Study to support impact assessment for options to reduce the level of ALDFG

Final Report

22-02-2018

Maritime

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February 2018

This study has been prepared under the Framework Contract EASME/EMFF/2016/029 - Inter-institutional service framework contract for Better Regulation related activities - Lot 2: Integrated Maritime Policy, by Monitor Deloitte and Wageningen Marine Research for the Directorate-General for Maritime Affairs and Fisheries

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Luxembourg: Publications Office of the European Union, 2018

Table of Contents

Table of Contents 5

1. Introduction 7

1.1 Results of stakeholder consultation 7

1.2 Reading guide 9

2. Problem tree 11

2.1 Problem drivers 11

3. Baseline scenario 15

3.1 Baseline for annual plastic waste from fishing and aquaculture gear entering European Seas 15

3.2 Baseline for total plastic waste stock from fishing and aquaculture gear entering European Seas 18

3.3 Effects of related EU Legislation on Baseline 19

3.4 Process of the baseline scenario 21

4. Policy options 23

4.1 Extended producer responsibility (EPR) without a deposit scheme (DRS) 23

4.2 Extended producer responsibility with a deposit scheme 27

4.3 Target setting 29

4.4 Alternative materials and product design 31

4.5 Link between problem drivers and policy options 35

5. Evaluation of the impacts of identified options 37

5.1 Extended producer responsibility without a deposit scheme 37

5.2 Extended producer responsibility with a deposit scheme 38

5.3 Target setting 39

5.4 Alternative materials and product design 39

6. Quantification of option impact 42

6.1 Quantification of Option 1a: EPR without DRS (manufacturers funding) 42

6.2 Quantification of Option 1b: EPR without DRS (with retrieval – funding by manufacturers) 47

6.3 Quantification of Option 2: Extended producer responsibility with a deposit scheme 49

6.4 Quantification of Option 3: A recycling rate target for fishing gear 51

6.5 Quantification of Option 4: Alternative materials and product design 52

7. Comparison of the options 53

I. Annex 1: List of stakeholders consulted 54

II. Annex 2: Questionnaire used for interviews 55

III. Annex 3: Responses to open questions from stakeholder consultation 60

IV. Annex 4: Summary and overview of options 69

V. Annex 5: Overview of the loss rate of fishing gear 70

1. Introduction

1.1 Results of stakeholder consultation

The information in this paragraph is based on the Online Public Consultation (OPC) on *'Reducing marine litter: action on single use plastics and fishing gear*' launched from 15th December 2017 to 12th February 2018. This consultation complemented previous exercises conducted by the Commission, such as an OPC (October to December 2013) focussing on possible actions, by different stakeholder groups, to address the issue of marine litter[1]. The consultation received a total of 1,807 responses across Member States. The analysis is done based on an Excel output file of the stakeholder consultation from 20 February 2018. The analysis has been performed for all questions of the consultation related to this study, both closed and open questions. Each question has been analysed by excluding all respondents not answering the question at hand. To get the complete picture, respondents were allowed to choose "Do not know" for answers, which always comprise a certain percentage. For questions with the possibility to select multiple options responses have been evaluated by amount of stakeholder responding and not by total of options mentioned. The details and highlights of the analysis are elaborated on in the following paragraph, a full overview of the responses to open questions provided by the stakeholders is given in Annex 3 of this report.

According to the open stakeholder consultation action to address the amount of marine litter (including fishing gear) in the seas and on beaches is necessary and urgent (95% of respondents replied positively to this statement). Focusing specifically on the amount of fishing gear in the seas and on beaches 79% of the respondents think that it is necessary and urgent to act. The issue of impacts of marine litter on fisheries and aquaculture are considered by 100% of respondents of fisheries organizations as quite or very important. Of the total respondents, 53% consider it very important or quite important. Additionally, clean-up costs of litter are considered by 84% of respondents as very important or important.

Assessing the role of stakeholders playing an important role for taking any further action the EU, Member States, Local and regional authorities, fishers and fisheries organization are considered. Only other international bodies, NGOs and the private sector seem to not play such an important role for reducing leakage of fishing gear into the marine environment. Especially, the latter one is surprising as the private sector could establish extended producer responsibility schemes to reduce marine litter or redesigning fishing gear. The most important role play the fishers as they are the direct users of the gear (80% indicate fishers as very important stakeholders in this issue).

The stakeholder consultation also asked for the experience of gear lost and discarded at sea per year. For all gear lost, only 1% of respondents indicate that all gear is lost on an annual basis. There is larger variation per type of fishing gear among the stakeholders indicating that most gear is lost ranging from 3% for seine nets to 23% for lines and cords. The majority of responses is that some gear is lost ranging from 28% for seine nets to 54% for gillnets. Between 6% and 28% indicate that hardly any gear is lost and between 1% and 4% none. The remainder of the respondents (between 22% and 36%) indicated that they do not know.

For all gear discarded, only between 1% and 2% indicate that all gear is discarded per year and 3-13% indicate that most gear is discarded. The majority indicate that some gear is discarded. The indication of some fishing gear discarded varies per type of fishing gear ranging between 22% for seine nets and 43% for lines and cords. Between 7% and 22% indicate that hardly any fishing gearis discarded and between 4% and 11% indicate none. Looking as reference specifically at responses from fisheries organizations about discarded gill nets, 40% claim that some are discarded, 25% hardly any and 25% none.

Analysing the open fields in the stakeholder consultation it becomes apparent that there is no widely accepted estimate for lost and discarded fishing gear out there and there is a lack of data related to this topic. Therefore provided open comments varied widely from 50% loss (reference to SPEKVIS project Belgium for dolly rope) and only 0.8% for demersal gillnets (reference to Ayaz et al., 2010), with other respondents citing 10% (reference to Gilman, 2015) or 20% (anecdotal evidence). Also

[1] http://ec.europa.eu/environment/consultations/pdf/marine_litter.pdf

in absolute terms comments vary from 5,500-10,000 net fragments lost per year (reference to BaltSea2020) to 640,000 tons lost annually worldwide (reference to Macfayden et al., 2009).

Asking the stakeholders for selection of measures to help reduce lost and discarded gear the most selected options are:

- Incentive to bring fished up litter and end-of-life gear ashore (88%)
- Better collection and sorting facilities on vessels and at ports (70%)
- Incentives/Funding of retrieval action (68%), and
- Better enforcement of existing rules (67%)

The open field comments expanded on the list above. First, stakeholders went one step ahead by proposing EPRs as measure to reduce ALDFG. Other comments were made by stakeholders requesting higher penalties for the fishing and aquaculture industry punishing its role in the pollution. Further, several respondents elaborated on the risk and inefficiency of retrieval actions, which have to be carefully evaluated before undertaken. Other comments underpinned the importance of education and awareness raising of fishers to reduce plastic fishing and aquaculture gear ending in the seas. Further, repeatedly the introduction and enforcement of gear marking has been mentioned. Additionally, respondents highlighted that the too high harbour costs lead to more discarding of gear at sea rather than return to port despite suitable facilities. Lastly, several respondents agreed that currently no or not suitable facilities are at ports leading to a disincentive for fishers to return gear to port entering formal waste management.

One further issue revealed is reporting and retrieving of lost gear. 56% respond that hardly any lost gear is reported and 52% state that hardly any is retrieved. Only 3% of the respondents state that most or all is reported and only 5% state that most or all lost gear is retrieved. This underlines the importance of the fishing and aquaculture gear lost in the seas. Gear retrieval is considered most successful if better retrieval equipment is available and more incentives to bring fished up litter and end-of-life gear ashore as well as incentives/funding of retrieval actions. In the open comments, specifically a stakeholder pointed out that often gear cannot be retrieved due to either safety limitations or simply traceability of lost gear in sea. Further, a relevant comment is that in certain countries legislation has to be changed to make gear retrieval possible as for example in Italy retrieved gear are classified as special waste and thus their disposal has to be paid by fishers.

Public funds should be used mainly for recovery of marine litter found in fishing nets during normal fishing activities ("passive fishing for litter") and recovery of fishing gear and marine litter washed up on beaches. However, here stakeholders highlighted specifically that rather than public funds fishers and producers should be charged and that focus should be placed on prevention rather than retrieval. Lastly, a strong comment has been made subsidizing the fishing gear recycling industry proves useful to help it grow and encourage better end of life treatment of fishing gear.

Especially, question 10 of the stakeholder consultation relates to this study, as it addresses which additional targeted measures are needed to support the management of gear brought ashore and/or end of life gear. Respondents favour with 59% deposit return schemes levied on fishers and with 53% extended producer responsibility scheme including levy on gear. More than one third of the stakeholders consulted see public funds as a suitable additional measure. Whereas, 13% do not know and another 13% see additional other measures as useful. In the open field addressing other measures as well as additional comments, stakeholders raise doubts that deposit schemes is not a good idea because it punishes fishermen with not returning the deposit for bad luck of unintentionally and not recoverably lost gear. Additionally, stakeholders remark that deposit schemes for gears with long lifespans render return scheme inefficient. Further, they highlight that disposal at port cannot be more expensive than illegally at sea, wherefore an EU-wide registration of nets as well as sample controls are proposed. Lastly, a stakeholder highlighted that only focus on collection is not sufficient, therefore focus has to be shifted to recycling of fishing gear. However, the stakeholder points out that support is required for gear recycling companies as they face challenges selling their recycles proposing therefore an incentive for market uptake and (mandatory) use of a % recycled content in various products

Reviewing the sorting of waste at the port in line with EU waste legislation and as envisaged in the PRF proposal, of the 50% providing another answer than "do not know" 60% agree that there is any

sorting of waste. However, the remaining 40% point out that there is no sorting of waste at ports, which are normally mandated by the Port Reception Facility Directive.

Additionally, the open stakeholder consultation sheds light on the recycling focusing on current recycling of gear and potentially recycling of gear. The outcome is very interesting as currently only 6% indicate that more than 25% is recycled, however 42% of the respondents indicate that potentially more than 25% could be recycled. Further, the stakeholder consultation assesses which measures could potentially increase recycling rates, which 28% indicate investment in recycling facilities and another 28% preferring the introduction of EPR or bring back schemes. Also, 26% believe the preferred measure to increase recycling rates is improving the management of transport of gear from ports to waste management/recycling facilities. Despite 54% not knowing whether re-use is undertaken in their country or sea are, 18% indicate that no re-use is happening, 21% state occasionally and only 7% say routinely. Lastly, an open field in the stakeholder consultation also allowed to indicate additionally which gear or material are currently recycled, which revealed an interesting fact that an Italian recycling company can only reach breakeven capacity if used fishing nets are imported from China because they do not receive enough from Italian fisheries and ports. Also it got indicated, that on the one hand repair of recycling can be also seen as a sort of recycling then leading to a 100% recycling rate, whereas on the other hand also incineration sometimes accounts for recycling rates.

Lastly, in the light of alternative product design and materials, it is assessed that the best potential substitution of plastics with other materials. The answers are very equal, however among the four options cords/lines, fish aggregating devices, buoys and dolly ropes, dolly ropes is selected with the least potential despite the dolly rope free project being the only project for fishing gear attempting to replace plastics and innovate with materials.

To conclude, the open stakeholder consultation highlights the importance of the study subject where action is necessary and urgent. Further, the policy options of extended producer responsibility and deposit scheme were desirable for the respondents in addition to the port reception facilities and the proposal for its revision. The study departs from there and elaborates as well as quantifies these options among a recycling target and alternative product designs, which also have been part of the open stakeholder consultation.

1.2 Reading guide

In this report, elements to support an impact assessment for options to reduce the level and detrimental impact of plastic from fishing gear and aquaculture gear are presented. The report follows a funnel-like approach, from a rather broad and qualitative description to narrow down to more specific and quantitative analyses of a selected group of policy options.

In chapter one, the background to this report is elaborated upon. In chapter two the problem of plastics at sea derived from (waste of) fishing and aquaculture activities is described, including an analysis of the drivers behind the abandonment, loss or discarding of gear at sea. This results in a problem tree for fishing and aquaculture gear waste.

Chapter three describes both the baseline of the current annual inflow of Abandoned, Lost or Discarded Fishing Gear (ALDFG) entering European Seas and a baseline model describing the stakeholders involved and the fishing and aquaculture gear flow between them. This baseline process-model serves as basis for the impact assessment of the policy options examined in this report

In chapter four, the policy options to address the current situation are described in qualitative terms. In principal there are three main policy option fields: the introduction of Extended Producer Responsibility (EPR) for fishing and aquaculture gear (with or without Deposit Scheme), setting a goal for recycling of used fishing and aquaculture gear and replacing current material used in several gears by either more biodegradable materials or via other product design. The EPR option is further detailed in 2 sub-options. All policy options are visualized in a process model.

In chapter 5 these policy options are further analysed by evaluating the impacts of identified options on financial, environmental and social impacts for different groups of actors in the process-model.

Impacts are scored using a relative scoring rationale, scoring the impact of different options against each other.

This analysis is quantified in chapter six, to the extent possible for the study given timeline, budget and scope of the study. The results of each policy option are then compared in terms of their financial, environmental and social impact in chapter 7.

2. Problem tree

The objective of the study, as defined in the terms of reference, is as follows: to provide a basis for an impact assessment of options at an EU level that could reduce the level and detrimental impact of plastic marine litter from fishing gear.

To address the objective of the study, the underlying problems need to be identified. The problems that result in the level and detrimental impact of plastic marine litter from fishing gear is twofold, as stated in the terms of reference:

Plastic is an important material for our economy. It offers characteristics (such as light weight and flexibility) which make it very interesting in many applications. Plastics, are, however, far from being circular, as less than 30% of plastic waste is being recycled. Reducing plastic leakages to the environment is one of the main objectives of the Strategy; in 2014, in line with Sustainable Development Goal 14, the Commission proposed an aspirational target of "reducing marine litter by 30 % by 2020 for the ten most common types of litter found on beaches, as well as for fishing gear found at sea, with the list adapted to each of the four marine regions in the EU"[2]

The problem statement is reformulated, so that it specifically focuses on the impact of plastics derived from fishing and aquaculture gear, which is the scope of this study. The main problem is as follows:

- Fishing gear not being brought ashore
- Lacking efficient lost gear recovery scheme
- ALDFG does not enter formal waste management

2.1 Problem drivers

18 problem drivers have been identified, these being driver categories existing either at sea or on land. The problem tree is shown in Figure 1 below showing the relationship between the two main problems, driver categories and the ultimate problem drivers.

The driver categories to which the problem drivers are linked, are:

1. Intentional dumping of ALDFG
2. Accidental loss of ALDFG
3. No appropriate formal waste management
4. ALDFG is not easily recyclable

The first two categories mainly address the problem of fishing gear not being brought ashore, rather becoming ALDFG.

When fishing and aquaculture gear is dumped or lost, it can still be retrieved by the boat that causes the lost, in nets as part of a normal fishing operation by another vessel (passive fishing for litter) or as a special trip (active fishing for litter). Without an effective recovery scheme lost gear remains in the sea harming wildlife and economic activities. The lack of an effective lost-gear recovery scheme therefore is the second category.

The final two categories address the problem drivers that come into play when the fishing gear are on land.

Intentional dumping of fishing gear

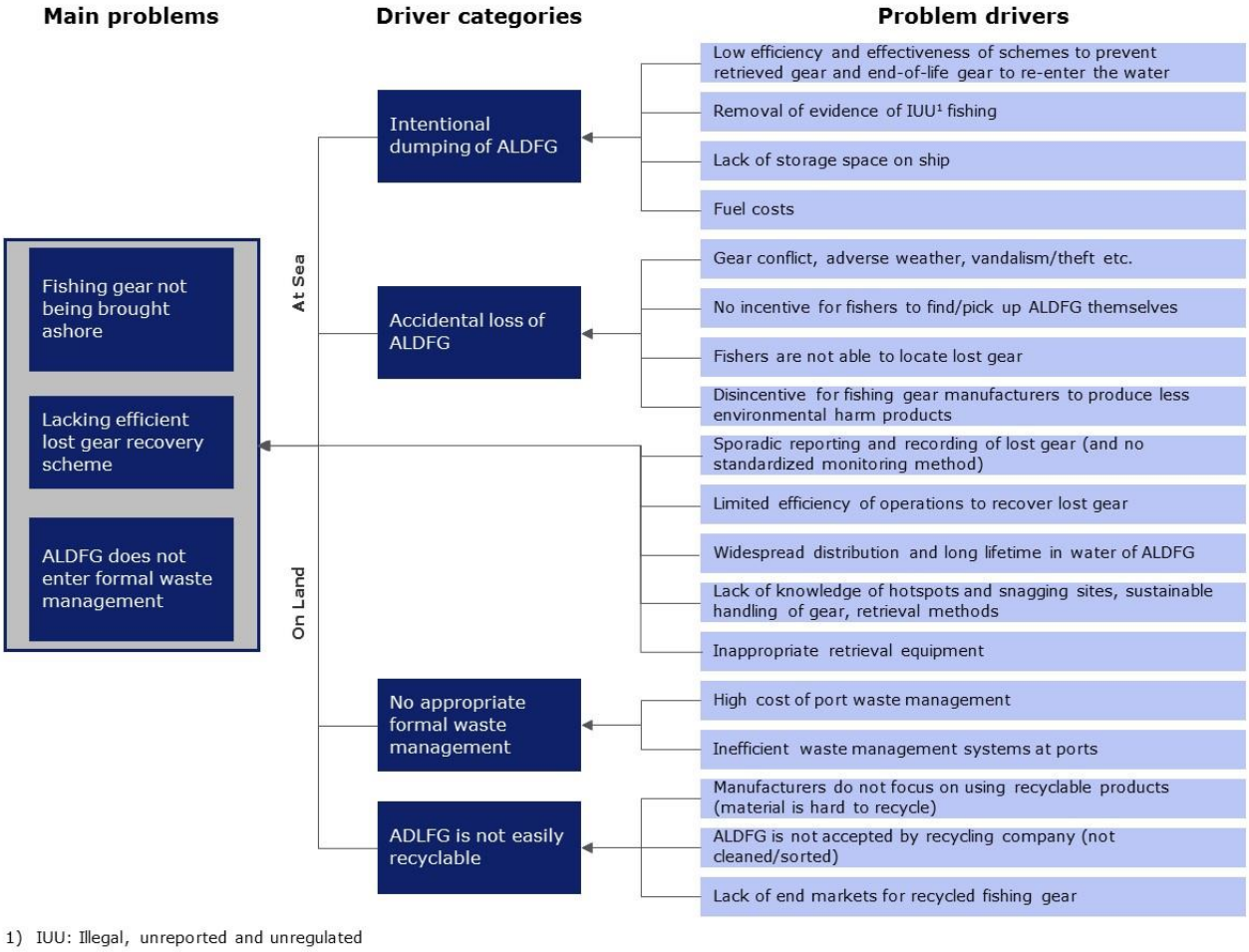
For intentional dumping of fishing gear, the following problem drivers have been identified:

- **Low efficiency and effectiveness of schemes to prevent retrieved gear and end-of-life gear to re-enter the water**. The proposed revision of the Port Reception Facilities will bring significant improvements as it removes financial disincentives to bring the waste from fishing gear ashore by means of the implementation of an indirect fee (fee is not dependant on the level of waste returned to ports). This revised PRF will be in place for all ports in Europe[i] (see page 12 of the Directive indicating that "In addition, the proposed Directive, like

[2] COM/2014/0398 final/2 */, also refered to in COM (2015) 614 final.

its predecessor, has a wider scope by covering all sea-going vessels and all EU ports visited by these vessels.") However, insufficient reception facilities in ports are currently not the only problem of low efficiency and effectiveness of retrieval schemes. Laborious onshore processes may still exist, also under the revised PRF, as waste facilities may still require a long and inefficient walk with heavy fishing gear for fishers**.** If bringing fishing gear to collection points for formal waste management were over-laborious, fishers would have an incentive to leave gear at sea. This holds for both retrieved gear and end-of-life gear, as from an economic point of view it would not make sense to dump functioning gear.

Figure 1: Problem tree for fishing gear litter



1) IUU: Illegal, unreported and unregulated

- **Removal of evidence of illegal, unreported or unregulated (IUU) fishing**, could hold for functioning gear. IUU fishing is a €10 billion market every year worldwide, making up 19% of the worldwide reported value of catches (DG MARE, 2016). Leaving the fishing gear at Sea removes the evidence of (IUU) fishing. IUU can in general be a problem of intentional dumping of fishing gear, as explained in literature, and certainly not specifically in the EU.
- **Lack of storage space on board ship** can also be a factor in intentional dumping the waste from fishing gear. Gilman et al. (2016) state that setting excessive gear can also result in discarding gear. For example, there may be insufficient room on board for all of the gear, such as when the space used to store nets when starting a trip is subsequently used as fish-hold.
- **Fuel costs.** Fishing gear usually is heavy and carries a lot of weight. Bringing ashore fishing gear on a fishing vessel increases the weight of the vessel and hence the fuel used during the trip, which provides an economic incentive to not bring ashore waste from fishing gear.

Accidental loss of fishing and aquaculture gear
Fishing gear can also be lost unintentionally[3], as described by Gilman et al. (2016). Some drivers of accidental fishing and aquaculture gear losses have been derived.

- As stated by Gilman et al. (2016) and FAO (2009), events like **gear conflict, adverse weather, vandalism and theft** are factors leading to losses of gear, and therefore contribute to the third driver of loss of fishing gear accidentally. Gear conflict is the contact of passing vessels with active gear, or even passive gear, which leads to gear losses.
- When gear is lost, there might be little to **no incentive for fishers to find/pick up ALDFG themselves**. The fishers might decide not to look for lost gear, as it is too costly to find it or too much of a hassle to pick it up. Having said, it should be taken into consideration that any loss of fishing gear for fishers results in a financial loss. (WWF, 2015).
- **Fishers are not able to locate lost gear.** This can have multiple reasons, e.g. damage by marine organisms, gear becoming snagged, removal of marker buoys and entanglement with passive gear. All of these reasons lead to the fisheries not being able to locate their gear, and therefore having to deem it as lost.
- Finally, there is a **disincentive for fishing gear manufacturers to produce less environmental harm products**, as this would lead to less consumption of fishing gear over time. Furthermore, as FAO (2009) states, mitigation measures to reduce the impact of ALDFG to the environment are limited in their extent and application as many may increase costs through reduced effectiveness of gear or higher gear prices.

Lacking efficient lost gear recovery scheme
When fishing gear is lost, efforts can be undertaken to retrieve fishing gear from the seas. An efficient lost gear recovery scheme would be an effective way to address the effects of ALDFG. The opposite, lacking an efficient lost gear recovery scheme, would however contribute to the detrimental impact of fishing gear in the sea. The following drivers related to recovery schemes have been identified:

- **Sporadic reporting and recording of lost gear (and no standardized monitoring method)**, resulting in the authorities having an incomplete overview of the amount of lost fishing gear in Europe. In the proposal for a revision of the Control Regulation, new rules are proposed on gear retrieval that can also contribute to reducing ALDFG:
    - Ease and improve the reporting of lost fishing gear, in line with the plastic strategy, by allowing fishermen to use the (electronic) logbook for such reporting, and at the same time removing current unnecessary and ineffective reporting obligations.
    - Remove the current derogation applicable to vessels < 12m to carry on board the necessary equipment for the retrieval of lost gear.

  Furthermore, there is no standardized monitoring method results in differences between the authorities that do monitor lost gear. Since lost gear is not restricted to borders, authorities could cooperate to effectively target and retrieve lost gear. Ineffective information exchange due to differences in monitoring methods could hinder this cooperation.
- There where operations are ongoing to try and recover ALDFG, the **limited efficiency of operations to recover lost gear** hampers the ease at which lost gear gets retrieved, or that some gear cannot be retrieved at all, for example if the right retrieval or ALDFG locating instruments are not present.
- The **widespread distribution and long lifetime in water of ALDFG.** This results in a wide area that needs to be covered to retrieve ALDFG, whilst the effectivity of retrieval is low, since the spread of ALDFG makes the retrieval per km^2 low. Since ALDFG has in general a long lifetime, it will pollute the sea for a long time, making retrieval necessary, which makes retrieving lost gear a cumbersome and often costly task.
- A **lack of knowledge of hotspots and snagging sites, sustainable handling of gear, retrieval methods**. Due to a lack of reporting about ALDFG it is not known which sea areas contain a lot of ALDFG, which hinder the effectiveness of retrieval operations.
- **Inappropriate retrieval equipment**. Fishers often do not specialized equipment on board to retrieve lost gear.

