This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 633680

Deliverable No. 5.1

DiscardLess

Strategies for the gradual elimination of discards in European fisheries

Grant agreement No: **633680**
Project co-funded by the European Commission within the
Horizon 2020 Programme

Start date of project: **1st March 2015**
Duration: **48 months**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 633680

Deliverable 5.1

Report on current practices in the handling of unavoidable, unwanted catches

(Month 6)

Due date of deliverable: 31 August 2015

Actual submission date: 07 December 2015

Dissemination Level: Public

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How to cite this document: Viðarsson *et al.*, 2015. Report on current practices in the handling of unavoidable, unwanted catches (Horizon 2020 DiscardLess Report D5.1) Zenodo doi: 10.5281/zenodo.1204294

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Revision Control

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Executive Summary

This document is the first deliverable in work package 5 of the DiscardLess project. The project is intended to contribute to a successful implementation of the landing obligation of the reformed Common Fisheries Policy of the EU. The work package 5 focuses on how unwanted, unavoidable catches can be handled on-board the fishing vessels i.e. from catch to first sale. The first step in that work is to provide an overview of current practices in the handling of unwanted catches, which is done in this deliverable. Discard estimates in global and European fisheries are presented; the most common methods of discarding and associated incentives are reviewed; the landing obligation of the CFP as well as landing obligations in other countries are accounted for; monitoring, control and surveillance alternatives are discussed and a number of initiatives temped to reduce bycatch and discards are reviewed.

The objective of this deliverable is to present basic back-ground information on discard mitigation issues and the available tools for battling the discard problem. Most of the discard issues and the available tools presented are not directly relevant for what can be applied on-board of the fishing vessels, but are nevertheless necessary information for project partners and stakeholders to identify possible on-board solutions.

The focus on what happens to unwanted catches on-board the fishing vessel has mainly been on monitoring, control and surveillance, where Fully Documented Fisheries and the use of Closed-Circuit Television to monitor catches and discards have been at the forefront. There has however not been much attention given to what to do with the unwanted catches once they have been taken aboard the fishing vessels. Species not covered by catch limits, species where high survivability can be demonstrated and catches falling under the de minimis exceptions can still be discarded under the CFP landing obligation; but everything else will need to be landed. In addition will catches under Minimum Conservation Reference Size need to be landed, but cannot be used for direct human consumption. It is clear that storage space will become an issue for much of the EU fleet when the landing obligation is implemented. The available alternatives for addressing that challenge are scarce, but some of the countries that have been working under a discard ban have been trying to find solutions. These solutions are though generally only applicable for large-scale vessels; but 83% of the EU fleet is under 12 meters long and 98% are under 30 meters.

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Abbreviations	
CBA	Capture Based Aquaculture
CCQS	Cod Catch Quota Scheme
CCTV	Closed-circuit Television
CFP	Common Fishery Policy
CQM	Catch Quota management
EC	European Commission
EFTP	European Fisheries Technology Platform
ERS	Electronic Monitoring System
EU	European Union
FDF	Fully Documented Fishery
FPC	Fish Protein Concentrate
FPH	Fish Protein Hydrolysate
DFO	Department of Fisheries and Oceans Canada
HMS	Highly migratory species
ICT	Information and Communications Technology
IT	Information Technology
ITQ	Individual Transferable Quota
IVQ	Individual Vessel Quota
MCRS	Minimum Conservation Reference Size
MCS	Monitoring, Control and Surveillance
MLS	Minimum Landing Size
REM	Remote Electronic Monitoring
RRM	Rest Raw Material
STECF	Scientific, Technical and Economic Committee for Fisheries
TAC	Total Allowable Catches
UUC	Unwanted, Unavoidable Catches
VMS	Vessel Monitoring System
WP	Work Package

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1 Introduction

Discards have been a part of fishing practices in most fisheries around the world since modern fisheries began. Fishermen have selected what fish to keep and what to release or throw back into the sea long before quotas and catch limits were invented. The introduction of quotas has however created new incentives for discarding, as fishermen try to maximise the value of their catches under quota regime. Unwanted catches, such as low value bycatches, catches exceeding quotas and catches of target species that are unlikely to attain highest prices are thrown back overboard due to this, and much of these catches are dead or dying. This has been the common practice in European fisheries under the Common Fisheries Policy (CFP) of the European Union (EU). European fishermen have annually discarded more than 1.5 million tonnes of perfectly good fish in order to maximise the value of their catch (EC, 2011a). This practice has though in recent years become more and more under debate, to a point where it has come to be literally unjustifiable for policy makers, fishermen and the public in general. As results the European Commission has introduced a discard ban as a part of the most recent reform of the CFP (EC, 2013). This means that all catches of species subjected to catch limits will have to be landed and will be counted against quota. The discard ban will be gradually implemented, as the first fisheries became subjected to this landing obligation in beginning of 2015 and by 2019 all EU fisheries will be required to land all catches.

The landing obligation presents a number of challenges for the European seafood sector. Fisheries strategies of individual fishermen will have to be enhanced, selectivity of fishing gear will need to be improved, on-board handling, sorting, storing and monitoring of compliance will need to be reconsidered, land based processing will have to adjust to different supplies and the markets will be affected. The aim of the DiscardLess project is to suggest solutions to these challenges and one of the initial steps to do that is to review current practices in handling of Unavoidable, Unwanted Catches (UUC). This document provides an overview of discards in marine fisheries, explains the primary reasons for discarding, accounts for the main discard practises, details what the new CFP landing obligation includes, reviews experiences and lessons learned from countries where landing obligation has been in effect for some time, gives an overviews of how discards can be monitored and accounts for some of the initiatives that have been tried to reduce discards and what can be learned from them.

This document is the first deliverable in work package 5 of the DiscardLess project. This work package focuses on how UUC can be handled on-board the fishing vessels i.e. from catch to first sale. The objective of this deliverable is to present basic back-ground information on discard mitigation issues and the available tools for battling the discard problem. Most of the discard issues and the available tools presented are not directly relevant for what can be done on-board of the fishing vessels to put a stop to discards, but are nevertheless necessary back-ground information for project partners and stakeholders to identify possible on-board solutions.

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2 Discards in marine fisheries

The extent of discards in global marine fisheries is difficult to estimate. Probably the most comprehensive studies carried out to attempt quantifying discards on a global level were carried out by FAO in 1994 (Alverson, Freeberg, Pope, & Murawski, 2004) and again in 2005 (Kelleher, 2005). The 1994 estimates reported global discards to be between 17.9 and 39.5 million tons (average 27.0 million tons), but the 2005 study gave estimates of 7.3 million ton yearly average discards, indicating that 8% of global catches were being discarded. The methodology and conclusions of these reports have since then been challenged, but a more comprehensive study has though not been performed on this level. A large number of studies have been done focusing on specific areas, fishing gear and target species, giving variable results. An update of this FAO worldwide estimate is foreseen for 2016.

According to Kelleher (2005) there is a significant difference in discard rates depending on fishing gear and fishing area. Discards in shrimp trawl fisheries can for example vary between 0% and 96%, with an average of 62.3%, as can be seen in Table 1 (Source: Kelleher, 2005).

Table 1: Summary of discards by major types of fishery

Fishery	Weighted average discard rate	Range of discard rates
Shrimp trawl	62,3%	0-96%
Tuna and HMS longline	28,5%	0-40%
Dredge	28,3%	0-60%
Mobile trap/pot	23,2%	0-61%
Demersal finfish trawl	9,6%	0,5-83%
Demersal longline	7,5%	0,5-57%
Tuna purse seine	5,1%	0,4-10%
Midwater (pelagic) trawl	3,4%	0-56%
Handling	2,0%	0-7%
Gillnet	1,5%	0-66%
Multigear and multispecies	1,4%	n.a.
Small pelagic purse seine	1,2%	0-27%
Tuna pole and line	0,4%	0-1%
Hand collection	0,1%	0-1%
Squid jig	0,1%	0-1%

In the period since Kelleher did his study, there have been advances in development of more selective gear, areas with high bycatch rates have been protected, stricter control mechanisms have been implemented and better information is now available on areas and catch composition. All this is likely to have contributed to decreasing discard rates, but studies do though give conflicting results.

According to Kelleher (2005) there is a significant difference in discard rates between FAO areas. Discards in the NE-Atlantic were estimated at just over 1.3 million tonnes, which relates to 13% discard rates. The estimates for the Mediterranean and Black Sea were 18 thousand tonnes

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that represents 4.9% discard rate. Discard rates for FAO fishing areas as estimated by Kelleher can be seen in Figure 1 (Source: Kelleher, 2005).

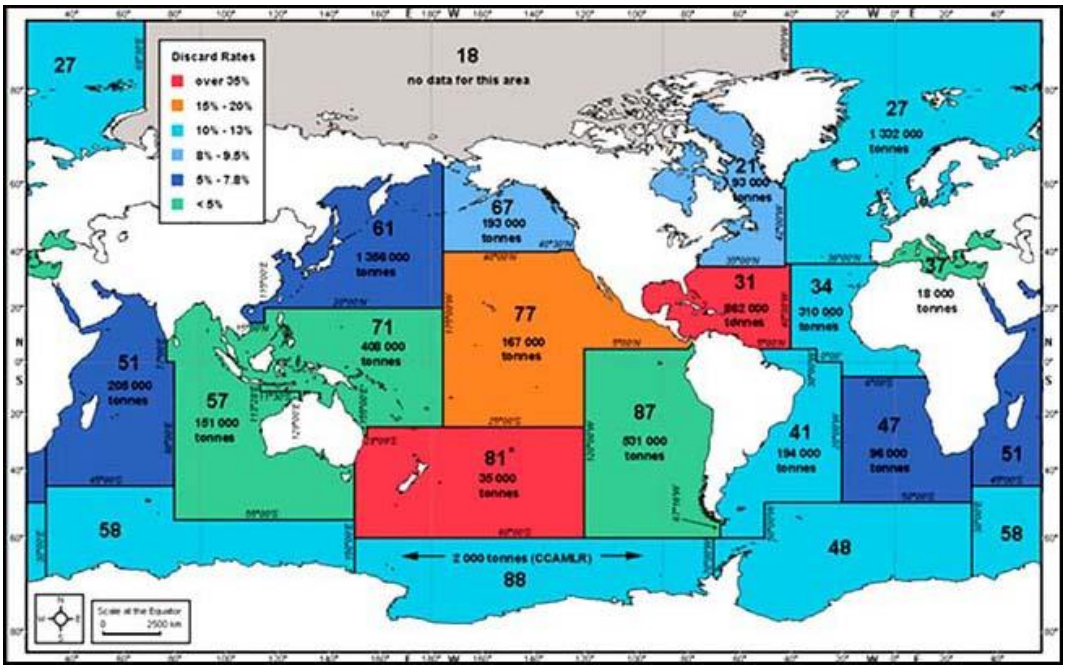

Figure 1: Recorded discards by FAO statistical areas

Whether these number are still valid or not is difficult to confirm. In a study published by the EC in 2011 (EC, 2011a) it was for example estimated that discards from EU fisheries were around 1.7 million tonnes, which represents a 23% discard rates. These numbers are not too fare from the results of Kelleher from 2005, having in mind that countries sharing FAO area 27 with the EU are generally known for low discard rates.

The utilisation and discarding varies a lot from one fishery to another. It is dependent on a large number of variables, such as the regulatory bodies that are set to monitor and control the fisheries and the cultural background from which the fishermen are coming from. There can for example be variability between fisheries working under the same framework, where culture and traditions may explain why it is accepted to discard in one fishery and not the other. There can also be a difference in "discard culture" between communities within the same fishery.

Looking at the EU fisheries as a whole, it is estimated that 23% of total catches are discarded annually (EC, 2011a). The accuracy of this estimate is though not perfect. Monitoring of discard rates are to a point covered under the European Data Collection Framework, that collects detailed biological data of the biomass, length, age, and species compositions of discards from the most important commercial fisheries (Quirijns & Pastoors, 2014). These are collected via national observer- or self-sampling programmes. Because the discard data are merely recorded from <2% of all fishing operations, they are extrapolated based on a fleet's fishing effort. Each Member State is obliged to provide these raised data for a selected number of species to the STECF as part of a detailed data call each year. However, not every Member State has the capacity to sample all relevant fisheries, so in case of missing values, fill-ins are made drawing

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upon available information from related fisheries. It is therefore clear that these estimates are not very accurate. In addition, the fact that 83% of the 85 thousand registered vessels in the EU fishing fleet are less than 12 meters long and therefore not providing data at the same accuracy level as the larger vessels, only adds to the level of uncertainty in estimating discards (EC, 2011a).

Discarding in the Mediterranean varies highly along the basin, both geographically and among the different fishing gears; with bottom trawls being responsible for the bulk of discards (Tsagarakis, Palialexis, & Vassilopoulou, 2014). Midwater trawls, purse-seines, and small-scale fisheries, have lower overall discard rates than bottom trawls, but produce nevertheless high discards quantities, since they are responsible for the majority of the landings. Discarding in the Mediterranean is to a point regulated by market demands rather than by legal constraints, and marketable bycatch may constitute an important supplemental source of income. A pattern in resource use related to socio-cultural characteristics is apparent, with welfare communities discarding more in terms of percentages. Natural conditions (e.g. environmental gradients) and fishers' strategies also substantially affect discarding.

The aim of this chapter is simply to identify the severity of the discard issue as a global challenge. Quantification of the problem is difficult and there are a large number of contributors that effect discards. Fishery-, spatial-, species-, gear- and cultural dependant issues are among those that need to be taken into consideration.

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3 Discard practices

Prior to the implementation of the landing obligation it has been an offence for a fishing vessel to land any fish for which it does not have valid quota or which is outside regulated size limits. At the same time it has been legal to discard any unwanted catches, which has naturally resulted in massive discards. Catches of species exceeding quota have been discarded, catches of species for which the vessel still have quota for have been graded and the part not likely to attain top value discarded (i.e. highgrading), all catches under minimum landing size (MLS) have been discarded (or landed illegally), as well as species of low commercial value. Deliberate slipping and discarding of bycatches in pelagic fisheries have also been common practices. Following is a brief description of the most common discard practices in EU waters. Further details on this can also be found in DiscardLess D1.1

3.1 Discarding of choke species

Most EU fisheries are governed by some sort of quota allocations to individual vessels, giving them limits on allowable catches of key species. In mixed fisheries it is inevitable that vessels will use up their quotas in one species, whilst still having unused quotas in other species. These so-called "choke species" place constraints on the fishery where one species can severally hinder fisheries for other species. For the most parts, EU fisheries in the past have dealt with choke species by simply discarding catches that exceed quotas. In some cases these can represent a significant part of the total catches in individual fishing trips. The concept of catch quota management (CQM) as stated in the Council of ministers General Approach of June 2012 does though entail that once the quota of one species has been taken in a mixed fishery, the fishery must stop (Schou, 2013). The least plentiful quota allocation will therefore "choke" the mixed fishery.

There are a number of available tools for reducing incentives for discarding choke species. The landing obligation includes for example a 10% year-to-year flexibility for this purpose; transferability of quotas can also be adopted between vessels or fisheries; but the fishermen do also have to take on responsibility for targeting species in correlation with their quota allocations.

3.2 Discarding catches under MLS

Minimum landing size has been applied in EU fisheries, and other fisheries around the world, in order to protect juveniles. This means that all catches under a predetermined size limits cannot be legally landed. The implementation of the landing obligation means though that MLS will be replaced with minimum conservation reference size (MCRS), where catches under MCRS must be landed but cannot be used for direct human consumption.

Discarding of catches under MLS in the EU fleet have been significant in the past, where discards due to MLS can represent an excess of 50% of total catches (EC, 2011b). The effects of these discards on the stocks are though dependant on the survivability of the discarded catches. The species resilience differ greatly and the condition is also dependant on the fishing gear that is used. Most catches caught with baited hooks or traps are likely to survive, whilst much of the discards from bottom trawlers have little chance of surviving (STECF, 2015).

Adoption of MLS has though not necessarily resulted in reduction of efforts or landing of juveniles in all fisheries. In some areas, the consumption and illegal marketing of undersized fish is a common practice. For particular species, given the cultural value of some traditional dishes,

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the demand for undersized specimens can be even higher than for legally sized fish, which combined with a relatively weak enforcement system has created an incentive for non-compliance (Damalas & Vassilopoulou, 2013). One such example is horse mackerel in Portugal, in which fish below the MLS of 15 cm usually achieve a higher price than the legal sized (Hafliðadóttir, et al., 2012). Other similar examples are undersized hake, squid and cuttlefish that are all highly sought-after in southern Portugal and Spain.

3.3 Highgrading

The term "highgrading" is used for the practice of selectively choosing only the most valuable individuals in the catch, based on species, size, appearance or some other characteristics; and discarding the rest. This practice is common under quota regimes where only a limited volume of fish is allowed to be landed.

Incentives for highgrading are particularly high if the fishermen or the owners of the vessels need to pay significant amounts for the quota, as opposed to being allocated quotas for free based on some sort of historic rights (grandfathering). Evidences from fisheries operating under ITQ management where quotas can be leased on annual bases show that the price of leasing quotas is often so high that the fishermen will lose money if they do not land only the most valuable part of their catches (Pinkerton & Edwards, 2009) (Kristofersson & Rickertsen, 2009).

A highgrading ban was already included in the CFP prior to the implementation of the landing obligation. The highgrading ban within EU waters dates back to 2009 when such a ban was implemented in the North Sea, Skagerrak & Kattegat (EC, 2008). But compliance to the CFP highgrading ban has though been questioned (Borges, 2015).

3.4 Discarding of bycatches

Discarding of bycatches is a common practice in many fisheries. Emphasis is placed on binging the target species ashore and "accidental" bycatches are then simply discarded. The incentives for this sort of discarding can be variable, such as lack of quota for the bycatch, low- or no commercial value of the bycatch, lack of space on-board the vessel or total devotion to the target species. Sharks are for example a common discarded bycatch in fisheries for highly migratory pelagic species, such as tuna and swordfish (Molina & Cooke, 2012) (Campana, Joyce, & Manning, 2009); finfish bycatches are a common problem in shrimp fisheries (Silva, et al., 2015) (He & Balzano, 2013) and in Nephrops fisheries (Ungfors, et al., 2013). Discarding of bycatches is as well a problem in pelagic fisheries and in most mixed fisheries (Borges, Keeken, Helmond, Couperus, & Dickey-Collas, 2008) (Tsagarakis, Palialexis, & Vassilopoulou, 2014).

3.5 Discarding of low- or no commercial value catches

Discarding of low value catches is a subset of highgrading and bycatch discard practices. Unwanted catches that have little or no value are in most cases discarded. This can for example apply to species sometimes referred to as "trash fish" species, undersized fish and damaged or spoiled fish.

