MARELITT Baltic

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WP3 Report

Strategies for preventing gear loss in the Baltic Sea

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Abstract

This study is part of the MARELITT Baltic project with an aim to identify methods or ways to reduce the gear loss rate in commercial fishery in the Baltic Sea. The study was narrowed down to focus on bottom rigged gillnets to both enable an in-depth study of the characteristics of the gear loss phenomenon and look at one of the worst gear types causing "ghost fishing".

Today, the Baltic Sea fisheries are undergoing a major restructuring. To better understand its impact on gear loss, the study was initiated by assessing *a fishing strategic context,* which was used to characterize the problem and frame the need for prevention. Using the gained fishing strategic knowledge, the aim was then to look for relevant and efficient solutions to achieve the objective.

The results indicate a declining trend in gillnet fishing effort. The reduction was found to be regionally differentiated. In some fisheries there is over 85% less gear in use compared to the 1990s. In other areas, the decrease is lower, but experts expect the downward trend to continue.

Just like the substantial variation in fishing effort, gear loss also showed a marked regional variation. In areas with low fishing effort (Estonia, Sweden), gear loss rate was found to be low or even negligible. Based on gained information, the gear loss rate in Germany has also dropped. In these three cases the remaining gear loss is either accidental (due to ice or incidental conflicts with recreational vessels) or deliberately caused by wreck fishing. In Poland, unpredictable snagging of nets on seabed objects was considered a major cause of gear loss. In combination a higher effort, gear loss is probably still a problem. Due to highly varying preconditions and general poor economic conditions with no sign of improvement, there were substantial differences in the willingness of fishermen to discuss prevention.

The studied DFG problem is multidimensional and probably cannot be solved by introducing one or two separate prevention methods. Clearly, regionally/nationally optimized strategies are needed. To secure a mutual basis for these strategies, the study recommends a two-step strategic tool. This tool offers a possibility for a gradual, regionally optimized transition from mitigation based purely on curative measures to one using both preventive and curative measures.

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1. Introduction

Abandoned, lost or otherwise discarded fishing gear (ALDFG) also called DFG (derelict fishing gear) is addressed worldwide as a source of marine litter with extensive hazardous effects on the marine ecosystem. Of all plastic litter present in the seas, 27% (EU Single-Use-Plastics Directive proposal) is estimated to be fisheries related. DFG is known to catch fish, marine mammals and in shallower coastal waters even birds. In turbid water, like the Baltic Sea, nets already in relatively shallow (30-40m) water, have proven to maintain their catching efficiency for years, probably for decades (Tschernij, Larsson, 2003). In dragging actions carried out by MARELITT Baltic during 2017-2018, nets that were 20-years old, or even older, were retrieved, in some cases with fish catch, both in Polish and Swedish waters (Predki P., Kalinowska M., Migdal S. 2019). Furthermore, nets entangled on shipwrecks can become deadly traps, not only for fish but also for divers. In addition, DFG that is covering wrecks or is left unmaintained on the open seafloor will gradually disintegrate into microscopic particles, which are today known to be absorbed in the food chain and eventually become a health risk not just for marine species but also for humankind.

The aim of the INTERREG-financed (R1.121/#R015) MARELITT Baltic project (2016-2019) was to improve capacity in the Baltic Sea Region to mitigate the DFG problem. This goal was planned to be achieved through the inclusion of all the key DFG mitigation actions; development of mapping and removal methodologies, improvement of reception and handling facilities in harbours and identification of sustainable waste management schemes including recycling options.

Today, it is estimated that 5.000 to 10.000 gillnets and trawls are lost every year in the Baltic Sea (Kasperek S., Prędki P., 2011). Obviously, if the aim is to find a sustainable long-term solution for mitigation of the DFG problem in the Baltic Sea, one of key objectives must be a marked future reduction of the gear loss rate during fishing operations.

1.1 Aim of the study

The aim of this study was to identify, develop and discuss efficient and relevant prevention measures or strategies for the reduction of fishing gear lost during fishing operations in the Baltic Sea. The chosen approach was based on an attempt not just to compare prevention method options but instead place the focus on the presumptions considered to frame the fishing strategic context in which the relevant prevention methods are expected to be implemented. Based on an improved understanding of the challenges involved, it was hoped that the project partners together with identified national key stakeholders would have better possibilities to identify and

discuss efficient, practical prevention methods that were acceptable to the fishing sector, in order to achieve the future goal of reducing the gear loss rate.

1.2 Scope and limitations

The focus of the study was on the reduction of fishing gear loss *during fishing operations*. The dumping of worn-out or otherwise discarded fishing gear is not included in the scope of the study. A key assumption for an *active* reduction of gear loss is that fishermen are, through strategic fishing decisions or technological solutions, able to manage the risk of losing their fishing gear. Furthermore, in cases where fishermen are found able through active choices to influence gear loss, the next question would be: what would be their terms for doing so?

In the MARELITT Baltic project, one of the guiding principles was to put the fishing sector in a key role during the entire project implementation. Fishermen have been part of the methodological development, planning and execution of sea activities as well as the interpretation of results. Their contribution, especially in the development of mapping and retrieval methodologies, has been crucial. The aim of the broad and deep involvement of fishermen was twofold; first to earn the trust of fishermen and secondly to build a mutual understanding of the challenges involved generally in mitigation of the DFG problem and especially regarding the aim of reducing gear loss during fishing operations.

Geographically, the work was planned to involve four case studies (Estonian west-coast, Germany, Poland and southern Sweden). The work was nationally coordinated by Keep Estonian Sea Tidy, WWF Germany, WWF Poland and the Municipality of Simrishamn. The requested fishing effort data (from logbooks) was received in Poland and Sweden, whereas in the two other cases (Estonia and Germany) only catch data was accessible. A standardized and optimized fisherman survey was carried out in three of the four cases; in Estonia, Poland and Sweden.

A wide range of fishing gear is used in the Baltic Sea. In the southern part, the dominant gear types are trawls (demersal and pelagic) and gillnets, which today are to a great extent bottom-rigged, because drift nets were banned by EU in 2008. In the northern part, commercially important gear types are pelagic trawls, demersal trawls, which are used only in restricted areas, gillnets (floating, semi-floating and bottom-rigged), traps and larger fyke nets used in coastal waters or in archipelagos. A decision was taken to narrow the scope of the study and to focus on one gear type – bottom-rigged gillnets. This gear type is common in all parts of the Baltic Sea and was by far the most common gear used in the southern Baltic sea when the fisheries peaked in the 1980s and 1990s. It is also considered to be the gear

type with the highest likelihood to be lost and if lost it is also a gear type that has a big impact (Huntington T, 2017). Moreover, because of the chosen approach to look at the fishing strategic context in relation to gear loss, focusing on one gear type was expected to provide the best knowledge to understand the challenges and thus identify not just efficient but hopefully also acceptable methods for active reduction of the gear loss rate in commercial fishery in the future.

2. Material and Methods

The initial methodology drafted by the MARELITT Baltic project group was adjusted and complemented during an international expert group workshop in the early autumn of 2016 organized by WWF Poland in Warsaw. Present were scientists from Poland and Sweden, fishing gear manufacturers from Poland and fishermen from Germany, Poland and Sweden.

The planned work can be divided into two phases:

1) Definition of fishing strategic context with preconditions for possibilities to reduce gear loss
    a. Assessment of fishing effort
    b. Assessment of reasons behind gear loss
2) Identification of methods to reduce gear loss in the future

2.1 Definition of fishing strategic context

Today, the Baltic Sea fisheries are undergoing a major restructuring. It was already clear in 2015, while writing the MARELITT Baltic project proposal, that all the major fleet components; coastal fleets using passive gear (gillnet, long-line), and demersal and pelagic trawler fleets were all developing but in different ways. To assess how this structural evolution together with accelerating technological development has impacted on the preconditions in gillnet fishing and gear loss, the study was initiated by defining *a fishing strategic context*. To establish this baseline, we decided to focus on two key parameters a) changes in fishing effort and b) reasons contributing to gear loss.

2.1.1 Assessment of fishing effort

The assessment of changes in fishing effort was based on a time series. Basically, the idea was to calculate the total amount of gear used per year and then compare it with by selecting three years from a period extending from around 1995-97 to 2015-16. The first of the years were to be selected around 1995-97 (as soon after the "cod boom" as possible), the second year was set to 2005-07 and the third and last year according to the latest accessible dataset preferably at least ten years after 2005-07. Data was

derived from official fishing logbooks with entries for: year, month, vessel (anonymized code), longitude and latitude, length or amount of fishing gear and catch (optional).

A request for the data was sent to Estonian, German, Polish and Swedish authorities through national project partners Keep Estonian Sea Tidy, WWF DE, WWF PL and the Marine Centre (Municipality of Simrishamn).

The requested data was delivered by the Polish and Swedish authorities. In the case of German data, the authorities do not have permission from the fishing sector to deliver data containing detailed information on the fishing effort covering hours at sea or length of static nets placed in specific fishing areas. Instead, and requested by European Law, the fishing effort is collected and available in the form of catch amounts aggregated per ICES rectangles. Estonian authorities do not collect fishing effort data. Instead, aggregated catch data was received from Estonia as well.

The Polish data contained years; **2007** (41.700), **2012** (38.600) and **2014** (43.300) and respectively the Swedish data: **1997** (37.600), **2007** (25.100), **2014** (20.900) and **2016** (19.700). The numbers in brackets indicate the amount of individual data entries (=fishing events/sets of nets) for one year.

The German gillnet catch data was not given per fishing event but instead aggregated per statistical ICES rectangle including the years: **1995** (35), **2002** (33), **2007** (56), **2012** (58) and **2015** (49). The numbers in brackets indicate the amount of data entries.

The Estonian catch dataset, also aggregated per fishing statistical rectangle, was delivered for years; **2009**, **2010**, **2011**, **2012**, **2013**, **2014**, **2015** and **2016**.

The principle for determining the amount of fishing gear exposed to a risk of becoming lost was based on *a fishing event*. From the time a vessel shoots its gillnet fleets until, after one or two days, it hauls them onboard, is considered as a fishing event. While the net fleets are in the water, they are considered in principle to be potentially exposed to a risk of becoming lost. The more often the nets are deployed, alternatively the longer the net fleets are, or both, the higher the risk that they will be lost. By totalling the net length (km) used in all reported *fishing events* for one year, a number is derived representing the accumulated length of netting used in a fishery thus exposed to a hypothetical risk of becoming lost.

In practice, the relation between the amount of netting used and the risk of gear loss is not linear. This fact will become obvious when we study the second selected parameter; reasons leading to gear loss. However, the total amount of gillnets in water per year is a simple and illustrative indicator to study changes in fishing effort between years as well as differences

between regions, or between countries, as in this study they happen to be equivalent.

2.1.2 Assessment of reasons causing loss of fishing gear

The objective of this assessment was to examine and determine reasons why fishing gear is lost during fishing operations. An attempt was also made to assess how frequently gear loss occurs. It was assumed that the reason might be both area and time-related. The area (=region) component was made tangible by separating data by country. A method to study changes over time was also applied in this case by dividing the examined time window into two periods;

1) Historical; including time before 1995-1997 including the period when fishing (catches) peaked during the "cod boom"
2) Present; including period (after "cod boom") starting from 1998 and extending to 2016

The needed data was planned to be collected using a fisherman survey. During a joint methodology workshop for MARELITT Baltic work package 2 (mapping and cleaning activities at sea) and 3 (prevention), a decision was made to run the survey jointly using one common questionnaire (appendix 1). Because some of the data needed in the two work packages was found to be interrelated, a joint survey seemed more cost-effective, thematically appropriate and time-efficient for both fishermen and the project group. An international expert group from the MARELITT Baltic project listed the most common reasons contributing to gear loss, (see chapter 3.2 Reasons for gear loss) which were added as options in the questionnaire.

During preparation and after initial consultations with the fishing sector, project groups identified crucial differences in preconditions for the planned survey in the three participating countries (Estonia, Poland and Sweden). It was decided that national teams would adjust the questions and optimize survey methodology to guarantee the best result in all targeted countries.

Estonia. Keep Estonian Sea Tidy translated the questionnaire to the native language and partly adapted it to prevailing preconditions. The questionnaire was sent to the managers/chairs of the three most important FLAGs (fisheries local action groups) in Estonia, which then distributed the questionnaire to all members. The contacted FLAGs are Hiiumaa, Saaremaa and Pärnumaa. There is no exact figure on how many fishermen received the questionnaire, but no questionnaires were returned. Later, when the project group members participated in local meetings, about 65-70 fishermen were individually interviewed and motivated to answer the questionnaire. This resulted in 50 validated answers. Some additional

questionnaires were emailed after the meeting giving 9 more answers. The total number of validated answers was 59.

Poland, WWF Poland translated the questionnaire to the native language and 70 copies were printed out and presented to a hand-picked group of fishermen during 3 meetings (Władysławowo, Kołobrzeg and Ustka) in November 2016. This directed effort resulted in 70 validated answers. Fishermen filled in the questionnaires on the spot during the meetings. Prior to filling in the questionnaire, the project group members explained each question to the participating fisherman.

Sweden. Marine Centre (Municipality of Simrishamn) translated the questionnaire into the native language. Due to a dramatically decreased gillnet fleet, many of the fishermen previously active in the targeted area had already stopped fishing or were thinking about stopping. Based on several consultations with a contracted expert group of four full-time fishermen, a plan was set to arrange 3 regional dialogue meetings (fig 1).