No appropriate formal waste management
Gilman et al. (2016) state that preventative measures are identified as the most effective way to tackle ALDFG, with the provision of adequate, affordable and accessible onshore port reception/collection facilities being one of these preventative measures to limit the influx of ALDFG. The following drivers have been identified related to no appropriate formal waste management:

- **High cost of port waste management.** This can be related to relatively high costs of waste management for management companies to treat port waste management and earn money out of the waste. For example, smaller ports with a limited number of fisheries, produce a small amount of fishing gear waste. To run an efficient waste management system within a lot of small ports divided over a large area is cost-ineffective, although this should be in place for all port in Europe under the revised PRF.
- **Inefficient waste management systems at ports** make it hard for fishers to dispose of their fishing gear waste, which makes it more likely that fishers will dump their fishing waste into the sea. For example, waste disposal point that are located relatively far from the ports docks can create a struggle for fishers to get rid of their, often heavy, fishing gear waste.

ADLFG is not easily recyclable
The last category contains drivers related to the lack of ease that is experienced with recycling fishing gear. Drivers related to this category are:

- **Manufacturers do not focus on using recyclable products (material is hard to recycle)**, as this would often mean using durable products, which are (more) expensive that products currently used in fishing gear. Since this would mean that prices of the fishing gear increase, manufacturers do not choose to do so.
- **ALDFG is not accepted by recycling company (not cleaned/sorted)**, due to the high costs of the recycling process. In general, recycling companies have high demand regarding the state of the materials. Gear that is handed in dirty or unsorted might not be accepted by recycling companies, as it takes too much time, effort and costs to get the material in a state that enables the company to recycle it. Before fishing gear can be recycled, it should be sorted, cleaned and transported to the recycling facility.
- **Lack of end markets for recycled fish gear** creates not enough demand for waste management companies to recycle fishing waste. Recycling is often a more costly process than landfilling or incineration, and therefore only worthwhile when there exist a market for recycled goods or materials. This can either be the fishing and aquacultural market itself (manufacturers using the materials again), or another raw material market, which is currently often not the case.

It should be noted that in Iceland for some valuable fishing materials (polyamide) a fee is received from recyclers, which covers transportation costs of waste from fishing gear. On the other hand, other interviews and the stakeholder consultation reveal that recyclers are not able to pay for waste from fishing gear (anymore). It has no economic value on the market anymore, as China is not accepting plastic waste anymore. Therefore, waste management companies in Europe now in general have to pay a fee to deliver the plastic waste at recyclers.

3. Baseline scenario

The baseline scenario describes and quantifies the current situation of plastic marine litter from fishing gear for the European seas assuming no interchange with waters outside Europe. It provides the basis for the evaluation of the impact of the EU policy options that aim to reduce the level and detrimental impact of plastic marine litter from fishing gear.

In available literature, global estimates range from 640,000 tons (National Geographic, 2016) to 1.15 million tons of lost and discarded fishing gear per year (Montarsolo et al., 2018). This chapter will specify the annual plastic waste from fishing and aquaculture gear entering European seas. The last paragraph, describes the process of the baseline scenario. The process is illustrated in a flow chart, which displays the stakeholders, material flow and includes the quantified data from the annual waste for each step.

3.1 Baseline for annual plastic waste from fishing and aquaculture gear entering European Seas

Marine litter is either from sea-based or land-based sources, with fishing gear[4] being one of the major sea based sources. A number of estimates suggest different contributions of fishing gear to the total marine litter based on locality (Macfadyen et al., 2009). Broad-scale quantifications of marine litter enable only a crude approximation of the share of fishing gear in the total marine litter. A lack of standards in surveying and measuring marine litter from fishing gears produces partially incompatible results due to varying products considered part of fishing gear or including/excluding aquaculture gear into the measurements. Differing temporality of seafloor, floating and beach litter make it hard to infer the annual input of fishing gear out of the total of fishing gear litter already in the seas.

Available literature provide little data on the annual amount of plastic from fishing gear entering the European seas. Starting point for this baseline are calculations from EUNOMIA, 2016, and 2017, which are based on 2015 PRODCOM data of sold fishing nets in the EU (plus imports minus exports) as an indicator for used nets on EU vessels (which does not mean that this is all used in European seas as some vessels fish outside European seas which could therefore bring a slight overestimation to the figures below). Using sales data as indication of usage data is confirmed by Brown et al. (2007) assessment of the average life-time of fishing gear lasting approximately one year, meaning annual replacement of all fishing nets. For the baseline developed in this study the PRODCOM data referenced by EUNOMIA (2017) have been updated and adjusted in two ways. First the EUNOMIA 2017 estimates are updated with the latest PRODCOM data from 2016 rather than 2015, which leads to an annual total usage of 25,710 tons when accounting for import and export compared to 28,571 tons referenced in Eunomia (2017) and thus a decrease of 2,861 tons.

Table 1: Annual tonnage of sold fishing nets in the EU (2016)

Product	Produced	Exported	Imported	Usage
13941233 - Made-up fishing nets from twine, cordage or rope of man-made fibres (excluding fish landing nets)	19,800	9,600	10,739	20,939
13941235 - Made-up fishing nets from yarn of man-made fibres (excluding fish landing nets)	5,554	5,798	5,015	4,771
Total (in tonnes)	25,354	15,398	15,754	**25,710**

This total is considered conservative, because monofilament nets and lines are not accounted for and not all European countries are reporting in PRODCOM and some are not reporting in full. The real

[4] Fishing gear means any physical device or part thereof or combination of items that may be placed on or in the water or on the sea-bed with the intended purpose of capturing, or controlling for subsequent capture or harvesting, marine or fresh water organisms (MARPOL, Annex V)

usage is underestimated, which can be corrected by comparing the data of the PRODCOM data to national production databases. This correction was left out of scope for this study.

Second is to adjust for all non-netting items, like buoys, pots and traps, cages, pipes and tubes, and cordage used for fishing and especially aquaculture, which are not accounted for in the PRODCOM product codes used above. This can be corrected looking at the weight distribution of netting items in comparison to total fishing and aquaculture litter weight, which can be taken from beach, seabed and floating litter surveys. Eriksen et al. (2014)[5] conclude that only 17% of the weight of plastic fishing and aquaculture waste comes from netting and lines compared to 83% resulting from buoys, traps, pots, etc. Legambiente (2016) provides results for floating litter from fishing and aquaculture for the Italian seas. This study indicates a less strong finding in comparison to Eriksen et al (2014), with 39% from netting and 61% from non-netting items.

Applying both percentage distributions of netting to non-netting by weight leads to a range of 40,213 and 125,525 tons annual waste from non-netting plastic items from fishing and aquaculture. Added to the total annual waste from plastic netting leads to an overall range of plastic waste from fishing and aquaculture between 65,923 and 151,235 tons, shown in Table 2 below.

Table 2: Estimation for total plastic waste from fishing and aquaculture

Category description	Unit	Amount	Source
Netting from fishing and aquaculture	tons/year	25,710	*PRODCOM, 2016*
Netting from fishing and aquaculture / Total Plastic Fishing and Aquaculture Gear by weight	%	17 – 39	*Eriksen et al., 2014* *Legambiente, 2016*
Non-netting from fishing and aquaculture / Total Plastic Fishing and Aquaculture Gear by weight	%	61 – 83	*Eriksen et al., 2014* *Legambiente, 2016*
Non-netting from fishing and aquaculture	tons/year	40,213 – 125,525	
Total plastic waste from fishing and aquaculture	tons/year	**65,923 – 151,235**	Netting and non-netting

EUNOMIA (2017) reports 15% of the total plastic waste from fishing and aquaculture gear lost to the environment. EUNOMIA (2017) refers on the lower end to FANTARED (2000), which reports loss rates of less than 5% based on surveys conducted with European fishers. On the upper end, EUNOMIA (2017) identified 75% of fishing and aquaculture not entering formal waste management by comparing PRODCOM production data to their waste entering formal waste management for EU28. According to EUNOMIA (2017), this gear can be accidentally lost, intentionally dumped or increase the stock of net in use.

After a thorough assessment of the limited quantitative data available for loss rates of plastic waste from fishing gear (displayed in Annex 5), it can be concluded that the loss rate of 15% proposed by EUNOMIA (2017) is reasonable. The 15% balances studies reporting low percentages underestimating the annual inflow due to not considering all possible inflow options of lost gear with other studies overestimating the loss of gear representing only certain geographies or types of fisheries gear with high loss rates. FANTARED (2003) reports less than 5% loss of fishing gear based on one of the most extensive studies conducted for static nets in Norway, Sweden, UK, Spain, Portugal and France. However, the loss is calculated based on reported *full nets* not incorporating parts of nets loss and loss due to wear and tear, net mending on sea or illegal dumping and therefore underestimating the real loss rate. On the other side of the spectrum, Brown et al. (2007) describe 33% (one fleet of nets lost out of three fleets per vessel) of net lost for a gillnet fishery based on UK gillnet fishery data. However, this is not indicative as gillnet fishery comprises only 21% of the total EU fleet in regards to fleet power (EUNOMIA, 2017) and the UK is geographically different from other fishing areas in Europe. Also, the 50% loss rate for dolly rope in the Netherlands (Strietman et al.,

[5] Based on averaged North Pacific, North Atlantic, South Pacific, South Atlantic, Indian Ocean, and Mediterranean Sea. (based on 891 visual surveys of floating marine litter)

2013) and Belgium (Bekaerd et al., 2015) is not representative as by weight it accounts only for a tiny fraction of all fishing gear and is mainly used only in the Netherlands and Belgium.

In general, the percentage of plastic from fishing gear ending in European seas has to be understood as an accumulation of (1) loss due to wear and tear, (2) loss of gear and gear parts which cannot be retrieved or are too risky to retrieve, and (3) unintentional and intentional dumping, with net pieces from net mending washed over board or illegal dumping of gear and gear parts. Given the above considerations, a loss percentage of 15% seems reasonable to assume.

Applying the 15% loss rate to the total plastic waste from fishing and aquaculture gear leads to a range between 9,888 and 22,685 tons of plastic waste from fishing and aquaculture entering the European seas annually displayed in Table 3 below.

Table 3: Estimation for total plastic waste loss from fishing and aquaculture (lower and middle bound)

Category description	Unit	Amount	Source
Total plastic waste from fishing and aquaculture	tons/year	65,923 – 151,235	
Loss of plastic waste from fishing and aquaculture	%	15	*Annex 5*
Loss of plastic waste from fishing and aquaculture	tons/year	**9,888 – 22,685**	

This result represents the lower and middle bound of plastic waste from fishing entering the European seas annually. The upper bound is 32,770 tons annual non-recovered fishing gear waste entering the European seas. The annual inflow is calculated by applying the 15% loss rate to 218,467 tons of annual plastic waste from fishing and aquaculture gear reported by EUNOMIA (2016), which is based on Norwegian plastic fishing and aquaculture gear waste data per capita and vessel translated to EU-28 (see Table 4 below).

Table 4: Estimation for total plastic waste loss from fishing and aquaculture (upper bound)

Category description	Unit	Amount	Source
Total plastic waste from fishing and aquaculture	tons/year	218,467	*EUNOMIA 2016*
Loss of plastic waste from fishing and aquaculture	%	15	*Annex 5*
Loss of plastic waste from fishing and aquaculture	tons/year	**32,770**	

The total loss of plastic waste from fishing is calculated cumulative for fishing and aquaculture, but can also be separated. An initial attempt is provided by EUNOMIA (2017) using the Norwegian weight distribution of 77% aquaculture gear waste and 23% fishing gear waste for EU-28. However, comparing catch data for fishing and aquaculture between Norway and the EU-28 shows that a simple extrapolation overestimates the aquaculture influence. Despite EU-28 and Norway having the same aquaculture production of between 1.3 and 1.4 million tons in 2015, the 2015 EU-28 fishing catch is with 5.1 million almost 2.5 times the 2.1 million catch from fishing in Norway (EUROSTAT, 2018). Therefore, the waste distribution can be expected to shift towards waste from fishing resulting in a more likely estimate of around 40% of weight of lost plastic waste coming from fishing with the remainder of 60% from lost plastic waste from aquaculture.

Applying the weight distribution of 40% plastic waste from fishing and 60% plastic waste from aquaculture to the lower, middle and upper bounds leads to the following results summarized in Table 5 below.

Table 5: Loss of plastic waste from fishing and aquaculture split by fishing and aquaculture

Category description	Unit	Lower bound	Middle bound	Upper bound
Loss of plastic waste from fishing and aquaculture	tons/year	9,888	22,685	32,770
Thereof, 40% **from fishing**	tons/year	3,955	9,074	13,108
Thereof, 60% **from aquaculture**	tons/year	5,933	13,611	19,622

Two comparisons are made to set the calculated loss ranges of plastic waste from fishing and aquaculture into perspective. First, several sources (Werner et al., 2016; Interwies et al., 2013; Macfayden et al., 2009) and one respondent to the open stakeholder consultation cite the annual inflow of ALDFG in the global seas to be 640,000 tons, being 10% of the global marine debris inflow of 6.4 million tons (Academy of Science, 1975; Macfayden et al., 2009). Applying the EU fleet and population data of around 10% to it, leads to a total of 64,000 tons ALDFG (EUNOMIA, 2017), which is very close to the upper bound calculated in this study of 65,540 tons per year. However, a more useful approach is to use instead of fleet and population data the European coastline of 5% of the global coastline (European Environment Agency), then 32,000 tons ALDFG enter annually the European seas, which is very close to the upper bound of our baseline of 32,770 tonnes.

The second comparison can be made to the calculated annual loss of plastic waste from aquaculture. Peter Sundt (2018) reports in his article about new investigations in Norway that 25,000 tons of plastic from aquaculture is discarded at sea annually, specifically float collars, plastic pipes, but also a lot of nets, feed hoses and ropes. According to EUROSTAT (2018), the Norwegian production is 1.4 million and EU-28 aquaculture production of about 1.3 million tons. Applying the production rates to the absolute annual loss of plastic waste from aquaculture in Norway leads to 22,809 tons for the EU-28. This is towards the upper bound of the baseline constructed for this study.

In conclusion, adjusting and updating the EUNOMIA calculations led to a lower bound of 9,888 tons, a middle bound of 22,685 tons and an upper bound of 32,770 tons for plastics from fishing entering the European Seas annually. Therefore, specifically EUNOMIAs lower bound of 3,500 tons has been raised significantly emphasizing the important impact fishing and aquaculture have in contributing to marine litter. Further, comparison calculations top-down from global ALDFG are within the calculated upper and lower bounds of this study.

3.2 Baseline for total plastic waste stock from fishing and aquaculture gear entering European Seas

Little data is reported on the total stock of plastic marine litter from fishing gear, specifically for the European Seas. EUNOMIA (2016) is the only (available) report presenting estimates, but only in broad ranges. EUNOMIA (2016) reports a stock of plastic debris of 130,000 to 550,000 tons from the fishing industry and 95,000 to 655,000 tons from aquaculture already present in European Seas. EUNOMIA (2016) bases this on comparing the current annual inputs to the historic trend in the global fishing industry growth. To put the Eunomia figures into context of the in paragraph 2.1 presented lower and upper bound of annual inflow, the annual percentage increase in European waters of plastic represents between 2.7% and 4.4% of the total stock, assuming no interchange with waters outside Europe.

Table 6: Estimation of inflow of plastic waste in European seas

Plastic debris from fishing and aquaculture in European Seas	Unit	Lower bound	Upper bound
Total stock	tons	225,000	1,210,000
Annual inflow	tons	9,888	32,770
Annual inflow/Total stock	%	**4.4%**	**2.7%**

In conclusion, between 23 and 37 years of constant inflow of plastic debris builds-up to the total stock.

3.3 Effects of related EU Legislation on Baseline

On an international level, the MARPOL Convention is the main convention for protecting the marine environment against pollution from vessels. The Port Reception Facility Directive (Directive 2000/59/EC) and the proposal for the revised Port Reception Facility Directive (PRF Proposal) implement relevant MARPOL norms on EU level regulating the EU shore side through provisions ensuring the availability of port reception facilities. Both consider fishing gear under the MARPOL waste category garbage described in Annex V (MARPOL Convention). The Port Reception Facilities Directive and the proposed revision thereof are set up with the objective to reduce marine litter. Panteia and PwC (2015) find in their ex-post evaluation of the initial PRF that 34% more waste has been collected comparing additional waste deliveries 2005-2012 compared to the baseline of 2004. The REFIT evaluation of the initial Directive gets more specific by providing data for additional Annex V garbage returned to port and concludes that in 2013 vessels are delivering more than double the amount of garbage than in 2004. However, the reported results are limited because they do not specify the increase of delivered fishing and aquaculture gear, neither report recent numbers nor include the proposal for the revised PRF and its implications.

The proposed revised PRF includes previously exempted small scale fisheries. Furthermore, the revised PRF is in place for all Ports in Europe, and indicates an indirect fee for all waste brought ashore by vessels. Therefore, the waste management for this group also falls under the PRF and provides additional incentives to return fishing gear to ports. However, no quantifications of the effect of successful implementation of the proposal for the revised PRF in regards to a reduction of fishing gear entering European seas or additional delivery thereof at ports can be obtained. Yet, the proposal for the revised PRF describes the Directive is instrumental in achieving the 2020 Commission's Circular Economy Strategy reduction target of 30% less amount of marine litter found on beaches and lost fishing gear found at sea (COM/2015/614 final, 'Closing the loop — an EU action plan for the Circular Economy'). This target is a good proxy to account for the minimum effect the full implementation of the revised PRF will have in reducing marine litter from fishing and aquaculture gear. It is explained that this will be instrumental in the Commission's Circular Economy Strategy to reduce by 30 % by 2020 the amount of marine litter found on beaches and lost fishing gear found at sea. The Commission's Circular Economy Strategy has set a reduction target for marine litter of 30 % by 2020 and acknowledged the specific role that the Directive 2000/59/EC has to play in this respect, by ensuring the availability of adequate facilities for the reception of garbage, and providing for both the right level of incentives and the enforcement of the delivery of waste to the on-shore facilities."). Legislation is still to be implemented, but as indicated the revised PRF will have a major contribution in achieving this target. Though, probably not the complete 30%. Therefore, 20% is used as an estimate (no hard data found nor possible to say about legislation still to be implemented).

Incorporating the 20% reduction target to the baseline reduces the annual loss of fishing and aquaculture gear for the lower bound by 1,978 tons and the upper bound by 6,554 tons. Therefore, the updated baseline results in a lower bound of 7,910 tons and an upper bound of 26,216 tons of fishing and aquaculture gear lost annually in the European Seas. This means that the total loss rate decreases from 15% to 12%. For the remainder of this report the revised PRF is taken into account and updated baseline figures are used.

The waste framework directive (Directive 2008/98/EC) also addresses fishing gear. However, the implementation does not affect the baseline of plastic fishing gear entering annually European Seas as its focus is on treatment of the collected waste.

The Control Regulation (Council Regulation (EC) No 1224/2009 of 20 November 2009) is the result of an in-depth reform that was completed in 2009. This Regulation lays down an extensive set of rules, the objective of which is to ensure overall compliance with the CFP and its conservation measures. The Regulation provides obligations addressed to private operators (vessel owners, vessel masters, buyers, transporters), to Member States and to the Commission.

Recent evaluations, discussions and exchanges of view in (amongst others) the Council, Parliament, EFCA, Member States and stakeholders confirmed that there is unanimous agreement that the current Fisheries Control System in place is not effective and efficient and that, as such, it is not entirely fit for purpose to sustain the achievements of the CFP objectives. Therefore, in June 2017 the Commission launched an initiative to revise the Fisheries Control System, with a view to ensure the proper functioning and implementation of the CFP.

The resulting Impact Assessment[1] outlines the problems of the current framework, including their drivers and consequences, and sets the objectives. It also presents the main policy options and examines the potential impacts of these options from an environmental, social, economic and administrative viewpoint.

Revision proposals relevant to this study are the ones related to reducing the loss or abandonment of fishing gear at sea. These could support the new European Strategy for Plastics with improved measures regarding the retrieval of fishing gears. The amendments proposed relevant to this study are the following:

1. Ease and improve the reporting of lost fishing gear, in line with the plastic strategy, by allowing fishermen to use the logbook for such reporting, and at the same time removing current unnecessary and ineffective reporting obligations.
2. Remove the current derogation applicable to vessels < 12m to carry on board the necessary equipment for the retrieval of lost gear.
3. The requirement to mark gear (including Fish Aggregating Devices/FADs; detailed requirements are included in the Control Implementing Regulation).

It is not expected that improved reporting of lost fishing gear has a direct effect on the ALDFG flowing into the Seas. It could help the efficiency of retrieval operations, but no effect on the baseline inflow of ALDFG is expected. The proposal that also vessels <12m should carry the necessary equipment to retrieval lost gear, could impact the inflow of ALDFG into Seas. The obligation to have necessary equipment on board for smaller vessels makes it easier to retrieve lost gear for smaller vessels. In the impact assessment of the revised Control Regulation this is not quantified in terms of reduction on ALDFG. Furthermore, it is not specified what retrieval gear should be taken in board or how (much) smaller fishers will use this. Therefore, it is at this point in time not possible to estimate if (or how much) the necessary equipment to retrieve lost gear on vessels <12m reduces the inflow of ALDFG in Seas. The same reasoning holds for the marking of fishing gear, there are no estimates what the consequences on the inflow of ALDFG is.

To summarize, for this study we take into account the following baseline figures.

Table 7: Summary of baseline figures

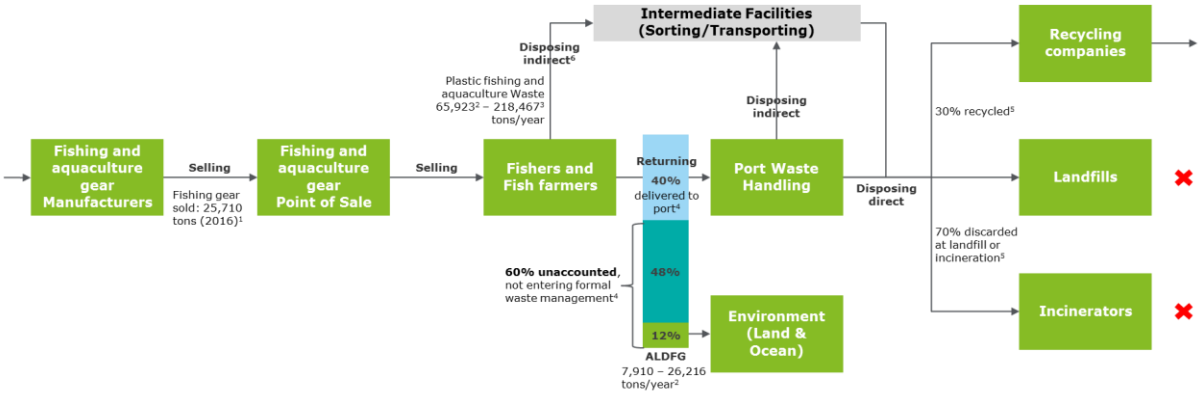
	Lower bound	Upper bound
Baseline	9,888	32,770
Revised PRF (20%)	1,978	6,554
Revised Control Regulation	Not able to estimate impact on ALDFG	
Baseline range for this study	7,910	26,216

[1] The text about the Control regulation is based on the Commission staff working document impact assessment accompanying the document proposal for a regulation of the European Parliament and of the Council,

3.4 Process of the baseline scenario

The baseline scenario is visualized in Figure 2, describing the stakeholders involved and the gear flow between them. The figure includes the relevant baseline quantification as described in the previous paragraphs. As the baseline figures of the previous chapters, the baseline process will serve as the basis for the impact assessment of the policy options.

Figure 2: Visualized process of the baseline scenario



1) PRODCOM data 2016 (project code 13941233 and 13941235, only reflecting fishing nets, not buoys, pots, traps and other aquaculture gear)
2) Baseline estimation of plastics from fishing and aquaculture entering the seas adjusted for proposal for revised PRF
3) EUNOMIA 2016
4) EUNOMIA 2017 adjusted for proposal for revised PRF
5) Nofir (assumption from Norway without Nofir/Eufir scheme)

Going from left to right, the first stakeholders are manufacturers who design and produce fishing gear from plastic (majority is nylon, polypropylene and polyethylene), lead, steel and wood among other materials. 25,710 tons (after accounting for import and export) of fishing and aquaculture nets were sold to fishers in Europe in 2016 (PRODCOM, 2016). They are sold via a point of sale of gear, the second group of stakeholders.