3.6 Deliberate slipping

Deliberate slipping is a term applied to catches (usually purse-seine catches) that are released in the water without being taken on-board the vessel (Kelleher, 2005). This happens primarily when fishermen realise that the catch is not "optimal" or if the vessel or quotas have been filled.

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The net is then lowered to allow the catch to escape, for example when catch is of undesirable size, the species composition is unpractical or the condition is an issue. Slipping the remaining catch from the purse-seine when the vessels hold has been filled or daily quota limitations have been reached is also quite common practise (Tenningen, 2014) (Stratoudakis & Marc¸alo, 2002) (MI, 2014). Slipped catches are considered to be discards, but quantities of slipped fish are difficult to estimate, as well as survival ratios. Slipping has been prohibited under EU law for a number of years, but monitoring and compliance has been lacking.

3.7 Discarding of rest raw materials

A big focus of the discard discussion in countries where a landing obligation has been in effect for some time has been on rest raw materials (RRMs). Vessels landing fresh groundfish frequently discard the viscera, including valuable by-products such as liver, roe, milt and other entrails. Most factory vessels also discard heads, trimmings and cut-offs; and only land the fillets or headed and gutted (H&G) whole fish. This kind of discarding is not addressed in the landing obligation of the CFP, but has been mad a focal point in recent years in countries such as Iceland, Norway, Faroe Islands, and Alaska (Grimsmo, et al., 2014) (Vigfusson, Sandholt, Gestsson, & Sigfusson, 2013) (Viðarsson & Þórðarson, 2015). Potential bio-active potentials of these RRMs have also been researched for a long time (Turid, 2002) (Rustad, Storrø, & Slizyte, 2011).

The aim of this chapter is to identify the most common discard practices used by the European fleet. This is not a completed analysis of the available discard practices, but gives nevertheless a representative description of the most relevant practices for the EU fleet. The focus of countries such as Iceland and Norway on full utilisation of RRMs is an issue that can contribute to development of on-board solutions for EU fleets to collect, store and bring ashore catches under MCRS.

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4 The landing obligation of the CFP

Fisheries within EU waters and fisheries conducted by EU fishing vessels outside EU waters are governed by the CFP. The CFP is in essence a set of rules for managing European fishing fleets and for conserving fish stocks. Designed to manage a common resource, the CFP gives all European fishing fleets equal access to EU waters and fishing grounds and allows fishermen to compete fairly.

A key component of the CFP is the setting of quotas, where it is decided how much of each species can be caught, in a certain area, for each year. Each country is then given a quota based on the Total Allowable Catches (TAC) and their traditional share of the TAC. The TACs are set annually by the Council of Ministers, based on proposals drawn up by the European Commission, which receives advice from Regional Fisheries Management Organisations such as ICES, and also consults its own scientific advisers (STECF). After the quotas are fixed by the Council of Ministers, each EU member state is responsible for policing its own quota. Different countries distribute their quota among fishermen using different systems.

The TACs have in practice been quotas on landed volumes, rather than catch volumes. This means that reported landings have been counted against quotas of each vessel, but not what is actually caught. This has led to considerable discards, where unwanted catches and catches that vessels do not have quotas for have been thrown back overboard. Discards have been considered among the best examples for the shortcomings of the CFP, as they have been difficult to justify to fishermen or the public. It is estimated that 1.7 million tonnes of fish is discarded in European fisheries annually, corresponding to 23% of total catches (EC, 2011a). In order to address this shortcoming, the commission has introduced a discard ban, or landing obligation, in the most recent reform of the CFP (EC, 2013). This represents a fundamental shift in the management approach to EU fisheries, as it introduces a switch from monitoring landings as a measure of TAC/quota uptake to the monitoring and regulation of catches as an essential component of the landings obligation and also introduces regionalised decision-making into the management of EU fisheries (STECF, 2014).

The landings obligation included under Article 15 of the new CFP basic regulation prohibits the discarding of species subject to catch limits i.e. TAC and quota species and those subject to minimum size limits in the Mediterranean (EC, 2013). The landings obligation will be gradually implemented, starting with the pelagic fisheries that became subjected to the discard ban on January 1st 2015. By January 1st 2019 the landing obligation will be in effect for all fisheries in EU waters and EU vessels fishing in non-EU waters.

The landing obligation contains a number of exemptions, namely in regards to species not covered by catch limits; species where high survivability can be demonstrated and; limited volumes of permissible discards which can be triggered under certain conditions, the so called de minimis exemptions, as well as inter-species and inter-annual quota flexibility mechanisms.

In order to protect juveniles, the landing obligation suggests establishing minimum conservation reference sizes (MCRS) for relevant species and prohibits the use of catches below those reference sizes for direct human consumption.

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The landing obligation also includes that member States are given the responsibility of monitoring compliance and ensuring detailed and accurate documentation of all fishing trips.

The landing obligation will be applied fishery by fishery. Details of the implementation will be included in multiannual plans or in specific discard plans when no multiannual plan is in place. These details include the species covered, provisions on catch documentation, minimum conservation reference sizes, and exemptions (for fish that may survive after returning them to the sea, and a specific de minimis discard allowance under certain conditions). Quota management will also become more flexible in its application to facilitate the landing obligation.

The landing obligation will create challenges for European fisheries and the seafood industry. There are still many components that are unclear and under debate, but it is at least clear that the fleet will have to adapt to severe changes because of this regulation.

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5 Landing obligation in other fisheries

There is a number of countries outside of the EU that have been operating under a landing obligation for considerable time. These countries have gradually improved their methodologies and approaches throughout the years and the experiences of these countries can therefore most certainly benefit European fisheries with the implementation of the CFP landing obligation. Following is a brief discussion on some of the fisheries that are already working under a landing obligation, with special focus on Iceland and Norway. These two countries have been chosen as case studies in DiscardLess, as they are European countries that contain similar fleet structures and target species as countries subjected to the CFP. An in-depth analysis of the situation in these two cases was therefore sought to bring in useful knowledge on experiences outside of EU.

5.1 Iceland

A landing obligation has been in effect in the Icelandic fisheries since 1977 (EC, 2007). It has gone through some changes and adaptions as management strategies have progressed from effort- to quota restrictions (Johnsen & Eliasen, 2011). The coverage of the discard ban has also gradually expanded, applying to more and more species. Today it applies to all significant commercial species. Catches that marginally exceed quotas can be legally landed by using quotas for the following year, as there is a built-in flexibility in the ITQ system that permits 5% of the quota to be transferred between years. Alternatively, fishers can land up to 5% of catches without deducting it from quota, but will then have to forfeit majority of the catch value. The vessel then receives 20% of the value and 80% goes to research (Directorate of fisheries, 2015). In 2014 these landings amounted to little over 2.036 tonnes in total. Fishermen are also allowed to land catches under MCRS and to count them only 50% against quota. There is therefore an incentive for them to land the catches. In 2014 these landings amounted to 1.350 tons.
Larger overruns and non-target catch can be covered through the purchase of additional quota. Failure to cover non-mandated catch with allowed overages or purchased quota can result in the revoking of fishing licences and fines (Sanchirico, Holland, Quigley, & Fina, 2006).

The capture of juvenile fish is discouraged through immediate area closures if MCRS exceeds proscribed limits (Johnsen & Eliasen, 2011). Non-compliance can lead to revoking of fishing licences, fines or even jail sentences. Catches are monitored onshore by the Directorate of Fisheries, as well as on-board with observers. The coastguard does also inspect vessels, to make sure that catches are reported correctly. Comparisons with catch compositions and length distributions are also used to monitor potential discards. Despite a policy of mandatory landings, discarding still occurs but has gradually declined since the early 1990s. According to annual estimations of the Marine Research Institute, haddock discard rates have fallen from 4.36% in 2003 to 0.12% in 2013, whilst cod discard rates have not exceeded 2% since 2001 and represented 0.60% in 2013 (Palsson, Bjornsson, Gudmundsson, & Ottesen, 2015).

The reliability of the discard estimates made annually by the Marine Research Institute can to a point be questioned. Discards are illegal and fishermen are therefore not going to admit to discarding or provide any documentation on such activities. The estimations are therefore based on observations and sampling. The general opinion of most stakeholders is though that the estimations are relatively reliable.

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An important factor in reducing discards in the Icelandic fleet is the extensive consolidation that has occurred over the past 20-30 years in the sector. This consolidation is one of the side-effects of the ITQ system, as smaller businesses that are not able to return healthy profits merge (or are bought up) with larger entities that benefit from economies of scale and better access to capital. Small companies operating with limited quotas, where the owners are working on-board the vessels or in very close personal collaboration with the crew, have almost completely gone out of business. In 1992 the ten largest quota holders owned 24% of the overall quotas, but in 2014 that proportion had risen to 50%; today the twenty largest quota holders own 71% of the quota and the fifty largest own 87% (Íslandsbanki, 2015). At the same time the number of fishermen has reduced by 35% as the vessels have become fewer, better equipped and having adequate quotas to be operated at full force all year round. The primary incentives for discarding have therefore been removed. The fishermen working for big seafood companies that possess adequate quotas have no good reasons to discard catches; which by the way would mean that they would be throwing away part of their income.
All of the biggest quota holders are large integrated seafood companies that include the catching, processing and marketing links in the value chain. The consolidation means that the processing and marketing is secured more raw material and constant supply all year round. This makes it possible to invest in expensive processing technology and gives competitive advantage at markets.

This consolidation is a development that will most certainly continue, as larger companies will become even larger, investing in more efficient vessels, processing technology and more quota share. Recent governmental taxes in the form of a significantly burdening resource rent will only speed up this development, as small operations will not have the operational margin to pay the resource rent.

The discard ban is generally accepted by all stakeholders in the Icelandic fishery and by the public. It would simply be considered unacceptable to discard catch in the fishery today. The focal point of the "discard discussion" in Iceland for the past decades has been on the utilisation of by-products, as full utilisation of the entire catch has been emphasised and the fishery has been relatively successful in doing so (Vigfusson, Sandholt, Gestsson, & Sigfusson, 2013).
In a report published by McKinsey & Company in 2012, it was reported that the Icelandic fleet was performing better on input utilization than other similar fleets, with for example a 57% yield on their cod catch compared to 41% in Norway (McKinsey Scandinavia, 2012). Icelandic researchers have since then re-evaluated these figures and are now claiming that the total utilization of cod catches is as much as 82%, as shown in Figure 2 (Arason, 2015).

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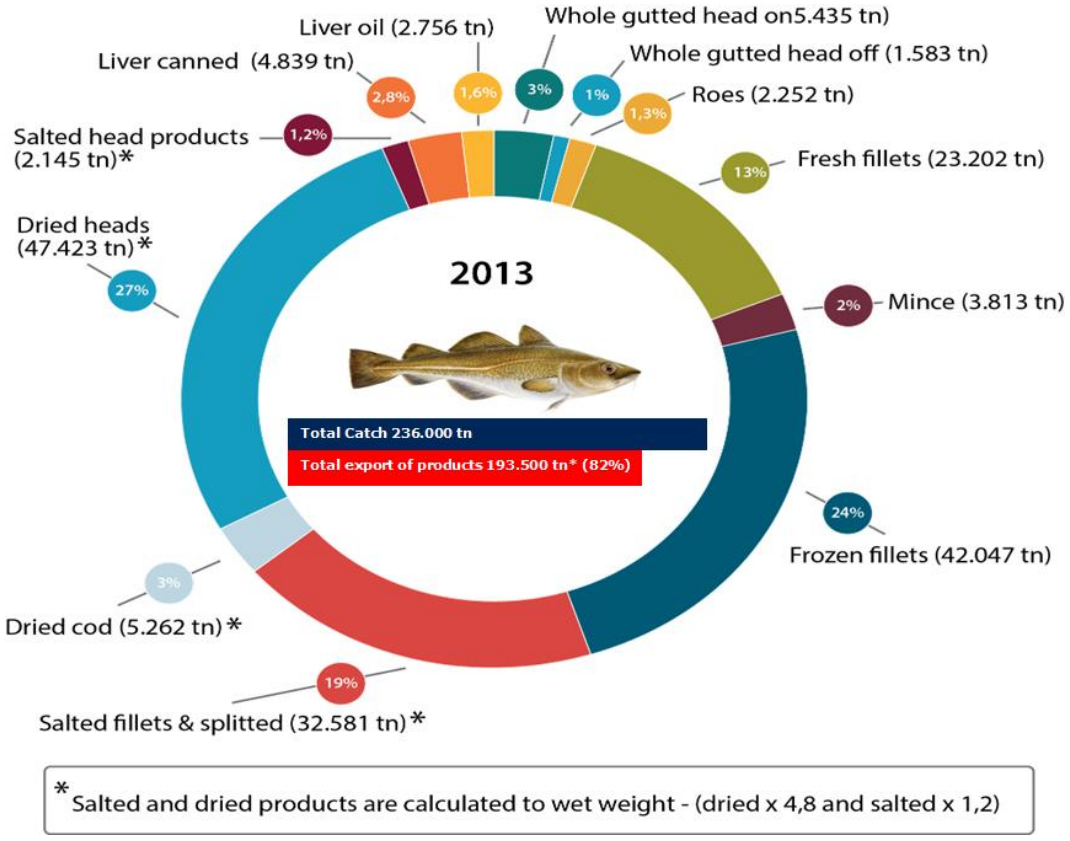

Figure 2: Utilization of Icelandic cod catches (wet weight)

In 2013 the Icelandic fleet caught 236 thousand tonnes of cod (wet weight whole un-gutted fish) which gave an excess of 193 thousand tonnes of exported products, when the effects of weight reduction or increase caused by salting or drying has been taken into account. This translates into 82% utilization. When domestic consumption, which is estimated at 4.142 tonnes, is also taken into account the total utilization amounts to around 84% (Statistics Iceland, 2015).
The interesting part of this is that in most other countries the heads (28.2%), liver (4.5%), roes (1.3%) and cut-offs and trimmings used in mince (2.0%) would have to a large extent been discarded. These by-products represented 36% of the catches, but 15% of the total exported value of cod products in 2013 (Arason, 2015).

The Icelandic seafood sector has also been utilizing other parts of the cod and making from them valuable products which are not accounted for in Figure 2, because either the statistics are not readily available or the volumes are insignificant. These are for example leather made from fish skins, pharmaceuticals and cosmetics made from bioactive compounds extracted from different parts of the cod (and other fish species), collagen made from fish skin, supplements and proteins made from different by-products, mineral supplements made from fish bones, enzymes extracted from viscera, skin and tissue repair patches made from fish skin, extracts from RRMs made into powder or bouillon (i.e. for making soups and sauces), silage made from viscera used for animal feed or as fertiliser, swim bladder and milt which are traditional products that have been utilized to a point in certain fisheries and markets.
Utilization of cod RRMs has lead the way in this field in Iceland, but by-products made from other species have though been following that lead. A good example of how waste has been

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turned to value in other species are the shrimp shells, which were a big problem in the sector only few years ago when they were mostly going into landfill. The company Primex is now producing chitosan from the shells and making supplements and pharmaceuticals. They are currently buying all shrimp shells that the entire Icelandic shrimp sector can supply.

There are a number of ways available for utilizing UUC and RRMs in the Icelandic fishery, including smelting into fishmeal, making silage, freezing, canning or turning it into added value products using biotechnological solutions. Following is a brief discussion on the most relevant methods, including requirement specification for on-board handling and identification of the main markets for the final products.

Drying

Dried heads and frames represent 27% of the total exports of cod products, when converted into wet weight, as shown in Figure 2. Additional 3% are exported as dried whole fish, which is called stockfish. Most of these products are made from RRM or UUC. The heads and the frames have little meat on it and have traditionally been discarded or used for fishmeal in most fisheries; and the stockfish is to a large extent made from cod that is under MCRS. Figure 3 shows these dried cod products (Haustak, 2015).

Figure 3: Dried whole fish (stockfish), dried frames (bones) and dried fish head

Heads and frames that are left after processing of haddock, saithe, tusk and ling are also dried, but heads and frames from more fatty fish species like wolfish and redfish are not applicable for drying. Utilizing heads and frames from fatty fish in an economically viable manner has therefore been a challenge that yet is to be solved. They are therefore usually either used for fishmeal or sold as bait.

Some UUC that have little commercial value are dried whole (gutted), such as starry ray, dab, megrim, witch flounder and even gurnard. Drying has traditionally been done outside on racks, but for the last few decades the drying process has been moved inside; utilizing inexpensive energy, increased automation and better control over the entire production flow. Figure 4 shows the traditional drying method and the drying method most commonly used today in Iceland.

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Figure 4: Traditional wind drying and state of art indoor drying plant

Fresh and frozen materials can be used alike for drying. More or less all cod heads coming from land based processing in Iceland are being dried and much of the frames and bones as well. Similar story can be told about most heads, frames and bones from land based processing of other lean whitefish species. The same cannot be said about heads and frames derived from frozen-at-sea processing, as only a part of that RRMs are landed.

Handling of materials going to drying on-board the vessels needs to ensure that freshness is maintained. In most cases the fish is landed fresh (whole with head on), which means that all parts of the fish has been properly handled. The handling of heads coming from frozen-at-sea processing is trickier, as the most commonly used de-heading machines on-board the Icelandic fleet cuts the heads with the collar bone attached to the head and a part of the liver is then usually also attached. The liver parts that are attached to the head need to be removed before the heads are frozen, or the entire head will become spoiled because of rancidity.

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Fish that is to be dried whole needs to be handled just as any other catch that is to be sold fresh or frozen. Fish that is below MCRS however needs to be kept separate if the vessel owners want to claim a 50% deduction in quota.

The main markets for dried whitefish products are in western Africa and particularly in Nigeria, where they are used for making soups. It is a big market that has been able to pay competitive prices for the products. In 2014 Icelandic producers exported 11 thousand tonnes of dried cod heads at an average price of 4.2 EUR/kg (Statistics Iceland, 2015). At the moment the economic and politic situation in Nigeria is though severally affecting global market conditions for dried whitefish products.

Liver, roe and milt

By-products made from cod liver, roe and milt have become increasingly valuable in recent years. The freshest materials become high value premium products and the rest is sold in bulk or used in lesser valued products. Figure 5 shows an example of premium products made from these RRMs (HBGrandi, 2015).

Figure 5: Premium products made from cod liver, roe and milt

The on-board handling is of the upmost importance in order to be able to use the RRMs in these premium products. The liver does for example have to be collected into plastic bags that can be sealed to minimise oxidation. The bags are then put on ice in plastic tubs and stored in the hold at the correct temperature. Roes and milt are not as vulnerable to oxidation, but need to be properly chilled or frozen. Livers that are not of the right quality are used for making fish oils and roes and milt that are of lesser quality are exported in blocks, as shown in Figure 6.