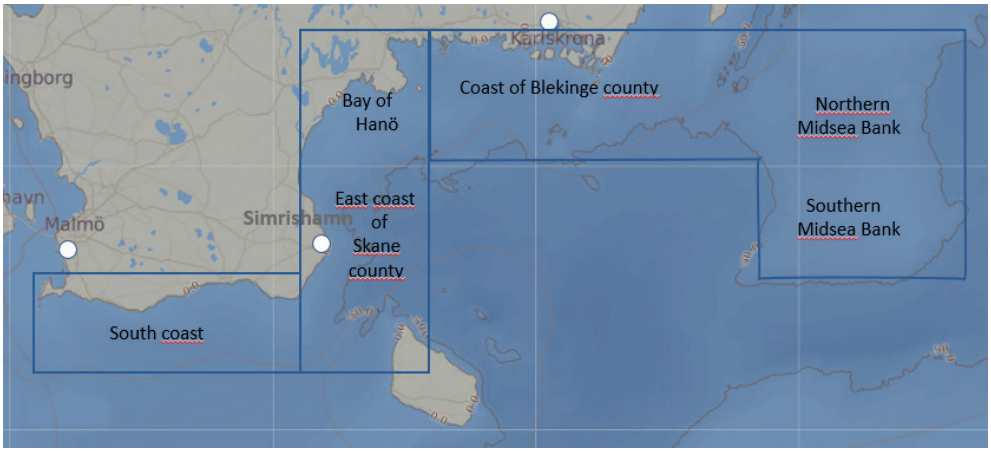


Figure 1. A map illustrating the planned geographical coverage of the three regional dialogue meetings aiming to collect data on reasons for gear loss and to generally discuss the DFG problem.

The first meeting was planned to be held in Malmö, focusing on the Swedish south coast, but was cancelled due to no confirmed participants. The second meeting was held in Karlskrona (Feb 17th 2017) for the fishing sector active in the eastern part of Blekinge county and in a large off-shore fishing area called Midsea Banks. The third and last meeting was arranged in Simrishamn (Feb 21st 2017) with representation from the eastern coast of Skane county and inner part of the Bay of Hanö. The missing results from the cancelled Malmö meeting were compensated by inviting fishermen to the Simrishamn meeting. The number of participants at the two meetings was 17, of which 10 were fishermen. The rest were regional and local authorities. In addition, 56 questionnaires were sent to a hand-picked group of active fishermen from the same regions covered by the regional dialogue meetings. 14 (25%) questionnaires were returned. In total, the

survey resulted in 31 validated answers. This result is to be considered a high representation of the active gillnet fleet, which today is estimated to consist of 25 to 30 vessels within the study area.

The project group also met the Swedish Coast Guard (SCG) on Feb 10th 2017 in Karlskrona, initiating a dialogue between SCG and the project. The project and future mitigation options for the DFG problem were discussed.

Germany: The questionnaire was translated into the native language by WWF Germany and distributed to the fisheries associations in Freest (Associated Partner in MARELITT Baltic), Fehmarn, and to the fisheries union of Eckernförde. The fisheries association Fehmarn is affiliated with the distributor Kutterfish, one of the largest fish producers in Germany. In addition, individual fishermen in the Mecklenburg-Vorpommern area were also asked in the fishing harbours of Warnemünde and Greifswald-Wieck to provide input. Although the questionnaire was anonymous, and the survey was promoted by the leading presidents of each association, the member fishermen did vote against filling out reasons and amounts of gear loss. In individual face-to-face meetings, only one retired fisherman was willing to fill out the questionnaire. Hence no statistical conclusions could be derived in Germany and no recent data on gear loss was provided by the fishing sector. Nevertheless, the current reasons for gear loss were expressed verbally by fishermen and the fishing control authorities in face-to-face meetings and will be included in the discussion below.

2.2 Development of methods to decrease gear loss in the future

After finalizing the first phase of this study, the obtained results were discussed at an international multiplier meeting and target group conference in Kolobrzeg/Poland in October 2017. A decision was made to continue the work on a regional/national basis using the defined prevailing preconditions as a starting point. The last (second) phase was executed in Estonia, Poland and Sweden, again using different, nationally optimized working processes.

2.2.1 Working process in Estonia

During the MARELITT Baltic project, the Estonian partner (KEST) has had regular contacts with 6 FLAGs (fisheries local action groups) in Estonia (Harjumaa, Hiiumaa, Läänemaa, Pärnumaa, Saaremaa and Virumaa). Moreover, KEST has met all active members of the three most dominant FLAGs from a historical and geographical perspective (Hiiumaa, Saaremaa and Pärnumaa). KEST has had a regular and fruitful dialogue with several key authorities e.g. Department of Fisheries Protection of the Estonian Environmental Inspectorate, Fishery Resources Department of Ministry of the Environment of Estonia, Marine Department of the Ministry of the Environment of Estonia and Estonian Maritime Administration.

Fruitful dialogues have been held with both fishing sector representatives active in FLAGs and the above-mentioned authorities during larger conferences and back-to-back or individual meetings. As Estonia is a small country, the field personnel of the Environmental Inspectorate have frequent contact with all professional fishermen, which provides invaluable, transparent contact with the existing problems regarding fishing in Estonian waters. For some time, even before MARELITT Baltic, prevention has been one of the common issues discussed widely in Estonia.

2.2.2 Working process in Poland

The Polish project group has arranged several national workshops for the fishing sector during implementation of the MARELITT Baltic project. Two meetings were held in Poznań (2018 and 2019) with fishermen, fishing gear producers and fisheries inspectors regarding prevention methods (using RFID gear marking). A further two meetings were held in Kołobrzeg (2017) with fishermen and Kołobrzeg Fish Producers Group focusing on selection of fishing methods (e.g. shooting nets in wreck areas). Useful information was gathered mostly during unofficial conversations. No notes were made during the meetings. On several occasions, attempts were made to discuss prevention issues and questions such as whether a reduction of gear loss during fishing operations was considered possible and if there were efficient measures that would be acceptable to the fishing sector.

2.2.3 Working process in Sweden

The results from phase 1 were communicated to national key target groups (fishing organizations, fishing authorities, control authority and MSC). A strategic question of how to continue the work was raised. According to the initial plan described in the MARELITT Baltic application, measures to reduce gear loss would be discussed using several identified alternative approaches. Among the suggested methods were use of new technologies, changes in fishing gear construction, fishing strategy and legislative measures. Furthermore, the possibility of implementing a voluntary approach to support responsible fishermen ("Responsible Fisheries Scheme") was to be assessed.

As a dramatic reduction in both gillnet and bottom trawl fishery is today an unquestionable fact in the study area, the fishing sector unanimously considered ghost fishing in the targeted part of Swedish waters (ICES SD24 and 25) as a historical problem. Discussions with the fishing sector and fishermen revealed that a further reduction of gear loss in Swedish fishery probably cannot be achieved through law and enforcement but instead by methods encouraging fishermen to choose fishing strategies that help to reduce the risk of gear loss. Moreover, it was suggested that an efficient way to elaborate prevention-related topics would be a *roundtable dialogue*, involving all key target groups; the fishing sector, fisheries and water

administrations as well as the control authority. Because all involved parties accepted roundtable discussions as the way forward, the Swedish project group arranged a one-day workshop, which was held on 10th February 2018 in Simrishamn. For participants, agenda and summary report, see appendix 2.

The Swedish partner has also been involved in drafting a preliminary national DFG policy document for the Swedish Marine and Water Management Agency. The formulation of this policy document has been based on the results from the MARELITT Baltic project and several national projects carried out on Sweden's west and east coasts. The policy document includes strategies to reduce gear loss in all user groups (commercial, recreational and sport fishermen).

3. Results

3.1 Changes in fishing effort

Based on the available data, the largest annual gillnet fishing effort in Poland is found in 2007 (the oldest available dataset). That year, the Polish gillnet fleet (605 vessels) used more than 41.000 sets, applying an effort corresponding to over 171.000 km of netting per year. The largest gillnet effort in Sweden with more than 123.000 km of netting (37.600 sets, 482 vessels) is found 10 years earlier than in Poland in 1997 (also the oldest available data). In Germany and Estonia, we can study changes in anticipated effort by looking at changes in catch levels. In Germany, the catches peaked in 2007 with an annual catch of 1.200 tons. The highest catches in Estonia (1.200 tons) were found in 2014. Corresponding changes in gillnet effort are not necessarily linear to changes in catch level but can be used as an indicative factor. We can get a rough estimate of the assumed effort by converting catch to effort using Swedish data (caught kg/km used netting) giving an average unit catch of 80 kg/km. Using this unit catch, the highest catch levels of 1.200 tons (2007 in Estonia and 2014 in Germany) were obtained using around 15.000 km of netting and the lowest reported catch levels (600 tons) in Germany (2012-2015) applying an effort corresponding to 7.500 km of netting (fig 2).

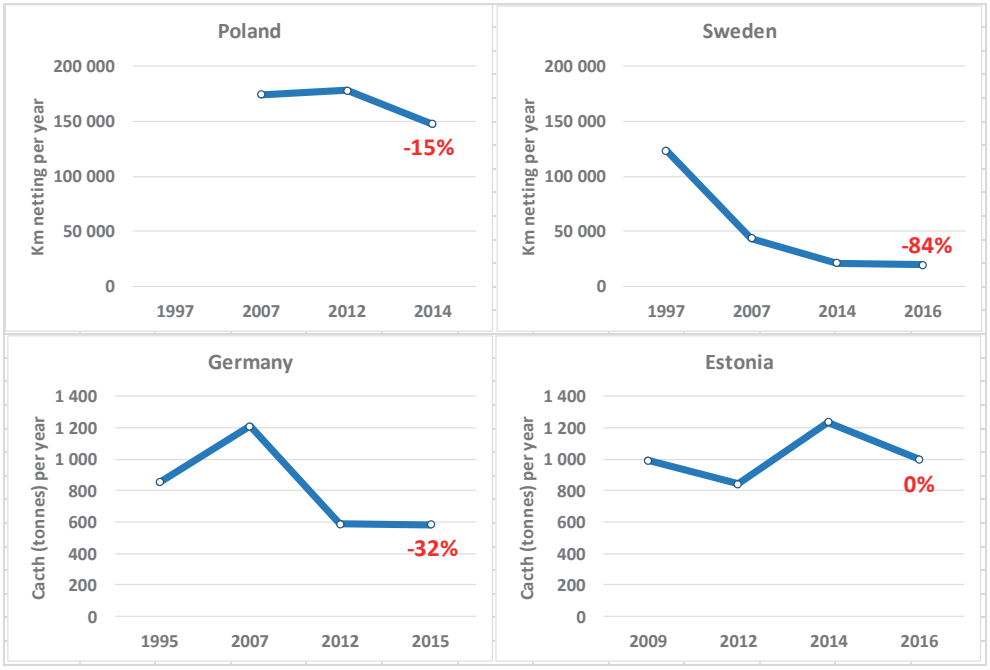


Figure 2. The development of fishing effort in terms of the amount of netting used per year by the Polish and Swedish fleets and in terms of the total landed annual catch for the German and Estonian gillnet fleets.

The overwhelmingly biggest and clearly systematic change in fishing effort can be observed in the Swedish gillnet fishery. The annual amount of used netting was reduced by -84% from 1997 to 2014. Between 2014 and 2016 the applied effort seemed stable but according to the latest information the reduction has continued in 2017-2018, and in 2019 the remaining gillnet effort seems extremely low. In the Polish fishery, there is no change in effort between 2007 and 2012 but after that we can see a clear reduction between 2012 and 2014 (-15% in two years). The Polish gillnet fishing effort has continued to shrink year after year after 2015 more or less for the same reasons as in Sweden (low prices, increasing damage to catches caused by grey seals) (pers. com. Kasperek, S. Inspector of Sea Fisheries, Szczecin). German data suggests an overall drop of -32% when compared to the 1995 level, but a larger decrease of -50% since the observed highest level in 2007. In Estonia, the catch levels have fluctuated between plus and minus ca 20% but in 2016 the total catch was again at the same level as in 2009 (appendix 3). These trends already provide a strong indication of marked regional differences in the development of fishing effort in the four studied cases.

3.2 Reasons behind gear loss

The international experts present at the first MARELITT Baltic methodology workshop in Warsaw in 2016 named the following causes as the most prominent contributors to gear loss in the covered part of the commercial Baltic Sea fishery.

Morphological objects on the seafloor e.g. rocks or "hooks". Fishing gear loss caused by snagging on seabed objects such as larger rocks, as well as all type of underwater obstacles (in Poland commonly called "hooks") was considered one common reason.

Fishing close to or on shipwrecks. Gillnets are sometime set close to or even directly on shipwrecks with an aim to increase the catch. It is commonly known that wrecks constitute ideal habitats for large, economically more valuable fish. Cheaper netting is often used to compensate for the increased risk of expected damage to the nets. In the past, say more than 15-20 years ago, it was not unusual for trawls to be snagged on wrecks as well. Today, modern trawls are expensive and due to more precise GPS navigation, advanced hydro-acoustic instruments e.g. side-scan sonars tuned to detect a wreck in combination with a real-time trawl monitoring system, trawl skippers can easily get close enough without having physical contact with a wreck. On the other hand, using GPS and a modern eco-sounder, a gillnet fisherman targeting wrecks can more easily locate a wreck and shoot the net fleets according to their plan.

Various conflicts. Due to increased competition in economically valuable fishing grounds between fishermen using different fishing techniques (passive and active gear), as well as the rise in traffic at sea of mercantile and recreational fleets, there has been an increase in the number of conflicts that lead to gear loss. Two type of conflicts can be identified; a) conflicts between bottom trawl and gillnet fleets and b) in some areas, e.g. round Bornholm, conflicts between mercantile and gillnet fleets. Along the German coast, recreational vessels are also reported to cut off flags/surface markers and buoys. In both cases, rope from the surface marker/flag can snag on the vessel and be towed away an unknown distance and eventually be left somewhere along the route of the vessel. In these cases, it will be almost impossible for the fisherman to relocate and drag for the gear. On the other hand, if the rope between flag and net fleet gets snapped, the fisherman can almost without exception recollect and retrieve their gear using GPS positioning. According to fishermen, today they always try to retrieve a lost net.