Fishers, as third stakeholder group, purchase the fishing and aquaculture gear at the point of sale. Gear consists of many parts and is assembled of nets, cords, hooks and buoys among others before used at sea. Repairs are undertaken by fishers, port services, point of sale or even manufacturers when broken. The gear is used until it either cannot be repaired anymore or is abandoned, lost or discarded at sea. For the first, according to Brown et al. (2007) the gear is discarded on average after one year[6]. For the latter, 12% of fishing and aquaculture gear are lost to the marine environment and not recovered after accounting for the revised Port Reception Facilities Directive (detailed explanation in Paragraph 2.1 of this report). The baseline quantification arrives at an amount of between 9,888 and 32,770 tons of plastic waste from fishing and aquaculture entering the European Seas annually. Whereby the environment, in this case the ocean or land, is another "stakeholder".

Ports and marinas represent the fourth stakeholder group, who receive end-of-life fishing and aquaculture[7] waste gears from fishers. However, not all ports have adequate facilities for collecting and handling waste from fishing and aquaculture, specifically as small fishing vessels are not covered under the PRF Directive. Anecdotal evidence was provided for example for small fishing harbours in remote areas in Scotland (Interview OSPAR). EUNOMIA (2017) reports that only 25% of plastic waste from fishing and aquaculture is returned to ports entering formal waste management, based on their comparison of production data with their estimate of gear entering formal waste management, leaving 75% unaccounted for. Accounting for the effect of the proposal of the revised Port Reception Facilities Directive, 40% of plastic waste from fishing and aquaculture is returned to ports and 60% are left unaccounted containing the 12% of fishing and aquaculture gear lost to the marine environment.

[6] EUNOMIA Annex (2017), p175 and EUNOMIA (2016), p. 86
[7] Aquaculture facilities are not obligated to bring waste to ports

The end-of-life fishing gear returned to ports, depending on the country and marina, passes through the intermediate process steps of cleaning, dismantling, sorting and transporting. Cleaning, dismantling and sorting is either performed by fishers on board or at ports, port waste management as in the case of Denmark (Interview with Plastix CEO and Chairman of the Board) or by port external stakeholders such as specialized cleaning and sorting companies. The transport is either performed by transport companies as external stakeholders or organizations like the Norwegian Nofir. According to the CEO of Nofir costs are €1,400 alone for the transport of a large 20 tons net in Norway (EUNOMIA, 2017).

Plastic fishing gear brought to port will be either recycled, incinerated or discarded at landfills or in some cases left unattended and washed back into the sea (Interview OSPAR). Nofir (2015) reports that the gear brought back to the port is split into approximately 70% of gear incinerated or discarded at landfills and 30% recycled in Norway according to the Norwegian Environment Agency confirmed by SINTEF (largest independent research organization in Scandinavia, analysing the Norwegian fisheries and aquaculture). Besides the negative environmental impact, costs for landfill are substantial and have been estimated to be around €280 per ton of net disposed at landfill excluding transport for the Norwegian case (Nofir) versus €68 per ton of net transported and recycled in Iceland (EUNOMIA, 2017). Iceland stands out with their specific collection scheme, which reaches currently a recycling rate around 60%. However, on an EU-wide basis, EUNOMIA (2017) reports a recycling rate of 1.5% based on the assumption that only UK, Denmark, Spain, Italy, Estonia, Greece, the Netherlands, Malta and Lithuania of all EU-28 countries participating in the Nofir project collect and recycle waste, the others were attributed with a recycling rate of zero percent.

Additional stakeholders (not displayed) indirectly impacted by the policy options are the consumers (by possible changes in fish prices) and the government and local authorities by additional administrative burden. Consumers and government will be taken into account in the analysis during the next chapters.

4. Policy options

This chapter qualitatively describes four possible policy options to consider to reduce the yearly inflow of ALDFG into European Seas: extended producer responsibility without a deposit scheme, extended producer responsibility including a deposit scheme, target setting and alternative materials and product design. For each policy option, a qualitative description, including a rationale for the specific option, including sub-options, is provided. Further evaluation and quantification of all options is elaborated upon in chapters 5 and 6.

As part of the qualitative description, each policy option is visualised with a process scheme, in which the impact of the specific (sub)option on the baseline situation described in the previous chapter, is being visualised. This chapter concludes with a final paragraph which links the problem drivers to the suggested policy options.

4.1 Extended producer responsibility (EPR) without a deposit scheme (DRS)

Extended Producer Responsibility (EPR) is a policy approach under which producers are given a financial and/or physical responsibility for the treatment or disposal of post-consumer products (products that have served their intended use). In this paragraph, we will examine three subcategories: 1) EPR without DRS (funding by manufacturers), 2) EPR without DRS (situation with retrieval – funding by manufacturers) and 3) EPR without DRS (situation with retrieval and recycling fee – funding by manufacturers).

Rationale

As pointed out also by Lanoie et al., 2011, cited by Oosterhuis et al., 2014, economic instruments, including extended producer responsibility (EPR), can stimulate gradual changes in the behaviour of users by allowing environmental costs, including costs of lost gear recovery/recycling, to be internalised by "polluters" through including costs of retrieval into the price of products or activities. Such an approach is in line with the 'Polluter Pays principle', which is one of the cornerstones of modern marine environmental laws (Liability and compensation) and furthermore a legally binding principle of EU law, enshrined in the TFEU.

The Polluter pays principle broadly speaking, demands environmental costs to be included in the price of product and services, and that those actors causing environmental damage should bear the costs of its abatement. Therefore, the polluter pays principle has a preventive function in that costs from polluting activities should be borne by the polluter causing it. Based on the relevant price elasticity, and taking into account the minimal EU requirements of an EPR, the costs will be distributed over the different segments in the production/value chain.

Despite the fact that the application of this principle is limited to problems related to the identification of the polluter and/or the extent of the environmental damage, the fact is that there have been, particularly within the framework of marine environmental law, compensation schemes in existence (i.e. Civil liability and Fund Conventions regulating compensation for oil pollution damage caused by tankers) according to which primary responsibility has been placed on the actual polluter (i.e. registered ship-owners) while subsidiary or 'top-up' liability, including in cases where the actual polluter is not known, has been placed to the producer or seller of a particular good (i.e. the oil industry (IOPC Funds, 2018).

Sherrington et al. (EUNOMIA, 2016) see one of the benefits of such policy option also in the fact that it may "shift consumption away from harmful products". In our particular case it may therefore reduce the use and/or abandonment of plastic components of fishing gear which are designed in such a way that they might break apart during their use, e.g. plastic dolly rope, and polystyrene floats and buoys not sealed in a protective cover. This could be achieved, according to the mentioned author, with an outright ban on sale and use of such items, or through an environmental tax (or fee) that will make alternative products, therefore products with less environmental impact, cost-competitive.

In the case of EPR, an additional fee could potentially be used to pay for, for example, improved waste management services, sorting and cleaning, recycling, education and awareness, R&D and collection or retrieval operations. In this way, it could also act as an (in)direct incentive to prevent the discarding of used fishing gear.

Despite EPR being, in theory, an individual obligation, in practice producers and manufacturers often exert this responsibility collectively. In collective schemes, a Producer Responsibility Organisation (PRO) is set up to implement the EPR principle on behalf of all the adhering companies (the obligated industry). A PRO is a collective entity set up by producers or through legislation, which becomes responsible for meeting the recovery and recycling obligations of the individual producers. PROs potentially exert three main functions (European Commission – DG Environment, 2014):

1. Financing the collection and treatment of the product at the end of its life (targeted waste stream) by collecting fees and redistributing the corresponding financial amounts;
2. Managing the corresponding data;
3. Organising and/or supervising these activities.

PROs can be implemented at three different levels:

Level 1	No collective EPR scheme (PRO), producers carry out responsibilities individually
Level 2	Collective EPR scheme, in the form of a PRO.
Level 3	2 sub levels are possible: • Multiple PROs, working together on responsibilities. The PROs can for example take on different parts of the waste treatment. E.g. within the packaging industry, one PRO takes on plastic whilst another takes on cardboard • Multiple PROs, competing for the same responsibilities.

So far, there are no examples found of PROs who handle the manufacturer responsibility for the entire EU (EU-28 level), all PROs function on a national or regional level. Below two examples are provided, one PRO handling the entire responsibility of manufacturers on a national level and a second example about competing PROs in the UK.

Box 1: Example of Auto Recycling Nederland (collective EPR)

Auto Recycling Nederland

Auto Recycling Nederland (ARN) is the overarching Producer Responsibility Organisation (PRO) for the Dutch automotive industry. This PRO only covers the financial responsibility of the manufacturers. ARN has been set up as a third-party to handle the EPR management of the automotive organisations. This scheme is highly effective in terms of recycling: 98.7% of all car parts are recycled and 88.9% are re-used.

The scheme works as follows: for new cars, a recycling fee - or in general terms, an Advanced Recycling Fee (ARF) is incurred with the cost of a car. The fee incurred is a fixed price, approximately 0.1% of the purchase price of an average car. The fee level is based on the costs of running the controlling body and the payments to car demolishers who take the cars apart. Since most car parts contain valuable parts that can be recycled, which generates revenue for the car demolishers, car demolishers will pay the car owners (which can go up to 500€ per car) for these recyclable parts.

An example of multiple PROs, competing with each other, is given below:

Box 2: Example of the UK packaging industry

UK packaging industry

In the UK, subsequent acts were passed in 1995, 1997 and 1998 which require producers to recover and recycle a specific percentage of their packaging waste each year with an increasing percentage over time. The goal of the program was to meet the EU packaging waste requirements.

Companies who were obligated to recycle could contract a waste handler themselves or joined a "compliance scheme", which essentially acted as a (for-profit) PRO. Since multiple of these compliance schemes existed, as they were run by different companies, multiple PROs were competing with each other on recycling waste.

The biggest compliance scheme in the UK is Valpak, in 2010 Valpak had a market share of approximately 50% of all business registered with a compliance scheme (PRO EUROPE, 2011). Since Valpak did not recycle themselves, but rather contracted out the collection and recycling of packaging waste, the idea of Packaging Waste Recovery Notes (PRNs) came up. These were material specific notes of every tons of material that was recycled.

Originally this was not a requirement by the government, but PRNs soon became the common currency necessary for trading. PRNs are traded amongst the obligated companies, reprocessors and compliance schemes. Reprocessors submit quarterly reports that state how many tons of packaging were recycled. The government then issues blank notes to the reprocessors, who fill them out and issue them to compliance schemes or obligated companies.

Since the recycling system has turned into a tradable credit system, the incentive to increase the design for environment (DfE) is limited. Packages are not made more recyclable, as this would only increase the cost of such a design whilst the benefit would be reaped across the marketplace as there is no brand sorting or tracing of products. Furthermore, there is also no incentive for the waste handlers to become more effective in recycling waste (and achieve a higher recycling percentage), as the PROs compete with each other on costs.

A consideration to take into account when implementing an EPR scheme is that fishing gear usually consists of several different parts and materials (i.e. trawl nets). Some of these parts (i.e. ropes) could be produced for a multitude of sectors and applications and not solely for the fishing industry. As such, fishing or aquaculture gear may include materials where it would be more challenging to add a fee related to ADLFG aspects.

Another important aspect regarding effective implementation seems to be the creation of a "level playing field". As the application of extended producer responsibility will result in increased costs for fishers regarding the acquisition of a specific type of gear, it will be paramount to assure that certain fishers will not be in a position to circumvent such obligation and use similar fishing gear for which the extended producer responsibility (fees and associated higher costs) would not apply. As such, having a fee system in place only works if all fishing gear manufacturers take part in the scheme, making it more difficult to buy or sell gear without a fee added.

Subcategories

As explained above, an EPR could be used for different purposes as long as it contributes to the principle that the producer has the responsibility to take back fishing gear at the end of its life. For the purpose of quantifying this policy option, we have looked into three subcategories: 1) EPR without DRS (normal situation – funding by manufacturers) and 2) EPR without DRS (normal situation with retrieval – funding by manufacturers) and. These will be described in the sections below, where option 1b will be compared to option 1a.

1a - EPR without DRS (normal situation – funding by manufacturers)

In this subcategory, a fee will be added to fishing gear, which could pay for improved services to collect fishing gear at fishing ports. The rationale behind this option is that providing better services (minimising the threshold to deliver used gear into port) could provide an additional incentive to fishers to deliver more waste from fishing gear back into ports. Other examples of activities paid for by such a fee could be awareness courses and education (see also the requirements mentioned in the proposed amendments for the Waste Management Directive 2008/98/EC described below) or harmonised reporting with a central database to facilitate identification of hotspots and snagging sites.

The fee could be added to the price of fishing gear by manufacturers. An alternative or additional option could be a fee paid for by fishers that could be levied as a certain percentage of the auction price of fish. The principle is the same: fishers pay an additional fee on their gear.

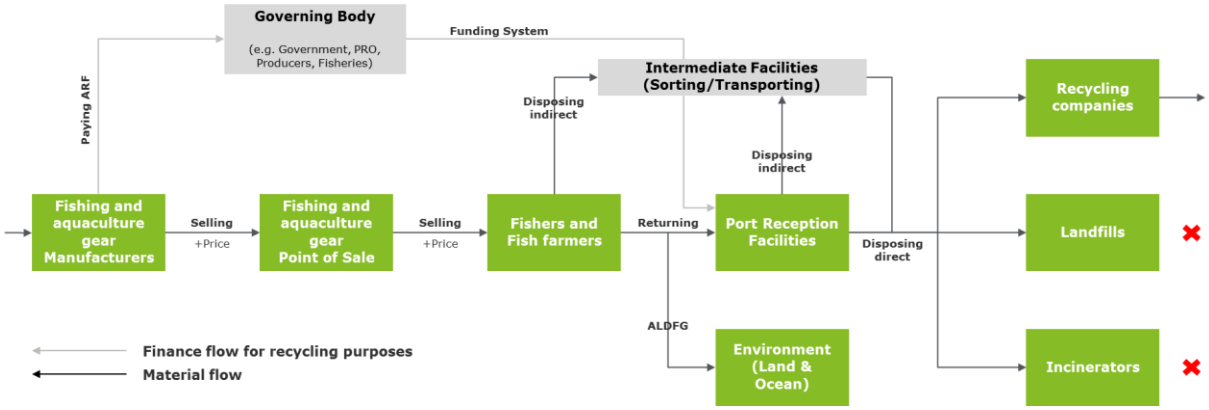
In this policy option, we take into account the minimum requirements of MARPOL Annex V, the Port Reception Facilities (PRF) Directive, and the Control Regulation for the Common Fisheries Policy (CFP), which are all part of the baseline for this study.

The proposal for the new amendments to the Waste Management Directive 2008/98/EC (which are expected to be adopted during the spring of 2018) specifically describes minimum requirements for EPR and is relevant to this policy option (DG Environment):

- With regard to the costs, these are clearly defined to cover the costs of separate collection and all subsequent treatment of that waste. The minimum requirements do not specifically include costs of clean-up of litter or costs of the management of residual waste in the mixed bag (i.e. not collected separately), but MS can ask EPR schemes to cover these costs. Minimum requirements do however ask EPR schemes to cover the costs linked to providing information to consumers on waste prevention and better waste management.
- The requirement to modulate EPR fees is linked to 5 criteria: durability, reparability, re-usability and recyclability and the presence of hazardous substances. There is no direct link to considering the aspects that the products are prone to littering.
- Another minimum requirement that could have an impact is that EPRs have to have a clearly defined geographical, product and material coverage without limiting those areas to those where the collection and management of waste are the most profitable. And a requirement that EPRs provide an appropriate availability of waste collection systems.

The process flow in Figure 3 shows the projected effects of this policy option on the different stakeholders:

Figure 3: Visualization of Option 1a - EPR without DRS (funding by manufacturers)



1b - EPR without DRS (with retrieval operations – funding by manufacturers)

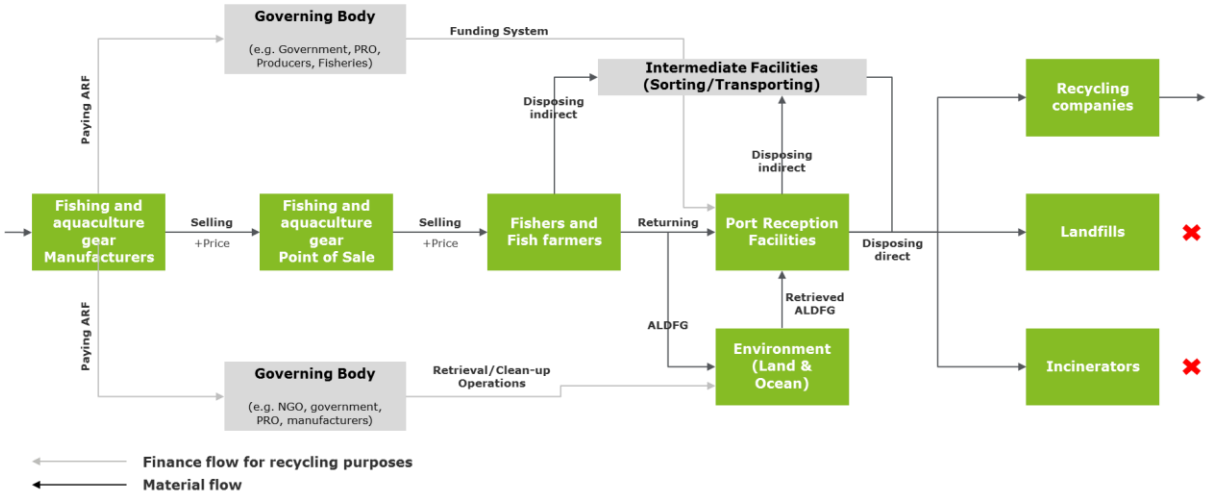
This policy option is the same as the one described above but now includes retrieval operations as part of the ERP (i.e. beach clean-ups, Fishing for Litter). We have made this a separate sub option to indicate the difference in level of ERP when retrieval operations are included in the ERP and what the level of ERP would be without retrieval operations included (sub option 1a). The rationale behind this policy instrument is that paying for retrieval operations would also make fishers more aware of the effect of not delivering used fishing gear back to ports and the importance of doing so.

A consideration to take into account when implementing such a scheme is that not all litter collected during retrieval operations is related to (current) fisheries operations or of fisheries occurring near the location of retrieval (i.e. a fishing net lost in Belgian waters may end up on a Dutch beach). As not all litter collected during clean-ups is related to fisheries, only the percentage related to fisheries should potentially be paid for by the fisheries sector.

As fisheries related litter collected at beaches or retrieved at sea may not originate from that particular area, a European wide fee system (including a governing body) and fund should distribute money to pay for the collective costs of clean-up and retrieval operations. Figure 4 shows the process flow of ERP without DRS and with retrieval operations.

The process flow in Figure 4 shows the projected effects of this policy option on the different stakeholders:

Figure 4: Visualization of option 1b - EPR without DRS (with retrieval – funding by manufacturers)



4.2 Extended producer responsibility with a deposit scheme

This policy option is the same option as the one described in the paragraph before, but the difference is that this option specifically includes a deposit scheme. A deposit scheme is intended to provide an incentive for fishers, fishing companies to return used fishing gear to receive back the deposit. Therefore, the rate of return is likely to be higher than current returning rates. The unclaimed deposits generated with this scheme might fund retrieval operations or collection of beach litter.

Rationale

A deposit-refund scheme is used in the consumer market for many items such as for example batteries, bottles and packaging. The recovery system requires the collection of a monetary deposit on a product's packaging (often beverage containers) at the point of sale. The deposit is refunded to the purchaser when they return the container to an authorised redemption centre. Non-recovered deposits may be used to finance waste collection and disposal facilities (Mrs. Véronique Monier, BIO Intelligence Service et al., 2014). In the more industrial B2B market deposit-refund schemes are for example used in the case of reusable pallets and containers.

According to Huntington (Global Ghost Gear Initiative, Part 1) some specific gear components, such as plastic pots and buoys could attract an end of life refund when returned to the manufacturer or their agent. Obviously, the deposit-refund scheme could be applied also to whole nets, not just its components, particularly if the objective of the return system is to discourage illegal or improper disposal of fishing gear.

Reference should be made to the fact that the deposit refund system is in fact best suited for products whose disposal is difficult to monitor and potentially harmful to the environment. The logic of such approach would be as follows: If used nets are lost (or discarded) at sea, a new net would be more expensive to buy as there is a deposit in place. Fishers will then pay for the ecological damage they cause by losing their nets. Reference should be however made to the fact that nets are, generally speaking, already an expensive item for fishers to purchase, hence they already pay attention not to lose, or even less, voluntarily discard their nets (Reinhard et al., 2012).

Also Gilman et all (FAO, 2016) seem to be of the opinion, that the best economic instrument to reduce cases of abandoned, lost or otherwise discarded gear is to create a mandatory deposit on new gear, which is returned when unwanted gear is delivered to an appropriate port facility reception, and not, for example, the granting of subsidies to fishers regarding the replacement of their nets. As an alternative, there is mention of, in case of sufficient resources for effective monitoring, to the introduction of onerous penalties which would create an incentive to avoid or reduce the incidence of ALDFG. The introduction (or increase of existing penalties) should be an additional- complementary measure to the introduction of extended producer responsibility and/or deposit scheme.

With a deposit scheme in place on top of an EPR scheme, there will be extra costs for the individual fisher or fishing company to buy fishing gear. However, the deposit is regained when the used gear is returned. This may well provide an incentive to fishers to return to port all of their own gear but also any gear found and retrieved out at sea. At a substantial rate of the deposit required this scheme may simultaneously provide a financial incentive to operate carefully with gear and not to lose it as well as bringing ashore as much gear as possibly feasible. Hence it might consist of the combination of preventive and curative action.

Operating a deposit-refund scheme will also bring extra costs of managing the system and port facilities have to be adequately equipped to receive returned fishing gear and administratively manage such a scheme. For such a scheme to be implemented, a governing body should be in place to organise retrieval and transport and pay the fishers the deposit on returning the gear, either directly or through a port facility where fishers can deliver their used fishing gear and receive the deposit on the gear back. Or in the case that several suppliers are involved, workshop cooperatives (or other places where fishing gear is prepared) or fish auctions could play a role in the collection of fishing gear and redistributing it to the original manufacturers/suppliers.

Like we mentioned earlier in the policy option 'ERF without a deposit scheme', fishing gear usually consists of several or many different parts (i.e. bottom trawling or pelagic gear, ropes attached to lobster cages, etc.). Fishing nets can also be bought, subsequently sold, combined with different gear and updated/repaired extensively throughout the product life. Therefore, fishing gear may consist of parts with and without a deposit. As a result, it would be almost impossible to return exactly the same product for a deposit refund or extended producer responsibility scheme. A possible solution to this could be to set the refund amount somewhat lower than the deposit amount. Another solution could be a requirement to return an equal volume or weight of fishing nets instead in order to achieve the intended effect (Sherrington et al., 2016).

Another practical issue to take into account is that, contrary to for example a bottle or battery deposit-refund scheme, fishing gear is subject to substantial wear and tear (materials used may not have the same properties anymore after a certain period of time) and also often only parts of the gear are being lost at sea. The question then arises when could (parts of) fishing gear still be eligible for a deposit? Therefore, if implementing such a scheme, there needs to be a (subjective) decision whether there is a refund of the deposit or not at some point in time.

Setting an optimum deposit level might be a challenge because of a variety of reasons. First of all, different sectors display a large variety of refund levels. Secondly, scientific articles on deposit schemes do not provide a calculation method for an optimal level which can be applied in relation to fishing gear. Thirdly, the practicalities mentioned earlier, in combination with the chance that used fishing gear may only be brought back to port in the case that the deposit is higher than the costs saved by abandoning fishing gear at sea, may make it a challenge to decide on an optimal refund level.