Figure 6: Cod liver oil and block frozen roes and milt

The processing decks on most Icelandic vessels today a designed so that these by-products can be collected and stored properly. This includes a system of tubes that collect the liver, roe and milt into the appropriate packaging.

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There are healthy markets for all of these products in Europe, as well as in other continents. Prices differ depending on quality, packaging, brands and markets.

Liver, roe and milt are more or less only utilized from cod on a large scale. Liver from saithe are though used for making fish oil and livers from other species are sometimes mixed with the saithe liver.

Trimmings, cut-offs and mince

Practically all trimmings and cut-offs from whitefish are utilized in the Icelandic fishery. Most of the trimmings and cut-offs are used to produce mince, which is then primarily sold block frozen and then used for production of fishcakes and fish fingers. Some cut-offs are however utilized differently, as for example some processors salt the belly flap and are able to sell them in niche markets in S-Europe. Figure 7 shows an example of these two products.

Figure 7: Block of frozen mince and salted belly flaps

Products such as these are extremely vulnerable and need therefore to be handled properly. The on-board handling is though usually not an issue, as the products are derived from processing on land. In the case of frozen-at-sea processing the trimmings, cut-offs and mince is block frozen as soon as possible.

Freezing the "non-marketable" RRMs

There are always some RRMs coming from processing that do not have much value and cannot be used for direct human consumption. In Icelandic processing companies these materials consist mostly of viscera that comprise largely of stomachs and what they contain. Many of the processing companies that specialise in producing from the catches of the small day-boats, which land their catch ungutted, are block freezing these RRMs and selling it as feed to mink farms. The freezing equipment is very basic vertical plate freezers and the blocks do not even require any packaging, as shown in Figure 8.

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Figure 8: Viscera and other rest raw materials block frozen as animal feed

This production is operating with a really narrow margin, but it saves the costs of having to dispose of it. Much of the products are sold domestically, but there are also some volumes exported to Danish mink farms.
These RRMs are not processed on-board fishing vessels and have until now been discarded out at sea, except when fish is landed ungutted. It are only the small coastal vessels that land their catches daily that land ungutted catches. Alternatives for making products from these materials on larger vessels would most likely involve silage production.

Silage production

Silage production has been tried in Iceland, but has not really caught on. The main reason is probably that almost all parts of the catches can be used for production of more profitable products. It is basically only the viscera that is discarded on the larger wetfish boats; and as discussed in chapter 5.1.4 the viscera of the whole un-gutted fish that is landed by the smaller day-boats is frozen for mink feed or smelted into fish meal. The larger vessels could potentially utilize viscera for silage production. This was tried in the 80's and 90's, but that experiment failed because of number of reasons, such as lack of storage space on-board vessels, difficulties to sell the production and low profit margins (Arason, Thoroddson, & Valdimarsson, 1990).

Silage production is relatively simple where whole fish and fish parts can be used, including the viscera. Everything is simply grinded and formic acid added to the mix. Enzymes from the fish break down fish proteins into smaller soluble units, and the acid helps to speed up their activity while preventing bacterial spoilage. The process takes place in a tank and it is important to mix the content thoroughly so that all the fish comes into contact with acid, because pockets of untreated material will putrefy. The acidity of the mixture must be pH 4 or lower to prevent bacterial action. After the initial mixing, the silage process starts naturally, but occasional stirring helps to ensure uniformity.
Fish silage is mostly used as animal feed, but can also be used as fertilizer or even raw material for fishmeal factories. Fish silage is currently not being produced in Iceland, neither for feed production nor fertilizer. This is a product that does not really have much market potentials in Iceland and exports of such an inexpensive product from Iceland would be difficult.

Fishmeal production

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UUCs and RRMs can be used for fishmeal production and there are factory vessels in Iceland that have fishmeal factories on-board. There are however not really any unwanted catches in Icelandic waters, which means that RRMs are solely used for the fishmeal production i.e. heads, frames and bones. Fishmeal's factories that are to be placed on a fishing vessels requires a relatively large vessel, which means that this solution is only an applicable for a relatively few vessels.

There is however a new solution available now, called Hedinn protein plant that is a bit more compact and not as energy intense (HPP, 2015). It still requires a relatively large vessel, but might be applicable for more vessels than a whole fishmeal plant, the entire protein plant is shown in Figure 9.

Figure 9: Hedinn Protein plant

The product coming from the protein plant is not a fully dried fishmeal, as there is still some moisture in it. It can then either be fully dried after landing or be used directly for animal feed. The protein plant is though not currently in use in any Icelandic vessels, but is about to be put up in harbours where there are currently no fishmeal factories available.

Pharmaceuticals, cosmetics, enzymes, supplements and other biotech solutions

Using whitefish RRMs for production of high value products that often depend on biotechnological processes have become increasingly important in the Icelandic marine sector over the last few years. These are though in most cases not sourcing huge quantities of RRMs. Below is a brief discussion on some of the products that are being produced in this field in Iceland.

Gelatine is made from fish skin, but disposal of fish skins has been a challenge in the Icelandic seafood industry for decades. Gelatine is used for various purposes, such as in pharmaceuticals to stop bleeding, making medicine capsules, and as gel in various food products like sweets (gummy bears for example), pate, jams and hams.

Collagen is made from fish skin and contains variable health benefits. Collagen can be used as pharmaceuticals to cure arthritis and osteoporosis, it can also be used in cosmetics as wrinkle medicine, and as supplements and protein drinks for athletics.

Amino acids can be made from fish proteins using enzymes. These amino acids are then used as food supplements.

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Food flavouring products in the form of bullions, powders and extracts are made from different whitefish RRMs. These are produced for example with the help of enzymes that are also a part of the RRMs. There are a number of companies in Iceland that are making such products, both selling consumer products and bulk. The products are primarily used for making soups and sauces.

Phospholipids can extracted from fish roes and can be used in baby food formulas, athletics food supplements and binding agent in food production.

Glucosamine can be made from chitosan, which is mad from shrimp shells, but chitosan is sold as food supplements with health benefits.

Calcium food supplements are made from fish bones using acid and alkaline precipitation. The calcium can also be used with industrial applications i.e. added to concreate or in cheese production for example.

Chitosan is a product made from shrimp shells that has variable applications. Chitosan can be used as food supplement that binds fat and lowers cholesterol. It has also shown to be effective in treating difficult wounds, reduce swelling and induce growth of bones. It is also used in cosmetics, shampoos and toothpastes. It does also possess antioxidants and is used as such for various purposes.

Fish oils and other omega-3 fatty acids can be processed from liver and viscera of various fish species and from the flesh of fatty fish. Considerable product development has taken place in this sector in recent years and some high value products, such as food supplements and pharmaceuticals are now containing omega-3 fatty acids.

Proteins can be extracted from basically all organic matter, fish proteins are extremely nutritious and are used as supplements and food targeted at solving health issues.

Enzymes can be extracted from cod viscera. Trypsin enzymes and Penzimes are currently being used for making cosmetics and pharmaceuticals by a company called Zymetech.

These are only some of the products that are currently being produced from RRMs using biotechnical solutions. They are however only by-products that make use of parts of the UUCs and do for the most parts not require particularly large supplies of RRMs. It is therefore debatable whether they can be of significant importance to the landing obligation. Most of the products rely on freshness of the raw materials, meaning that on-board handling needs to be in order.

<u>Alternative by-products</u>

There are also examples of other "alternative" products that can be made from RRMs. These are for example fish leather, wound patches and lamps. These are all made from fish skins, but the volumes of skins needed are insignificant.

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Wound patches from Kerecis are an interesting innovative by-product. The patches are intended for assisting with transplants, healing of large open wounds and large bedsores. Main competing products are patches produced from pig skin, which big part of the human population does not want to use because of religious believes. Kerecis is also making Omega-3 healing creams.

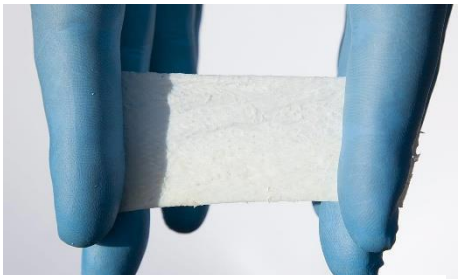

Figure 10: Wound patches from Kerecis

Fish skin is also used in leather, which is then used to produce fashion clothes, accessories and even lamps and furniture. These products can be made from most fish species, but the skin must be undamaged and preferably be from a rather large fish i.e. so that the leather patches do not have to be stitched together.

Figure 11: Fashion clothing and accessories made from fish skin

These products are an interesting addition to already expanding portfolio of by-products. They do however not require significant volumes of fish skin. The utilization of the fish skins is therefore unlikely to have significant contribution to the implementation of the landing obligation.

Summation

Icelandic fisheries have been operating under a landing obligation for almost 40 years with good success. One of the side-effects of the ITQ system is that most vessels today are owned by large integrated seafood companies that possess ample quotas for their vessels, which has almost completely removed all incentives for discarding. Fishermen are working for big companies and they do not have any benefits from discarding catches, opposed to how it was two decades ago when fishermen owned their own boats that were operated with limited quotas. The mentality of the general public is also strongly opposed to discarding of any sort. It is simply regarded unacceptable to discard catches and people think that if someone is not utilizing everything he catches then he should not be allowed to fish from this common resource. The development in Iceland has therefore focused in recent years on utilizing everything from the fish i.e. making by-products from all raw materials. This may not be very relevant for the landing obligation of the CFP but can though contribute to identifying alternative ways of utilizing UUCs.

5.2 Norway

A discard ban has theoretically been in force in Norwegian fisheries since 1983, but was first implemented in 1987 when it was applied to the most important species (EC, 2007). It has undergone considerable changes throughout the years and the number of species subjected to this landing obligation has also gradually been increasing. The landing obligation covers now all significant commercial species and applies to all vessels fishing in Norwegian waters (Diamond & Beukers-Steward, 2011). These species are managed under TACs subdivided into Individual Transferable Quotas (ITQs) and vessel group quotas (Eliasen, Sverdrup-Jensen, Holm, & Johnsen, 2009). Catch is counted against quotas and all fishing activities that run the risk of catching that

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species must stop when the quota is filled. Marginal overshooting of quotas can be legally landed and retained by fishers. Larger catches that exceed quotas or catches under MRLS can be landed without prosecution or penalties but the catch is confiscated by the sales organisations or the Directorate of Fisheries. The fishing company receives then 20% of the sales value, in order to cover landing costs and provide marginal incentives for landing the catch. The sales organisations and the Directorate of Fisheries keep 80% for themselves.

Any kind of discarding of target species or bycatches, as well as falsifying of logbooks or sales documents, results in expensive fines and confiscation of the catch (Gezelius, 2008). Revoking of fishing licences is also an option. A system of area closures is applied to protect juvenile fish. Immediate closures are used if more that 15% of the total catch of target species is under MCRS. The coastguard makes on-board inspections to ensure that catch matches regulations. If the level of undersized catch or non-target species is too high, vessels are required to move at least 5 nautical miles to different fishing grounds.
Improvements in the selectivity of fishing gear have been effected by the discard ban and such solutions have for example been a condition for allowing vessels to fish in certain areas. This is for example the case in the Barents Sea shrimp fishery, where the use of grids has been made a condition for fishing in some areas (Graham, Ferro, Karp, & MacMullen, 2007).

Despite of the landing obligation it is known that some discarding still exists, but as in Iceland the available information is mainly based on estimations rather than concrete data; because fishermen are not likely to report their illegal activities. Unfortunately no routines have been established in Norway to estimate the amount of discards before and after the introduction of the discard ban, but some work and projects have been conducted for some species and fisheries to estimate the most likely amount. For pelagic fisheries the discard rates are estimated at 3% of which slipping accounts for 2%; and discards in demersal fisheries are usually estimated between 1% and 5% depending on gear, quota, year-class strength and market (Nedreaas & Iversen, 2015).

The discard ban is generally accepted by all stakeholders in the Norwegian fishery and by the public. It would simply be considered unacceptable to discard catch in the fishery today. The focal point of the "discard discussion" in Norway now is on the utilisation of by-products, as significant parts of RRMs from on-board processing of whitefish are discarded (Grimsmo, et al., 2014). Recent estimations show that utilisation of Norwegian whitefish is around 73% of live weight. Considerable parts of Norwegian whitefish products are exported whole (gutted with or without head) which gives a relatively high utilisation factor. However, when looking at utilisation of whitefish RRMs it is estimated that only 37% are utilised, as shown in Figure 12 (Richardsen, Nystøyl, Strandheim, & Viken, 2015).

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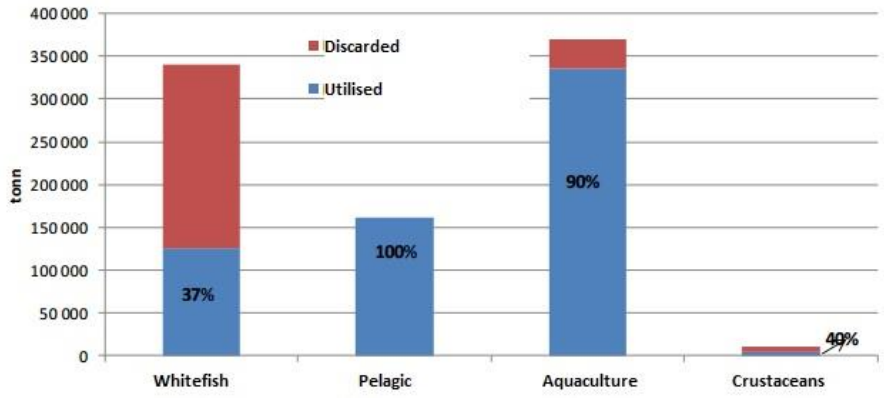

Figure 12: Utilisation of Rest Raw Materials in the Norwegian seafood industry in2014

Unutilised whitefish RRMs amount to around 200 thousand tons a year, comprising mainly of heads, liver, roe, frames, cut-offs and viscera, as can be seen in Figure 13 (Richardsen, Nystøyl, Strandheim, & Viken, 2015).

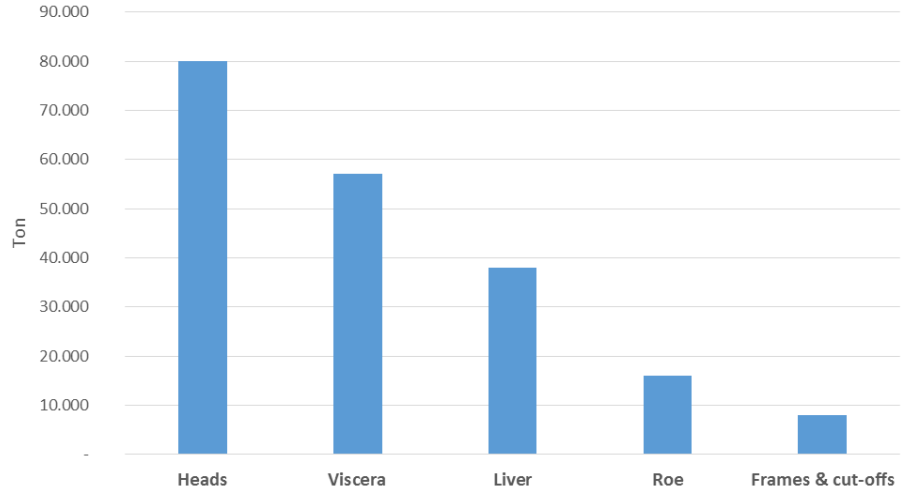

Figure 13: Unutilized Rest Raw Materials in the Norwegian seafood industry in 2014

Norwegian authorities have invested heavily in research and development in recent years in order to improve utilisation of by-products and RRMs. They have been looking into traditional processes, increased automation, biotechnology and other possibilities. The main challenge is though the seasonal variability in catches of whitefish and high labour costs, which both are difficult to address.

Norwegian whitefish catches have amounted to around 800 thousand tonnes a year, for the past five years (Fiskeridirektorated, 2015a). By far the most important species are cod, saithe and haddock, representing close to 90% of the catches. The share of each of these species can fluctuate slightly between years depending on stock size, but in 2013 and 2014 cod accounted for 58% of the total whitefish catches, saithe for 19% and haddock for 12%. The fisheries for these species are highly seasonal, particularly for cod and saithe, as over 60% of the cod catches are landed in the first four months of the year and 50% of the saithe catches are landed in the period between February and May. This uneven seasonal distribution has the effect that production needs to cope with extremely high throughput during the first four months of the

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year, making it difficult to allocate efforts on by-products and RRMs that do not create similar value as the main products. Figure 14 shows the seasonal distribution in Norwegian cod catches 2010-2015 (Fiskeridirektorated, 2015a).

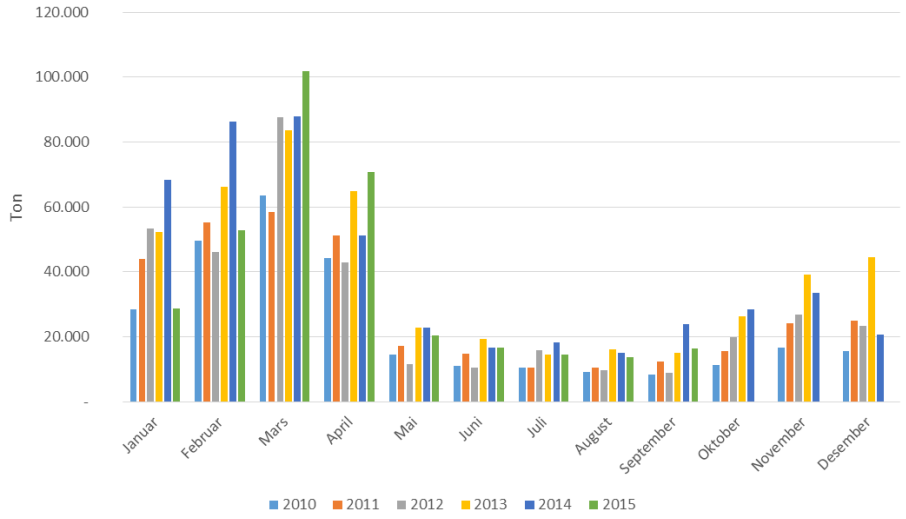

Figure 14: Norwegian cod catches 2010-2015 by month

This seasonality can contribute to discarding in the form of highgrading when fishermen potentially place efforts on "saving" the most valuable catches. This has however not been properly researched. The processing is also affected by this seasonality as almost all frozen-at-sea cod production is block frozen H&G, where heads and intestines are discarded. Processing fresh catches from the coastal fleet is also a challenge because of extreme supplies during January – April. The land-based processing industry is as well having difficulties in competition with other industries for labour and having to deal with much higher wages than their competitors. Wages in seafood processing in 2013 was for example 60% higher in Norway than in Iceland (Henriksen & Viðarsson, 2014).