Environmental factors. Fishing gear loss caused by environmental factors was one of the reasons pointed out by fishermen from all four countries. Fishermen from Estonia considered ice as a typical environmental factor, whereas Swedish and Polish fishermen indicated strong currents as a potential factor causing fishing gear loss. Although less common in the southern Baltic, the German fisheries control authority has also reported ice as a reason for gear loss (in this case, gillnets).

Other reasons. Theft and sabotage were listed as typical reasons.

In total, 160 fishermen from Estonia, Poland and Sweden were interviewed. The results, categorized between historical and present, and according to the above-listed factors, show that seafloor objects are the most common reason for gear loss with a small margin to the next important category of factors (conflicts). This overall result seems to roughly cover all the three included regions (countries) but in Estonia it is not possible to pinpoint one single reason as clearly as in Poland or Sweden (table 1). Germany is not included in the statistical comparison because fishermen did not provide written answers to the questionnaires.

Table 1. A table summarizing the results of the fisherman survey conducted in Estonia, Poland and Sweden based on 160 interviews.

	Estonia		**Poland**		**Sweden**		
Factors	Past	Present	Past	Present	Past	Present	Total
Seabed objects	-	**29**	**47**	**40**	21	21	158
Conflicts	-	**26**	19	27	**40**	**43**	155
Shipwrecks	-	9	24	23	16	19	91
Environment (strong current)	-	0	9	10	14	12	45
Environment (ice)	-	**23**	0	0	0	0	23
Environment (wind/waves)	-	14	0	0	0	0	14
Other reasons (theft, sabotage)	-	-	-	-	9	5	14

Using the applied categorization, the third most common reason in Estonia (ice/winter fishing) revealed that *region* as a parameter can clearly characterize the ghost fishing phenomenon, which in this study happens to correspond to country. In the case of Estonia, it is ice, which is a typical environmental factor not regularly present in the southern Baltic Sea. However, thanks to the strong involvement of the Polish and Swedish fishing sector, it was also possible to identify and understand regional differences in DFG distribution in cases with seemingly similar fleet structure, gear composition and geographical location (southern Baltic Sea).

An illustrative example of how valuable the fisherman input can be to understand the DFG problem is the fact that despite a concentration of Swedish gillnet fishery in fishing grounds with a hard and rocky seabed, seabed objects (e.g. rocks) are not considered the most common reason for gear loss in Swedish waters. Polish fishermen on the other hand, fishing on a softer, smoother and sandy seafloor, do experience snagging on seabed objects as the most important reason. They also indicate that shipwrecks constitute a serious problem. During the study, Polish fishermen have indicated that snagging of nets on seafloor objects is unpredictable in Polish waters.

In terms of wrecks, conflict and seabed objects, it seems that Swedish fishermen reported conflicts (with other than fishing vessels) as the most important cause of gear loss, whereas in Poland almost 2/3 of losses are caused by seabed objects and wrecks.

In terms of differences between past and present, the results do not reveal any marked changes. Two of the most prominent changes concern Poland. The seabed object as a cause for gear loss has dropped from 47 to 40%, whereas conflicts have increase from 19 to 27%.

In Germany, the fisheries control authority pointed to a coastal ice incident that led to substantial gillnet losses in an area near the border with Poland, which has probably affected fisheries in both countries, although it was not explicitly mentioned by Polish fishermen as a reason for gear loss. During verbal interviews, fishermen indicated conflicts with other vessels as the major reason for gear loss in German waters today. Both mercantile vessels operating outside shipping fairways and recreational vessels are mentioned as reasons for gear loss. In both cases, the flags and buoys are driven off and gillnet segments are dragged to unknown locations, such that they cannot easily be recovered even when the loss position is reported. Conflict between different types of fisheries is not an issue in German gillnet fisheries, because the gillnet and trawl fishing areas are separated. Gillnets can be set within the 3-nautical mile zone along the coast and on shallow banks, while trawls are only allowed to operate outside the 3-nautical mile zone. Trawls are also excluded from shallow sand banks as protected areas.

Answers to the question of how often fishermen experience gear loss reveal the unfortunate fact that fishing gear loss in some cases is still a problem today. A clear majority of the interviewed Polish fishermen admit they lose nets from time to time (table 2).

Table 2. A table showing how often the interviewed fishermen experience gear loss.

Country/region	Less than once/year	Once/year	Once/ Month	Never	Total
Polish	22	**30**	12		70
Swedish	**4**	2	-		24
Estonian	4	-	1	**18**	59

Of 70 interviewed Polish fishermen, 64 (91%) answered that they lose nets once or less than once a year. 12 out of 70 (17%) fishermen estimated that they lose nets once a month. The corresponding share of Swedish fishermen losing nets once or less than once a year was 25% (6 of 24 interviewed). In Estonia, very few of the interviewed commercial fishermen (5 out of 59 = 8%) lose gear. 18 (30%) of the fishermen answered that they

never lose gear. Note that 6 Polish, 18 Swedish and 36 Estonian fishermen did not provide an answer. The reason was either that in their case the number of lost nets was probably more than "never" but was less frequent than "once a month" or another reason could be that they refused to answer.

A higher estimated gear loss rate in a region should logically correlate with a higher probability of retrieving newly lost nets. This assumption was verified by the randomized retrieval results gained during MARELITT Baltic's dragging activities in 2017-2018. In Poland, 19% of recovered nets were 5 or less than 5 years old and 51% were between 5 and 10 years old. In Sweden, the corresponding figures were 0.3% and 3% respectively meaning that over 96% of nets found in Swedish waters are more than 10 years old (Predki P., Kalinowska M., Migdal S. 2019).

3.3 Preconditions for reduction of gear loss

The first planned intermediate output of our study was a determination of a fishing technological and strategic context framing the preconditions that theoretically define the type of methods that can be used to reduce gear loss in commercial fishing fleets using bottom-rigged gillnets.

This study focused on two factors; *fishing effort* and *reasons for gear loss.* Because both showed a clear regional variation, it is justified to believe that they are shaping not just the characteristics of the DFG problem but logically also framing the efficient methods for how to reduce the amount of fishing gear lost during fishing.

This general but important discovery of a marked regional variation in the DFG problem was also backed up by work package 2 of the MARELITT Baltic project, focusing on mapping of DFG host areas. The collected statistical information on fishing effort and morphological data together with fishermen's knowledge of typical environmental factors e.g. *type of seafloor* (rocky or soft), *water current*, *water depth* etc. seem highly decisive when determining typical areas found to host DFG. Also, this new knowledge confirms regional differences as characteristics for the DFG problem.

Table 3 summarizes the studied fishing strategic and technological preconditions in the four included areas; Estonian west-coast, Germany, Poland and southern Sweden.

Table 3. For comparison, we have used year 2014 because it is the latest year for which we have most complete data. In the case of Germany and Estonia we have no official fishing effort data and no data on gear loss from Germany.

Poland		Sweden	
Fishing effort (km netting)	**147 743**	Fishing effort (km netting)	**21 400**
Fleet size (no gillnet vessels)	**621**	Fleet size (no gillnet vessels)	**191**
No of sets	43 192	No of sets	4 842
% of fishermen losing nets	91	% of fishermen losing nets	25
Causes of gear loss	Seabed object, conflicts	Causes of gear loss	Conflicts (other than fish.vessels), seabed objects
Germany		**Estonia**	
Fishing effort (km netting)	n/a	Fishing effort (km netting)	n/a
Fleet size (no gillnet vessels)	n/a	Fleet size (no gillnet vessels)	n/a
No of sets	n/a	No of sets	n/a
% of fishermen losing nets	n/a	% of fishermen losing nets	8
Causes of gear loss	*)Conflicts (other than fish.vessels), weather	Causes of gear loss	Seabed objects, conflicts, ice

*) Not from standardized fishermen survey

Conclusions:

Marked differences in fishing effort and amount of netting used

The amount of netting used by the Polish gillnet fleet in 2014 was almost 7 times (690%) bigger compared to that used by the Swedish fleet. The number of vessels reporting catches according to official logbook data was 621 in Poland, which is over 3 times more than in the Swedish fleet (191 vessels).

We can confirm that the marked reduction in both fleet size and fishing effort has continued in Sweden after 2014. In 2016, the Swedish gillnet fleet comprised 168 vessels (23 fewer in 2 years) using in total 19.800 km of netting (7% drop in 2 years). In 2017, fewer than 20 vessels caught 70% of the total annual landed cod catch caught with gillnets. Moreover, there were no more than 14-15 bottom trawlers fishing actively in the area. The Swedish gillnet fishery has continued to decrease during 2018, and in 2019 it is expected to end at an all-time low level. The number of actively operating Swedish bottom trawlers is reported to be 5-6. Only 10-15% of the annual Swedish share of the TAC in eastern cod stock is expected to be landed. This extreme drop in effort and landings in coastal and active gear fishing has naturally further decreased the amount of fishing gear that is lost. While our study shows radically decreasing commercial fishing, a national report revealed in 2016 that half of the nets found in coastal waters (surveyed 2015) were from user groups other than commercial fishermen (Tschernij, V. 2016).

Unfortunately, we do not have data from Poland after 2014 but according to gained information, the fishing effort has started to decline in Polish gillnet fishery due to the same reasons as in Sweden (low profitability, increasing catch damage caused by grey seals) but also due to financial

compensation from authorities to abstain from fishing (pers. com. Stanislaw Kasperek, Inspector of Sea Fisheries in Szczecin). A dramatic elimination of an entire coastal fishery, as can be seen in Sweden, cannot be excluded as a realistic option in Poland as well. Coastal fisheries in the eastern part of the Polish coast are already dealing with major problems caused by grey seals. In Poland, as well as in Sweden, fishermen are offered an opportunity to receive financial compensation for the economic loss caused by grey seals. In Poland, all fishermen do not report the damage properly, or are not able to report, or they refuse to apply for the provided compensation. Because there is still no plan to restrict the growth of the grey seal population, it is likely that the problem of catch damage caused by seals in Sweden and Poland will gradually increase. The prospect of grey seals continuing to migrate into German waters seems very likely based on developments so far. Thus, it is only a matter of time before German coastal fisheries will be affected, leading to a gradual decrease in fishing effort.

We lack comparable and relevant data from Germany but the clear overall reduction of 32% also indicates a downward effort in German gillnet fisheries. Such a major drop in catch rate must correlate in a clear reduction of the total length of fishing gear used. The German coastal fleet is one of the first fleets in the Baltic Region to have switched from pure commercial fishing to a combination of fishing tourism and traditional fishing. The reduction in catches is probably a reflection of the restructuring of the coastal fleet in Germany. All these factors together and the increased environmental awareness of German fishermen have contributed to the reduced gear loss rate in commercial fishing.

In Estonia, gear loss among commercial fishermen seems to occur rarely (8% of those interviewed reported gear loss). Bottom trawling is not prohibited but is nevertheless not conducted at present due to a strained economy. Estonian authorities point out fisheries groups other than commercial fishermen as more important contributors to gear loss in Estonian waters.

Regional variation in reasons contributing to gear loss.

The most common reason for gear loss in Polish waters is snagging on seafloor objects followed by gear conflicts. 91% of interviewed Polish fishermen experienced gear loss at least once per year. 25% of interviewed Swedish fishermen said that they lose nets less than once per year mostly because of conflicts and snagging on seafloor objects. This result suggests that fishing gear loss is more common and a much larger problem in Polish waters than in Swedish waters. In fact, the randomized retrieval operations carried out by the MARELITT Baltic project in 2017 and 2018 in Poland and

Sweden (ca 2.400 hours per country) resulted more often in finding nets that were less than 5 years old in Polish waters, clearly suggesting that nets are lost more often compared to the studied Swedish waters, for example.

Due to less detailed knowledge on the situation in German and Estonian waters, we are not able to provide a presumptive description of the preconditions for methods aiming to decrease the loss of fishing gear. However, some general conclusions can be drawn from the evidence collected during the MARELITT Baltic project from authorities, fishermen, divers and retrieval teams. According to information derived from Estonian partners, the gear loss rate today in Estonian commercial fishery is at a very low level. Generally, instead, Estonian authorities consider non-professional fishermen as a much more prominent contributor to gear loss. In Estonia, retrieved gillnets were low-quality imports, which suggests that the recreational fishery is responsible for some of the present losses. A similar trend with a recreational component in gear loss is also observed in Sweden, while in both Germany and Poland gillnets are not allowed in recreational fishing. A licence with instructions and requirements on gillnet material quality is not in place in either Estonia or Sweden. Likewise, in Germany, sport vessels are responsible for at least some of the interventions leading to gear loss. Small motor vessels and scooters can be rented without a licence. Hence, awareness-raising measures might have a large impact on loss reduction, as discussed below.

When fishermen have been challenged to mitigate ghost fishing

We have not evaluated whether the occasions when a fishing sector has been confronted with expectations to mitigate the ghost fishing problem have had an influence on the results of this study. However, it is justified to expect that the longer a problem like ghost fishing has been addressed by the media and recognized by a broader public and authorities, the more likely it is that the attitude among fishermen will become more favourable toward mitigation as well as preventive actions. In Sweden, in the region where the MARELITT Baltic project and this study were carried out, the fishing sector has been aware of ghost fishing since 1996, i.e. 23 years this year (2019). One year later in 1997, Sweden became the only country in the Baltic Sea Region to take part in the EU project, FANTARED II, and many of the fishermen became involved in the activities. In Poland, the ghost fishing problem was mentioned in one national scientific report in 1999 but it was not until WWF made the broad public and authorities aware of the ghost fishing problem in 2011, that the fishing sector became seriously involved. This means the period that Polish fishermen have dealt with DFG is 8 years. Our results clearly point to regional differences in the presumptions, magnitude and attitude toward prevention of the DFG problem. The fact that Swedish fishermen have been involved in mitigation

actions almost three times longer than their Polish colleagues could be one reason for a more positive attitude and readiness to seek preventive methods among Swedish fishermen. On the other hand, a dramatic reduction of fishing activities in Swedish waters, which is not yet the case in Poland, has resulted, as we have shown, in less competition between fishermen. In theory at least, less competition means larger catches and better economic conditions, which may have had an influence on the more openminded attitude toward preventive measures among Swedish fishermen operating in the studied area.