A review of literature provides some practical example of how the mentioned policy option can be applied in practice. The first assessed case relates to Germany, where a deposit refund scheme was applied for EPS fish box. The user (fishers, fish processor, retailer. Consumer) had to pay a certain deposit for each EPS fish box (i.e. 0.5- 2 EUR). When returning the fish box to the fish box collecting point (i.e. in ports, at local fish markets, in retail) the deposit is paid back (Interwies et al., 2013)

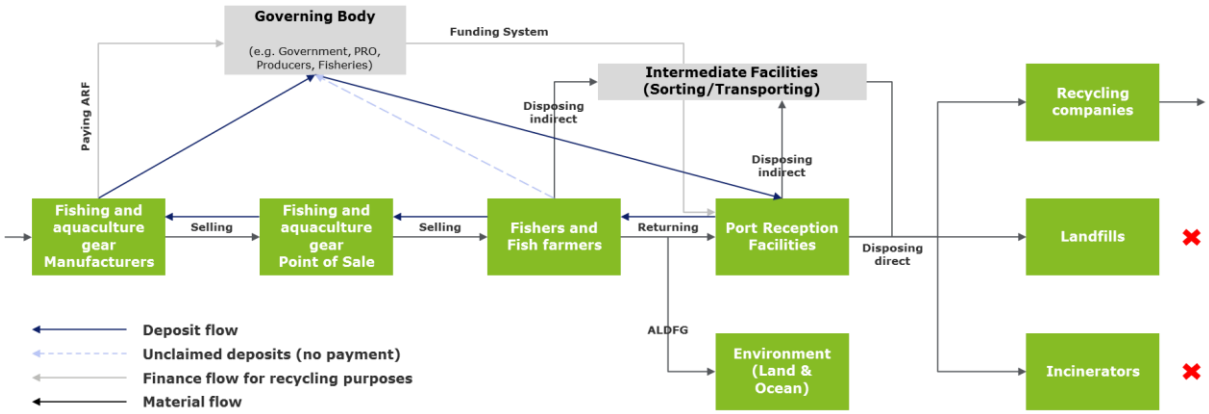
A second example relates to the Republic of Korea, a case prompted by the sinking of a passenger ferry, after it became entangled in discarded fishing gear. The Korean Government Department, Ministry of Maritime Affairs and Fisheries (MOMAF) decided to purchase used fishing gear returned to port by fishers. This is reported to be highly effective in terms of recovery and disposal of gear albeit fully dependent on public spending. The costs of this programme were split between the central and local government and in 2006 amounted to 3.678.000 USD and resulted in 5.137 tonnes of collected fishing waste (Macfadyen et al., 2009). Translating this to the European situation, it could be that EMFF (European Maritime and Fisheries Fund) provides a (financial) incentive to fisheries to return fishing gear to port. The EMFF is the main supporting financial instrument to the CFP. It seeks to improve the social, economic and environmental sustainability of Europe's seas and coasts by supporting local projects, businesses and communities on the ground.

Additional administrative burden could be envisaged for gear designers and manufacturers regarding the traceability of the designed/manufactured gear and its registration/entry into a specific register. This would on the other hand lead to additional burden for statutory regulators as there would be a need to establish and maintain a database of gear ownership (Macfadyen et al., 2007).

The administration of the deposit refund/penalty scheme would also require more involvement from Port Authorities and so may increase their administrative burden for (fishing) ports (Sherrington at all, 2016).

The process flow in Figure 5 shows the projected effects of this policy option on the different stakeholders:

Figure 5: Visualization of option 2 - EPR with DRS



4.3 Target setting

Recycling of fishing nets contributes to the concept of circular economy. Setting a recycling target for fishing gear is in itself a curative option and therefore not considered to be a preventive measure. It may, however, contribute in making more fishers aware and dedicated to bring back to port as much used fishing gear as possible.

There are two ways in which recycling of fishing gear can take place:

- The first option is 'mechanical recycling for second raw material production'. This option works best when the waste collected consists of a rather homogenous mass of material that is relatively pure and clean. Used fishing gear usually does not fulfil this criterion as it may be contaminated with biological fouling, sand and small rocks and possibly other plastic debris such as dolly ropes in trawl nets. Should there be a considerable number of encrusting organisms preventing access to the mechanical recycling phase, further pre-treatment operations will be necessary with a preliminary cleaning of the nets.
- A second option is chemical recycling such as pyrolysis, should mechanical recycling be too costly and burdensome in terms of organisation. In the pyrolytic process, waste is heated in the total absence of oxygen. The treated material is not burnt or reduced to ash, but undergoes thermal degradation to be transformed into materials whose chemical and physical properties differ from the original substance and are consequently more desirable.

Apart from fishing gear in most cases not being pure and clean, other characteristics may make it more challenging to recycle. For example, most fishing nets consist of several separate parts and hence of several types of plastics and material which will not all to the same degree be fit for recycling. Also the value of the different types of material can differ rendering for example only the recycling of specific parts economically feasible. Case in point is the Nylon 6/polyamide retrieval from fishnets currently used as base material for clothing: the Healthy Seas Socks.

Box 3: Icelandic fishing gear recycling scheme

Example: the Icelandic fishing gear recycling scheme

In Iceland, it is mandated by law that all used fishing gear should be taken back to shore, and lost gear retrieved. A recycling target is set at 60%. The recycling rate for fishers is monitored at a macro level. Research reveals that for every ton of fish caught, one kilogram of plastic waste is produced. Due to quotas and corresponding fishing gear used, it is possible to estimate the plastic waste produced by the fishing industry. This is compared to the plastic waste from fishing gear delivered at recycling facilities to check whether the targets are reached by the fishing industry. Currently, the target is met as around 70% of retrieved gear can be recycled. Of this 70%, 90% is sent for recycling to recycling facilities in Lithuania.

The recycling scheme for fisheries gear is coordinated by the fisheries sector (the Federation of Icelandic Fishing Vessel Owners (LIÚ)). In this scheme, fishers take back to port end-of-life or broken fishing gear, where it will be either repaired or cleaned, sorted and disposed of for recycling. Sorting and cleaning takes place in their own facilities, by fishers themselves or by specialised professionals in workshops/repair shops in the harbour.

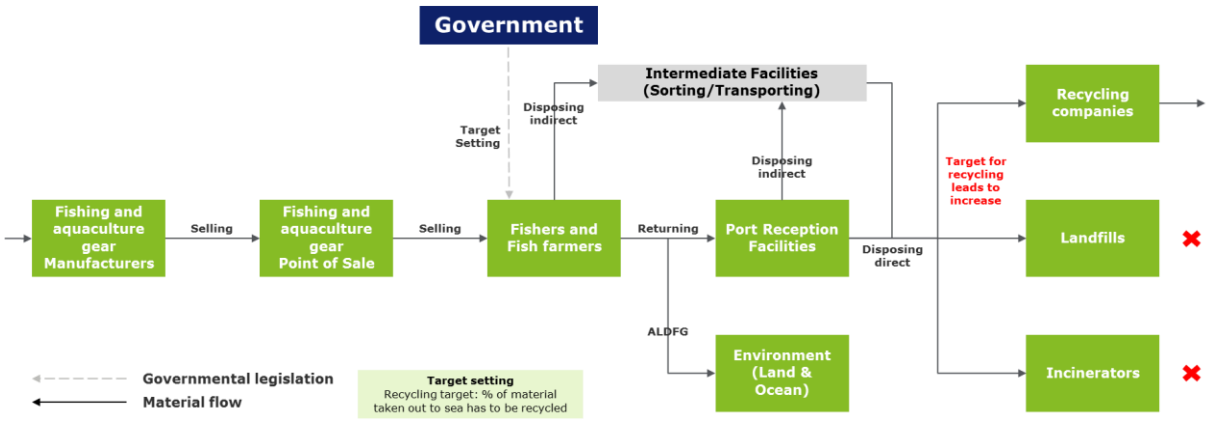
Fishers or the fishing companies owning the fishing vessels then get compensated by the recycler for delivering clean, sorted plastics from fishing gear which has value on the end market. The compensation depends on the quality and type of material. Specifically, polyamide creates a higher monetary value in recycling than other materials, a value sufficient to pay for the transport costs of all the fishing gear from the local harbours to the recycling facility in Lithuania.

When setting recycling a target for fishing gear, the following considerations should be taken into account:

- The incentive by recyclers to pay (a higher value) for the (sorted and cleaned) waste from fishing gear may in some cases be minimal. Waste from fishing gear is usually a small portion of the total waste that is offered to recyclers.
- It is not expected that specialised facilities for the recycling of fishing gear waste will start operations in the near future, as fishing gear waste consists of many different and unsorted materials which make it difficult to recycle and the economic value of most fishing gear waste is zero or negative. The consequence is that waste will need to be transported to recycling facilities which are not located closely to most ports and hence considerable transportation costs could be in place.
- As a stand-alone option, setting a recycling target entails no (financial) incentive for fishers to bring ashore more used fishing gear. For a recycling rate target to work for fishers, ports should offer a very practical and low threshold system of waste collection to fishers that will allow collection of waste at a minimum effort for the fishers (in which the revised PRF foresees).

The process flow in Figure 6 shows the projected effects of this policy option on the different stakeholders:

Figure 6: Visualization of option 3 - Target setting



In theory, next to a recycling target, a collection target could also be a policy option to consider with the aim of reducing ALDFG. In such an option, a target would be set for fishing vessels or fishing harbours for the amount of used fishing gear to be delivered to ports based on an assumption on what could be expected to be delivered to ports on an annual basis. Such a target could then act as a benchmark to compare the actual amount of used fishing gear brought back to port on an annual basis and to create action plans to improve the situation.

Theoretically, such an option might look like a reasonable option. For this study, we therefore looked into the potential of implementing such a policy option. Through interviews it became clear that in practice it will be quite a challenge to implement this option effectively and with the support of stakeholders involved. Some of the reasons mentioned were that the practicalities involved with keeping detailed track of new and used fishing gear for each vessel will be (too) complicated. Secondly, it would be very hard to prove what has happened to fishing gear at sea based on the amount of used fishing gear taken back to ports (interviews: Coen Peelen, Dutch Ministry of Infrastructure and Waterways & Mike Mannaart, KIMO International). Thirdly, there is other European legislation in place which targets and monitors fishing gear waste (more specifically, the (revised) PRF which implies that all Ports should have reception facilities for fishing gear waste and the revised Control Regulation which targets to improve the reporting of lost fishing gear).

An initiative which could have a positive effect on recycling and collection of used fishing gear is the Circular Ocean initiative (http://cfsd.org.uk/wp-content/uploads/2018/02/Circular-Ocean_Research_Products_FINAL_02-02-18-wecompress.com_.compressed.pdf). This initiative intends to highlight commercially viable products that include re-used used fishing gear (such as fishing nets / ropes / other products). The described initiatives try to use retrieved fishing material from retrieval operations from projects like Healthy Seas.

4.4 Alternative materials and product design

In this paragraph, we will describe the policy option 'Alternative materials and product design'. This policy option is focused on substituting currently used materials with more sustainable alternatives (i.e. biodegradable polymers) and using more sustainable product designs (i.e. gear markings). It should be highlighted that the Impact Assessment of the revised Control Regulation also takes into account the requirement to mark fishing gear (see also chapter 3 of this report).

Rationale

In its basic design fishing gear is composed of different materials, of which plastics are an important component. Choices over which materials to use under which circumstances are usually based on characteristics such as the strength, flexibility, durability, buoyancy, price and past experiences in using certain materials or designs. In this way, fishing gear can consist of a heterogeneous compilation of materials with different characteristics. As such, fishers usually opt for the most cost-effective options. Such choices do, however, not always reflect the most environmentally friendly options (such as biodegradability in seawater, recyclability of parts and/or possibility to track lost or abandoned gear).

For this policy option to be effective, gear should be designed or compiled with both the potential environmental impact and end-of-life solutions in mind. This could either be achieved by focusing on alternative materials or different product designs that would both reduce the risk of loss and the potential harm to the environment in case of loss. In the sections below, we will examine both options in more detail.

Subcategories

4a - Alternative materials

Various types of plastic are currently utilised for different types of gear and equipment; an overview is given in Table 8:

Table 8: Overview of plastic types utilized in fishing gear (Source: Eunomia, 2017)

Material	Use
Nylon (Polyamide)	Nets (mostly gillnet and seine nets), lobster and crab pots
Polypropylene	Nets (mostly gillnet and trawl net), rope, mesh
Polyethylene	Nets (mostly trawl net, purse seine net); longlines; Aquaculture: rope, cage, floats, tubes, disks
HDPE	Trawl doors, dredges, small parts and cladding
Polystyrene, Polyurethane	Insulation, floats and buoys, including in fish aggregation devices (FADs)
PVC	Aquaculture: cages, tubing and piping
Acrylonitrile butadiene styrene (ABS), Polyvinyl difluoride (PVDF)	Aquaculture: valves
Aramids, Ultra High MW Polyethylene, Aromatic polyester	Rope, net (newer technology)
GFRP (glass fibre reinforced plastic)	Aquaculture (newer technology)

Of the materials mentioned in the table above, polyethylene and polyamide are the most commonly used type of materials in fishing gear (Interview Ben Wensink, Ymuiden Stores).

When looking into the potential use of alternative materials that are more environmentally friendly than the currently most used ones, only certain parts of fishing gear may qualify for substitution. More environmentally friendly materials could either be better suited because of increased recyclability, biodegradable in seawater or stronger material less prone to wear and tear. These latter type of materials could be materials that are in itself not environmentally friendly (not biodegradable in seawater or recyclable), but because they are less likely to end up in sea, a better option than conventionally used materials.

However, not all materials used in fishing gear can be easily substituted with another type of material. Either because of the preferred characteristics (i.e. strength, buoyancy) or because of legal considerations. For example, under the CFP technical measures the mesh size of fishing nets is being defined. This implies that the material used to make the nets should not be expanding (then fishers lose fish) or shrinking over time (then fishers are not compliant to legislation). This renders some materials inapt to replace certain currently used plastics in nets (Interview Ben Wensink, Ymuiden Stores).

There are, however, parts of fishing gear that could potentially be replaced with more environmentally friendly substitutes. One of these materials is dollyrope, one of the most commonly found litter items on beaches around the North Sea. Dolly rope (also referred to as ´Chaffe´ in the UK or 'vahiné rope' in France) is the name for the orange or blue plastic threads that are used to

protect (the cod-end) of bottom trawling nets against wear and tear. Due to abrasion, a part of these threads end up in the sea during fishing operations.

In the Netherlands, the DollyropeFree project is focused on achieving a significant reduction in the amount of dolly rope that ends up in the sea. The project started in 2013 and is currently running. One of the approaches in the project is the development of alternative materials and designs. Materials tested have so far included natural fibres (i.e. sisal, manila), biopolymers (both compostable and in seawater degradable materials) and non-degradable alternatives (but extremely strong and therefore less prone to wear and tear). The tests are currently ongoing and the results look promising but need further testing. Therefore, potential costs and impacts of solutions tested in this project are not know yet (interview Wouter Jan Strietman, Wageningen Economic Research, project coordinator DollyropeFree).

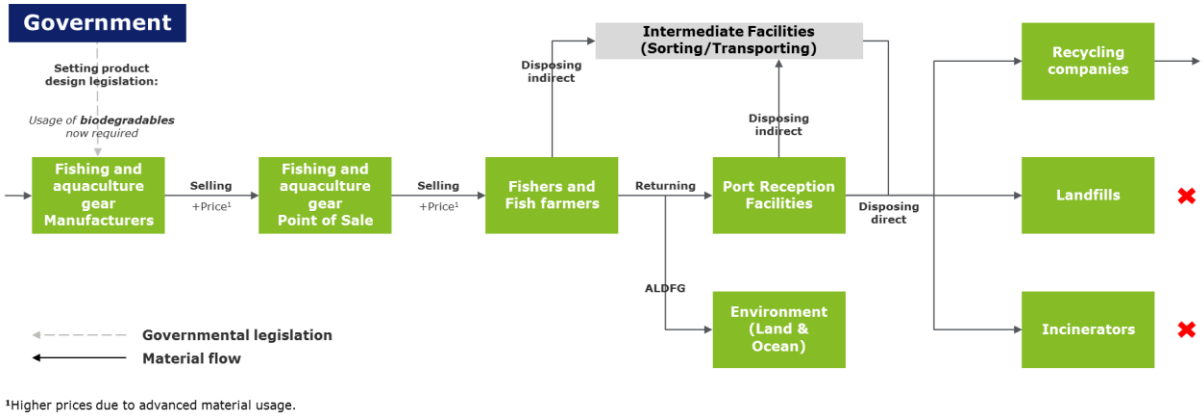
The results of the DollyropeFree project show that it is quite a challenge to develop, or find, affordable environmentally friendly alternatives that can replace materials currently used in fishing gear, such as dollyrope. One of the type of materials that has been looked into in the DollyropeFree project are plastics that are biodegradable in seawater (in seawater biodegradable biopolyners). The knowledge about this topic and the development of these kind of materials is still in its infancy and part of ongoing research.

Below is a short summary of the current knowledge regarding the issue of biodegradability of plastics in seawater. This information is taken from both the report 'Biobased Plastics in a Circular Economy' (CE Delft, 2017) and from information published through the European Open-Bio project, which focused on the sustainability of bio-based resources and potential testing methods for this criterion (Open Bio-Project, 2018)**:**

- Plastics can be defined by their biodegradability. They are either categorised as non-biodegradable, biodegradable in industrial composting installation, or biodegradable in water/nature. The biodegradability depends on the 'aggressiveness' of the environment. Aggressiveness increases from marine water to fresh water to soil and to a composting facility (DeConink, S. and B. De Wilde, 2013). As such, an industrial composting installation creates a more aggressive environment than home composting.
- With regard to biodegradability and compostability, standards are more complex. In the presence of oxygen, biodegradable plastic is converted into water and CO2 by micro-organisms. When no oxygen is present, methane can be produced. Both degradability as well as compostability depend on conditions such as temperature, the material and the application (European Bioplastics, 2018). Non-biodegradable plastics will not be converted by micro-organisms. Whether a plastic is biodegradable does not depend on the resource used; it depends on its chemical structure. This means that biobased plastics can be non-biodegradable, whereas fossil-based plastics can be biodegradable (European Bioplastics, 2018), although most are not.
- Plastics that are biodegradable in seawater are available. These plastics can or have been certified. For example, since March 2015, an official certificate is available for plastics that are biodegradable in seawater. The certificate is called OK biodegradable MARINE and issued by Vinçotte (OKCompost, 2018). In this case, degradation is tested under laboratory conditions, where disintegration of a slim film of the material tested should happen within 2½ months and biodegradation within 6 months.
- However, out of the laboratory, in field conditions, the biodegradation of materials in the marine environment is still difficult to predict (Open Bio-Project, 2018). The ability to biodegrade can vary a lot and depends on the properties of the material and on the environmental conditions. The variable degradation rates in different habitats and locations can be attributed to the environmental conditions such as the differences in nutrients, the abundance of microorganisms, seasonal and yearly climatic variations and the potential amount of fouling by micro- and macro-organisms.

The process flow in Figure 7 shows the projected effects of this policy option on the different stakeholders:

Figure 7: Visualization of option 4a - Alternative materials (biodegradable materials)



Because of a lack of commercially available and/or affordable alternative materials (especially in seawater bio-degradable materials) for large scale use in the fisheries, the practicalities and (im)possibilities involved with substitution, this policy option currently seems like a bridge too far in the near future.

4b - Alternative product design

In this section, we will describe the policy option "alternative product design" and focus on the marking of fishing gear and alternative designs for Fish Aggregating Devices (FAD's) as measures to assist in the prevention of ALDFG.

Gear markings

In February 2017, a technical consultation on the marking of fishing gear organised by the FAO took place. During this meeting the practicalities of marking fishing gear were discussed. The information provided below is based on the outcomes of this consultation (FAO, 2018).

During the last couple of years, various new technologies have been developed to mark fishing gear. Examples of these include electronic tagging (i.e. RFID identifiers), coded wire tags, QR coding, colour coded ropes, metal stamping, metal tags, chemical marking and radio beacons and transponders. The aim of (better) gear marking is to reduce the risk of loss of fishing gear or to stimulate the retrieval of loss fishing gear.

The benefits of gear marking include:

- Acting as a deterrent for deliberate or inappropriate disposal of fishing gear
- Providing identification of ownership and responsible parties for the fishing gear
- Assisting in the prevention of unauthorised setting or use of fishing gear which reduces the potential for gear conflict and loss
- The incorporation of tracking and relocation technology to enable location of fishing gear to be tracked and subsequently retrieved
- Reducing economic losses to gear owners and authorities by preventing gear loss, minimising retrieval and replacement expenditure, and reducing catch loss via ghost fishing
- Reducing damage to the environment and harmful interactions with aquatic wildlife including aiding in the identification of gear components entangled on marine animals
- Reducing the risk of vessel and diving accidents and loss of life at sea
- Facilitating more effective management of fisheries, including capacity control and assisting with the prevention of IUU fishing.

In many cases, only portions of the full component of gear are lost, and therefore this an important consideration when choosing the type (or combination) of gear marking(s).

If applied, the costs to the stakeholders involved are not known and need further study.

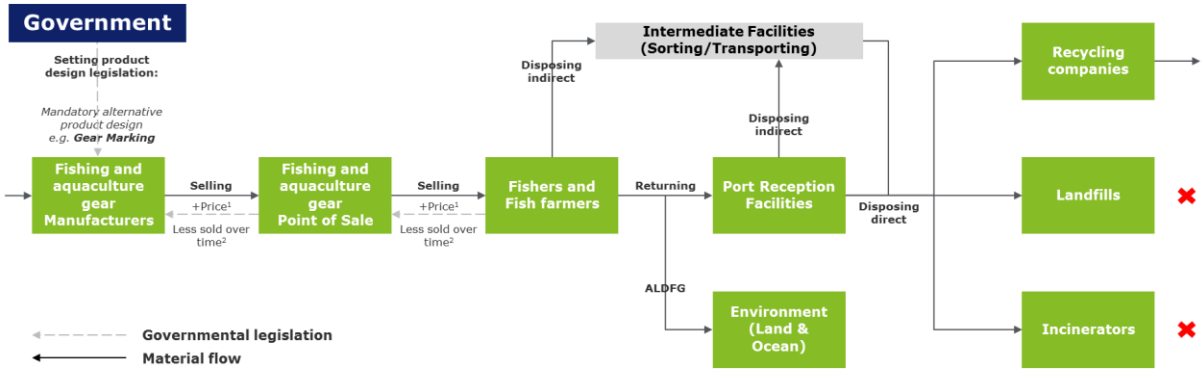
Fish Aggregating Devices (FAD's)

FAD's are artificial floats deployed by fishers to attract and follow ocean going pelagic fish such as tuna. They usually consist of buoys or floats either tethered or not tethered to the ocean floor with concrete blocks. These buoys or floats can either float subsurface or at the surface. FAD's may include sonar and GPS capabilities so that the operator can remotely contact it via satellite to determine the amount of fish population under the FAD. Currently, no legal requirement is in place to recover lost or abandoned FAD's.

Through the Global Ghost Gear initiative, several best practices have been examined meant to prevent, mitigate, and cure the risks to marine life and ecosystems associated with lost or abandoned FADs. Examples of these are: adding marking and tracking devices, testing and applying biodegradable materials to FAD constructionn, developing a register/record of FAD deployments, recovery, and abandonment (Global Ghost Gear Initiative, 2018). If applied, the costs to the stakeholders involved are not known and need further study.

The process flow in Figure 8 shows the projected effects of this policy option on the different stakeholders:

Figure 8: Visualization of Option 4b - Alternative product design (gear marking)



¹Higher prices due to advanced material usage. ²Less sold due to less wear and tear/loss of products

4.5 Link between problem drivers and policy options

The policy potions are defined based on the defined problems and policy objectives. The relationship between the problem drivers and the four policy options is presented in Table 9:

Table 9: Resolving option related to the problem drivers

Problem drivers	Related policy option
Low efficiency and effectiveness of schemes to prevent retrieved gear and end-of-life gear to re-enter the water	• EPR without/with DRS • Target setting
Removal of evidence of illegal, unreported and unregulated fishing	
Lack of storage space on ship	• EPR without/with deposit scheme • Target setting
Fuel costs	• EPR without/with deposit scheme • Target setting
Gear conflict, adverse weather, vandalism/theft etc.	• Alternative product design
No incentive for fishers to find/pick up ALDFG themselves	• EPR with deposit scheme • Alternative product design
Fishers are not able to identify location where they lost gear	• Alternative product design

Disincentive for fishing gear manufacturers to produce less environmental harm material	• Target setting • Alternative product design
Sporadic reporting and recording of lost gear (and no standardized monitoring method)	• EPR with DRS • Target setting
Limited efficiency of operations to recover lost gear	• EPR without/with DRS
Widespread distribution and long lifetime in water of	• Alternative product design
Lack of knowledge of hotspots and snagging sites, sustainable handling of gear, retrieval	• EPR without/with DRS
Inappropriate retrieval equipment	• EPR without/with DRS
High cost of port waste management	• EPR with DRS • Target setting
Inefficient waste management systems at ports	• EPR without/with DRS • Target setting
Manufacturers do not focus on using recyclable products (material is hard to recycle)	• Alternative product design • Target setting
ALDFG is not accepted by recycling company (not cleaned/sorted)	• Alternative product design • Target setting
Lack of end markets for recycled fishing and aquaculture gear	• Alternative product design • Target setting

5. Evaluation of the impacts of identified options

This chapter provides insight into the potential impacts of the four policy options on the stakeholders involved. For each policy option, tables are provided, which show plusses and minuses to indicate the potential effects on stakeholders in *relative terms* (meaning that the tables should be compared to the other policy options and not in absolute terms in the sense that more plusses also mean much high costs/benefits). Explanation on these impacts is provided in the accompanying text. Further quantification of these impacts is provided in chapter 6.