The RRMs that are collectively utilised from the entire seafood sector are used for production of silage, fishmeal and fish oil and about 10% goes into human consumption, as shown in Figure 15 (Richardsen, Nystøyl, Strandheim, & Viken, 2015).

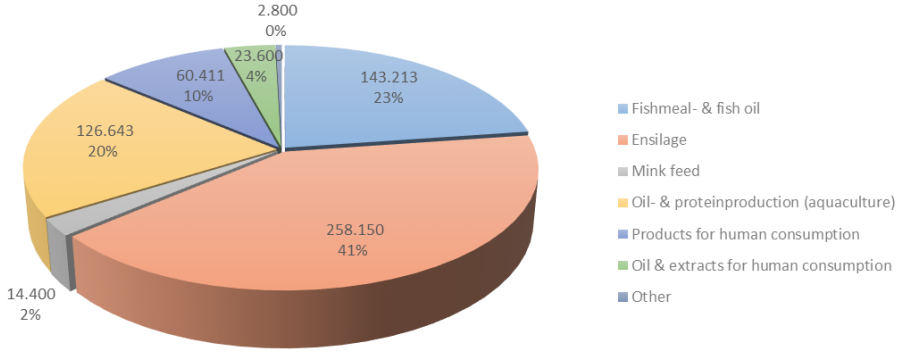

Figure 15: Allocated Rest Raw Materials used for production of by-products in 2014

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The largest volumes are coming from the aquaculture and pelagic sectors, but the whitefish sector contributes mainly to production of products for human consumption, oil and extracts for human consumption and ensilage production. These are for example cut-offs used for mince, liver used for canning or cod liver oil production, roe and milt for direct consumption, roe used for production of caviar, heads used for drying or production of cod cheeks and tongues, and viscera used for ensilage production.

There is a considerable difference in utilisation of whitefish RRMs in Norway, compared to Iceland because of a number of reasons. The seasonality of catches is one factor, availability of labour and labour expenses are another, the number of landing docks and distances between them make it also difficult to have specially-equipped production facilities that need large and reliable supplies of RRMs and energy costs are relatively high. There are though many examples of by-products that the Norwegian seafood sector is producing with great success, including cod tongues & cheeks, canned roe and liver, as well as the famous caviar that is made from cod roes.

Figure 16: Norwegian caviar and canned cod liver

The Norwegian seafood industry produces large amounts of silage, which is particularly relevant for the CFP landing obligation i.e. in the context of possible production streams for catches under MCRS. The silage is made from different RRMs that are derived from aquaculture, pelagic and whitefish production. By far the biggest company in this sector in Norway is Hardafor AS. Hardafor produces the necessary equipment for making silage and can set them up were requested. They do also operate their own silage production facilities in nine locations in Norway, as well as having production facilities in Denmark and Faroe Islands. They do also buy silage from smaller producers. Hardafor operates five specially equipped tanker vessels and four trucks that collect RRMs and silage at various production stages (Hardafor, 2015).

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Figure 17: Hardafor's silage production facilities and one of its tanker vessel

There are basically two "end products" that are made from the silage i.e. Fish Protein Concentrate (FPC) and Fish Protein Hydrolysate (FPH).
FPC is made by separating the oils/fat from the rest of the silage and then removing the water with evaporation from the rest of the silage, until you are left with solid matter that is about 40% of the original volume. The FPC is then sold as ingredients for animal feed, primarily for pigs. Norwegian FPC production in 2014 was 64 thousand tons, which were mostly sold to Norwegian and Danish pig feed producers, but also to feed producers across Europe and Asia.
FPH is produced from silage in a similar manner as FPC, except that enzymes are used during the degradation process that makes it possible to extract specific peptides and amino acids for higher value products. It is for example possible to use the products in nutriceuticals, health supplements and other functional foods for human consumption; or in higher value animal feed. Norwegian FPH production in 2014 was 17 thousand tons, which was primarily used in aquaculture feed. It has been showed that FPH in aquaculture feeding can give fish more disease resistance and stimulate their immune system (Shahidi & Barrow, 2007). Studies have also shown that FPH addition to fishmeal leads to more fish meal consumption, suggesting that FPH may act as a feeding stimulant.

It is difficult to estimate the contribution of the discard ban to improving selective fishing practises in Norwegian fisheries. The management system has at least been successful at reducing the capture of juvenile fish (Graham, Ferro, Karp, & MacMullen, 2007). But some species, such as the Norwegian coastal cod, are though still struggling due to low stock size and overfishing (ICES, 2015). The fact that all catches are utilised for making valuable products, along with strict MCS and wide scale social opposition against discarding, has contributed to making discarding a minor issue in Norwegian fisheries.

5.3 Faroe Islands

The Faroese Islands have operated under a full discard ban since 1994 (Gezelius, 2008). 90% of the Faroese fishing fleets are managed under effort controls, whilst larger vessels operating in deeper waters are managed under quotas and bycatch limits for cod and haddock (Løkkegaard,

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Andersen, Boje, Frost, & Hovgård, 2007). Trawling is prohibited inside the 12 nautical mile limit except for a limited number of small trawlers targeting plaice and lemon sole during the summer months. Fishermen operating in this area are obliged to report high catches of undersized fish and if juveniles of cod, haddock or saithe contribute more than 30% of the catch, an area closure is implemented. Area closures are also applied if more than 4% of cod catches are below 40 cm. Outside the 12 nautical mile limit, the mandatory use of minimum mesh sizes and sorting grids in trawls is applied to reduce the capture of juvenile fish. Discarding in the demersal fisheries in Faroese waters is thought to be low or non-existent (ICES, 2014). The Faroese demersal fisheries are managed through effort controls which do not create incentives for discarding, but there are however no actual discard data available to evaluate the effects of the discard ban. Information on changes in fishing behaviour to avoid bycatch and juvenile fish is also missing, but it has though been argued that juvenile haddock have not been sufficiently protected through technical measures in the longline fisheries (Løkkegaard, Andersen, Boje, Frost, & Hovgård, 2007). Without discard data it is difficult to assess whether selective fishing has been incentivised by the discard ban. It is however clear that the current effort control management system has failed in protecting the cod, haddock and saithe stocks, regardless of the discard ban.

5.4 Alaska

A discard ban has been in effect in the Alaskan groundfish fishery for Pacific cod and pollock since 1998, supported by one of the most comprehensive observer programs in the world (Graham, Ferro, Karp, & MacMullen, 2007). There are observers on-board all larger vessels in the fleet, which provide near real-time information on the fisheries to the industry and authorities, giving them opportunity to react quickly to conditions that might otherwise trigger discarding (Faunce, Cahalan, Bonney, & Swanson, 2015). Commercial species in Alaskan waters are managed through Individual Vessel Quotas (IVQs) or fishing cooperatives, placing constraints on the capacity of the fishery (Sigler & Lunsford, 2001). Non-target species are protected through fishery specific bycatch levels. Species that are vulnerable or commercially important, are defined as Prohibited Species. Exceeding the proscribed bycatch levels for those species will trigger area- or fishery closures.

Since the discard ban was implemented, the discard rates of the Alaskan walleye pollock pelagic trawl fishery have fallen significantly and Pacific cod discard rates have fallen from 6.8% to 0.4%, and pollock discard rates are less than 1% (Graham, Ferro, Karp, & MacMullen, 2007). Changes in selectivity in the fishery has been observed in response to bycatch limits. More selective pelagic trawls have for example been introduced in the walleye pollock fishery in response to high catch rates of prohibited crab and halibut. Pelagic trawls are now mandatory and levels of bycatch are less than 2%. Selectivity has also been improved in the demersal longline fishery after a voluntary fleet wide communication programme designed to reduce the incidental capture of halibut was implemented (Gilman, Dalzell, & Martin, Fleet communication to abate fisheries bycatch, 2006). Observer catch- and bycatch data are collated by the Fisheries Information Services and the locations of bycatch hotspots, along with advice on bycatch reduction techniques, are reported to vessels within the programme. As a result fishing effort has redistributed away from areas associated with increased bycatch and the bycatch rates of participating vessels are 30% lower than the rest of the fleet.

The introduction of Individual Vessel Quotas (IVQs) has reduced the capacity of the sablefish and halibut longline fishery. With fewer vessels operating, fishing grounds are less crowded

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allowing the remaining effort to concentrate in more productive areas where the abundance of juvenile fish is lower (Sigler & Lunsford, 2001).
Implementation of a discard ban in the Alaskan groundfish fishery has reduced discard levels of the designated species (Graham, Ferro, Karp, & MacMullen, 2007). Placing limits on bycatch that will constrain fishing have incentivised more selective fishing, with a shift in fishing grounds and gear choice, and increased fleet communication. This has been aided through a high level of observer coverage and allocation of individual quotas.

5.5 Canada

Discarding is banned in the groundfish fisheries off both Canada's west and east coasts, as well as in the Atlantic pelagic longline fishery (EC, 2007). The discard ban has been in effect since 1995, but the regulatory framework has been in constant reform since then as instruments such as flexibility and transferability in quotas, selective fishing policy, area closures and increased MLS tolerance have been implemented.

Scotia Shelf groundfish fishery

The groundfish fishery on the Scotia Shelf, off the east coast of Canada, is managed primarily by an ITQ structure for those using vessels less than 65 feet and enterprise allocations (EAs) for all vessels greater than 65 feet (EC, 2007). The fixed gear sector using vessels less than 45 feet is managed under a competitive community-based management system. When ITQs were first introduced to smaller mobile gear vessels (<65 feet) in 1991, the ITQ strategy suffered from discards of non-directed species. Since 1995 discarding of groundfish has been prohibited through a mandatory landing regulation which requires all licence holders to retain all groundfish species unless their licence authorizes or requires them to discard some species.
To mitigate the impacts of the discard ban, those under ITQs or EAs must ensure they have adequate quota to cover expected catch before leaving on a fishing trip. Each licence holder must ensure that they have a positive balance before leaving port. While it is not an offence to overrun a quota holding while at sea, vessels are prohibited from going fishing again until they have balanced their previous overrun through temporary transfers from other licence holders
Compliance is enforced through the monitoring of every landing at dockside (EC, 2007). If landings are in excess of quota for any species, the license holder must acquire additional quota from other licensees to account for the over-run before leaving on the next trip. This latent quota may be acquired through a management board if the vessel is in the fixed gear sector or from other ITQ license holders if in the mobile sector. The price of the additional quota depends on availability and demand at the time. The fish caught as a result of all fishing activity is sold on the same open market. The system has contribute to reducing discards, more selective fishing practices and protection of juvenile fish.

Canadian Atlantic longline fishery

Quota management has played a part in reducing discards in the Canadian Atlantic longline fishery (EC, 2007). Before 2004, the fishery for highly migratory large pelagic fish off the Canadian east coast was highly segmented into a longline fishery that caught some Bluefin tuna as an unavoidable bycatch; and a hand-line, trolling and harpoon sector targeting only bluefin. While the longliners had to discard dead bluefin, the hand-liners had difficulty catching bluefin. This situation was made more complex by the management of the handline fishery since quota

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was fished competitively among seven fleets based on region of home port. Under this competitive management structure, a bluefin hand-line fleet in one region would not permit a similar fleet in another area to enter partnerships with longline operators to land bluefin since this would provide an advantage to that fleet and catch a larger share of the bluefin quota. This situation changed in 2004 with a new bluefin fleet quota management structure which removed competitiveness between the fleets. Under the new regime, bluefin quota transfers are permitted from bluefin hand-line licenses to longline licenses under certain conditions. In addition to this quota flexibility between fishers and fleets, the authorities have adopted a 15% tolerance for minimum size fish, which has reduced discards of small fish. This has in particular made it easier to land smaller swordfish catches (<125 cm). Temporary closures and permanent closures of areas are applied in the fishery, in order to protect juveniles and nursing grounds.

British Columbia Ground fish fishery

In the groundfish fishery of British Columbia, there is a single groundfish licence and every species is assigned catch limits, including those caught as bycatch (EC, 2007). Catch limits are divided into individual vessel quotas (IVQs). As on the east coast, vessels are not allowed to discard their bycatch – everything caught must be landed. The catch is either deducted from existing quota holdings or quota must be purchased from other fishers to compensate for the bycatch. Transfer of quota within and among fleets is allowed to ensure total catches remain within assigned species' TACs. The monitoring of the fishery is supported by 100% observer coverage (Rice, 2003). Overages of up to 37.5% for halibut and 15% for hake can be legally landed without the purchase of additional quota, reducing the incentive to discard (Branch & Hilborn, 2008). This overrun is subtracted from the following year's quota and the value of the catch is forfeited. This removes any incentive to target over quota catch that can be legally landed, whilst encouraging fishermen to match catches to available quota. Marketable discarded catch is counted against quotas, after allowing for estimated discard survival rates, discouraging "highgrading" where fishermen try to maximise profits by landing only the larger more valuable individuals. Non-target and non-quota species are managed through bycatch limits.

The Canadian policy for selective fishing is the cornerstone of discard mitigation policy in the North Pacific Groundfish fishery off Canada's west coast (EC, 2007). In this complex fishery, 77 species of fish are landed and 27 different groundfish stocks are assessed and subject to annual allocations in six different management areas. There are many bycatch issues in this fishery, for example, rock sole are caught as bycatch of the Pacific cod fishery and English sole are caught as bycatch in the trawl fishery for rock sole and Pacific cod. A policy on selective fishing was announced in May 1998, which represented a fundamental change to the Pacific fishery. It allows fishermen from all sectors to continue to harvest more abundant stocks while reducing bycatch and protecting weaker stocks. With the co-operation of First Nations, commercial and recreational fisheries, selective fishing techniques have been tested on Canada's west coast since 1998. The methods take advantage of research that has improved understanding of the behaviour of many fish species, as well as the latest advances in fishing gear design. Together, the techniques are designed "to avoid, or release unharmed, non-target stocks or species of concern.

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The direct effect of the discard ban in promoting more selective fishing in Canada is difficult to evaluate. More selective fishing has been incentivised, but the role of the discard ban in this change is unclear. Constraining bycatch limits and a reduction in the benefits of discarding, facilitated through observer programmes and area closures, have encouraged fishermen to match catches to available quota and avoid excessive bycatch, which ultimately reduce discards (Condie, Grant, & Catchpole, 2014) (Branch & Hilborn, 2008).

5.6 New Zealand

New Zealand fisheries have been managed under a discard ban incorporated within an ITQ system since 1986 (Condie, Grant, & Catchpole, 2014) which was permanently grounded into the management system with the Fisheries Amendment Act of 1990 (EC, 2007). Prior to the introduction of the Fisheries Amendment Act, discarding of non-commercial species, highgrading of commercial species and discarding of damaged fish was legal and did not need to be reported. At the time of the introduction of the provisions, the Ministry had limited at-sea compliance capacity and reverted to a comprehensive reporting based regime that could be audited on land. This approach ensured the integrity of the system but left open the possibility of undeclared discarding at sea. Discarding of catch is only allowed for species with high survival rates or those below the legal MLS. The landing of over quota, non-target or bycatch species is allowed, but has to be later covered by purchasing of additional quota or payment of a fine representing "deemed value" of the catch.

To discourage excessive overruns of quota, the deemed value will increase with the scale of the overage. A 20–40% overrun of an individual's quota will incur 20% larger deemed values dependent upon the species in question. Subsequent purchase of quota to cover this catch will result in a refund of the deemed value.

The authorities have at their disposal the possibility to severally punish non-compliance, as the fisheries Act prescribes that any fisher who breaches the discarding provisions of the Act is liable for a fine not exceeding NZ$ 250,000 and forfeits to the Crown any property used in the commission of the offence and, if the Court orders, any ITQ held by the fisher (EC, 2007). The Act provides for the return of the forfeited property under terms and conditions set by the Courts. Any fisher who is convicted of two or more offences for illegal discarding is, in addition to the penalties imposed by the Courts for the offences, prohibited for a period of 3 years from engaging in fishing or benefiting from fishing. It is therefore evident that the possible penalties are far more important that any possible gains from discarding.

The current effect of the discard ban is difficult to evaluate as data on discarding are sparse (Davies, Cripps, Nickson, & Porter, 2009). However, a lack of sufficient incentives for selective fishing or increased catch utilisation has been linked to an increase in illegal discarding of non-target or over quota catch (EC, 2007). Large quota overages resulting in high deemed values may incentivise fishermen to discard catch before arriving into port. High deemed values may also encourage highgrading.

5.7 Experiences from other fisheries where discard ban is in place

The nationally adopted discard ban policies in Iceland, Norway, Faroe Islands, Alaska, Canada and New Zealand are the best documented examples of landing obligations available. There are though also other examples available that confirm the main lessons that can contribute to a successful implementation of the CFP landing obligation. These are for example the discard ban

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for Antarctic toothfish in the Ross Sea instrumented by CCAMLR and the discard mitigating initiatives implemented by NAFO for the Northern Prawn trawl fishery (EC, 2007). All of these fisheries have difficulties with estimating the effects of the discard ban, but all have adopted similar solutions in order to reduce incentives for discarding. These solutions are:

- Quota flexibility, where portion of next year's quota can be used.
- Quota transferability where quotas can be bought after the over-quota catch has been landed.
- MLS/MCRS tolerance, where part of undersized catch can be landed without being deducted from quota.
- Allowing for landing of over quota catches if the sales value is forfeited (e.g. fishermen receives 20% of the sales value and the rest is allocated to fisheries research).
- Improved fishing gear selectivity in regards to species and sizes.
- Improved communication between fishermen to avoid bycatch and catches under MCRS
- Monitoring, control and surveillance, which can be both on-board and on-land. This can include on-board observers, ICT solutions, comparing landed catches with rest of fleet etc.
- Strict punishments for non-compliance.
- Area closures

The emphasis is mostly on how to avoid catching unwanted species or catches under MCRS; and to ensure that unwanted, unavoidable catches are landed.

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6 Monitoring, control and surveillance of discards

Monitoring, control and surveillance (MCS) is one of the cornerstones of successful fisheries management, and in particular where there is a discard mitigation programme in place. There are a number of tools available for supporting MCS on-board and on-land. Following is a brief review of the most relevant tools available for MCS of discards and a short description of MCS in fisheries that are already operating under a discard ban.

6.1 Monitoring and surveillance tools

Discarding unwanted catch at sea in response to regulatory and/or market forces during commercial fishing has been a part of EU fisheries during the last decades (Kelleher, 2005). The estimation of the amount of discards has been legislated through the Data Collection Framework (EC, 2000). As part of nationally adopted on-board observer programmes, experts collect the biomass, length, age, and species compositions of discards from their most important commercial fisheries and feed these data into stock assessments (EC, 2009) (Uhlmann, et al., 2013). While these types of discards were encouraged or even mandatory through regulations, their extent was tracked and estimated. However, with a landing obligation that comes with a reformed CFP – other measures to monitor the amount of discards need to be in place. Several methods exist and those most relevant are listed below.