Coastal fisheries facing marked economic challenges

Finally, it is important to emphasize that commercial fishing today, especially coastal fisheries in the Baltic Sea, faces substantial economic challenges. Fleets are shrinking, and effort is decreasing in many regions as this study has shown. Unfortunately, due to a steadily increasing grey seal population and the catch damage caused by the seals to the passive gear fleets, not even radically fewer fishermen operating in certain parts of Baltic Sea can guarantee the needed catch rates to secure satisfactory economic conditions. Poor economic conditions, in combination with no clear sign of an improvement in the future, do not motivate fishermen to focus on topics like prevention.

3.4 Recommended methods to reduce gear loss

In Estonia, a result of a long and still ongoing dialogue between the fishing sector and the responsible fisheries and environmental authorities is that the main problem in terms of gear loss within the Estonian waters in the Baltic Sea is not caused by professional fishermen. This observation is based on close contact between a small fishing sector and field personnel working for the authorities. The Estonian results of our fisherman survey (8% of fishermen experience gear loss) justify this common understanding. If a net would be lost due to e.g. rough weather, attempts are made to retrieve the net. If the net is not recovered by the fisherman, it will eventually be driven to the shore by waves and currents, due to an open coastline and dominating SW winds.

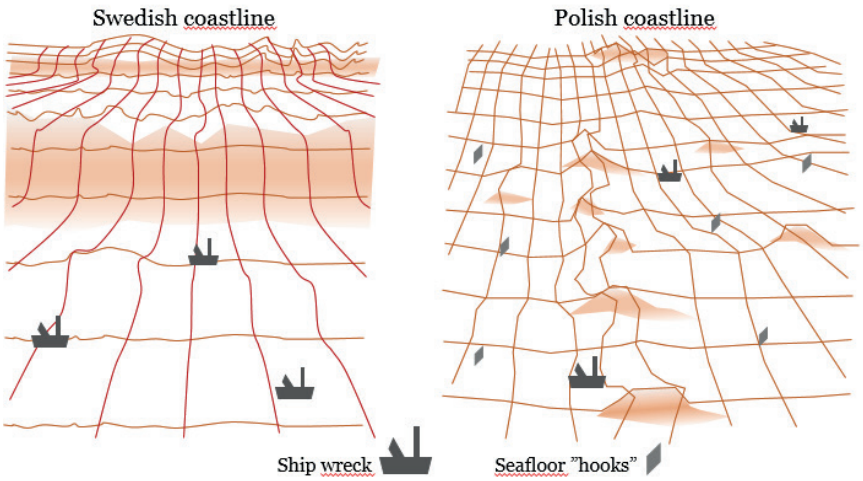
Moreover, bottom trawling is not prohibited in Estonia but at the moment, due to low profitability, it is not conducted in Estonian waters, thus gear conflicts between passive and active gear and incidents where trawls snag on shipwrecks are very rare today.

Thanks to an open and transparent dialogue, Estonian authorities know that those responsible for most incidents causing gear loss in Estonia are illegal or recreational fishermen. These groups normally use low-quality gillnets imported from the Asian market and pay little attention to whether a net is lost or not, partly because of the low monetary incentive to retrieve

the net. Because the MARELITT Baltic project was not structured to address these target groups, no specific attention was paid to matters other than commercial fishery-related issues.

In Estonia, improved gear marking and lost gear reporting together with enhanced retrieval procedures and education to raise awareness of the damage that DFG causes to the marine environment often with socio-economic effects, are found to be the best recommended measures to gradually reduce gear loss during fishing. The Estonian Environmental Inspectorate is currently implementing this long-term strategy in co-operation with other national partners and KEST.

In Sweden, in the investigated area, the gear loss rate today is already very low. In fact, it was considered mainly to be a historical problem. Due to a small fishing fleet and thus dramatically reduced fishing effort, the need for active and passive fleets to operate close to each other or from time to time even share the same fishing grounds, is no longer necessary. In general terms, the geographical pattern of Swedish passive and active fishing effort was found to be more structured and less mixed compared to that of the Polish fishing pattern (fig 3), logically contributing to less conflicts (Predki P., Kalinowska M., Migdal S. 2019). Even looking from a historical perspective (period 1990s-2000s) conflicts between passive and active fleets were mainly a problem between Swedish trawlers and foreign gillnet vessels. The few interventions today leading to gear loss occur mainly in two restricted sea areas (west of Bornholm and east of a large island, Öland) between multinational mercantile vessels and the Swedish gillnet fleet. These two areas are pointed out as "hot spots" by the MARELITT Baltic project (Predki P., Kalinowska M., Migdal S. 2019).



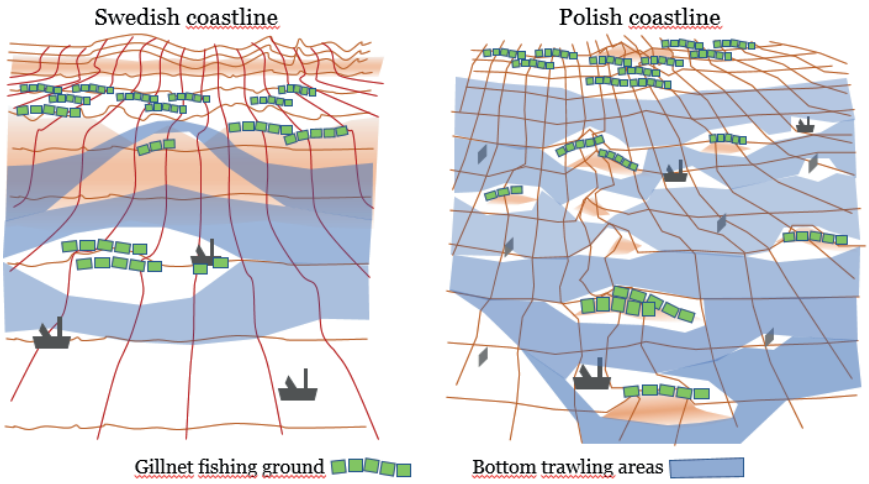


Figure 3. A schematic illustration of the differences between the Swedish (to left) and Polish fishing patterns and the way active and passive fleets are operating. In Sweden, the fleets using passive and active gears are operating in a pattern which is much less mixed and more clearly separated, often by morphological shapes e.g. steeper slopes. In the Polish area, the seafloor is mostly sandy and smooth with fewer natural formations to separate gillnets from bottom trawling. The result is a more mixed overall pattern with a higher risk for conflicts. Moreover, according to obtained information, the "seafloor hooks" typical for Polish fishing grounds are not a problem in Swedish waters.

Conclusively, a further reduction of the already low gear loss rate using proposed methods (change of fishing strategy, improved gear construction etc.) was not considered realistic because a major part of gear loss today is due to deliberate deployment of gillnets on shipwrecks with an aim to increase unit catch. A wreck fishing ban was discussed but not found efficient enough due to obvious difficulties in practice to control enforcement of such a measure.

The solution recommended by a unanimous Swedish working group is based on a principle by which responsible fishermen are distinguished from irresponsible ones. The core of this solution could be e.g. a voluntary "responsible fisheries scheme" that interested fishermen could commit themselves to. The scheme would expect compliance to a set of requirements (improved gear marking, better cooperation with controls, improved reporting of gear loss etc.) and in return the market could offer these fishermen economic rewards e.g. by prioritizing their "ghost fishing-free" catch and by paying a higher price. There are plans at local/regional level in Skane county, within a LEADER project working to promote locally-caught fish, to include "ghost fishing-free" as one argument for consumers to choose more environmentally-friendly produced fish.

After participation in the MARELITT Baltic site-visit in Kolobrzeg (October 2017), the Swedish Marine and Water Administration Agency has drafted a first national DFG policy document, which is now in place and distributed

to involved Swedish key authorities (e.g. Swedish Environmental Protection Agency, Ministry of the Environment). During 2016, a national report was published (Tschernij V. 2016), showing the existence of lost nets in all tested locations along the Baltic Sea coastline originating from recreational fishery. This first national DFG policy document includes actions targeting not only the commercial fishing sector but also recreational and sport fishing. Reduction of gear loss is included as a long-term objective to be obtained e.g. through improved information to a wider public and educational initiatives directed at different fishing gear user groups including recreational fishermen.

In Poland, fishermen considered reduction of gear loss during fishing operations complicated and to some extent even impossible. Fishing in Polish waters, just like in Swedish waters, is primarily concentrated in specific areas to secure a higher catch level. Unfortunately, operations in these waters seems to imply an impending risk of gear loss. Moreover, a comparison of the fishing strategic context in Poland with Sweden shows that the amount of netting used by the Polish gillnet fleet is 7 times higher than the amount used by the much smaller Swedish fleet. Experts expect the high effort in Polish waters to gradually shrink in future following the trend in e.g. Sweden. The first signs of this development could be seen in this study. Higher effort and more vessels per roughly the same size of area as in Sweden mean in relative terms more competition for a good spot on the fishing grounds and consequently a higher risk of conflicts. In addition, Polish fishermen seem to have a higher random risk of unexpected snagging of nets on seabed objects than fishermen in Swedish waters. It is not unusual that these unexpected snaggins can be a result e.g. of a net entangling on dumped, stripped cars. According to Polish fishermen, a lot of large junk like cars, washing machines etc. are constantly thrown overboard from mercantile and other larger vessels passing by (fig 4).

Figure 4. The macroscopic waste Swedish bottom trawlers have reported and brought ashore within the project "Fishing for Litter", show the problem that the Polish fishermen are addressing. E.g. a car (photo to left) is way too heavy for gillnets to bring it to the surface but no problem for a trawler. If a gillnet is stuck on a heavy object like a car or sometimes even a washing machine (photo to right), the obvious result is that part of the netting of the net fleet is ripped and remains on the seabed.

The seabed in Poland is smoother with fewer morphological formations (steep slopes or very rocky areas) than in Sweden. A clear division of fishing grounds into typical gillnet and trawling grounds is thus not as structured as in Sweden, naturally increasing the risk of conflicts between active and passive gear fleets (fig 3 on previous page).

If a reduction of gear loss during fishing operations without marked economical drawbacks seems unrealistic, the focus could instead be put on minimizing the effect of lost fishing gear. This objective can be achieved e.g. by implementing a scheme of regular, annual retrieval campaigns similar to those successfully used in Norway since the mid 1990s (per.com. Langedal G., Norwegian Directorate of Fisheries, Development Section. See also web links after reference literature). Implementation of a Norwegian type of preventive method implies both improved marking of fishing gear, an imposed reporting obligation for gear loss and annual retrieval campaigns. For the success of retrieval campaigns, it is crucial that retrievals are carried out regularly, immediately after the fishing season to avoid gear displacement by currents. It is also crucial that the Norwegian Directorate of Fisheries carries out the retrievals financed by the Norwegian government. In all countries, it became clear that fishermen are afraid to report gear losses because of high operational costs in the case that retrieval is required. Returning gear to the owners and an insurance system or other secured funding for retrieval campaigns alleviate the financial burden on individual fishermen and would enhance willingness to report gear loss

and thereby improve the environmental status of the Baltic seafloor environment.

Polish fishing inspectorates and fishermen agree that modern gear marking systems e.g. based on RFID (radio frequency identification) technology seem an efficient, practical and cheap way of marking fishing gear. Moreover, fishermen are aware that through automatization many logistical procedures in terms of documentation in fishing companies can be improved though an electronic gear marking system. Nevertheless, there was no interest in the fishing sector to recommend any specific preventive method or to discuss more widely ways to reduce gear loss during fishing.

4. Discussion

The boosted growth of the fishing fleet during the "cod boom"

The transformation of the Baltic Sea fishing fleet from a traditional fishery using passive gear landing in local harbours, to today's fragmented, highly specialized and partly industrialized fishery, has been huge. The same evolution peaking in the 1980s and 1990s can be observed all over the world (Huntington T, 2017). There is, however, one detail that makes developments in the Baltic Sea extreme, and perhaps seen from today's perspective, unfortunate. Beside the general growth driven by fast, technological evolution, expansion of fisheries was further boosted by a short but prosperous cod fishery during the "cod boom" (1978-1989) – often recalled as the golden era of Baltic Sea fisheries.

The cod boom peaked in 1980-82 with an annual cod catch of over 400.000 tons, which is more than 16 times higher than the catch level today. Thanks to a thriving and subsidized fishery, the fleets and total effort grew uncontrollably. The segment that grew most was the gillnet fleet in the southern Baltic Sea area. The factors that made gillnet fishing attractive – and for many of the new entrepreneurs with no previous experience of fishing, the only way "to make money" – was a lower investment threshold and a diminished need for technological experience. Furthermore, most of the fishing vessels in the 1980s (built 1950-70) were equipped with engines that were inadequate for pulling a heavy bottom trawl, which made gillnetting their only option.

In the mid-1990s, after less than 10 years of intensive fishing, the cod population started to shrink rapidly. At that time, the gillnet fleet targeting cod with bottom-rigged gillnets was by far the largest fleet in the study area. There were vessels fishing 24 hours per day using up to 24 km of netting. The declining catch rates led to ruthless competition between fishermen, resulting in severe conflicts between passive (gillnet) and active (bottom trawler) fleets.

