revenue consist of hake, anglerfishes, megrims and horse mackerel. Despite this, the fleet lands up to 65 other species which indicates how difficult the on-board handling and storage can be.

Figure 16: Typical medium sized mixed demersal bottom trawler fishing in the Bay of Biscay

The suggested solutions aim to improve the on-board condition for handling of the most valuable species, as well as to simplify sorting and storing of UUC and fish under MCRS.

The suggested changes on the processing deck are aimed handling target catch and other valuable catch according to best-practise, where each fish is subjected to optimised bleeding, cleaning, chilling and storage. It does also enable, where appropriate, quick handling of UUC where it is separated from the target cachet and sent directly to the hold.

There are three distinctive paths that lead from the bleeding station. The first handles the UUC and fish under MCRS which are not bled or gutted due to their poor value. The second is for the target catch that only needs bleeding. The last handles the target catch that needs to be bled, gutted and cooled. This makes the processing more flexible, as the target species are bled on time and directly placed in a bleeding tank. Figure 17 shows how two bleeding tanks are placed in front of the gutting station, one can serve as a batch related bleeding tank while the other is constantly conveyed at controlled speed. The reason for this is that some species, such as mackerel are not necessarily desired together with other more sensitive species in both the bleeding and cooling tanks.

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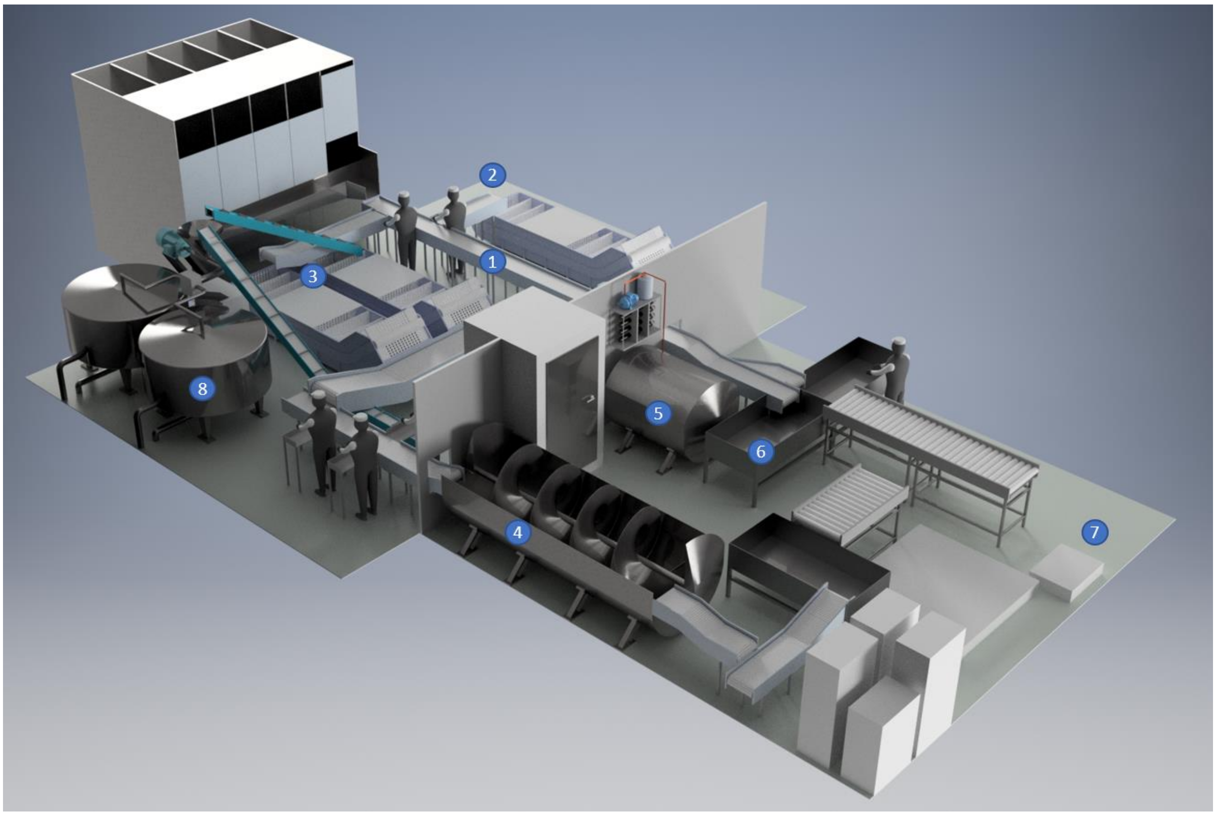

Figure 17: Overview of the production deck. The deck is separated into production room at left and packaging room at right. No.1-Path for UUC/MCRS, No.2-Target catch (only bled), No.3-Target catch (bled, gutted, cooled), No.4-Rotary cooling tank, No.5-Slurry ice buffer tank, No.6-Fish buffer tank with slurry ice, No.7-Elevator down to hold, No.8-Silage unit.