6.1.1 Vessel monitoring system

A fishing vessel monitoring system is a cost-effective tool for the successful MCS of fisheries activities (FAO, 2015). VMS provides a fishery management agency with accurate and timely information about the location and activity of regulated fishing vessels. It is a programme of fisheries surveillance, in which equipment that is installed on fishing vessels provides information about the vessels' position and activity. This is different from traditional monitoring methods, such as using surface and aerial patrols, on-board observers, logbooks or dockside interviews.

6.1.2 Electronic logbooks - documentation

The Electronic recording and reporting system (ERS) in the EU is used to record, report, process, store and send fisheries data (catch, landing, sales and transhipment). The key element is the electronic logbook where the master of a fishing vessel keeps a record of fishing operations. The record is then sent to the national authorities, which store the information in a secure data base. These information can be used to estimate discards using statistics by comparing catch composition from vessels that are fishing in the same area.

6.1.3 Video monitoring - CCTV

Fisheries with catch quotas (as opposed to landing quotas) need to be fully documented in order for the landing obligation to be successfully implemented. There are a number of ways to ensure this, one of which involves implementing on-board video cameras, or Closed-circuit television (CCTV) (Ulrich, et al., 2015) (Seafish, 2012) (Needle, et al., 2014). The technology is similar in many ways to that used in terrestrial monitoring systems. Cameras are fixed to specific points on a fishing vessel, and the number of cameras depends on the fishing operation and the management objectives. Cameras may be switched on all the time, or activated by the movement of the vessel over the fishing ground, or by the use of a particular piece of deck equipment, such as the winch. The equipment begins to capture footage of the activity and these images can either be sent electronically to a central monitoring point or saved on-board and collected the

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next time the vessel visits port. Footage can then be analysed to count fish, identify species, and estimate discard rates (through measuring length and using existing weight-length relationships). To date the analysis has generally been carried out by human observers, which is slow, prone to error and can lead to staff dissatisfaction. Work is underway the UK to develop automated image analysis systems in which fish identification and measurement is carried out using computer algorithms, and this will be reported later in the *DiscardLess* project.

6.2 MCS experiences from countries with a discard ban in place

A number of countries have had a discard ban in place for a long time and their MCS of the fishery has therefore taken the discarding problem seriously. The experiences of these countries can potentially contribute to more successful implementation of the CFP landing obligation. Following is a brief discussion of MCS in some of these countries.

6.2.1 Iceland

The Icelandic fisheries management system is based on ITQs and it depends on monitoring and controlling of individual vessels (Johnsen & Eliasen, 2011). Landed catch is weighed by accredited harbour officials and registered in the central database in the Directorate of Fisheries. According to a legal mandate, the catch and quota use is published through the Web site of the Directorate of Fisheries in order to ensure transparency.

The vessels are obliged to fill in detailed catch logs with information about fishing area, catch composition, and quantities. Landing of the catch is monitored by inspectors from the Directorate of Fisheries, who also have access to the vessels' catch log. If the inspections demonstrate that the catches contain too many small fish, the actual fishing grounds can be closed. Moreover, the Icelandic Coast Guard monitors and inspects the vessels operating in Icelandic waters.

To ensure that catch information is reliable, buyers and sellers are obliged to report to the Directorate of Fisheries. The Directorate can react against discrepancies, and if the management legislation is violated, the lawbreakers are subject to fines, revocation of fishing licence or, in some cases, imprisonment. The responsibility for proper conduct is placed on the fishermen, who are responsible for ensuring that they have quotas for the respective species they fish and land. In order to stop discards, a general discard prohibition clause is in place.

If a vessel overfishes or brings in vast amounts of bycatch, the company has the option of obtaining additional quota within a certain period of time after landing. Thus, the fishermen have an incentive to land all the fish they catch. In addition it is allowed to land a bycatch percentage without using quota. This amount of fish will be sold at an auction for the benefit of a research fund.

6.2.2 Norway

All commercial species in Norwegian waters are in a quota and subjected to a discard ban (Johnsen & Eliasen, 2011). If a vessel has used up its quota in a species at risk of being caught, the vessel must cease all fishing activities. The discards are monitored by mandating vessels larger than 13 m to keep catch logs. Every haul must be recorded immediately with data about fishing ground, species caught and estimated quantity. The skipper is responsible for an accurate recording of the catch, and the estimates should not deviate more than 10% from the actual quantity landed. The log can be checked both through landing control by inspectors from the

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Fisheries Directorate and through inspections at sea by the Coast Guard (Fiskeridirektoratet, 2008) (Gezelius, 2006). Moreover, the landed catch is reported by the vessel and the buyer to the Sales Organisation and checked against the fishing rights of the vessel. This control is performed by the Sales Organisation and the Fisheries Directorate. Finally, the Fisheries Directorate can perform physical inspection of landings, sales and export (Norwegian parliament, 1951). To protect juveniles and undersized fish, the Fisheries Directorate continuously monitors fishing grounds to introduce real-time closures when needed. The monitoring is based on risk assessments in different fisheries and is undertaken both by chartered vessels conducting surveys in areas where the risk of undersized fish is high, as well as by inspectors on-board ordinary vessels. Several projects are undertaken to develop electronic systems for reporting and surveillance, and for vessels over 15 m in length, satellite transponders for Vessel Monitoring Systems are mandatory (Fiskeridirektoratet, 2015b).

6.2.3 The Faroe Islands

In the Faroe Islands, a system of effort regulation is in place for demersal fisheries where licence holders are allocated a certain number of fishing days annually based on capacity for each vessel or gear group. A great challenge in such a system is measuring and monitoring capacity increase (Johnsen & Eliasen, 2011). The monitoring in the Faroese system consists of VMS which has to be installed in larger vessels and landing tickets for the smaller ones (Gezelius, 2008).

6.2.4 Alaska

A discard ban has been in effect in the Alaskan groundfish fishery for Pacific cod and pollock since 1998, supported by one of the most comprehensive observer programs in the world (Graham, Ferro, Karp, & MacMullen, 2007). There are observers on-board all larger vessels in the fleet, which provide near real-time information on the fisheries to the industry and authorities, giving them opportunity to react quickly to conditions that might otherwise trigger discarding (Faunce, Cahalan, Bonney, & Swanson, 2015).

6.2.5 Canada

Monitoring, control and surveillance in Canadian fisheries is based on two pillars i.e. enforcement activities carried out by Fishery Officers of the DFO who conduct regular patrols on the land, on the sea and in the air; and at-sea observers & electronic monitoring program where certified private-sector observers are made compulsory on-board all fishing vessels (DFO, 2015). Canada's At-Sea Observer Program places certified private-sector observers aboard fishing vessels to: monitor fishing activities; collect scientific data; and monitor industry compliance with fishing regulations and licence conditions. The Pacific region's ground fish fishery is as well subjected to a strict Electronic Monitoring Program that uses multiple cameras and sensory devices on-board fishing vessels to monitor fishing activities; collect scientific data; and monitor industry compliance with fishing regulations and licence conditions. The at-Sea Observers and Electronic Monitoring programmes are carried out by private-sector observers and IT providers; and the industry assumes the full costs of running the programmes.

The above mentioned countries are only examples of how countries operating outside of the CFP are addressing MCS. Some of the countries have 100% observer coverage, whilst others rely

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more on strict documentation regulations, supported by occasional observer visits, VMS, CCTV and at-land inspections.

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7 Initiatives to reduce discards

There are basically just two ways to reduce discards, either to increase selectivity within the fishery or to bring larger ratios of the catch to harbour. Those two methods are not mutually exclusive and it could even be argued that they supplement each other. There is though one common factor that has to be in place, there has to be some economic incentive for the fishermen so that they are willing to change their habits and for any regulatory changes to become affective without a drastic increase in the surveillance industry. This chapter presents some interesting initiatives that have been attempted in order to improve selectivity and reduce discards. Most of the cases come from European pilot projects, but there are also some highly relevant cases presented from fisheries were landing obligation is already in effect. This review is not an exhaustive list of projects, but represents a large panel of initiatives.

7.1 European funded pilot projects

In 2010 Catchpole and Gray published a paper were they reviewed 15 discard-related pilot projects to find out what were the most important determinants of their success or lack of it, and to recommend ways in which the prospects of future pilots could be improved (Catchpole & Gray, 2010). Nine of these 15 projects were aimed at improving selectivity of fishing gear, four were aimed at gathering data (mostly self-sampling by fishermen) to improve knowledge on discard patterns, one was on real-time area closures to avoid unwanted catches and one was a pilot trial discard ban where two fleets were intended to implement a discard ban on trial basis. Most of these projects focus on how to avoid unwanted catches and do as such not contribute a lot to what happens to unwanted catches on-board fishing vessels (which is the focus of WP5). The trial pilot discard ban project would though have been likely to give relevant results, but that project failed from the beginning because of disagreements between the EC, local governments, scientists and other stakeholders. Catchpole and Gray concluded from these 15 projects that successes or failures of the pilots had come down to that stakeholders needed to feel that the projects would solve some perceived crises or would provide economic incentives; and that their successful implementation relied on stakeholder participation; adequate funding; expert knowledge; strong leadership; and strict enforcement.

In 2011 the European Fisheries Technology Platform published a report where ongoing and completed discard related European projects were identified and briefly discussed, along with few national projects (EFTP, 2011). A total of 26 ongoing and 21 finished EU projects were presented, providing a good overview of what initiatives have been attempted and what have been the main focus points. The report also mentioned additional 21 national and international initiatives that were particularly worth mentioning.
Of the 47 EU funded projects covered in the EFTP report, 19 were focusing on fishing gear selectivity, 12 on management measures, 10 on valorisation, 2 on communication programmes, 1 at estimating discard rates, 1 on artisanal fisheries and 2 were marked "confidential" not providing information on the main focus of the projects.
With respect to the focus of this report and the objective of WP5, which is on what to do with UUC on-board the fishing vessels "from catch to first sale", it are primarily projects on management measures and valorisation that are relevant. Most of the projects looking at management measures were though in the end coming only with solutions on area closures and selective fishing gears, which do not contribute significantly to WP5. The same can also be said

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about most of the valorisation projects, which were specifically looking at utilization of by-products for making bioactive compounds, cosmetics and pharmaceuticals. These were primarily looking at utilisation of RRMs that are currently not utilized after land-based processing.

There are though a number of projects identified by Catchpole & Gray and EFTP that are particularly relevant for utilisation and MCS of UUCs on-board the fishing vessels. These are projects such as BADMINTON, FAROS and iSEAS that are aimed at understanding and developing management measures; The Scottish Conservation Credit Scheme and the Danish Fully Documented Fishery projects looking at MCS (including implementation of CCTV); and BIOTECMAR, MARMED and iSEAS that have the objective to develop products from UCCs and RRMs.

Following are brief discussions on the projects that have potential contribution for WP5, along with short coverage of selected projects that provide a descriptive cross-section of EU funded discard projects.

7.1.1 BADMINTON

BADMINTON (Bycatch And Discards: Management INdicators, Trends and locatioON) was a MariFish project that ended in 2012 (Vassilopoulou, et al., 2012) (Margeirsson, Sigurdardottir, Stefansdottir, & Vidarsson, 2012). The aim of the project was to build up the knowledge of discarding patterns and factors in European fisheries, evaluate the efficacy of selective devices and other discard management measures that have been implemented in the past, and improve methods to analyse, monitor, and manage bycatch and discarding.

The project developed a number of tools, distinguished in three categories i.e. selectivity related tools, tools to appraise and understand the discarding issue and tools to devise discard mitigation strategies. An overview of the tools are found in Table 2.

Table 2: The tools developed in the BADMINTON project

Type of tool	Description
Selectivity related tools	• A modelling tool to estimate gear selectivity based on fish morphology • Preliminary indicators of fishing selectivity at the fleet and ecosystem scales
Tools to appraise and understand the discarding issue in a given region, area or fishery	• Modelling tools to establish catch and discard maps and devise spatial approaches to the management of discards, based on on-board observer data • A series of discard indicators embedded in a discard indicator dashboard, to monitor and manage the discards in a given fishery – the concept and methodology to estimate and present these indicators based on on-board observer data have been developed and demonstrated on a short list of case studies • A generic model to determine the relative importance of inferred discard drivers • A list of factors to be used in semi-structured stakeholder interviews, and interview methodology
Tools to devise discard mitigation strategies at various scales	• A framework to develop a fishery-specific mitigation strategy based on inferred drivers of discarding behaviour • A detailed evaluation of 12 discard mitigation measures, alone

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	and in combination

The results from the evaluation of twelve different mitigation measures are available in Sigurðardóttir et al. (2015) where Strengths , Weaknesses, Opportunities and Threats associated with each of the mitigation measures are assessed (SWOT analysis available in Appendices). Following this assessment, the following process for managers aiming to mitigate discards were developed:

1. Describe the fishery, in particular looking at discard patterns and indicators.
2. Analyse which drivers are in place in the market, regulations as well as community perspective, and if the drivers interact in influencing discard behaviour, pattern and level.
3. Establish a suite of mitigating methods designed to address the most important drivers or combinations of drivers. The analysis and formulation of the set of methods could be in some form of co-management with stakeholders to gain knowledge and legitimacy of the set up.
4. Implement mitigation methods, in collaboration with stakeholders.
5. Monitor and evaluate the effect of the mitigation methods.
6. Identify gaps involving stakeholders in the process and develop new methods to increase efficiency.
7. Repeat 1-6.

The BADMINTON project provided a good overview and assessment of most of the available mitigation measures. It showed that there are variable methods available, each with its pros and cons. None of the measures are though specifically targeted on the UUC while it is on-board the boat.

7.1.2 FAROS

FAROS (Integral Networking of **F**ishing Sector **A**ctors to Organize a **R**esponsible, **O**ptimal and **S**ustainable Exploitation of Marine Resources)[1] is a European project co-funded under the LIFE- and ENVIRONMENT PROGRAMME of the EU which ended in 2013 (FAROS, 2015). The objectives of the project was to develop and implement a bycatch management network, comprising all actors present in the fishing sector (fleets, ports, auctions, industries, etc.) that would aim at minimisation of discards/bycatch as well as optimal valorisation of UUCs. The valorisation technologies that were focused on had already been identified in a previous LIFE project called BE-FAIR, that primarily involved production of valuable chemicals for the food and pharmaceutical industry.

Amongst the products of the FAROS project was the *iObserver* which is a decision support software that is able to gather data along the entire supply chain, giving information on where to fish and using what kind of gear, as well as what to do with the catch on-board the vessel with respect to market demand and utilisation alternatives.

The objectives of the FAROS project are highly relevant for WP5 in DiscardLess, linking together the entire value chain from catch to market gives an added value in identifying plausible alternatives. When FAROS ended in 2013 it provided "proof of concept" of a number of alternatives that were then worked on further in a linked project that followed, called iSEAS.

[1] www.foarosproject.eu

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7.1.3 iSEAS

iSEAS (Knowledge-Based **I**nnovative **S**olutions to **E**nhance **A**dding-Value Mechanisms towards Healthy and **S**ustainable EU Fisheries)[2] is a Spanish LIFE project that is running from 2014 to 2018 (iSEAS, 2015). The objective of the project is to demonstrate that a number of specific existent knowledge and novel innovative solutions for discard reduction can be implemented to enhance sustainability in EU fisheries. iSEAS focuses on three plausible alternatives that have been developed in other projects i.e.

1. To test the implementation and performance of the *iObserver* on-board vessels. The *iObserver* is a real-time information system that was developed in a previous LIFE project named FAROS. Part of this task will be to demonstrate how technological solutions can be used to perform qualified observer work on-board fishing boats. The *iObserver* is also able to gather data along the supply chain and use it to predict what fishing grounds are likely to have significant volumes of bycatches and high discard ratios.
2. To optimize fishing activities through the development of a reliable tool based on mathematical models that is able to analyse the spatio-temporal conditions of considered fishing areas. This tool will enable fishermen to take real-time decisions on what fishing grounds to choose in order to enhance selectivity of the fishery.
3. To define a real fully operative in-land demonstration facility for discards valorisation processes and trade named *iDPV* (Integral Discards Processing and Valorisation Point).

This project is therefore meant to demonstrate how ICT solutions can be used to observe and provide information that enables fishermen to be more selective in their fishing activities, as well as demonstrating how UUC can be used to produce valuable products. It is therefore highly relevant for WP5 in DiscardLess.

7.1.4 Scottish Cod Catch Quota Scheme

In 2008 the Scottish authorities started trials with Remote Electronic Monitoring (REM) as a tool to investigate efficiency of discard ban for cod in the North Sea (Needle, et al., 2014). Equipment was installed on 7 vessels that in return got two trips that where not counted against quota or effort limits. The vessels were also obliged to bring all cod to land. In August 2008 Scotland, other parts of UK, Denmark and Germany signed the Aalborg statement recommending use of CCTV (part of REM system) in fisheries monitoring. In 2010 this developed into the Cod Catch Quota Scheme (CCQS)[3]. The CCQS required participating vessels to land all cod but the incentive was initially 30% additional quota, additional days at sea and permits to fish within real time closures. Vessels wanting to participate in this program had to make a bid for the ratio of additional quota needed for their participation, with a maximum of 30%. Vessels participating in the program were not allowed to lease out quota or days at sea. The number of participating vessels in CCQS has grown from 20 in 2010 to 27 vessels in 2014. The demand for participating has always been higher than the available quota for the program. The retention rate in the CCQS has been rather high; in a four year period from 2010 to 2014 a total of 46 vessels participated in the scheme. By 2014 there were 27 vessels that were still participating, 12 had left for unknown reasons, five were expelled, one sold and one sank.

MCS is one of the main focus points of WP5 in the DiscardLess project and the experiences gained from the CCQS are a valuable input into that work.

[2] www.lifeiseas.eu

[3] http://www.gov.scot/Topics/marine/Licensing/FVLS/catchquota

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 633680

7.1.5 Danish Fully Documented Fishery with Catch Quota

In 2008/2009 Danish authorities initiated a pilot project for Catch Quota management Fully Documented Fishery (FDF) by electronic observation using CCTV. Participants received additional quota, an act that got endorsement from the EU in 2010. Then in 2011 it was made mandatory for all vessels to register discards in log books (Ulrich, et al., 2015) (Ulrich, et al., 2013). A report comparing log books and landed catch from vessels participating in FDF program and those who were not, showed that all vessels participating in FDF reported discard while only few non-FDF did.