5.1 Extended producer responsibility without a deposit scheme

In this section we will examine the potential impact of the policy option 'EPR without DRS'. The section is subdivided into three subsections: 1) EPR without DRS– funding by manufacturers; 2) EPR without DRS (with retrieval – funding by manufacturers).

Subcategories

1a - EPR without DRS (funding by manufacturers)

The first subcategory examined is EPR without DRS (funding by manufacturers). The potential impact of this measure for each stakeholder involved is shown in Figure 9 below:

Figure 9: Impact on stakeholders of option 1a – EPR without DRS (funding by manufacturers)

Option 1a: EPR without DRS (prevention)		Stakeholders									
Impact Categories		FG Manufacturers	FG Point of Sale	Fishers and Fish farmers	Port Waste Handling	Intermediate Facilities	Recycling Companies	Landfills	Incinerators	Consumers	Government
Financial costs	Investment (€)	++	0	0	0	0	0	0	0	0	+
	Operational cost (€)	++	++	++	0	+	+	+	+	0	+
Financial benefits	Waste handling business revenue (€)	0	0	0	0	++	++	++	++	0	0
	Operational benefit (€)	0	0	+	0	0	0	0	0	0	+
Administrative burden	Administrative burden	++	0	0	0	+	+	+	+	0	+
Environmental benefits	(Plastic) Waste in seas (%)	-									
Social benefits	Social benefits due to less ALDFG	+									

The largest overall financial impact of this option is expected to be for manufacturers due to their role in setting up and running such a scheme and fishers because they will most likely not be able to levy the extra costs onto their customers. In order to keep the profit margins similar to those before the price increase, manufacturers will most likely levy the extra costs of setting up and running such a scheme onto points of sale; points of sale will likely levy these costs onto fishers. Due to reasons of competitiveness in a global market for fish, it would be harder for fishers to levy these extra costs onto their customers. Fishers will therefore most likely bear the extra costs related to this scheme.

In terms of the economic impact, the waste handling business revenue is expected to increase in a similar way for intermediate facilities, recycling companies, landfills and incinerators due to an expected increase in the amount of used fishing gear delivered back into port.

Other impacts that standout are less economic impact to fishers due to operational benefits (i.e. less time mending nets, cleaning equipment gearbox inspections, less fouled propellers, less contaminated catches) and to the government because of an expected decrease in the amount of fishing litter that needs to be retrieved from sea or collected from shores.

The environmental impact is expected to decrease (a positive effect on fish stocks is expected) due to an expected decrease in the overall amount of fishing gear entering the sea.

Social benefits are assessed in three ways: effects on employment, social benefits from cleaner Seas and social benefits from cleaner beaches (as a result of a decline in ALDFG). These social benefits are closely related to two effects; if more waste is retrieved in ports and offered to intermediate facilities / recyclers / landfills / incinerators this will have a positive effect on the employment levels at these companies. Less ALDFG in Seas and on beaches have a positive effect on tourism (cleaner beaches are more attractive for tourists), fishers (less fouling and higher fish stocks). For option 1a the level of ALDFG is expected to go down which has a positive social impact.

1b EPR without DRS (with retrieval – funding by manufacturers)

The second subcategory examined is 'EPR without DRS (with retrieval – funding by manufacturers)'. The potential impact of this measure for each stakeholder involved is shown in Figure 10 below:

Figure 10: Impact on stakeholders of option 1b – EPR without DRS (with retrieval – funding by manufacturers)

Option 1b: EPR without DRS (prevention + retrieval)		Stakeholders									
Impact Categories		FG Manufacturers	FG Point of Sale	Fishers and Fish farmers	Port Waste Handling	Intermediate Facilities	Recycling Companies	Landfills	Incinerators	Consumers	Government
Financial costs	Investment (€)	+++	0	0	0	0	0	0	0	0	+
	Operational cost (€)	+++	+++	+++	0	++	++	++	++	0	+
Financial benefits	Waste handling business revenue (€)	0	0	0	0	+++	+++	+++	+++	0	0
	Operational benefit (€)	0	0	+	0	0	0	0	0	0	++
Administrative burden	Administrative burden	+++	0	0	0	+	+	+	+	0	+
Environmental benefits	(Plastic) Waste in seas (%)	--									
Social benefits	Social benefits due to less ALDFG	++									

In comparison to subcategory 1a, the main difference is an increase in the operational costs to manufacturers, points of sale, fishers, intermediate facilities, recycling companies, landfills and incinerators due to an extra fee levied that finances retrieval operations at sea and beach cleaning.

In comparison to subcategory 1a, in terms of the economic impact, the waste business revenue is expected to increase for intermediate facilities, recycling companies, landfills and incinerators due to an expected increase in the amount of used fishing gear delivered to the waste handling industry.

Other impacts that standout in comparison to subcategory 1a are the increase in operational benefit to the government because of lowered costs to retrieve used fishing gear from sea or to collect it from shores.

Similar to 1a, the environmental is expected to decrease (a positive effect on fish stocks is expected) due to an expected decrease in the overall amount of fishing gear entering the sea. Also, a positive social impact is expected due to lower levels of ALDFG and an increase in the activities related to waste management which have a positive effect on employment levels.

5.2 Extended producer responsibility with a deposit scheme

In this section we will examine the potential impact of the policy option 'EPR with DRS'. The potential impact of this measure for each stakeholder involved is shown in Figure 11 below:

Figure 11: Impact on stakeholders of option 2 – EPR with DRS

Option 2: EPR with DRS		Stakeholders									
Impact Categories		FG Manufacturers	FG Point of Sale	Fishers and Fish farmers	Port Waste Handling	Intermediate Facilities	Recycling Companies	Landfills	Incinerators	Consumers	Government
Financial costs	Investment (€)	++	0	0	0	0	0	0	0	0	+
	Operational cost (€)	+	+	++	0	++	++	++	++	0	+
Financial benefits	Waste handling business revenue (€)	0	0	0	0	+++	+++	+++	+++	0	0
	Operational benefit (€)	0	0	+	0	0	0	0	0	0	++
Administrative burden	Administrative burden	++	0	0	0	+	+	+	+	0	+
Environmental benefits	(Plastic) Waste in seas (%)	---									
Social benefits	Social benefits due to less ALDFG	+++									

In comparison to subcategory 1a (EPR without DRS), the main difference is that the costs of running a scheme that includes DRS will now be distributed over more stakeholders; the investment and operational costs and administrative burden will likely increase for manufacturers, points of sale and fishers. Another difference is that there will likely be unclaimed deposits (which occur in all deposit schemes); these unclaimed deposits could be used to lower an EPR fee.

Having a DRS system in place on top of an EPR could act as an extra incentive to deliver more used fishing gear back to port. Like in option 1b (and compared to 1a), an increase in operational costs is expected for recycling companies. This scheme is also expected to incentivise fishers to deliver more used fishing gear back to port. It is therefore also expected to result in an increase in the amount of fishing gear processed by the waste management industry.

In terms of the economic impact, the waste business revenue is expected to increase for intermediate facilities, recycling companies, landfills and incinerators due to an expected increase in the amount of used fishing gear delivered to the waste handling industry.

Other impacts that standout in comparison to subcategory 1a are the increase in operational benefit to the government because of lowered costs to retrieve used fishing gear from sea or to collect it from shores.

Similar to 1a, the environmental impact is expected to decrease (a positive effect on fish stocks is expected) due to an expected decrease in the overall amount of fishing gear entering the sea. Also, a positive social impact is expected due to lower levels of ALDFG and an increase in the activities related to waste management which have a positive effect on employment levels. This social impact is expected to be even higher than options 1a and 1b.

5.3 Target setting

In this section we will examine the potential impact of the policy option 'A recycling target for fishing gear'. The potential impact of this measure for each stakeholder involved is shown in Figure 12 below:

Figure 12: Impact on stakeholders of option 3 – Target setting

Option 3: Recycling target		Stakeholders									
Impact Categories		FG Manufacturers	FG Point of Sale	Fishers and Fish farmers	Port Waste Handling	Intermediate Facilities	Recycling Companies	Landfills	Incinerators	Consumers	Government
Financial costs	Investment (€)	0	0	++	0	0	0	0	0	0	0
	Operational cost (€)	0	0	+++	0	+	++	-	-	0	0
Financial benefits	Waste handling business revenue (€)	0	0	0	0	++	+++	-	-	0	0
	Operational benefit (€)	0	0	0	0	0	0	0	0	0	0
Administrative burden	Administrative burden	0	0	++	0	+	+	-	-	0	0
Environmental benefits	(Plastic) Waste in seas (%)	0									
Social benefits	Social benefits due to less ALDFG	+									

In comparison to subcategory 1a (EPR without DRS), the main difference is that the costs of running a scheme based on setting a recycling target will mostly be felt by fishers and recycling companies, as these stakeholders will need to implement measures to reach a recycling target (i.e. sorting, cleaning, collection and handling).

In terms of the economic impact, the waste business revenue is expected to increase mostly for intermediate facilities and recycling companies, due to an expected increase in the amount of used fishing gear delivered to the waste handling industry for recycling and for intermediate facilities the sorting, cleaning and transportation of fishing gear in case this is not done by fishers themselves.

As a recycling target not (directly) targets the inflow of ALDFG in the Seas, no environmental benefits are expected in terms of reduced ALDFG. It should be noted that recycling is less detrimental to the environment in terms of reduction in Greenhouse Gas and that it stimulated the circular economy, but these effects are not shown in Figure 12. There is a positive social impact expected, as employment rates could increase due to the increase activity related to waste management.

5.4 Alternative materials and product design

In this section we will examine the potential impact of the policy option 'alternative materials and product design'. The section is subdivided into two subsections which describe the following two subcategories: 1) Alternative materials and 2) alternative product design.

Subcategories

4a Alternative materials

In this section we will examine the potential impact of the policy option 'alternative materials'. The potential impact of this measure for each stakeholder involved is shown in Figure 13 below:

Figure 13: Impact on stakeholders of option 4a - Alternative materials

Option 4a: Alternative materials - biodegradables		Stakeholders									
Impact Categories		FG Manufacturers	FG Point of Sale	Fishers and Fish farmers	Port Waste Handling	Intermediate Facilities	Recycling Companies	Landfills	Incinerators	Consumers	Government
Financial costs	Investment (€)	+++	0	0	0	0	0	0	0	0	0
	Operational cost (€)	++	++	++	--	-	-	-	-	0	0
Financial benefits	Waste handling business revenue (€)	0	0	0	--	-	-	-	-	0	0
	Operational benefit (€)	0	0	+	0	0	0	0	0	0	+
Administrative burden	Administrative burden	0	0	0	0	0	0	0	0	0	0
Environmental benefits	(Plastic) Waste in seas (%)	--									
Social benefits	Social benefits due to less ALDFG	0									

In practice, implementing such a policy measure is quite a challenge and at this stage certainly not possible in a lot of situations due to practical or financial restraints (simply put: alternatives are either not commercially available yet or very expensive).

When proven effective and implemented, this policy option measure may result in higher costs for gear manufacturers, relating to research and development and the higher costs of alternative materials (especially biodegradable). These costs will likely be levied onto fishers and fishing companies. It is also possible that this policy measure will result in a decrease of sales (revenue) for certain manufacturers and/or gear producers, as fishers may resort to manufacturers and/or gear producers which produce more environmentally friendly materials. It is not known what type of impact could be expected for waste handlers.

It is also not known what the effect would be in terms of the amount of fishing gear being taken back to port and available for collection, handling and treatment and therefore the overall amount of fishing gear entering the sea. Also the social impact of this option is not certain. On the one hand there could be less work related to waste management as less waste could be offered at ports, on the other hand less ALDFG is expected which could have a positive social impact.

4b Alternative product design

In this section we will examine the potential impact of the policy option 'alternative product design'. The potential impact of this measure for each stakeholder involved is shown in Figure 14 below:

Figure 14: Impact on stakeholders of option 4b - Alternative product design

Option 4b: Alternative product design – Gear Marking		Stakeholders									
Impact Categories		FG Manufacturers	FG Point of Sale	Fishers and Fish farmers	Port Waste Handling	Intermediate Facilities	Recycling Companies	Landfills	Incinerators	Consumers	Government
Financial costs	Investment (€)	+++	0	0	0	0	0	0	0	0	0
	Operational cost (€)	++	++	++	0	+	+	+	+	0	0
Financial benefits	Waste handling business revenue (€)	0	0	0	0	++	++	++	++	0	0
	Operational benefit (€)	0	0	+	0	0	0	0	0	0	+
Administrative burden	Administrative burden	++	0	0	0	+	+	+	+	0	0
Environmental benefits	(Plastic) Waste in seas (%)	--									
Social benefits	Social benefits due to less ALDFG	++									

A cost-benefit analysis to calculate the impact of implementing mandatory gear marking described in chapter 4 would be beneficial to assess the impact for each stakeholder involved. As of yet, such an analysis has not been carried out. Therefore, it is not known with certainty what the impact of implementing such a measure might be. The qualitative impact assessment described in this section should therefore considered to be speculative and based on a qualitative assessment.

When implemented, this policy option measure may potentially result in higher costs to gear manufacturers, relating to research and development or adding certain parts or materials to fishing

gear. These costs will be then (at least partially) be levied onto fishers and fishing companies. It is also possible that this policy measure will result in a decrease of sales (revenue) for certain gear producers, as fishers may resort to manufacturers which produce fishing gear with certain gear markers.

Additional administrative burden could be envisaged for gear designers and manufacturers regarding the traceability of the designed/manufactured gear and its registration/entry into a specific register. This would lead to an additional burden for statutory regulators as there would be a need to establish and maintain a database of gear ownership (Macfadyen et al., 2007) and/or define standards/guidelines/recommendations with regard to materials to be used in the production of fishing gear. This may involve an additional administrative burden also for fisheries control agencies with regard, for example, establishment and registry and database of lost/abandoned gear and/or enforcement of the various regulations and standards.

Another impact could potentially be the projected increase in operational benefit to the government because of lowered costs to retrieve used fishing gear from sea or to collect it from shores (due to more fishing gear being delivered back into port).

Similar to 1a, the environmental impact is expected to decrease (a positive effect on fish stocks is expected) due to an expected decrease in the overall amount of fishing gear entering the sea. Positive social impacts are expected related to option 4b, as ALDFG will decrease and there could be a positive employment effect related to waste management activities.

6. Quantification of option impact

This chapter aims to quantify the impact of the different options on stakeholders. For each option (and sub option) a quantification has been performed. The sections in this chapter explain how the calculation are performed, and what the effects of the different policy options are compared to the baseline calculations in chapter 3.

6.1 Quantification of Option 1a: EPR without DRS (manufacturers funding)

In option 1a, the establishing of an EPR without DRS, the manufacturer will pay an ARF (Advanced Recycling Fee) used to ensure the reception, cleaning, sorting and transporting of plastic fishing gear to recycling facilities, incineration or landfills.

The main effect of the EPR are higher costs per net sold for the manufacturer, since the net price will now include an ARF. The ARF is used by a governing body, to cover costs related to waste management and the costs of running the governing body itself. For the quantifications of this option we assume that a Producer Responsibility Organisation (PRO) will act as a governing body, which acts directly on behalf of the manufacturers and is most commonly used to execute an EPR (Deloitte, 2014) (chapter 4 of this report). Therefore, the governing body will not take a share of the ARF as a fee, except for cost related to operating the governing body, which will make the ARF calculation a direct representation of the actual costs related to management of waste. Table 10 provides an overview of the costs covered by the ARF.

Table 10: Indicators used for quantification of EPR (ARF influencing)

Operational costs
• *Port Waste Handling costs* (reception costs) = Handling costs per tonne · (additional) tons returned • *Recycling costs (incl. sorting, cleaning and transportation costs)* = Recycling costs per tonne · (additional) tons returned • *Landfilling/Incineration costs (incl. transportation costs)* = Landfilling /Incineration costs per tonne · (additional) tons returned • *Annual cost of governing body* = Operating costs of the governing body (PRO)

The following costs are not covered by the ARF described under this option, as only the yearly recurring operation costs are included in the calculated ARF fee (for simplicity). Furthermore, there are additional benefits expected of the ARF which do not directly flow into the ARF but which are benefits as a results of the implementation of an ARF and therefore shown separately in the Table 11 below.

Table 11: Indicators used for quantification of EPR (Non ARF influencing)

Investment costs	Operational benefits
• Setting up the governing body	• Decrease in beach clean-ups • Decrease in fishing litter costs to fishers and fish farmers (e.g. less propeller fouling)

ARF influencing

Setting up the required facilities and organising the cleaning, dismantling, sorting and transportation for the fishers free of charge will incentivise them to deliver more plastic fishing gear to the ports. The stakeholder consultation of the PRF (Panteia, 2015) revealed that more than 60% of port users agreed that a reason to discharge fishing gear waste at sea is too high fees and ports not accepting all types of waste as well as around 40% agreed that insufficient port reception facilities capacity is the reason. Hence, in the case of plastic fishing gear an incentive is given to return more gear if formal waste management is organized by the governing body. Also, the revised PRF states that all ports in Europe should have facilities to collect (fishing gear) waste at Ports against an indirect fee only. Therefore, for this option the only quantification taken into account at the Port reception facilities is what is expected as *additional fishing gear waste* brought ashore (compared to the current baseline calculation in chapter 3) that the ARF pays for and not all current fishing gear waste collected at port reception facilities.

In the current baseline distribution (see chapter 3) 40% of plastic fishing gear is entering formal waste management and the remaining 60% may be lost at the sea (ALDFG and unaccounted waste). Introducing an ARF and assuming that the revised PRF is fully implemented, a minimum of 10% less fishing waste may be expected (based on the stakeholder consultation for the PRF, in which some 40% of the respondents indicate they will land more plastic and fishing gear ashore with better facilities, therefore a 10% less abandoned, lost or otherwise discarded fishing gear should be possible as a minimum). Hence, these 10% will be additionally entering formal waste management.

In the best expected case, the Icelandic situation can be achieved, where currently 90% of gear is retrieved in ports (source: Interview CEO and Operational Manager Icelandic Recycling Fund). Therefore, 50% more waste compared to the baseline scenario will enter formal waste management.

10% less fishing gear waste annually from our baseline is between 6,600 and 21,800 tons. Therefore, this amount enters additionally formal waste management, which final treatment is currently split in 30% recycling and 70% ending at landfills or incineration. The cost per ton of recycled plastic waste from fishing gear in Iceland are 68€ (EUNOMIA, 2017). However, to get waste prepared for recycling, the port reception facilities need to handle the waste by cleaning, sorting and transporting it, these costs are set at 380€ per tonne. This number is derived from the handling costs per drink container as stated in Hogg et al. (2010), which consists of capital costs for the reception system, space infringement re-imbursement and labour costs associated with the take back of container collection. This number is then converted to a cost per tonne, since the costs a port experienced when handling waste from fishing nets are similar to that of drink container retrieval, except that the products retrieved are bigger and heavier, which therefore incur higher handling costs. Therefore, total costs for recycling a ton are handling costs and recycling costs, which equate to 448€ per tonne (i.e. 380€ + 68€ = 448€). Landfill costs are 350€ per ton delivered (which includes transportation and do not need handling (sorting and cleaning) at ports or by fishers).

Finally, to express the ARF as a percentage of costs, the average costs of fishing nets (to fishers) is taken into account. Fishing nets mainly consist of Polyethylene (60 – 70%) or Polyamide (20% - 30%), where Polaymide is a more durable source. Costs of these nets are €5,50 – 6,00 for every kilo of Polyethylene and €6,50-8,50 for every kilo of Polyamide depending on the thickness of the nets (source: interview Ben Wenskink, responsible for R&D within Ymuiden Stores, a Dutch professional fishing gear manufacturer). These net costs per kilogram are used for the calculation of ARF as a percentage of net costs.

Applying the costs for recycling and landfill for additional waste landed ashore compared to the baseline leads to total additional costs for recycling between €0.9m and €2.9m and for landfill and incineration between €1.6m and €5.3m. In total, the additional amount of plastic fishing gear delivered costs between €2.5m and €8.2m.

For the 90% retrieval rate of Iceland, 50% more fishing gear waste is delivered to Ports compared to the baseline, which is between 33,000 and 109,000 tons annually. Applying the same factors as above, the additional costs for recycling are estimated between €4.4m and €14.6m and for landfill and incineration between €8.1m and €26.7m. In total, the additional amount of plastic fishing gear delivered due to the establishment of the EPR costs are estimated between €12.5m and €41.3m.

For calculating the ARF, the annual operating costs of the governing body (in this example a PRO) have to be taken into account as shown in Table 10. Hogg et al. (2010) calculated the operating costs of a PRO in the UK. For option 1a, the amount of ports needed to be serviced in the EU are compared to the amount of stores that are serviced in the paper by Hogg et al. (2010), as they are the touchpoints that the governing body leads. In Table 12, it is shown how the annual governing body costs in this option are derived from Hogg et al. (2010). The variable costs of the PRO are allocated as a ration (ports versus stores), where the fixed costs of a PRO have been fully incorporated in our calculation. Since the paper by Hogg is in British Pounds, the number is later converted to Euro's.

Table 12: Comparison between annual governing body costs in Hogg et al (2010) and Option 1a

Comparison between annual governing body costs in Hogg et al. (2010) and Option 1a		
Stores serviced in DRS case by Hogg et al. (2010)		36,000
Ports serviced in EU EPR scheme (based on Eurostat[8])		1,500
Ratio applied to personnel relevant costs		**0.04**
Cost segment	**Hogg et al. (2010)**	**Option 1a**
IT costs – Maintenance, hardware & software costs (£m)	0.50	0.50
IT costs – Licenses (£m)	3.60	0.18
Staff costs – Accounting/database & customer service staff (£m)	4.25	0.21
Office space costs – Leasing office furniture (£m)	0.72	0.04
Support services costs (£m)	0.60	0.03
Communications/Marketing costs (£m)	5.00	0.21
Total costs (£m)	14.67	1.16
Total costs (€m)	16.53	1.31

The estimated annual governing body costs of €1.31m are incorporated as part of the ARF calculation of the additional waste from fishing gear that is brought ashore. Following the minimum EPR requirements of the EC, the costs have to be compensated by the ARF, which is calculated as the additional costs for introducing and executing the EPR divided by the total amount of plastic fishing gear used. The denominator is the baseline annual use of plastic fishing gear between 66,000 and 218,000 tons. The nominator are the calculated costs above. This results for the 10% less ALDFG case in an ARF around €0.04 per kg of plastic fishing gear sold. For the case of Icelandic retrieval rates, the ARF will be around €0.20 per kg of gear sold. This is equal to the €0.20 per kg the Icelandic Recycling Fund estimated what the costs of an EPR with ARF should be if Iceland switches to an EPR with ARF (Interview CEO and Operational Manager Icelandic Recycling Fund).

It should be noted that the ARF is purely funding a system that focuses on prevention of ALDFG through better port reception infrastructure and intermediate facilities. There are however more options with which a governing body can aim to decrease ALDFG and increase recycling rate. For example, a part of the ARF can be used to provide training to fishers (awareness raising of the ALDFG problem). By showing fishers the importance of decreasing ALDFG, and the possible benefits associated with less ALDFG, fishers can be incentivized to create less ALDFG. Another possibility is to use ARF funds to stimulate innovations related to fishing gear or marking of fishing gear which makes retrieval more efficient. Within the scope of this study it is not possible to quantify these effects.

Related to administrative burden it should be noticed that an EPR especially involves administrative burden for manufacturers (to provide an administration related to ARF) and for ports to keep track of the handling process of waste landed ashore. Within the scope of this study it is not possible to quantify the effects, but from a qualitative perspective it should be noted that administrative burden for both manufacturers and ports will increase compared to the baseline scenario.

Non-ARF influencing

There are certain costs not influencing the ARF for manufacturers, however it is important that they should be quantified as they have an important influence on the total economic impact due to the implementation of the option. These are the one-off governing body investment costs and the benefits associated with less beach clean-ups and decrease in ALDFG related costs to fishers. It is

[8] Annex VII (EUROSTAT list of European ports), as included in 2005/366/EC: Commission Decision of 4 March 2005 implementing Council Directive 95/64/EC on statistical returns in respect of carriage of goods and passengers by sea and amending Annexes thereto (notified under document number C(2005) 463)

important to note that only ALDFG decrease (and not unaccounted waste) is taken into account when calculating the benefits related to less beach clean-ups and a decrease in ALDFG related costs. Otherwise, the number would be overestimated, as a decrease in unaccounted waste has no influence on ALDFG related costs and beach clean-ups.