According to this suggestion, there is a wall placed in the middle of the deck to separate between the bleeding and gutting stage and the packaging. This is not a necessity, but can help with maintaining hygienic working conditions.

When the fish arrives into the packaging room, the target catches arrive properly cleaned and chilled thought the rotary cooling tank, while UUC fish enters in the middle of the room and fish under MCRS at the right site, as shown on Figure 18. The tubs are filled with slurry to both cool down the fish and to maintain its temperatures during the time it takes to package and sort the fish into boxes. These boxes are then moved to the elevator which leads down to the storage hold.

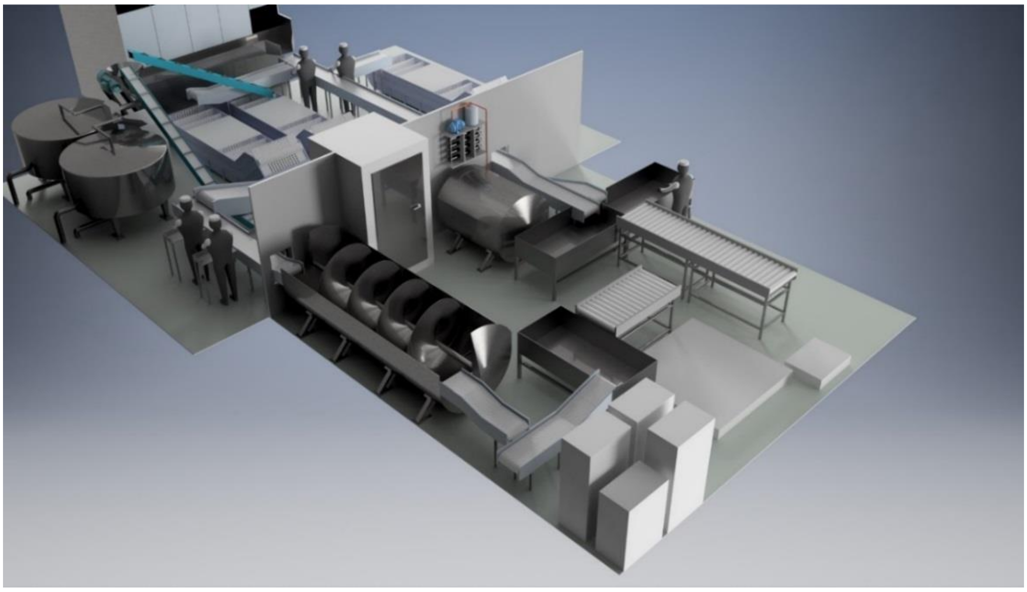

Figure 18: The packaging room. Target species enter out of the rotary cooling tank on left, UUC in the middle and fish under MCRS at the right side.

As with all other cases addressed in this report, the temperature control in the storage hold is essential to maintain the quality of the catch. Keeping the ambient temperature close to 0°C should give optimal products when landed. Placing ice on top of each box before stacking them in the cargo hold also limits the temperature fluctuations experienced by the fish itself.

The LO will force the BoB trawl fleet to change its operations in a number of ways. It will for example need to drastically shorten the fishing trips as some boats operating in those areas have been reported to stay out for almost two weeks – some even longer. But with no discard allowed these boats will reach their carrying limits much sooner than normally and will therefore have to shorten their time spent fishing and land more frequently. This will in turn result in better quality of the raw materials.

One of the alternatives available for handling UUC and MCRS on-board these vessels is to install a silage production unit, which could receive all unwanted biomass. The setup is shown in Figure 19. Conveyor belts lead from the gutting table where viscera and offal's are separated and from the bleeding station where UUC and MCRS catches can be sorted out. The raw material is simply conveyed up into a funnel with a mincer at the bottom that shreds the material. Pump feeds the material into the silage tanks on the main deck and monitors the volume of raw material entering the tank. Formic acid is then added in proportion to that. These two silage tanks seen on the main deck, sometimes called primary silage tanks, are only used to trigger the digestion by applying heat to the material and adding the acid. This ensures even and rapid digestion and more uniform product. When the material has stayed for approximately 24 hours in the primary tank it can be pumped down to specific storage tanks, such as ballast tanks or other available tanks. The required size of each primary day tank is estimated 3 cubic meters and the space required for storage of the silage is 15 cubic meters.