Ghost fishing problem probably peaking in first half of the 1990s

Unfortunately, there is no official information available concerning how many nets and trawls were lost during the cod boom and the years afterwards. Interviews with Swedish fishermen and harbour personnel revealed that waste containers in all landing harbours were constantly full of gillnets that trawlers brought ashore because of frequent conflicts. There were attempts to communicate between fishermen but mostly without result. In some areas e.g. the southern Midsea Bank, trawl skippers were left with no other option than to deliberately run through net fleets to push back the competing gillnet vessels from actively utilized trawling grounds.

Moreover, the price of a net fleet was roughly 50% of the price of a net fleet (1.2 km) today (~ 1.300 euro). In 1997, the price of fuel (diesel) was 0.09 €/litre. Today, it costs over 600% more (0.65€/litre), whereas the price of fish has not gone up. If a fisherman lost his surface marker during the cod boom, it was in economic terms cheaper to steam home and buy new nets than to use valuable fishing time for dragging. Moreover, with several hundred vessels fishing simultaneously in the crowded fishing areas, net fleets were deployed so close to each other that without modern GPS positioning it was simply impossible to drag for a fleet without snagging on colleagues' net fleets.

By putting together this fragmented information, it is justified to believe that the ghost fishing problem in terms of the number of lost gillnets, was probably at its highest level somewhere around 1992-1997. An additional detail that strengthens this assumption is that towards the end of the 1990s demersal trawlers started to gradually switch from soft-seabed to rock-hopper gear. This new gear guaranteed trawl skippers less damage to gear while targeting rockier areas and slopes where the last larger cod schools were spotted (fig 5).

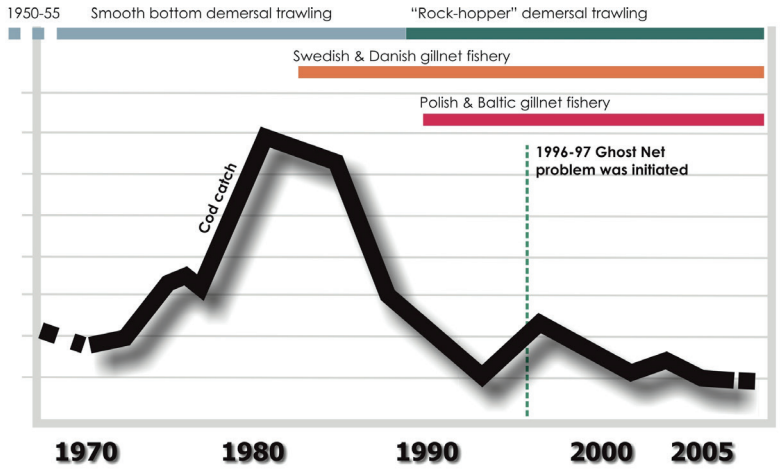


Figure 5. The growth of the cod fishing fleet during the "cod boom". The first to increase gillnetting (1982) were Danish, Swedish and German fishermen followed

by Polish and Baltic fishermen ten years later (1990-92). Rock-hopper trawls started to gain ground 1985-87, allowing bottom trawlers to conquer new rockier grounds, causing the "no man's land" between gillnet and trawling grounds to shrink.

From a golden era to an ecologically and economically challenging future

After the year 2000, despite several attempts, fisheries managers have not succeeded in reversing the negative trend, especially in the Eastern Baltic Sea cod stock. On the contrary, the latest scientific advice in April 2019 from ICES (International Council of the Exploration of the Sea) recommends not only a fishing stop in the eastern cod stock due to its critical status but also a reduction by more than 50% of the quota in the western cod stock. Unfortunately, the problem in the eastern stock is no longer just a small population. Cod living east of Bornholm seem to have stopped growing. They are skinny and, in some regions, infected by parasites spread by grey seals. The scientists fear a collapse in the stock.

Cod fishery is one of the backbones of coastal fisheries, particularly in the southern part of the study area. A cod fishing ban, or just a major reduction in TAC (total allowable catch), would probably lead to a major cut in the fishing effort. If cod fishery is closed, then the catch of flounder will be hindered as well, because flounder and cod are caught with nets in the same mesh size range. As we have seen in this study, e.g. in southern Sweden, gillnet fishery already seems to be heading toward a total wipe-out due to a multitude of reasons (low catch rates, low demand and fish price, damage caused by grey seals etc). A cod fishing ban that hinders flounder fishery as well would probably either put to an end to, or radically restrict, the gillnet fishery in parts of the southern Baltic sea region.

In addition, many Baltic Sea countries are planning, or have already implemented, market-driven fisheries management, which is based on an individual quota system. In some countries, the individual quotas are transferable, meaning that fishermen can chose either to fish or sell their quota. In fisheries with low profitability, transferable quotas tend to concentrate in a small number of larger companies, which often choose to operate larger vessels and supply them with bigger quotas. This leads to a fleet with fewer, but larger, vessels. We can see a dramatic decrease in small-scale fisheries e.g. in Denmark after the introduction of an ITQ (Individual Transferable Quota) system in 2005 (Høst J. 2015).

The study reveals that fishing effort in coastal fisheries in the four covered cases shows a downward trend and experts see no reason to believe that this trend will change. On the contrary, the decline might even accelerate in the southern Baltic Sea, especially if the problems in the eastern cod stock (or in both stocks) get worse or persist for a long period (fig. 6).

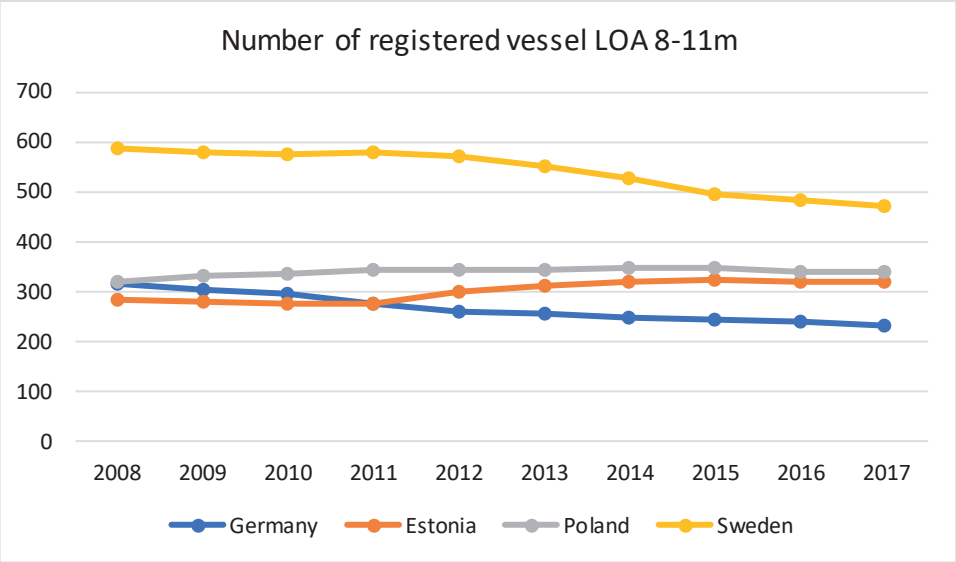


Figure 6. EU statistics show a downward trend in the German and Swedish fleets (LOA 8-11m), whereas the Polish and Estonian fleets seem stable (source: https://ec.europa.eu/fisheries/). The question is how well the number of registered vessels reflects reality. E.g. according to official Swedish statistics, there are 30 registered coastal fishing vessels in Simrishamn (the municipality included in this study) but today only one of them is fishing on a commercial scale.

Ghost fishing problem is decreasing – in some areas it's history

Based on the results of this study, it seems justified to believe that the ghost fishing problem in terms of the number of bottom-rigged gillnets lost during commercial fishing, is clearly smaller today than during what is thought to be the peak level period in the 1990s. Shrinking fishing fleets and effort have contributed to the low gear loss rate in some regions/countries. The decreasing fishing effort is widely recognized as a driving factor to reduce gear loss (Macfadyen, G.; Huntington, T.; Cappell, R. 2009). On the Estonian west-coast, demersal trawling is not conducted due to poor economic conditions, so there are no conflicts (between passive and active gear). In Sweden, both the gillnet and trawler fleets are so small that conflicts are extremely rare. In these two cases, the gear loss rate is today estimated to be so low that the DFG problem relating to ghost fishing is considered mainly a historical problem.

Even though gear loss on a large scale is not a problem anymore, occasional gear loss may still occur e.g. due to extreme weather (e.g. ice, strong winds) or in cases where desperate fishermen in the hope of a larger catch deliberately shoot their net fleets on shipwrecks. In the case of Germany, the indications are that the gear loss rate has generally dropped but from time to time fishing gear is still lost. Typically, a recreational vessel running outside official waterways accidentally collides with a surface marker cutting the rope between marker and net. If the net is then moved by a current, the fishermen may not be able to retrieve it, even if they try.

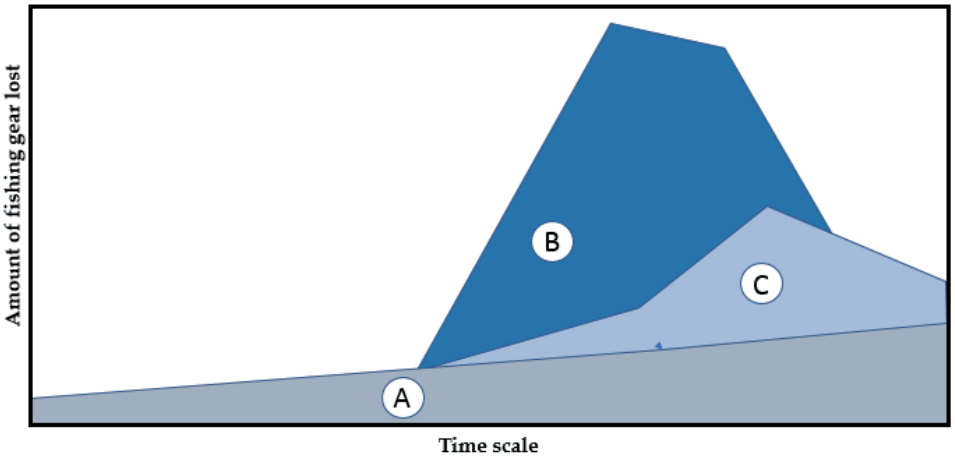
Although the current gear loss rate in Estonia and Sweden is considered to be low to negligible, it was still found to be a marked problem in Poland. Some of the incidents leading to gear loss during fishing in Poland were related to randomly occurring snagging of nets on unexpectedly distributed seabed objects or "underwater hooks" as fishermen call them. These "hooks" can be everything from dumped cars and large items of junk to shipwrecks. In the case of Poland, the possibility of a link between a higher effort and a bigger gear loss problem should be addressed and examined. This relationship is mentioned in the literature generally (Huntington T. 2017., Macfadyen, G.; Huntington, T.; Cappell, R. 2009) but also proved to be a significant cause for gear loss e.g. in Australia (Richardson, K.; Gunn, Riki.; Wilcox, C and Herdesty, B.D. 2018). The question is: will a higher effort level be sustained in Polish waters? Our study confirmed a clear effort drop (-15%) in the Polish gillnet fishery, which might be a first sign of a forthcoming larger decline. Polish experts confirm that they expect effort to decrease in the coming years. It remains to be seen just how big the drop within gillnet fisheries will be and if it will affect both the Polish and German passive gear fisheries.

DFG – a multidimensional problem even when looking at one gear type
From a global perspective, there seems to be no marked difference in the reasons for gear loss found in this study, except regarding IUU (illegal, unregulated, unreported) fisheries. Globally and in the study area, the most common reasons why fishing gear is lost are: weather, operational fishing factors and conflicts.

Accumulations of DFG are, on the other hand, poorly documented and understood (Macfadyen, G.; Huntington, T.; Cappell, R. 2009). A detailed understanding of why fishing gear is lost, abandoned or discarded is needed when designing and tailoring effective measures to mitigate the problem (Macfadyen, G.; Huntington, T.; Cappell, R. 2009). The objective of our study was not only to assess why and where fishing gear is lost but also *if* fishing gear is still being lost.

Due to the large variation in fishing strategic contexts, differences in the rate of gear loss and substantial regional differences in how keen the fishing sector is to discuss prevention, it seems more appropriate for our study to develop a strategic tool than to recommend a set of nationally tailored, detailed action plans. Our results show a need for national processes leading to regional solutions but because of strong interregional dependency, a tool is needed to improve transregional understanding of the reasons why differentiated preventive strategies are needed.

By utilizing the new fishing strategic understanding, the assessed DFG problem can be divided into three sub-problems with different characteristics and also, logically, different solutions (fig. 7).



A. Traditional type of gear loss (including all gear user groups as well as recreational fishers)
B. Gear loss generated as a result of large fleets or high effort ("race to fish")
C. Economically driven gear loss (i.e. increased delibrate risk taking e.g. fishing on shipwrecks)

Figure 7. A schematic illustration suggesting "one assumed DFG problem" to be divided into three sub-problems with varying characteristics addressing different types of preventive and mitigation measures. Even if the used time scale is time-irrelevant, the pattern of how the three sub-problems (A, B and C) develop over time can be linked with the general development of fisheries and the suggested peak period of the DFG problem in the early 1990s.