The extra quota share incentivises FDF vessels to land what they previously discarded (Catch Quota without a discard ban), As a result, discards ratios have largely decreased compared to the rest of the fleet, but did not completely disappear. A comparison of the reported discard and the discard observed from footages showed that discard estimates of the crew were slightly lower than observer's estimates (Ulrich et al., 2015). Clear changes in discarding behaviour has been observed for some participating vessels, as shown in Figure 18, where the smallest size category marketable fish appears in the landings of vessels in the FDF, shown as yellow, but is not present in reported catches the same vessel before entering the trial. This shows clearly that CQM combined with FDF increased compliance and reduced high-grading (Ulrich, et al., 2013).

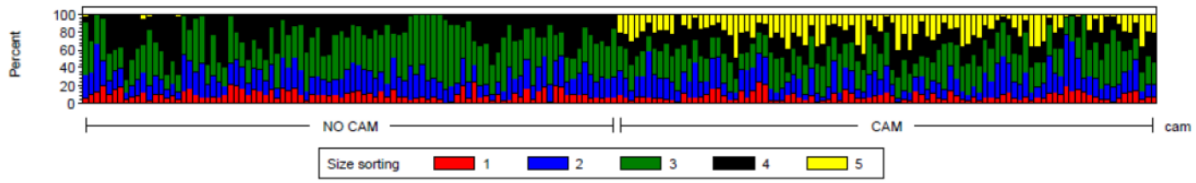

Figure 18: Market categories distribution per trip of a given vessel trawling with before and after entering the FDF

This project showed that CCTV and other FDF tools can contribute to solving the discard problem. In this case there were CQM incentives that drove fishermen to implement the FDF, but it also demonstrated that CCTV and FDF is an applicable tool for MCS; and is as such highly relevant for the upcoming work in WP5 in DiscardLess.

7.1.6 BIOTECMAR

BIOTECMAR (Biotechnological exploitation of marine products and Byproducts)[4] is an INTERREG project that finished in 2011 (BIOTECMAR, 2015). The main objective of BIOTECMAR was to set-up and incorporate a fully integrated chain for production of value added compounds derived from marine resources. The project was able to set-up a network capable of supporting development of an integrated chain using marine by-products and products derived from fishing, aquaculture, seaweed and food industry for the production of valuable ingredients for food, animal and human nutrition, cosmetics and health. This project was specifically looking at biotechnological solutions, which are relevant for WP5 in DiscardLess.

[4] http://www.biotecmar.eu/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 633680

7.1.7 MARMED

MARMED (Development of innovating biomedical products from marine resources valorisation)[5] is an INTERREG project lead by Portuguese researchers that ran for two years in 2012 and 2013 (MARMED, 2015). The project aimed at isolating and purifying biomolecules and biopolymers from UUC and other marine materials, with potential biomedical applications that could be used in the context of pharmaceutical, medical and nutraceutical areas.

MARMED focused on how biotechnology can be applied to produce valuable products from UUC and RRMs. It is likely that results from that work can be applied on-board fishing vessels in the context of the landing obligation.

7.1.8 The Scottish real-time closure pilot

In 2007 a real time closure pilot in the North Sea was initiated by the Scottish Government, acting through the Marine Laboratory in Aberdeen (Catchpole & Gray, 2010) (Little, Needle, Hilborn, Holland, & Marshall, 2015)[6]. Participation was voluntary and only open for members of the Scottish Fishermen´s Federation. Participation was incentivised by offering additional quota and extra days at sea. An area of 15x15 miles square was closed if captain reported of three positives counts, in 48 hours, that showed more than 60 fishes caught below the minimum landing size of 35 cm. The area was kept closed for 21 days and reopened automatically after that. The number of total closure was limited to nine areas and only three areas in a square of 45x45 miles could be closed at the same time. It is estimated that the pilot saved 300,000 juvenile cods from capture. The minimum landing size was increased while the project was ongoing, and this caused the focus to move from juvenile to spawning cod.

Although the pilot helped Scottish fishermen to obtain extra days-at-sea and an 11% extra cod quota, it is unclear whether cod discards were reduced as a result of it. The fact that closures were decided based on reports from fishermen was in interesting experiment, as reliability of the reports became an issue.

7.1.9 Irish Sea data-enhancement pilot

In 2006, the EC proposed that in fisheries where stock size or fishing mortality was poorly known, a 25% default reduction in TACs and fishing effort would be applied (Catchpole & Gray, 2010) (Hoare, Graham, & Schön, 2011). As results the North Western Waters Regional Advisory Council decided to initiate a data collection pilot in 2007 to provide accurate data on catches, landings and discards; in order to enhance the existing information, and to pave the way for discard-reduction initiatives. However, the pilot was delayed by EU bureaucracy and funding difficulties, while fishermen who took part saw it as hijacked by administrators and scientists, and complained about the excessive paperwork involved. The data collected was incomplete, and could not feed into ICES assessments because it lacked a time series of several years. This was the second least successful pilot. Even though the project was a failure it shows that industry responds to minimize economic damage from regulatory changes, as there was a clear incentive for them to have the quota increased again.

[5] http://www.marmedproject.eu/

[6] http://www.gov.scot/Topics/marine/Sea-Fisheries/management/restrictions/closures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 633680

7.1.10 Dutch self-sampling pilot

Sensing that the discard rates used by the Institute for Marine Resources and Ecosystem studies (IMARES) for stock assessment of the North Sea plaice were flawed, the Dutch Fish Product Board (DFPB) started their own sampling program for plaice in 2004 and later for cod (Kraan, Uhlmann, Steenbergen, Van Helmond, & Van Hoff, 2013) (Catchpole & Gray, 2010). IMARES analysed the data for 2005 and 2006 and found out that their numbers were significantly higher than the numbers from the sampling program, 44% higher for 2005 and 55% higher for the 2006. At-sea sampling of commercial fishery catches by observers is expensive and a single observer can't sample all hauls. Data from observers can therefore be clustered and effectively of small sample sizes. Sampling by fishermen is therefore an interesting alternative, because a larger number of trips can be sampled at lower cost. Self-sampling need though to be taken with some reservation, as there can be an issues of reliability and data-acceptance related to it.
The Dutch self-sampling pilot led to trials for more selective gear designs with the support of the industry. The project was initiated by the industry as they felt that scientists were using too high mortality rates. The fact that the industry could take the matter into their own hands and come up with a solution and alternatives that were practical, realistic and to a point reliable is something worth keeping in mind.

7.1.11 The Scottish self-sampling pilot

"The sustainable supply Chain Project" was initiated by the Clyde inshore fishery industry when faced with quota cuts and in their opinion too high discard rate estimates use by scientists in the Nephrops fisheries, which is the most important fishery in the area (Catchpole & Gray, 2010). The project covered 12 months period in 2006-2007. Every vessels in the Nephrops fishing fleet were invited to participate in the sampling plan were data such as crew, vessel, gear type, catch condition and composition and discard would be collected. The data was provided to scientists and did encourage trials of more selective gear. It is however not expected that fishermen will be willing to make the change to more selective gear if there is no economic incentive, such as higher market price for Nephrops caught with selective gear.

7.1.12 English self-sampling pilot

As part of the UK Fisheries Science Partnership programme, the fishing industry requested that cod fishery skippers collect their own information on cod catches, both landings and discards, because of feelings that the scientists' estimates of the 2005 year class of cod were too low due to fish escaping beneath the survey ship trawls, and that consequently cod quotas were too small (Large, Brown, South, & Hale, 2008) (Catchpole & Gray, 2010). In this pilot, known as the 'Codwatch Project', 12 fishing vessels belonging to the Eastern England Fish Producers' Organization were paid £50 per day to record during a 12-month period (April 2007–March 2008) the incidence, distribution, and abundance of the 2005 and 2006 year classes, and of cod in general, from their commercial catches, as well as data on fishing location, fishing effort, fishing gear, and target species, etc. More than 1,000 hauls were sampled between April and July 2007, the data from which was submitted to Producers' Organisation for collation, analysis, and comparison with estimates from the Cefas Discard Observer Scheme, before onward transmission to Cefas scientists and the Eastern England Fish Producers' Organization members. This project demonstrated how fishermen, producers' organisations, scientists and authorities can work together for a common cause.

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7.1.13 Netherlands, "What do pelagic freezer trawlers discard?

In the period 2002-2005 Dutch scientists went on 27 fishing trips with Dutch pelagic freezing trawlers to try out different methods for estimating discard and slippage (Borges, Keeken, Helmond, Couperus, & Dickey-Collas, 2008). The result showed that some 30,000 tons were discarded annually by the fleet, thereof was 10% contributed to slippage. Discard estimates of target species was considerable and the species with the highest discard rates were mackerel (41%), herring (19%) and horse mackerel (15%).

The project was not deliberately intended to reduce discards, rather just to quantify the problem. The results revealed that the problem was much more severe than originally expected.

7.1.14 Beam trawlers in Devon

In 2009 the Devon Beam Trawler Fleet and UK scientists started a pilot project with the aim of reducing discards of juvenile fish by 50% in the English Channel (Mcllwain, 2015). The project was called Project 50%. The Devon beam trawler fleet had at the time one of the highest discard rates in the UK. The project used social scientists to understand the reasons behind the apparent resistance to adopting new gear modifications and to help guide a new approach to developing discard reduction techniques. Collaboration was a core element in this project. This provided an opportunity for crews to identify barriers and gaining support from authorities to remove regulatory restrictions. The crews then worked with local net-makers on improvements. At the end of the project there were 11 different modifications in mesh size and trawl structure. The project was a success with the average discard reduction of 52% and the most successful boat achieved a 69%. The results also concluded that gear has to be adapted to individual vessel, season and fishing area for optimal results.

Despite the successful changes made in the fishery, additional alterations to management will be needed under the new CFP to meet the landing obligation. The fishery continues to operate under conventional fishery management that has created limitations on the fleet's ability to be selective and to reach the newly adopted requirements of the CFP. Nevertheless, the fishery has a head start through Project 50%. With the incorporation of appropriate management design features, the fishery can continue progressing towards meeting the landing obligation.

7.1.15 The Swedish Nephrops fishery

A pilot project to find technical solutions to minimize bycatch in the Swedish Nephrops fishery was initiated in 2002 after implementation of a national ban on cod fishing (Catchpole & Gray, 2010). The results from the project included a new trawl grid, the so called Nordmore grid, which was trialled successfully. In 2004 the Nordmore grid became compulsory for Swedish vessels trawling in Swedish waters. This created "a near complete protection for adult round fish in Swedish waters. As an incentive to implement Nordmore grid and square mesh codend, authorities offered to subsidize the gear, removal of effort restrictions and access to areas closed for trawling. By 2006 a total 90, out of 110, vessels were using the gear. But lack of similar incentives by other countries caused vessels from other countries not to make similar changes.

7.1.16 French Nephrops fishery

Due to high levels of hake discard in the Nephrops trawl fisheries in the Bay of Biscay, the European Commission decided in 2002 to increase the minimum mesh size from 70mm to 100mm (Catchpole & Gray, 2010). The France authorities got a derogation for two years for the industry to develop alternative solution; and after trials of various gears a 100 mm square mesh

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panel gave the best results. The National Nephrops Committee made the use of the square mesh panel a perquisite to obtain a fishery license. Instead the commission opened a closed area for them, a decision that is reviewed annually.
There were nevertheless still massive discard problems in the fishery, particularly in the discarding of juvenile Nephrops. During the period from 2004 to 2006 the discard of small Nephrops in the fishery was estimated as high as 42% by weight and 61% by number; and there where over quota landings going on as well(Catchpole & Gray, 2010) (Nikolic, et al., 2015). This resulted in significant cut in the Nephrops quota in 2006, and the industry responded by starting a pilot project for testing a gear that could reduce discard of undersized Nephrops. French trawlers were equipped with a variety of selective devices, such as square-mesh panel, flexible grids, ventral square-mesh, larger mesh size in cod end etc. Even though the results were inconclusive the industry still made the use of three selective devices obligatory for obtaining a fishing license.

7.1.17 English Nephrops pilots

In 2005 and 2006 there were two pilot projects initiated in the English Nephrops fisheries aiming at reducing discards. Both were conducted by the Seafish Industry Authority, and in both featured the "coverless trawl" that is designed to encourage the escape of round fish bycatch.
The first project was focused at catching Nephrops for the live market. The captains where incentives to participate with a promise of teaching them about the live animal market. The project was successful as it reduced discard and increased the ratio of life Nephrops. The market for live Nephrops however preferred creel-caught animals over the trawl-caught and as results there were no skippers that adopted the coverless trawl after the pilot ended.
The second project was purely aimed at reducing discards of bycatches. The project succeeded in doing so, with examples of 70% reduction in whiting discards and 33% reduction in discards of other round fish species.
The economic incentive for fishermen to continue using the coverless trawl after the pilot ended is likely to explain the lack of uptake, but with the implementation of discard ban there might be a new incentives to try it again.

7.1.18 German discard ban pilot

German scientists along with the German fishing industry planned two discard ban pilots in two different fisheries (Catchpole & Gray, 2010). The former was the saithe fishery in the North Sea known for little discard while the latter was cod fishery in the Burg/Fehmarn region with a known discard problem. The aim of the project was to improve stock assessment data, simplify regulations and stop discarding of marketable fish. The project failed at start as the EU commission was not willing to grant the derogations needed. There are claims that this is at least partly due to lack of support from the German government and lack of enthusiasm by some of the scientists. It is hard to come to a conclusion from limited information on why this project actually failed.
The fact that this project was a cooperation between the scientific community and the industry shows that industry is open to changes and willing to participate.

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7.1.19 The Italian square-mesh codend pilot

In 2007 the EU council issued a directive imposing either 40mm square mesh or a 50mm diamond-mesh on Mediterranean fishing vessels (Catchpole & Gray, 2010). This caused Italian scientists and fishermen to initiate a pilot for square mesh codend. The pilot covered 12 months period in 2005-2006. The results were very promising; as the squared meshed codend was more selective than the traditional diamond-mesh codend. There were some losses of target species but the Hake that escaped was below the minimum landing size and the negative economic impact was minimal. Captains proved willing to adopt the square mesh cod-end given that all captains did the same. The General Fisheries Commission for Mediterranean agreed to implement the 40mm square mesh on voluntary basis in 2007 and to evaluate the results in 2010.

This pilot project showed clearly that fishermen are willing to implement changes given that the playing field will be level.

7.1.20 The Northern Irish Nephrops pilot

When quota and effort restriction were imposed by the Irish Sea Cod Recovery Programme, fishermen in the Anglo-Northern Irish Producer´s Organization began to explore options that could allow them to be exempted from those restriction. To do so a pilot consisting of four projects was initiated.

In the first one, large diamond meshes were inserted in the top sheet of the trawls, but the results were inconclusive. The second was a data gathering project, collecting data to improve stock assessments; but again the results were inconclusive. In the third project the possibility of using creels out in the open seas was explored, this proved only to be economically viable if there were 1,000 creels per vessel. The high number of creels was considered to cause conflict with trawlers by limiting their fishing area. The aim of the fourth project was to improve the selectivity of the Nephrops trawl, testing more types than the first project. The project came to halt because of a funding problem in 2007.

7.1.21 The English beam-trawl pilot

The UK Centre for Environment, Fisheries and Aquaculture Science (CEFAS) ran a pilot consisting of four projects were the aim was to reduce discard in the British beam-trawl fisheries (CEFAS, 2007) (Catchpole & Gray, 2010).

In the first project three modifications were tried, two were aimed at reducing the catch of cod and other round fish while the aim of the third modification, a square-mesh panel, was intended to reduce bycatch of unwanted benthic invertebrates. Only the third one showed promising results.

The second project ran simultaneously with the first one and tested the same panel as had shown promising results in the first project, the results from the first project were confirmed.

The panel was then tested under commercial conditions for the period of 12 months in the third project. There were promising results but the gear needed further development.

The fourth project was a competition, "Clean Fishing Competition", were the panel was developed further and used for six months in 2006-2007. The completion winner reduced discard by 60% and had record landings of target fish at the same time. The gear also contributed to increased catch quality, resulting in higher prices. Twelve other vessels tested the gear but captains of other vessels feared loss of target species and would therefore not use it.

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7.1.22 The Irish Nephrops/cod pilot

During the first introduction of closed areas and seasons in the Irish Sea by the EU in 2000 the Irish industry initiated the Nephrops/cod pilot project (Rihan & McDonnell, 2003) (Catchpole & Gray, 2010). The aim of the pilot was to test a separator panel designed to release spawning cod. The panel proved so effective that fishing with Nephrops trawls fitted with separator panels was permitted within a defined part of the closure area in 2001. However, although an increasing number of vessels took advantage of this permission, the permitted area was too small and too poorly policed for the gear modification to have much impact on spawning stocks.

7.1.23 The Baltic Sea BACOMA project

The Baltic fishers' organizations sought to head off heavy cuts in quotas or large-scale fishing closures by initiating trials of selective gear during 1997–2000 (Suuronen, Tschernij, Jounela, Valentinsson, & Larsson P-O, 2007). A total of 465 trawl tows trialled various types of codends, the results suggesting that the best device for reducing cod discards was an escape window in the codend. A square-mesh window, called the BACOMA window, installed in the codend was chosen by the industry as the preferred design. When a 120 mm version was prescribed for the Baltic cod fishery in 2002, use of the BACOMA-window codend was widespread. However, the target catch losses to trawlers using it were considerable – up to 70% – and most skippers therefore switched to the alternative permitted by the regulations, a 130 mm diamond-mesh codend, which resulted in a resumption of high discard rates and the consequent closure of the fishery by the EU in April 2003. The ban was lifted in September 2003 but only for vessels using a 110 mm BACOMA-window codend.

7.1.24 Summary

This section described a number of initiatives that have taken place in the past regarding discards reduction. With the current implementation of the landings obligation, increased focus is given on this topic. DiscardLess Work Packages 3 and 4 are specifically dedicated to this, and will provide updated reviews and meta-analyses of technological and tactical solutions.

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7.2 Initiatives tempted to reduce discards in countries outside CFP waters

A number of initiatives have been attempted in order to reduce discards in countries where discard bans are already in effect. Countries such as Iceland, Norway, New Zealand, Alaska, Canada and Faroe Islands have tried different approaches to incentivise or force fishermen to land all catches and to produce valuable products from those catches.

Many of the incentives and/or enforcement measures tempted are either a part of the management measures that have been discussed in chapter 5 or the MCS measures discussed in chapter 6. The initiatives covered in this chapter are examples of more targeted attempts where specific solutions have been successfully applied.

7.2.1 Iceland

Landing obligation has been a part of the Icelandic fisheries management system since 1977 (EC, 2007). In the beginning the discard ban only applied to few species, but it has been gradually extended and since 1996 there has been a total discard ban on all commercially important species.