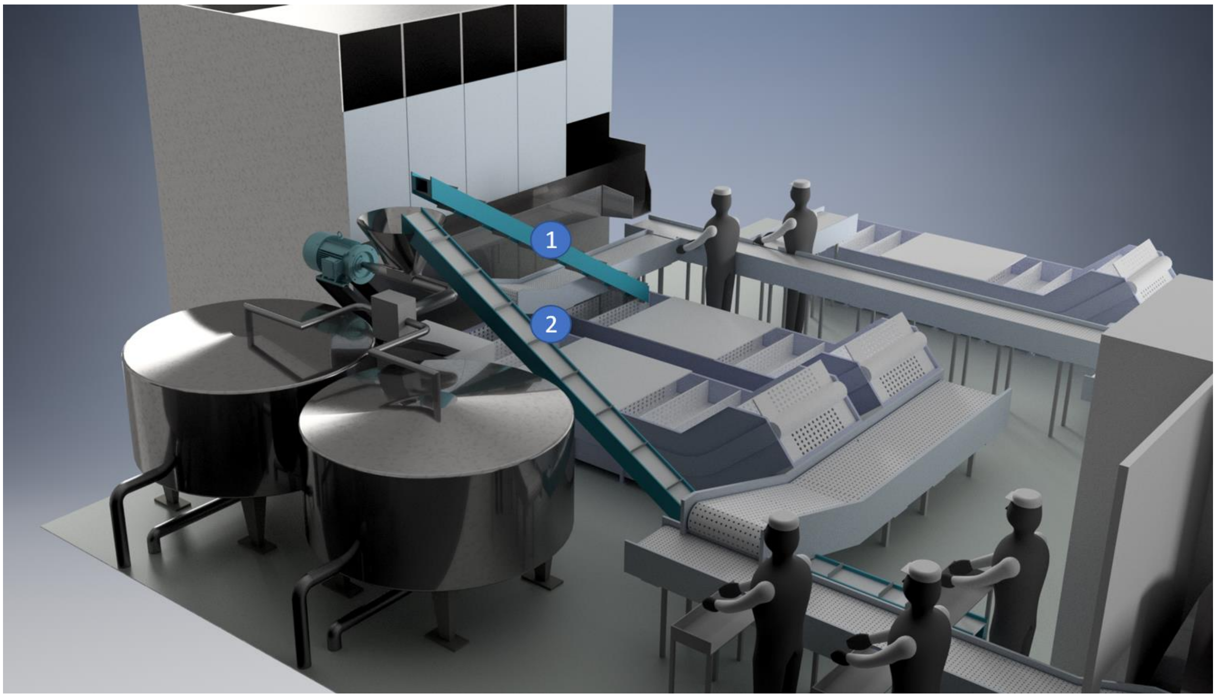

Figure 19: The production room. Two employees perform the bleeding and sorting of the catch in front of the reception, they have the alternative to sort whole UUC and or fish under MCRS on to a conveyor belt that leads to the silage unit or it can be sent straight to packaging. The wanted catch however goes through bleeding and the most valuable catches trough gutting as well. There are three employees performing the gutting beside the two large primary silage tanks. The viscera and the offal's are gathered and utilised into silage. The conveyor No.1 receives whole UUC and MCRS while conveyor No.2 receives viscera and offal's.

The variability in catches and catch composition within this fleet segment is extreme and the suggested solutions presented above are therefore only few of many alternatives. The 3D drawings are available on the DiscardLess webpage where it is possible to get more information on the recommended solutions. A simple cost-benefit tool that allows stakeholders to estimate the cost of installing and operating these solutions, along with expected value creation is also available at the DiscardLess webpage.

6 Large wetfish bottom trawlers

Large wetfish trawlers ranging between 40 and 80 meters represent an important part of the EU fleet. This type of vessels used to be quite common within Europe, but have been decreasing in numbers for the past few decades. This is though still a sizable fleet, which is very efficient and accounts for a significant part of EU catches. The vessels are mostly fishing in deep waters targeting cod, haddock, hake, saithe, redfish, monkfish, place and other similar species.
The setup on-board these vessels can be quite variable, which is why the authors of this report have chosen a "reference vessel" that is used to demonstrate the suggested solutions. The trawlers selected is a 51-meter-long and 12.8-meter-wide wetfish trawler that is mostly operated in the North-East Atlantic Ocean (Figure 20). The trawler has a crew of 14 persons and the average fishing trip is around 6 to 8 days. Their main target species are cod, saithe, redfish, whiting and haddock and the total discard rates have been estimated at 21% in recent years, indicating that there is plenty of UUC that needs to be handled. The boat has a large refrigerated storage hold which is rarely full; so UUC catches and fish under MCRS could therefore be landed in a traditional way without reducing the fishing capacity of the trawler.