Type A – accidental or incidental gear loss

There is good reason to believe that fishing gear has been lost as long as humans have been fishing. Even if most fishermen try to minimize the risk of gear loss, fishing gear has been, and still is, accidentally lost. There is no reason to believe that this type of loss (A, see figure 7) could be totally stopped. In three of our four cases, the gained information shows the stabilization of a previously much higher gear loss rate including e.g. type B gear loss (see fig. 7), at a lower level where accidents play an important role. In two cases (Estonia and Sweden), we learned that recreational fishermen are considered a major contributor to type A gear loss. To successively mitigate this problem, a much broader approach with a wider dialogue concerning the DFG problem has already been initiated in Estonia, Germany and Sweden. Estonia and Sweden report ongoing or planned communication campaigns carried out by the authorities to improve awareness among gear users of issues associated with the ghost fishing problem. The focus is to obtain in the long run a more responsible attitude toward prevention on an individual level. To markedly reduce gear loss in this category, as well as in the two other categories (B, C), it is recommended that long-term cooperation and integrated information

measures are carried out by a broad range of target groups e.g. NGOs, fishing organizations and fishing and water administration authorities (Huntington T. 2017, GGGI report part 2).

Type B – effort-related gear loss

Based on the gained knowledge about fishing effort-related gear loss (type B, fig. 7) in the examined cases, it seems that its scale varies greatly. In Estonia and Sweden, the dramatic drop in gear loss rate and fishing effort has not been primarily due to any specific management action but rather to poor economic conditions forcing fishing companies either to abandon a fishery or, alternatively, leave the fisheries for good.

Negative effects in overcrowded fisheries such as an increased gear loss rate, have been successively combated e.g. in Australia by incorporating management actions like spatial or temporal area closures, restrictions on certain gear types, improved education for fishermen or simply through a substantial reduction of fishing effort (Richardson, K.; Gunn, Riki.; Wilcox, C and Herdesty, B.D. 2018).

While a substantial reduction of fishing effort is likely to be a delicate political topic, actions like spatial or temporal area closures or fishing gear-based zoning are far less controversial measures. A successful design and implementation of zoning schemes aiming to minimize conflicts or avoid snagging of nets requires accurate effort data (non-aggregated) in combination with equally accurate data on reported gear loss. According to Polish fishermen, snagging on seabed objects is to some extent random, suggesting that collection of gear loss data will probably not reveal specific hot spots for snagging. Moreover, the likely gradual decline in fishing effort in the coming years will also probably lead to a decline in the gear loss rate, as we have witnessed in Estonia and Sweden.

Type C – economically-driven gear loss

Economically-driven gear loss is independent of effort level or size of fleet as the Swedish example clearly demonstrates. Although the number of actively operating gillnet vessels in Swedish coastal waters is far fewer than 50, there are still fishermen willing to take a deliberate risk that leads to gear loss. The numerous shipwrecks known to attract not just fish but large fish, offer lucrative fishing spots for those prepared to incur higher gear costs. Many of the fishermen targeting shipwrecks prefer low-cost nets to minimize material costs.

Discussions among the involved Swedish stakeholders resulted in a common opinion that it is extremely difficult to stop fishermen targeting shipwrecks by using law and enforcement measures. Fishing on wrecks can be prohibited, but what is a wreck? Do we only consider those that are officially documented as wrecks, or should the law include all wrecks?

One effective way to combat this type of gear loss is to offer economic incentives to those who refrain from wreck fishing. With today's GPS positioning, avoidance of wrecks is as easy as targeting them. The question is on what terms are fishermen willing to switch from targeting to avoidance? The approach that Swedish fishermen and fishing organizations recommended was to reward fishermen who deliver fish without losing nets. To be able to verify "ghost fishing-free" operations, nets need to be properly marked, documented and their use controlled. Fishermen should also commit themselves to report lost gear, before they can replace it.

Initial discussions with MSC (Sweden) about including economic incentives in their label was not considered possible with the present certification procedure. DFG-related criteria, on the other hand, could be emphasized more clearly in the certification scheme. However, the problem of poor economic conditions would not be solved by a guaranteed slot on the label with no economic rewards.

A "third party certificate" promoting ecologically sustainable fishery preferably with the broad support of key target groups (NGO, fishing organizations, fishing and control authorities) could be an option in the future (Huntington T. 2017, GGGI report part 2**)** but extended with an economic incentive based on an agreement between market actors on either a local or regional level**.**

What preventive methods would be both effective and relevant
Currently, a lot of emphasis is placed on curative measures e.g. retrieval and beach clean-up campaigns, whereas preventive measures are likely to be more cost-efficient (Macfadyen, G.; Huntington, T.; Cappell, R. 2009). To introduce prevention as a mitigation measure in a situation as described in this study, where the fishing sector in one region refuses to discuss the topic while fishermen in a nearby region fully support the idea, is challenging.

Preventive measures may therefore be appropriately taken on international, national and, in some cases, local level. It is also likely that some measures will need to be legislated and made mandatory, while others need only be voluntary, and indeed may be more effective for being so (Huntington T. 2017, GGGI report part 1**)**. For example, in fisheries with potential for local-level arrangements to result in a degree of consensus between participants, measures could be applied voluntarily (Huntington T. 2017, GGGI report part 1**).** Conversely, due to the transboundary character of the DFG problem and the fact that some causes are universal in nature, interregional and/or international collaboration may be appropriate to address some aspects. This can be done through voluntary or legislated measures, but their application, support and enforcement may often be

necessary at a national or even local level, even if based on international conventions (Huntington T. 2017, GGGI report part 1**)**.

The palette of preventive measures that participating stakeholders in this study put forward can be divided into three main categories:

- educational and informative initiatives aiming to increase awareness
- enhancement of gear marking, control and reporting of gear loss
- introduction of a "responsible fisheries scheme (RFS)" with an emphasis on economic incentives

All these methods are mentioned in global survey reports audited e.g. by FAO 2009 and GGGI 2017. Beside these methods, the literature lists several other potential preventive methods used or tested round the world. Below is a short review of potential methods designed to improve mitigation of the DFG problem in situations relevant to those fisheries included in this study.

Gear marking

Gear marking is widely considered to be one of the keys to efficient prevention. This was also clearly brought up in this study. Gear marking lays a foundation for systematic documentation and efficient control of fishing gear that is either in active use or temporarily stored.
MARELITT Baltic has developed and tested a "smart tag" based on RFID technology, optimized for the marking of both gillnets and trawls (Grabia, M.; Markowski, T.; Sitarz, P.; Kaczmarek, B.; Borowiak, K. and Gruszka, P. 2019.) This electronic tag can store and transmit short electronic identification codes, which not only offers possibilities for smooth and efficient control but also provides help for easy onboard documentation.

RFID tags are being used successfully in some fisheries, such as in South West England. Here, fishermen allocated a potting permit will be supplied RFID tags secured to each pot. Marine enforcement officers can then scan each pot using a hand-held RFID reader. This will ensure that only those fishermen with permits are operational within their jurisdiction. One limitation is that the reading distance is only about one metre. This means gear needs to be hauled onboard to access RFID data. The cost and logistical requirements might also be seen to outweigh the benefits (Huntington T. 2017, GGGI report part 1**)**.

There are also more sophisticated, fully automated data loggers that read, store onboard (during fishing) and send the data to a server or authority as soon as the vessel returns to harbour (http://www.pelagicdata.com/).

Gear marking is essential for preventive measures like RFS because responsible fishermen (committed through a responsible fisheries

agreement) need to be distinguished from irresponsible ones. Without appropriate gear marking and improved control, this is not possible. Furthermore, in cases where fishing gear is marked, retrieved gear can be returned to the owner. Unfortunately, because conflicts and snagging of nets on seabed objects/wrecks are the most common causes of lost gear according to this study, retrieved net fleets in the Baltic Sea are often badly damaged or torn into small pieces. Marking of nets that are probably wrecked when lost, is not equally justified or beneficial for the gear owner compared to a situation where the owner can continue to fish with the retrieved nets.

Gear marking has a long history as an applied preventive method. We learned that as far back as 1918, Polish legislation recommended marked buoys and flags in its safety rules. This is explicitly regulated in the ministerial order from 1922 and included a determination of ownership. Since 2004, EU rules apply directly to Polish fishermen.

On the international level, the Convention on Conduct of Fishing Operations in the North Atlantic (the Atlantic Convention) was adopted in June 1967. The requirements covered signals for different fishing activities e.g. lighting when trawling and marking of the ends of nets, lines and other gear with flags, buoys and radar reflectors. These recommendations have been updated by e.g. FAO 1993 and FAO 2016. Today, gear marking is legislated through EU control regulation 1224/2009 in all member countries.

Gear marking was one of the preventive methods that was discussed in many of the national processes. Generally, fishermen had no objections to marking their gear. Most of them do it not primarily for improved control, but rather for security in case the gear is moved for some reason, and if intact, the finder can return the gear to the owner. This is the original reason, and still the main one, why fishermen mark their gear.

There was a debate among Swedish fishermen about whether electronic gear marking would provide an additional advantage compared to e.g. a traditional metal tag attached to the headrope of the net. For example, if the RFS type of third-party certifications were to be compulsory in the future, then control of fishing gear would have to be both improved and above all made more practical. Electronic gear marking would guarantee far smoother control onboard. Any fishermen committed to a marketing scheme that secured substantial economic rewards would certainly do everything in their power not to lose gear. By doing so, gear marking costs would drop, making even an expensive marking device more realistic. If fishing gear is lost due to conflicts or snagging on seabed objects and is severely damaged as a result, the use of advanced and more expensive equipment is not economically justified.

Reporting of gear loss

Tampering with, or encroaching on, someone else's fishing gear was prohibited by the Fisheries Act of 1963. However, there has been no indication of a reporting obligation for gear loss until EU control regulation 1224/2009. In a local regulation of 1996 for Szczecin Lagoon, reporting to the territorial fisheries inspector on the loss or retrieval of fishing gear has been implemented. However, this rule has been heavily mutilated in the subsequent local regulations including the currently valid version of 2018.

A reporting obligation was implemented in Sweden in accordance with the EU control regulation 1224/2009. Since implementation, 40 reports of lost gear have been sent in. The majority of these are from the last couple of years, indicating an improved willingness to act. The EU control regulation 1224/2009 applies to all the Baltic Sea countries, except Russia, which is not an EU member state.

This topic was discussed, and its further enforcement was officially supported by Swedish fishermen.

Fitting transponders to gear improves the ability to locate gear in the water. This is an added cost to the fisherman and is therefore most likely to be used by fishing operations where gear tends to be larger and more expensive than in artisanal fisheries (Macfadyen, G.; Huntington, T.; Cappell, R. 2009). The use of simpler, small low-cost transponders is technically possible, but currently there are no "ready-to-use" products available on the market suitable for gillnet fishing (Lindahl, D.; Boyd, L. 2018). Generally, the loss of a whole gear assembly is unusual. Often, segments of the gear are lost – for example a net panel or codend through contact with the bottom, or a smaller number of pots from a string (Huntington T. 2017, GGGI report part 1**)**. Especially in cases where a net fleet is run over by a trawler, fishermen report that it is virtually impossible to retrieve it.

Poor economic conditions. No sign of improvement. A great challenge

Widespread concern about the poor ecological status of the Baltic Sea and uncertainty regarding future management actions naturally cast a shadow over the fleets that are already in deep economic trouble. Clearly, this is not the best time to enforce preventive methods that either reduce revenues or incur additional costs. On the other hand, macro- and microplastic waste in the oceans is a huge and serious problem. Together with the additional associated mortality that DFG brings, this calls for powerful and effective action.

To successively introduce and strengthen prevention as a part of mitigation of the DFG problem, implementation probably needs to be done gradually

and in all likelihood be regionally adapted. Initially, measures that involve additional costs or reducing revenue should be avoided.

The MARELITT Baltic project showed that curative mitigation actions like retrieval campaigns are, without exception, strongly supported by the fishing sector. These campaigns are successfully used today to clean up areas where gear was lost recently or years ago. However, retrieval actions can with small adjustments be transformed to become more "prevention-oriented" in combination with improved reporting of lost gear. This approach can provide the fishing sector with a smoother transition to a first step where the only preventive measure would be a reporting obligation for gear loss. Together with increased awareness and broader stakeholder participation, e.g. fishing market actors, the first step may help to bring about a gradual shift towards a more prevention-friendly attitude among fishermen. During the first step, gear marking is improved, and control of fishing gear is enforced.

As soon as interest is awakened among some of the fishermen in committing to RFS-type certification systems, and when support from local fishing markets is in place, preparations for step two can be initiated. A "responsible fisheries scheme" – a type of licencing system rewarding fishermen delivering "ghost fishing-free" catches is implemented. This will probably encourage more fishermen to commit themselves to more ecological and more profitable fishing with a minimized gear loss rate as one of the key objectives.

With improving economic conditions, fishing companies will automatically invest in technology and equipment, which will further help them to be more ecologically sound. Transducers can be mounted on gear made of biodegradable netting to help to locate the gear if it lost etc.

5. Conclusions

1. Varying fishing strategic contexts, seabed morphology and characteristics (rocky/smooth seabed) as well as incidental factors (water current, ice) contribute to regionally differentiated gear loss.
2. The assumption that fishermen can always manage the risk of gear loss seems not to be true. At least not, if stable profitability is expected.
3. In the case of Polish waters, the prevailing fishing strategic context and specific seabed characteristics makes the reduction of gear loss during fishing complicated.
4. In Estonia and Sweden, the gear loss rate in commercial fishery is very low, mainly because of no commercial trawling or a small effort. The remaining gear loss is either accidental of deliberately caused e.g. due to wreck fishing. Generally, ghost fishing in commercial fishery can be considered a historical problem.
5. Enforced fishing gear marking and improved reporting of gear loss were widely considered as a practical foundation for prevention of gear loss in the future.
6. Fishermen were divided on the issue of modern electronic gear marking methods e.g. the RFID system developed in the MARELITT Baltic project. One group considered them efficient and practical for marking fishing gear and making documentation easier onboard, whereas others regarded traditional metal tags cheaper, enabling several tags to be attached to one net. This is critical because lost net fleets are often cut into shorter sections.
7. Regional differences in readiness to implement preventive methods was observed between fishermen. Some refused to discuss prevention, whereas others were prepared to accept methods where responsible fishermen were distinguished from irresponsible ones and rewarded economically for complying with a "responsible fisheries scheme".
8. A positive attitude towards prevention may depend on the time fishermen have worked on mitigation of the ghost fishing problem. In our study, those who were more openminded towards prevention had 23 years of experience, whereas those refusing to talk about prevention had only 8 years of experience.
9. Today, the coastal fishing sector faces severe economic challenges. Raised environmental awareness and a positive attitude towards mitigation of the DFG problem will probably not be enough to change the behaviour of fishermen. Readiness for more responsible fishing needs to be economically rewarded.
10. Other fishing gear user groups (recreational and illegal fishermen) are considered major contributors to gear loss in Estonia and Sweden.