For the one-off governing body investment, the paper of Hogg et al. (2010) is used as a basis for the calculation. This paper indicates the level of one off costs of a governing body.

A comprehensive calculation for the cost of the governing body investment is performed in Hogg et al. (2010), based on three steps necessary to build the governing body: model decisions, building the interim organisation and system construction. Finally, there is a cost category for the fees related to the usage of professional services. In this option, the costs of building the governing body are assumed to be equal to Hogg et al. (2010) in every category, except for system construction. This is due to the fact that all the costs related to the amount of clients that the system services (the system size) are all positioned in the system construction step.

For steps in system construction related to the amount of client's services, the ratio of ports to the stores in the example by Hogg et al. is used to calculate the costs, equal to the approach for annual governing body costs. Costs are calculated by the number of days necessary to complete the task, with a day rate of £1,500 plus additional capital costs necessary for the governing body.

Table 13: Comparison between governing body investment in Hogg et al (2010) and Option 1a

Comparison between governing body investment in Hogg et al. (2010) and Option 1a		
Stores serviced in DRS case by Hogg et al. (2010)	36,000	
Ports serviced in EU EPR scheme[9]	1,500	
Ratio applied to personnel relevant costs	**0.04**	
Cost segment	**Hogg et al.**	**Option 1a**
Model Decisions (£m)	0.23	0.23
Build interim Organisation (£m)	0.16	0.16
System Construction (£m)	27.08	1.21
Professional services fees (£m)	4.04	4.04
Total costs (£m)	31.51	5.64
Total costs (€m)	35.51	6.36

Based on the calculations in Table 13, the one off investments costs of setting up a PRO for an EPR scheme are estimated at €6.4m euro.

The costs associated with less beach clean-ups are calculated by looking at the amount of fishing gear within the total litter found during beach clean-ups. The relative decrease in ALDFG will influence the total litter found on beaches, and therefore imply a decrease in costs. The data for litter found on beaches comes from OSPAR (2017). Here, the percentage of fishing gear as a percentage of all litter is calculated. A lower and upper bound is taken, as there are differences between the different geographical areas in the EU. The lower bound is found in the Bay of Biscay and Iberian Coast, with 15.0% of total waste being fishing gear. The upper bound is found in the Northern North Sea, where 34.1% of the total waste is fishing gear. For the cost of clean-ups, data from Mouat et al. (2010) is used, which sets a lower bound of 7,300€ and an upper bound of 34,000€ to clean up 1 kilometre of beach. Finally, the total coastline of the EU used in the calculation is 68,000 km[10]. However, not all coastline of the EU is beach, furthermore not all beach is cleaned up. Since no data could be found on how much beach is cleaned, we assumed that 5% of the total EU coastline is used as beach that will receive clean-ups. The total decrease in beach clean-ups then is €0.1m as a lower bound and €0.8m as an upper bound for the 10% decrease in ALDFG and unaccounted waste, which translates

[9] Annex VII (EUROSTAT list of European ports), as included in 2005/366/EC: Commission Decision of 4 March 2005 implementing Council Directive 95/64/EC on statistical returns in respect of carriage of goods and passengers by sea and amending Annexes thereto (notified under document number C(2005) 463)
[10] https://www.eea.europa.eu/themes/water/europes-seas-and-coasts/europes-seas-and-coasts

to a 2% ALDFG decrease. Whilst for the 50% case, which translates to a 10% ALDFG decrease, the costs were between €0.4m and €3.9m.

There is a benefit to the fishers, due to the decrease in ALDFG, which in its turn decreases ALDFG related costs to fisheries. EUNOMIA (2017) and Werner et al. (2016) place a lower an upper bound of 1% to 5% of yearly fishing revenue annually spent on ALDFG related costs. EUNOMIA (2016) reports a (non-exhaustive) list of ALDFG issues for fishers, containing: time lost clearing nets of debris, cleaning equipment, time lost fixing nets, time lost with fouled propellers, repairing nets, unfouling propellers and gear box inspection. Also, a larger fish stock can be added to this list of benefits of a decrease in ALDFG. Unfortunately, no good indicators for the increase in fish stock due to ALDFG decrease have been found, but it is assumed this effect is positive as well.

The total revenue of the EU fishing sector is given in STECF (2017), which is valued at €7.27 billion in 2015. Therefore, a decrease of 10% in ALDFG will lead to a decrease of ALDFG related costs between €1.5m and €7.3m, whilst a 50% decrease in ALDFG (and unaccounted waste) will lead to a decrease of ALDFG related costs to fishers between €7.3m and €36.4m.

All relevant calculations for the quantification are performed, an overall result for the 10% decrease case is shown in Table 14, whilst the 50% reduction case is shown in Table 15:

Table 14: Results of quantification of option 1a - 10% reduction

Quantification of option 1a - EPR without DRS (manufacturers funding)		
Input indicators (process flow)	Value	
Increase in waste delivered in ports (%)	10%	
Fishing gear waste annually (tonnes)	66,000	218,000
ALDFG and unaccounted waste (%) and delivered in ports (%) **before** option implementation	60%	40%
Recycling (%) and landfilling/incineration (%) **before** option implementation	30%	70%
Input indicators (costs)	Value	
Handling costs for recycling at ports (€/Tonne)	380	
Recycling costs (€/Tonne)	68	
Landfilling/incineration costs (including handling) (€/Tonne)	350	
Fishing net costs – Polyethylene & Polyamide nets (€/kg)	5.50	8.50
Output indicators	Value	
ARF Influencing		
ΔGear delivered to ports (tonnes)	6,600	21,800
ΔGear recycled (tonnes)	2,000	6,500
ΔGear landfilled/incinerated (tonnes)	4,600	15,300
ΔRecycling costs (€) – including handling & transport	900,000	2,900,000
ΔLandfilling/incineration costs (€) – including transport	1,600,000	5,300,000
Annual governing body costs (€)	1,300,000	
ARF/Tonne (€)	43.58	
ARF/kg (€)	0.04	
Non-ARF Influencing		
Governing body investment costs (€m)	6,400,000	
Decrease in beach clean-ups (€m)	100,000	800,000
Decrease in ALDFG related costs (€m)	1,500,000	7,300,000

Table 15: Results of quantification of option 1a - 50% reduction (Icelandic example)

Quantification of option 1a - EPR without DRS (manufacturers funding)		
Input indicators (process flow)	Value	
Increase in waste delivered in ports (%)	50%	
Fishing gear waste annually (tonnes)	66,000	218,000

ALDFG and unaccounted waste (%) and delivered in ports (%) **before** option implementation	60%	40%
Recycling (%) and landfilling/incineration (%) **before** option implementation	30%	70%
Input indicators (costs)	Value	
Handling costs for recycling at ports (€/Tonne)	380	
Recycling costs (€/Tonne)	68	
Landfilling/incineration costs (including handling) (€/Tonne)	350	
Fishing net costs – Polyethylene & Polyamide nets (€/kg)	5.50	8.50
Output indicators	Value	
ARF Influencing		
ΔGear delivered to ports (tonnes)	33,000	109,000
ΔGear recycled (tonnes)	9,900	32,700
ΔGear landfilled/incinerated (tonnes)	23,100	76,300
ΔRecycling costs (€) – including handling & transport	4,400,000	14,600,000
ΔLandfilling/incineration costs (€) – including transport	8,100,000	26,700,000
Annual governing body costs (€)	1,300,000	
ARF/Tonne (€)	195.41	
ARF/kg (€)	0.20	
Non-ARF Influencing		
Governing body investment costs (€m)	6,400,000	
Decrease in beach clean-ups (€m)	400,000	3,900,000
Decrease in ALDFG related costs (€m)	7,300,000	36,400,000

6.2 Quantification of Option 1b: EPR without DRS (with retrieval – funding by manufacturers)

For option 1b, an extension to option 1a is made in the form of a retrieval scheme. This means that the governing body that oversees the EPR, now also funds a scheme for the retrieval of ALDFG from the sea. The implementation of a retrieval scheme changes the level of the ARF charged as more costs are then covered by the ARF (e.g. also costs of retrieval operations).

ARF influencing

Due to the inclusion of retrieval costs in the ARF, the assumption that there is a decrease of 10% in ALDFG and unaccounted waste is now extended (e.g. building on the lower bound of option 1a). We assume that the retrieval scheme is able to retrieve another 10% of the remaining ALDFG and unaccounted waste. After the ALDFG and unaccounted waste decrease due to the implementation of option 1A, there is still 50% ALDFG and unaccounted waste left. Then, a 10% decrease in ALDFG and unaccounted waste, due to retrieval operations, mean that in absolute numbers in ALDFG the decrease is 10% + 0.1 · 50% = 15%. We did not take the upper bound into account for option 1b, as already within option 1a the upper bound consists of a 90% retrieval of (potential) ALDFG and unaccounted waste.

It is not assumed that there are differences to the handling costs for recycling or landfilling, or the recycling and landfilling costs themselves. Nor is any difference to the percentage that gets recycled or landfilled assumed. More waste reaches formal waste management, however for now the assumption is that the effectivity of recycling does not go up.

The costs for retrieval of ALDFG needs to be calculated. Hwang and Ko (2007) present a cost for the retrieval of ALDFG, as they showed that a clean-up programme of ALDFG had an average clean-up costs of €1,160 per ton over a six year period. This number is used as an indicator for ALDFG retrieval costs. This number is in line with the estimates mentioned in the Eunomia 2017 report: 'The Fishing for Litter project is operated by KIMO International in Scotland, South West England, the Netherlands, Belgium, and the Baltic Sea. The Scottish project retained 242 tonnes over 3 years starting in April 2008 with a cost of 1,000 €/T of marine litter retrieved. Results build on the previous

period 2005-2008 in which 117 tonnes were recovered with a cost of 2,600 €/T.[11] In 2011-2014, the project in Scotland had landed 375 tonnes of gear at a cost of €846/T.[12]'

This set-up of the EPR without DRS, but with retrieval operation costs included leads to the following results. The additional ALDFG and unaccounted waste retrieved is between 3,300 and 10,900 tonnes, based on the baseline. This then gets delivered to ports, where it is added to the already additional waste gathered by option 1a. This leads to a total amount between 9,900 and 32,700 tonnes delivered to ports, which is the sum of the additional retrieved gear and the already delivered gear to ports (as in 1a).

Of the gear delivered to ports, 30% gets recycled and 70% gets landfilled. In calculating the costs, the additional retrieval costs are between €3.8m and €12.6m, based on the ALDFG retrieval costs as mentioned within option 1a. Recycling costs and landfilling/incineration costs are between €1.3m and €4.4m and €2.4m and €8.0m respectively.

No changes to the annual governing body costs are assumed. This is done as the size of the coverage of the governing body does not change, as the same amount of ports have to be serviced. The components within the governing body costs therefore do not change. Furthermore, an assumption is made that retrieval operations are led from the ports, so that they can levy the costs of retrieval on to the governing body.

It should be noted that the administrative burden, compared to option 1a, is assumed to increase. In a qualitative sense, the administrative burden for running the government body (for manufacturers) does not increase. However, as the ports handle more waste, this will imply an increase in the experienced administrative burden

All costs combined result in an ARF of 120.64€ per tonne, which comes down to 0.12€ per kg. This should be compared to the baseline or to option 1a (lower bound).

Non-ARF influencing

These are also changed due to the implementation of a retrieval scheme. In line with the annual governing body costs, the assumption that the size of the governing body does not change holds here as well. Therefore, there are no differences in the one-off investment necessary.

Finally, the additional decrease in ALDFG due to the retrieval scheme is taken into account in the calculation of beach clean-up cost decrease. This decrease in costs is, with retrieval, between €0.1 and €1.2m. The decrease in ALDFG related costs, with retrieval, is between €2.2m and €10.9m. All indicators used in the quantification of option 1b and the results are shown in Table 16.

Table 16: Results of quantification of option 1b

Quantification of option 1b - EPR with DRS (with retrieval – funding by manufacturers)		
Input indicators (process flow)	Value	
Increase in waste delivered in ports (%) – due to prevention	10%	
Increase in waste delivered in ports (%) – due to retrieval	10%	
Fishing gear used annually (tonnes)	66,000	218,000
ALDFG and unaccounted waste (%) and delivered in ports (%) **before** option implementation	60%	40%
Recycling (%) and landfilling/incineration (%) **before** option implementation	30%	70%
Input indicators (costs)	Value	
ALDFG retrieval costs (€/Tonne)	1,160	
Handling costs for recycling at ports (€/Tonne)	380	
Recycling costs (€/Tonne)	68	

[11] KIMO (2011) *Final Report. Fishing for Litter Scotland 2008-2011*, 2011, http://www.kimointernational.org/WebData/Files/FFL%20Scotland/FFL%20Scotland%20Report%20FINAL.pdf

[12] http://www.fishingforlitter.org.uk/assets/file/Report%20FFL%202011%20-%2014.pdf

Landfilling/incineration costs (including handling) (€/Tonne)	350	
Fishing net costs – Polyethylene & Polyamide nets (€/kg)	5.50	8.50
Output indicators	Value	
ARF Influencing		
Absolute ALDFG and unaccounted waste decrease (%)	15.0%	
ΔGear retrieved from sea (tonnes)	3,300	10,900
ΔGear delivered to ports (tonnes)	9,900	32,700
ΔGear recycled (tonnes)	3,000	9,800
ΔGear landfilled/incinerated (tonnes)	6,900	22,900
ΔRetrieval costs (€)	3,800,000	12,600,000
ΔRecycling costs (€) – including handling & transport	1,300,000	4,400,000
ΔLandfilling/incineration costs (€) – including transport	2,400,000	8,000,000
Annual governing body costs (€)	1,300,000	
ARF/Tonne (€)	120.65	
ARF/kg (€)	0.12	
Non-ARF Influencing		
Governing body investment costs (€m)	6,400,000	
Decrease in beach clean-ups (€m)	100,000	1,200,000
Decrease in ALDFG related costs (€m)	2,200,000	10,900,000

6.3 Quantification of Option 2: Extended producer responsibility with a deposit scheme

For option 2, a deposit refund scheme is added to option 1a. This means that the governing body now also is in charge of running a deposit refund scheme. The unclaimed deposits can be used to finance (part of) the governing body. This could impact the ARF in a way that the ARF for manufacturers could go down. Furthermore, fishers are now more incentivized to bring back fishing gear, instead of dumping it, as a refund is paid for the returning of fishing gear.

ARF and deposit scheme influencing costs

Compared to option 1a, it is assumed that the DRS is able to decrease ALDFG and unaccounted waste, as it financially incentivizes fishers to bring back fishing gear to ports. It is assumed that the decrease in ALDFG and unaccounted waste is 50%, corresponding to the Icelandic example in option 1a. This is done as the retrieval rate in Iceland if 90% (source: Interview CEO and Operational Manager Icelandic Recycling Fund), which corresponds to an ALDFG and unaccounted waste decrease of 50%, and the implementation of an EPR with DRS can have the same effect.

Furthermore, an assumption needs to be made on the level of the deposit. For a return rate of 90%, Hogg et al. (2010) come to use a deposit of 15cents per beverage container. With an average beverage container price of €2 (Hogg et al., 2010), this is a deposit of 7.5%, which is also used in this option to calculate the deposit on fishing gear. This entails a deposit between 413€ and 638€ for a tonne of fish nets, costing between 5,500€ and 8,500€ per tonne.

Again, it is not assumed that there are differences to the handling costs for recycling or landfilling, or the recycling and landfilling costs themselves compared to the estimates provided under option 1a. Nor is any difference to the percentage that gets recycled or landfilled assumed, compared to the estimates provided under option 1a. More waste reaches formal waste management, however it is for now assumed that the effectivity of recycling does not go up.

The EPR scheme with a DRS then leads to the following results. The decrease in ALDFG and unaccounted waste entails that between 33,000 and 109,000 tonnes of waste are additionally delivered to ports. Of the gear delivered to ports, 30% gets recycled and 70% gets landfilled/incinerated. This means that between 9,900 and 32,700 and between 23,100 and 76,300 get recycled and landfilled/incinerated respectively.

In calculating the costs, the additional recycling costs are between €4.4m and €14.6m, whilst the landfilling/incineration costs are between €8.1m and €26.7m.

It is assumed that the governing body increases in size, as a sizeable extension to the system is made. It is believed that additional IT systems and personnel have to be acquired to regulate the DRS. An assumption is therefore made that the governing body triples in size compared to a situation where only an EPR is implemented, which means that the annual governing body costs in this option are now estimated at €3.9m.

Now the ARF is calculated, however as the deposit is dependent on the net price, the ARF is also dependent on the net price. We therefore calculated the unclaimed deposits in a lower bound (LB) scenario and an upper bound (UB) scenario. In the LB scenario, we take the lower bound for additional gear delivery in ports and the low net costs of 5.50€ for every kilo, whilst in the UB scenario we take the upper bounds for additional gear delivery in ports and the high net costs of 8.50€ for every kilo.

The LB scenario results in €2.7m in unclaimed deposits (based on a return rate of fishing gear of 90% and hence 10% unclaimed deposits), whilst the UB results in €13.9m in unclaimed deposits. Using these numbers in the ARF calculation, results in and ARF of 207.58€ (LB) and 143.58€ (UB), which is and ARF of 0.21€ and 0.14€ per kg respectively.

With the increased waste to be managed at ports, the administrative burden has increased relative to option 1a and 1b for ports.

Non-ARF influencing

There are also changed in this category due to the implementation of a retrieval scheme. In line with the annual governing body costs, the assumption that the investment size of the governing body triples holds here as well. Therefore, the upfront investment is now estimated at €19.1m.

Finally, the additional decrease in ALDFG due to the retrieval scheme is taken into account in the calculation of beach clean-up cost decrease. This decrease in costs with a deposit refund scheme, between €0.4m and €3.9m. The decrease in ALDFG related costs, with retrieval, is between €7.3m and €36.4m. All indicators used in the quantification and the results are shown in Table 17.

Table 17: Results of quantification of option 2

Quantification of option 2: Extended producer responsibility with a deposit scheme		
Input indicators (process flow)	Value	
Increase in waste delivered in ports (%)	50%	
Fishing gear waste annually (tonnes)	66,000	218,000
ALDFG and unaccounted waste (%) and delivered in ports (%) **before** option implementation	60%	40%
Recycling (%) and landfilling/incineration (%) **before** option implementation	30%	70%
Input indicators (costs)	Value	
Handling costs for recycling at ports (€/Tonne)	380	
Recycling costs (€/Tonne)	68	
Landfilling/incineration costs (including handling) (€/Tonne)	350	
Fishing net costs – Polyethylene & Polyamide nets (€/kg)	5.50	8.50
Input indicators (Deposit Refund Scheme)	Value	
Deposit as % of fishing net costs	7.5%	
Return rate (%)	90%	
Output indicators	Value	
ARF influencing		
ΔGear delivered to ports (tonnes)	33,000	109,000
ΔGear recycled (tonnes)	9,900	32,700
ΔGear landfilled/incinerated (tonnes)	23,100	76,300
ΔRecycling costs (€) – including handling & transport	4,400,000	14,600,000
ΔLandfilling/incineration costs (€) – including transport	8,100,000	26,700,000
Annual governing body costs (€)	3,900,000	

Unclaimed deposits **-** €5.5 (LB) and €8.5 (UB) per kg case (€)	2,700,000	13,900,000
ARF/Tonne - €5.5 (LB) and €8.5 (UB) per kg case (€)	207.58	143.58
ARF/kg (€) - €5.5 (LB) and €8.5 (UB) per kg case (€)	0.21	0.14
ARF as % of fishing net costs	3.8%	1.7%
Non-ARF influencing		
Governing body investment costs (€m)	19,100,000	
Decrease in beach clean-ups (€m)	400,000	3,900,000
Decrease in ALDFG related costs (€m)	7,300,000	36,400,000

6.4 Quantification of Option 3: A recycling rate target for fishing gear

In this example, the option of imposing a recycling rate on fishers is further explored. A recycling target of 55% is proposed to start with, which is a bit lower than the 60% recycling target which is currently in place in Iceland (but Iceland has this target already for some years and is increased over the past years up to the current 60%) and in line with the recycling rate target of 55% which is in place for the packaging industry (Deloitte, 2014). The recycling rate has no direct effect on the amount of fishing gear that is collected by fishers (which is regulated by the (revised) PRF and the Control Regulation). This also means that it is assumed that the amount of ALDFG and unaccounted waste flowing into the Seas is not affected by a recycling rate (only).

A recycling rate will bring costs for fishers (cleaning, sorting, transportation of waste, and recycling costs of the waste itself). Also, as the costs of recycling are higher than the costs of landfilling / incineration, hence the total handling costs of the waste fishing gear will increase. With the recycling rate target of 55%, recycled waste will go up by 25% (from 30% to 55%), whilst landfilling/incineration will go down by 25% (from 70% to 45%). This means that out of annually disposed fishing gear at ports, which is between 26,400 (40% of 66,000) and 87,200 (40% of 218,000), between 6,600 (25% of 26,400) and 21,800 (25% of 87,200) extra tonnes will get recycled instead of landfilling/incineration. The absolute recycling percentage, as measured of all the fishing gear disposed (and therefore including ALDFG and unaccounted waste), increases from 12% to 22%.

In terms of costs, the increase in recycling costs is estimated between €3.0m and €9.8m, whilst less landfilling and incineration costs are estimated between €2.3m and €7.6m. The result is that the recycling target implies a cost increase of between €0.7m and €2.2m.

Table 18: Results of quantification of option 3b

Quantification of Option 3: A recycling rate target for fishing gear		
Input indicators (process flow)	Value	
ALDFG and unaccounted waste (%) and delivered in ports (%) **before** option implementation	60%	40%
Fishing gear waste annually (tonnes)	66,000	218,000
Recycling (%) and landfilling/incineration (%) **before** option implementation	30%	70%
Recycling (%) and landfilling/incineration (%) **after** option implementation	55%	45%
Input indicators (costs)	Value	
Handling costs for recycling at ports (€/Tonne)	380	
Recycling costs (€/Tonne)	68	
Landfilling/incineration costs (including handling) (€/Tonne)	350	
Output indicators	Value	
Absolute recycling (%) and landfilling/incineration (%) of total generated waste **before** option implementation	12%	28%
Absolute recycling (%) and landfilling/incineration (%) of total generated waste **after** option implementation	22%	18%
ΔRecycling costs (€) – including handling & transport	6,600	21,800
ΔLandfilling/incineration costs (€) – including transport	-6,600	-21,800
Δrecycling costs (€) – including handling	3,000,000	9,800,000

Δlandfilling/incineration costs (€) – including handling	-2,300,000	-7,600,000
ΔWaste handling costs (€)	700,000	2,200,000

6.5 Quantification of Option 4: Alternative materials and product design

No quantification of this option possible.

7. Comparison of the options

This chapter provides an overview of the different policy options included in this study. The table below gives a high-level overview of the total costs involved, expected reduction in ALDFG and the benefits of the ALDFG reduction in monetary terms. Annex 4 provides a full overview of the calculations made to arrive at the totals displayed in Table 19, based on the figures presented in chapter 6.

Table 19: Overall comparison of policy options

Summary					
	Option 1a (10%)	**Option 1a (50%)**	**Option 1b**	**Option 2**	**Option 3**
Costs					
Total costs for stakeholders (€m)	9.5	42.6	26.3	31.3	2.2
Benefits					
Increase in waste delivered in ports (%)	10%	50%	15%	50%	0%[13]
Total benefits of ALDFG decrease to stakeholders (€m)	8.1	40.3	12.1	40.3	0.0

It can be concluded that policy options 2 (implementing an EPR and a DRS) is from an economic point of view the most favourable option as total benefits are higher than total costs. It should be noted however, that the costs and benefits are not evenly distributed among the stakeholders involved, as shown by the relative tables with plusses and minuses in chapter 5. For the EPR with DRS, costs are mainly born by manufacturers and to a lesser extent by fishers and recycling facilities. Benefits on the other hand land mainly at recyclers and to a lesser extent at governments. Hence, on a macro-economic level there seems to be a positive business case to implement an EPR with DRS, but redistribution effects should be taken into account to achieve maximum impact.