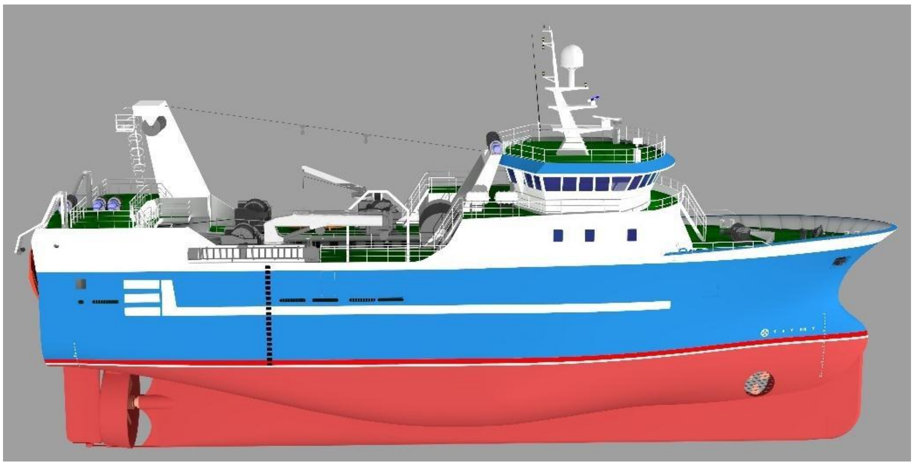

Figure 20: The demonstration vessel.

The general set-up suggested for the vessel is aimed at ensuring best-practice handling of the catches, whilst providing an option for less intensive handling of lower valued UUC.
The catch is brought in from the reception onto a main conveyor belt placed in the middle of the deck, as shown on Figure 21. The crewmembers are located on each side and perform both sorting and gutting of the fish. Target species that need to be bled and gutted are drawn from the main conveyor, processed and placed on either of the two conveyors leading to the bleeding and cooling units. Viscera and offal that are left over at the gutting station are transferred into slides located under each gutting board and to a conveyor that leads to the silage mincer. Other parts such as liver and roe can be sorted into specific holes in the gutting table before being transferred in pipes to storage tubs located in the hold. This arrangement allows for 100% utilisation of all catches and ensures that nothing goes to waste.