6. Recommended strategy to reduce gear loss

Taking into consideration the multidimensional characteristics of the studied gear loss problem, implementation of one or two separate methods will probably not bring about a marked reduction of gear loss during fishing. Due to the ongoing dramatic restructuring of the fisheries in combination with a trend of declining effort in coastal fisheries, identification of relevant and effective preventive methods is challenging. In addition, coastal fishing companies are unfortunately facing deep economic problems with no sign of a better future. Symptomatic for the present situation is that not even a dramatically reduced fishing fleet would seem to guarantee a more profitable future.

Instead of implementing one or two separate methods, a strategic approach with several parallel and integrated actions implemented in two steps seems more justified:

1. The first step would be to enforce better gear marking, improve control and enhance reporting of gear loss. In parallel, annual retrieval campaigns (following the Norwegian example) would be carried out to minimize the negative impact of DFG on the marine ecosystem. Implementation of the first step would provide time for stabilization within the sector regarding structural transformations, more time for increased information campaigns to improve knowledge of the ecological and socioeconomic problems associated with ghost fishing, more time for the industry to shift gradually towards more prevention-orientated fishing operations and the fishing market to orientate towards demand that rewards ecological and "ghost fishing-free" catches.
2. The second step would be to involve the local "value-added" fishing markets to offer economic benefits for fishermen willing to commit themselves to a "responsible fisheries scheme (RFS)". The economic benefit for delivering "ghost fishing-free" catches should be big enough to gradually encourage all fishermen to commit themselves to an RFS or similar local or regional third-party market-driven licensing initiative!

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https://www.youtube.com/watch?v=HqfFi6UiIrk
http://cnogear.org/news/english/the-annual-norwegian-retrieval-survey-is-finished
http://cnogear.org/news/english/successful-retrieval-survey-along-the-coast-of-norway-copy
file://fiskeridirektoratet.no/Ressurs/Brukere/baaar/Downloads/CleanNordicoceansPresentations.pdf
http://cnogear.org/news/english/successful-workshop-for-cno

Appendix 1. The questionnaire for fishermen survey.

MARELITT Baltic

Interreg Baltic Sea Region

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Anonymous questionnaire for fishermen November 2016 within the MARELITT Baltic project

The results of this questionnaire will be used exclusively to plan actions at sea and design actions to minimize the loss of fishing gear during fishing activities. Individual responses will not be published. Only the summary and conclusions will be used for the purposes of the Marelitt Baltic project.

This questionnaire aims to accumulate detailed knowledge of gear loss that occurs during fishing operations. The method used is based on combining the following data;
A) a certain specified geographical fishing area (a square on the provided map)
B) reason or reasons leading to gear loss in that area
C) if gear loss in this area is
C1 historical (occurred before 1997)
C2 ongoing/present (1998-2016) and
C3 will probably **continue in the future (beyond 2018)**

1. What is the size of your fishing vessel? Length: _____m/no of crew members:_____

2. In which fishing areas do you work (fish)? Mark the squares with number (1) on the provided map where you are fishing today and with number (2) those squares where you were fishing earlier. Define the year (roughly) when you changed your fishing grounds:_____. If you have always used the same fishing grounds, mark the squares with number (1). Why did you change your fishing grounds?

   _____

   _____

3. What fishing gear do you use? (Underline the correct answer(s))

   Gillnets Trawl Long line Drifting lines

   Others, please specify: _____

4. Have you lost fishing gear? (Underline the correct answer)
   Yes No

5. If so, how often does it happen?
   - less than once a year
   - once a year
   - once a month
   - once a week
   - more than once a week, please specify how often_____

6. Have you managed to retrieve lost fishing gear? (underline)
   Yes No Always

7. If so, please specify the method used to retrieve the lost fishing gear
   _____
   _____

8. If you have not tried to retrieve/or not retrieved your lost fishing gear, please specify why
   _____
   _____

9. Have you reported lost but not retrieved fishing gear to the authorities? (Underline the answer)

   Yes No

10. Have you retrieved gear belonging to other fishermen? If so, how often? (Gear retrieved in projects designed to drag lost fishing gear is not counted)

    Ones Twice Five times Ten times More

11. Can you provide the exact location (geographical coordinates) at which the gear was lost and retrieved by you or other fishermen?
    _____
    _____
    _____
    _____
    _____

12. If you do not have exact positions for the lost but retrieved fishing gear, please write the letters **LR** (lost/retrieved) on the attached map in those squares where you found the lost nets!

13. What is the most common reason, or reasons, for the loss of fishing gear during fishing operations. Indicate a ranking by writing number 1 for the most dominant reason, 2 for the second most important reason, 3 for third most important, 4 for fourth most important etc. Note that we want you to rank the reasons from a historical point of view (before 1997) and from the perspective of the present/today.

Before 1997 | Present

_____/_____ (SB) Type of sea bottom (e.g. big rocks)

_____/_____ (H) Underwater objects ("hooks", rocks etc.)

_____/_____ (SW) Shipwrecks

_____/_____ (C1) Conflicts between same gear e.g. gillnet

_____/_____ (C2) Conflicts between bottom trawl and gillnet

_____/_____ (C3) Conflicts with non-fishing vessels

_____/_____ (E1) Environmental factor like strong current

_____/_____ (O1) Other factors, please specify _____

_____/_____ (O2) Other factors, please specify _____

We want you to mark the areas (squares on the provided map) where you consider gear loss occurs. Use the indicated letter codes (in brackets) for the various reasons e.g. C2 in a square indicates that this area is a typical area for conflicts between bottom trawls and gillnetters.

14. What would you do with a retrieved fishing net?

_____
_____
_____
_____
_____
_____

15. What do you do with old/worn-out or for other reasons discarded nets?

_____
_____
_____
_____
_____

16. Are there places/containers in the ports where you can deposit old nets or retrieved lost nets free of charge?

Yes No

17. Exclusively for the project, could you indicate the exact location of underwater objects on which nets snag (hooks), identified on private maps? This information will not be published and will be used exclusively to determine study areas.

_____
_____
_____
_____

18. Have you ever had an accident caused by lost fishing gear? E.g. A vessel stuck on lost drifting lines? If so, when? Where? And why?

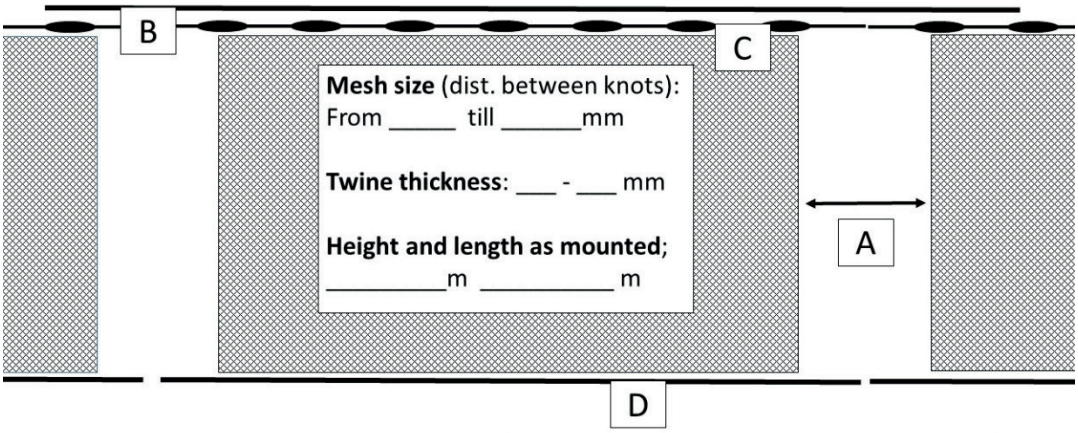
_____
_____
_____

19. Do you have any other comments that could be useful for the MARELITT Baltic project and could help to identify measures to mitigate gear loss?

_____
_____
_____
_____
_____
_____

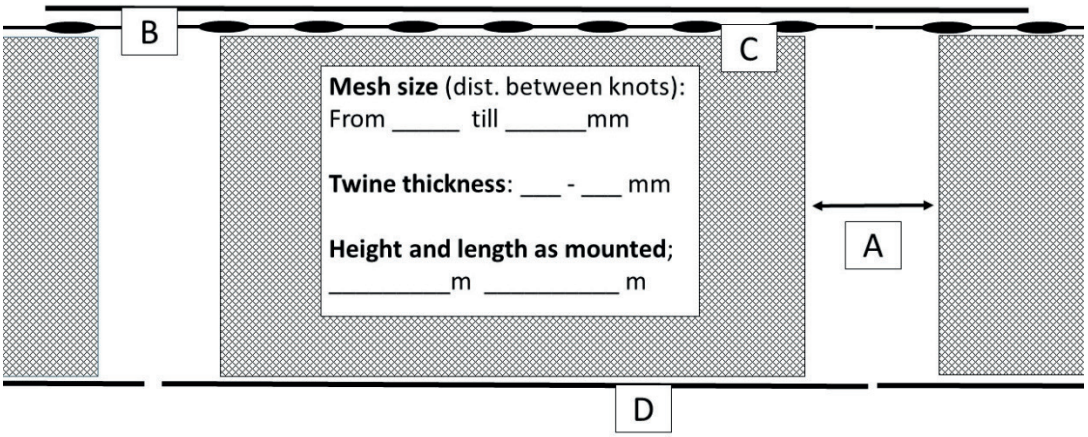
The purpose of the final questions is to collect detailed information on how your nets are constructed today. The construction of a net fleet determines the strength of forces that can be applied on the net fleet without breaking it while dragging. Please fill in the requested information on the provided illustration. If you have changed the main construction of your nets or net fleets, please fill in the new values on the provided second illustration and state approximately when this change occurred.

Present (the design you use today) net and net fleet design



A distance between nets:	m	C float line material: PE/PP	mm
B fleet line material: PE/PP	mm	D lead line material: PE/PP	mm

Earlier net and net fleet design:



A distance between nets:	m	C float line material: PE/PP	mm
B fleet line material: PE/PP	mm	D lead line material: PE/PP	mm

Appendix 2. Report from the national prevention workshop in Sweden.

MARELITT Baltic – how to prevent gear loss in the future?

Result from a national workshop February 8th 2018, Simrishamn

Participants:

Lisa Bredahl Nerdal	Swe. Agency for Marine and Water Adm. (SMWA)
Fredrik Palm	Swedish Board of Agriculture (SBA)
Malin Skog	Swedish Fishermen's PO (SFPO)
Tommy Lang	Sea and Coastal Fishermen's PO (HKPO)
Bo Landén	Fisherman, Fisherman association, Malmö
Kristian Nilsson	Fisherman, Fisherman association, Malmö
Bengt Andersson	Fisherman, Fisherman association, Malmö
Anders Paulsen	Fisherman, Fisherman association, Simrishamn
Richard Nilsson	Gill net fisherman, Fisherman association, Sölvesborg
Swedish Coast Guard	*Invited but responded that they chose not to participate*.
Madeleine Lundin	MARELITT Baltic, Simrishamn
Camilla Witt	MARELITT Baltic, Simrishamn
Vesa Tschernij	MARELITT Baltic, Simrishamn

Programme:

10.00	Welcome and introduction (Vesa) A short presentation of participants Two presentations of the policy work (Lisa and Fredrik) *Questions and discussion*
10.45	Presentation of MARELITT Baltic and this workshop (Vesa)
11.45	Is adoption of "a zero vision" beneficial (no nets lost in the future)
12.00	Lunch
13.00	Actions to minimize loss of fishing gear in the future Methods discussed (strategic, technological, legislation) Law and enforcement or "responsible fisheries scheme"?
16.00	Summary and end of workshop

Meeting started with a general discussion

Information given in the three presentations inspired the group to have a vivid general and detailed discussion on the problem itself and its mitigation. Thanks to a broad spectrum of professional backgrounds among the participants, the topics that were raised covered a multitude of issues ranging from policy building and future financial instruments to suggestions for detailed solutions. Without going any deeper into this initial discussion in this context, there were, however, a couple of topics mentioned that have a profound effect on possibilities to solve the DFG (derelict fishing gear) problem in the future. One fundamental aspect is the question of whether DFG is addressed in existing legislation. The

representative for SMWA stated that according to her review of current legislation, DFG is not recognized by any law. There is one law that comes close in this respect but basically deals with "lost property". This law from the 1980s assumes that all retrieved unmarked fishing gear has an owner – an owner that must be given a fair chance to collect their gear! Clearly, there is a need to update parts of the legislation. The group expressed among other things a deep concern about the recreational dimension of the ghost fishing problem mainly because of its far more diffuse character and dispersed geographical distribution. SMWA stated that the authorities have already started to identify potential ways to deal with recreational fishery. One example of how this broad target group would be handled is through an application for a recreational fishing licence. The licence could be granted to a person who passes a test available on the internet. There was also a discussion on registration of recreational fishing gear or/and EPR schemes (extended producer responsibility).