Option 1, implementing an EPR without DRS, is from an economic point of view less attractive than implementing an EPR with a DRS. On the other hand, the costs and benefits for an EPR are almost equal but social and environmental benefits are expected. Worthwhile mentioning is that the high increase in costs incurred on stakeholders faced by option 1b (the ERP which also includes coverage of costs for retrieval operations) shows the high costs of retrieval operations conducted, which makes a strong case to focus on preventive measures instead of focusing on curative measure to reduce ALDFG.

A positive social impact is expected related to both options 1 and 2, as more employment is expected related to waste management activities and cleaner Seas and beaches have positive effects on tourism and fishers.

Option 3, the implementation of recycling rates for fishers, will not directly contribute to the reduction of ALDFG in the seas, which means that the direct link to the study objective is missing. For option 4, alternative materials and product design, too little quantitative figures are available for a sensible analysis and (much) more research is needed. In the qualitative description in chapter 4 this policy option is classified as a bridge too far in the near future, and hence not taken into account any further.

The outcomes of the stakeholder consultation performed for this study also indicate a strong preference by stakeholders for the implementation of an EPR and/or DRS as most favourable policy options. Respondents favour with 59% deposit return schemes levied on fishers and with 53% extended producer responsibility scheme, which make these two policy options most favourable among the consulted stakeholders.

[13] No ALDFG decrease, however recycling percentage increases from 30 to 55%

I. Annex 1: List of stakeholders consulted

#	Organisation	Name	Interview
1	VisNed	Pim Visser	Feb 14, 2018
2	KIMO International	Mike Mannaart	Feb 9, 2018
3	WOODZ/EUROCORD	Martin du Bois	Feb 6, 2018 Feb 16, 2018
4	DG Mobility and Transport	Anna Bobo-Remijn	Feb 15, 2018
5	DG Environment	Michail Papadoyannakis	Feb 13, 2018
6	DG Environment	Silvija Aile	Feb 16, 2018
7	Plastix	Hans Axel Kristensen (CEO) Bernard Merkx (Board Member)	Feb 19, 2018
8	Icelandic Recycling Fund	Ólafur Kjartansson (CEO) Guðlaugur Sverrisson (Operational Manager)	Feb 13, 2018
9	OSPAR	John Mouat	Feb 15, 2018
10	Dutch Ministry of Infrastructure and Water Management	Coen Pelin	Feb 20, 2018
11	Rijkswaterstaat Zee en Delta	Wouter Rooijakkers	Feb 16, 2018
12	MARE Foundation	Olga Sarna	Feb 15, 2018
13	Danish Fishermen PO	Sofie Smedegaard Mathiasen	Feb 16, 2018
14	Lankhorst Euronete/WireCo	Ben Wensink	Feb 14, 2018
15	Mediterranean AC	Rosa Caggiano	Feb 14, 2018
16	Mepex Consult AS	Peter Sundt	Feb 21, 2018

II. Annex 2: Questionnaire used for interviews

Introduction

Dear Sir/Madam,

We (DELOITTE Consulting and Wageningen Research) are currently carrying out a study, commissioned by the European Commission (EC) / DG Mare. This study looks into the contribution of fishing gear and aquaculture to the total amount of marine litter in European seas and ways to reduce this.

As part of this study, data about cost of gears, life span of gears, numbers and type of gears lost, efforts undertaken to retrieve them and views about the effectiveness and relevance of existing obligations regarding marking and retrieval of gears is to be collected. At the same time, policy options for future regulatory action have to be designed and tested.

The study is intended to provide input for an **impact assessment on a follow-up action to the EU plastics strategy**.

Questions on future possible policy options

We are currently looking at a number of policy options to address the issue of plastic waste derived from fishing gear. These options include:

1. *Extended producer responsibility without deposit scheme*
2. *Extended producer responsibility + deposit scheme*
3. *Recycling system and target for plastic material*
4. *Product design (including the possibility of substitution of plastics in fishing gear by other materials and design to reduce the risk of loss).*

Below, a short description of each policy option is provided:

1 Extended producer responsibility without deposit scheme

Extended Producer Responsibility (EPR) is a policy approach under which producers are given a financial and/or physical responsibility for the treatment or disposal of post-consumer products (products that have served their intended use). Policy instruments related to EPR can include different types of product fees and taxes commonly called "advance recycling fees" (ARFs), product take-back mandates, virgin material taxes, and combinations of these instruments.

Both EPR and ARF may directly influence the costs and benefits of the fishing operation by increasing the costs of fishing gear. Higher costs would entice the operators to more carefully use the gear and not to abandon it at sea. In addition, both EPR and ARF could generate funds to actively finance a curative operation of retrieving lost fishing gear from the sea or support the setting up recycling systems.

Are you aware of an EPR system in place? Please describe or explain which aspects you consider important.

2 Extended producer responsibility including a deposit scheme

A deposit-refund scheme is used in the consumer market for many items such as for example batteries, bottles and packaging. The recovery system requires the collection of a monetary deposit on a product at the point of sale. The deposit is refunded to the purchaser when they return the product to an authorised redemption centre.

As with the EPR/ARF scheme there increased investment costs are likely to occur for the individual fisher to invest in gear. However, this deposit is regained when the used gear is returned. In addition, under this system any gear retrieved form the seas and returned will earn the fisher who collected the gear a deposit. This may well provide an incentive to fishers

to return to port all of their own gear but also any gear found and retrieved out at sea. This scheme may simultaneously provide a financial incentive to operate carefully with gear and not to lose it as well as bringing ashore as much gear as possibly feasible.

Are you aware of an EPR system in place? Please describe or explain which aspects you consider important.

3 Recycling system and target for of plastic material

Recycling of plastic material is in itself a curative option and not a preventive measure. Recycling does not prevent waste from fishing gear to end up in the sea. Yet it does provide an intermediate solution to lost fishing gear by providing the opportunity to collect ADLFG in port. This policy option might be more effective when targets are set and possible fines are in place in case plastic gear is not offered for recycling.

Are you aware of recycling systems in place? Please describe or explain which aspects you consider important.

4 Alternative product design (including substitution plastics/materials in fishing gear and design to reduce risk of loss)

In its basic design fishing gear is being composed of different types of plastics. Based on considerations regarding material characteristics and the costs of materials and/or plastic products, the desired product is purchased and used. In this way, the most cost-effective materials will be used, which may not always materials or designs that are most environmentally friendly.

In terms of alternative materials that could potentially be used to substitute materials that are prone to wear and tear (i.e. dollyrope or bottom trawling nets), they would have to be more environmentally friendly (i.e. biodegradable) than the currently most used ones; or less prone to wear and tear (which would reduce the amount of plastics entering the sea). These latter type of materials could be materials that are in itself not environmentally friendly, but because they are less likely to end up in sea, a better option than conventionally used materials.

The design of material can be altered to reduce the risk of losses; hooks can e.g. be added to cages … are you aware of solutions like these and if yes please provide details

Questions for each policy option

1. *According to you, which conditions need to be in place for these policy options to work and contribute to a reduction in lost or abandoned fishing gear at sea?*

2. *Can you, per policy option, list the main stakeholders involved and in which way? Think of:*

    a. *Producers of fishing gear*
    b. *Ports*
    c. *Fishermen*
    d. *Recyclers*
    e. *Waste management facilities*
    f. *Other (please specify)*

3. *What could be the potential costs of this policy option for the different stakeholders involved and listed under question (2)? Answers can be given in absolute terms if possible or otherwise in a percentage increase / decrease compared to the current situation.*

4. *Do you see any potential administrative burden arising from these policy options? And if so, where and relating to whom (please specify per stakeholder and per policy option)? Please quantify if possible?*

5. *Can you make an estimate of the benefits for stakeholders and the environment per policy option (preferably a reduction in plastics in % of Tonnes if the individual policy option is implemented)?*

General questions related to the four options

1. *Which (other) option(s) do you see as promising to reduce ALDFG from the fishing industry?*

2. *Why do you consider this as a successful possibility?*

3. *What needs to be in place to realize this option?*

4. *What can you say about costs, benefits to environment and AB of this policy option?*

5. *Any other remark you would like to make?*

Additional questions not directly related to the four options

1. *As a non-constraining action – would awareness raising among fishers and port authorities/management lead to a reduction of ALDFG?*
2. *If awareness raising among fishers and port authorities/management in your opinion reduces waste from fishing and aquaculture can you indicate a % reduction you foresee this measure could cause?*
3. *Will full implementation of the current legal provisions under the fisheries control regulation and the promoting of the use of the support for collecting marine litter and the removal of lost fishing gear under the European Maritime and Fisheries Fund contribute to the reduction of ALDFG?*
4. *How much reduction in fishing waste (%) can be achieved in your opinion if full implementation of the current legal provisions under the fisheries control regulation and promote use of the support for collecting marine litter and the removal of lost fishing gear under the European Maritime and Fisheries Fund is achieved?*

Additional collection of data regarding fishing gears

Below we included some other questions relevant to our study. If you can answer (some of these) questions that would be very helpful, or alternatively provide us with documents that have information related to the topic. Many thanks in advance.

All operators (including ports)

- *Do you consider losing fishing gear a significant economic and environmental problem? Please detail your reasoning and provide quantities figures (for losses in total and in % of gains) as much as possible.*

- *Please state what are the standard acquisition costs of the different types of fishing gears (aquaculture nets) you (or your membership) use in EUR per gear.*

- *Do you modify fishing gears you buy or do you request the manufacturer to tailor them to your requirements before buying them? Please specify the type of gear and the amounts.*

- *What are the materials the fishing gear you use are made of? Which part of the gear consist of plastic (in% and in weight, if possible)?*

- *How do you mark your fishing gears?*

- *Are you aware of the legal obligations regarding marking of fishing gears under the EU fisheries control regulation? Do you consider them as being effective, relevant and acceptable?*

- *What would you suggest to make them more effective, relevant and acceptable to you?*

- *For how long do you use the gears normally? What is their normal life span? Please specify per type of gear.*

- *What do you do with nets that have reached the end of their operational life?*

- *Are there in the fishing ports where you operate mechanisms and facilities to deposit and deal with derelict fishing gear? If so, please describe.*

- *What could be done to improve the collection and storage facilities (1) on vessels and (b) at ports.*

- *Do you have to pay fees for accessing the mechanisms and facilities to deposit and deal with derelict fishing gears? If yes, how much?*

- *How often do you (or your membership) lose fishing nets per year? Do you lose entire fishing gears or part of them?*

- *In case you lose gear, what are the reasons for the loss?*

- *Would better knowledge of the gear and the handling of the gear help you to avoid losing it? How should such knowledge or training be provided (manual, training at ports, training at fishers association, FLAGs, other)*

- *In case you lose parts of them, what is the basis for you to opt between repairing and disposing the damaged fishing gear?*

- *What is the costs of repairing a fishing gear? (please specify in EUR and by type)*

- *What part of your variable or fixed costs do the acquisition and repair of fishing gear represent?*

- *Do you hold equipment on board that allows you to retrieve gear in case of loss? If yes, what does that equipment consist of?*

- *Please describe your efforts to retrieve a lost gear. Please specify how many did you retrieve of these you lost in the last 5 years.*

- *What do you do in case you cannot retrieve a lost gear?*

- *To what extent do you believe that fishing gears are deliberately dumped into the sea?*

- *What are the motivations for deliberately dumping fishing gears into the sea?*

- *Are you aware of the legal obligations regarding retrieval of fishing gears under the EU fisheries control regulation? Do you consider them as being effective, relevant and acceptable?*

- *What would you suggest to make them more effective, relevant and acceptable to you?*

- *How much marine litter do you fish up during a standard fishing operation? How much of that is plastic, and how much is fishing gear (in tonnes and in % of all fished up litter and in % of average catch)?*

- *Are you aware of the support possibilities for collecting marine litter and lost fishing gears under the European Maritime and Fisheries Fund and for improving storage facilities on board?*

- *Have you applied / benefitted to/from any such support since 2014? If so, please specify.*

For ports only

- *Do you have in place facilities to separately collect and store derelict fishing gears? If so, please explain how they operate.*

- *In the negative, do you intend to put such facilities in place? Please, explain what and when these will be deployed.*

- *What are the costs of operating such facilities?*

- *Do you derive any income from such mechanisms and facilities? If so please state how much income and from whom (fishermen, gear recycling companies) you get it.*

- *Do you have in place mechanisms to manage waste from derelict fishing gears (including preparation, cleaning on site, waste collection, transfer to recycling site etc.)? If so, please explain how they operate.*

- *In the negative, do you intend to put such mechanisms in place? Please, explain what and when these will be deployed.*

- *What are the costs of operating such mechanisms?*

- *Do these mechanisms create employment at the port itself? If yes, please qualify e.g. type of work, qualifications needed, kind of contracts etc)*

- *Do you derive any income from such mechanisms? If so please state how much income and from whom (fishers, waste management facilities, gear recycling companies) you get it.*

III. Annex 3: Responses to open questions from stakeholder consultation

Below, the complete overview of open answers relevant to this study out of the stakeholder consultation are given. Answers have not been edited in the Annex.

A. From your experience, how much fishing gear is lost at sea per year? (Percentage on a vessel of that gear): Other -> If "other", please specify -> If you have more precise numbers for lost gear please provide them here

- Dolly rope. Estimation for Belgium: 50% of 90-130 tonnes/year (reference: SPEKVIS project). Probably this includes discarded gear...
- BaltSea2020 estimates 5500-10,000 net fragments lost per year. Polish fishermen suggest 1 gillnet fragment lost per month (MARELITT Baltic evidence). German fishermen do not loose nets regularly, but gillnets are torn by boats regularly during the gillnetting season, and are frequently not recovered due to dragging from the fishing location. Loss of lines and hooks in hobby fishing activities occurs regularly at the German Baltic coast, including in nature conservation areas.
- 1 every 6 years
- In France, 27.1% of plastic waste comes from fishing – Expedition MED
- On average, at least per boat in a solar year tends to lose a couple of trawl doors and in most cases it is difficult to recover them from the seabed (Fisher)
- In industrial trawls that are completely lost a network can happen once or twice a year at the most (Academic)
- During a scientific fishery survey in 2016, using a bottom trawl net, several shellfish nets (those used in longlines) have been caught on EACH haul done in proximity of the italian coast (of about 30 minutes). The amount of nets raised in the north adriatic (Veneto).
- In all seas and lakes nearly 650000 tons is yearly lost
- there are no accurate data available. today based on best 'guesstimates' which are not in line with the volume of nets produced. 20% said to be lost / discarded at sea = 640.000 tonnes meaning that the full yearly market to be 5 times higher at least. There is so far no evidence of any such production volume of such scale in the world. This does however not mean that the issue needs to be tackled. Preventive collection and improved Port Reception facilities is important
- 1.15 million tonnes per annum globally (only small part from North Sea)
- There are no exact figures for lost gear, or for abandoned gear, but combined the best estimate is 640.000 tonnes of gear is lost, abandoned or otherwise discarded globally each year (Macfayden et al., 2009). The lack of data is a problem for designing effective measures, so improved data collection should inform any action the Commission decides to take.
  In a study by Ayaz et al. (2010)4, results display that 0.8% and 3.4% of demersal gillnets and trammel nets, respectively, are lost per year. The geographical focus of the study is the Mediterranean; Section of the Gokova Special Environmental Protection Area off Turkey, eastern Mediterranean Sea, demersal gillnet and trammel net fisheries.
  In a study by Santos et al (2003)5, results show that the average annual number of net panels lost per vessel was 3.2, 5.1 and 7.4 for the local, coastal and hake fisheries, respectively. The study was conducted in Algarve, Portugal on local, coastal and gill net hake and trammel net fisheries.
- MCS litter surveys find that fishing related litter makes up about 11% of all litter on UK beaches. This includes litter from commercial and recreational fishing and items such as Fishing line, fishing nets, tangled nets/string/rope, plastic floats/buoys, gloves, fish boxes, lobster/fish tags, lobster/crab pots, octopus pots, oyster nets/mussel bags, oyster trays, mussel sheeting.

Gear loss/abandonment/discard indicators from around the world

Region	Fishery/gear type	Indicator of gear loss and data source
North Sea and north-east Atlantic	Bottom-set gill nets	0.02-0.09% nets lost per boat per year (EC contract FAIR-PL98-4338 (2003))
	Trammel nets (several species)	774 nets per year (EC contract FAIR-PL98-4338 (2003))
English Channel and North Sea (France)	Gill nets	0.2% (sole & plaice) to 2.11% (sea bass) nets lost per boat per year (EC contract FAIR-PL98-4338 (2003))
Mediterranean	Gill nets	0.05% (inshore hake) to 3.2% (sea bream) nets lost per boat per year (EC contract FAIR-PL98-4338 (2003))
Gulf of Aden	Traps	c.20% lost per boat per year (Al-Masroori, 2002)
ROPME Sea Area (UAE)	Traps	260,000 lost per year in 2002 (Gary Morgan, personal communication, cited in Macfadyen et al., 2009)
Indian Ocean	Maldives tuna longline	3% loss of hooks/set (Anderson & Waheed, 1988)
Australia (Queensland)	Blue swimmer crab trap fishery	35 traps lost per boat per year (McKauge, undated)
Gulf of Carpentaria	Trawl nets (59.2%), gill nets (14.1%), unknown (26.2%)	845 nets removed by rangers from approximately 1190km of north Australian coastline (GhostNets Australia, 2012)
North Pacific	Drift nets	0.06% set resulting in 12 miles of net lost each night of the season and 639 miles of net lost in the north Pacific Ocean alone each year (Davis, 1991, in Paul, 1994)
North-east Pacific	Bristol Bay king crab trap fishery	7,000 to 31,000 traps lost in the fishery per year (Stevens, 1996; Paul et al., 1994; Kruse & Kimker, 1993)
North-west Atlantic	Newfoundland cod gill net fishery	5,000 nets per year (Breen, 1990)
	Canadian Atlantic gill net fisheries	2% nets lost per boat per year (Chopin et al., 1995)
	Gulf of St Lawrence snow crab trap fishery	792 traps per year
	New England lobster fishery	10% traps lost per boat per year (Erin Pelletier, Gulf of Maine Lobster Association, personal communication, 2014; Sarah Cotnoir, Maine Department of Marine Resources, personal communication, 2014)
	Chesapeake Bay	Up to 30% traps lost per boat per year (NOAA Chesapeake Bay Office, 2007)
Caribbean	Guadeloupe trap fishery	20,000 traps lost per year, mainly in the hurricane season (Burke & Maidens, 2004)

Source: adapted from Macfadyen et al. (2009)

From source: Marine Debris Ghost Fishing Report

Rates of static fishing gear loss in the European Union (EU) were found to be low, at 500m are most likely to be lost due to excessive net length, increased soak times and gear stress (Hareide et al., 2005). Deepwater fisheries in the northeast Atlantic were a noted exception to low gear losses, as they accounted for more than 25,000 nets of the total 33,038 reported lost (Brown et al., 2005).

- The networks for mussel farming are in some cases broken in the event of a storm; in others they are abandoned when the fishermen empty them from the mussels.
- we have estimates of plastic whelk and crab pots from fishermen - > 500 000 ghost fishing around Ireland and higher losses now than ever before for a number of reasons - see Coastwatch report 2017 (NGO)

B. From your experience, how much fishing gear is discarded at sea per year? (per vessel) : Other -> If "other", please specify -> If you have more precise numbers for discarded gear please provide them here

- In total, abandoned, lost and discarded fishing gear representes 10% of all marine litter (Gilman, 2015, Status of international monitoring and management of abandoned,lost and discarded fishing gear and ghost fishing, Marine Policy, 225-239).
- 1 every 4 years
- There are no accurate numbers, Some divers reported to have found 'old nets'which may imply that present day fishermen bring obsolete gear on land. In practice we see a lot of

parts of nets / rope etc i.e. on beaches. These are often consequence of repairs on board or in ports and or wear and tear. With improved equipment on board fishing vessels can better avoid shipwrecks, rocks etc. We find an increasing number of angler lines on shipwrecks and other places
- Dolly rope. It's for protection of the fishing net and it gets most stress during fishing. During fishing trips it needs reparation, many cut pieces are commonly found on beaches which indicates many cut dolly rope pieces go into the sea.
- The networks for mussel farming are in some cases broken in the event of a storm; in others they are abandoned when the fishermen empty them from the mussels.

D. From your experience, how important is the contribution to marine litter of the following types of aquaculture? : On - bottom shellfish (inter-tidal) -> If "other", please specify -> If you have more precise numbers for aquaculture gear lost please provide them here

- In France, 3.14% of plastic waste comes from shellfish farming

5. In your opinion, which measures would help reducing lost or discarded gear? -> If other, please specify

- The fishing nets: numerus clausus and joint management
  The fishing nets should become a collective (or public) asset, no longer a private one. Fisherman may not hold and/or buy nets, but receives the regular gear – compliant with mesh size, length and marking requirements - in usufruct from a local managing body (the fishing net is as a collective good) or from the State (fishing net as a public good).
- We need systems, technologies and markets that fundamentally revalue the materials being recycled. The cash value of the materials being recovered or retrieved is currently to too low to sustain the recycling of large volumes of that low specification material. Their quality forces a coupled approach where virgin plastics are required to dilute their technical impacts (e.g. mechanical strength). Bulk uses in construction, chemical reformulation as transportation fuels or other chemical feedstocks seem to be better options for longer term
- Fishers dump plastics at sea on purpose and litter from there own activities. Damaged gear is just thrown overboard. There need to be far stiffer penalties on the fishing aquaculture industry for its role in plastic pollution. There are numerous abandoned salmon aquaculture sites on the Irish Atlantic seaboard being allowed to break up into the ocean. A method of audit needs to be developed so that it is not possible to just dump damaged ropes, cords, nets etc overboard.
- EU policy on the tagging of fishing nets! (Must be on EU level, not regional).
- Retrieval can be helpful, but can also be harmful. It is costly and slow. Better to stop the flow of gear. Portside facilities are usually absent. Fines and observer reporting is also usually absent.
- Awareness raising and outreach / Information/education of fishermen
- nets / rope assemblies could be equipped with buoyant devices, which become active after beeing submerged for extended time. Also parts of nets could be made of soluable material, which dissolves after a few month and would have do be replaced in routine operation from time to time. large trawler nets might benefit from some sort of pinger, which allows retrieval of nets after beeing lost (which respect to the costs of a net this might be of economical benefit for the fishing industry). An watchdog-released epirb also might help to retrieve large nets. If (at least for moderate size fishing gear) the lifetime of nets could be limited to (biodegradeable withing e.g. 5 years) a buildup of vagabounding nets in sensitive marine areas could be limited.
- Incentives should not be financial as this may lead to prolems later on if financial incentives are withdrawn. Education and awareness raising is good. Incentives should be that fished up litter should not be charged for at ports.
- Most vessels have retrieval anchors on board. All other aspects are investigated as part of MARELITT Baltic. Incentive to report lost gear instead of disincentive has to be provided: Cost for retrieval in case of loss needs to be clarified and standardised, e.g. by insurance measures for fishermen that lost gear retrieval is funded. In Germany, reporting although enforced in principle, does not occur in practice. Hence reporting and subsequent steps to avoid accumulation of lost fishing gear on the seafloor needs to be improved.
- Legislation with strong enforcement sanctions
- Derzeit besteht zwar eine Markierungspflicht, um verloren gegangene oder illegal entsorgte Fischernetze zuordnen zu können, sowie eine Berichtspflicht für Netzverluste. In der Praxis

ergeben sich jedoch gleich mehrere Probleme: Zum einen tragen angeschwemmte oder gefundene Netzstücke gar keine Markierung mehr, zum anderen sind die hohen Entsorgungsgebühren für Müll in den Häfen ein Anreiz, kaputte Netze auf See zu entsorgen. Der Verlust bzw. die illegale Entsorgung eines Netzes muss deshalb künftig teurer werden als die legale Entsorgung an Land/im Hafen.
Wir schlagen deshalb eine EU-weite Registrierpflicht für Netze, entsprechende (ggf. stichprobenartige) Kontrollen in Häfen und einen angemessenen Strafkatalog vor.