Fishing regulations are enforced through on-board and on-shore observers and by the coast guard. Electronic log books and VMS are also mandatory. Area closures are used to protect juveniles and vulnerable areas, and gear selectivity devices have been made mandatory in some fisheries and areas.

Even though estimates indicate that discards are below 1% in the Icelandic fishery and that discards are considered socially unacceptable by fishermen, authorities and the general public alike; there are still a number of solutions provided within the fisheries management act that contribute to minimising discards and incentivise fishermen to land all catches. These have for the most parts already been covered in chapter 5 and 6. There are however also a number of initiatives that have been implemented in the past that are aimed at specific fisheries or fleets. These initiatives are for example the establishment of the "bycatch catch bank", the landing obligation on lumpfish, catch ban on halibut, landing obligation on cod heads, allowance to land catches without deduction from quotas or subjective to partial deduction of quotas, and development of decision support systems to minimise discards.

<u>The bycatch bank</u>

In 1989 the Icelandic government launched a pilot project called "the bycatch bank" (Clucas, 1997). The primary aim of the bank was to demonstrate to fishermen and the fishing sector that there were markets for unusual species of fish caught as bycatch and where necessary introduce and promote those new species to consumers. This was done by such activities as "strange fish weeks" in restaurants, manuals which assist in identification of new species and recipe booklets. The bank also bought and collected together small volumes of marketable fish, creating larger batches that would be more attractable for processors. The bank organised to purchase blocks of frozen fish of "non-commercial" species from fishing boats, arranged taste panels, promotion schemes and sales to restaurants etc. As results of the project, a number of species that had previously been discarded because they had little or non-commercial value are now landed and sold for good value.

<u>Landing obligation on lumpfish</u>

The lumpfish fishery in the N-Atlantic has traditionally been focused almost solely at harvesting of the roes (Þórðarson, Pálmason, & Reykdal, 2013). The male and the carcases of the female,

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which account for approximately 70% of the weight of the female, have subsequently been discarded at sea. The Icelandic authorities however decided in 2010 to impose a landing obligation on the lumpfish fishery, which took effect in 2011. At that time there were very little opportunities for processing any kind of marketable products from the catch. The industry and the R&D community was simply given the task to find solutions, which they did. New markets were developed in China, where the National Association of Small Boat Owners in Iceland took the lead in getting all of the necessary players on-board. As results the fishery is now "discard-free", valuable products are being produced from previously discarded catches and new job opportunities have been created. In 2014 were almost 2500 tonnes of these products, valued at close to 3.5 million EUR exported from Iceland to China (Statistics Iceland, 2015)

Ban on targeting Atlantic halibut

A total ban on targeting of Atlantic halibut was regulated in Icelandic waters in 2012 (Icelandic Ministry of Fisheries, 2012). The ban entailed that accidental bycatches of halibut should be released if assessed likely to survive, but otherwise to be landed and the entire landing value forfeited and allocated to a research fund. This has resulted in a 90% reduction in reported halibut landings, but there are indications that this has created a "black market" for halibut. Buyers at auction markets have also complained that quality of what little halibut is available is very pore, due to the fact that fishermen do not have any economic incentives to land top quality.

Landing obligation on cod heads

A regulation obligating Icelandic fishing vessels with on-board processing to bring a shore a certain proportion of cod heads that derive from catches within Icelandic waters came into force in 2012 (Viðarsson & Þórðarson, 2015). During preparation on the regulation the Ministry had gone from demanding that all cod heads and cod livers should be landed, down to only a 30-40% landing obligation on the cod heads alone. The reason why the regulation was initiated in the first place was perhaps more contributed to moral responsibility i.e. that if a vessel is allowed to fish from a resource owned by the nation as a whole, it should utilise the whole catch.

The regulation has though had limited effects on the volume of landed cod heads, as most factory vessels subjected to the regulation had already met with the requirements before the regulation came into effect. The cod heads have become a valuable part of these vessel's catches, but the capacity of the freezers and available space in the freezing hold is however a limiting factor, which is why parts of the cod heads are still being discarded. As results the industry and R&D have been looking into possibilities to process the most valuable parts of the cod heads, such as tongues and cheeks at sea.

VS-catches

Fishermen are allowed to land up to 5% of catches without deducting it from quota, but will then have to forfeit majority of the catch value. The vessel then receives 20% of the value and 80% is allocated to a research fund* (Directorate of fisheries, 2015). In 2014 these landings amounted to little over 2.036 tonnes in total. Fishermen are also allowed to land catches under MCRS and to count them only 50% against quota. In 2014 these landings amounted to 1.350 tons.

Both of these initiatives create incentives for fishermen to land catches that otherwise would have been in danger of being discarded.

* *Verkefnasjóður Sjávarútvegsins (VS) e. Project fund of the seafood industry*

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Decision support tools

Icelandic researchers, fishing companies and software providers have increasingly been using data collected within the value chains to take informed decisions on where and when to fish, what products to produce and for which markets etc. (Margeirsson S. , 2008). One component of this work is to map up fishing areas in regards to catch composition, size distribution, yield, gaping, nematodes etc. As results, fishermen can now avoid discard hot spots and maximize value of their quotas. Companies can chose to share data or solely rely on own data. Discards are though only a part of what these decision support tools contribute to the fishing sector, as they enable companies to reduce costs, increase value and optimise their whole production. Examples of such decision support tools are TrackWell Maritime[7], WiseFish[8], Innova[9] and combinations of other more specific software's that provide captain's and fleet managers with relevant information, such as e-logbooks[10], plotters[11], processing information's and traceability data.

The initiatives mentioned above have had variable effects on reducing discards and their relevance for WP5 of DiscardLess are also variable.

7.2.2 Norway

Norway has a long experience of discard ban, which was initially implemented in 1987 but has gradually expanded and covers now all commercially important species and all Norwegian waters (Condie, Grant, & Catchpole, 2014). Norwegian fisheries are managed by ITQ and vessel group quotas, where fishing activities that are at risk of exceeding quota should generally be stop. It is however legal to land small amounts exceeding quota or non-target species and sell. Larger quota overruns can also be legally landed but the catch is then forfeited i.e. the vessels receive 20% of its value to cover landing cost and the rest is allocated to the Directorate of Fisheries and the Sales Organisations. Norwegian fisheries management relies to a large extent on area closures to protect juvenile and vulnerable areas. A focus has been placed on development in gear selectivity improvements in the Norwegian fishing industry and many of the solutions that originally were voluntary implemented have now become mandatory.

The Norwegian authorities have invested heavily in R&D to increase selectivity and improve utilisation. The industry itself has also invested considerably in technology to improve utilisation with the objective to increase profitability. Gear selectivity, fleet communication and ICT for decision support and development of technology to utilise by-products are amongst solutions that have been focused on.

The Norwegian authorities have initiated few large scale projects that have very extensive objectives, such as the CRISP project and the Cod program (Torskeprogrammet) that are to address many challenges in a coordinated manner. They are also funding smaller R&D projects looking at more specific challenges.

[7] http://www.vmsfisheries.com/
[8] http://www.wise.is/english/customer-care/wisefish
[9] http://marel.com/fish-processing/innova
[10] http://www.vmsfisheries.com/fisheries-solutions/trackwell-fangstdag and http://www.olsps.com/elog/index.php
[11] http://www.maxsea.com/

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CRISP

Centre for **R**esearch-based **I**nnovation in **S**ustainable fish capture and **P**rocessing technology (CRISP)[12] is a 200 million NOK (22 million EUR project) ongoing eight year R&D project that focuses on all aspects of catching and processing (Forskningsradet, 2015). The project is broken into six work packages that are all highly relevant for the CFP landing obligation. The work packages are

- WP 1. Pre-catch identification of catch
- WP 2. Monitoring of fish behaviour and gear performance
- WP 3. Active selectivity and release in fishing gears
- WP 4. Low-impact fishing gears
- WP 5. Quality improvement by gear and handling modifications
- WP 6. Value adding in a sustainable fishery framework

WP1, which is on pre-catch identification, is developing and testing two solutions for identifying species and size on individual fishes, using transducer applications and broadband echo sounders. These can enable fishermen to make informed decisions before setting their gear on likely fishing grounds.
WP2 is developing technologies to monitor species, size and quantity hat is in the fishing gear, enabling the fishermen to decide if to continue fishing in an area and when to haul because of sufficient catches. A product that is currently being introduced to the market leading from this work is the DeepVision technology that Scantrol AS is leading.
WP3 is working on similar solutions as WP2, using computer vision technology to identify each fish and then decide whether to catch or release it. This is based on the CatchMeter technology developed by Scantrol AS, but the solution is still under development.
WP4 is developing trawl gear that does not come into contact with the seabed.
WP5 is looking at different possibilities to improve quality of catches, but most of the effort is awarded to reducing haulback speed, using pumping technologies to get the fish on-board and keeping the fish alive on-board the vessels. These solution will then enable fishermen to process catches with the best imaginable quality or land catches alive into capture based aquaculture (CBA). The Norwegian authorities and the entire fishing industry have been looking enthusiastically at CBA for some time, as it could make it possible to address the extreme seasonality of the cod fishery and allow them to raise juvenile catches to more marketable size products.
WP6 is then looking at the economic impact of the solutions suggested in the other WPs using cost-benefit analysis.

Figure 19 shows some of the solutions that have been developed and tested in WPs 1-4 (MRI, 2015)

[12] http://www.imr.no/crisp/en

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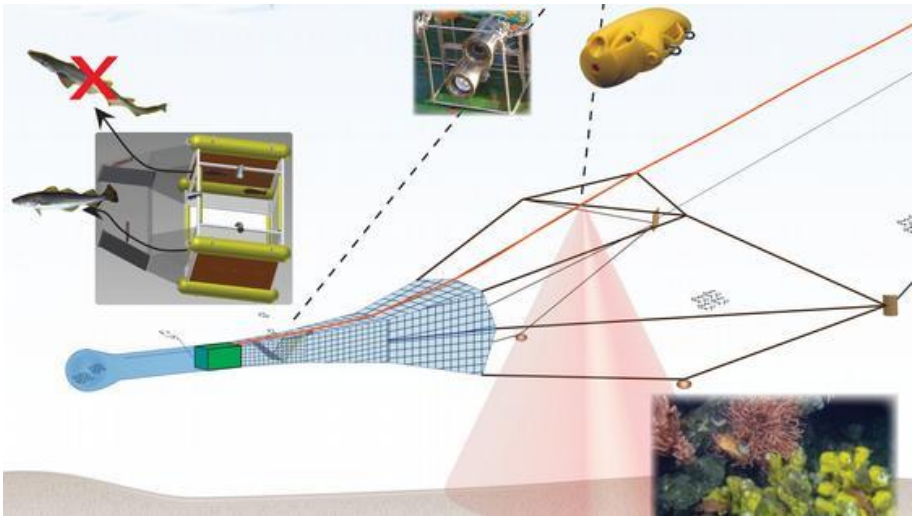

Figure 19: Solutions developed within the CRISP project

The possible solutions that the CRISP project can contribute to WP5 of the DiscardLess project are the once that are focusing on getting catches alive on-board the vessel and keeping them alive for possible CBA. If successful in binging catches alive on-board and keeping them alive, there might be a possibility in demonstrating high survival rate of released catches. The other alternative is using catches under MCRS for CBA, but how the landing obligation of the CFP would address that remains to be seen i.e. catches under MCRS cannot be used for direct human consumption according to the CFP landing obligation.

The cod programme

Torskeprogrammet[13] is a five year 22 million NOK (2.5 Million EUR) framework program funded by the Norwegian Seafood Research Fund (FHF) (Torskeprogrammet, 2015). The objectives of the project are to analyse socio-economic and legal aspects surrounding the Norwegian cod fishery and how those can be improved to create competitive advantage for the sector as a whole. The Norwegian seafood sector is hugely important for regional development and socio-economic impacts in certain areas in the country. The fisheries management and legal environment in which the sector has to operate has been affected by this, which to a point is hampering optimisation and making the sector not as competitive as many other sectors. The results of the project will be used to take informed decisions by the authorities on how to improve competitiveness of the cod sector whilst taking into effect socio-economic impacts, such as regional development.

As in Norway, the CFP is hugely affected by socio-economic and legal constrains. Changes in management have severe impacts on rural development and social implications on relatively broad scale. This is why the Cod programme could potentially contribute to WP5 in the DiscardLess project and the CFP landing obligation. As in most EU countries, the Norwegian coastal fleet comprises of small vessels that do not return significant economic profits, despite of being favoured by legislative decisions. These are also the vessels that are the most difficult to MCS, have the biggest problems with maintaining quality of the catches and are likely to discard

[13] http://torskeprogrammet.no/

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low value catches because of lack of storage space. The results from the cod programme are therefore going to be interesting in a CFP landing obligation context.

RUBIN

RUBIN[14] was a Norwegian research fund that was operated in Norway from 1992 until 2012 which had the sole purpose of contributing to increased utilisation of by-products (RUBIN, 2015). Much of the advances that have been made in utilising RRMs have come from projects funded by RUBIN. These include for example production of silage, FPH, FPC, drying of heads and bones, collection of RRMs, marketing of by-products etc. The Norwegian Seafood Research Fund (FHF) has now taken over the responsibilities of RUBIN.

These are only some of the initiatives that have been introduced in Norway in recent years that have potential relevance for the DiscardLess project. As with similar initiatives in other countries the main focus has been on gear selectivity and product/process development, but little advances have been made on issues addressing the UUCs while they are on-board the vessels.

7.2.3 Faroe Islands

Faroese fisheries are managed with effort controls, which means that there are no catch limits and subsequently no invectives for discarding marketable catches. The general consensus is therefore that discarding does not exist in Faroese waters. The emphasis now is however on discarding of RRMs, as the Faroese fishing industry utilizes today almost solely the fillets and discards all potential by-products. Faroese authorities are now putting extra effort into researching possibilities to bring everything ashore and make valuable products from it, for example through the research project "Alt I land" (Norden, 2015). It has even been suggested that it should be put into regulation that everything should be landed, including viscera, heads, frames, roes, liver etc. (Bertholdsen, 2015)

7.2.4 US and Alaska

A number of fleet communication initiatives have been successfully implemented in US/Alaskan fisheries over the past twenty years (Gilman, Dalzell, & Martin, 2006). These have for example been implemented in the Alaskan demersal longline fishery, the US North Pacific and Alaska trawl fishery and the US North Atlantic longline swordfish fishery.

In 1992 the North Pacific Longline Association voluntarily instituted a fleet communication program by hiring a private company, Fisheries Information Services, to manage fleet communication to reduce halibut bycatch, and in 1999 added fleet communication to reduce seabird bycatch in Alaska demersal longline fisheries for freezer-longline vessels. This fleet communication program is still in operation.

Observer program raw data is delivered to the US National Marine Fisheries Service via radio. US National Marine Fisheries Service observer data include catch data for each observed vessel: observations of number and weight of target and bycatch species hooked, locations of set deployment and retrieval, and fishing effort. Fisheries Information Services accesses the government observer database over the internet and sends reports to managers and skippers,

[14] www.rubin.no

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via e-mail. Fisheries Information Services e-mails weekly "report cards" to the fleet and provides detailed information on individual boats' bycatch to each vessel owner. Weekly information includes raw numbers of birds caught and weight of halibut bycatch for each vessel and totals for the entire fleet. Vessel codes rather than vessel names are used in the report in order to protect confidentiality. However, all vessels have provided their codes to a fishery organization, the North Pacific Longline Association, which is then able to contact individual vessels whose bycatch levels and rates are high. This separation of the analytical and "enforcement" parts of the program is deemed critical. The entire fleet participates in this voluntary programme today, which makes it difficult to estimate its effectiveness. However, during a period of seven years here were about ten boats that did not participate in the programme, during which average halibut bycatch rates of non-participating boats were 10–30% higher than participating vessels. Analysis also showed that fishing effort moved away from bycatch hotspots after warnings were issued to the fleet.

In 1994, the US Washington, Oregon, and Alaska trawl fisheries, voluntarily hired a private company, Sea State, Inc., to establish and manage a fleet communication program. The program was aimed at reducing bycatches of salmon in pollock fisheries; halibut in flatfish and cod fisheries; several species of crab in flatfish, cod and scallop fisheries; and several species of rockfish in pollock, mackerel and whiting fisheries. The program is still in operation and participation has always been high, reaching now 100% of the involved fleets.
Methods used for fleet communication are e-mail via several satellite systems and the Northwest Groundfish Observer Program, short catch logs via satellite-based vessel monitoring systems (VMS), and occasional phone calls. Most of the trawl fisheries have high on-board observer coverage and send their observer data directly to Sea State. The observer data includes bycatch data for each vessel on the number of bycatch species hauled aboard, location where bycatch species were hauled aboard, and fishing effort. Some smaller trawl fisheries that have relatively low observer coverage submit their own observations of bycatch to Sea State. Sea State analyses the bycatch data to produce maps, tables, commentary, and other products providing information on the location of bycatch hotspots, and sends these products daily, usually via e-mail, to the fleet.
No formal evaluation of the effectiveness of the Sea State-managed fleet communication programs has been conducted. Because abundance of bycatch species is not well understood, trends in bycatch rates do not necessarily provide an accurate indicator of the effectiveness of the fleet communication program, but instead could be caused by changes in abundance of bycatch species. The concrete effects of the programme can though be estimate in monetary value reaching millions of dollars a year. The program has for example enabled the fleets to operate days and perhaps weeks longer in some years, as they would have been closed down due to bycatch limits if not for the communication programme. Also, fuel savings in the pollock fishery can mount into millions of dollars due to the program, enabling the fleet to avoid time and area closures, which would increase distances from port to fishing grounds.

In 2001 the Blue Water Fishermen's Association voluntarily established a fleet communication program for the US North Atlantic longline swordfish fishery, primarily to reduce loggerhead and leatherback sea turtle bycatch. This communication programme amongst the members of the fleet exchanging information on how to avoid where turtle bycatch is a high risk is now a

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standard part of the information shared between vessels. Vessels use short and long range radio and e-mail to communicate. Information communicated amongst the fleet incudes sea turtle encounters, sightings of clusters of sea turtles, and specific oceanographic features. The fleet-wide communication protocol enables vessels to avoid fishing on the warmer side of oceanographic fronts and tight bends in the edge of an oceanographic front, where fishers found relatively high interaction rates with turtles. There is enormous peer pressure among fishers to avoid turtle interactions to ensure a government threshold is not exceeded. Turtle bycatches have reduced by 50% since the fleet communication programme was implemented.