Ghost fishing is a historical problem in the project area

In the part of the sea area covered by the MARELITT Baltic project and where the Swedish fishing fleet operates, the industrial representatives considered ghost fishing to be predominantly a historical problem. There are several underlying factors leading to this conclusion. One of them is, as shown by MARELITT Baltic, a marked reduction in the overall fishing effort in the commercial fishery. The decrease has been dramatic especially in the gill net fleet (-85% from 1997 to 2014) during the past 20 years and the number of active vessels is still declining. According to the official logbook statistics from 2016, 17 gillnetters caught 70% of the total annual cod catch caught by the Swedish gill net fleet in the Baltic Sea. The same trend can be seen in the demersal trawler fleet. In 2016, 14 vessels landed 94% of the annual cod catch. Smaller fleets mean less nets in use and with few operating trawlers, conflicts are very rare today. It turned out that none of the fishermen at the meeting had lost their nets in the past 10 years. In some restricted areas, it is not unusual that vessels from the merchant fleet run over a surface marker, cutting the rope leading down to the net fleet. Because the rope breaks, the net fleet often stays where it was shot, ensuring that the fisherman will be able to retrieve it using GPS and retrieval gear.

In addition to the decreasing fishing effort, the price of both fishing gear and fuel has gone up, whereas in relative terms the price of fish has stayed at a low level. Lower profitability has forced fishermen to become cautious. In the 1980s and until the late 1990s, it was not unusual that fishermen, in cases where their surface markers (flags) were cut off or their net fleets were run over by a trawler, did not even try to retrieve the nets because it

was more justifiable economically to buy new nets than to use valuable fishing time retrieving lost nets. The group identified a general shift towards a more responsible attitude due to growing environmental awareness among active Swedish fishermen.

Can we adopt "a zero vision" to mark a future incentive

Today, according to the participating fishermen, the amount of commercial fishing gear that is lost at sea in the project area has probably reached a level where a further reduction can be challenging or even impossible. There are, however, fisheries and regions where circumstantial factors still cause net loss. In addition to the example presented earlier (conflicts with merchant fleet), there are e.g. specific areas (Öresund; a sound between Sweden and Denmark) where the strong currents and rocky seabed cause higher gear loss. Furthermore, there are fishermen targeting shipwrecks in the hope of getting a bigger catch but unfortunately there is a high risk of net fleets getting entangled on the wreck.

The group considered in accordance with e.g. an incentive to reduce casualties in traffic, whether "a zero vision" could serve a similar purpose in fisheries. However, having zero casualties in traffic is just as unlikely as having no gear loss in commercial fishery in the future. Nevertheless, having "a zero vision" could be an efficient way to communicate the ambition and dedication of the fishing sector to minimize the consequences of the DFG problem in the future.

Law and enforcement or something else?

The MARELITT Baltic project group representatives suggested a discussion to evaluate if

1) changed fishing strategy (e.g. avoiding certain areas or circumstances etc.)
2) improved fishing gear technology
3) or changes in fishing legislation

could result in an additional reduction of the gear loss rate in the future?

The industrial representatives had great difficulties in identifying specific methods that could systematically lower the probability of fishing gear loss. As discussed earlier, depending to great extent on the circumstantial nature of the reasons, a low gear loss rate was considered inevitable today as well as in future commercial fishery.

The group regarded traditional prevention methods based purely on "law and enforcement" as neither practically viable nor efficient. For example, how can we control a fishing ban on shipwrecks or in rocky areas? Instead

of new rules and more control, the overall objective of the implemented preventive actions should be to i) enable a distinction between responsible and irresponsible fishermen and ii) offer clear economic benefits for responsible fishermen for their environmental engagement.

Prior to a discussion on recommended precautionary actions to minimize gear loss, the fishermen raised a topic linked to the improved reception and handling of derelict, discarded or end-of-life fishing gear.

Free-of-charge service for collection of end-of-life and retrieved fishing gear in harbours.

From time to time, fishermen retrieve lost fishing gear when they haul in their gear. It should be made easier and more attractive for fishermen to bring these old nets to harbour. Harbours should be enjoined by law to provide containers designated for collection of both end-of-life and derelict fishing gear. Moreover, this service should be made free-of-charge for fishermen just like collection of household refuse is free-of-charge for all citizens.
SMWA stated that they have already started discussions with the responsible authority (Swedish Transport Agency) about a change in the national harbour litter reception directive, which today does not recognize any marine litter other than vessel-generated litter.

The group identified and discussed the following measures or preconditions to support the efficient implementation of the above recommended precautionary approach.

How to distinguish between responsible and irresponsible fishermen?
Today, all responsible fishermen mark their gear. Some of them even attach small signs on each individual net in a net fleet. However, unmarked fishing gear today seldom leads to palpable consequences. Both fishing organizations and the fishermen gave strong support for the intensified use of fishing gear marking as a fisheries management tool. Marking and registration of fishing gear should be made a condition for getting or keeping a fishing licence. Logically, unmarked or unregistered fishing gear should result in a withdrawn licence or some other perceptible sanction like e.g. preventing fishermen from selling their catch on the market.

The group emphasized that marking of fishing gear should also apply to DFG stemming from recreational fishing.

Representatives of MARELITT Baltic raised the idea of introducing an electronic marking system to facilitate smoother, more efficient control and administration of the marking system. In fact, a Polish project partner is looking at RFID tags, a system based on radio waves. These devices are very small and can be placed inside a 30mm float in a typical gillnet float-line. Another type of available solution could be small, electronic "smart tags" that can be easily incorporated in nets, pots or other types of fishing gear.

These types of interactive tag can be easily controlled using an electronic "wire-free reader", which automatically logs into a central database, identifying if the documented nets are listed and thereby legal. Alternatively, the vessel can be equipped with a "sensor" which automatically registers the nets that are hauled onboard. It can document their position (coordinates) and transfer the collected data to a database administered by the fishing authorities. When a net or fishing gear is detected missing, the administration system logically expects this gear (with a certain ID number) to be reported either as "lost" or "discarded and replaced".

In principle, there was no consistent resistance to an electronic marking system, provided it isn't too expensive for fishermen/fishing companies.

Could various technological features be physically built in to one instrument?

The project representatives stated that there have been contacts with Swedish scientists engaged in the development of "pingers" (an instrument to make harbour purposes observant of gill nets). Pingers are now obligatory for vessels over 12m but there are plans to make pingers obligatory for all gill net vessels. The idea that MARELITT Baltic has raised is to equip future pingers with more technological features like an electronic marking system ("smart tags") or/and passive strengthening of hydro-acoustic signals to enhance possibilities to detect lost fishing gear in the future.

There were scathing comments from fishermen regarding the use of pingers. Fishermen consider that today's pingers are a life-threatening risk. The instrument is too heavy, big and can be hurled like a projectile from the hydraulic net-hauler. If it hits you in the head, you're dead!

How can environmental awareness be promoted and how can incentives be provided for responsible fishermen?
MARELITT Baltic has suggested in the application a voluntary "Responsible Fisheries Scheme (RFS)", which requires the participating fishermen to agree to certain terms e.g. that they use a legally enforced fishing gear marking system, they have committed to report lost fishing gear etc. In return, catches from these RFS-licensed fishermen are guaranteed a higher demand and price on the market.

A remark from the project. MARELITT Baltic has been in contact with MSC, which has shown an interest in including conditions in their licensing system to prevent ghost fishing in the future. According to the information provided by MSC, the organization will in the near future review certain parts of their licensing process and is interested in a dialogue with MARELITT Baltic.

There was a remark from the fishing industry (HKPO) that so far big international labelling schemes like MSC have not resulted in notable positive effects regarding catches from coastal or small-scale fisheries. Secondly, due to an extremely expensive licensing system, MSC is not economically viable for small-scale or coastal fisheries.

SFPO pointed to the known challenges involved in labelling. Some ten years ago, the Swedish fishing sector branded and launched a label, "Närfiskat (=Caught locally). Despite a relatively large economic investment from the sector and broad support from several market stakeholders, the campaign did not increase demand for locally caught fish and has now been discontinued.

There were several people who emphasized that labelling with the aim of promoting locally produced fish or food must have a clear local identity. There are large umbrella labels like "Seafood" in Great Britain, but it is always combined with a smaller geographical region or area as in, for instance, "Seafood Cornwall" etc. to ensure a clear local identity.

HKPO stated that they have started to look at local labelling to promote Swedish fishermen's ecologically caught fish. The interest in regional/local labelling has been surprisingly strong among contacted stakeholders in the county of Halland. Representatives of the Marine Centre also mentioned that there are similar plans in Simrishamn.

The conclusions are:

- Loss of fishing gear within the project area is predominantly a historical problem.
- The gear loss rate today is negligible. A further decrease was considered challenging.
- A small gear loss rate is inevitable in the future, thus we need a sustainable solution
- Fishing gear marking should be more strongly enforced and controlled. Unmarked fishing gear should result in tangible consequences e.g. withdrawal of a fishing licence.
- Responsible fishermen – fishermen who have committed to act according to certain environmental conditions e.g. they will report lost fishing gear – should be rewarded

Appendix 3. Report from the national prevention workshop in Sweden.

Results of the assessment of Polish fishing effort.

	2007		2012		2014	
Total km/year	174 215		178 355		147 743	
Diff.%	*Index year*		2,4		-15,2	
Length of nets/set/ vessel	**No of sets**	**% of sets**	**No of sets**	**% of sets**	**No of sets**	**% of sets**
Data missing	2	0,0	25	0,1	1 953	4,5
0 - 1 km	3 204	7,7	2 728	7,1	4 757	11,0
1 - 5 km	28 824	69,1	25 493	66,1	26 910	62,3
5 - 10 km	6 022	14,4	5 999	15,5	8 137	18,8
10 - 20 km	3 416	8,2	4 141	10,7	1 424	3,3
20 - 40 km	233	0,6	190	0,5	4	0,0
40 - 60 km	9	0,0	5	0,0	7	0,0
Total no sets	41 710		38 581		43 192	
No of vessels*)	605		562		621	
Sets/vessel	68,9		68,6		69,6	
*) No of reporting vessels with gear code GNS						

Results of the assessment of Swedish fishing effort.

	1997		2007		2014		2016	
Total km/year	123 627		43 997		21 458		19 884	
Diff.%	*Index year*		-64,4		-82,6		-83,9	
Length of nets/set/ vessel	**No of sets**	**% of sets**	**No of sets**	**% of sets**	**No of sets**	**% of sets**	**No of sets**	**% of sets**
Data missing	12 756	33,8	849	8,4	0	0,0	0	0,0
0 - 1 km	1 110	2,9	179	1,8	226	4,7	242	5,4
1 - 5 km	12 662	33,6	4 758	47,0	2 638	54,5	2 254	50,7
5 - 10 km	9 246	24,5	4 126	40,7	1 928	39,8	1 823	41,0
10 - 20 km	1 650	4,4	218	2,2	50	1,0	122	2,7
20 - 40 km	261	0,7	0	0,0	0	0,0	1	0,0
40 - 60 km	0	0,0	0	0,0	0	0,0	0	0,0
Total no sets	37 685		10 130		4 842		4 442	
No of vessels*)	482		255		191		168	
Sets/vessel	78,2		39,7		25,4		26,4	
*) No of reporting vessels with gear code GNS								

Results of the assessment of German (upper) and Estonian catches.

Year	Catch ton	Change %
1995	853	*index*
2002	717	-16
2007	1209	42
2012	586	-31
2015	584	-32

Year	2009	2010	2011	2012	2013	2014	2015	2016
Tons	993	956	811	841	1154	1236	1053	998
Change%	*index*	-4	-18	-15	16	24	6	0

MARELITT Baltic

Interreg Baltic Sea Region

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

The MARELITT Baltic project

Derelict fishing gear (DFG) is addressed worldwide as a source of marine litter with extensive hazardous effects on the marine ecosystem. From 5.500 to 10.000 gillnets and trawl nets are lost every year and despite intense media focus – the problem is poorly known in the fisheries industry and among politicians.

The MARELITT Baltic project is one of the first transnational initiatives in the world to provide an operation oriented all-in-one solution for how to approach DFG. It will turn a diffuse problem into a clear and apprehensible topic that can contribute to an enhanced international readiness to act.

The project is divided into five work packages (WP), where package 2, 3 and 4 are the major parts concerning the cleaning, prevention and recycling of lost fishing gear.

Cleaning the sea and planning future action at sea
The aim of WP 2 is to plan and execute DFG retrievals in Sweden, Estonia, Poland and Germany both on the seafloor and wrecks. The activities will be based on methodologies and techniques tested in earlier national projects. These experiences will contribute to a common methodology which is crucial given the extreme hydrographic and morphological variation in the Baltic Sea. The new operation platform will make cleaning operations both transparent and demonstrate if the task is physically possible.

Responsible fisheries prevention scheme
The aim of WP 3 is to develop an overall approach to mitigate the problem of lost fishing gear in the future. It can roughly be divided into three types of actions. Firstly, the project will increase knowledge on fishing technological and strategic changes over time and how these changes have influenced the evolution of gear loss. In the second step, the project will focus on the potential causes to why fishing gears are lost. The third category of action includes development of preventive methods such as gear marking technologies helping to track irresponsible fishermen or assisting responsible fishermen to locate lost gears.

Marine litter reception facilities and recycling
The aim of WP 4 is to identify the options for a safe and fully sustainable handling and recycling of the lost fishing gear in a circular approach. Within this work package the phase from reaching the harbour through cleaning, sorting, transport until processing of recycling of the nets will be dealt with. The work encloses a variety of approaches such as creating a knowledge baseline about the transnational status and capacities of harbours, waste handling systems and industries in the Baltic Sea countries.

Projectpartners

Sweden
Municipality of Simrishamn, Lead partner
Keep Sweden Tidy

Germany
WWF Germany

Poland
WWF Poland Foundation
Maritime University of Szczecin
Kolobrzeg Fish Producers Group
Institute of Logistics and Warehousing

Estonia
Keep the Estonian Sea Tidy
Estonian Divers Association

More information

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