- Some ship can throw the used discarded gear into the ocean when this is useless for them. Some other can have a problem, so the gear get fixed to something in the seabed.
  Those to cases are very different. In the first case, one the shipowner or the spyker doesn't whant to carry with something that as no value. In the second case, the skyper has had a problem with his net and he is having a big lost of time and money (ussually the electroacustic equipments cost much more than the net, and is not ussual to have replacement on board).
  To solve first case it is possible to prosecute this kind of way of acting or giving incentives for not acting that way.
  Second case can't be solved; is just an accident.
  If there isn't an incentive to prevent first caser there will be more second cases
- monitoring and clean up actions on a regular seasonal dynamics
- The lack of a receptive structure and disposal or recovery of marine litter, involves in almost 90% the abandonment on the sea bed or the rejection of the latter at sea. An incentive policy together with ecocompacters' investments, which award a prize of any kind to the presentation of these wastes in the form of tickets, could also partially solve a question that at least in Italy, at the moment, is complex.
- I think tath introduction biodegradables materials or re-introduction of natural materials could be helpful in a world were is too easy to bypass rules (in particular in case of aquaculture or gill nets, where nets are not subject to huge mechanical stress as in trawl nets).
- Fisheries should have to apply a unique tag on their gear, so when it is found they may be fined.
- more sustainable fishing techniques, less sensitive to wear and loss
- The factors which cause fishing gear to be abandoned, lost or otherwise discarded are numerous and include: adverse weather; operational fishing factors including the cost of gear retrieval; gear conflicts; illegal, unregulated and unreported (IUU) fishing; vandalism/theft; and access to and cost and availability of shoreside collection facilities. Weather, operational fishing factors and gear conflicts are probably the most significant factors, but the causes of ALDFG accumulation are poorly documented and not well understood. A detailed understanding of why gear is abandoned, lost or discarded is needed when designing and tailoring effective measures to reduce ALDFG in particular locations.
  A variety of measures are currently in place to reduce ALDFG, and these are profiled in this report. They include those which are preventative or ex-ante, and those which are curative or ex-post. Evidence suggests that while both are important, much of the emphasis to date has been placed on curative measures such as gear retrieval programmes and clean-up of beach litter, while preventative measures may generally be more cost-effective in reducing ALDFG debris and its impacts.
- Educational and rasing of awaweness in the fishing industry, fishers and skippers mainly, and shipowners
- Remediation is always an issue and good, but we first should stop the inflow and take away any legal blocking of bringing obsolete gear on land. Wear and tear issues are not solved by retrieval actions. Retrieval on hotspot areas may be a good focus. Individual divers to collect 1-2 gears have proved to be very expensive and not very effective, unless the ghost gear is causing a direct danger for i.e. ships. The Norwegian system where fishermen have to mandatory advise the Coast Guard in case of lost gear seems to be pragmatic and effective
- Sensitization of the stakeholders involved (cooperatives, fishermen, sub); Harmonization at European level of the methods of collection and disposal of waste caught at sea. Schemes of deposit-refund systems for mussel-growing retinas.
- gill nets and pots lost at sea are usally towed away by bigger boats ,so more protection of static gear boats and inshore waters from towed gear
- More EPR from fisheries

- • (Mandatory) application of the 'Best Practice Framework for the Management of Fishing Gear' by all parties involved in the fisheries supply line including gear manufacturers, fishers, fish product and fish retail organizations, etc.
  • Extension of traceability and fish sustainability certification schemes to include whether or not the Best Practice Framework for the Management of Fishing Gear is applied in the fish supply line
  • Improved efforts to prevent the loss or abandonment of fishing gear. These can include: soak times, spatial planning of fishing activities, usage of certain types of gear in certain areas, promotion of zoning initiatives to reduce gear conflict, etc.
  • Support the Global Ghost Gear Initiative (GGGI)
  • Elimination of fisheries subsidies that (intentionally or unintentionally) lead to overcapacity by 2020, in line with the SDG 14 goal
  • Improved availability of port reception facilities for fishing gear across the European Union, with a 100% no special fee for depositing of fishing gear waste
  • Enforcement of the Code for Responsible Fisheries gear marking guidance to ensure fishing gear is traceable to source.
  • Producer responsibility for fishing gear manufacturers to provide either subsidies for the return of damaged or old gear for recycling or appropriate method for responsible disposal.
  • Encouragement and funding for manufacturers to focus on circular economy design for fishing gear with an emphasis on gear that is recyclable, easy to dissemble and therefore easier to handle at end of life.
  • Wherever possible return to using natural rope fibers instead of plastic to minimise harm to the marine environment.
  • Requirement for vessels to allow for a designated amount of space for the adequate handling and storage of fishing gear
  • Improved implementation and enforcement of EU regulations for reporting lost gear to responsible authorities.
- To get the appropriate financial incentives not to release waste into the sea.
- To make compulsory to leave the waste in PRF and introduction of sanctions if not respected. The new provisions proposed by the Commission in the PRF directive on Cost recevory systems is a proposal to solve the problem.
- Active retrieval might also be a good option but specific education and well suited equipment is key for this to function. Otherwise, such measures and also active 'fishing for waste' might further harm sealife. Certain standards / procedures need to be defined and followed.
- Develop alternatives for dolly rope
- Innovation for fishing gear and dolly rope should be promoted
- **Important measure would also be better waste management system, at present fishermen in some Baltic countries needs to cover the cost of reception, transport and utilisation of old nets by the waste management companies. These costs are high/problematic for the majority of fishermen.**
- It is important that a suit of measures are applied together.
  We ran a pilot model harbour scheme as INTERREG Ireland Wales 2001 and 2002 and got a huge positive response as fishermen and harbour masters worked together and saw their efforts appreciated and acknowledged. But this only covered ± 40 harbours and sadly we could not get government support at the time to roll it out to all.
- • It must be ensured that the measures do not cause additional harm (such as bottom trawling in order to retrieve lost gear)
  • Better product design is key: gear should be longer lasting, less prone to breaking and wear and tear. For very specific applications, biodegradable materials can be solution should their degradability be ensured in the respective environment
  • Deposit schemes for fishing gear should be considered
- Education & awareness training for fishers on the impacts of discarded gear and fragments of cord / rope / line, including the impacts on the local economy of tourism, via beach litter and impact of contamination of fish and shellfish via ingestion. Contamination of fish with microplastic fibres create negative publicity for their marketable product.
  Training and awareness should be led by fishers who can relate to those working in the industry rather than scientists ./ conservationists.
  Additionally the cost of disposal at port should be reduced - currently in the UK fishers

must pay for disposal themselves unless they are part of Fishing For Litter / KIMO programme.

8. Which measures would make gear retrieval more successful? -> If other, please specify

- We need to stop the inflow from outside the EEZ, so address illegal fishing and net dumping in international waters.
  We need economically and environmentally sustainable uses for the retrieved materials
- **This question fails to address the fact that often gear can not be retrieved - either through safety limitations, or the fact that it has been moved due to weather or other vessels. In our fishery for example, the majority of pots which can not be retrieved find themselves that way after they have been towed away by other fishing vessels; causing both time and financial impacts; weather can move static nets and rocks can snag trawls. No amount of enforcement, or gear marking can address these situations and serious consideration should be made in how to retrieve such things,**
- Clarification of responsibilities for retrieval in case 24 hour retrieval attempts were not sufficient to retrieve lost gear (enforce reporting, see above). Improvement of collaboration with divers. Simplification of funding application for fishermen through EMFF for cleaning measures.
- As I was telling, lossing a gear is a big problem because of the lost of time (1, 2 or even 3 days without working) and a big lost of money. Skypers I know are always doing its bigger effort to retrieve the gear
- **In some country the legislation has to change to make the gear retrieval possible. In Italy for example the gears are classified as special waste and thus their disposal has to be paid by the fishers. However, most lost/discarded gears are old and unrecognizable and the only way to proceed to their disposal is if the collectivity takes charge for it.**
- • Better public financing for gear retrieval
  • Replication of Norwegian Directorate of Fisheries model where government funded retrievals in areas of high fishing intensity are undertaken during the off-season
  • Enforcement of existing rules for fishing vessels to carry equipment on board to enable retrieval
  • Enforcement of existing rules for lost gear to reported and support provided for recovery from relevant coastal authorities
  • Extension of traceability and fish sustainability certification schemes to include whether or not the Best Practice Framework for the Management of Fishing Gear is applied in the fish supply line
- Active retrieval might also be a good option but specific education and well suited equipment is key for this to function. Otherwise, such measures and also active 'fishing for waste' might further harm sealife. Certain standards / procedures need to be defined and followed.
- Most of these measures are already part of EU Control Regulation 1224/2009.
- The most important here is cooperation with fishermen and their good will in sharing the knowledge about lost gear locations in the Baltic. Fishermen often know where the lost nets are located, but due to the competitive advantage are not eager to share this knowledge, nor the coordinates of underwater obstacles, which are the major reason for gear loss in the Baltic.

9. In your opinion, which types of actions against marine litter should be supported with public funds? -> If other, please specify

- Fishery loses money with lost gear, it is in their interest to recover / keep the gear. Fishery organisations and companies should be willing to contribute costs also.
- Prosecution where discarding of fishing gear is proven.
- Surveys = national monitoring surveys (e.g. beam trawl surveys) with additional attention to marine litter (MSFD, OSPAR)
- Actions against marine litter should focus on mitigation rather than recovery. Regulating the amount littered is more promising than the difficult, expensive and uneffective recovery of already littered materials. We know that rivers and fishery are main emitting sources. Actions focussing on "cleaning rivers" and regulating the plastic use and recycling in fishery are mandatory.

- Tagging and enforcement.
- in terms of fishing gear - try to make it retrievable or biodegradeeable.
- This should be the job of the individuals and not for the public to fund. You would only end up making the situation worse if you had public funds cleaning up after the fishermen
- **Subsidising the fishing gear recycling industry to help it grow will encourage better end of life treatment for fishing gear. Research into material alternatives for problematic items such as dolly rope and other forms of plastic rope which are highly likely to shed large quantities of plastic fibers into the water. If fishing for litter waste is included in a 100% no special fee system for fishing harbours, there should be a national fund to help keep these costs low, so that the burden to pay for others waste does not fall entirely on fishermen. Ships calling at commercial harbours should contribute to this fund as part of the polluter pays principle.**
- To promote actions aiming at retrieving marine litter and other types of waste - and reincorporating them into the cycle. In a spirit of circular economy, to turn marine litter into a valuable resource. To promote initiatives that are contributing to this aim.
- We think the fishing industry should financially support the retrieval/removal of lost gear, not the public.
- Important measure would also be better waste management system, at present fishermen in some Baltic countries needs to cover the cost of reception, transport and utilisation of old nets by the waste management companies. These costs are high/problematic for the majority of fishermen. Also, the innovative projects testing and putting in practice the electronic marking system for fishing nets. Fishermen are strongly against any new legal restrictions, so the only way to introduce the electronic marking system would be with "step-by-step" approach, creating EU funded projects to test/practice new marking solutions by small group of fishermen first and to expand this group afterwards.
- Funds should be granted to the operators which recover fishing gear. But the emphasis should be on established supply chains, as a part of waste management flows and not on the lost fishing gear. It is neccessary to apply the solution at the root cause of the problem; not to discard the fishing gear in the nature in the first place. The material should enter into controlled waste stream and end up at recovery facility
- We urgently need to funding and incentives to substitute certain inshore gear made of plastic by more environmental sound materials as the losses are too high and effective retrieval too expensive. e.g. traps and ropes.
  Local authority environment officers - there is not enough staff to enforce regulations and to raise awareness.
  A harbour/port award scheme for (i) waste and oil management (ii) reception facilities (iii) positive initiatives for nature, reuse of gear/materials and (iv) commercial activity around the harbour/port as in some tourist areas the cumulative impact of fishing gear plus consumer waste is striking. (e.g. have free potable water from fountains to reduce plastic bottle use.
- Collaboration and communication between fishers and diving organisations - lost gear can be retrieved if reported - which could be anonymous. Training fishermen as ambassadors to promote good practise , currently lost gear is not declared due to belief there is no significant impact and an unwillingness to reveal fishing areas.

10. The proposal for a revised Port Reception Facilities (PRF) Directive foresees the introduction of a 100% indirect fee for waste from fishing vessels (including "passively" fished waste) and the separate collection and handling of this waste in ports. What additional targeted measures are needed to support the management of gear brought ashore and/or end of life gear? -> If other, please specify

- A presumption that current fishing gear (i.e. straight off the boat) is recyclable under plastics waste recycling directives, and that initial steps of that recycling should be carried out at the ports themselves wherever possible.
  Without that crucial step we would end up with long transport distances of very low value bulk wastes and situations whereby we divorce the problem from the solution. You end up trading issues in the ocean for issues in the atmosphere. We can address both by instituting a locally-based solution and only transporting higher value wastes.
- Mandatory at shore delivery of gear at end of life/broken, costs for waste collection and processing is for the fishing company; alike citizens pay for their waste collection. Gear

accidentilly encoutered and fished to be brough ashore mandatory as well.
If waste is re-usable in a recycling process, then perhaps passive fishing (collection) of waste onboard, combined with delivery of broken or end of life gears can supply a sufficiently sizable waste stream to earn back the costs for the fishing companies. Plastics are a raw material, and so I'd expect that at least a sizable part of the waste collection and processing infrastructure (onboard and in ports) can be earned back by the sales of the raw material.

- Some sort of "net or fishing gear deposit" might help to reduce the amount of waste a little. But note: nets and fishing gear is not lost intentionally. fishing gear is expensive and if you loose your fishing gear you do not earn money. Its not a good idea to punish fishermen for bad luck.
  Support the use of biodegreadable materials for fishing gear whereever possible.
  improve fishing gear retrieval technology (see above)
  make retrieval of lost fishing gear a business (make sure this does not lead to damage to seabed structures or increased risk in contaminated areas)
- Deposit return schemes only work for gillnets from regional markets, long livetime of trawls renders return schemes inefficient. Frequent markings on lines to identify owners, communication with fishermen about loss "hotspots" and problematic conflicts such as gear conflicts as well as conflicts with other marine traffic.
- Das fachgerechte Entsorgen von defektem Fanggerät/Netzen an Land darf nicht teurer sein als ein illegales Entsorgen auf See. Deshalb schlagen wir eine EU-weite Registrierpflicht für Netze, entsprechende (ggf. stichprobenartige) Kontrollen in Häfen und einen angemessenen Strafkatalog vor.
- with every old used fishing gear, they shoudl give discounts when one has to buy new one!!!!, or try to fix the old ones, instead of just cuting the line.....
- But again only focus on collection is insufficient. There are meanwhile some recycling companies specialised in the recycling of fishing gear. In practice we see that they have major challenges to sell the recyclates evolving from these recycling activities. So an incentive for market uptake and (mandatory) use of a % of recycled content in various products needs to be part of a solution. Just collecting it will mean landfill or incineration
- It is totally inappropriate to introduce a payment that taxes the waste coming from fishing vessels that can be brought by fishermen when they carry out their fishing activity, it would be not only unfair but to make such activity carried out mainly by trawlers carrying gear other than trawling, disappear , if they are taxed for bringing this type of marine garbage.
- • We fully support the 100% indirect fee system for waste from fishing vessels, but it is essential that the inclusion of fishing gear and fished waste does not result in significantly higher fees for the fishermen. Alternative systems of funding this fee system must be found, including national subsidies, EMFF funding, a national fund paid into by all vessels or other systems.
  • Investment to support recycling through the establishment of a network for the collection of end-of-life fishing gear and logistics support for transport to recycling facilities. The provision of adequate port reception facilities is called for in MARPOL Annex V
  • Inclusion of redundant fishing gear into port waste management plans
  • Development of agreements with both local gear manufacturers and recycling businesses to maximise opportunities for the cost-effective and environmental responsible disposal of landed waste
  • Information exchange with IMO’s PRF database to ensure that specialist reception facilities are easily located.
  • Link the creation of ‘free of charge’ port reception facilities with active implementation of Fishing for Litter programmes across more parts of the EU
- 1. incentives for fishermen to switch to non plastic gear
  2. Better storm preparedness. A lot of gear is lost during storms and high tides. There appears to be no preparing for this in most harbours. Waste is stored or heaped in areas vulnerable to storm waves.
  3. Port dues influences by amount and likely loss of plastic gear would be ideal but would need to go through trial /pilot stages to make sure it is fair and works as incentive to reduce most easily lost plastic.

To your knowledge, which kind of gear/material are currently recycled?

- some fishing nets made from nylon are recycled, but there is still only one company in Italy that has this technology and they actually have to import used fishing nets from China to reach break even capacity, because they simply do not receive enough from Italian fisheries, ports, etc.
- repair of fishing gear is also some sort of recycling. if you are lucky, this could last for years.
  in that respect the recycling rate is close to 100% percent as all fishing gear will be repaired and not discarded.
- No end-of-life gear is recycled in Germany, discarded gear is incinerated. Plastic parts of gear are single polymer and could be recycled to at least 70%. Lead and metal fragments are re-used, but could also all be recycled after use. Problem is separation of metals and plastics and separation of different plastic types in floats and lines.
- To my knowledge the only truly recycled material is Nylon 6 which is used only in gillnets. Other gear components like floats and leads can be re-used.
- In Ireland there is a Pilot project, in collaboration with UK (Liverpool) for recycling discarded fishing nets. Macroom E (http://macroom-e.com) and BIM (Bord Iascaigh Mhara -Irish Sea Fisheries Board) are the Irish partners.
- Depending on the area, most of what is currently recycled is monofilament nylon 6 gill nets, some nylon seine nets, some polyethylene trawl and seine gear, and some polypropylene ropes. Mixed polymer ropes and traps are very difficult to recycle currently, given the difficulty involved in separating their various components.

IV. Annex 4: Summary and overview of options

Table 20: Comparison of quantitative option assessment

Comparison of Options					
	Option 1a (10%)	**Option 1a (50%)**	**Option 1b**	**Option 2**	**Option 3**
Input indicators (process flow)					
Increase in waste delivered in ports (%)	10%	50%	15%	50%	0%
Recycling (%) and Land/Inc (%) **before** option	30% 70%	30% 70%	30% 30%	70% 30%	70% 30%
Recycling (%) and Land/Inc (%) **after** option	30% 70%	30% 70%	30% 30%	70% 30%	70% 30%
Output indicators					
ARF Influencing (upper bounds)					
ΔRetrieval costs (€m)	0.0	0.0	12.6	0.0	0.0
ΔRecycling costs[14] (€m)	2.9	14.6	4.4	14.6	9.8
ΔLand/Inc costs[21] (€m)	5.3	26.7	8.0	26.7	-7.6
ΔWaste handling costs (€m)	*8.2*	*41.3*	*25.0*	*41.3*	*2.2*
Annual governing body costs (€m)	1.3	1.3	1.3	3.9	N/A
Total waste and governance costs (€m)	*9.5*	*42.6*	*26.3*	*45.2*	*2.2*
Unclaimed deposits (€m)	0.0	0.0	0.0	13.9	0.0
Total Costs for ARF - minus deposits (€m)	**9.5**	**42.6**	**26.3**	**31.3**	**2.2**
ARF/kg (€)	0.04	0.20	0.12	0.14	0.0
Non-ARF Influencing (upper bounds)					
Governing body investment costs (€m)	6.4	6.4	6.4	19.1	N/A
Decrease in beach clean-ups (€m)	0.8	3.9	1.2	3.9	0.0
Decrease in ALDFG related costs (€m)	7.3	36.4	10.9	36.4	0.0

[14] Including handling

V. Annex 5: Overview of the loss rate of fishing gear

Assessing the rate of annual inflow of plastic waste from fishing and aquaculture is a difficult pursuit. Beach, seafloor and floating litter assessments only assess retrospectively and further only the total rather than inflow. Hence, these figures do not reflect reality about the annual inflow. Therefore, it is important to rely on sources using interviews with fishers and relevant firsthand knowledge. Further, to address, understand and represent the full extend the rate of annual inflow of plastic waste from fishing and aquaculture, the following has to be borne in mind that this rate for a time period of one year consists accumulative of:

- Wear and tear
- Loss (gear and gear pieces not able to retrieve)
- Discard (illegal as well as unintentional dumping, e.g. pieces from net mending washed overboard)

Table 21: Review of % of plastic fishing and aquaculture gear lost or discarded annually in European Seas

Source	%	Explanation	Representative?
Literature and Interviews			
Bekaerd et al. (2015)	~50%	About half of all dolly rope ends up in the sea for Belgium either by abrasion or dumping according to interviews with fishers and salesmen	No, dolly rope only tiny fraction of all gear and only in NL and BE used heavily, hence % is overestimating total
Strietman et al. (2013)	~50%	About half of all dolly rope used ends up in the sea for the Netherlands, 25% comprising of wear and tear as well as 25% due to net mending activities at sea and then net fragments dumped (stakeholder interviews)	No, dolly rope only tiny fraction of all gear and only in NL and BE used heavily, hence % is overestimating total
Nofir (2015)	35%	35% dumped at sea, which they base on worldwide ALDFG loss rates brought to an EU level (MacFayden et al., 2009; World Animal Protection, 2014; Interwies et al., 2013) and fishing equipment legally discarded in Europe (Nofir knowledge).	No, global figures are only translated with rough 10% EU factor (5% of coastline is better indicator) and no cited source for fishing equipment legally discarded in Europe -> Overestimation
Brown et al. (2007)	33%	One out of three fleets of nets lost per year. Based on a hypothetical EU gillnet fishery populated with realistic data based on interviews and published costs and earnings data from a UK gillnet fishery. Gillnets 21% of total EU fishing by fleet power (EUNOMIA 2017)	No, only gillnet (21% of total fishing activity) and based on only UK data, therefore limited geography -> Overestimation
EUNOMIA (2016, 2017)	15%	Assumption based on <5% loss for most fisheries and 75% unaccounted gap between 25% nets entering formal waste management and 100% of nets sold and used.	
Sundt (2018)	~13%	Plastic in aquaculture is 190,000 tons. Thereof, 25,000 tons are discarded every year equal to 13% of the total.	Relatable as Norway has the same catch aquaculture rate as total EU-28.
Macfayden et al. (2009)	10%	Around 10% of all marine litter entering the seas is ALDFG (global)	No, very wide geographic scope, also outside EU and no explanation of how to arrive at 10%
Interview Dutch Fisher	1-5%	Annual loss are between 1-5% for Dutch fisheries (trawling with transition to pulse fishing)	No, advanced fisheries with pulse nets and only limited geography

Brown et al. (2007)	1%	"Rates of permanent net loss in European waters appear to be low and typically below 1% of nets deployed […] The total length of nets being set in EU waters is high, and the total length of netting permanently lost may be significant, and the economic, social and environmental costs of gear loss therefore considerable. In addition, there are some specific fisheries operating in deep water where appears to be particular cause for concern about net "loss" and resulting ghost catches." Especially for the latter (deep water net fisheries) 25,080 nets are lost with a length of 1254km (Hariede et al., 2005), which is for the length six times more than all losses and for the number three times than reported by FANTARED 2 (2000) for Sweden, UK, Spain, Mediterranean, French North and West Brittany as well as French North sea and East Channel as well as selected Norwegian net fisheries.	No, only loss of full nets registered as well as no wear and tear, loss of net mending and illegal dumping. Further, only reviewing static nets. -> underestimation
FANTARED (2000)	1%	Around 1% of nets are lost (registered loss of full nets) and not retrieved annually (by extensive interviews with fishers from Sweden, UK, Spain, Mediterranean, French North and West Brittany as well as French North sea and East Channel as well as selected Norwegian net fisheries)	No, only loss of full nets registered as well as no wear and tear, loss of net mending and illegal dumping. Further, only reviewing static nets -> underestimation
Open Stakeholder Consultation			
Open Stakeholder Consultation (Gillnet loss at sea/year)	1% 11% 54% 6% 2% 26%	All (Fishers only 0%) Most (Fishers only 6%) Some (Fishers only 44%) Hardly any (Fishers only 25%) None (Fishers only 13%) Do not know (Fishers only 12.5%)	Yes, good indication that majority believes some rather than hardly any or no nets are lost annually
Open Stakeholder Consultation (Trawl loss at sea/year)	1% 6% 48% 19% 2% 25%	All (Fishers only 0%) Most (Fishers only 0%) Some (Fishers only 33%) Hardly any (Fishers only 50%) None (Fishers only 5%) Do not know (Fishers only 11%)	Yes, however majority of fishers believes that hardly any nets are lost
Open Stakeholder Consultation (Gillnet discarded at sea/year)	1% 7% 36% 14% 7% 33%	All (Fishers only 0%) Most (Fishers only 0%) Some (Fishers only 47%) Hardly any (Fishers only 7%) None (Fishers only 40%) Do not know (Fishers only 7%)	Yes, good indication that majority believes some rather than hardly any or no nets are discarded annually
Open Stakeholder Consultation (Trawl discarded at sea/year)	1% 5% 34% 35% 10% 35%	All (Fishers only 0%) Most (Fishers only 0%) Some (Fishers only 35%) Hardly any (Fishers only 18%) None (Fishers only 29%) Do not know (Fishers only 18%)	Yes, good indication that majority believes some rather than hardly any or no nets are discarded annually