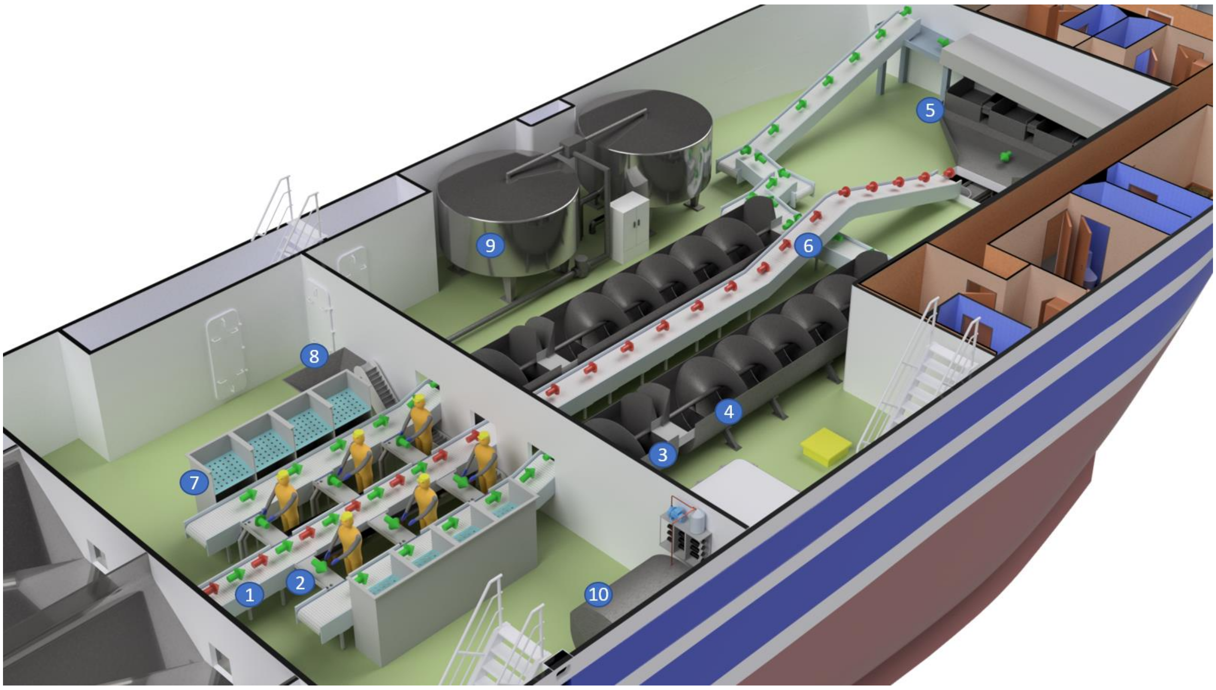

Figure 21: Overview of the production deck. No.1-Main conveyor, No.2-Gutting board, No.3-Bleeding tank, No.4-Rotary cooling tank, No.5-Automatic sorting unit, No.6-Mayn conveyor (no bleeding or gutting), No.7-Sorting tubs for MCRS, No.8-Silage mincer, No.9-Silage day tanks, No.10-Slurry ice buffer tank.

One of the advantages of this system is that fish species such as redfish that are not bled, gutted or cooled can be conveyed directly down to the hold on the main conveyor. This eases the handling when redfish is caught in large volumes as workers won't have to lift or transfer large amount fish between conveyor belts. The reason for redfish not being treated as cod and saithe and sent to bleeding and cooling is due to buyer's requirement of redfish.

The sorting takes place on the gutting station, where UUC and fish under MCRS can be sorted into specific temporary-storage tubs for later processing or sent directly with the viscera into silage processing, as shown on Figure 22. These tubs are filled with slurry ice, as they may have to stay there for some amount of time before being processed. When it comes to processing these catches, the bottom plate of the tubs is raised and fish brought up on the conveyor belt for processing. These tubs are also used for other target species that are caught in small volumes.

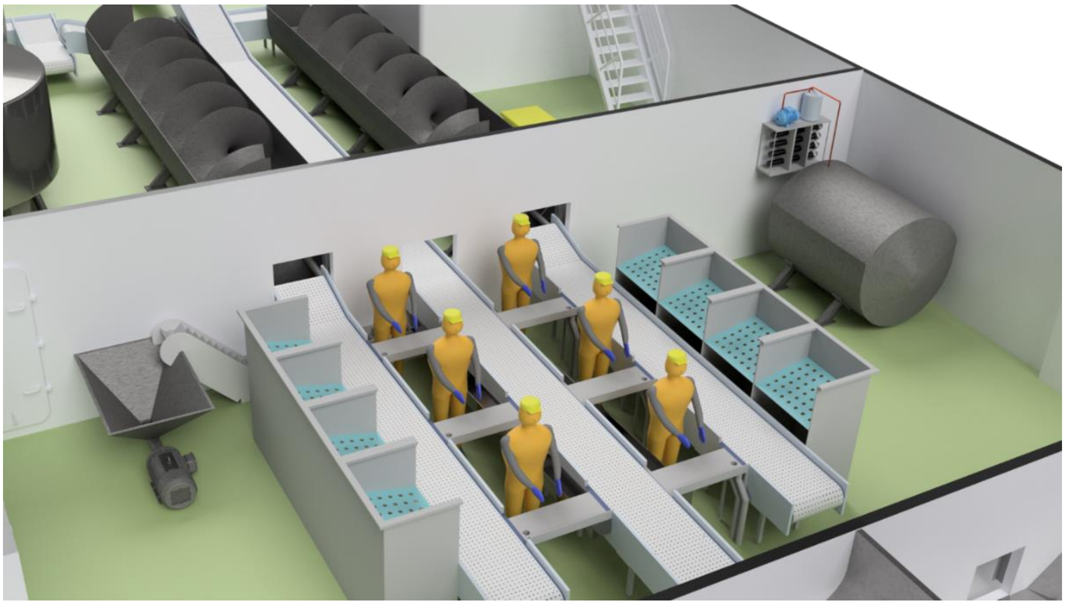

Figure 22: On left, silage mincer and the silage conveyor. In middle, is the gutting and sorting station with the main conveyor in the middle, gutting tables with holes in it and sorting tubs on the sides. On right site is the slurry ice buffer tank.