A discard ban was implemented in the US Alaskan groundfish fishery in 1998 and the ban is supported by one of the most comprehensive observer program in the world, with 100% observer coverage (Condie, Grant, & Catchpole, 2014). The targeted species are managed through Individual Vessel Quotas or fishing cooperatives while the non-target species are managed with bycatch limits. Species that are commercially important or vulnerable are defined as prohibited; and exceeding bycatch limits will cause area or fishery closure. Implementation of the discard ban and related regulatory framework lead to volunteer change in the fleet towards more selective gear, which have then been made mandatory. A group of longline fishermen have also formed a group to exchange information on catch areas, size and bycatch levels so that areas with high discard ratio can be avoided. Those who participate in this programme have 30% less bycatch compared to the rest of the fleet.
The sharing of information between fishermen in order to avoid unwanted bycatch is an interesting component that could potentially be implemented in some EU fisheries. There have been attempts made to develop ICT solutions for this purpose, but the uptake on a large scale has not been successful yet.

Fleet communication programs are only partly relevant for WP5 in DiscardLess, but may be further looked at in WP4, as they can potentially be extremely effective in certain fisheries. It involves gathering information on-board vessels and forwarding the data to competent entities. Effective MCS needs to be in place on-board the vessels and the captains need also to make informed decisions based on information disseminated by the programme.

7.2.5 New Zeeland

New Zeeland implemented an ITQ system with a discard ban in 1986 (EC, 2007). Discard is though allowed for species with high survival rates and catches below MLS. To incentivise compliance it is allowed to land over quota, non-target species or bycatches. This has though to be meet by acquiring additional quota or by paying a fine based on the market value of the catch. The fine is scalable and increases with the amount landed. The system does provide little incentives to avoid juvenile catch and discard of fish below MLS, or even catches surpassing quota. The only incentive is that the fishermen do only get a smaller part of the catch value (or in some cases no part at all). In order to reduce discards, the authorities have at their disposal the possibility to severally punish non-compliance, such as discarding, with extremely high fines or even confiscation of gear, license and vessel. Any fisher who is convicted of two or more offences for illegal discarding is automatically prohibited for a period of three years to work as a fisherman or benefiting from fishing.

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The approach of the New Zeeland authorities has been to a large extent to battle discarding by allowing fishermen to land unwanted catches if they forfeit a part of the landing value and by imposing extremely high punishment for non-compliance. Whether this is a plausible alternative for EU fisheries remains to be seen, as the allowance of landing bycatch opens up a possibility for significant overshooting of quotas and such a severe punishments for non-compliance could create significant socio-economic problems in European fishing villages where there are few job opportunities outside the marine sector.

7.3 Summation

The initiatives aimed at reducing bycatch and discards presented in this chapter are only an example of what has been tried in this respect in EU waters and selected fisheries around the world were discard bans are in place. The objective is to give an overview of what can be done, what has been tried, what has worked, what has failed and what are the necessary components to ensure success. In a paper published by Catchpole and Gray (2010) where they reviewed 15 European initiatives aimed at reducing discards, they found seven factors that they perceived important for their success. These were as follows:

1. There has to be perceived crisis in the fishery to unify stakeholders
2. Economic incentives need to be in place
3. Stakeholder participation i.e. authorities or researchers cannot be successful if the fishermen are not included
4. Proper funding needs to be in place
5. Expert knowledge needs to be available
6. Leadership and proper allocation of responsibilities is needed
7. Enforcement capabilities needs to be in place

The first two are strongly related, as the first one suggests that stakeholders are trying to circumvent or find mitigating measures to avoid negative impact. The perceived crisis factor was not critical for the success of the projects, but its presence in majority of pilots strongly suggests that it is an important factor to kick-start any project. The economic incentive can be at different stages of the project, it can be in the form of avoiding crisis, it can be direct payment for participating or implementing new solutions, or contributing to providing higher prices at the market. It can be in different forms, as direct payment for participation or subsidised gear, additional quota or extra days-at-sea or granting access to closed areas or higher revenues either because of higher price or increased catch. The economic incentive was found to be a key factor for the success of projects.

Stakeholder participation was considered an important factor and in the most successful projects, where fishermen were the senior partners, driving the projects and making decisions significantly increased the success rate. In one of the least successful projects the industry was not involved at all in driving the projects, giving the fishermen the perception that the project had been taken over by scientists and administrators.

Funding was also found to be important. It could be argued that this should not matter if the economic incentives were high enough, but Catchpole's and Dray's results suggest otherwise. Some of the pilots reviewed were quite expensive, the cost of the Swedish Nephrops project was for example 480,000 € and the French Nephrops pilot costed 1,400,000 €. Even when adequate funds where available bureaucracy around the funds had negative impact and at least in two cases prevented the participants from applying for more funding.

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Expert knowledge was available in all of the successful pilots. The role of the scientists was to help the crews to develop their ideas and often let the crew do the fine tuning. They also had a vital role observing the results and determine the success.
As in all organisations there is a direct relationship between strong leadership and success. In all the most successful projects there was a strong entrepreneurial leadership.
Enforcement was needed in some projects, most likely in the absence of proper economic incentives. In those cases fishermen sometimes proved willing to implement changes given that it would not create a disadvantage against other vessels participating in the same fishery. Catchpole´s and Gray´s (2010) conclusion regarding enforcement are in line with Eliasen´s (2014) findings that changes in regulations have to be received as fair by the fishermen and it is vital to keep the playing field level. All participants have to obey the same rules. When fishing vessels from one nation are for example not subjected to the same rules as other vessels, but are still targeting the same stocks, the playing field is tilted. This creates a risk that legitimacy of national regulations like this will be undermined and there will be lack of compliance.

The examples from countries where discard ban is already in place show that flexibility in quota and landing requirements is needed. Allowing fishermen to transfer quotas or land UUCs without being deducted from quota (but then forfeiting the sales value) are methods that have proven to be successful in reducing discards without creating incentives to target bycatches. Sharing of information is particularly interesting alternative, where examples have shown that fishermen can avoid unwanted catches by sharing information on their location.
Countries with active discard ban in place have chosen different paths in regards to enforcement and MCS. Alaska and Canada have opted towards placing observers on-board almost all vessels, whilst Iceland, Norway and Faroe Islands have relied more on IT and occasional visits by observers and coastguard. The approach of New Zealand to impose such strict punishments for non-compliance is an interesting approach, where fishermen that have been caught two times for not complying with the law are not allowed to work in the industry for at least three years. This should be enough to scare anyone from even considering to discard fish; but introducing this approach in Europe would probably create more problems than it would solve.

In countries with long experiences of discard bans, such as Iceland, Norway and Faroe Islands, it has become socially and morally unacceptable to discard catches. In these countries the fishing resources are considered a common property of the nation as a whole, and the fishermen are only awarded utilisation rights. This means that the fishermen are expected to treat the resource with respect, including that they should bring everything they catch ashore, regardless of whether they make money out of it or not. In these countries discarding of UUCs is not really an issue anymore, and the focus has therefore been awarded to fully utilising the catches i.e. utilization of by-products and RRMs. Whether solutions developed in these countries to utilise RRMs will be relevant or applicable in the context of the CFP landing obligation remains to be seen, but there are though some obvious linkages between RRMs in these countries and catches below MCRS in the CFP landing obligation.

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8 Discussion

The aim of this document has been to report on current practices in the handling of UUC. Discard estimates in global and European fisheries have been presented, the most common methods of discarding and associated incentives have been reviewed, the landing obligation of the CFP as well as landing obligations in other countries have been accounted for, MCS alternatives have been discussed and a number of initiatives temped to reduce bycatch and discards have been reviewed.

What this document is intended to do is to present basic back-ground information on the most important discard mitigation issues and the available tools for battling the discard problem. This will then serve as input to stakeholder interactions in later stages of the DiscardLess project, particularly when it comes to interacting with fishermen. As this is a deliverable in work package 5 of the DiscardLess project, which focuses on how UUC can be handled on-board the fishing vessels, it is logical to discuss what content of this report can actually be adopted on-board the fishing vessels.

There are basically two ways of eliminating discards in marine fisheries i.e. improve selectivity in the catching link and then bring everything ashore that cannot be avoided. The DiscardLess project focuses on these two possibilities in four work packages i.e. improving fishing gear, improving fishing strategies, handling UUC on-board the vessels and handling the UUC after it has been landed. Most of the research and effort of the authorities in EU and countries were discard bans are already in place have been focused on reducing bycatches with improved selectivity of fishing gear; and by adopting strategies and management measures so that unwanted catches can be avoided and unavoidable catches be landed. The focus on what happens to UUC on-board the fishing vessel has mainly been on MCS, where FDF and the use of CCTV to monitor catches and discards have been at the forefront. There have been very interesting developments in MCS in recent years, where Denmark and Scotland have been the pioneers. The experiences from these cases will undoubtedly benefit future work in WP5 in DiscardLess.

There has not been awarded much attention to what to do with the UUC once it has been taken aboard the fishing vessels. Species not covered by catch limits, species where high survivability can be demonstrated and catches falling under the de minimis exceptions can still be discarded under the CFP landing obligation; but everything else will need to be landed. In addition will catches under MCRS need to be landed, but cannot be used for direct human consumption. Whether the under MCRS catches need to be landed separately seems to be still up for a debate. It is clear that storage space will become an issue for big part of the EU fleet if they need to keep each species under MCRS separate. The available alternatives for addressing that challenge are scarce, but some of the countries that have been working under a discard ban have been developing solutions. These are though generally only applicable for large-scale vessels i.e. on-board fishmeal factories, silage factories, on-board processing of by-products, surimi production etc. Trying to develop solutions for the EU fleet to properly store, process and bring ashore UUC will therefore be a challenge, keeping in mind that 83% of the EU fleet is under 12 meters long and 98% are under30 meters.

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Appendix

A list of the mitigation methods with description and a classification (Sigurdardottir, et al., 2015).

No.	Mitigation measure	Description	Category
1	Multi-species catch quota	Limiting the catch of a mixed species group, as opposed to single species quotas.	TAC & quotas
2	Catch quotas, not landing quotas	Limiting catches instead of landings.	TAC & quotas
3	Fishing effort and capacity	Introducing or modifying limits to fishing effort and/or fleet capacity.	Fishing effort & capacity
4	Temporary/spatial restrictions	Restricting particular/all fishing activities in a certain area and/or for a defined time.	Technical
5	Selective practices	Prescribing types of gear and devices, or other practices better suited to avoid unwanted catch whilst maintaining commercial catch rates. Selectivity can be based on fish size, shape, species and/or behaviour.	Technical
6	Change of Minimum landing size (MLS)	Introducing or modifying MLS, the minimum size at which a fish can be landed.	Technical
7	Catch composition	Changing the proportion of non-target marketable catches allowed to be retained.	Technical
8	Discard ban	Requiring to land all catches of defined categories.	Technical
9	Transferability of quotas	Introducing or modifying the rules of lease, acquisition or swap of quota for specific species.	Technical
10	Co-management	Directly involving stakeholders in research, development and implementation of discard mitigation methods. May occur at different levels, i.e. stakeholders as consultants, partners, delegation or leaders.	Social
11	Society awareness of discard issues	Changing the awareness of stakeholders regarding discarding and discard related issues - may include e.g. education.	Social
12	Improving existing and/or finding new markets	Improving existing markets and finding new markets for species which are not currently utilised; this may include products for human consumption, fish meal, pharmaceuticals and other industries.	Market

Strength, weaknesses, opportunities and threats of 12 discard mitigation methods (Sigurdardottir, et al., 2015).

Mitigation measure	Strengths	Weaknesses	Opportunities	Threats
Multi-species quotas	Reduces quota related discards. Robust to short-term variation in biomass of those species that are within the framework of the mixed-species quota.	Will not address discards driven by factors other than quota. With a cap on total landings you might not get as high landings.		Fishers might target the most valuable species and could potentially discard the less valuable species to maximise short-term earnings.

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	Provides fishermen with more flexibility in achieving viable catch compositions reducing the level of selectivity required in the fishing methods.			
Catch quotas, not landing quotas	Means that the fishers are accountable for their total catch, not only the landings. Eliminate quota driven discards. The monitoring required to enforce catch quotas would generate better data on size distribution and fishing mortality, thus improve stock assessments	Requires monitoring the catch rather than only the landings; if using CCTV or full coverage surveillance to achieve this, it will be expensive In a full monitored catch quota system many species can turn out to be choke species. Some because of weak stock situation, other because of mismatch between TAC and actual abundance.	Fishers should aim for highest economical revenues and therefore choose more selective fishing gears. ITQs based on total catch instead of landings may decrease the incentive to discard as a catch quota setting, discards would count against the quota. . Transferability of quotas can smooth the quota distribution and use, and prevent fishing stop due to choke species	Lack of detailed information about discards at current state. CCTVs may be resisted by fishers or even contravene their fundamental rights. Abilities to circumvent CCTVs or other monitoring schemes.
Changing fishing effort and capacity	Restricting number of days at sea is easier to enforce than many other measures. Long term economic profit if stock increases.	Fishers will resist unless offered compensation. With limited time at sea fishers may opt to use less selective fishing methods, or be forced to fish in areas of high abundance of unwanted species/size classes	Could create incentive for fishers to improve catching efficiency (e.g. by using selective gears) to maximise landings. Increased economic efficiency of the fishery.	Increased likelihood of unemployment rate amongst fishers and onshore workers on the short term. Risk of unstable supply.
Temporary/spatial restrictions	Adaptable and can work in real time. Can serve as a buffer against management errors and recruitment failure. Long term economic profit if stock increases. Supports use of co-	Has resulted in extensive fishing on the closed area borders, such as the plaice box Requires robust information on spatial distribution and population structure of fish stocks.	Reduced supply of fish to markets, because of closure, can lead to higher market price. Closure might incentivize fishers to explore new and rich fishing grounds.	If not all fishing gears are prohibited in an area, the other ones also generate discards and might benefit from it and no gain is made in the end. If not all gear types are excluded from fishing this might

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	management when fishers are made responsible for reporting to support real time closures. High level of compliance when supported by satellite monitoring.	Needs to carefully reflect a species distribution and abundance pattern in time and space, otherwise risk that discards just move to areas where fishing pressures have been transferred. Difficult to enforce without VMS or similar monitoring technology.	Creates incentives amongst operators to use selective gears when access is conditional to the gear deployed.	create non-compliance due to feeling of unfairness. Possible income loss when fishers are kept from their usual fishing grounds having to move further distances and could threaten less mobile fleets which are less able to move to new fishing grounds. Risk of unstable supply.
Selective practices	Decreased discard mortality. With selective gears income can be increased because of better quality of catch and reduced cost for fuel for some towed gears, moreover, revenue from quotas can be maximised where unwanted fish are counted against quota Improves efficiency of fishing vessels by reducing man-hours taken to sort the catch. Improving selective properties of gears does not affect fishing opportunities. Long term economic profit if stocks increase.	Costly for fishers and government to develop and implement. Fishers don't like using selective gear if their profits are compromised by a loss of marketable fish. Some selective innovations can be deemed to be illegal when fishing net designs are legislated for.	Bridging the gap between environmental and economic issues. Increased probability of getting an eco-label. Adopting more selective fishing methods can warrant better fishing opportunities and improve positions during negotiations for fishing opportunities.	Too high species-selectivity can make fishers vulnerable to quota reductions.
Change of MLS	Lowering MLS could substantially decrease MLS-driven discards. With lower MLS and favourable market profits would increase with knock-on economic benefits. .	Shifting to a target of smaller fish could impact negatively on the stock and result in loss of profit in the long term. Different MLS for different species causes difficulties in multi-species fisheries.	Opportunity to match MLS with selectivity parameters or marketable sizes.	

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Change/remove catch composition regulations	Designed to make sure that the correct gear types are employed for targeted species and to prevent inappropriate gears that would lead to higher discards/catches of small/juvenile fish Changing regulation to fit actual catch composition could reduce regulation related discards.	Can generate discards of marketable catches, when defined catch composition is not reflected by catches taken with specified gear. Additional complexity in recordkeeping. Changes in catch compositions driven by relative changes in population abundance can become incompatible with defined catch composition.		If this method is legislated with too little flexibility, discards might not be eliminated because of variation between vessels.
Discard ban	If unwanted catch is sold at a sufficient price there would be additional revenue. The monitoring required to enforce a ban would generate better data on size distribution and fishing mortality, thus improve stock assessments.	Landing this otherwise discarded material could come at a financial cost to fishers. A larger part of the catch would need to be sorted onboard and handled in the landing ports. In the absence of other supporting measures, it doesn't solve problem of unwanted catch being caught. Increased fishing mortality since some discarded animals survive. Storage and processing space needed for otherwise discarded species. High level of enforcement needed; costly.	Opportunities for new markets for formerly discarded species/size classes. A discard ban is expected to encourage fishers to fish more selectively.	Without markets for previously discarded species, biological waste on the harbours might increase. Lack of sufficient infrastructure to handle material.
Transferability of	Adding transferability	High leasing prices	Increased	Increased

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quotas	to IQs decreases discard proportion. Increasing transferability of quota allows fishers to match quota composition to their catch composition.	compared to catch value can increase discarding. Requires costly IT systems.	transferability and documentation of quotas may support traceability of catch.	transferability might disconnect quota trade from fishing opportunities.
Co-management	Fishers' experience and knowledge helps to develop management measures better adapted to local or regional conditions. Co-managed system results in fishers increased sense of ownership of management methods, which increases voluntary compliance.	If incentive structure changes or leading figures disappear, the co-management structure can erode. Cooperation between fishing industry and management need careful design to be appropriate for each situation.	Can lead to better/ more detailed data provided to managers. Mutual respect between fishing industry and managers.	
Society awareness of discard issues	Provide a forum for knowledge of different stakeholders to be highlighted Society awareness can form a basis for developing new markets which can absorb otherwise discarded species and sizes			More people involved without sufficient knowledge may result in methods that are too simplistic. Increased awareness can lead to campaigns of radical greens/fishers where voices of key-stakeholders can get lost.
Improving existing markets/finding new markets	Profits from otherwise discarded material to the industry and knock-on economic benefits. Good for the public image of the fisheries to utilize a larger part of the catch.	The infrastructure must be in place or needs to be developed. May require a change in social attitude and taste. (This could also be an opportunity.) Could increase fishing mortality on species/size classes of fish that would have otherwise survived	Creates an incentive for landing more of the catch, thus allowing collection of more accurate data. Regionalising markets to respond more seasonally to what's out there in the sea.	For the new targeted species you might not have the management tools/knowledge. Could increase fishing pressure for new species or size classes beyond sustainable levels. New markets might disturb existing markets.

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		the discard process.		

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How to cite this document: Viðarsson *et al.,* 2015. Report on current practices in the handling of unavoidable, unwanted catches (Horizon 2020 DiscardLess Report D5.1) Zenodo doi: 10.5281/zenodo.1204294