As for the previous case, focusing on the vessels operating in the Bay of Biscay, silage production is an interesting alternative when it comes to utilizing viscera, offal, UUC and possibly fish under MCRS. The applicability of this solution might however need a legal review since vessels are obliged to land these catches separately. These recommendations are therefore presented as an alternative over the status quo scenario with the knowledge of the fact that some legal issues should be addressed. There are however examples from within EU where vessels have been granted permission to produce silage on-board (Fiskeritidende, 2016).

The first stage of the silage production is to gather the raw material. Slides are located under each gutting station so that crewmembers can trough in viscera, offal's, UUC and fish under MCRS. These slides lead down to a conveyor belt which feeds the material to a mincer. The mincer shreds the material apart and feeds it forward with the help of a pump into the primary silage tanks. In these tanks, commonly referred to as day tanks, formic acid is mixed in proportions with the raw material and heated up to 25-30 °C to speed up the digestion and to create a more uniform product. Each tank has a pump for constant circulation of the material to prevent settling of bones and other particles.
When the material has been kept in these conditions for approximately 24 hours it is pumped into a storage tank, which can be located at any place where space can be found and so that they are easily cleaned and emptied. Taking into consideration the expected catches of this vessel, the day tanks should hold 6 cubic meters each and the storage tank approximately 30 cubic meters. These two tanks, both the primary as well as the storage tanks can be seen in Figure 23.

Figure 23: The primary silage tanks (top) and the storage tanks (bottom)

The variability in catches and catch composition within this fleet segment is considerable and the suggested solutions presented above are therefore only few of many alternatives. The 3D drawings are available on the DiscardLess webpage where it is possible to get more information on the recommended solutions. A simple cost-benefit tool that allows stakeholders to estimate the cost of installing and operating these solutions, along with expected value creation is also available at the DiscardLess webpage.

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7 The Cost-benefit tool

Amongst the tasks reported on in this report was to develop a simple cost-benefit tool that would allow stakeholders and, in particular, fishing vessel owners, a chance to estimate the investment and operational costs of the suggested solutions, as well as estimating the likely economic returns.

This tool is now available at the DiscardLess webpage. It is excel-based, which means that the users can download the tool and manage the numbers within it to fit them to their respective operations. It is designed for each of the four fleet segments discussed previously in this report. It allows stakeholders to enter their own assumptions regarding expected catches, composition, UUC, MCRS etc. It is then offered to select from different technical options, which in turn estimates the total investment cost and likely added landing value. Figure 24 shows a screenshot of the tool.

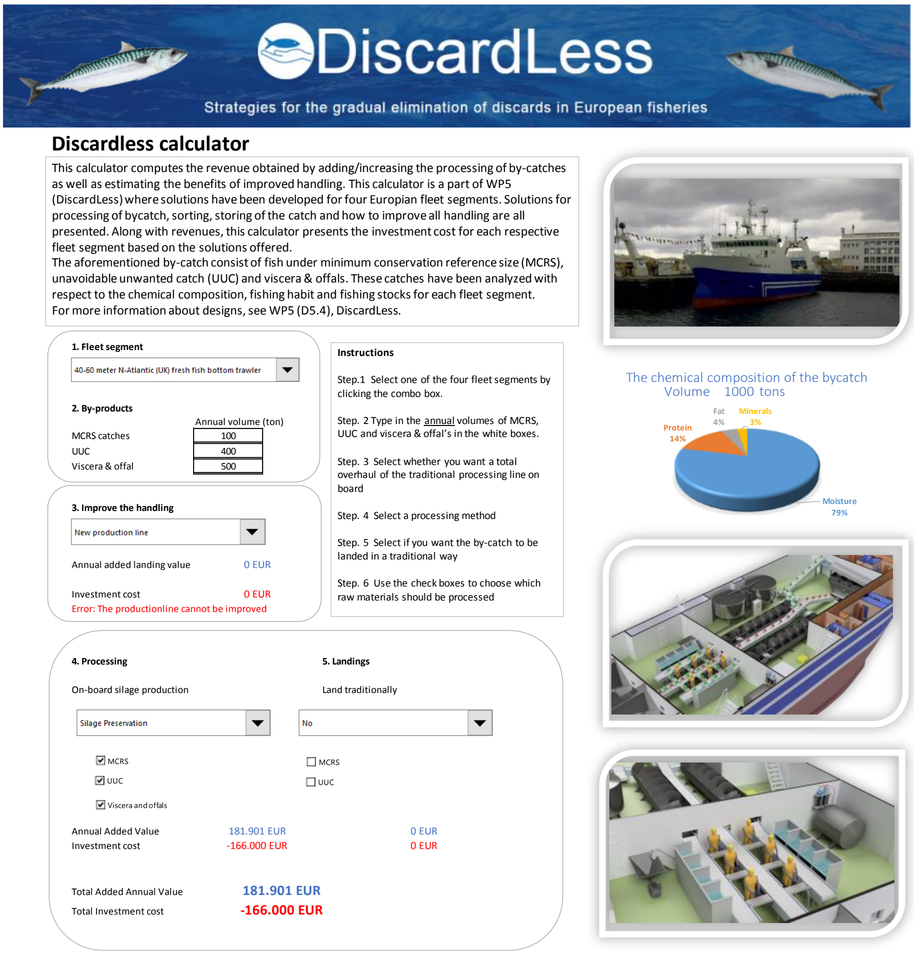

Figure 24: Screenshot of the cost-benefit tool

It needs to be taken into consideration that the tool is only intended to give a rough estimation of potential investment cost and the likely return. The tool is mostly based on a number of assumptions, which are made with the best available expert knowledge. These assumptions along with mass balance and cost benefit equations are presented in appendix A and B.

8 Discussion

Proper handling of all catch and organization of equipment and staff on-board fishing vessels is an essential part of returning highest quality material to shore. The solutions offered in this report focus on these aspects by limiting all physical impacts the fish might experience on its way to the cargo hold, focusing on correct bleeding and cooling procedures of catch meant for human consumption and categorization of each species into respective storage. Four unique case studies were tackled, each representing one specific fleet segment, ranging from small coastal vessels up to large trawlers operating in the North-East Atlantic. In all cases except for the smallest vessels, an on-board silage production was presented as an alternative to discarding UUC and fish under MCRS. These silage systems were different for each fleet segment, but relied on the same core principles. It is up to each respective vessel to choose what might be utilized into silage and what should be stored in the cargo hold. Different market values for each species based on location might affect these decisions, as well as available space on-board. Nevertheless, it is essential that the main catch meant for human consumption is handled adequately to improve quality for the consumer and extend shelf life.

There are limited options available for handling the UUC and those options are dramatically reduced as the vessels get smaller. The smallest vessels are only able to store UUC and below MCRS separately and then need to transfer the responsibility for further handling ashore. The larger vessels have more alternatives, such as sorting into differently coloured tubs, bulk storage, mincing, compressing, silage production (FPH/FPC), fishmeal production and other alternatives, which have been identified in D5.2. In this report, the most applicable solutions have been selected for further development. There may be other alternatives available and even more practical, but these are the once selected by the authors to expand on. The hope is that this report and the 3D drawings, along with the cost-benefit tool that is now publicly available at the DiscardLess webpage, will contribute to better understanding of some of the available options that can facilitate successful implementation of the CFP LO.

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Appendix – A – Equations and methodology used in the cost benefit tool

In principle, when it comes to cost benefit analyses, the evaluation of investment costs, added value due to improved handling procedures or landings of UUC and MCRS catches, is largely based on assumptions and available data. When it comes to estimating potential revenue of silage production however, slightly more complex and accurate approach is recommended. Silage is known to be sold directly to life stock producers such as mink or pig farmers but the current and most common and convenient way is to sell silage directly to fishmeal producers. There is always a demand for fresh and good raw material in the fishmeal industry. Producing silage when the raw material is freshly caught on board fishing vessels is a good way to make sure that the quality of the final product is high and therefore convenient for fish meal production. The fishmeal producers are furthermore much more accessible than the livestock farmers which simplifies both landings and transportation of the material. For that reasons, the cost benefit tool presented with this deliverable assumes all silage is to be sold directly to a fishmeal producer.

When fishmeal producers buy raw material, they put a high emphasis on good quality and the chemical content. Fishmeal and fish oil is priced relative to many quality factors and it can become difficult to evaluate quality in advance. For that reason, producers use the chemical composition and mass balance calculations to determine how much fish oil and fishmeal can be produced from the raw material. These calculations are based on the principal of conservation of mass. The main material streams are the mass balances of oil, moisture and fat free dry matter. The fishmeal process involves removing oil and water from the raw material producing dried fishmeal and fish oil. The calculations are conducted by assuming for specific water and oil content of the fishmeal. The fish oil is assumed to be pure fat and that the material vapor is assumed to be pure vapor. With that known, the amounts can be solved out of the following four equations.

$$m: mass$$
$$x: chemical\ content$$

Mass balance:

$$m_{silage} = m_{vapor} + m_{oil} + m_{fishmeal}$$

Fat free dry matter balance:

$$m_{silage}(x_{protein} + X_{minerals}) = m_{vapor} * 0 + m_{oil} * 0 + m_{fishmeal}(X_{protein} + X_{minerals})$$

Fat balance:

$$m_{silage}(x_{fat}) = m_{vapor} * 0 + m_{oil} * 1 + m_{fishmeal}(X_{fat})$$

Moisture balance:

$$m_{silage}(x_{moisture}) = m_{vapor} * 1 + m_{oil} * 0 + m_{fishmeal}(X_{moisture})$$

Matís has for decades cooperated with the largest fishmeal producers in Iceland, both regarding cost benefit analyses and other more specific analyses on the production. The experience indicates that the cost of raw material is most often around 65% of the revenue of sold fishmeal and fish oil in these fishmeal factories. This knowledge can be used to determine the silage value by estimating the revenue of the potential fishmeal and fish oil and multiply it with 65% to obtain the silage value.

When the chemical composition and the amounts of fishmeal and fish oil have been determined, the potential revenue can be calculated by using world prices for fishmeal and oil. The fishmeal prices are most often represented as a price per ton fishmeal with at least 65% protein content. To take advantage of this and considering the chemical composition of the fishmeal which is a determining factor regarding its quality and its functionality in aquaculture for example, the prices are converted to price per ton fishmeal protein. As can be seen below, the fishmeal prices are assumed to be 1000 EUR per ton fishmeal with 65% protein content.

Fishmeal value:

$$Fishmeal\ prices = 1000\ (\frac{EUR}{ton\ fishemal\ 65\%\ protein})$$

$$Fishmeal\ protein\ price = \frac{1000}{65\%} = 1538.46(\frac{EUR}{ton\ fishemal\ protein})$$

$$Revenue_{Fishmeal} = m_{fishmeal} * x_{protein} * Fishmeal\ protein\ price$$

Oil value:

Regarding fish oil, the amount of oil is multiplied with world fish oil prices, assuming for bulk deliveries.

$$Fish\ oil\ prices = 1424\ (\frac{EUR}{ton\ fish\ oil})$$

$$Revenue_{oil} = m_{oil} * x_{fat} * Fish\ oil\ price$$

Silage value:

When the revenue of the potential fishmeal and fish oil has been determined these values are adde and multiplied with 65% to get the purchase price of silage into fishmeal factory.

$$Revenue_{silage} = \left(Revenue_{oil} + Revenue_{fishmeal}\right) * 65\%$$

Appendix – B – Assumptions for the cost benefit tool

The establishment of a cost benefit calculator requires many assumptions to be made to represent different fleet categories, marine areas and catch composition. These following assumptions consider the chemical content, investment costs, the potential added value and sales prices. These are more or less assumption that have already been made in deliverable 5.2.

Table 1: Combined chemical composition of viscera and offal, MCRS and UUC for three fleet segments based on landing and discard data. These values are used to establish the chemical content of silage for the three following fleet segments.

	Moisture	*Protein*	*Fat*	*Minerals & other*
Small bottom trawlers in North Sea				
Viscera & offal	83%	10%	4%	3%
Medium sized bottom trawlers in Bay of Biscay				
MCRS	65%	18%	16%	1%
UUC	80%	17%	2%	1%
Viscera & offal	70%	13%	14%	3%
Large wetfish bottom trawlers in North Sea				
MCRS	73%	18%	8%	1%
UUC	75%	18%	4%	3%
Viscera & offal	83%	10%	4%	3%

Table 2: Annual added sales value gained by improving the onboard handling procedures and the investment cost based on deliverable 5.2

	Annual added value	**Investment cost**
Small coastal vessels in North Sea	40000 EUR	70000 EUR
Small bottom trawlers in North Sea	90000 EUR	100000 EUR
Medium sized bottom trawlers in Bay of Biscay	300000 EUR	215000 EUR
Large wetfish bottom trawlers in North Sea	0 EUR	0 EUR

Table 3: Sale prices for fish under minimum conservation reference size (e. MCRS) and unwanted unavoidable catches (e. UUC)

	MCRS		**UUC**	
Small coastal vessels in North Sea	1	EUR/kg	0,6	EUR/kg
Small bottom trawlers in North Sea	1	EUR/kg	0,6	EUR/kg
Medium sized bottom trawlers in Bay of Biscay	1	EUR/kg	0,6	EUR/kg
Large wetfish bottom trawlers in North Sea	1	EUR/kg	0,6	EUR/kg

Table 4: Estimated investment cost of installing silage production unit based on deliverable 5.2

	Investment cost	
Small bottom trawlers in North Sea	50000	EUR
Medium sized bottom trawlers in Bay of Biscay	143000	EUR
Large wetfish bottom trawlers in North Sea	166000	EUR